The Crossrail Business Case

Cross London Rail Links Limited
Strategic Rail Authority
Transport for London

July 2003

Executive Summary

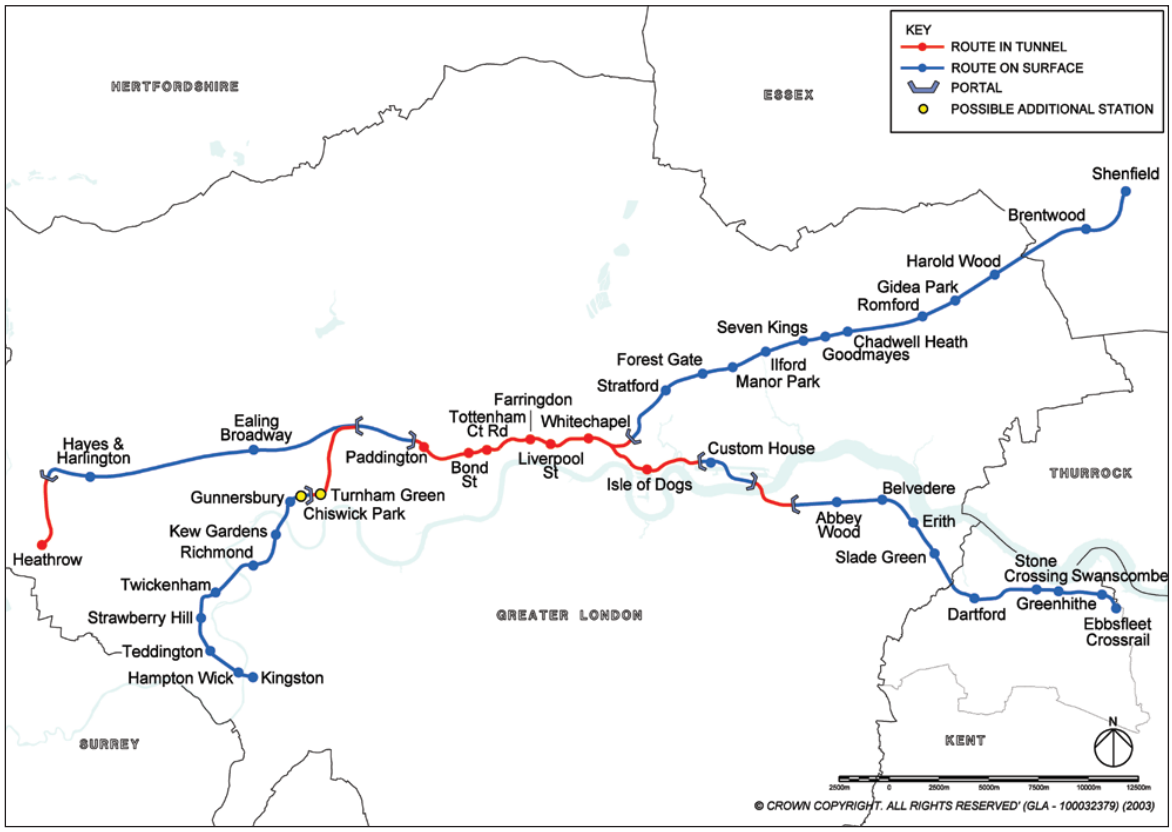
Why Crossrail is Needed

London's present day transport networks face significant challenges in meeting peak period demand for their services. On the National Rail network, crowding is experienced on the approaches to most London termini, while large sections of the London Underground network around and within central London carry passenger flows considerably in excess of their planning standard.

As well as struggling to meet current levels of demand, improving the quality and quantity of transport within London are two of the key enabling factors in supporting the anticipated growth in London's economy. By 2016 London is expected to absorb an additional 738,000 people and 636,000 jobs. With such growth, even with planned improvements to the existing transport system, the level of crowding is likely to increase uncomfortably in key sections such that it constrains future economic growth.

Governmental initiatives aim to spur the development of 200,000 housing units throughout London focusing on regenerating under-developed or deprived areas in the Thames Gateway. The success of this development will depend upon the availability of adequate transport links, including Crossrail.

The Route



The Crossrail route presented for consideration, 'the benchmark scheme' consists of a tunnelled section through the centre of London using the currently protected alignment from Paddington to Liverpool St plus extensions:

- East from Liverpool St to Whitechapel and then branching to Stratford and on to the Great Eastern lines serving stations to Shenfield
- East from Whitechapel to Canary Wharf and on through the Royal Docks, crossing the Thames to join the North Kent lines at Abbey Wood, with 4 trains per hour running on to Ebbsfleet
- West from Paddington and then southwest to serve Richmond and Kingston
- West from Paddington to serve Ealing and Heathrow, taking over the Heathrow Express service.

It is envisaged that the project would be delivered as a complete entity but that the operating service would have a phased start-up programme to allow a sensible period of hand-over, testing and training. This would be spread over a period of about 12 – 18 months.

The Benefits of Crossrail

With the planned capacity for 600,000 passengers per day, Crossrail will significantly augment the existing transport network. The scheme would make a significant contribution to relieving congestion on the National Rail and London Underground networks as well as improving accessibility across central London and to the Isle of Dogs. In addition, Crossrail would release capacity to operate additional train services into Paddington and Liverpool Street stations.

Crossrail is designed to ensure that the London economy, with its unique national focus on financial business services, continues to develop and prosper and that development areas in the Thames Gateway are served.

The Crossrail proposal offers a positive benefit – cost ratio of 1.99:1 taking account of the benefits beyond the first thirty years. The scheme performance has therefore been improved following the thorough review of costs and benefits undertaken since the interim business case was submitted to Government in February 2003.

That work has not changed the conclusion that the project has a robust benefit – cost ratio, after applying optimism bias on both capital and operating costs, as per the Treasury Green Book appraisal criteria. The transport case for Crossrail is now stronger than that given in the interim business case, using agreed methodologies.

Investigation of the performance of the scheme components has confirmed the conclusion in the February 2003 interim business case that the removal of any of the western or eastern branches would diminish the benefit – cost ratio.

Project Costs

Continuing review of the project costs support their base level as previously presented with some refinement in the risk premia that should be attached to them, reducing the base cost of the project to £6.9 bn. The base costs are derived from the out-turn costs of projects such as the JLE and CTRL. The out-turn costs reflect real world experience of effects such as cost overruns, delays and poor project management as experienced on the comparator projects. This methodology therefore provides a prudent basis for the estimate of costs.

In addition to the effective provision for contingencies already included in the base costs, there are additional contingencies to reflect, *inter alia*, the possibilities for changes in scope during grant of power and during construction. These contingencies range from 20% for tunnels that are relatively tightly specified to 146% for surface route infrastructure works that are at earlier stages of specification. In aggregate £3.2 bn has been added for additional contingencies on top of the base estimates.

Financing

Recent work on financing the project suggests that, to a very significant extent, the project could be privately financed. A concessionaire should be required to raise PPP/project funding at the concession level, which under current market conditions could raise £3.5 bn. Additional amounts can be raised under a pay-as-you-go funding structure under a FundCo that would require Government support.

Farebox Revenues

The project has substantial revenue potential as shown in the transport appraisal. With assumptions of capacity constraints, much of these revenues would be new to the public transport system. In aggregate the revenue potential for the project ranges from £1.8 bn to £3.3 bn over the first thirty years. The use of premium fares could increase these revenues further.

Alternative Revenue Sources

The project team has made significant progress, in consultation with London business groups and in conjunction with government departments, over the issue of alternative revenue streams. A detailed attempt at quantification on the scope for raising revenues by these means and discussions with some businesses on the acceptability of a London contribution suggests that London would make a contribution of above £3 bn towards the cost of Crossrail.

Costs to the Exchequer

Excluding optimism bias contingencies, the cost to the Exchequer of building Crossrail is of the order of £2.6 bn to £4.1 bn, where the range depends critically upon the revenue assumptions made in respect of the 'without Crossrail' case. Additionally, there would be an Exchequer funded provision for additional contingencies of £3.2 bn, making a total provision for public sector finance of up to £7.6 bn over the period to 2042. It is worth reiterating that whatever revenue assumption is made, the transport case remains attractive.

Next Steps

The next steps in securing the delivery of Crossrail are to:

- Confirm and safeguard the preferred route
- Consult on this route
- Prepare material to support a hybrid Bill
- Commence procurement.

A public statement on Crossrail prior to the summer recess would keep open the option of submitting a hybrid Bill for Crossrail in 2004.

Conclusions

The business case provides a clear position for the SRA and TfL to endorse the project and to reinforce their recommendation made in the February 2003 interim business case to proceed to the next stage; this would be to prepare the necessary material to support the passage of a hybrid Bill through Parliament.

Contents

Tables

Figures

Chapter 3 – The Crossrail Proposal

Chapter 5 – Business Case

Chapter 6 – How Crossrail Supports Government Policy

Chapter 8 – Exchequer Costs of Crossrail

1. Introduction

1.1 The Strategic Rail Authority, Transport for London and their joint venture company Cross London Rail Links submitted an interim business case for the Crossrail project to the Secretary for State for Transport on 22 February 2003.

1.2 The interim case was prepared following consultation on 6 route corridors to Aylesbury, Watford, Reading, Shenfield, Ebbsfleet (both via the Royal Docks and via Charlton). The route to Richmond and Kingston was also included in the interim case, although no consultation had taken place at that stage. The recommended scheme comprised:

- The currently protected alignment between Paddington and Liverpool St
- East from Liverpool St to Whitechapel and then branching to Stratford and on to the Great Eastern lines serving stations to Shenfield
- East from Whitechapel to Canary Wharf and on through the Royal Docks, crossing the Thames to join the North Kent lines at Abbey Wood
- West from Paddington and then south west to serve Richmond and Kingston
- West from Paddington to serve Ealing Broadway and Heathrow incorporating Heathrow Express.

1.3 Since February, the following areas have been subject to significant development:

- The capital cost estimate (including risk assessment in relation to optimism bias)
- The financing and procurement strategy
- The costs of Crossrail to the exchequer.

1.4 The results of this development are provided in this report. The capital cost estimate has been reviewed to provide a more detailed assessment of the risks associated with the project and to provide a robust assessment of optimism bias, as required by the HM Treasury 'Green Book'.

1.5 Additionally, there has been further refinement of the case in the following areas:

- The transport and economic effects of the scheme through improved forecasting processes
- Further assessment of risk and uncertainty in the appraisal through sensitivity analysis
- The scheme design for the route to Richmond and Kingston
- Further investigation of transport and economic effects of serving Heathrow.

1.6 As before the report has been prepared in accordance with the SRA Business Case Manual and the DfT New Approach to Appraisal (NATA).

1.7 The remainder of the report is organised as follows:

- **Chapter 2** **The Need for Crossrail**
- **Chapter 3** **The Crossrail Proposal**
- **Chapter 4** **Project Costs** including an assessment of risk
- **Chapter 5** **Business Case** prepared in accordance with DfT guidelines,
- **Chapter 6** **How Crossrail Supports Government Policy** describes the wider policy, economic and regeneration benefits of Crossrail
- **Chapter 7** **Procurement and Finance** describes the proposed strategy for delivering and financing the project
- **Chapter 8** **Exchequer Costs of Crossrail.**

1.8 Conclusions are provided at the end of each chapter.

1.9 The supporting working papers are listed at Appendix A and are available as a CD ROM.

2. The Need for Crossrail

Why is Crossrail Needed?

2.1 The objectives for Crossrail published by the CLRL Board in 2002 are to:

- Support the transport, planning, social and environmental objectives of the Government's 10 Year Plan, the Mayor's Strategies for London, the Strategic Rail Authority's Strategic Plan and Regional Planning Guidance
- Relieve congestion and overcrowding on the existing National Rail and Underground networks and support the development of a network of strategic interchanges
- Facilitate the continued development of London's primary finance and business service activities which are now located in both the City and the Docklands
- Facilitate the improvement of London's international links, including Heathrow
- Facilitate the regeneration of priority areas, such as the Thames Gateway and the Lea Valley
- Provide improved east-west rail access into and across London from the East and Southeast regions.

2.2 Crossrail would achieve these objectives by:

- Addressing existing and future problems on the LUL and NR networks, principally problems caused by an excess of demand over capacity into and within the central area
- Enabling the growth expected for London generally and specifically for the key financial and business services sectors (West End, City and Isle of Dogs).

Existing and Future Transport Problems

2.3 The current National Rail and London Underground networks are characterised by high levels of crowding on services into and through central London during the peak periods. On the National Rail network, crowding is experienced on the approaches to most London termini, while large sections of the London Underground network around and within central London carry passenger flows in excess of their capacity. At present over 90% of passengers travelling to central London in the morning peak hour on London Underground or National Rail services endure crowded conditions for at least part of their journey.

2.4 Congestion on rail lines, congestion within stations, service unreliability (in part due to very high passenger loadings) all produce real economic costs. London's main wealth generating sectors are heavily clustered within the central area. They have the highest rail mode share of any part of the UK and suffer the highest levels of crowding. Analysis of current and future public transport performance and problems is described in Chapter 5.

2.5 Problems for the rail network will be exacerbated in the future because employment growth is expected to continue to be concentrated in the central area which already suffers the highest levels of rail crowding. Despite planned increases in capacity on the National Rail and London Underground networks, the overall rail network is forecast to be more crowded in 2016 than at present. In addition, there are no plans to increase highway capacity in central London, so growth will have to be accommodated on public transport.

Future Growth

2.6 Regional Planning Guidance for the South East (RPG9, 2001) seeks to support and develop the London economy, promote employment and population growth in the Thames Gateway and the London Stansted Cambridge sub region, and support sustainable economic prosperity in the west. RPG9 recognises that derelict land, surplus labour, and proximity to Central London combine to make the Thames Gateway a location for focusing and accommodating sustainable growth in the South East region. Transport infrastructure is seen as a significant component in the strategy for delivering growth in the Thames Gateway.

2.7 More recently the Sustainable Communities Plan (2003) was published setting out plans for growth in the Thames Gateway and the Lea Valley – Stansted area. It plans for an additional 200,000 new homes in excess of levels currently planned in regional planning guidance, and 300,000 new jobs in Thames Gateway by 2031. These projections have not been included in the scheme appraisal. A Government announcement on the delivery of growth in the Thames Gateway is imminent.

2.8 Substantial growth is planned in London over the medium term. The Mayor has prepared a draft London Plan that provides a strategy for accommodating that growth. It is consistent with regional planning advice (RPG 9) and forecasts future population and employment growth. Although based largely on an extrapolation of historic trends, the forecast growth rates in the London Plan are in general lower than has been experienced over the last 15 years. The draft London Plan sets out a spatial development framework, identifying key areas where this growth can be accommodated, as well as a range of transport policies and proposals, including Crossrail, to help achieve the Plan.

2.9 Under the Plan, London's population is forecast to increase by 2016 by 738,000 over the 2001 levels and employment by 636,000. A large proportion of the employment growth would take place in central London and the Isle of Dogs while much of the population growth would be accommodated in east London (including the Thames Gateway). Employment in the Isle of Dogs would grow fastest (from 52,000 in 2001 to 115,000 in 2016 and 200,000 in 2026), but in absolute terms, expected employment growth in the West End/City is higher still.

2.10 East London is the sub region predicted to accommodate the second largest share of growth. It is anticipated that a minimum of 142,00 additional homes (30% of the London total) and 255,000 jobs (40% of the London total) will be accommodated in East London.

2.11 In West London the draft Plan anticipates growth of 60,000 new homes and 89,000 jobs to be accommodated in high density development at locations with existing or potential transport capacity so as to maximise the use brownfield land and protect the Green Belt.

2.12 The draft London Plan was subject to an examination in public during spring 2003. The report of this examination is not yet available, but no evidence has yet emerged that would lead to substantial change to these projections. The Strategic Rail Authority and Transport for London believe that the London Plan projections provide the right basis for the scheme appraisal.

The Role of Crossrail

2.13 Crossrail would play a vital role in improving service levels for passengers, facilitating forecast growth, facilitating regeneration of under-utilised land and encouraging sustainable development. It would achieve this in three principal ways:

- By reducing crowding levels on heavily loaded LUL and National Rail networks
- By increasing capacity into and within the central area thereby overcoming the constraint to central area growth posed by very high levels of crowding
- By increasing accessibility to the central area from locations where large increases in residential population can be accommodated. This includes the Thames Gateway area which would be directly served by Crossrail and the Lea Valley which would benefit from a higher service frequency into Liverpool Street due to the release of terminal capacity as a result of Crossrail.

2.14 Crossrail would increase rail capacity across the central cordon by 7% and across a cordon around the City by 20%. These represent very large increases in capacity that would have a significant effect on crowding in the central London area and its east and west approaches for both LUL and National Rail network operators. These effects are described in Chapter 5 and the scope to enhance London's development prospects are described in Chapter 6.

2.15 Crossrail's role within development and regeneration areas is also important. Employment growth in the central area relies on the ability of London and the surrounding regions to accommodate the required increase in population. Crossrail is integral to a co-ordinated approach to this challenge. In the east, Crossrail has a route along the Thames Gateway, opening up access to key development sites on both sides of the river, while in the west the key opportunity area of Hayes would be served. In addition, by reducing the number of terminating services at Liverpool Street, Crossrail allows additional services to be operated over the Lea Valley line into central London. Crossrail makes these areas accessible to the additional jobs and increases the amount of development that would take place within them. Residential development in these areas will also add new local employment opportunities and contribute towards the regeneration of currently deprived communities.

2.16 Therefore the Crossrail project, by adding significant capacity into and across central London, is designed to ensure that London's economy continues to develop and prosper. The business case presented here in Chapter 5, assumes that, as is accepted practice under established methodologies, without Crossrail, London and its economy would grow nonetheless. In practice, with deteriorating conditions for commuters, business travel, residents and tourists alike, this assumption imparts an intrinsic conservatism to the analysis.

Stakeholder Support for the Project

2.17 Crossrail has attracted considerable business support, at local, regional and national levels. Organisations including the CBI, London First, The Institute of Directors and London Chamber of Commerce have all expressed their support for the project, recognising it to be an investment which meets the transport, economic and social objectives of both the Mayor and Government. The project is seen as reinforcing London's role as a world financial centre, fostering regeneration in the Thames Gateway and providing access to land for housing and commercial development.

Conclusions

2.18 In conclusion, Crossrail:

- Has a significant role to play in addressing existing and future problems of crowding on the LUL and National Rail networks
- Has a significant role to play in achieving the London Plan by facilitating economic development and promoting regeneration
- Has significant support from major stakeholders.

3. The Crossrail Proposal

Development of the Strategic Specification

The Evolving Background to Crossrail

3.1 The original Crossrail scheme was developed in the late 1980s, and while some of the original objectives remain, some have evolved over time. Critically, since then, the Docklands regeneration and growth ambitions have come to fruition and have now been extended into the wider Thames Gateway plan. While the Jubilee Line Extension and the DLR have been developed around the emerging pattern of demand in East London, there has been a sustained period of growth, both in population and employment.

3.2 Against the expectations of some commentators, London has strengthened its role in financial and business services. It has also retained its strong role in the creative arts and businesses and continues to be a strong tourist attraction. The annual demand for travel by the expanded Underground is higher than in 1991, reflecting a sustained off peak growth in particular. The National Rail network, now privatised, has experienced high levels of growth, with typically 30% uplifts in carryings. The pattern of excessive demand on key central London Underground lines remains, with the Central and Victoria lines amongst the most crowded. Serious overcrowding also now occurs on some National Rail lines into the major London terminals, including the routes via London Bridge, Waterloo, Liverpool Street and Fenchurch Street.

3.3 There are further key changes including the adoption of the PPP programme for London Underground which brings a medium term commitment and a long term plan for the renewal and enhancement of the Underground network. Whereas it was previously possible to argue that scarce public sector resource should go towards Underground renewal before expenditure on new lines, that argument no longer holds. Crossrail now has to be assessed against agreed programmes for investment in both the Capital's rail networks.

3.4 The introduction of congestion charging in central London, while having only a relatively small effect on rail carryings to date, could have significant effects if extended to the west where there are potentially more car trips to divert. It would be even more significant if/when the charging zone is extended further. The pressure for more rail capacity would be all the stronger, particularly as the pattern of car use in London (unlike that of rail use) is very dispersed. For this reason, the fact that Crossrail would establish a framework of strategic interchanges is particularly pertinent.

3.5 The original Crossrail concept was focused on central London's problems but now the consideration is necessarily wider. Central London's economy is of very great significance nationally and extending its already substantial job catchment area and improving the efficiency and dependability of access journeys (from home, for commuters, and from the international and national gateways for business travellers) is a very important feature of Crossrail. The scheme was originally developed before Heathrow Express was implemented, and no firm plans for its inclusion could be devised. Heathrow is a clear feature in the new proposal.

3.6 Previously, it was also possible to envisage incorporation of mainline services with little change to the national rail network. The intensification of use of the network in the intervening years means that this is no longer possible. Moreover, it is essential now to implement projects so that the Exchequer is not exposed to substantial compensation costs for those businesses established as franchisees providing national rail passenger services.

Development of the Scheme Concept

3.7 The cross central London tunnelled route has been reserved since 1994, and it is sensible to continue to anticipate using it. In any event, the few alternatives feasible for an east west alignment have each been considered by CLRLL and found wanting with weaker business cases.

3.8 On the east side, the need to serve the development and regeneration areas means that the original single line Crossrail formulation (to Shenfield) is now inappropriate. After considering a number of variants, the preferred scheme, which splits into two lines has emerged as a very attractive package. Continuing to divert Shenfield line trains into Crossrail, but extending the new alignment for Crossrail route eastwards has the advantage of allowing the growth of additional services over the Lea Valley and the route to Stansted and Cambridge, where strong growth is anticipated.

3.9 This route of Crossrail alone means that service frequencies on the Shenfield lines would have to be reduced and, while the longer trains Crossrail provides would go a long way to meeting the capacity short-fall, there would be inadequate capacity for growth. CLRLL's solution is to include a grade separated junction at Bow so that services can also be reliably retained between Liverpool Street and Shenfield once Crossrail is introduced. In this way, Crossrail now offers a significant capacity increase from the east side into the City.

3.10 The second eastern branch route diverges east of the planned new station at Whitechapel. This is a further development since the 1980s, when no station was to be provided in inner east London. The interchange with the East London Line and the District line at Whitechapel would significantly broaden the spread of Crossrail benefits as well as serving an area in need of regeneration. This would be one of the new strategic interchanges created by Crossrail.

3.11 The line through the Isle of Dogs and the Royal Docks would have only two stations at Canary Wharf and Custom House before reaching Abbey Wood (for Thamesmead) south of the Thames. However these two stations would be further new strategic interchanges by engaging with an extended DLR, which from Custom House may be extended towards the key regeneration sites on the north side of the Thames. Crossrail fills a key role in this concept of a modal hierarchy to improve accessibility in this area, working in conjunction with, and not against, other modes. Further east this line serves a string of development sites directly as well as the important centre of Dartford.

3.12 As with the Shenfield line, the cross-river route has been examined to see if additional use can be made of the line capacity available, following the introduction of Crossrail. Again a valuable additional use has been found by retaining the link to the North London Line east of Custom House. This would allow North London Line services to extend south of the river giving connections to Stratford from the south.

3.13 On the west side demand levels into central London are lower, at least into Paddington. The earlier idea of adding in the Aylesbury route has been found to have a number of disadvantages and is no longer favoured. Instead, a new route to the southwest has been identified, which by use of a new tunnelled alignment may allow an interchange to be made with the Piccadilly and District lines at Turnham Green or Chiswick Park. This would be another key interchange and provide passenger transfer for a whole range of journeys that are extremely difficult to make by rail at present.

3.14 The line then continues to serve a number of places with strong central London commuting flows – Chiswick, Kew, Richmond, Twickenham, Teddington and Kingston – the latter being an important regional centre in its own right. The effect of this addition is to spread to the south west the congestion relief benefits of Crossrail, both on National Rail services to Waterloo and Underground services via Earls Court.

3.15 The route west of Paddington would serve Ealing, Hayes and Heathrow and the best overall business case is achieved if Crossrail runs in place of the existing Heathrow Express services. This means that Crossrail will have to be designed to a high standard to avoid jeopardising the established rail market share at Heathrow, but this will be helped by the considerable extension of the number of direct links Crossrail will offer to the Airport.

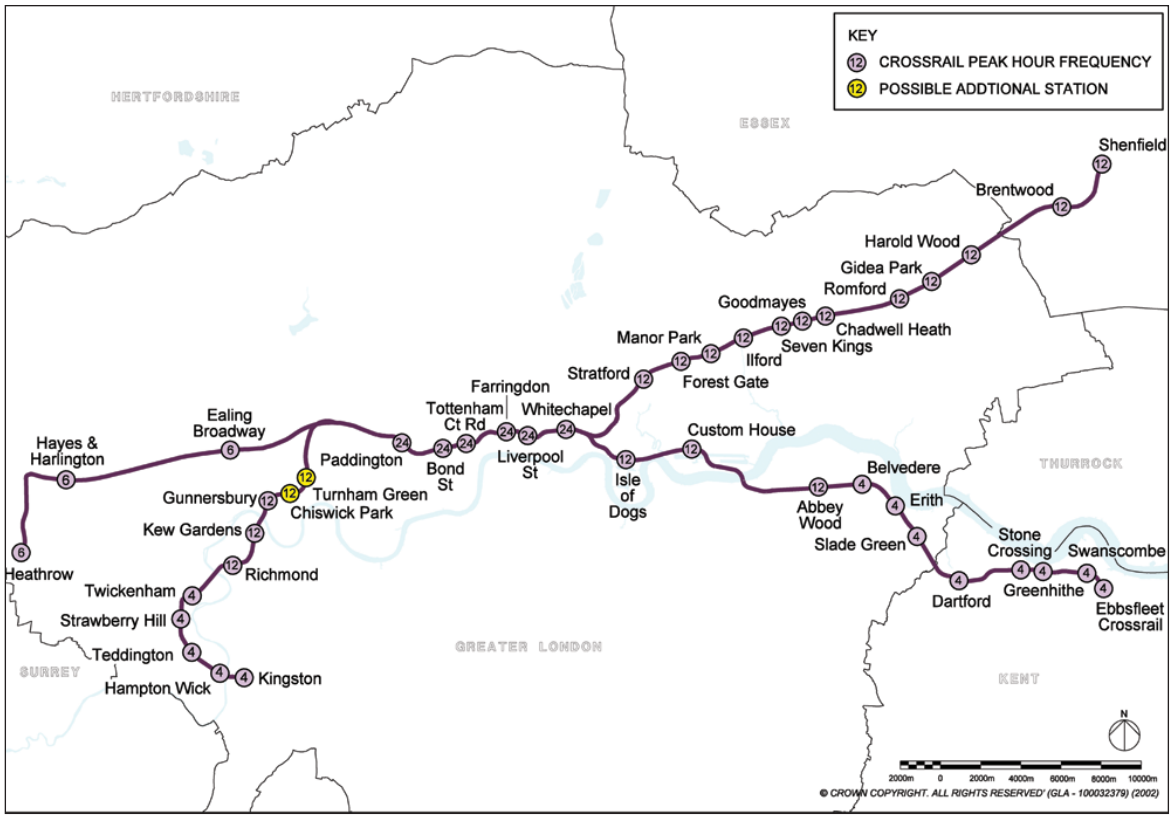
3.16 A critical decision taken before the Interim Business Case was submitted was to adopt a less lengthy train design for the project than envisaged up until that time. The train design is now very largely compatible with existing infrastructure on the National Rail network and at Heathrow obviating the need for major and comprehensive route re-building.

The Crossrail Benchmark Scheme – Service Pattern

3.17 The Crossrail proposal presented has been termed the 'Crossrail benchmark scheme'.[1] This section outlines the service pattern assumptions underlying this proposal.

3.18 Crossrail would operate a 24 trains per hour (tph) peak service in both directions through Central London. Crossrail services would generally operate as 'all stations' services, although a number of lesser-used stations along the corridor would be omitted where they could not be served economically. In addition, services to and from Heathrow Airport would call only at Hayes & Harlington and Ealing Broadway to the west of Paddington.

Figure 3.1: Crossrail Benchmark Scheme – Crossrail Peak Service Frequency



1. *Working Paper 3.1, Scheme Definition.*

3.19 In the east, a 12 tph service would operate in the morning peak hour from Shenfield, replacing much of the existing Great Eastern Metro service, although a number of these services would continue to operate between Gidea Park and Liverpool St. From north Kent, 4 tph would operate from Ebbsfleet, with a further 8 tph starting at Abbey Wood. Operation of the 4tph Crossrail service from Ebbsfleet would require the substitution of two existing Connex London Bridge trains per hour through Dartford. With Crossrail, the journey time from Dartford to the Isle of Dogs would be approximately 21 minutes, while Abbey Wood (for Thamesmead) to Tottenham Court Road would take 22 minutes. There may also be a case for extending Crossrail services further into the Thames Gateway from Ebbsfleet to Gravesend.

3.20 Provision has also been made for the current North London line to use the route between Custom House and Abbey Wood. This service would be rerouted to start at Abbey Wood with Silvertown and North Woolwich stations being closed.

3.21 In the west, a 6 tph service would operate from Heathrow Airport using the Great Western Main line to Paddington, replacing the current 4 tph Heathrow Express service. A number of changes to services on the Great Western Main Line would be required to allow the Crossrail service to operate on the Relief Lines. From Heathrow (Terminals 1,2,3), the direct Crossrail journey times to Tottenham Court Road and the Isle of Dogs would be around 25 and 37 minutes, respectively. The Heathrow definition is subject to achieving agreement with BAA. Should this not be possible, the scheme could be terminated at an appropriate point to the west of Airport junction.

3.22 On the Kingston branch, a 12 tph service is proposed, with 4 tph commencing at Kingston and 8 tph at Richmond. This service pattern assumes a 1 tph reduction in the LUL District line service from Richmond and termination of the North London line at Gunnersbury. For the purposes of the business case, it has been assumed that the withdrawn 1 tph District Line service would be diverted to serve Wimbledon, where crowding on the existing District Line service is a significant problem. Opportunities may exist to further enhance the benefits of this branch of Crossrail by providing an additional strategic interchange at either Chiswick Park or Turnham Green, although the business case has been prepared without assuming these benefits.

Other Service Improvements with the Benchmark Scheme

3.23 A major benefit of Crossrail would be release of platform capacity in Liverpool Street station that can be used to improve train frequencies to other destinations. On the advice of the SRA, CLRLL has assumed that Crossrail allows additional trains to operate on both the Great Eastern and West Anglia routes into Liverpool St station.

3.24 On the Great Eastern line it has been assumed that as well as the 12 tph Crossrail service from Shenfield, a 6 tph service would operate between Gidea Park and Liverpool St, making a total train frequency on this line between Gidea Park and Stratford of 18 tph in the peak period. This increase in frequency combined with the greater length of the Crossrail train amount to an overall increase in capacity of 40% over the current service. The Liverpool Street service would continue to serve Maryland station which cannot be served economically by Crossrail.

3.25 On the West Anglia line, an additional 6 tph are assumed to operate with Crossrail. Two of these additional services are assumed to serve Stansted Airport, with the other four originating from Cheshunt and Hertford East. These additional services would offer an increase of over 20% in capacity on this route.

3.26 The benchmark scheme has the further major network benefit of releasing capacity on the Great Western services into and at Paddington, as well as providing an alternative route for the Southwestern lines into Waterloo. Only the congestion relief benefits have been included in the business case at this stage. Congestion on some of the busiest services into Waterloo would be reduced and some beneficial service changes are likely to be possible. Crossrail would free up fast line capacity on the Great Western and platform capacity at Paddington, which in practice would be available for an appropriate mix of performance and capacity benefits for services to Oxford, the M4 corridor to Bristol and South Wales, the Cotswolds and the West of England.

The Crossrail Benchmark Scheme – Infrastructure Requirements

3.27 The Heathrow route would require new track in the form of modifications to Airport Junction to allow additional train movements from the Great Western Relief Lines to the airport but would utilise existing and future Terminal 5 Heathrow Express tunnels and platforms.

3.28 The Kingston route would utilise a tunnel from the Ladbroke Grove area to Turnham Green before using the existing alignment via Gunnersbury to Richmond. Crossrail services would then go forward to Kingston via the existing route via Twickenham and Strawberry Hill.

3.29 The central area tunnel would run from a portal at Royal Oak to portals at Bow and the Royal Docks. There would be new stations at Paddington, Bond Street, Tottenham Court Road, Farringdon, Moorgate/Liverpool Street, Whitechapel and the Isle of Dogs.[2]

3.30 All new stations would provide interchange to existing Underground services, National Rail stations and/or other transport modes. Platforms would be 205 metres long to accommodate trains of up to 10 car, 20 metre vehicles. Most stations would have two ticket halls to maximise the catchment area and improve safety. They would be designed to enhance effective passenger movement and maximise security and comfort. Crossrail central area stations would be fully accessible, with interchanges and existing stations made step free where reasonably practicable.

3.31 A link would be provided from the tunnels via Bow Junction to Stratford and Crossrail trains would then run on existing track to Shenfield. Improved station facilities and extended platforms would be provided at some stations between Stratford and Shenfield to support a 10 car service. Shenfield Station would be remodelled, and sidings would be constructed at Shenfield and Gidea Park for the stabling of rolling stock.

3.32 The Ebbsfleet route would run from the portal at Royal Victoria Dock. A new station would be built at Custom House. Sections of the North London Line and North Kent Line would be used to create a new route from Docklands to Ebbsfleet via a new tunnel beneath the Thames emerging at a portal near Plumstead Station. Major works beyond Plumstead would comprise additional tracks, re-modelling and extra platforms at Abbey Wood, and safeguarding for a new station at Ebbsfleet.

---

2. ***Working Paper 3.1, Scheme Defintion.***

Rolling Stock

3.33 Crossrail would operate trains at 2.5 minute intervals in peak periods with high performance dual system (overhead and third rail) trains capable of 160 km/h running.[3]

3.34 Trains would be 200m long (10 x 20 metre cars). Each car would have two sets of double doorways per side with wide set-backs to facilitate rapid exit and entry of passengers. Passengers would travel in quiet, climate-controlled conditions. The interiors would be carefully designed to accommodate the needs of commuters as well as those making short trips within central London. Each train would have a crush load approximately double that of a Central Line train. With the exception of the fire hardening necessary to operate in deep tunnels, the train design would be little different from other modern Electric Multiple Unit stock, thus reducing the procurement risks associated with using a bespoke design.

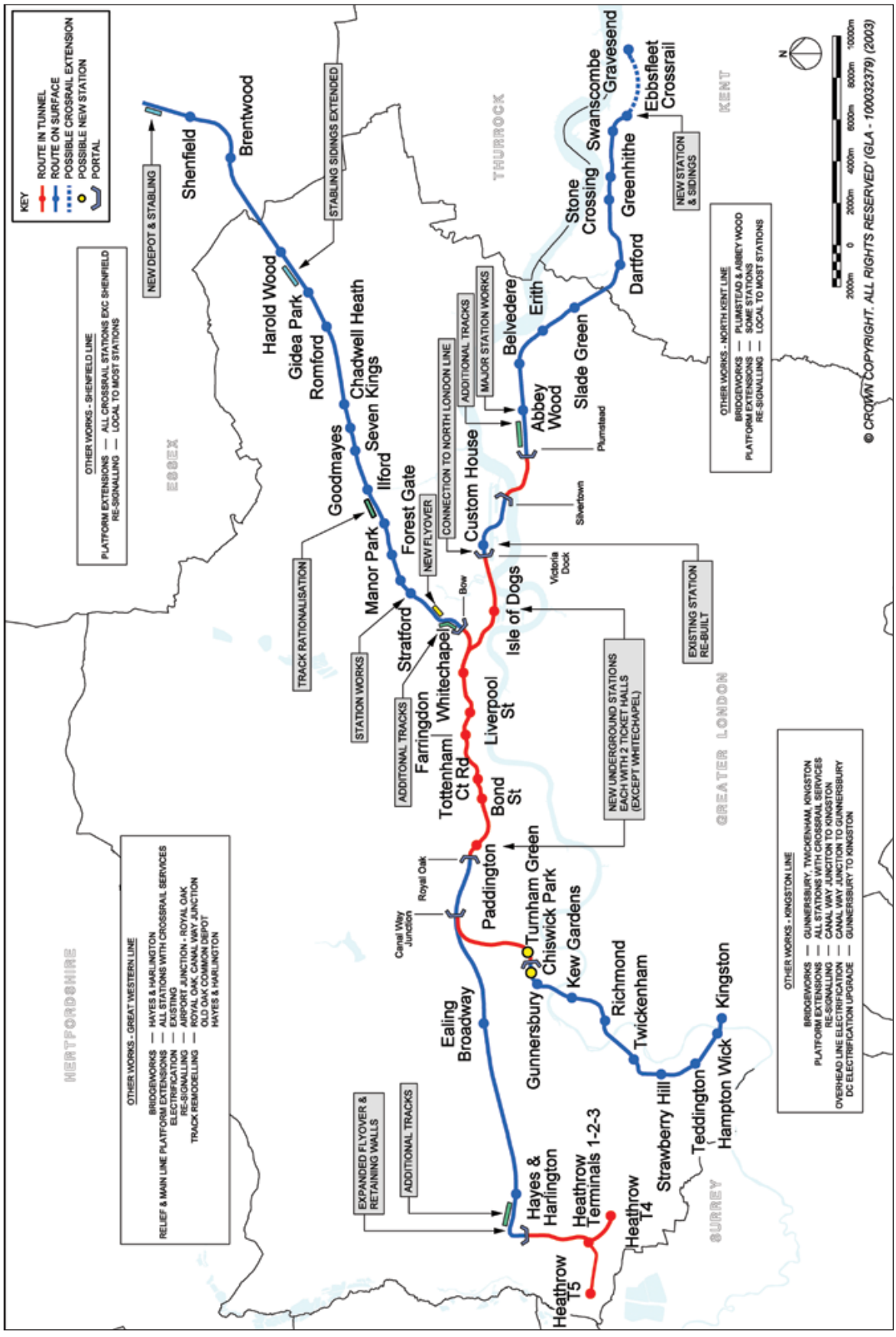
3.35 Trains in the central area would be automatically controlled in the same manner as the Victoria Line to allow consistent train performance and maximise available capacity. In the surface-running sections, the trains would operate under driver control with appropriate safety equipment such as Train Protection and Warning Systems (TPWS).

3.36 A depot with all the appropriate facilities, consistent with modern maintenance practices would be constructed. Appropriate stabling for rolling stock during the overnight and interpeak periods would be provided on each branch of the network.

---

*3. **Working Paper 3.1, Scheme Definition.***

Figure 3.2: Scheme Definition – Infrastructure Requirements

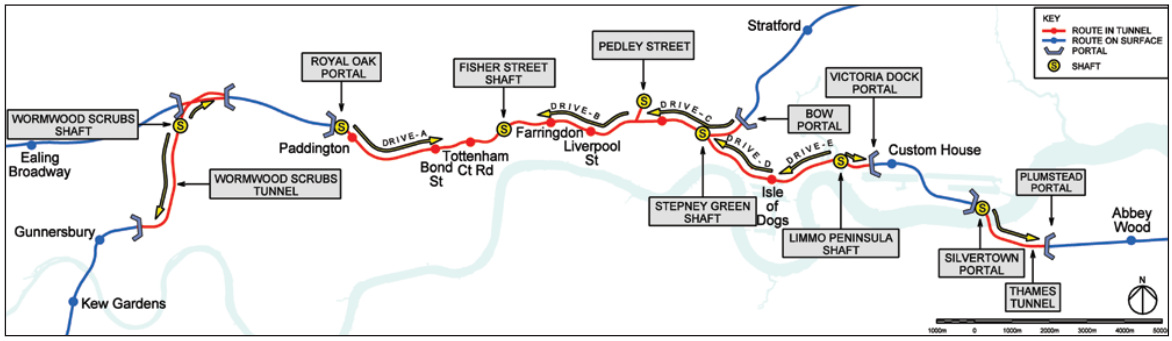


Constraints on Construction and Staging

Construction Strategy

3.37 The construction of the central section of Crossrail would present significant construction challenges. Planning authorities will require that, wherever possible, the spoil produced by tunnel construction is removed by either rail or river. This will limit the number of sites available for tunnelling. For the central area, rail-served sites have been identified at Royal Oak Portal, Pedley Street Shaft and the Bow Portal and river-served sites at the Isle of Dogs Station and Limmo Peninsula Shaft. The locations of these sites and the resulting tunnelling strategy are shown in Figure 3.3.

Figure 3.3: Crossrail Central Area Tunnelling Strategy



Construction

3.38 Fitting out of the tunnels would require access by works trains, which must be able to load at a road/rail depot. Suitable sites for these loading depots have been identified on the Great Western and Great Eastern lines. In practice this means that the western section – Drive A in Figure 3.3 - would be fitted out from the west and the eastern section – Drives B, C, D & E in Figure 3.3 - would be fitted out from the east.

3.39 Construction of Drives C & D must be complete before trains can run to Shenfield or the Isle of Dogs. This is to allow the Tunnel Boring Machine (TBM) from Drive D to be removed from the Stepney Green Shaft. If this were not done it would be necessary to construct an additional shaft in the Stepney Green area to remove the machine. No suitable site for an additional shaft in this area has been identified. The Fisher Street Shaft would be used to remove the TBMs from drives A & B.

Commissioning

3.40 It would be necessary to bring such a large project into use in stages.[4] This is to allow for activities such as staff training and commissioning. When bringing a section of the system into use it is important that the commissioning takes place without interfering with the operating railway or with parts of the system which are still under construction. Sections that are commissioned require a facility to turn trains at either end of the section as well as access to a depot.

3.41 The Crossrail central tunnels would have crossovers at the Isle of Dogs, Stratford, Farringdon and near the Western Portal. This means that 12 tph could be turned at each of these locations except for the one near the Western Portal which could handle 24 tph. It is anticipated that the depot facilities used for commissioning the rolling stock would be on the Great Eastern line. This leads to the proposed commissioning strategy for Crossrail shown in Table 3.1.

Table 3.1: Proposed Crossrail Commissioning Strategy

Stage	Section Constructed	Crossrail Service
Stage 1	Farringdon to Isle of Dogs	Farringdon to Isle of Dogs
Stage 2	Paddington to Farringdon	Paddington to Isle of Dogs
Stage 3	Stepney Green Junction to Shenfield	Paddington to Isle of Dogs and Shenfield
Stage 4	Heathrow to Paddington	Heathrow to Shenfield and Isle of Dogs
Stage 5	Isle of Dogs to Ebbsfleet	Heathrow to Shenfield and Ebbsfleet
Stage 6	Kingston to Paddington	Heathrow and Kingston to Shenfield and Ebbsfleet

4. ***Working Paper 3.2 Project Staging.***

3.42 The assumption used in preparing this business case is that all of these sections would be brought into use at the same time. In practice, this probably means over a period of about 18 months.

Possible Staging of the Works

3.43 It would be possible to stage the works over a longer time period. This would lead to a spreading of the finance burden and would reduce any perceived market pressure caused by capacity constraints in the construction and project management sectors. Staging would be done by increasing the period between constructing the various sections set out in Table 3.1. Analysis of the impact of this on the business case indicates that it would reduce the benefit - cost ratio. This is because of the relatively high costs of the central section would not bring in the full benefits until the relatively cheaper outer legs were completed.

3.44 The possibility of constructing one of the outer legs first, rather than the central section, has also been examined. The only part of the system which would be practical to construct as a stand-alone section would be the southeast line between Custom House and Abbey Wood. Although this may have some advantages in terms of allowing early commissioning of systems and permitting the operation of North London Line services over it, the benefit - cost ratio for this section alone (as opposed to as part of the Crossrail project as a whole) is poor. There must therefore be other specific policy reasons for doing this early.

Conclusions

3.45 In conclusion:

- The Crossrail Benchmark route presented here consists of a tunnelled section through the centre of London using the currently protected alignment from Paddington to Liverpool Street
- In the east, extensions would run to Shenfield via Stratford and to Ebbsfleet via the Isle of Dogs, Royal Docks and Abbey Wood
- In the west, extensions would run to Kingston via Richmond and to Heathrow by taking over the Heathrow Express services
- The Crossrail Benchmark proposal would release capacity to operate additional train services into Liverpool Street and Paddington stations
- It is envisaged that the project would be delivered as a complete entity but with a phased start-up over 12-18 months.

4. Project Costs

Capital Costs

4.1 The base capital cost for the project is £6.886 bn at 1st Quarter 2002 prices. Table 4.1 provides a breakdown of these capital costs by work category.[5]

Table 4.1: Capital Cost of Crossrail by Work Category

Work Category	Base Cost Estimate (£m)
Land & property	695
Tunnels	1,680
Surface route infrastructure	314
Trackwork	298
Stations	2,201
Railway systems	919
Stabling, depot, maintenance vehicles, etc.	283
Project team and commissioning	496
Capital Cost @ 1Q2002 prices	**6,886**

4.2 This represents the net capital cost of Crossrail in that it has been adjusted for an item of cost avoided. In real prices, i.e. adjusted for construction price inflation during the construction period but excluding RPI, the net capital cost is £7.678 bn.

4.3 The gross capital cost is £6.936 bn at 1Q2002 prices which includes an allowance of £50m for potentially needing to upgrade the power supply for the route serving Richmond and Kingston. This planned network enhancement has been deferred by the SRA until later years but is not avoidable. This is included in the gross Crossrail cost but is cost neutral, and therefore deducted in deriving the net cost.

---

*5. **Working Paper 4.1, Capital Costs.***

4.4 As the scheme definition becomes more refined, it is to be expected that the base cost will increase and the necessary level of contingency provision will diminish. Since the interim business case was prepared, the base cost estimate has been increased from £6.054m to £6.886m to take account of more conservative design assumptions. The three main reasons for this change are:

- In February, the route from Paddington to Richmond and Kingston was assessed on the assumption that it would be constructed as a surface railway and the possibility of a requirement for a tunnelled route was treated as a contingency. The choice of surface or tunnelled routes is still under investigation, however the base costs now assume the more expensive tunnelled option. This is a more prudent approach
- Higher cost estimates have been included within the base costs for potential poor ground conditions in the tunnelled sections in the east. Provision for these conditions were previously included in the contingency
- Finally, a more conservative view of the scope for savings in station costs has been taken. Work is continuing on ways of reducing station costs and these will be incorporated as specific proposals are developed.

Cost Benchmarks

4.5 The base costs for the project have taken account of out-turn costs of similar projects undertaken recently. For example, the cost of tunnelling was estimated using the out-turn costs of the tunnels bored for the Jubilee Line Extension. As the out-turn costs already include the substantial project overruns experienced on that project, the base cost estimates for Crossrail effectively include large provisions for contingencies. These base cost estimates are therefore conservative estimates of the project costs for the scheme as currently defined. Table 4.2 shows the empirical benchmarks used for various components of the project.

Table 4.2: Empirical Benchmarks Used for Cost Estimation

Route Section	Crossrail Estimate Category	Empirical Benchmark
Land and property	3,500 properties identified for temporary or permanent acquisition	Market prices estimated by London Transport Property
	Survey and monitoring costs	Unit costs on East London Line Extension (ELLX) and Kings Cross Station redevelopment
	Value recovery from sale of land currently assumed to be zero	No benchmark required for conservative estimate
Tunnels	Tunnel boring	Unit outturn prices on Jubilee Line Extension (JLE)
	Tunnel lining	Prices on JLE and CTRL
	Ground stabilisation and treatment	Prices on JLE, ELLX and King's Cross station
Surface route infrastructure	Possessions costs	Estimated from current possessions experience on Network Rail
	Scope of works assumes higher cost options and technically feasible; cheaper options under investigation	No benchmark required
Trackwork	Track upgrades identified	Current costs on Network Rail
	Possessions costs	Estimated from current possessions experience on Network Rail
Stations	Detailed bill of quantities for stations planned during previous phase of work	Outturn prices on similar civils works
	Overall costs for underground stations range from £230m for Whitechapel to £320m for Isle of Dogs with others in the same range	JLE stations cost less: £90m for Canada Water, £290m for London Bridge and £190m for Canary Wharf
Railway systems	Early indications for system operational standards; ventilation strategy under review	Discussions with potential suppliers; other benchmarks not easily comparable
Stabling, depot, maintenance vehicles, etc.	Two light maintenance depots identified	Depot construction costs in London since 1990
	Maintenance vehicles identified	Indicative prices obtained from suppliers
Project team and commissioning	Resourced organisation identified in detail	Current market rates for skills and overheads

4.6 Table 4.3 provides a breakdown of the costs by route section. The largest single element relates to the Central section. This has been under development since the late 1980's and the design and scope are comparatively well advanced. The existing designs continue to be interrogated to ensure compliance with current standards and to optimise construction. The greater scope definition in this section enables a better understanding of the quantities of work and the constraints on construction methods.

Table 4.3: Cost of Crossrail by Route Section

Cost Heading	Base Cost Estimate (£m)
Heathrow Airport to Old Oak Common	309
Westbourne Park to Isle of Dogs and Stratford	4,749
Stratford to Shenfield	318
Isle of Dogs to Abbey Wood and Ebbsfleet	738
Extension to Richmond & Kingston	772
Capital Cost @ 1Q2002 prices	**6,886**

4.7 Some sections of the project, notably the extension to Richmond and Kingston and the service to Heathrow, require more work on optimising the scope and design of the final alignments. Where the project scope is under review and there are options, the higher cost options have been included.

Risk Assessment and Management

4.8 The risk management process adopted for Crossrail will mitigate the project's exposure to risk. The way risk has been and is to be evaluated and managed is valid, consistent and robust. The process reflects best practice in the industry; it is being used successfully on other projects and follows detailed guidance on risk management issued by HM Treasury. The key steps are:

- Identify the risks and uncertainties on the project
- Prioritise risks to eliminate major uncertainties early
- Assess likelihood and impact
- Formulate detailed management control actions
- Implement actions to reduce inherent exposure
- Identify contingency and/or secondary risks for those that cannot be avoided
- Analyse the risks (both to costs and schedule) quantitatively to derive a project contingency
- Control and review actions to ensure risk are managed effectively.

4.9 The principal implementation risks have been identified following analysis of the risk registers established so far for the project. Risks/causes that are common in separate location-specific registers have been developed into key management issues across the project. The Project team has reviewed the impacts of these risks and initial management control actions for them have been developed. These actions will be used to manage the strategic issues and will reduce the project's risk exposure. They will also assist in exploiting opportunities currently available to the project. The principal implementation risks are:

- Assumed possession working regimes not realised, thus causing delay in signalling and trackwork modifications
- Delay in securing Railway Agreements or other agreements for access, works or services
- Constraints on methods of working arising from environmental impact or local objections
- Existing asset condition not as assumed, necessitating additional work to achieve required standard
- Inability to secure access and worksites for construction of the Central section
- Delay in securing LUL, Network Rail or HMRI approval
- Changes in standards or legislation
- Delay in commissioning the railway into operational mode
- Insufficient resources - industry capacity or specialist resources
- Ground conditions are different from assumptions in Crossrail design or methods of construction.

4.10 Assessment of the risk is being applied in a systematic and practical way. Refinement of the contingency on project costs will continue throughout development of the project and the process for producing a fully Quantified Risk Analysis (QRA) will establish a more detailed risk profile for the project.

Contingency Analysis

4.11 The methodology for cost estimation and accounting for optimism bias is consistent with guidance provided by HM Treasury in the Green Book that identifies two major causes for optimism bias:

- Poor identification of scope and objectives due to poor identification of stakeholder requirements, resulting in omission of costs during project costing
- Poor management of projects during implementation so that schedules are not adhered to and risks are not mitigated.

4.12 Concerns about optimism bias have been exclusively addressed in the base cost estimates. Better identification of stakeholder requirements, project definition, value engineering and a competitive procurement process will help in reducing the cost of those elements where the assumptions are particularly conservative. The approach to accounting for this is summarised in Table 4.4.

4.13 In addition to the conservative base cost estimates, allowance has been made for additional contingency provisions based on a risk assessment. These provide for the possibility of even higher out-turn costs than the relevant benchmarks and for changes in scope during the process of obtaining powers. Again, this is in keeping with the process recommended in the Green Book, which advises appraisers to:

- Estimate capital costs of each option
- Apply adjustments to these estimates, based on the best empirical evidence available at the stage of appraisal
- Subsequently reduce these adjustments according to the extent of confidence in capital cost estimates, extent of management of generic risks and the extent of work undertaken to identify and manage project specific risks.

4.14 Specific risks would be catered for in the methodology adopted in estimating costs for the project.

4.15 Based upon this methodology, Table 4.5 shows the additional contingency provisions included in the Crossrail estimates. Where the scope has been well defined, such as tunnels, there is an additional contingency provision of about 20%. On other cost elements, such as the costs for railway systems and surface route infrastructure that are dependent upon condition of existing assets and are subject to changes in both technology and standards, the contingency provisions are much higher. In aggregate, nearly £3 bn has been added for additional contingencies at this stage.

Table 4.4: Accounting for Risks in Crossrail Costs

Base Costs	Additional Contingencies
Design development	Scope changes before commencement of construction
Changes in programming or construction methodology	Possible extreme conditions worse performance than relevant benchmarks Scope changes during construction
Market imperfections and constraints	Changes in scope or methodology arising from inadequate powers

Table 4.5: Additional Contingency Provisions

Work Category	Additional Contingency %	£m
Land & property	33%	229
Tunnels	20%	329
Surface route infrastructure	146%	457
Trackwork	100%	298
Stations	29%	631
Railway systems	78%	717
Stabling, depot, maintenance vehicles, etc.	20%	57
Project team and commissioning	27%	136
Additional contingency @ 1Q2002 prices		**2,854**

4.16 One aspect of the Jubilee Line Extension that was a major contributor to the cost overruns and delays was the use of the New Austrian Tunnelling Method, which was then untested in London soil conditions. As a result of both the JLE and CTRL, there is now an improved empirical understanding of the costs of tunnelling, which have been used to inform the base cost estimate.

4.17 The new underground stations represent just under one-third of the total project costs. The costs for each station are as shown in Table 4.6, together with the out-turn costs for comparable JLE stations. These estimates reflect the vision of modern stations and the engineering challenges of integrating these stations with existing facilities. Nevertheless, we have included a 29% additional contingency on the cost of stations to allow for unforeseen expenditure on stations.

4.18 Working on existing railway assets will require access arrangements and possession working. The costs of possessions have already been included in the base costs. The project team is currently working to identify major possessions so that discounts for early notice can be secured. Work on possessions would be integrated with the work that Network Rail and LUL carry out as their planned works. The contingency of 146% on surface route infrastructure and 100% on trackwork reflects the uncertainties around the work on existing assets.

Table 4.6: Cost of Crossrail Underground Stations

Crossrail Stations		JLE Stations	
Station	**Cost £m**	**Station**	**Cost £m**
Cut and cover box:			
Paddington	230	Canary Wharf	190
Isle of Dogs	322	Canada Water	90
Tunnelled:			
Bond Street	277	London Bridge	290
Tottenham Court Road	324		
Farringdon	237		
Liverpool Street	299		
Whitechapel	237		

4.19 For railway systems, principal uncertainties stem from changes in standards, use of new technology, poor system performance or inadequate systems integration. On other projects, unexpected changes in the extent of upgrade required to existing systems have led to scope increase and project delay. Crossrail has deliberately avoided untested technology because of the associated uncertainties. Whilst all systems would still require testing and commissioning to confirm robust performance, the extent of development is limited to their adaptation to Crossrail. The experience from other projects, such as the JLE, is therefore largely avoidable.

4.20 The process for securing acceptance from the HMRI, an issue that also was a major contributor to delays on the JLE, is now better established and understood, thereby reducing the acceptance risk.

4.21 The capital cost estimate presented here includes some works that would have to be done to the National Rail network even if the project were to be abandoned. It is difficult to determine how much of the capital costs fall within this category but the number is likely to be substantial. Other potentially significant savings are expected as a result of developer contributions and recoverables at the end of the project but these savings are not included anywhere in either the base cost or additional contingency adjustment.

4.22 In advance of a QRA, the methodology for delivering a contingency is based on pricing the key uncertainties in the scope and pricing for each work category in the scheme:

- **Land & Property** – adjustments of 5% in the central section and 15% for the outer section on the number of properties affected. 10% has been added to the property values although the fall in the value of commercial properties in London provides a buffer against future price increases. A heavily risk-adjusted provision of 15% has been added for changes in compensation law
- **Tunnelling** – the costs have already been benchmarked against JLE and CTRL costs but further provisions of 10-15% have been included for ground conditions or changes in alignment in route sections where engineering is less well developed. Further pricing adjustments of 5-10% have also been made even though the base already includes conservative assumptions on tunnelling productivity
- **Surface route infrastructure** – £150m has been added to provide additional contingency as a buffer against changes in the route engineering for the extension to Heathrow. Base costs have been enhanced to accommodate more pessimistic assumptions on access. TOC compensation has been uplifted to £110m as a worse case
- **Trackwork** – the base cost estimate already includes uplifts for possession working and management that are in line with Network Rail benchmarks and provision has already been made where new infrastructure meets existing notably at Bow Junction and Old Oak Common. A contingency of 100% is allowed on top of substantial provisions already within the base cost estimate
- **Stations** – for the central area, a further 25% of base cost has been added as a contingency for the complexities of working in central London. On existing surface stations, a 50%, uplift has been allowed to accommodate more pessimistic assumptions on scope change and access
- **Railway systems** – an independent review of the cost estimate and specification assumptions by SRA advisors confirms that they are appropriate given the current level of design. A systems risk review has ascertained a reasonable outer range of cost at 78%. This is likely to reduce as system specifications and budget prices are explored further with suppliers
- **Maintenance and stabling** – the base cost estimate accommodates two major depots on the scheme, even though one is likely only to be for stabling, cleaning, etc. Given there is already over-provision for depots, the specific risks relate to site constraints and environmental mitigation. A 20% contingency provides a buffer against scope change
- **Project team** – a project organisation has been created using detailed resourcing of functions within the project delivery team. A contingency has been derived for a scenario where the project is delayed by 18 months and the level of resources during the project duration increases by 10%.

Programme and Indexation

4.23 The capital costs shown above were built on a price basis of 1Q2002. Given that the project would take several years to construct, the consequences of real price escalation in the construction industry have been included by factoring for real price escalation of 1.5% (in addition to RPI) on our entire cost base. This is a conservative estimate and should account for the demand side pressures that Crossrail would place on the construction market in London. The base cost is £7.68 bn in real prices, assuming an eight year construction project (including advance works) completed by end of 2012.

Operating and Maintenance/ Renewal Costs

4.24 Operating and maintenance costs include the cost of leasing, maintaining and operating the rolling stock as well as operating Crossrail stations, maintenance of new infrastructure and track access charges where Crossrail runs on the existing network.[6]

4.25 Operating costs for the project were computed on the basis of detailed modelling of the operations with a choice of rolling stock and due consideration of service patterns. All costs have been computed separately on a gross basis and, after subtracting operating costs avoided on the National Rail and LUL networks, on a net basis. The net costs represent the economic costs of the project.

4.26 Maintenance and renewals costs for new infrastructure were computed on the basis of cyclical repair and renewal cycles and by benchmarking against asset life assumptions used by London Underground and Network Rail. Operating costs are assumed to rise in line with RPI whereas a real cost factor of 1.5%pa has been applied to new infrastructure maintenance costs to reflect construction inflation up to 2012.

4.27 The costs are also based on access assumptions that minimise loss of service availability. Hence uplifts on unit rates have been derived for annual maintenance carried out in engineering hours or short possession working. Cyclical repair and maintenance would be carried out in major (weekend) closures. The asset maintenance strategy assumes no blockades or other major restrictions on asset availability. With alternative public transport available for most of the Crossrail route, the short possession assumption is inherently conservative and there is the potential for considerable savings in the costs for maintenance of new infrastructure. The assumption here is that the assets will be maintained to a condition and performance that will sustain maximum availability of the railway. These assumptions build in a level of cost that is likely to reduce as more detailed strategy for asset management and access regimes are developed

4.28 Table 4.7 shows the gross and net operating, maintenance and renewal costs over a 60 year period.

---

6. ***Working Paper 4.2, Operating Costs.***

Table 4.7: OMR Costs for Crossrail (60 Year Operating Period)

	Operating Cost (Including Maintenance on NRN) @1Q2002 prices	New Infrastructure Maintenance Cost @1Q2002 prices	Total @ 1Q2002 prices
Net Costs	£98.9 mpa	£123.4 mpa	**£222.4 mpa**
NPV	£1,794 m	£2,374 m	**£4,168 m**

4.29 In addition to the base costs a 20% contingency on all operating, maintenance and renewal costs is included for the purposes of financial analysis. This amounts to £834m (NPV). This level of contingency is consistent with tests carried out assuming pessimistic assumptions on costs for operating staff, train maintenance and access regimes, these being the key cost drivers.

Conclusions

4.30 The estimates of the capital costs of the project have been built up from a detailed analysis of the individual components and are appropriate for the current level of design definition. Unit costs have been derived from empirical evidence including outturn costs from JLE and other recent projects. This base cost has been adjusted upwards to take account of a forecast of real increases in construction costs.

4.31 For appraisal purposes, the estimate has been further adjusted to make allowance for appropriate levels of contingency which has been estimated on a basis consistent with the guidance set out in the HM Treasury's Green Book.

4.32 Operating costs are primarily derived from modelling of the train service specification and, in respect of maintenance costs, are based on Track Access Charges and assumptions on asset renewal cycles used elsewhere in the railway industry. For appraisal purposes, a contingency has been allowed as a sensitivity on operating and maintenance costs.

5. Business Case

Introduction

5.1 The business case is prepared in accordance with Government guidance[7] on the appraisal of major transport projects and assesses the scheme against the following five objectives:

- Economy – Support of sustainable economic activity in appropriate locations while demonstrating value for money
- Environment – Protecting the built and natural environments
- Safety – Improvement of safety for all transport users
- Accessibility – Improving access to facilities for those without a car and reducing community severance
- Integration – Ensuring that all decisions are taken in the context of a wider policy framework.

5.2 Since the interim business case was prepared, the appraisal of Crossrail has been refined through:

- Better model validation leading to more robust forecasts
- Refinement of the costs[8] and benefits
- A review of potential developer contributions[9]
- Investigation of further sources of benefit, e.g. bus cost savings
- Sensitivity analysis of the assumptions in the appraisal
- Further investigation of the costs, benefits, operational and environmental implications of serving Heathrow, Richmond and Kingston
- The use of new TEE tables based on Department for Transport adivice.

Value for Money – Transport Economic Efficiency

5.3 Crossrail will deliver a significant increase in rail capacity to central London that will deliver considerable economic benefits. Established DfT methodology assesses whether these benefits represent value for money through an assessment of the Transport Economic Efficiency of the scheme, summarised in a TEE table.

5.4 The main benefits are:

- Time savings experienced by users of Crossrail
- Crowding relief for passengers using Crossrail and other services
- Increased fare revenue
- Reduction in highway congestion arising from a shift to public transport.

5.5 These economic benefits are assigned monetary values and compared with the net costs and subsidy requirements of Crossrail. The TEE table is used to calculate the values of indicators used to measure the performance of a project:

- net present value (NPV): net benefits - net costs
- the benefit - cost ratio (BCR): net benefits/net costs.

---

7. ***A New Deal for Transport: Better for Everyone",*** *DTLR, 1998.* ***"Guidance of the New Approach to Appraisal"*** *(NATA), DETR, 1998,* ***"Guidance on the methodology for Mutli-Modal Studies"*** *(GOMMMS), DETR, 2000. SRA Appraisal Criteria, April 2003.*

8. ***Reported in Chapter 4, Project Costs***

9. ***Reported in Chapter 8***

5.6 For Crossrail, the indicators were derived through forecasting the effects of the benchmark scheme using consistent and established planning assumptions. The sensitivity of the result to variations in these assumptions, either singly or in combination, was then assessed.

5.7 Benefits and demand forecasts were prepared using the London Transportation Survey (LTS) and Railplan models developed by TfL.[10] The performance of the models has been extensively reviewed since February 2003 leading to improved validation of the forecasting process.[11] The forecasts are based on the projections of population and employment embodied within the draft London Plan for the year 2016.[12] This demand is assigned to a transport network that incorporates likely future changes advised by both the SRA and TfL.[13] This also includes a more detailed representation of travel to Heathrow including Terminal 5 available from DfT SERAS studies.[14] Empirically derived elasticities[15] were used to estimate the net additional use made of the network as a result of Crossrail. The net difference between the 2016 'base case' and 'benchmark' forecasts provides the basis for the estimation of benefits.

The Base Case – London without Crossrail

5.8 The forecasts for 2016 were based on the London Plan forecasts described in Chapter 2. Between 2016 and 2026, peak period net demand growth throughout London was assumed to increase by a further 0.7% per year, with the exception of the Isle of Dogs, where further growth in employment to 200,000 was assumed (consistent with its confirmed development). No peak growth was assumed beyond 2026. Off-peak growth in public transport demand was assumed to grow between 2016 and 2042 in line with the latest Treasury projections of GDP. On average, this approximates to growth of 2.0% p.a. No off-peak growth was assumed after 2042.

5.9 The base case for the appraisal of Crossrail assumed a number of transport network improvements:

- Changes to the National Rail network (including committed projects in the SRA's January 2003 Strategic Plan such as enhancements to Chiltern services, the East London Line, the Thameslink 2000 Project and the introduction of Channel Tunnel Rail Link Domestic Services) that on current programme might reasonably be expected to have been implemented by 2016
- Enhancement to the LUL network as anticipated in the PPP up to 2016 as shown in Table 5.1. The Victoria, Piccadilly, Metropolitan and District improvements are in Phase 2 of the PPP, which is not yet contractually committed.

---

10. ***Working Paper 5.1, Forecasting Scheme Effects***
11. ***Working Paper 5.2, Model Validation***
12. ***Working Paper 5.3, Demand Growth***
13. ***Working Paper 5.5, Network Assumptions***
14. ***Working Paper 5.4, Heathrow Demand***
15. ***Working Paper 5.8, Elasticity of Demand***

Table 5.1: LUL Assumed PPP Service Improvements

Line	Central Area Peak tph		Speed Increase	Timescale
	2001	2016		
Waterloo and City	18	21	0	2005
Central (eastbound improved only)	24	28	0	2006
Jubilee eastbound	24	30*	8%	2009
Jubilee westbound	20	30*	8%	2009
Circle/H&C (introduction of "Panhandle")	15	15	10%	2010
Northern (City and Charing Cross branches)	19	25	10%	2011
Victoria	28	33	10%	2011
Piccadilly	27	30	10%	2014
Metropolitan (Finchley Road – Baker Street)	22	30	10%	2014
District (Earls Court – Mansion House)	22	26	10%	2016

*** Includes lengthening to 7 cars**

5.10 As a result of changes in capacity and demand between 2001 and 2016, the National Rail network is forecast overall to become slightly less crowded by 2016. Crowding will be reduced on services into Kings Cross, London Bridge and Victoria, primarily as a result of the introduction of Thameslink 2000 and Channel Tunnel Rail Link Domestic services, while crowding will increase on services into Liverpool Street, Fenchurch Street and Waterloo. These changes in crowding on the National Rail network are shown in Figure 5.1.

5.11 On the LUL network, overall crowding is forecast to increase by 2016 within and around central London, despite the provision of additional capacity on most lines. The main exception to this will be the Northern Line which will benefit from both additional capacity and relief by Thameslink 2000. Changes in crowding between 2001 and 2016 on individual LUL lines are shown in Figure 5.2.[16]

*16. **Working Paper 5.6, Demand, Capacity and Level of Service** contains more discussion on capacity and demand changes between 2001 and 2016*

Figure 5.1: NRN – Changes in Levels of Crowding 2001 – 2016 (witbout Crossrail)

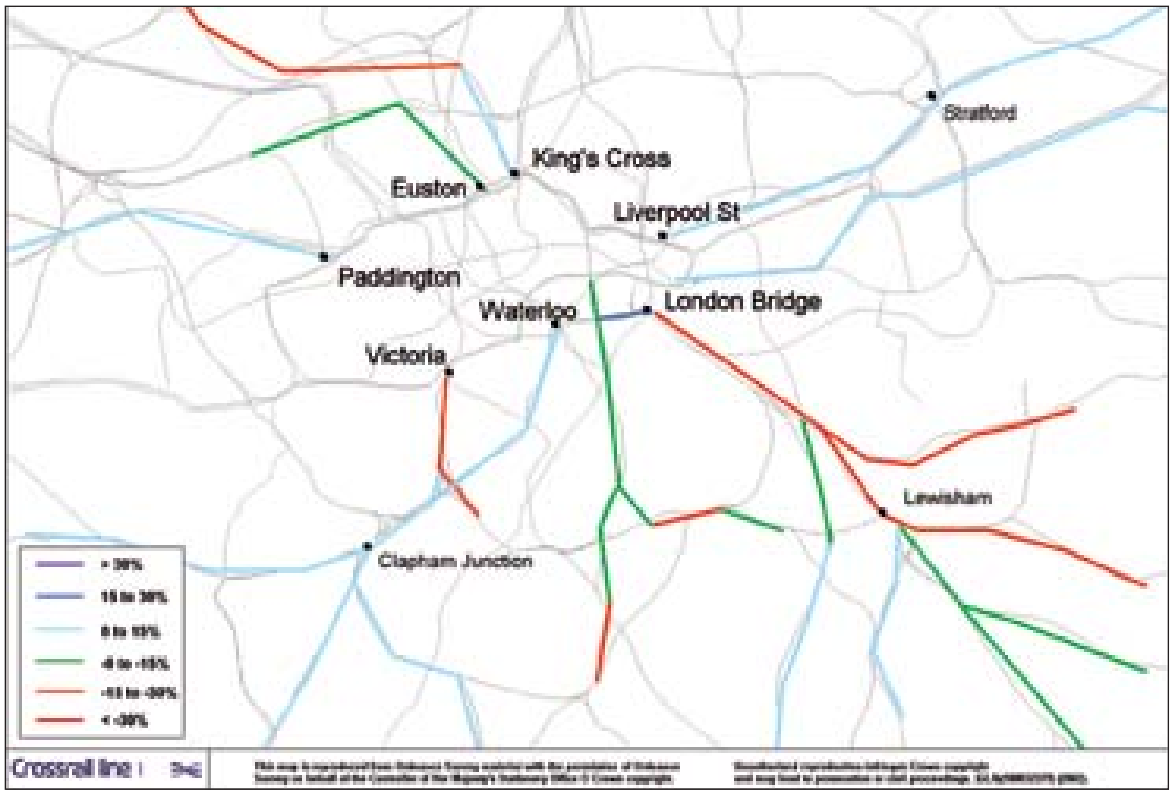
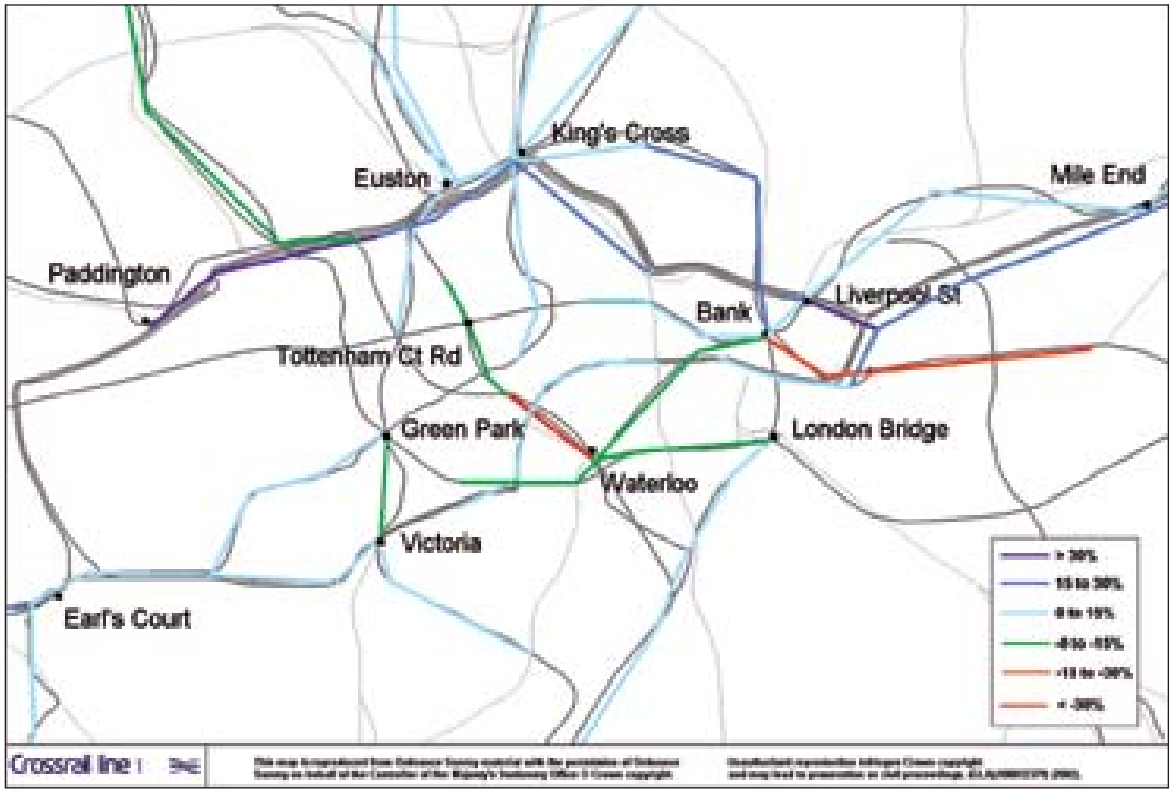


Figure 5.2: LUL & DLR – Changes in Levels of Crowding 2001 – 2016 (without Crossrail)



5.12 The net overall effect is an increase in levels of crowding compared to the already significant crowding observed in 2001.

The Transport Benefits of Crossrail

Crossrail Usage

5.13 Crossrail is forecast to be used by a total of 158,000 passengers in the morning peak period in 2016 (0700-1000hrs). This is slightly higher than the number of boarders who use South West Trains services at present in the morning peak. Unless otherwise stated, all floor values quoted in this section are for the morning peak period (0700 - 1000) in 2016.

5.14 The maximum loadings on each of the branches into the Central area would be:

- 36,000 from the Shenfield branch (approaching Stratford from the east)
- 19,000 from the Isle of Dogs/North Kent branch (approaching the Isle of Dogs from the east)
- 20,000 from the Kingston branch (approaching Paddington from Gunnersbury)
- 16,000 from the Heathrow branch (approaching Paddington from Ealing Broadway).

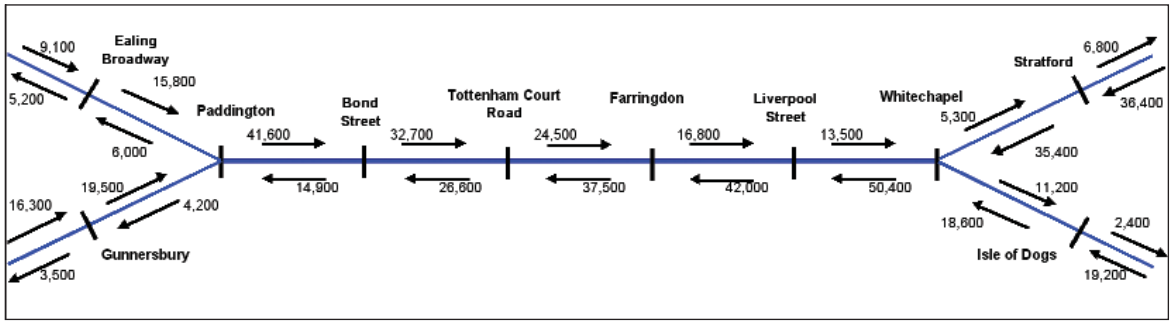
5.15 In the central area (Paddington – Whitechapel) the scheme would also be heavily used by passengers interchanging from other NRN or LUL services:

- 24,000 boardings in the eastbound direction of which 11,000 would be at Paddington
- 20,000 boardings in the westbound direction.

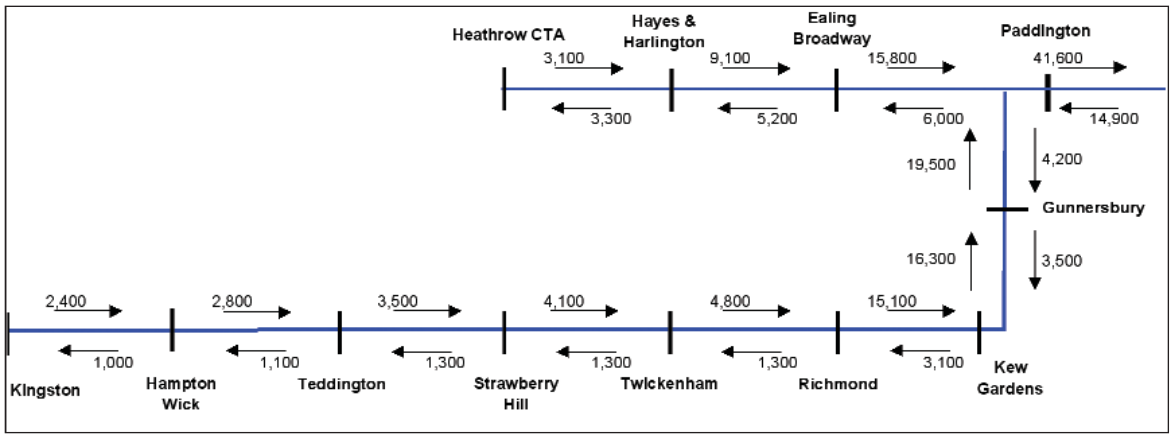
5.16 Crossrail central area loadings are shown in Figure 5.3. In the Eastbound direction, passenger numbers would reduce steadily from around 42,000 leaving Paddington to 13,500 approaching Whitechapel and 11,000 approaching the Isle of Dogs, while in the Westbound direction, the peak period loading of 50,000 leaving Whitechapel would fall through the Central area to 15,000 approaching Paddington.

Figure 5.3: Crossrail Passenger Loadings (AM Peak Period)

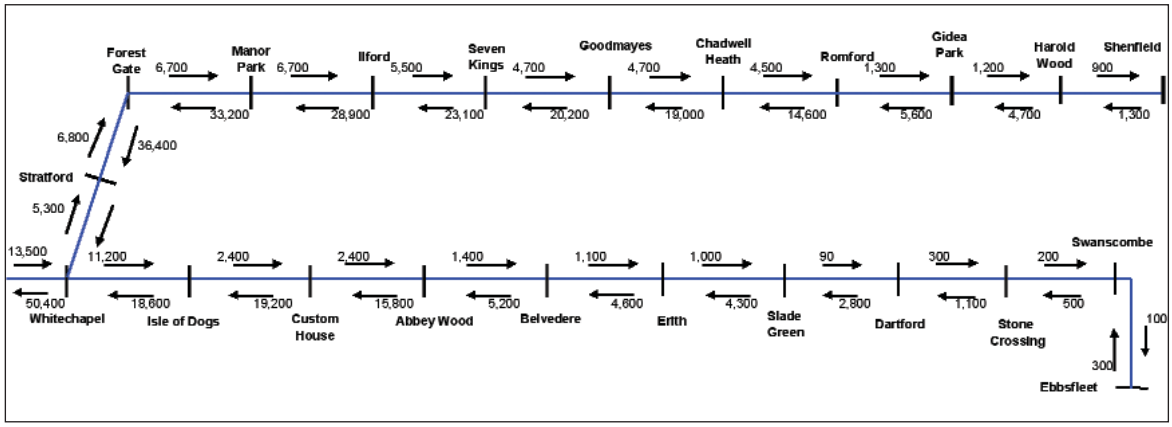
Central Area



West



East



5.17 Due to the attractive journey times to central London offered by Crossrail, services are forecast to be heavily loaded in the peak periods. Based on the 2016 line loading forecasts for the Benchmark scheme, Crossrail would carry flows in excess of its planning capacity on eastbound services between Ilford and central London and on westbound services between Ealing Broadway and central London. Flows on the Kingston and Ebbsfleet legs would be less heavily loaded with around 80% of the planning capacity utilised. Services through the central area would operate just below their planning capacity at the points of maximum load. Further work will be required to ensure that Crossrail frequencies on the individual legs are optimised to meet differing level of demand.

5.18 Crossrail would be used to access the Isle of Dogs by 9,000 passengers from the West and 1,800 from the East. These figures would reach 20,000 and 3,500 by 2026 when employment on the Isle of Dogs is forecast to reach 200,000.

Forecasts of Additional Demand with Crossrail

5.19 The forecasting process assumes that the demand would grow with Crossrail as a result of mode transfer and journey time improvements. This approach suggests an additional 23,500 public transport trips (an increase of approximately 1%) in the morning peak period in 2016. Most of this growth occurs on the eastern approaches to central London.

Interchange

5.20 Crossrail would deliver considerable benefits by enabling passengers to avoid interchange at Liverpool Street, Paddington, Waterloo and London Bridge in particular. The number of passengers entering central London at Liverpool Street and Paddington on Crossrail would be 42,000 at both locations. Many of these passengers would either avoid an interchange or otherwise have a more convenient journey with Crossrail and represents an excellent utilisation of the assets with a good balance of east and westbound flows.

Impact on LUL

5.21 Table 5.2 shows that all LUL lines with the exception of the Northern line see a decrease in boarders following the opening of Crossrail, with the greatest percentage decreases occurring on the Central, Bakerloo, Jubilee and Metropolitan/Hammersmith & City lines. Very substantial crowding relief benefits are achieved across the LUL network, particularly on the lines listed above. The very high level of crowding relief is achieved from just a 5% reduction in total LUL boarders, demonstrating that Crossrail provides effective relief for some of the most crowded parts of the LUL network.[17]

Table 5.2: Changes in LUL Boarders and Crowding with Crossrail

Line	% Change in Boarders	% Change in Crowding
Bakerloo	-8	-29
Central	-9	-27
District	-4	-21
Metropolitan/ H&C/Circle	-8	-25
Jubilee	-6	-18
Northern	+2	-2
Piccadilly	-3	-12
Victoria	-3	-8
Waterloo & City	-14	-31
LUL Total	**-5**	**-17**
DLR Total	**-8**	**-30**

17. ***Working Paper 5.6, Demand, Capacity and Level of Service contains more discussion on the impact of Crossrail on LUL***

5.22 The changes in levels of crowding on the LUL network in 2016 with Crossrail are shown in Figure 5.4. This shows that significant reductions in crowding are achieved over large parts of the LUL network, in particular:

- Westbound on the Central line between Stratford and central London
- Westbound on the District line between east and central London
- Eastbound on the Piccadilly line between west and central London
- Southbound on the Bakerloo line between Paddington and Oxford Circus
- Eastbound on the Metropolitan/ H&C/Circle line between Paddington and Moorgate
- On the Waterloo & City line.

Figure 5.4: LUL & DLR – Changes in Levels of Crowding with Crossrail

5.23 Although Crossrail eliminates excessive crowding from several parts of the Central, District and Piccadilly lines, LUL flows on many lines within central London remain above their Planning Guideline Capacity following its opening.

Impact on NRN Network

5.24 Table 5.3 shows the impact of Crossrail on the most affected sections of the National Rail network. The most significant impacts occur on the Liverpool Street (Great Eastern) and Waterloo service groups.[18]

5.25 Services into Fenchurch Street, Charing Cross, Cannon Street and Waterloo all see fewer boarders and crowding due to the diversion of passengers on these lines onto Crossrail services. Boarders however increase on West Anglia services into Liverpool Street due to the provision of additional services on this route following the opening of Crossrail.

Table 5.3: NRN – Changes in Boarders and Crowding with Crossrail

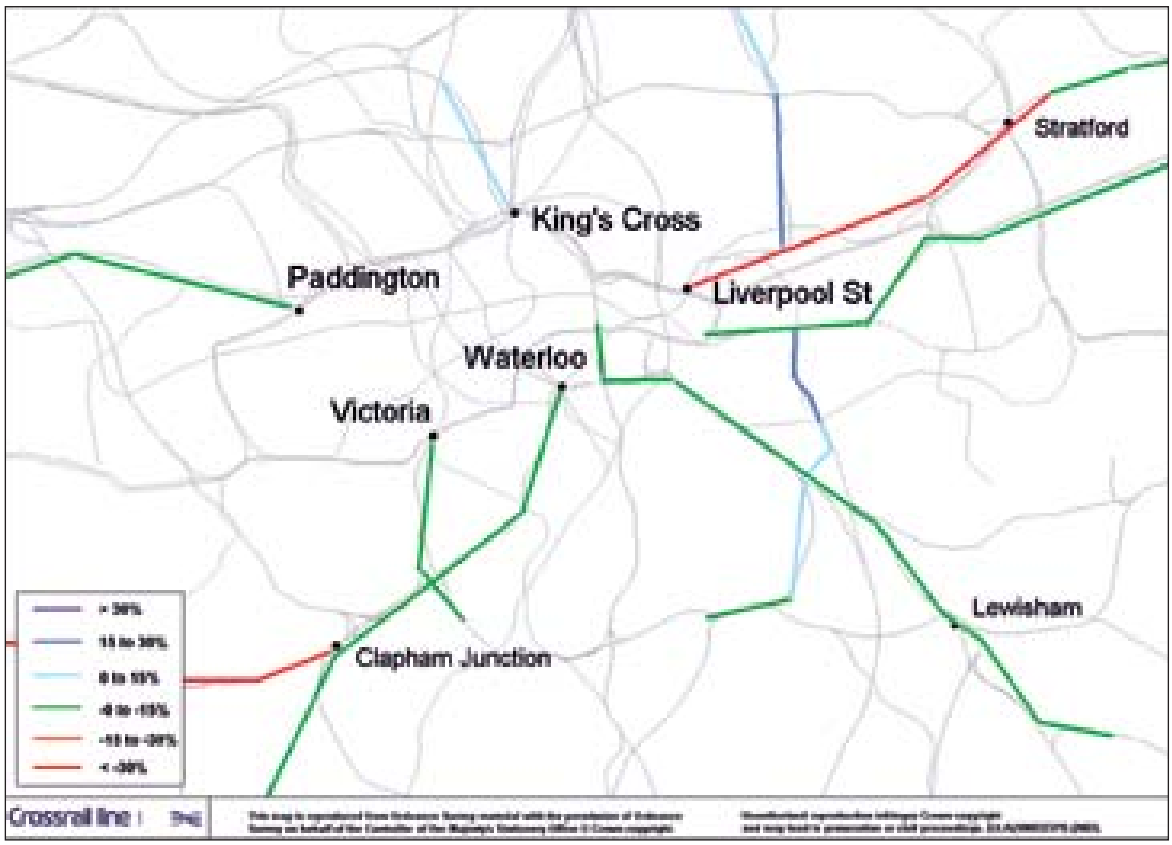
Service Group	% Change in Boarders	% Change in Crowding
Paddington	-10	-9
Liverpool St (Great Eastern)	-35	-36
Liverpool St (West Anglia)	+15	-12
Fenchurch Street	-2	-5
Charing Cross/Cannon St	-8	-12
Waterloo	-2	-25
Total NRN (excluding Crossrail)	**-5**	**-11**

*18. **Working Paper 5.6, Demand, Capacity and Level of Service** contains more discussion on the impact of Crossrail on the National Rail network*

5.26 The changes in levels of crowding on the national rail network in 2016 with Crossrail are shown in Figure 5.5. This shows that Crossrail achieves:

- Relief of Great Eastern and London, Tilbury and Southend lines into Liverpool Street and Fenchurch Street
- Relief of North Kent lines into London Bridge, Charing Cross and Cannon Street
- Relief of Richmond and Wimbledon lines into Waterloo

Figure 5.5: NRN – Changes in Levels of Crowding with Crossrail



Impacts in the Heathrow Corridor

5.27 Crossrail services to Heathrow would have the following effects compared to the 2016 without Crossrail base case:

- Increase the seating capacity of the rail service to Heathrow by up to 80%
- Increase journey time from Paddington to Heathrow by around 4 minutes.
- Eliminate the need for interchange at Paddington and improve journey times for airport passengers travelling to Crossrail stations to the East.
- Increase the level of service to Heathrow from Ealing and Hayes (particularly useful for airport employees).
- Reinforce the status of Heathrow is a major interchange hub by increasing journey opportunities.
- bring significant benefits to Paddington Station environs where currently there is a very high onward mode share from Heathrow Express to taxi.

5.28 In addition, it will increase capacity, reduce wait times, reduce journey times and reduce the need to interchange for passengers from Ealing and Hayes to central London and Docklands.

Appraisal

5.29 The user benefits of Crossrail derived from these forecasts include:[19]

- Journey time savings for passengers using shorter, more direct routes. The savings would include:
  - Waiting time
  - Interchange time
  - In-train journey time

  Values of time are applied to these savings to calculate the monetary benefit[20]
- Net crowding relief savings.[21] These include the perceived benefits of travelling in less crowded conditions on trains and in stations. The on-train benefits include the effects of lower levels of crowding and an allowance for the reduced delays on-train caused by extended dwell-times in crowded conditions
- Net passenger revenue[22] based on an estimate of average pence per passenger kilometre applied to the changes in passenger kilometre forecast for all routes and operators
- Quality Benefits.[23] An assessment of the monetary value of improvements in the quality of stations and services has been made using a methodology consistent with that employed by LUL for investment appraisal. Improvements in access to the mobility impaired [24] through the construction of central area stations to full Disability Discrimination Act (DDA) standards.

5.30 Benefits to those travelling to Heathrow are calculated using parameters specific to airport users.[25]

---

19. ***Working Paper 5.7, Appraisal Assumptions***
20. ***Working Paper 5.14, Values of Time for Appraisal***
21. ***Working Paper 5.10, Station Crowding Benefits***
22. ***Working Paper 5.16, Revenue Estimation on Bus Rail and LUL***
23. ***Working Paper 5.12, Quality Benefits***
24. ***Working Paper 5.11, Mobility Impaired Benefits***
25. ***Working Paper 5.15, Heathrow Benefits***

5.31 Crossrail will also generate benefits to users of the road network resulting from the transfer of some users to the public transport network, including:

- Journey time savings[26]
- Vehicle operating cost savings (net of taxation)
- Accident cost savings.

5.32 Annual costs, revenues and benefits are expressed in 2002 prices. The scheme is assumed to open on 1 December 2012 and non-capital costs and benefits incurred over a 60-year operating period are discounted back to 2002.

5.33 The Treasury Green Book states that "costs and benefits considered should normally be extended to cover the period of the useful lifetime of the assets encompassed by the options under consideration."[27] In the case of the Crossrail, the main capital assets, the tunnels and new underground stations in the central section, have a design life of over 100 years.

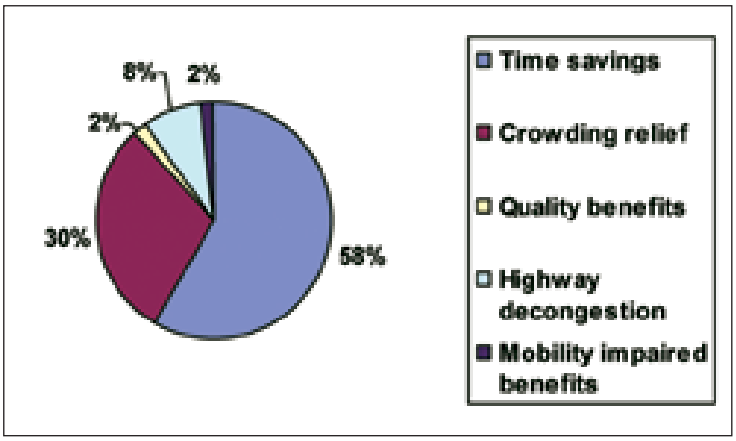
5.34 Given that Crossrail would continue to deliver significant benefits beyond the first thirty years of life, an appraisal has been made assuming a residual net present value based on costs and benefits during the second thirty years of operation.

5.35 A full schedule of all the appraisal assumptions is given in Working Paper 5.7.

Total User Benefits

5.36 The breakdown of user benefits is shown in Figure 5.6.

Figure 5.6: User Benefits of Crossrail



26. ***Working Paper 5.9, Highway Decongestion Benefits***
27. ***Paragraph 5.10***

Revenue Generation

5.37 Revenue changes were derived from the model forecasts through application of a simple multiplier of 11.4p per passenger kilometre to the changes in journey distance arising from Crossrail. On this basis, Crossrail would generate gross revenue of £7.7 bn (pv). Taking into account displaced revenue on other services over the same period, net rail revenue would be £2.7 bn (pv).

5.38 This analysis results in the conclusion that while Crossrail provides significant decongestion benefits, only about a third of the traffic carried on Crossrail is new, with the remaining two-thirds being diverted from LUL, the National Rail Network and buses. Assuming that the transport network has capacity constraints leads to higher projections of net revenues, with lower decongestion benefits. This is further discussed in Chapter 8.

Developer Contributions

5.39 The TEE table anticipates that there may be developer contributions to the cost of providing infrastructure. None have been included here, but their potential is described in Chapter 8.

The Costs of Crossrail

5.40 Capital and operating costs shown in chapter 4 were discounted for use in the appraisal. Estimates were prepared for years 1 to 30 and years 31 to 60 in accordance with the presentation in the TEE table. An allowance was made for the cost of obtaining access to Heathrow. As recorded in Chapter 3, the appraisal uses an allowance of 41%[28] of capital costs and 20%[29] of operating costs for optimism bias.

Bus Network Cost Savings

5.41 Additional cost savings have been identified from reduced bus operations following the opening of Crossrail. This is because Crossrail is forecast to abstract passengers and revenue from a range of bus services. The likely response to this impact would be a re-working of the bus network. Initial work has identified a number of services that could be operated at a reduced frequency with the resultant cost savings ranging from £17 - £54 m p.a, or a present value of £223 - £690 m when assessed over a 30 year period. The proposed reduction in bus services would generate disbenefits for those continuing to use buses through increased wait times. This disbenefit is valued at £3 - £22 m p.a. or a present value of £33 - £285 m. The net impact, on the basis of the initial analysis, is therefore estimated at £54 - £190 m present value, with the lower figure included in the business case.

Benefit - Cost Conclusions

5.42 The TEE table is attached as Appendix B. It shows that the Benchmark scheme has a benefit - cost ratio of 1.99:1 including the NPV for the thirty-year period beyond 2042.

5.43 Investigation of the performance of the scheme components has confirmed the conclusion in the February 2003 interim business case that the removal of any of the western or eastern branches would diminish the benefit – cost ratio.

---

28. ***Working Paper 4.1, Capital Costs provides derivation of this value***
29. ***Working Paper 4.1, Capital Costs provides derivation of this value***

Station Parking Revenue

5.44 Additional revenue benefits have also been identified as arising from income generated from new or enlarged car parks on the Crossrail network. The size of this benefit is estimated to be fairly small in value, withan NPV of around £26 million over the first thirty years.[30] This preliminary estimate, which has not been included in the benefit - cost ratio calculations, is likely to prove to be conservative.

Appraisal Summary Table

5.45 An Appraisal Summary Table (AST) was prepared for the benchmark scheme in accordance with the DfT's GOMMMS requirements and attached as Appendix C.[31] When assessed against the Government's other four objectives for transport, the AST for Crossrail reveals that the scheme would deliver significant benefits, which can be expressed under the headings of Environment, Safety, Accessibility and Integration. Further discussion of Crossrail's benefits in relation to regeneration and agglomeration is contained in Chapter 6.

5.46 Temporary impacts during construction would be the most significant environmental effects. These would include temporary severance and traffic impacts arising from construction work sites.

5.47 Noise increases from Crossrail operation would, potentially, be the most significant permanent effects. However, they are assessed to be relatively slight because in all cases, surface running of Crossrail trains would take place in existing rail corridors.

Sensitivity Analysis

5.48 The Green Book and GOMMMS requires sensitivity analysis to test the vulnerability of schemes to unavoidable future uncertainties. The uncertainties addressed in the appraisal of Crossrail are:

- Demand growth
- Future network capacity
- Heathrow benefits
- Project costs
- Performance of the forecast models

Demand Growth

5.49 The benchmark test anticipates the delivery of the London Plan and its transport strategy. The London Plan anticipates population growth of 9% and employment growth of 11%. To test the effects of lower growth, Sensitivity **Test 1** assumed that growth anticipated in the London Plan by 2011 was achieved in 2016, and beyond 2016 peak growth was half the rate of the benchmark case until 2026. Off peak growth was assumed to be 0.25% p.a. less than Treasury 'neutral' projections of GDP.

5.50 Consistent with lower demand projections, this demand level was assigned to a network with lower capacity, on the basis that if outturn demand proved to be lower, fewer improvements in capacity would be implemented. The LUL PPP Phase 2 (para. 5.10) was removed from the network as a proxy for this reduction. The resulting benefit – cost ratio for Test 1 is 1.89:1. In **Test 2**, the original base network was used. This more extreme set of assumptions would reduce the benefit – cost ratio to 1.69:1.

---

30. ***Working Paper 5.19, Parking Strategy***
31. ***Working Paper 5.18, Derivation of the Appraisal Summary Table***

5.51 **Test 3** employed even lower demand by using the 2001 demand level, i.e. no future peak or off-peak growth, except at Heathrow where the completion and operation of Terminal 5 was retained. This demand level was assigned to the network employed in Test 1, i.e. including anticipated network improvements save for the PPP Phase 2. Even under this scenario with significantly less crowding thoughout the entire project life, Crossrail returned a benefit – cost ratio of 1.12:1.

5.52 Conversely, the off peak growth rates could be regarded as cautious as the rates assumed are lower than usual practice based on the standard railway forecasting guidance. **Test 4** therefore employed a rate 1% above the GDP projections in line with standard practice and this resulted in a 10% improvement in the benefit - cost ratio to 2.30:1.

Future Network Capacity

5.53 By inference from the results for Tests 1 and 2, exclusion of the PPP Phase 2 from the base network would increase the benefit – cost ratio of Crossrail by 0.25 to 2.24:1.

5.54 In **Test 5**, the effect of removing Thameslink 2000 from the base network was assessed. Consistent with the assessment in the Interim Business Case, Thameslink 2000 has a limited effect on the appraisal. Serving a different market on a north south alignment, it does not compete with Crossrail and the effect on demand and benefits is slight. The effect of removing Thameslink would therefore be limited to local design issues at the Farringdon interchange between the two services.

Heathrow Benefits

5.55 There are potentially significant benefits to be derived from Crossrail operating to Heathrow. However, estimation of demand and benefits is subject to uncertainty, in part because of the interface between the SERAS and Railplan models with their differing specifications. The SERAS model is focused on the characteristics of air passengers and employs "mode constants", which are generally a reflection of the need to forecast the demand for new modes. Railplan does not employ such constants and therefore their effect is excluded. This is not uncommon in cases where mode constants are employed but in Sensitivity **Test 6**, an allowance for their potential effect has been made. This reduces the benefit – cost ratio to 1.89:1.

5.56 The Department for Transport (DfT) were also able to provide demand forecasts assuming a third runway at Heathrow. **Test 7** shows that, as would be expected, this would improve the benefit – cost ratio to 2.20:1, although further investigation is necessary to establish whether this service would have sufficient capacity under these assumptions.

Project Costs

5.57 The benchmark appraisal was undertaken using an optimism bias range of 20% to 146%, (an average 41%) for capital costs based on the analysis set out in Chapter 4. This reflects the analysis of risk undertaken since February when a 66% measure was used. The results of **Test 8** show the effect of using the February costs with a 66% optimism bias now would be a benefit – cost ratio of 1.80:1. In fact, the costs are based largely on out-turn costs. If optimism bias is removed, the benefit - cost ratio would be 2.86:1.

Performance of the Forecast Models

5.58 The benchmark scheme was appraised using an elasticity approach to estimate the extra demand generated by Crossrail. This effect can also be estimated using the LTS model distribution-mode split function which more explicitly takes account of features such as the new river crossing. Appraised on this basis in **Test 10** the benefit – cost ratio would improve to 2.16:1 arising principally from increased revenue projections.

Results

5.59 The results of the sensitivity analysis are summarised in Table 5.4.[32] The most significant effects on the benefit – cost ratio arise from:

- the optimism bias in the costs
- he demand projections, both overall demand and the off peak
- Phase 2 of the PPP on the Underground.

The economic performance of the scheme remains strong in all cases.

Conclusions

5.60 In conclusion:

- The benefit - cost ratio of the benchmark Crossrail project is 1.99:1
- Sensitivity analysis suggests these conclusions remain robust to a wide range of uncertainties surrounding market growth and the development of the rail network.
- Crossrail would improve travel across London with journey time savings accounting for 58% of the total benefits
- Crossrail would provide an additional 7% peak hour capacity into central London, thereby relieving crowding on significant sections of the existing rail network - this accounts for 30% of the benefits
- While there will be significant impacts during construction, permanent significant adverse effects are not expected.

Table 5.4: Sensitivity Analysis

Sensitivity	Benefit-Cost Ratio
Benchmark assumptions	1.99:1
1. Lower growth with reduced network (no PPP Phase 2)	1.89:1
2. Lower growth only	1.69:1
3. No demand growth - 2001	1.12:1
4. Higher off peak growth	2.30:1
5. No Thameslink 2000	1.97:1
6. Heathrow mode constant effects	1.89:1
7. Heathrow 3rd runway	2.20:1
8. Optimism Bias 66%	1.80:1
9. No Optimism Bias	2.87:1
10. LTS appraisal (assigned to Railplan)	2.16:1

*32. Further details of the sensitivity tests reported here and many others are given in **Working Paper 5.17, Sensitivity Analysis.***

6. How Crossrail Supports Government Policy

Introduction

6.1 The business case in Chapter 5 principally described the quantified transport benefits of building Crossrail using established methodology. This chapter describes the wider benefits of the project in three areas:

- Support for the planning and transport policies of Government, the London Mayor and the transport authorities
- Support for London's financial and business service (FBS) sector
- 'Regeneration effects', particularly in the Thames Gateway.

6.2 Since February investigation of agglomeration effects in the finance and business sector has focused on identifying links between crowding and growth.

6.3 The regeneration analysis now reflects recent feedback from DfT/ODPM. It includes regeneration benefits by location and sensitivity analysis. The potential negative effects on regeneration areas outside the study area have also been assessed.

Policy Benefits from Crossrail

Government Policy

6.4 The Government 10-Year Transport Plan aims to tackle congestion and pollution by improving all types of transport. The Plan allocated £154m to investigate a new east-west rail link across London that is now being progressed by CLRLL.

6.5 Crossrail addresses five of the National Rail objectives set out in the Transport Plan. It would:

- Increase the use of rail
- Improve service quality
- Provide better service integration
- Improve commuter services in London
- Provide modern trains and more attractive stations.

SRA Policy

6.6 Crossrail also contributes to the goals of the SRA Strategic Plan 2003 to:

- Promote a 50% growth in passenger traffic
- Reduce overcrowding on services in the London area
- Improve train service punctuality and reliability.

6.7 Crossrail is forecast to lead to approximately 70,000 additional boarding on the National Rail network in the morning peak. This is a net increase of 6% compared with the base case in 2016 without Crossrail and represents 25% of the peak period rail demand growth forecast between 2001 and 2016. There would also be significant growth in off peak use. Crossrail therefore makes a significant contribution to the SRA policy on passenger growth.

6.8 The strong contribution to the reduction of crowding in the London area was reported in Chapter 5.

6.9 The project would also support the general policies and principles of national planning guidance[33] and the Sustainable Communities Plan. Crossrail would provide more sustainable transport choices, promote the use of public transport to jobs, shopping, and leisure activities and reduce the reliance on travel by car. The improved transport capacity and accessibility would encourage:

- Office and retail development at new transport nodes
- Development in regeneration areas, including brownfield land
- High density residential development.

London Planning and Transport Policy

6.10 The draft London Plan advances a development strategy for the growth of London that sustains London's world city role. Most of the employment growth is expected in central London and the Isle of Dogs. The plan is supported by a transport strategy that identifies Crossrail as a pivotal transport scheme in sustaining the FBS clusters by linking the City to Isle of Dogs and relieving capacity constraints.

6.11 The draft London Plan also presents a hierarchy of International, Metropolitan, Major and District Centres. It identifies Opportunity Areas, where access by public transport should be maximised, and Areas for Intensification where existing accessibility and capacity should be exploited. Many of these centres and areas would be served by Crossrail, including Isle of Dogs, Royal Docks, Paddington and Hayes.

6.12 The Mayor's Transport Strategy seeks to increase rail capacity in London by 50% between 2001 and 2016. Crossrail would be the largest single contributor to achieving this objective.

Agglomeration Benefits in the FBS Sector

6.13 Crossrail would strongly support the continued success of the FBS sector in central London and the Isle of Dogs. The very high density of employment in these areas that means it can only be served by rail based public transport and the very high productivity of central London helps justify further rail capacity. The two issues of density and productivity are related:

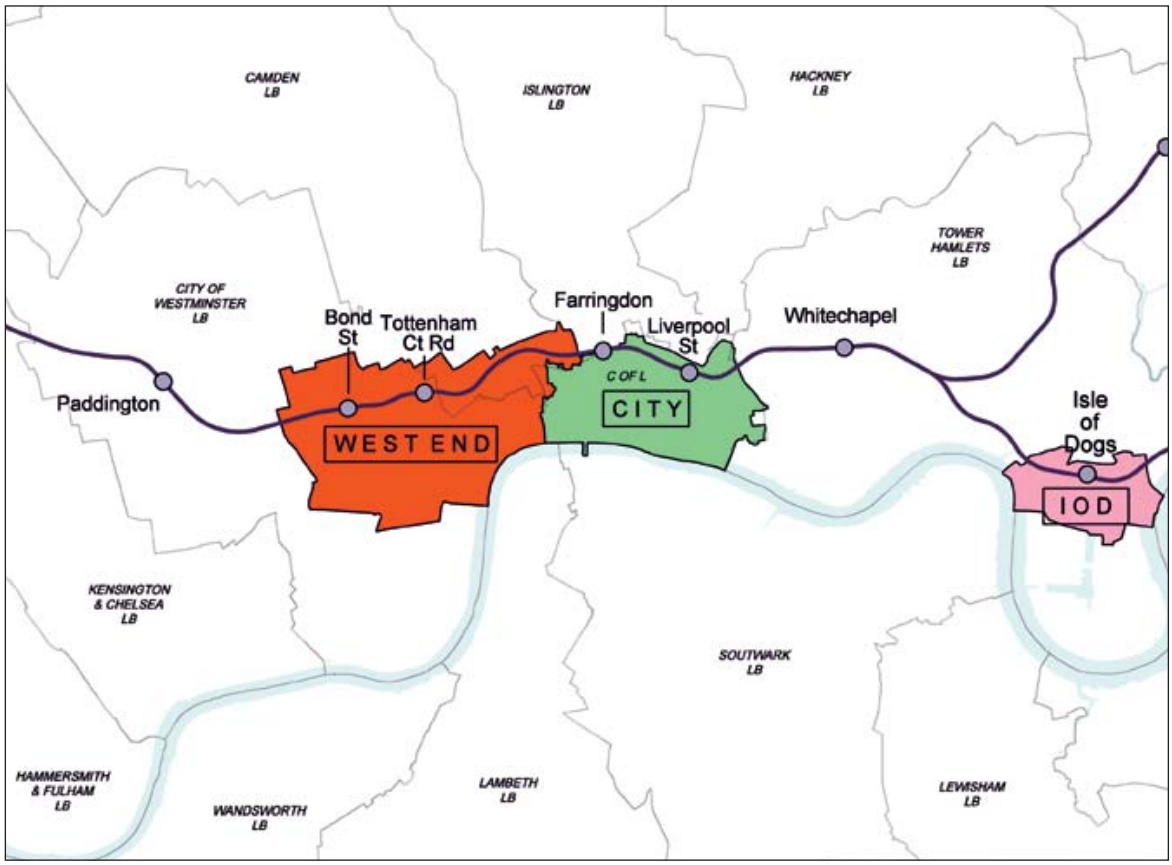
- Firms locate in central London because productivity is much higher than elsewhere
- Productivity is so much higher than elsewhere partly because of the very high densities that exist.

6.14 'Agglomeration', or clustering, benefits represent the advantages to both new and existing companies from locating within the existing high-density areas. London is the premier European financial district and one of three global financial centres (with New York and Tokyo). Crossrail has been designed to serve those existing clusters as shown in Figure 6.1.

---

33. ***PPG1.***

Figure 6.1: London's Financial and Business Service Clusters



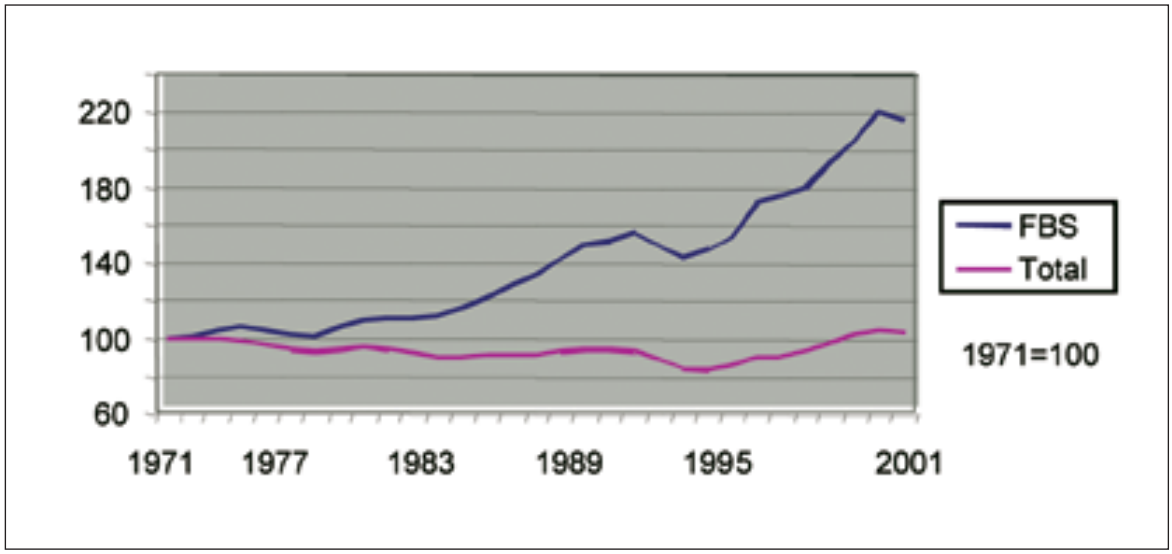
6.15 Agglomeration benefits partly explain why rents in central London can be at least twice those in any other European city and why it is becoming increasingly different from the UK average. Agglomeration effects provide a major incentive for new companies to locate within existing clusters and ensure that existing companies, within the clusters, benefit from additional entries.

6.16 The appraisal in Chapter 5 assumes that principal impact of Crossrail on the economy is provided through user benefits. Although the transport models themselves predict an increase in trips to central London (reflecting increased employment there) as a result of Crossrail, no value is assigned to the change in future employment distribution, even if it results in a net increase in high value areas.

Central London

6.17 London's employment in the FBS sectors has risen steadily over a 30 year period, from 750,000 in 1971 to 1.4 million in 2000 as shown in Figure 6.2. The FBS sectors currently account for over one third of employment in London. The projections for the draft London Plan indicate a growth by 2016 of 420,000 jobs in the central area boroughs where employment has already been expanding faster than the rest of London for a considerable period.

Figure 6.2: Greater London FBS and Total Employment Change, 1971-2000



6.18 Productivity in central London is higher than elsewhere, within each sector as well as reflecting a different sectoral split – for example business services are 60% more productive in central than outer London.

6.19 At the same time, the clustered businesses of central London are more highly dependent on accessibility by public transport than anywhere else in the country with central London, and particularly the City of London, having 80% of morning peak travel to the centre by rail.

Rail Capacity and Central Area Growth

6.20 Data for the period 1981 to 2000 show a strong negative relationship between the level of crowding on an Underground link and the future growth in demand on that link[34] suggesting that lack of capacity does constrain growth. As shown in Chapter 5, crowding will become worse by 2016, even assuming that the planned capacity and service improvements have all taken place. Table 6.1 shows the effect on specific cordons around the central area clusters and the relief arising from Crossrail.

6.21 These crowding effects were used to estimate the constraint on future development and its consequential effect on central area employment.[35]

---

*34. **Working Paper 6.1, Appendix C***
*35. **Working Paper 6.1 Appendices 2 & 3.***

Table 6.1: Change in Crowding on Central Area Cordons Relative to 2001

Cordon	2016 no Crossrail	2016 with Crossrail
Isle of Dogs	+4%	-2%
City	+8%	-3%
Central	+29%	+2%

6.22 An alternative approach to estimate changes in employment was also developed. Macro economic modelling employing a non-linear relationship between cost and crowding, similar to the crowding function within Railplan, was used to estimate changes in employment.[36]

6.23 The effect of the two approaches is shown in Table 6.2. Both approaches incorporate a time lag of at least five years between relief of congestion and increases in employment, which means that the 2027 results incorporate the full effect.

Table 6.2: Forecast Increases in Central London Employment with Crossrail

Approach	2017	2027
Cordon analysis of crowding	6,000	20,000
Macro-economic analysis	7,000	23,000

6.24 Those results are broadly consistent with other recent estimates of the effect on employment using the LTS distribution-mode split model and the DfT LASER model, which both suggested that approximately 30,000 jobs would be supported by Crossrail.

---

*36. **Working Paper 6.1, Appendix 3.***

The Value of Additional Central London Employment

6.25 The preceding analysis suggests that Crossrail would support increases in Central London employment. This would not necessarily be beneficial if it was simply a redistribution of future employment growth as the appraisal makes the conservative assumption of full employment with or without Crossrail. Benefits would however arise because of central London employment productivity, especially the agglomeration benefits.

6.26 Two approaches to estimating the value of the employment growth on GDP were developed. The cordon analysis was combined with different average productivity between sectors and the different sectoral splits of employment in central London. This gave a net increase in the present value of UK GDP of £8.6 bn.

6.27 The macro-economic approach assumes that all of the workers would find jobs elsewhere even if constraints exist on central London growth. The net addition to output is therefore simply the difference in productivity of the Central London jobs and average jobs. This increases UK GDP by £350 m p.a. in 2017 rising to £750 m in 2027 and constant thereafter. That equates to a present value of £7.7 bn at 1999 prices and values.

6.28 These benefits have not been explicitly quantified or valued within transport appraisal and there is no agreed methodology. The effect of changes to the assumptions supporting the analysis was therefore assessed.[37] This included a lower GDP/employment scenario consistent with the low growth test undertaken in Chapter 5 and an assumption that capacity increases across the central cordon were only 50% of those projected. The results are given in Table 6.3.

Table 6.3: Results of Sensitivity Tests

Scenario	GDP Growth (£ billion)	% Change from Base
Base case	7.7-8.6	
Lower GDP/ Employment scenario	5-6	-30 %
Lower network growth assumptions	9-10	+15 %

37. ***Working Paper 6.1, gives the details***

6.29 The size of the impact on UK GDP presented here, and the degree to which the benefit of this increased output is additional to the transport benefits identified in Chapter 5 is the subject of continuing discussion with Government who have commissioned their own studies.

The Regeneration Benefits of Crossrail

6.30 In conjunction with other Government initiatives, such as housing, training, infrastructure investment, education and health, Crossrail would have significant benefits for regeneration areas by:

- Increasing public transport accessibility
- Improving accessibility to additional jobs, education opportunities and cultural facilities outside regeneration areas
- Improving the image and perception of regeneration areas.

6.31 These regeneration benefits have been measured[38] although not included in the economic appraisal reported in Chapter 5.

Regeneration Areas Served by Crossrail

6.32 Crossrail would provide a new strategic link across London, which is vitally important to the integration of London's key strategic growth and regeneration areas shown in Figure 6.3.

Estimated Employment Growth in Regeneration Areas

6.33 In accordance with Government guidance on transport appraisals,[39/40] regeneration benefits are assessed by forecasting the employment attracted to regeneration areas. It is estimated that Crossrail would enable or attract between 56,000 to 110,000 jobs as a result of development activity within key regeneration areas directly served by the route. Between 45,000 to 78,000 of these estimated jobs would be enabled in the Thames Gateway (excluding employment growth in the Isle of Dogs)

6.34 The number of those jobs that could be taken up by the unemployed and economically inactive residents were estimated by calculating and totalling:

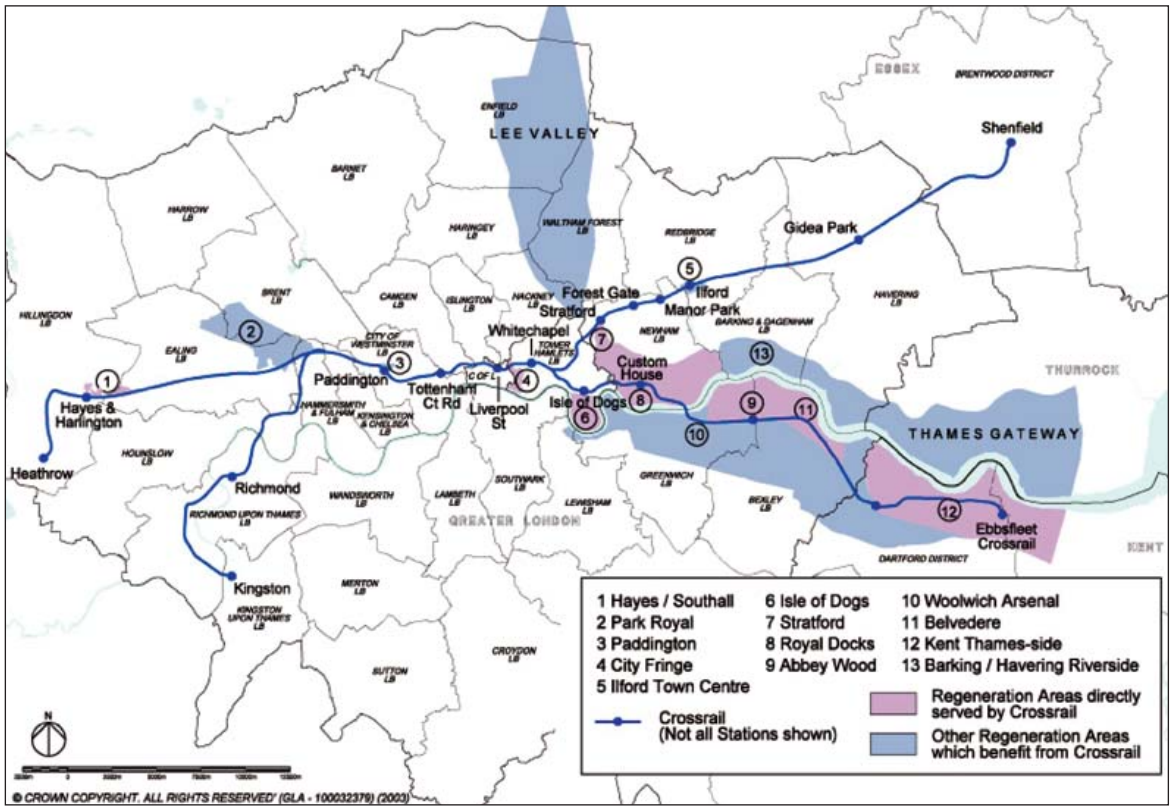
- Job creation due to new economic activity attracted to regeneration areas
- Jobs accessible within a 30 minute travel catchment
- Jobs from new residential activity in regeneration areas.

6.35 Only a share of these jobs would be taken up by the most deprived people. The estimate of the total number of jobs that would be taken up by currently unemployed or economically inactive regeneration area residents is between 18,000 to 32,500 jobs within five years of Crossrail opening.

---

38. ***Working Paper 6.2, gives details***
39. ***Guidance on the Methodology for Multi Modal Studies (GOMMMs)***
40. ***Draft E Economic Impact Report SDG for DTLR December 2001***

Figure 6.3: Areas of Regeneration that Benefit from Crossrail



Conclusions

6.36 Crossrail provides major benefits that are not quantified within the business case in Chapter 5.

6.37 Crossrail supports national, local and regional policy objectives covering transport, planning and sustainable communities.

6.38 The "agglomeration" benefits, or the impact of Crossrail on employment in central London, could result in a large increase of £8-9 bn PV in UK GDP. These findings are subject to continuing discussion with Government who have commissioned their own studies.

6.39 Crossrail also supports Government policies for regeneration areas, enhancing accessibility to jobs and encouraging new development within existing deprived areas.

7. Procurement and Finance

Introduction

7.1 The purpose of this chapter is to make recommendations on procurement and financing structures for the Crossrail project. The chapter brings together the results of much of the analysis of the more detailed working papers set out at Section 7 of Appendix A.

7.2 A range of procurement structures has been considered and compared against various criteria. Two of these were considered for further analysis and also tested against expert market soundings for feasibility.

7.3 The main recommendation in respect of the newly constructed central core referred to here as the "off-network" works is that an availability-based concession should be let for the design, construction and maintenance phases for up to 30 years. The off-network construction works should be based on target based price and schedule rather than the more conventional lump sum fixed price basis because of the particular issues associated with a project of this magnitude and complexity.

7.4 Works on the existing Network Rail system referred to here as the "on-network" works will be procured in line with the existing procurement arrangements between the SRA and Network Rail through the Enhancement Facilitation Agreement. In essence these will be incentivised construction contracts with the works transferred to Network Rail on completion.

7.5 It is recommended that the interests of the public sector should be managed by a Project Client Team (PCT). The PCT should be responsible for letting the off-network project contract, managing some of the many interfaces with the key public sector parties and monitoring performance against the target contracts. The PCT would incorporate a Technical Adviser (TA) at a very early stage to prepare the target price mechanism, define the target cost allocation between the parties and prepare the bid documents for the off-network concession competition. The TA would provide project management capability if required.

Procurement Objectives and Principles

7.6 This section explains why an evolution of the traditional procurement structures was considered appropriate for Crossrail and considers the criteria against which the structure options were compared.

7.7 Crossrail will be an unusually large engineering project, and therefore presents some challenges. These challenges do not lie in untested or unfamiliar engineering practices and methodology. The off-network works, which comprise the great majority of the cost, are essentially a stand-alone civil engineering project in a constrained site, but from the design work already undertaken the means of construction are well defined.

7.8 Nonetheless, the scale of the project and its complexity, which will test the capacity of the construction markets, require that a different approach is taken to normal project procurement so that the potential capacity and complexity risks are properly managed.

7.9 The need to achieve value for money in the procurement suggests the following criteria:

- **Price** - the likely relative cost of each option and the degree of out turn price certainty before and during construction; the ability to use competitive pressure at all stages to drive down the eventual cost to the public sector.
- **Deliverability** - the capacity of the proposed structure to deliver a safe and operable railway on time and to budget, in particular taking account of construction market capacity constraints.
- **Risk** - the extent to which the structure allows risk to be appropriately allocated between, and managed by, public and private sector participants
- **Whole life costing** - whether the structure accommodates the benefits achieved by the whole life costing principles adopted by most concession companies
- **Incentives** - the extent to which the private sector can be incentivised to deliver the procurement objectives
- **Flexibility** - how well the structure can control and minimise cost of the inevitable uncertainties in that will arise in the delivery of a project of this size, from the point of view of all participants
- **Visibility/Monitoring** - how easily the public sector can monitor and control the progress of the project participants
- **Fundability** - the ability to achieve a robust and affordable funding solution, optimising the contribution from the private sector (where this can be shown to be value for money).

7.10 A number of informal consultation interviews were held with key participants in the railway and infrastructure construction industries, and the conclusions of this paper are consistent with the views expressed in the interviews.

Initial Review of Possible Structures

7.11 Preparatory work for the business case assessed six basic procurement models against these objectives and a set of additional value for money criteria set out in supporting paper 7.3[41] Based on this work, two were taken forward for further analysis and four were not considered further.

7.12 The two proposals taken forward for further analysis for procuring the "off network" works were:

- A three concession lump sum availability based procurement structure; and
- A target price availability based procurement strategy with or without a concession.

Supporting paper 7.42[42] sets out the arguments for and against the different approaches in detail. Set out below are a discussion on the nature of the proposed concession followed by comments on the relative merits and demerits of Lump Sum and target price procurement structures.

Availability Based Concessions

7.13 Under an availability-based concession for the off-network core section, a private sector concessionaire would contract to design, construct and maintain the infrastructure required for Crossrail, for a given period of time, say 30 years. These requirements would be specified in the form of required outputs or service levels from the Concessionaire. In return for meeting these outputs or service levels the Concessionaire would be paid a performance based sum annually. This contract would incentivise the concessionaire to ensure efficient construction, performance and finance where appropriate. The procurement competition would compete the level of availability payment required for providing the outputs set by the public authorities.

---

*41. **Working Paper 6.3 'Crossrail procurement: principles and options'***
*42. **Working Paper 6.4 'Detailed procurement structure issues'***

7.14 It is not envisaged that the Concessionaire would procure or manage the operation of passenger services in the medium to long term. It is proposed that a new or modified existing TOC should undertake this in accordance with normal franchise procedures.

7.15 Within the availability-based structure various contract structures are possible. Considered below are the two structures shortlisted for further evaluation.

Lump Sum Approach

7.16 Lump sum turnkey ("LSTK") is the approach used in most project finance or PFI/PPP transactions. Such an approach provides a price and time certain contract from the concessionaire for a given scope of work and programme to completion. It has the following advantages:

- Price certainty - the contractor accepts an assured price for delivering an agreed output. Variations are limited to scope changes requested by the client
- Risk transfer - the contractor accepts an agreed range of risks from the outset
- Whole life costing - it optimises the allocation of capital and operating costs for the public sector client
- Familiarity - it is a well understood technique in both construction and financing markets.

7.17 The LSTK approach is well understood through a long association with large-scale infrastructure projects, and recent successful examples include the £900 million Dutch High Speed Link, Docklands Light Rail extension and the PFI road schemes.

7.18 However, market consultation has confirmed Crossrail's view that by virtue of the project's size, a single contractor/consortium could not manage the entire project on a fixed price basis. It would therefore need to be split into several concessions and whilst there are various ways in which this could be done, CLRLL considered a functional split of the works as follows:

- **Systems** £2.1 bn: track, signalling, communications and M&E systems.
- **Civils East** £2 bn: tunnelling and for escalators, lifts and M&E in the four new stations.
- **Civils West** £2 bn: tunnelling, and escalators, lifts and M&E in the three new stations.

7.19 Whilst fixed price contracting has been successful in the past it has not been tried on this scale before and given the project size CLRLL considers the technique has several disadvantages. In particular it is considered likely that LSTK would not deliver value for money because, given the market size constraint, it is unlikely that the market would accept sufficient risk to ensure that the traditional benefits of LSTK are fully delivered. It is also likely that a competition to deliver the works by way of several concessions would result in a low level of competition as the major "world class" contractors would be spread too thinly between the three concessions, and specialist skills even more so. A competition may not therefore deliver the best contractors for the job.

Target Price Construction Management Approach

7.20 A target-based contract provides for construction costs to be reimbursed to the contractor in full but CLRLL would agree the "target" cost and schedule against which the contractor is incentivised to deliver efficient performance. The contract would provide for incurred costs in excess of the "target" to be shared between the contractor and CLRLL whilst in the situation where incurred cost was less than the "target" the benefits would be shared. This thus establishes a pain/gain sharing. The contract would define the nature of costs which could be incurred against the target and thus define the risk allocation between the parties. In this manner the risks of the contract would be shared.

Target Price Concession Based Approach

7.21 A target-based contract could, in theory, be let by PCT with or without an availability-based concession.

7.22 A target price concession structure would aim to let a single target-based design and construction contract to a special purpose vehicle (spv). The treatment of the maintenance of the works under this structure will need to be considered further with respect to embracing the costs of maintenance with the capital costs of design and construction for the purposes of computing the availability charge. This would enable the transfer of long term responsibility for the maintenance of the system (thereby optimising whole life cost) and the availability of private finance.

7.23 The involvement of private finance and the lenders' technical advisors who will review the project in detail should provide substantial comfort that the project's cost estimates are robust. A degree of equity provided by the concessionaire will also be at risk and ensure that a whole life costing approach for the project is considered so that value for money can be demonstrated in both the construction and operating phases.

7.24 However, the procurement process is likely to take longer, and bid costs will be higher, compared to a non-concession approach.

7.25 There is further work to be undertaken on how a bidder would price the maintenance works as a fixed sum before the construction contracts were placed and certainly before the outturn construction costs were known. The level of specification at the outturn and the known standards requirements of the accepting bodies should facilitate this. However various options including the possibility of applying "capped" target or fixed price option mechanisms for the maintenance element are being considered further.

Relative Benefits of the Target Price Approach Compared to the Lump Sum Strategy

7.26 In this section we compare the target based approach and the lump sum approach against the criteria identified above

- **Price** – a fixed price approach would normally deliver greater certainty albeit at a higher price. A target based approach shares risk and may therefore provide less certainty on the level of outturn cost to be borne by the parties. However it is CLRLL's view that a target based approach can generate good competition from a well-prepared outline design and specification which CLRLL would include in the tender documents. This will generate a better allocation of risk and therefore better value for money.

- **Deliverability** – CLRLL recognises that this approach will require close management to ensure that the target price does not rise without good cause. This is however no different in concept to the need to ensure strong claims management in the case of fixed price contracts.

- **Risk** – a target based approach is essentially about the precise allocation of risks and costs between the parties and rigorous project management. However as noted above, increased competition from a target based approach should ensure the competed pain/gain share, sub contracts and target price mechanism deliver an appropriate incentivisation to the private sector.

- **Whole life costing** – a fixed price approach to both construction and maintenance will facilitate optimisation of whole life costs. As noted above CLRLL is working to develop mechanisms to optimise whole life costs within a target structure.

- **Incentives** – Incentives under a target based approach are driven by the pain/gain share in the contract and a limited level of equity or equity type cushion to be provided by the project manager. It is to be expected in an LSTK approach that the level of equity would be higher but this is a function of the level of risk accepted by LSTK contractor compared with the target based approach where risks are shared. It is also likely that given the scale of this project adequate third party equity for an LSTK structure would be very difficult to source because of market capacity constraints.

- **Flexibility** – A target based approach will permit a less developed design to be put to the market and this has advantages in terms of timing of the process, partially offsetting the time to bid by bidders. However a less well developed design does emphasise the importance of rigorous project management in controlling the target price.

Off-Network Works: Recommendation

7.27 It is concluded in respect of the off network central core works that the preferred basis of procurement is through a competitively bid concession for the design, construction finance and maintenance of the works rather than direct procurement by the public sector client. We also conclude that the concession based structure should be on a single target based contract for the works rather than three fixed price concessions, the only other potential alternative of those we studied. These conclusions are drawn on the basis of the criteria identified as those most relevant to ensure value for money is delivered.

On-Network Works: Recommendation

7.28 The analysis above has considered structures for the off network core section. Below we summarise conclusions in respect of the on network works set out in more detail in Working Paper 7.4.

7.29 It is recommended that all on-network works are packaged into suitably sized contracts and procured separately under the Enhancement Facilitation Agreement between the SRA and Network Rail (or an evolution of this structure if experience from other projects suggests this is necessary ahead of Crossrail). This will involve letting Design, Build, Finance and Transfer contracts for individual projects prior to acceptance into the network by Network Rail as the long-term holder of the asset. As a general matter DBFM structures are not considered appropriate for on-network major enhancements, inter alia, because of (i) the operational and safety requirements to have a single network operator and (ii) if the current regulatory structures of 5 year reviews were to apply, this would make the benefits of passing long term maintenance contracts to the private sector as part of the concession less effective or more complex to achieve.

Mitigating Cost Overrun Risk and Obtaining Value for Money

7.30 Achieving these critical objectives requires the most efficient procurement and contract structure to ensure the private sector is fully and properly incentivised to deliver the overall project to time and budget. A properly resourced public sector client is essential to manage the procurement process before contracts are let and to deliver the public sector interfaces during the construction phase.

7.31 Within the management of the concession itself the first mitigant of cost overrun and delay risk is a world class project manager managing the sub-contracts on a properly incentivised basis. It is likely that this project will attract the world's best project managers.

7.32 A second mitigant would involve layering the risk of cost and time overrun within the target price mechanism to ensure the risks are borne by third parties as appropriate. Details of such mechanisms have already been developed in connection with the CTRL financing and CLRLL would envisage utilising such principles for the Crossrail project. Layering of risk would involve an initial sharing of cost overrun risk between the contractors and the project manager by putting their fees and profits at risk on an agreed basis. Further layers could be envisaged involving the insurance markets and may not exclude public sector support for more remote layers of risk.

Project Client Team (PCT) Arrangements

7.33 The sections above have considered the procurement of the works. The sections that follow consider the management of the relationship between the public sector client and the concessionaire.

7.34 It is proposed that an effective PCT, acting as agent of the Government, would have responsibility to Government through its shareholders for overseeing the delivery of the project. As a working assumption, PCT would let the concession contracts and be the counterparty to the concessionaire. Its principal role would be to monitor and report on progress and to authorise any necessary variations to the target price. It would also manage some of the many public sector interfaces in delivering the project. An experienced technical advisor (TA) would also be employed to support the PCT until project completion to help monitor progress and to ensure that the works are completed in accordance with the specification. The TA would be appointed some time prior to the letting of the main concession in order to assist in defining the specification of the works, developing the target price mechanism and the programme. The TA would also provide support to the PCT during the Hybrid Bill procedures and the subsequent concession competition negotiations.

The Function of the PCT prior to Commencement of Construction

7.35 Prior to letting the concessions and commencement of construction the PCT would have three main roles. First in developing contract specification and planning of works, and specifying and agreeing public sector dependencies.[43] Secondly, the PCT would be responsible for the procurement of enabling works, for ensuring that those works are completed to schedule and that where necessary responsibility for their completion is handed over to the concessionaire efficiently. Thirdly, and with assistance from the TA, the PCT would be responsible for developing the target price mechanism, pain/gain share and managing the procurement competition for the target works. The target price cannot be set with reasonable certainty until towards the back end of the Hybrid Bill process. This may be the natural time to hold the competition for the concessionaire.

---

43. Public sector dependencies are those things which will be provided to the concessionaire in order for him to complete the task, and which if not provided become relief events/compensation events. This could be anything from track possessions and site access to powers or drawings. PCT will also enter into appropriate agreements with the providers of dependencies.

7.36 The bidders for the target price concessionaire role would be asked to bid on:

- acceptance of the target price for the project works
- the design of pain gain share mechanisms, or suggested alternatives
- their assessment of the optimal procurement strategy
- confirmation of open book and transparent joint procurement of civils and systems subcontracts.

The Function of the PCT during Construction

7.37 During construction the PCT's role would be limited to consultation and monitoring with the help of its TA. This would encompass the approval of changes to the scope of works or of changes to the target price and sharing of cost overruns and the approval of risk mitigation where the public sector will be likely to bear some of the cost.

7.38 Under the recommended single concession target price approach, the PCT may also have responsibility for raising finance external to the concession funding. This is discussed further in Working Paper 7.4.

The Function of a Project Manager in a Concession

7.39 In a target based concession contract the project manager contracts with the concession spv to manage the works and let the sub-contracts which may be on a target or a lump sum basis. It is likely the project manager would also be a shareholder in the concession spv.

7.40 It is envisaged that, in addition to responsibilities in delivering the target-based works, the project manager would also act as agent for Government for the delivery of the on-network DBFT based contracts and management of the interface between the contracts.

Financing

7.41 The following sections lay out the current view on the financing options and recommended structure. At this stage the requirement is to be able to set out in broad terms the types of financing available and their impacts on the project. Final decisions on financing may not need to be taken for some time and changing market conditions may influence the choice over options presented here.

7.42 More detail of proposed financing arrangements is provided in the financial advisers report in Working Paper 7.12.

Potential Sources of Finance

7.43 There are at least four potential sources of funding which can be applied towards the cost of the Crossrail project:

- PPP / Project finance raised at a concession level
- Structured finance raised outside (or instead of) a concession
  - Securitisation vehicles
  - Leasing
- Alternative funding mechanisms, direct developer and Section 106 contributions
- Quasi-Government funding.

7.44 All of these methods can be used to reduce or eliminate the requirement for direct Government grant during the construction phase.

PPP / Project Financing Raised in a Concession

7.45 The table below illustrates the current estimate of the sources of private sector PPP/ project finance available to be raised within a concession. It should be noted that bank syndication market conditions at the time of writing are substantially tighter than at any point since the early days of PPP, and the assumptions reflect this. If liquidity recovers to that seen in recent years, market capacity is likely to be greater at the time when funds are actually raised in the future. Market appetite will also be dependent on external factors, such as future bank mergers and acquisitions, the impact of the proposed Basle II capital adequacy directives on project finance, and general sentiment towards PPP structure.

7.46 The potential sources of concession level funding are set out in Table 7.1.

Table 7.1: Potential Concession Level Funding Sources

Funding Source	Assessment of Current Capacity
Monoline wrapped project paper:	£1,000 million per monoline (AMBAC and MBIA) although we believe that monolines are likely to consider their overall exposure.
Fixed rate bonds	Market capacity is around £2 billion across total project exposure.
Index-linked bonds	£100 million to £400 million.
Senior Bank Project Debt	£1, 000 million to £1,500 million.
Bank guaranteed leasing	Likely to require bank letters of credit. Substitutive not additional to Senior Bank Project Debt.
Mezzanine products	£50 million to £100 million.
European Investment Bank ("EIB") with private sector guarantees during construction with public sector guarantees during construction	EIB has signalled willingness to consider contributing between £500 million to £1,000 million. If private sector guarantees then EIB will be substitutive, as the guarantees will reduce the private sector financing available to take project risk.

7.47 Project financing DBFM structures using lump sum strategy are well known and understood. From a financing point of view, target price concession structures are less well established. Unfamiliarity with target price concessions may inevitably dilute the appetite of funders, lessening the amount of project finance available.

7.48 It would be possible to raise project finance funding within a concession-based target price contracting strategy if the cost overrun support is sufficient, clear and unambiguous and either

- The Government top slice cost overrun support is extensive enough that funders are confident that failure to complete is exceptionally remote, or
- The termination compensation for contractor default during construction is robust and
- The ultimate stream of availability charges flexes depending on actual outturn costs. Flexibility in the income stream will not, of itself, provide the required flexibility to fund cost overruns/delay costs – these liquidity shortfalls will need to be met through the cost overrun support including directly by the Government.

7.49 The target price concessionaire can be expected to raise up to £1.5 bn traditional project finance and a further £2 bn in the monoline wrapped capital market.

European Investment Bank Contribution

7.50 Based on discussions with officials from the European Investment Bank (EIB) up to £1 billion could be raised from this source. To the extent guarantees will be provided by the public sector, EIB funding is an additional, not substitutive, source of funding for the project.

Structured Finance

Leasing

7.51 The rolling stock leasing market is well developed and is the preferred finance option for rolling stock. Rolling stock lessors are capable of taking maintenance and residual risk on rolling stock and of financing depots. Rolling stock design will be as standard as possible to facilitate value for money.

7.52 There may be other assets which are capable of being owned outside of any concession and which are capable of being leased. However, it is difficult to see what real risks lessors would take and the value for money of leasing assets (apart from rolling stock) outside of the concession.

Securitisations

7.53 A significant capital contribution could be raised by establishing a securitisation vehicle ("Fundco"). This may be able to be achieved by considering:

- An irrevocable assignment of some of the subsidy payable to a Crossrail TOC, their successors or the SRA where it acts as operator of last resort
- An assignment of deferred grant payable to CLRLL or other entity. The Network Rail structure proposes securitising both track access payments and future grant funding
- A capacity type charge which would be paid as long as a railway capable of taking trains exists. This payment might take force majeure type risks but would be bankruptcy remote from any concessionaire.

7.54 To be highly rated a securitisation "FundCo" vehicle would have to take no (or very little) construction risk. This could be achieved by a full pay out of senior debt if construction was not complete by a defined date. This is likely to have a balance sheet impact during construction. In addition the vehicle would have to take little if any performance risk and no risk of cross default based on the performance of the concessionaire.

7.55 The Network Rail financing is likely to set many precedents for this structure, in particular the implications of either Network Rail or the Crossrail Infrastructure Controller going into special administration.

7.56 The major advantage to this route is if the funding is deemed "off balance sheet". In current market conditions the likely ranges of structural complexity premia (RBS estimate 60 bps to 70 bps over Gilts) appear relatively expensive given the limited risk transfer.

Short term Government loan

7.57 The concessionaire could be partly funded during construction by way of a Government subordinated loan (in place of the grant otherwise payable) which, after completion of the scheme, would be repaid through the proceeds of a similar securitisation as detailed above.

Alternative Funding Mechanisms ("AFMs")

7.58 Potential revenues derived from AFMs are an important part of the Crossrail business case and are more fully detailed in Chapter 8.

7.59 Based upon work done over the last year to estimate the potential for value uplift and to translate these into incremental revenue streams, changes to the way business rates are computed could result in additional revenues of £3,170 million (NPV) over the period 2005-2040, roughly corresponding to the beginning of Crossrail's construction to the end of the appraisal period.

7.60 Any debt raised from a securitisation of incremental taxes is likely to be "on balance sheet". This has not, therefore, been investigated further.

Direct Contributions from Developers and S 106 Agreements

7.61 Direct developer contributions and Section 106 partnerships have the potential for raising additional amounts of money, although with little prospects for either securitisation or materialisation during the construction period. Negotiations with selected developers in the Isle of Dogs, and potentially in the vicinity of Farringdon and Liverpool Street stations will be carried out towards this end. It must be recognised that, with an expectation that the route will pass through all of these stations, the negotiating levers for such contributions are limited to design of stations and to some extent service frequency and start date of service. Nevertheless, the willingness of some property developers to contribute towards the cost of Crossrail will be fully utilised.

7.62 Additional property related income may also accrue from property partnerships related to the land and property Crossrail will acquire for construction.

7.63 Canary Wharf plc made direct contributions to the funding of the Jubilee Line Extension. At an appropriate time CLRLL will formally approach Canary Wharf and other identified entities in respect of direct contributions. Initial discussions have taken place with Canary Wharf, which indicated a willingness to consider funding some station works against a repayment availability stream.

7.64 As expected at this point in the procurement cycle developers are unlikely to commit, even in principle, to any contributions.

7.65 Section 106 contributions are generally paid to the local authorities when development is taking place and it is likely that such funds would be related to peripheral works during the construction period.

7.66 Although potentially important politically to demonstrate business "commitment" the potential quantum of funding which could be raised is not significant for the business case.

Quasi Government funding

7.67 Grant funding can be made directly to a concessionaire or through the FundCo. In addition, different streams of deferred grant could be created that could be securitised to provide funding during construction as discussed above. Whether such an approach is attractive will depend on the potential cost of funding and whether the structure is "off balance sheet" for the Government.

Financing Recommendation

7.68 The recommendation is based on the assumptions that:

- An all public sector funded option, even if good value for money, is unlikely to be affordable
- The disciplines introduced by project finance funding raised at the concession level are desirable
- The funding structure needs to be flexible enough to cater for private sector funding raised outside of the concession where it can be demonstrated at the time of the fund raising that the funding is both off balance sheet and value for money (this is currently unproven).

7.69 Based on these assumptions it is recommended that:

- A concessionaire be required to raise PPP/project funding at the concession level. Under current (summer 2003) market conditions, the target price DBFM concessionaire can be expected to raise up to £1.5 billion traditional project finance with up to a further £2 billion being raised in the monoline wrapped capital market
- If a "FundCo" can be structured to be off balance sheet at acceptable pricing and acceptable structural support then further funding could be raised in this manner
- The rolling stock requirements be leased outside of the concession
- The maximum contribution from the EIB is used, guaranteed by a public sector entity
- Direct developer contribution and any relevant S106 funds be used in place of grant funding where possible
- The balance of the funding during the construction period be grant funded.

7.70 To achieve this the ultimate repayment stream for PPP / project funding will be via an availability style payment. Revenues from AFMs could be an important source of reducing the burden of this availability payment on the exchequer.

8. Exchequer Costs of Crossrail

Project Costs

8.1 The total costs of the project in 1st Quarter 2002 prices is £6.886 bn as indicated in chapter 4. When the effect of real cost increases in the construction industry is taken into account, this increases to £7.680 bn.

8.2 These estimates were prepared on the basis of outturn costs in other projects, such as the Jubilee Line Extension and the Channel Tunnel Rail Link and therefore contain provisions for contingencies as experienced on the comparator project.

8.3 In addition to these capital costs, the project cost estimates currently contain provisions for additional contingencies that range from 20% for tunnels that are better specified and designed to 146% for surface route infrastructure where cost estimates are dependent upon an assessment of existing asset conditions. In aggregate the project costs have an allowance for nearly £3 billion in additional contingencies.

Revenues

8.4 Revenue projections for Crossrail's business case were done on the basis of the modelling undertaken for the transport appraisal. The transport appraisal itself was done on the basis of the London Transport Studies (LTS) and Railplan models. LTS is a distribution and mode split (DMS) model that sets out the mode share for public transport and the distribution within the public transport network. Railplan models used the output matrices from LTS and applied an elasticity approach to estimating public transport usage. The models estimate these impacts for a single year, in this case 2016. Beyond 2016 the models assume that the proportional share of traffic carried on Crossrail, LUL and the TOCs remains unchanged with overall traffic growing at the rates assumed. Further, the assumption is that demand growth is not dependent on additions to network capacity.

8.5 This analysis results in the conclusion that while Crossrail provides significant decongestion benefits, only about a third of the traffic carried on Crossrail is new, with the remaining two-thirds being diverted from LUL, the National Rail Network and buses.

8.6 While this methodology is widely accepted for estimating economic benefits it does not take account of the possibility that demand may be limited by the available capacity. The economic appraisal assumes that a given volume of demand has to be accommodated on the network and additional capacity has the effect of reducing crowding. This is illustrated in Figure 8.1. An alternative view is that demand will be limited by capacity and extra capacity allows growth in demand and revenue which would otherwise have been suppressed. This latter view would attribute a higher amount of revenue to the new line – and smaller crowding benefits. This is illustrated in Figure 8.2. It also indicates that applying this approach would imply that Crossrail itself will fill to capacity within a few years after opening and its revenue would then be capped.

Figure 8.1: Annual Revenues on London Rail Network as per Transport Appraisal (£m, Real 2002 prices)

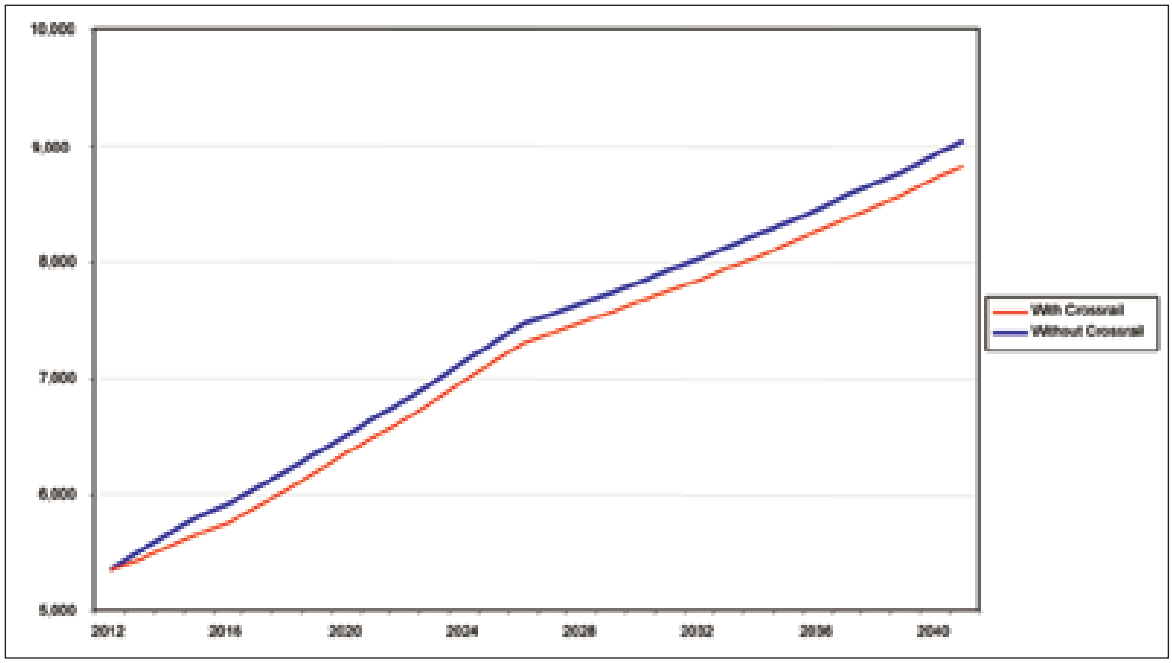
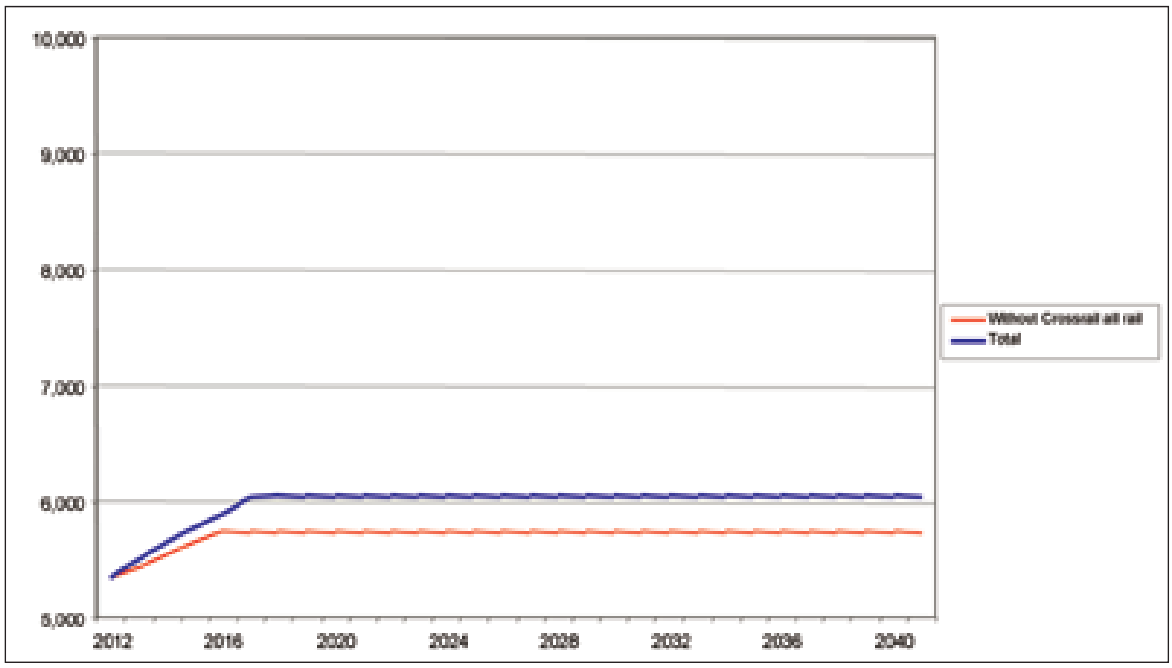


Figure 8.2: Annual Revenues on London Rail Network with Capacity Constraints (£m, Real 2002 prices)



8.7 Table 8.1 shows the gross and net revenues earned by Crossrail under each scenario for the first thirty years of operation.

Table 8.1: Crossrail Revenues (£m) during the First Thirty Years

Revenue	As in Transport Appraisal		With Capacity Constraints	
	Real 2002 prices	NPV	Real 2002 prices	NPV
Crossrail revenues	11,942	5,134	8,757	3,877
Net rail revenues	4,334	1,831	7,923	3,325

8.8 Table 8.1 already accounts for the substitution effects of services such as Heathrow Express and those parts of the Great Eastern Service that will get subsumed by Crossrail. The gross revenue figures for Crossrail have therefore been adjusted downwards to reflect these substitutions.

8.9 The conclusion regarding net revenues is not particularly sensitive to the assumption regarding network capacity constraints. For example, if 10% more traffic could be accommodated on the existing network it would reduce Crossrail net revenues by £257 m (NPV), or roughly 7.7%; a 20% higher capacity would similarly result in a reduction of £492 m (NPV), or roughly 14.8%. Even in the 20% downside case, the net revenues would still be about £2.8 bn, roughly 60% more than the estimate in the transport appraisal. It is worth noting that, even with increases in capacity assumed for both LUL and the national rail network, the LUL services in central London are substantially more crowded in 2016 than in 2001 while national rail services are modestly less crowded.

8.10 The fare calculations shown here are based on an assumption that fares increase in line with RPI. Relaxing that assumption by allowing fares above RPI will result in increased fare revenues. For example, a premium of 10% on Crossrail fares only would result in a modest increase of £4 m per annum, or an NPV of £52 m. A premium fare on all Zone 1 passengers could yield £82 m per annum or an NPV of £1.069 bn. These amounts would be ddditional to the fare revenues listed in Tables 1 and 2 of Appendix D.

8.11 It is worth considering how robust these revenue estimates are, especially since some rail projects, especially light rail, have not met their initial revenue projections. The experience of rail infrastructure in central London has been largely the opposite. Initial scepticism about passenger growth on the Jubilee Line extension or even the Victoria Line extension turned out not to materialise as passenger numbers have been higher than forecast.

8.12 Rail has a very high mode share for travel into central London and this is likely to be the case in the absence of other alternatives. Unlike other projects, such as trams, the Channel Tunnel or the Channel Tunnel Rail Link, demand for Crossrail does not rely on assumptions of changes to mode share (e.g., getting people out of cars and into public transport). Neither is there the potential for much competition from other modes, as has been the case with the Channel Tunnel.

London Contribution through Alternative Funding Mechanisms

8.13 In addition to the benefits to riders, which are captured by fares, new infrastructure produces additional benefits to non-users, especially to owners of land and property in the proximity of stations. However, the existing systems for property taxation do not allow higher revenues to be collected when a public investment in infrastructure results in value being realised by private parties.

8.14 Several changes have been mooted for the system of property taxation for business properties, known as the National Non-Domestic Rate (NNDR) or business rates, to enable collection of higher revenues. These include tax increment financing and supplementary rates. While legislation will be required to amend the provisions of the Local Government Finance Act (1988), the potential value of doing so is large. There is gathering momentum now for a change in legislation to enable London businesses to contribute to infrastructure that is valuable to them.

8.15 Each of the proposed changes seeks to alter the existing mechanisms for computation of the NNDR, specifically the provision that the tax take on existing properties can only increase by RPI. This mechanism mandates that between revaluations the tax rate on properties increase in line with RPI. At revaluation, which take place every five years, the base value on which the tax is charged gets reassessed at current market rents. However, the tax rate is simultaneously adjusted so that total collections do not increase by more than RPI.

8.16 This provision leads to a situation where the higher the increase in assessed rental values the lower is the resulting tax rate. Therefore, if Crossrail leads to higher property values, there is no concomitant benefit to the Exchequer since the tax rate would adjust to allow only nominal increases in collection.

8.17 The tax increment financing proposal seeks to correct this situation by excluding properties in the Crossrail impact area from the computation mechanism of the tax rate. The tax rate would still decline over time due to other factors but excluding these properties would capture a share of the benefits that Crossrail creates through higher collections of taxes. The computed effect on the tax rates is small. Without the tax increment financing proposals being implemented the tax rate would decline from its current value of about 45% to less than 20% by the end of the Crossrail appraisal period; with implementation it would drop by about 0.23% less than otherwise.

8.18 Based upon work done over the last year to estimate the potential for value uplift and to translate these into incremental revenue streams, tax increment financing can raise £6.157 bn (real 2002 prices) over the period 2005-2040, roughly corresponding to the beginning of Crossrail's construction to the end of the appraisal period. This translates into an NPV of £3.170 bn.

8.19 The supplementary rate proposal, by contrast, imposes an additional rate on top of the computed rate for all properties within a defined area. The yield from the supplementary rate could be made to vary with the choice of rate. A 3% supplementary rate would yield roughly the same amount of money.

Net Exchequer Costs

8.20 The net funding costs to the Exchequer of Crossrail are obtained by subtracting revenues and the London contribution from the construction costs. Table 1 of Appendix D shows the Exchequer costs with revenue estimates derived from a constrained network. Table 2 of Appendix D shows the same with revenues as in the transport appraisal. Table 3 of Appendix D presents the annual provisions for additional contingencies.

8.21 Based on robust estimates of costs and revenues, the net Exchequer costs of Crossrail are in the range of £2.647 bn to £4.140 bn (NPV), with an additional contingency provision of £3.224 bn (NPV), which would also need to be funded by the Government.

Appendix A

List of Working Papers

3. The Crossrail Proposal
3.1 Scheme Definition
3.2 Project Staging

4. Project Costs
4.1 Capital Costs
4.2 Operating Costs

5. The Business Case for Crossrail
5.1 Forecasting Scheme Effects
5.2 Model Validation
5.3 Demand Growth
5.4 Heathrow Demand
5.5 Network Assumptions
5.6 Demand, Capacity and Levels of Service
5.7 Appraisal Assumptions
5.8 Elasticity of Demand
5.9 Highway Decongestion Benefits
5.10 Station Crowding Benefits
5.11 Mobility Impaired Benefits
5.12 Quality Benefits
5.13 Annualisation Factors
5.14 Values of Time
5.15 Heathrow Benefits
5.16 Revenue Estimation on Rail and LUL
5.17 Sensitivity Analysis
5.18 Derivation of the Appraisal Summary Table
5.19 Parking Strategy
5.20 Bus Strategy

6. How Crossrail Supports Government Policy
6.1 Agglomeration Effects
6.2 Crossrail and Regeneration

7. Procurement and Finance
7.1 Not used
7.2 Technical/Construction Risk Register
7.3 Crossrail Procurement: Principles and Options
7.4 Detailed Procurement Structure Issues
7.5 On Network Works: Procurement Structure and Relationship with Network Rail
7.6 Infrastructure Controller and Regulation
7.7 Integration and Interface Risk
7.8 Headline Risk Categories
7.9 Overall Management and Risk Mitigation Structure
7.10 Structure and Function of Project Client Team
7.11 Not used
7.12 Crossrail Financing Strategy
7.13 Not used
7.14 Licencing, Access and Regulatory Issues

Appendix B

TEE Table

This TEE table is based on a layout developed by the DfT. The project costs are consistent with those given in the report text, but have different values here arising from the manipulations necessary for the purposes of cost - benefit analysis.

Appendix B : Economic Efficiency of the Transport System (TEE)

Run No. (150) 25-Jun-03	Total present values at 2002 prices and values		Benchmark assumptions Highway	Public Transport			
User benefits							
Time Savings							
PT benefits	13259			13259			
Congestion Relief:							
Highway	1739		1739				
In-train	4020			4020			
train/platform interaction	1045			1045			
station	1720			1720			
Vehicle operating costs	133		133				
User charges	0		0	0			
Accessibility and Ambiance:							
MIPS	290			290			
Quality	217			217			
During construction and maintenance	(22)		(22)	0			
NET USER BENEFITS	22401	*(1)*	1849	20552			
Private Sector Provider Impacts (Net)				**Crossrail**	**Bus**	**Rail (Excl Crossrail)**	**LUL**	**DLR**
Revenue								
Public transport	1609			7021	(467)	(2858)	(1962)	(124)
MIPS generation	145			145				
Quality generation	31			31				
Station decongestion	405			405				
Other revenues (advertising)	54			54				
Present Value of Revenues	2244			7656	(467)	(2858)	(1962)	(124)
Operating costs	(1238)			(2940)	915	775	11	0
Maintenance costs	(2849)			(2849)	0	0	0	0
Capital / Investment Costs	(8869)			(8869)	0	0	0	0
Heathrow Access	(137)			(137)				
Property Recovery	142			142				
Grant / subsidy	10707			6998	(448)	2083	1951	124
Subtotal	0	*(2)*		0	0	0	0	0
Other private sector impacts								
Developer contributions	0	*(3)*		0				
NET PRIVATE SECTOR IMPACT	0	*(4)=(2)+(3)*		0				
TOTAL **Present Value of Transport Economic Efficiency Benefits**	22401	*(5)=(1)+(4)*						

Notes: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values.

Appendix B : Public Accounts

Run No. (150) 25-Jun-03	Total present values at 2002 prices and values	Benchmark assumptions					
Government Impacts		**Highway**	**Crossrail**	**Bus**	**Rail (Excl Crossrail)**	**LUL**	**DLR**
Grant / subsidy payments	10707		6998	(448)	2083	1951	124
Developer and other contributions	0		0				
Indirect tax revenues	565	89	476	0	0	0	0
Total Present Value of Costs (PVC)	11273	89	7474	(448)	2083	1951	124

Notes: Costs appear as positive numbers while revenues ands "Developer and other contributions" appear as negative numbers. All entries discounted to present values.

Appendix B : Analysis of Monetised Costs and Benefits (AMCB)

Run No. (150) 25-Jun-03	Total present values at 2002 prices and values	Benchmark assumptions
Noise		For future use
Local Air Quality		For future use
Greenhouse Gases		For future use
Journey Ambiance		217
Accidents		84
Users		22184
Providers		0
Reliability		For future use
Option Values		For future use
Present Value of Benefits (PVB)		**22486**
Public Accounts		11273
Present Value of Costs (PVC)		**11273**
OVERALL IMPACTS		
Net Present Value (NPV)	NPV=PVB-PVC	**11213**
Benefit to Cost Ratio (BCR)	BCR=PVB/PVC	**1.995:1**

Appendix C

Appraisal Summary Table

OBJECTIVE	SUB-OBJECTIVE	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ECONOMY	Transport Economic Efficiency	Journey time, frequency and capacity enhancements will benefit existing public transport users and encourage shift from car with associated reductions in road congestion. New stations and rolling stock will improve passenger environment and contribute to mode shift and reliability.	PV benefits: £ 22.3 bn PV costs: £11.2 bn Benefit – Cost ratio: 1.99:1	Large beneficial
	Wider Economic Impacts	By increasing capacity and accessibility, Crossrail removes transport constraints, thereby securing the draft London plan growth forecast for central London. The Central London FBS clusters have high added value, and are internationally mobile; growth provides a net increase to UK GDP. Crossrail provides significant regeneration benefits.	7-10,000 additional jobs in Central London by 2016 rising to 20-23,000 by 2027 Potential PV increase in UK GDP of £7.7-8.6 billion per annum. 24,000 jobs taken up by unemployed and economically inactive residents in Regeneration Areas.	Large beneficial
ENVIRONMENT	Noise	Railway Noise: There will be increases in noise levels due to increases in train movements on surface sections between Gidea Park and Shenfield, Plumstead to Ebbsfleet, and Gunnersbury to Kingston. There will be decreases in noise levels between Royal Oak and Heathrow where there will be some replacement of diesel with electric traction. Road Traffic Noise: Reductions in road traffic noise through modal transfer will be imperceptible.	It is not anticipated that properties adjacent to the overland sections of the route will be subject to significant increases in airbourne noise (an increase of 3dB or more). Neither is it anticipated that properties that are likely to be effected by groundbourne noise will experience what is considered to be a significant impact (40dB or more).	Neutral
	Local Air Quality	Slight improvements to local air quality may occur due to modal shift from road to rail. However, such changes are unlikely to be quantifiable and small.	Reduction in average vehicle kilometres travelled on the road network will be negligible (i.e. less than 1%) compared to the ‘do-nothing’ scenario.	Neutral
	Greenhouse Gases	Modal shift from cars to trains is predicted to result in a decrease in emissions of CO2. Decrease is equivalent to approximately 0.7% of Greater London’s CO2 emissions from road transport per year.		Slight beneficial
	Landscape	Presence of Shenfield depot will result in slight adverse impact on surrounding landscape and views.		Slight adverse
	Townscape	Demolition of property and the presence of portals, ventilation shafts and new station development will have an impact on townscape. At the same time, there will be opportunities for improved urban design through the proposals, especially around stations.		Slight adverse

OBJECTIVE	SUB-OBJECTIVE	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
	Heritage of Historic Resources	Demolition of one listed building in central London and modifications to listed stations and structures. Impacts on Archaeological Priority Zones within, and adjacent to, route corridor. Potential impacts on listed buildings and structures due to settlement and vibration.	-	Moderate adverse
	Biodiversity	Potential for impacts due to works within, or adjacent to, Sites of Importance for Nature Conservation (SINCs) including Hyde Park, which is a Site of Metropolitan Importance.	40 SINCs potentially affected.	Slight adverse
	Water Environment	Diversions of culverts, sewers and a river. Minor changes in flow in a shallow aquifer may occur in London.	-	Neutral
	Physical Fitness	By encouraging people to use public transport, Crossrail will encourage physical fitness via additional cycling and walking.		Slight beneficial
	Journey Ambience	Crossrail will improve journey ambience by: a) providing a clean, reliable service with clear information for passengers, a pleasant journey environment and high levels of in-vehicle security; and b) providing services that are accessible to the mobility impaired.		Large beneficial
SAFETY	Accidents	Rail is a very safe mode of transport, Crossrail will encourage people off roads and will be equipped with a wide range of safety measures on trains and at stations	Fatal – 0.1 accidents saved per annum Serious – 3 accidents saved per annum Slight – 32 accidents saved per annum	Slight beneficial
	Security	Works at stations means major increase in security for passengers (CCTV, open design, lighting, landscaping, boundaries).		Large beneficial
ACCESSIBILITY	Option values	Crossrail provides significantly enhanced journey opportunities for trips to many destinations. There are significant time savings from all Crossrail branches to central London locations, and to many of London's town centres.	60-minute population catchment of City increases by 360,000, Isle of Dogs by 610,000, and the West End by 430,000.	Large beneficial
	Severance	As Crossrail mostly serves existing stations, there is no significant effect on severance.	-	Neutral
	Access to the transport system	Through serving key London town centres, Crossrail will improve accessibility to local services, social and cultural amenities. Crossrail will be accessibile to mobility impaired passengers.		Large beneficial
INTEGRATION	Transport Interchange	Crossrail forms part of an integrated transport network, with increased multi-modal interchange and mobility impaired access. It significantly reduces the need for passengers to make undesirable rail interchanges at Liverpool Street, Paddington and Waterloo.	24 Major Interchanges stations with other National Rail, Underground and/or DLR services. Average number of interchanges per Crossrail trip falls from 1.33 to 1.07.	Large beneficial
	Land-Use Policy	Crossrail supports London's world city role by sustaining and developing the FBS sector in Central London and providing connections to Heathrow, City Airport, and CTRL interchange at Stratford and Ebbsfleet. It serves Thames Gateway and supports development opportunities in East London and the Lower Lea Valley at Isle of Dogs, Stratford and the Royal Docks.		Large beneficial
	Other Government Policies	Crossrail demonstrates significant benefits against the policy objectives set out in the government's ten year transport plan.		Large beneficial

Appendix D

Exchequer Costs

Table 1: Exchequer costs of Crossrail with constrained network (£million, 2002 prices)*

	Land and Utility	Availability Charge	Operation, Maintenance and Renewal	Total Costs	Fare Revenues	TIF Revenues	Base Exchequer Costs
2002/03	-	-	-	-	-	-	-
2003/04	-	-	-	-	-	-	-
2004/05	107	-	-	107	-	-	107
2005/06	306	-	-	306	-	(-97)	210
2006/07	397	-	-	397	-	(-97)	299
2007/08	303	-	-	303	-	(-98)	205
2008/09	-	-	-	-	-	(-98)	(- 98)
2009/10	-	-	-	-	-	(-99)	(- 99)
2010/11	-	-	-	-	-	(-139)	(- 139)
2011/12	-	-	-	-	-	(-140)	(- 140)
2012/13	-	-	19	19	0	(-140)	(- 121)
2013/14	-	463	131	594	(-66)	(-141)	386
2014/15	-	463	131	594	(-107)	(-142)	345
2015/16	-	463	131	594	(-128)	(-186)	279
2016/17	-	463	150	613	(-131)	(-187)	295
2017/18	-	463	150	613	(-275)	(-188)	149
2018/19	-	463	150	613	(-301)	(-189)	123
2019/20	-	463	150	613	(-301)	(-190)	122
2020/21	-	463	187	650	(-301)	(-191)	158
2021/22	-	463	187	650	(-301)	(-192)	157
2022/23	-	463	187	650	(-301)	(-194)	155
2023/24	-	463	187	650	(-301)	(-195)	154
2024/25	-	463	242	705	(-301)	(-196)	208
2025/26	-	463	242	705	(-301)	(-197)	207
2026/27	-	463	242	705	(-301)	(-198)	206
2027/28	-	463	242	705	(-301)	(-199)	205
2028/29	-	463	223	686	(-301)	(-200)	185
2029/30	-	463	223	686	(-301)	(-201)	184
2030/31	-	463	223	686	(-301)	(-202)	183
2031/32	-	463	223	686	(-301)	(-203)	182
2032/33	-	463	181	643	(-301)	(-204)	139
2033/34	-	463	181	643	(-301)	(-205)	138
2034/35	-	463	181	643	(-301)	(-206)	137
2035/36	-	463	181	643	(-301)	(-207)	136
2036/37	-	463	245	708	(-301)	(-208)	200
2037/38	-	463	245	708	(-301)	(-209)	199
2038/39	-	463	245	708	(-301)	(-210)	198
2039/40	-	463	245	708	(-301)	(-211)	197
2040/41	-	-	326	326	(-301)	(-212)	(- 186)
2041/42	-	-	326	326	(-301)	(-213)	(- 187)
NPV	**977**	**5,671**	**2,494**	**9,142**	**(-3,325)**	**(-3,170)**	**2,647**

* Revenues adjusted to reflect network capacity constraints; revenues reflect net increases in rail revenues due to Crossrail; impacts of Crossrail on lower bus revenues offset by lower costs of bus network.

Table 2: Exchequer costs with revenue assumptions as in transport appraisal

	Land and Utility	Availability Charge	Operation, Maintenance and Renewal	Total Costs	Fare Revenues	TIF Revenues	Base Exchequer Costs
2002/03	-	-	-	-	-	-	-
2003/04	-	-	-	-	-	-	-
2004/05	107	-	-	107	-	-	107
2005/06	306	-	-	306	-	(-97)	210
2006/07	397	-	-	397	-	(-97)	299
2007/08	303	-	-	303	-	(-98)	205
2008/09	-	-	-	-	-	(-98)	(- 98)
2009/10	-	-	-	-	-	(-99)	(- 99)
2010/11	-	-	-	-	-	(-139)	(- 139)
2011/12	-	-	-	-	-	(-140)	(- 140)
2012/13	-	-	19	19	0	(-140)	(- 121)
2013/14	-	463	131	594	(-66)	(-141)	387
2014/15	-	463	131	594	(-107)	(-142)	345
2015/16	-	463	131	594	(-128)	(-186)	280
2016/17	-	463	150	613	(-131)	(-187)	295
2017/18	-	463	150	613	(-133)	(-188)	292
2018/19	-	463	150	613	(-135)	(-189)	289
2019/20	-	463	150	613	(-137)	(-190)	286
2020/21	-	463	187	650	(-139)	(-191)	319
2021/22	-	463	187	650	(-142)	(-192)	315
2022/23	-	463	187	650	(-140)	(-194)	316
2023/24	-	463	187	650	(-142)	(-195)	313
2024/25	-	463	242	705	(-144)	(-196)	365
2025/26	-	463	242	705	(-146)	(-197)	362
2026/27	-	463	242	705	(-149)	(-198)	358
2027/28	-	463	242	705	(-151)	(-199)	355
2028/29	-	463	223	686	(-153)	(-200)	333
2029/30	-	463	223	686	(-155)	(-201)	330
2030/31	-	463	223	686	(-157)	(-202)	327
2031/32	-	463	223	686	(-159)	(-203)	324
2032/33	-	463	181	643	(-161)	(-204)	279
2033/34	-	463	181	643	(-164)	(-205)	275
2034/35	-	463	181	643	(-166)	(-206)	272
2035/36	-	463	181	643	(-168)	(-207)	269
2036/37	-	463	245	708	(-171)	(-208)	329
2037/38	-	463	245	708	(-173)	(-209)	326
2038/39	-	463	245	708	(-176)	(-210)	322
2039/40	-	463	245	708	(-178)	(-211)	319
2040/41	-	-	326	326	(-181)	(-212)	(- 67)
2041/42	-	-	326	326	(-184)	(-213)	(- 71)
NPV	**977**	**5,671**	**2,494**	**9,142**	**(-1,831)**	**(-3,170)**	**4,140**

*** Revenues reflect net increases in rail revenues due to Crossrail; impacts of Crossrail on lower bus revenues offset by lower costs of bus network.**

Table 3: Additional contingency provisions

	Base Exchequer Costs	Capital Cost Contingency	OMR Contingency	Total Contingency	Total Exchequer Costs with Additional Contingency
2002/03	-	-	-	-	-
2003/04	-	-	-	-	-
2004/05	107	36	-	36	144
2005/06	210	104	-	104	314
2006/07	299	135	-	135	434
2007/08	205	103	-	103	308
2008/09	(- 98)	-	-	-	(- 98)
2009/10	(- 99)	-	-	-	(- 99)
2010/11	(- 139)	-	-	-	(- 139)
2011/12	(- 140)	-	-	-	(- 140)
2012/13	(- 121)	-	4	4	(- 117)
2013/14	386	195	26	222	608
2014/15	345	195	26	222	567
2015/16	279	195	26	222	501
2016/17	295	195	30	225	520
2017/18	149	195	30	225	374
2018/19	123	195	30	225	348
2019/20	122	195	30	225	347
2020/21	158	195	37	233	390
2021/22	157	195	37	233	389
2022/23	155	195	37	233	388
2023/24	154	195	37	233	387
2024/25	208	195	48	244	452
2025/26	207	195	48	244	451
2026/27	206	195	48	244	450
2027/28	205	195	48	244	449
2028/29	185	195	45	240	425
2029/30	184	195	45	240	424
2030/31	183	195	45	240	423
2031/32	182	195	45	240	422
2032/33	139	195	36	231	370
2033/34	138	195	36	231	369
2034/35	137	195	36	231	368
2035/36	136	195	36	231	367
2036/37	200	195	49	244	444
2037/38	199	195	49	244	443
2038/39	198	195	49	244	442
2039/40	197	195	49	244	441
2040/41	(- 186)	-	65	65	(- 121)
2041/42	(- 187)	-	65	65	(- 122)
NPV	**2,647**	**2,725**	**499**	**3,224**	**5,871**