MAYOR OF LONDON

LONDON INFRASTRUCTURE PLAN 2050: TRANSPORT SUPPORTING PAPER

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INTRODUCTION

Purpose and aims

This document supports the Mayor's interim consultation about London's infrastructure investment requirements to 2050.

Its purpose and aims are to set out in more detail the potential transport elements of the Mayor's 2050 Infrastructure Investment Plan, and in particular:

– The implications for transport of the forecast employment and population growth together with where this might take place

– How, through planning the city's future transport system, we might shape the pattern of London's growth and development to help bring about a more sustainable outcome

In doing so, it will help make the case for London's long term transport investment as well as provide more strategic context to inform current decision making about investment. The intention at this stage is not to provide a fully costed and prioritised plan, but rather to propose a strategic package of transport investment based on the analysis we have undertaken to date.

Responses to the consultation will provide a vital input for the next stages. We are particularly keen to hear responses

to the broader spatial and funding questions. These will help us define an affordable and deliverable long term vision for the future development of the capital along with a prioritised strategic transport investment plan to help realise it.

London's transport system

Transport is such a routine part of life we can easily forget how fundamentally it shapes our lives and our city. Throughout its history, London's growth has been predicated on and, in turn, shaped by its transport system. From the city's origins, with the construction of London Bridge, through to its airports with their global reach, transport has created the opportunities that have defined London's role in the world through the ages. Any vision for London's future must have transport at its heart.

The demands placed on London's transport system are both enormous and varied, ranging from personal travel to the transportation of goods, and from the international to the local. London's airports, and its vast network of railways, Tube lines, highways, local roads, bus routes, pedestrian and cycle links, trams and light railways cater for these needs.

1 Journey segments between two Oyster card 'taps' by Michael Batty

2 Clusters of Activity in Minicab Journeys across London by Edward Manley

3 Oyster Card Volumes of Travellers Using Oyster Cards at Peak Times by Michael Batty December 2013

4 Crossrail underground modelling, Liverpool Street

5 Bike flows from the Barclays Cycle Hire Scheme by Martin Austwick

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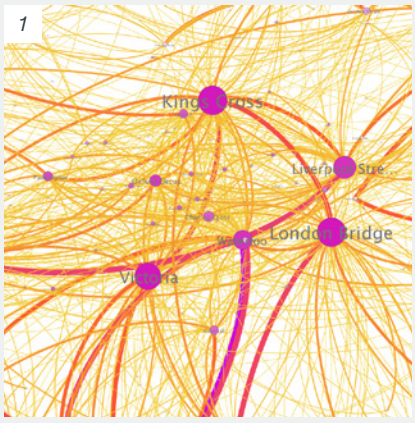

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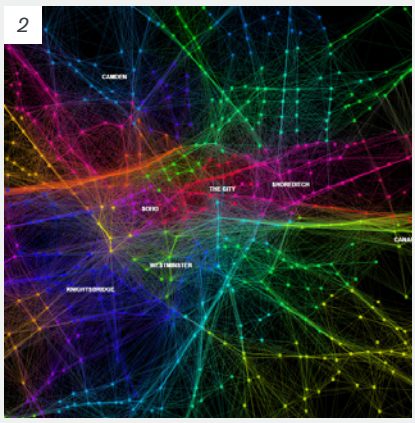

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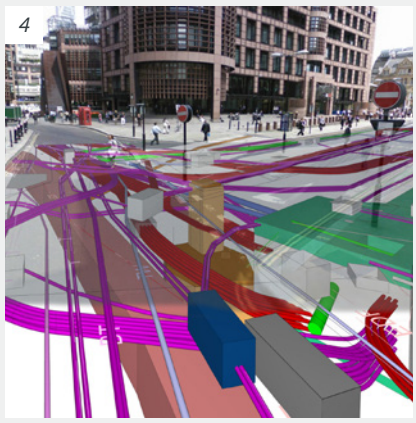

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Mostly these work well, but they are often under pressure, operating at or close to maximum capacity at times of peak demand. Some elements of the system also impose unacceptable impacts on people and the environment. London's growth poses additional challenges and considerable investment will be needed in new capacity and connections to support the city's growing and evolving needs.

Significant investment has been – and continues to be – made in the system by Transport for London, Network Rail boroughs and others. TfL's expenditure plans over the next ten years are set out in the TfL Business Plan which is delivering many of the transport requirements identified in the Mayor's Transport Strategy, which looks to 2031. Nevertheless, schemes such as Crossrail and the Tube Upgrade Programme represent just the beginning of what is going to be needed.

London has benefitted for many years from an impressive legacy of earlier generations who built the world's best urban transport system between the early 1800s and the outbreak of World War II.

A more reactive, ad hoc approach was perhaps understandable in the second half of the 20th century in the context of economic upheaval and declining population, but London is now facing a very different set of circumstances.

We are a growing city but we need to face up to increasingly tough competition from other growing cities across the world. London needs to ensure a transport system that will be fit for a leading world city in 2050.

London's growth and development

In order to plan for London's 2050 infrastructure requirements we need an understanding of the likely future scale and shape of London. This involves considering:

– How many people will be living and working in London in 2050?

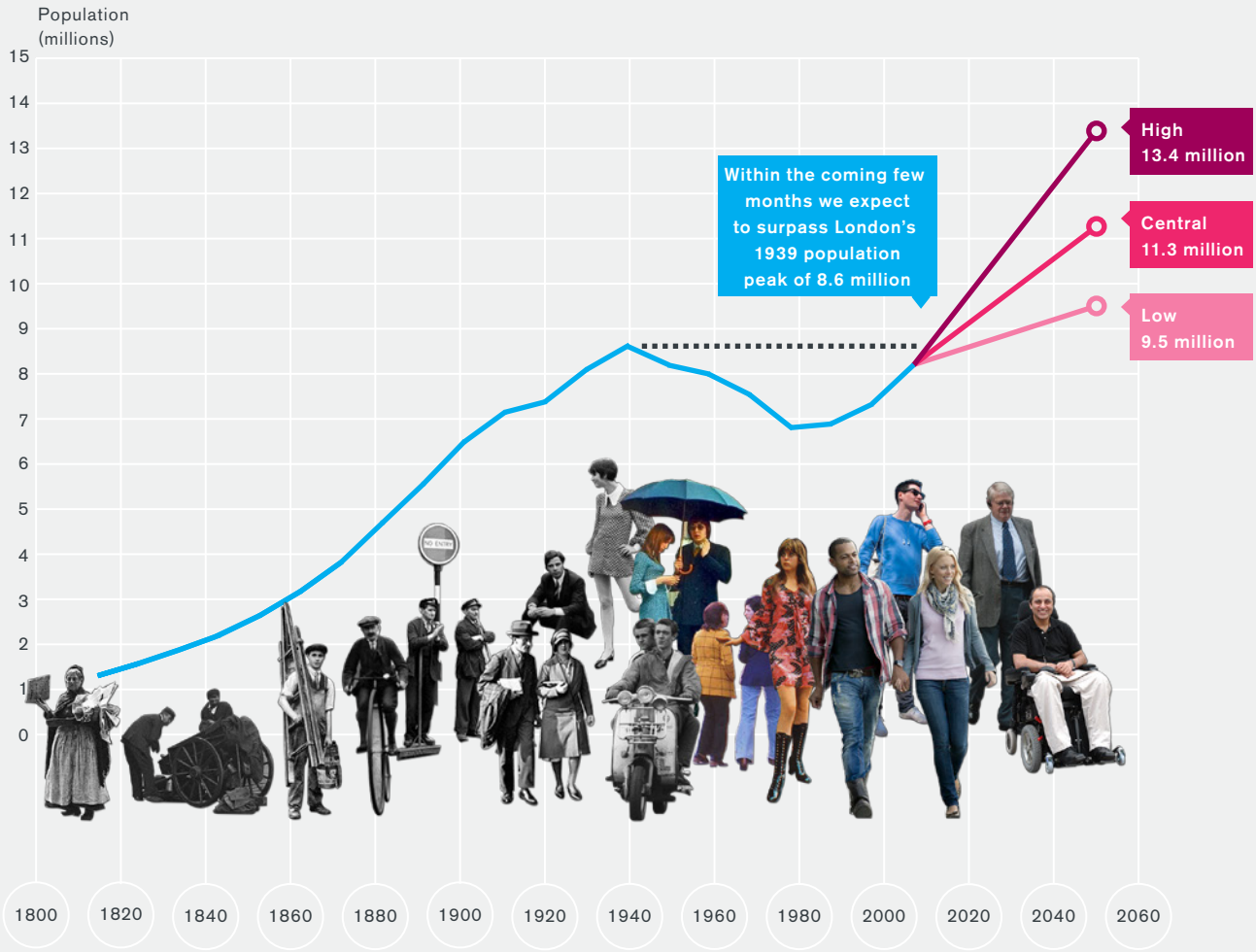
– How will the economy develop and where will people work?

– Where and how will people in London live?

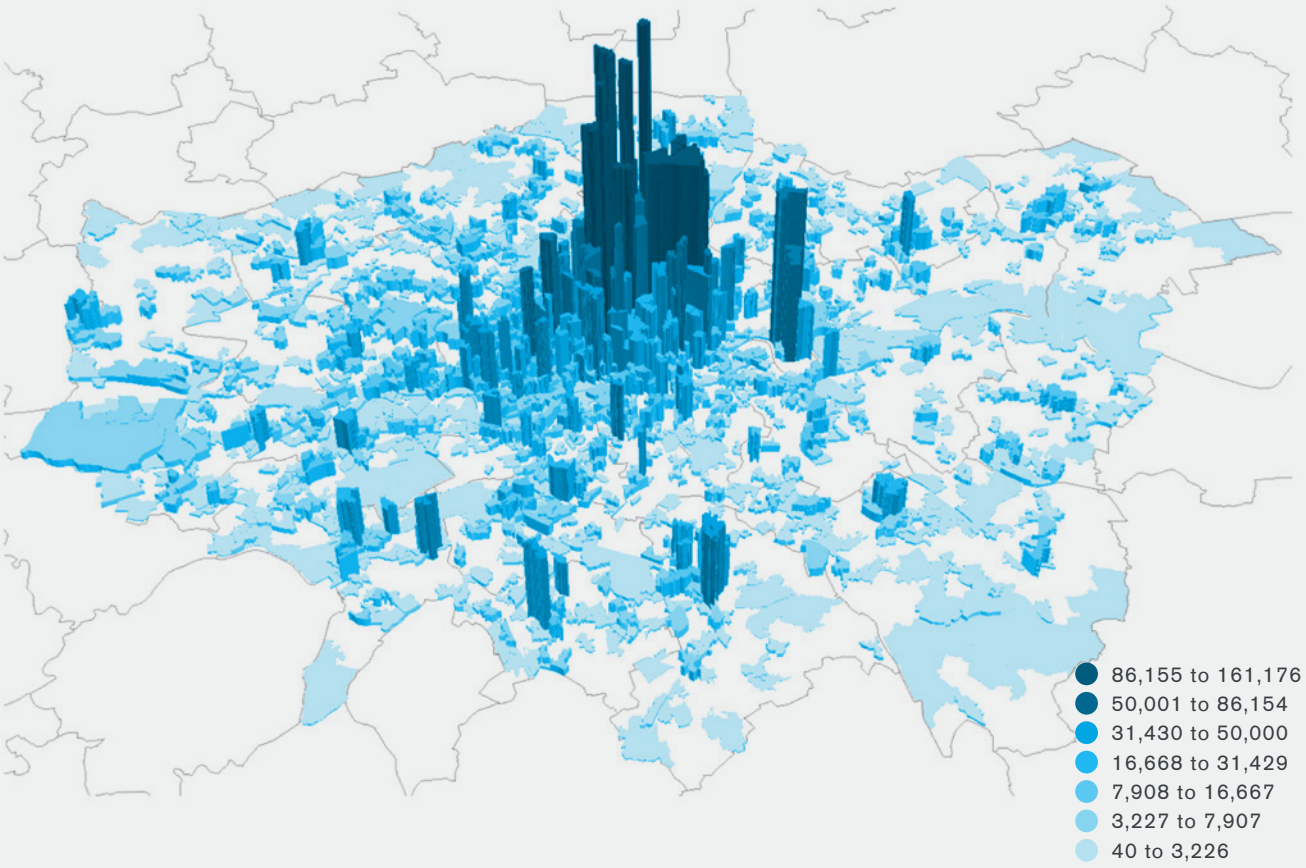
– What will happen beyond London's boundary?

– How will decisions about future airport capacity affect the above factors?

Population by year (millions)



Employees per square kilometre



London's population

London is growing rapidly and is expected to continue doing so. Its population in 2011 was 400,000 higher than pre-census estimates and is poised to overtake its pre war peak of 8.6 million. It is expected to reach 10 million by the early 2030s and nearly 11.5 million by 2050.

Employment in London

The number of jobs in London has also been growing quickly and now stands at around 5.4 million. It is projected to reach 6.3 million by 2050. London's overall employment growth is in large part driven by its internationally oriented economy and role as a leading world city. The multiplicity of high value activities associated with this are largely located in the dense employment core of central London, the 'Central Activities Zone' (CAZ), which accounts for over thirty per cent of London's jobs but only 2 per cent of its area.

The 1.3 million people who work in the CAZ are on average 70 per cent more productive than those in the rest of the UK. These exceptional productivity levels depend partly on skill

levels in the workforce but also on economies of agglomeration resulting from the unparalleled density of employment.

Despite the growth in mobile and remote working enabled by technology, the physical clustering of jobs in knowledge rich sectors is likely to remain as important as ever. Property market intelligence indicates strong continuing demand for office space in central London, with international businesses continuing to place a high value on the benefits of locating there.

Projections show over 40 per cent of the forecast employment change to 2050 is in the 9 central London boroughs, with the biggest absolute changes in Tower Hamlets, the City, Camden and Westminster.

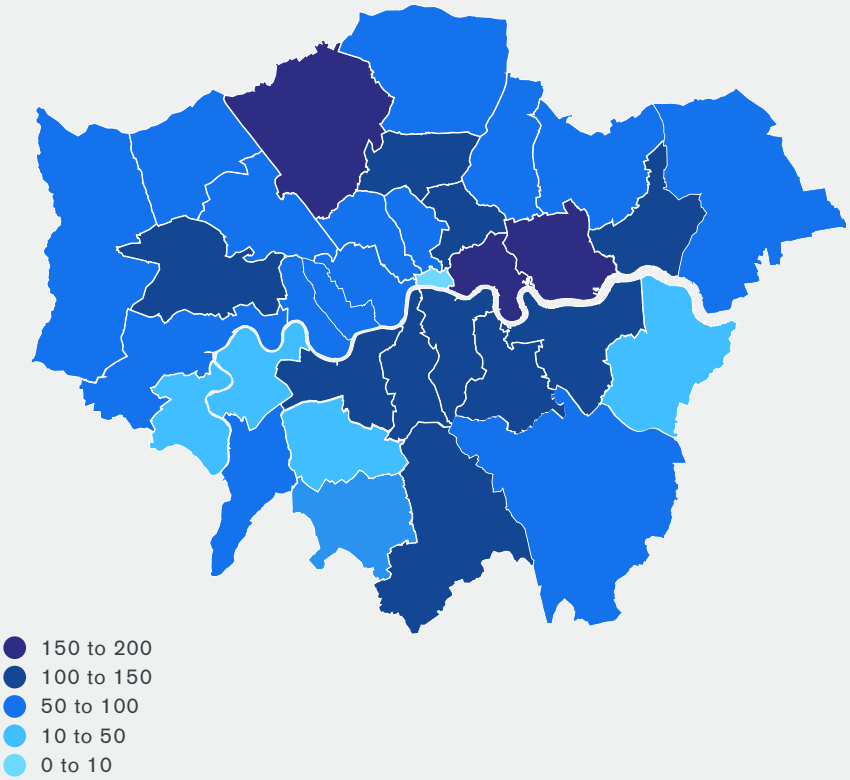
We have considered whether a more decentralised model of economic growth would offer benefits (see Section 2). We found that there would be major impacts on productivity and incomes as agglomeration benefits would be lost. And footloose international businesses would be far more likely to relocate to overseas centres that compete with central London, such as Singapore, rather than to other locations within London. Over time these losses would significantly outweigh any savings from lower costs of infrastructure.

However, two thirds of London's jobs are located outside the CAZ, many in sectors that directly serve London's population, such as healthcare, education and leisure. There are particular clusters emerging in different parts of London, for example the Golden Mile in Hounslow or bio-sciences clusters around major hospitals such as the Royal Marsden site in Sutton. Town centres in particular remain vital with London's high streets accounting for around 40 per cent of the city's total employment.

Housing the growing population

London's continuing economic success will, alongside demographic factors, drive growth in its population. This population growth, will be more widely dispersed across London than new jobs. The GLA's forecasts, which are shown on the map below,

Absolute change in population, 2011 to 2050 (thousands)



show all areas of London growing in the period to 2050, with particular increases in inner and East London.

Given the timescales and different factors involved, there is some uncertainty about how this growth – particularly in terms of where people will live – will emerge spatially and future policy choices will be an important influence. Since these cannot be predicted we have considered various different spatial scenarios in order to determine whether these lead to significantly different infrastructure challenges.

It is clear that, in any scenario, the rate at which new housing is delivered in London needs to increase just to meet current needs, let alone future needs. The Mayor has identified a need for 49,000 new homes per year[1] between now and 2025 to address current need and to tackle the backlog. This means current delivery levels of around 25,000 will need to almost double.

The clear starting point for achieving this is to consider how we can make the most of the currently designated Opportunity Areas. Our analysis indicates that this approach could unlock enough housing for the equivalent of around 10 per cent of London's current population. While this will make a vital contribution, it is clear that additional development capacity will be needed.

1- Further Alterations to the London Plan (FALP), GLA, 2014.

Within this context we've undertaken analysis to identify how and in what circumstances more housing could be accommodated both within London and outside London. We have considered the following different means of increasing housing provision across London:

– Increasing densities in town centres

– Increasing densities in areas with good public transport provision

– Renewal of suburban housing

– Growth in areas outside London

These scenarios have been considered as 'what if' scenarios in order to assess the breadth of spatial variations that might influence transport, and other, infrastructure requirements. We have applied the guideline housing capacities as set out in the London Plan, but it should be emphasised that we have left aside questions of deliverability and acceptability of these scenarios.

Bearing in mind these important provisos, our analysis indicates that the projected population growth could be accommodated. There is relatively little variation in the overall scale of transport demand and all scenarios will share many of the same core requirements. For example the major radial rail capacity schemes such as Crossrail 2 provide capacity that is versatile enough to meet many of the needs identified across the spatial scenarios we have considered.

There are nevertheless some variations between the scenarios in the particular patterns of transport demand and their implications. These are considered further in Section 2 and in Appendix A. Infrastructure planning doesn't just anticipate the future, it can also shape it. In practice the scenarios are not mutually exclusive - all of these approaches are likely to be needed to a greater or lesser extent and the real question is where the balance between them will be struck.

The scale and nature of the transport challenge

The demand for transport largely arises from the activities that the population needs to access - the relationship between where people live, work, study, shop and 'play' is at the heart of the transport challenge. The scale and distribution of jobs and population, as discussed, are thus key determinants of transport infrastructure requirements across London.

A fundamental challenge for us is to provide a transport system that generates sustainable travel patterns in a larger, denser city of the future while providing good access to jobs and opportunities for people living across the capital.

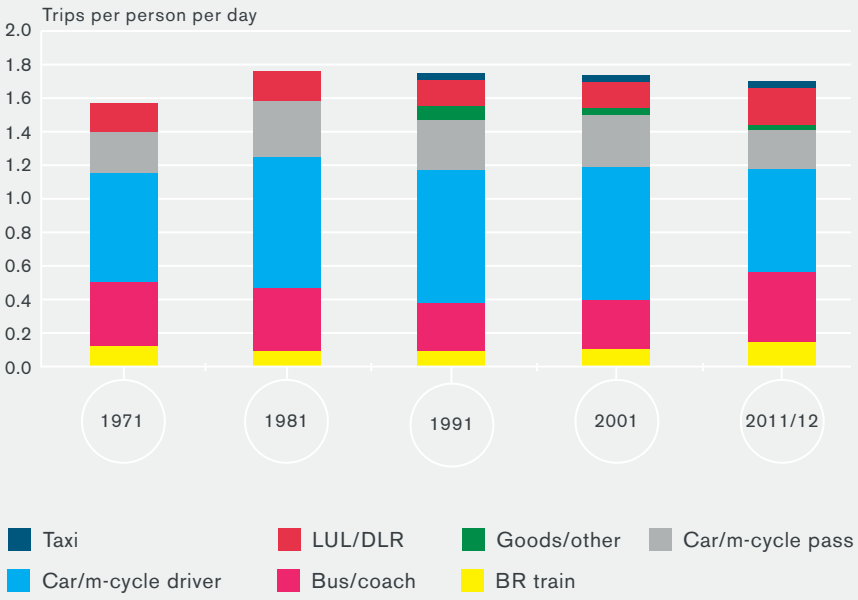
Given the range of variables at work it clearly isn't easy to plan for a horizon more than 36 years in the future. We only have to compare London's situation in 1914 and 1950 to see how much change can take place over such a period of time.

But the planning and delivery of infrastructure itself takes years and the lag between conception and implementation means that we need to anticipate future needs as far as possible. In any case, while many aspects of infrastructure planning over a thirty five year timescale will be subject to some uncertainty, there are also many areas about which we can be reasonably confident.

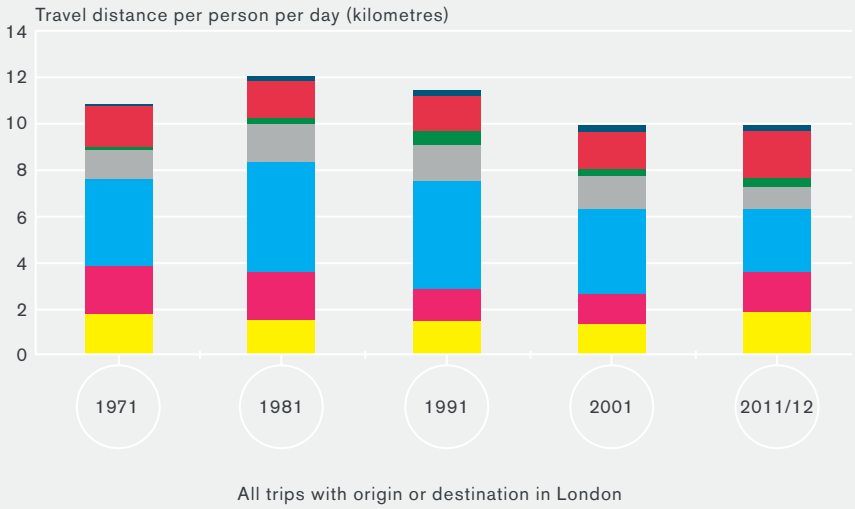
The campaign for Crossrail took over 15 years before the Crossrail Bill was passed in 2008, and while progress since has been good, it will still be another five years before the first Crossrail trains run. This is why it is vital to think a long way ahead when considering investment in transport infrastructure.

Despite much talk in previous 'futurology' exercises of home working and technology reducing the need to travel, travel rates have remained relatively stable for many years with some increase reflecting growing affluence. Meanwhile, the average total time travelled per person has remained consistently close to one hour per day over the past 30 years.

Londoners continue to make around 1.7 trips per day...



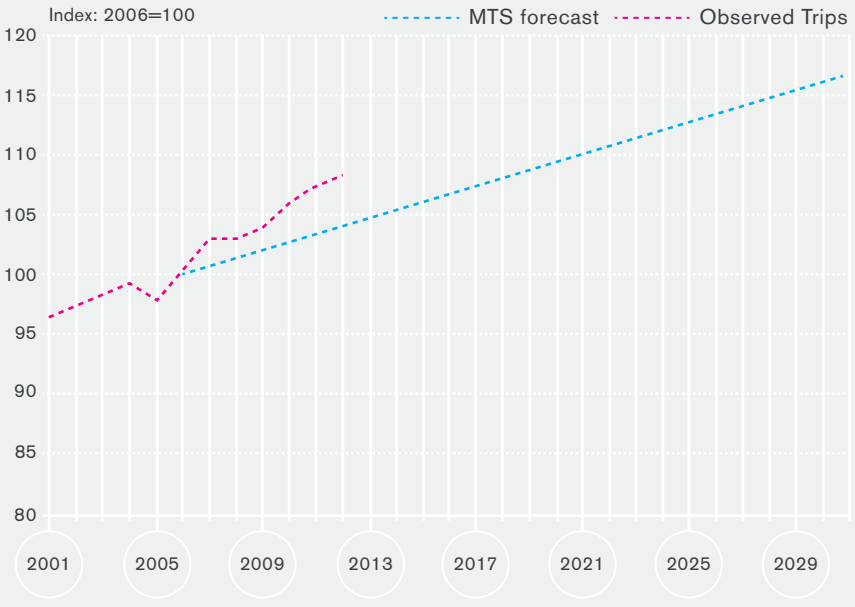
...and the distance people travel has not increased



All trips with origin or destination in London

While there may be some more flexible working eg one day a week from home, we expect trip rates to continue to remain fairly stable. However, with increasing population, the overall number of trips will increase significantly. Growth in trips is already significantly outstripping forecasts made in the MTS in 2011.

Observed trips in London compared with MTS forecasts



Under the central population projection, this would mean an increase of 35-40 per cent in the number of trips by 2050, with even higher growth in demand for public transport expected (50-60 per cent increase in trips and up to an 80 per cent increase in rail trips) reflecting increasingly dense patterns of development.

However within these high level assumptions, there are likely to be many variables which will affect the demand for transport

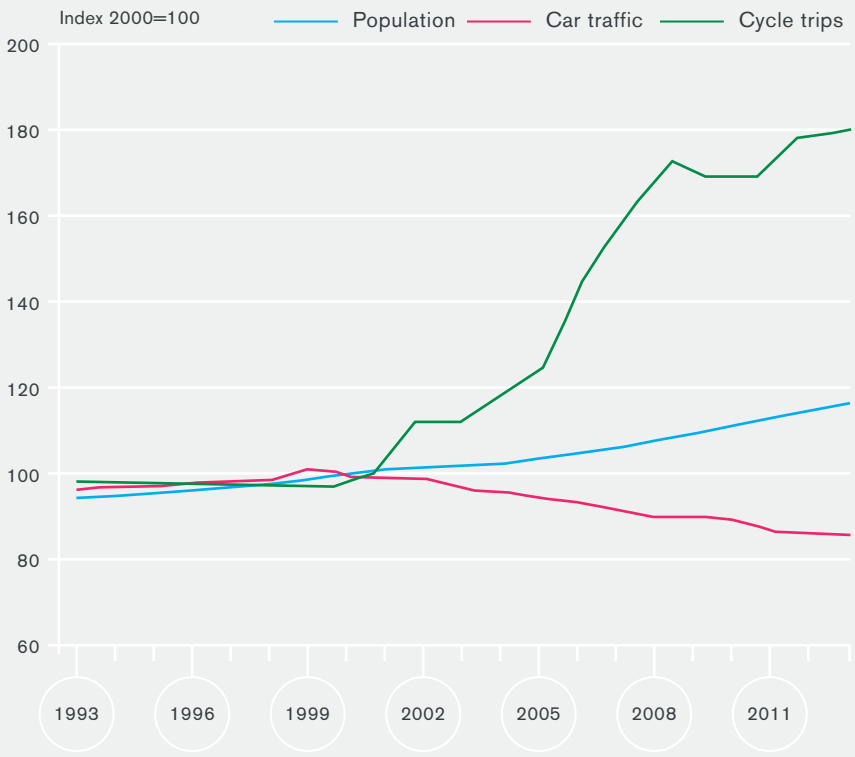
and also significant developments in the way transport is provided over the next 35 years. This may lead to more diverse and less predictable travel patterns - whether in terms of time, destinations, or particular requirements of users.

These variables include:

– Changes in the structure and characteristics of the population will be reflected in changing requirements of the transport system. For example, as we have more older people, accessibility will become increasingly important (growth in this group constitutes a significant proportion of overall forecast population growth)

– Changes in attitudes and behaviour. For example there is evidence of a downward shift in relation to car ownership and usage, particularly in Central and Inner London, over recent years and this may extend further as population densities increase. There has also been a recent significant uplift in cycling

Cycle trip growth compared with population and car traffic



– Changes in lifestyles, for example in relation to how people use their leisure time, including shopping, are also likely to be reflected in the demands made of the transport system

– Developments in technology, for example, 'connected or autonomous vehicles' technology are likely to have significant implications for how transport services are delivered

– The decision about where to locate additional hub airport capacity will have a profound impact on the future shape of the city and its transport requirements

These and other factors are considered through the rest of the report. Demand management offers some potential to reduce the pressures, particularly road pricing which could play a significant role in the future in addressing some of the challenges. This will not, however, obviate the need for additional infrastructure[2].

2 - Previous evidence suggests for example a 30% fare increase would reduce Underground use by at most 5% and national rail use by 2.5% (less in central London)

Why it's important to support London's growth

"[Global cities] are the ports of the global age, the places that both run the global economy and influence its direction. The cities where decisions are made, where the world's movers and shakers come to exchange the latest news and information... in a word they have clout." (AT Kearney, the Urban Elite)

"Over the next 15 years, the makeup of the group of top 600 cities will change as the centre of gravity of the urban world moves south and, even more decisively, east. One of every three developed market cities will no longer make the top 600." (McKinsey)

Some people argue that London's growth should not be encouraged. Given the pressures, this is understandable but unrealistic. Our city's growth matters – both for London and the UK as a whole.

The UK needs to compete in an ever more globalised world and in this context having a leading participant in the global 'city race' will be increasingly important. Large cities are home to 38 per cent of the world's population but generate 72 per cent of global GDP. Future trends strongly suggest a view that cities, and especially international cities, are likely to continue to become relatively more important.

In London, the UK has one of the most successful big cities in the world, and easily Europe's leading international city.

London has succeeded in placing itself at the heart of a network of 'world cities'. Being part of this 'super network' lifts London to a different level of competition from most other cities. McKinsey forecast that London will have the third highest GDP[3] of any of the cities in its top 600 list in 2025, while only three other European cities appear in the top 25 (Paris, Rhine – Ruhr and Randstad)

In this context, the UK's cities aren't competing with each other but with the rest of the world. They stand the best chance of succeeding by working together. London's population growth, the case for investing to support its growth and the wider economic benefits this delivers for the UK are all inextricably linked to London's role as a leading global city.

London's agglomeration of high value internationally traded service activities, supported by its international connections, make it uniquely well placed to act as the UK's gateway to the rest of the world, attracting investment, trade and visitors to the benefit of the whole country. This is the underlying rationale for accepting – and embracing – its success and growth.

3 - McKinsey (June 2012), Urban world: cities and the rise of the consuming class

Top 25 hotspots in 2050 from MGI Cityscope

Bold text - developed regions[1]
Normal text - developing regions

Rank	GDP[2]	GDP growth 2007-25	Total population	Children[3]	Total households	Households with annual income over $20,000[4]
1	**Tokyo**	Shanghai	**Tokyo**	Kinshasa	**Tokyo**	**Tokyo**
2	**New York**	Beijing	Mumbai	Karachi	Shanghai	**Osaka**
3	**London**	Shenzhen	Shanghai	Lagos	Beijing	**New York**
4	**Los Angeles**	Guangzhon	Beijing	Mumbai	Chongqing	**London**
5	Shanghai	Tianjin	Delhi	Dhaka	**Osaka**	Beijing
6	**Paris**	Chongqing	Kolkata	Kolkata	**New York**	Shanghai
7	Beijing	**Los Angeles**	Mexico City[5]	Mexico City[5]	Mumbai	**Paris**
8	**Osaka**	**New York**	**Sao Paulo**	Delhi	**London**	**Rhine-Ruhr**
9	**Rhine-Ruhr**	Sao Paulo	Dhaka	Manila	Sao Paulo	**Los Angeles**
10	**Chicago**	Wuhan	Chongqing	**Tokyo**	Delhi	Sao Paulo
11	Sao Paulo	Moscow	**New York**	**New York**	**Paris**	Moscow
12	Shenzhen	Shenyang	Karachi	**Los Angeles**	Lagos	Mexico City[5]
13	Moscow	**London**	**Osaka**	Sao Paulo	**Rhine-Ruhr**	**Seoul**
14	**Houston**	Hangzhou	**London**	Cairo	Mexico City[5]	**Nagoya**
15	**Dallas**	Chengdu	Lagos	Lahore	Kolkata	**Chicago**
16	Guangzhou	Singapore	Manila	Buenos Aires	Tianjin	**Milan**
17	**Washington, D.C.**	**Dallas**	Kinshasa	**London**	Shenzhen	Mumbai
18	Tianjin	Nanjing	**Los Angeles**	Baghdad	Hangzhou	Istanbul
19	**Randstad**	**Tokyo**	Shenzhen	Kabul	Chengdu	Hong Kong
20	Mexico City[5]	Foshan	Buenos Aires	Luanda	**Los Angeles**	**Dallas**
21	**Seoul**	Bangkok	Cairo	Istanbul	Moscow	**Randsted**
22	**Nagoya**	Istanbul	Istanbul	Khartoum	Wuhan	Bangkok
23	Singapore	**Paris**	**Paris**	**Paris**	Dhaka	Shenzhen
24	Hong Kong	**Houston**	Tokyo	Nairobi	Buenos Aires	Taipei
25	**Atlanta**	**Seoul**	Bangkok	Dar es Salaam	**Seoul**	**Houston**

1 Developed regions comprise the United States and Canada, Western Europe, Australasia, Japan and South Korea
2 GDP 2007 to 2025 in predicted real exchange rate
3 Population below age 15
4 Households with annual incomes greater than $20,000 in purchasing power party (PPP) terms
5 Mexico City Metropolitan Region
NOTE: For metropolitan regions, we use the first name of the region: e.g. New York for New York-Newark.

We certainly shouldn't take London's international success for granted. Competition from across the world is intensifying rapidly and London must be properly equipped to continue to compete successfully.

While London's growth is posing major challenges in terms of the scale and pace of investment in infrastructure needed to continue to support it, these 'problems' of success are far preferable to dealing with challenges of decline which some other European cities are facing.

However, if this growth is to be successful and acceptable to people across the city, there must be sufficient infrastructure to support this properly, ensure it's sustainable, mitigate potential adverse impacts and ensure that everyone can access the opportunities on offer.

And if this growth – and the investment required in infrastructure to support it - is to be acceptable more widely to people across the UK we also need to ensure other cities can participate more actively.

There should be strong mutual benefits if we can more fully integrate the economies of London and the UK's other major cities so that they work together, complementing each other's strengths while at the same time capitalising on London's world city status.

A promising way forward would be to develop a Randstad-type economic network of competitive well connected cities stretching beyond the South East (such as Birmingham, Manchester and Leeds) which can generate greater value than the sum of their parts.

London's success remains critical to this and in its world city role it can – and will continue to - do some things which the other cities cannot. But investment is needed in both London and key conurbations elsewhere in the UK. Regional projects can often show good comparative value for money but the total benefits are larger in London. Both sorts of projects are needed in the national portfolio. The success of these locations should be considered as complementary to, rather than in competition with, the Capital.

London's success is important to the UK...GVA per hour worked in Inner London is 43% higher than the UK average; 40% of the top 250 companies with global or regional headquarters in Europe are located in London; London accounted for over a third (584) of foreign direct investment projects in the UK in 2012/13.

The costs of transport investment in London are high, but so too are the benefits, for example:

- The overall scale of transport investment set out in this document (around £200 billion) would help support 1.3 million extra homes and 1.4 million extra jobs

- If the central London economy were to be constrained as a result of transport problems this could result in an annual loss to national output of approximately £70 billion, or 5.4 per cent of GDP

- While an investment such as Crossrail costs about £16 billion, the total benefit from such a scheme alone could be as much as £80 billion

– Taking a simple calculation of the economic benefit of an additional job in central London and what it would cost to relieve the likely constraint on supplying it suggests that there is a ten year payback period for rail infrastructure investment[4]. Given that new rail infrastructure can be reasonably expected to have at least a 60 year life, there is both room for error in these calculations, and very considerable economic profit potential

– It will support much needed regeneration across London by unlocking economic and social opportunities and helping create more balanced, mixed communities

– Dense cities and public transport also support more sustainable growth. There is a negative correlation between density and the share of people driving alone to commute, and also a positive correlation with the share of bicycle commuters

It is clear that delivering the scale of additional infrastructure required - on top of maintaining and renewing the existing infrastructure - must be supported by a larger future funding envelope. Traditional sources of funding and taxation won't be sufficient.

This creates a need and opportunity for new ways of generating funding; further fiscal powers must be devolved to London's Mayor enabling the capital to raise more towards what is needed – and also to other areas outside London.

We also know that the resources available for infrastructure will always be finite. So we need to try to prioritise the investment required.

The next section of this report sets out in more detail the challenges and opportunities that emerge from the scale, nature and potential pattern of London's growth and the third section considers potential priorities for transport investment in order to address these challenges and capitalise on the opportunities available.

4 - This assumes a constant wage differential that results from the central London location of around £15,000 per annum. Different projects clearly have a variety of costs, but a mid-point of cost of rail infrastructure to support each additional work trip is around £150,000. This is entirely a cash calculation, with no allowance for inflation, discounting or productivity growth. In practice these on balance net out, so this is a fairly good rule of thumb.

THE KEY CHALLENGES & OPPORTUNITIES

Consistent, integrated infrastructure planning over a 30 year timeframe will be an essential tool in ensuring a more prosperous, sustainable and liveable city and mitigating potential adverse impacts.

Overall the challenges and core transport infrastructure requirements are not likely to change significantly between the different spatial scenarios. This is in part because a core assumption underlying the spatial structure is that central London is retained as high density employment centre, and continues as a dominant trip destination.

Future variations in the location of the demand origins represent a more marginal change to the underlying transport pressures given the scale of growth required across London in all scenarios. However, the alternative scenarios do lead to some variations in the patterns of transport demand in different places and the nature and focus of some of the transport challenges that need to be addressed.

We have summarised the challenges into four key areas:

A Ensuring the foundations for London's continued global city success

B Helping to house a growing London

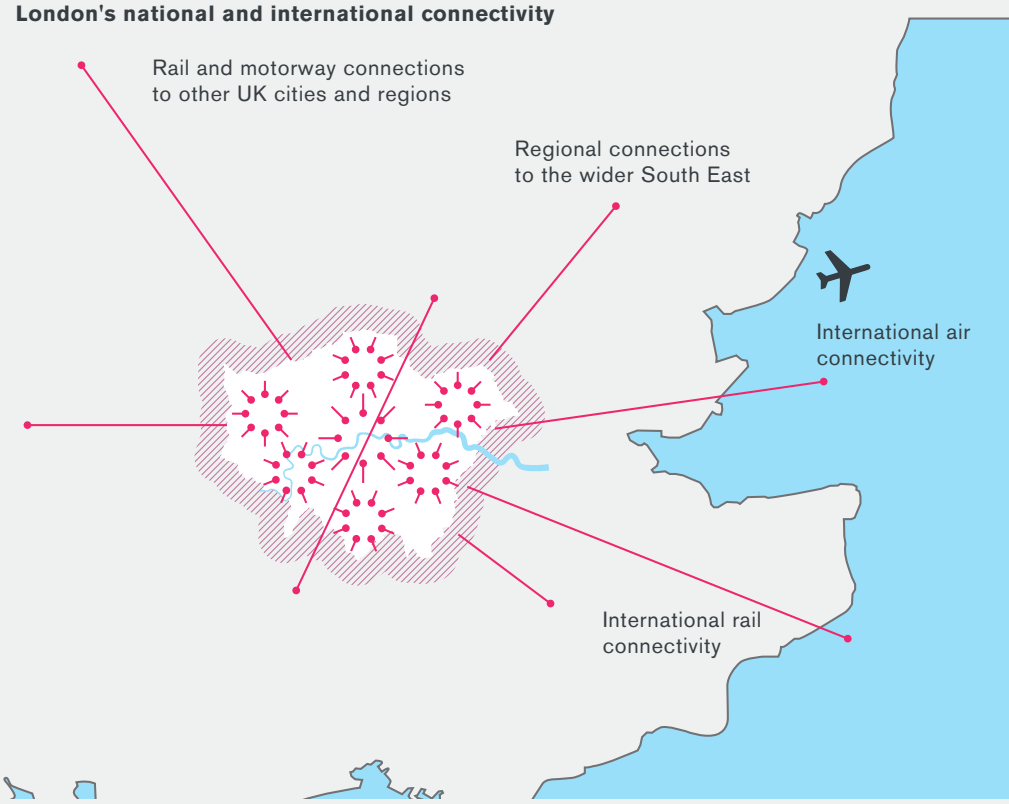
C Supporting a better, not just bigger, London

D Innovating to develop the transport system of tomorrow

(A) Ensuring the foundations for London's continued global city success

London has been able to establish and maintain its position to date as a leading world city by building on its inherent strengths, such as its time zone and the fact that English is spoken, but also through its exceptionally well connected transport system. Economic vitality is dependent on connectivity at a local, regional, national and international level, as illustrated on the map below.

London's national and international connectivity



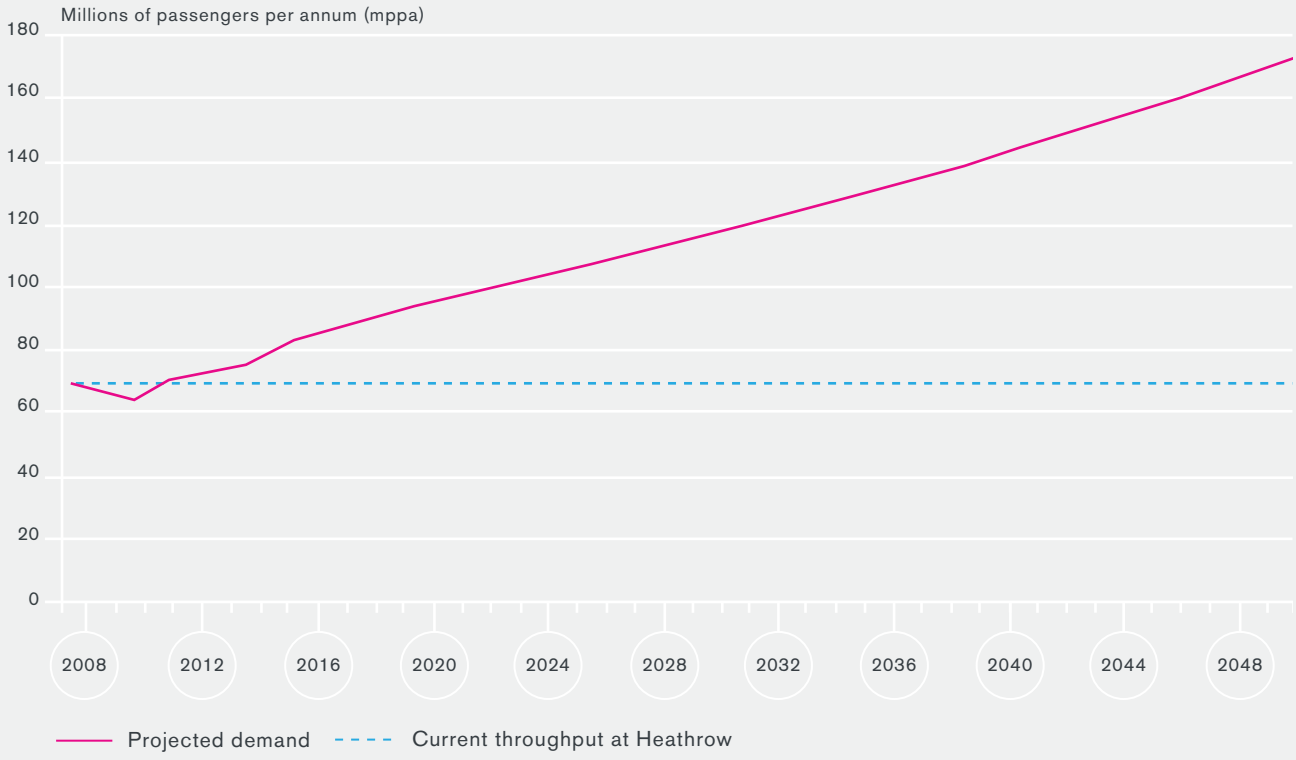
Global aviation connections

Ready access to a global network of direct, frequent international air services is important for many global companies' location decisions and is an essential factor allowing London to play its leading role in the UK and world economy. In 2010, FDI-generated jobs represented 13 per cent of all jobs in London and in 2008, the last year before the global recession, contributed £52 billion to London's economy.

The international tourism market is set to double by 2030, driven by Asia and Europe. London currently lags behind other cities in attracting tourists from some major markets such as China and there is a significant opportunity to make

London and the UK a more attractive destination. The quality of our air links is an important factor in this.

Projected growth in demand and current throughput at Heathrow Airport



However, scarce airport capacity at Heathrow is constraining its growth and, if left unaddressed, could cause a reputational loss with severe economic consequences. As demand increases, the impacts of capacity constraints will become more damaging.

This means that while London remains very well connected to its traditional markets by air, it has fewer new routes to emerging destinations than its rivals, such as Frankfurt and Paris.

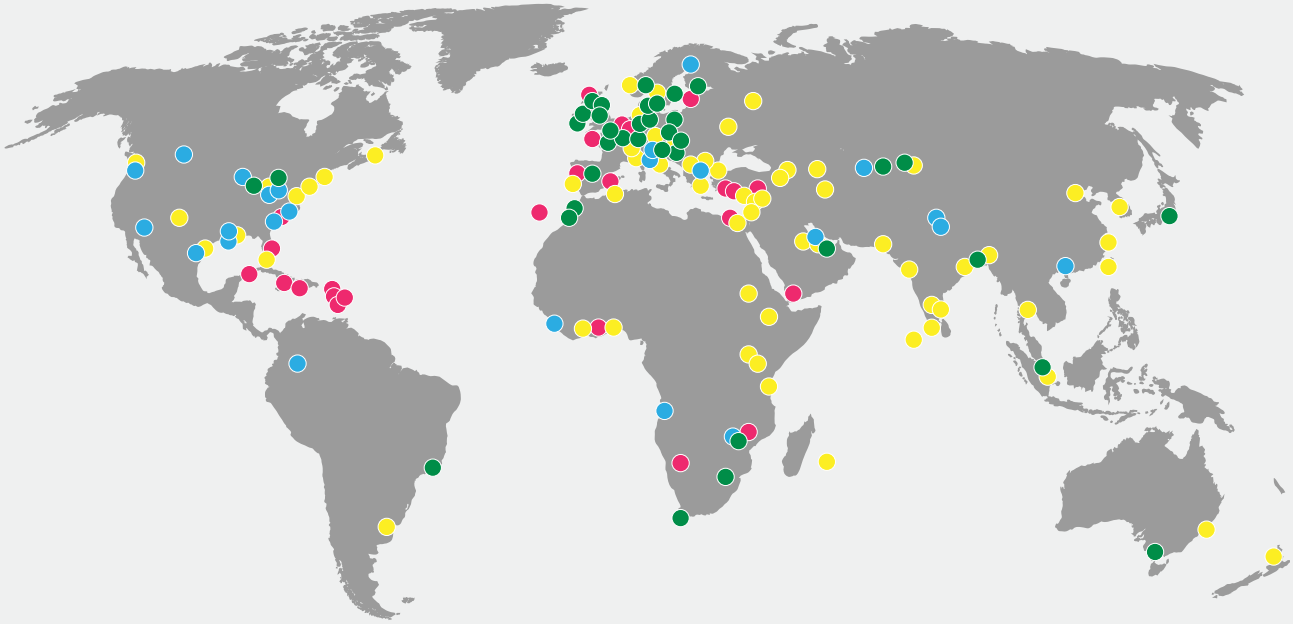
There are at least twice as many seats on flights from Germany and France to China per head of population than from the UK. France earns £1.3 billion per year from Chinese tourist spending compared to £115 million in the UK

Two emerging groups of nations with rising income levels are the BRICs (Brazil, Russia, India and China) and the CIVETS (Colombia, Indonesia, Vietnam, Egypt, Thailand and South Africa). Of these countries, London and the UK have high frequency services only to Russia, India and, to a lesser extent, Thailand[5].

Furthermore, the capacity constraints at the airport mean that many routes, including most UK destinations, have been displaced or lost frequency in response to emerging needs.

5 - Excluding Hong Kong from China total

Change in destinations from Heathrow



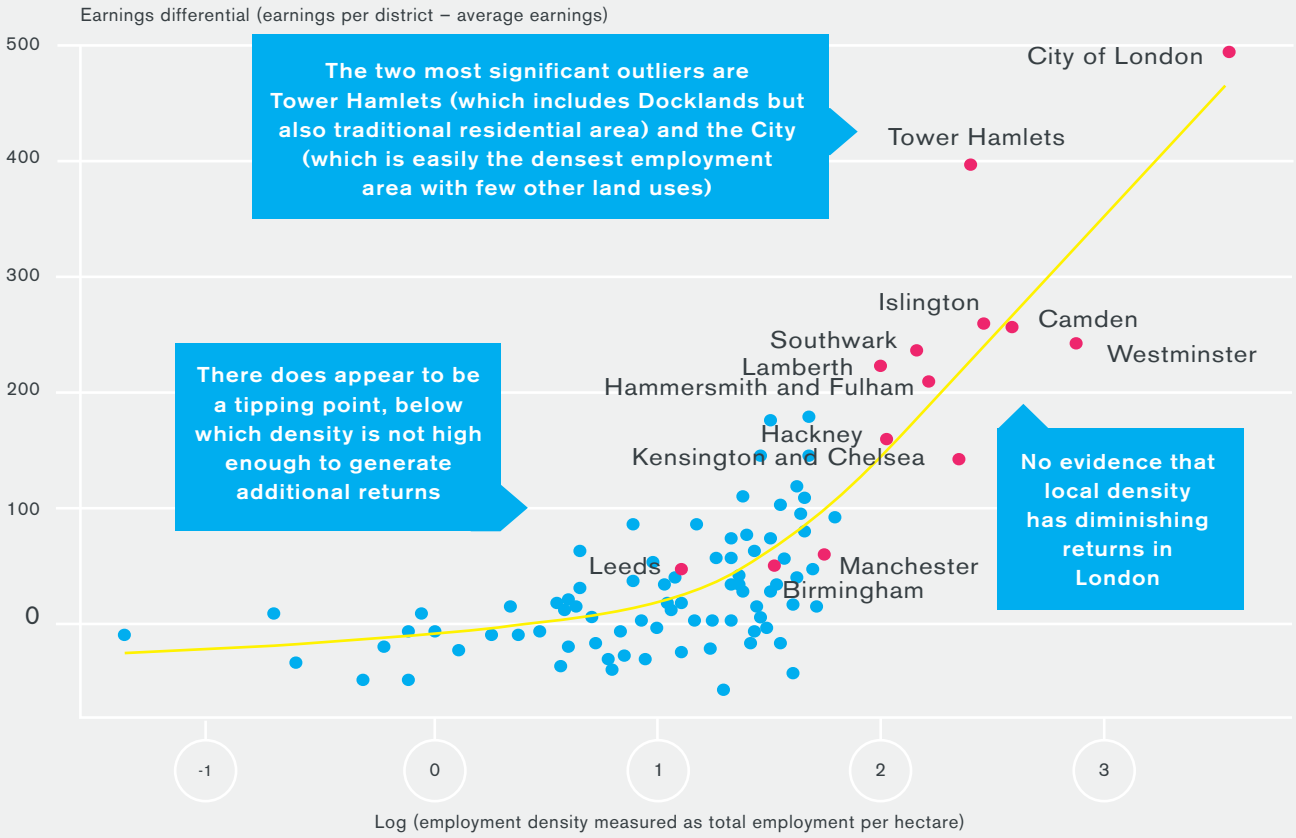
This highlights the need also for faster and more direct rail connections where rail can compete with air, eg to locations on the near Continent, and also to link London to the UK's regional centres more effectively. There also need to be better rail connections between the Continent and the rest of the UK. Such links will help drive wider economic growth in the UK and ensure that other cities, such as Birmingham and Manchester are well connected to key markets, helping them grow and diversify their economies.

The case for growing the CAZ

London's successful reinvention over the last thirty years as one of the main centres of the global economy also depends on its continuing ability to host a very dense concentration of employment in central London in a range of high value service sectors that benefit from economies of agglomeration.

The chart below highlights the average wage differential between employment in CAZ boroughs and the 150 largest UK employment centres.

Earnings differential vs log employment density (top 100 UK districts by employment size)



We have looked at whether a more decentralised model of economic growth would offer any savings and benefits. This work, undertaken by Volterra, suggests that even if it was in theory achievable there would be negative economic consequences with the loss of productivity from reduced agglomeration economies.

Over time these would significantly outweigh any savings from lower costs of infrastructure. There would also be adverse environmental effects including higher car mode shares and more diverse patterns of transport that are difficult to serve through public transport.

Overall, the firm conclusion is that "investment in density offers good payback" and there is no suggestion that diminishing returns will appear as densities increase. This is at the heart of the case for further investment to support the growth of the CAZ.

The vital role of rail in growing the CAZ

There are a number of ways in which the CAZ can grow, as shown below. While economically the agglomeration model

Source: Volterra (July 2014), London, growth and opportunity

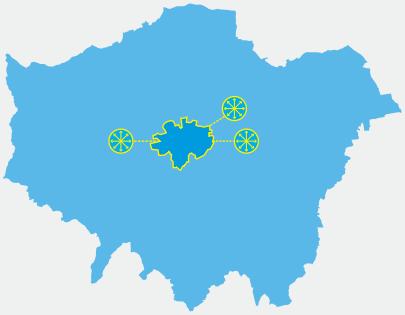
Further intensify the CAZ

Densification of existing/established areas of the CAZ through both redevelopment and accommodating more people in existing buildings.

Expansion of CAZ

Expanding the CAZ into less established areas around its fringes, close to public transport hubs, e.g. King's Cross, London Bridge, Paddington, VNEB

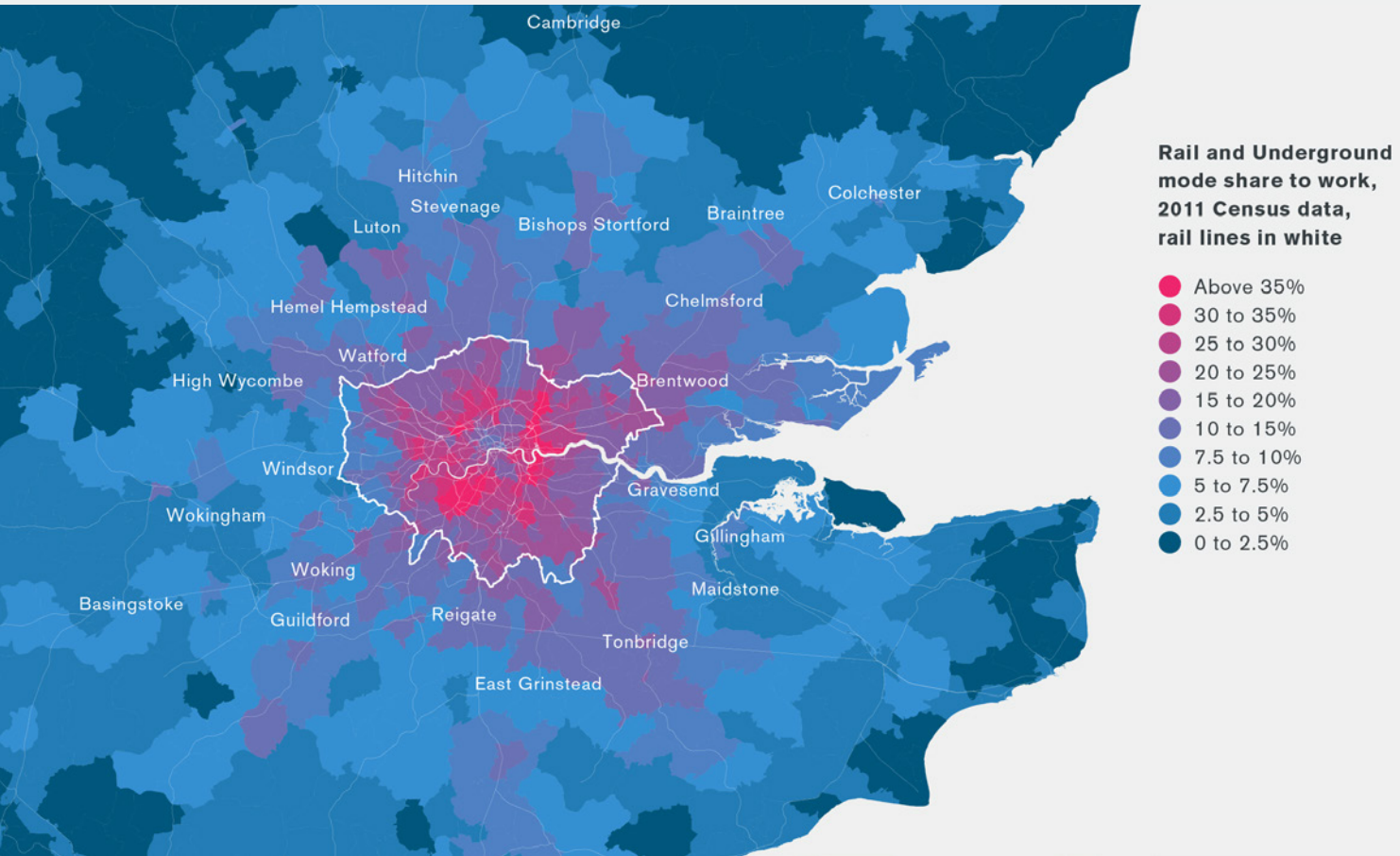
Satelite activity zones



Going further beyond the traditional and physical boundaries to create/expand a small number of satellites linked to the CAZ and with a similar employment densities (as happened at Canary Wharf), such as Stratford and Old Oak Common

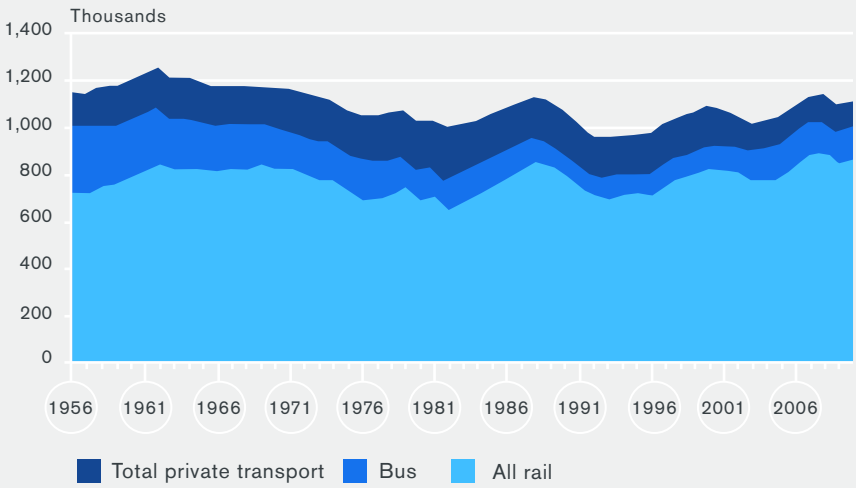
offers a highly effective spatial structure, it generates high radial commuting travel demands in the morning and evening peak periods.

1.17m million people travel into central London each working day, swelling its daytime population by over 500 per cent. The radial rail networks in particular are crucial in supporting this (although clearly buses and increasingly cycling also play an important role).



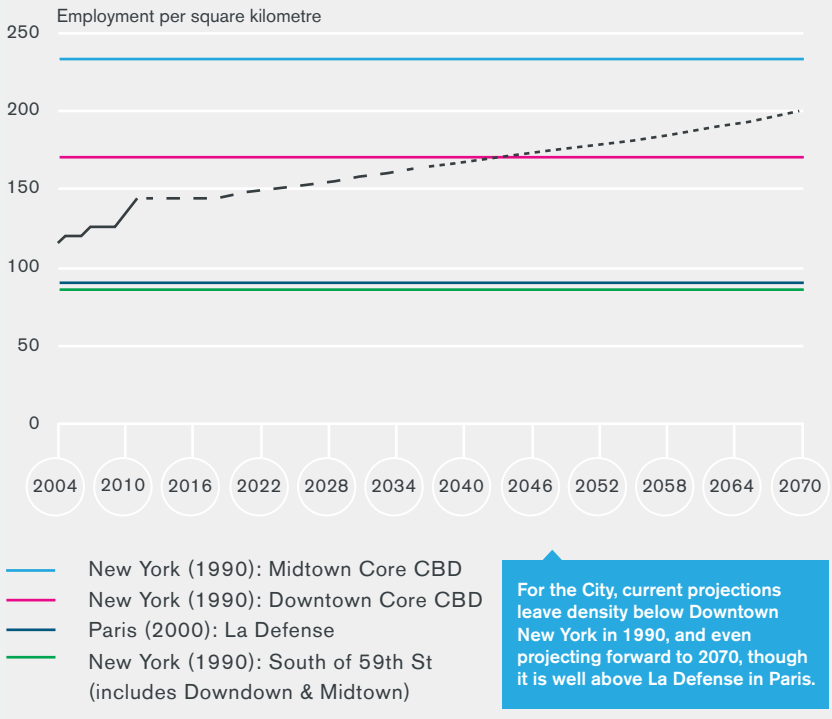
Currently, around 80 per cent of the journeys into central London are by rail and / or Underground, as shown below. Rail investment to increase capacity and reliability over short and long distances will therefore be vital for each of the ways in which the CAZ might grow.

People entering central London in the weekday AM peak



There would appear to be scope for employment densities in established areas of central London to increase further. For example, the peak level of employment density is currently around 140,000 jobs per square kilometre (this represents the level of density around Bank) which compares with around 150,000 in New York[6].

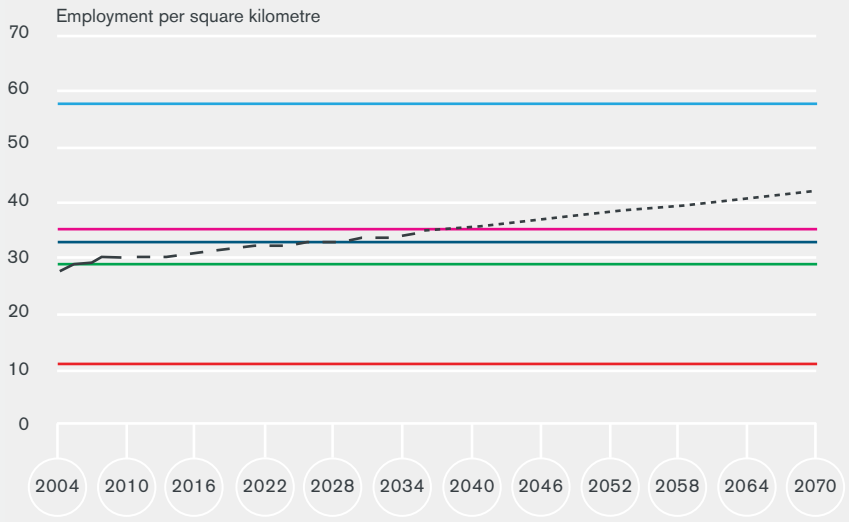
Employment density in City of London and comparators



6 - Source: LSE Cities (December 2012), Urban Age Electric City Conference

The charts compare the current and future employment density projections for the City and Westminster with historic densities in some major world cities. Meanwhile, property market specialists expect forecast demand for office space in central London to remain high and that densities of office occupation will increase.

Employment density in Westminster and comparators



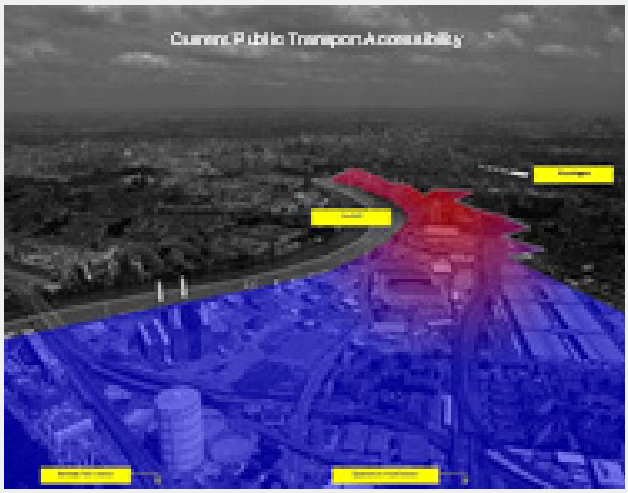
In Westminster, densities generally sit somewhere around the Paris Level from 1990, and only get above this level after the 2030s but remain well below Tokyo core CBD levels

Increasing employment densities in this way will place added pressures on radial routes and more than offset any impacts from more flexible working. This means that by 2050, there could be 1.3 to 1.4 million trips into central London each morning. There may be a limit at some stage to the density that can be supported within more traditional areas of the CAZ.

The second strategy is therefore to expand the high density core to underused areas on its fringes. Re-use of large industrial sites such as Vauxhall Nine Elms Battersea (VNEB) is both a challenge and an opportunity. London's renewed growth and the realisation that cities provide the most effective source of increasing productivity means greater interest in the regeneration opportunities of sites near the main central areas. Again rail schemes play a vital role in realising the potential.

Source: Volterra (July 2014), London, growth and opportunity

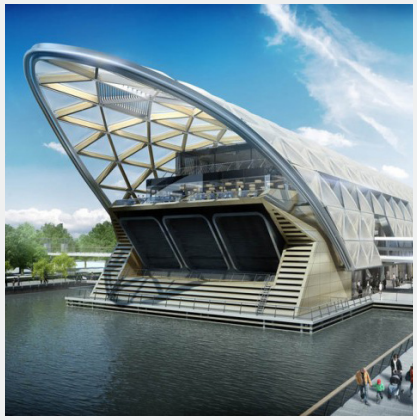
The £1 billion extension of the Northern Line is generating the level of accessibility that makes it possible to extend the productive core of London into the VNEB area.



With two new stops it is enabling a new high quality city quarter to be created with 16,000 homes and 25,000 jobs. The net economic benefit of the additional jobs is estimated by Volterra at up to £6.7 billion.

Beyond the fringes of the CAZ are some new, larger scale areas that have the potential to be integrated into the core functional economic area, albeit they are further away geographically. This includes areas such as Stratford and Old Oak Common where the high levels of accessibility (current or potential) can reduce the 'effective' distance.

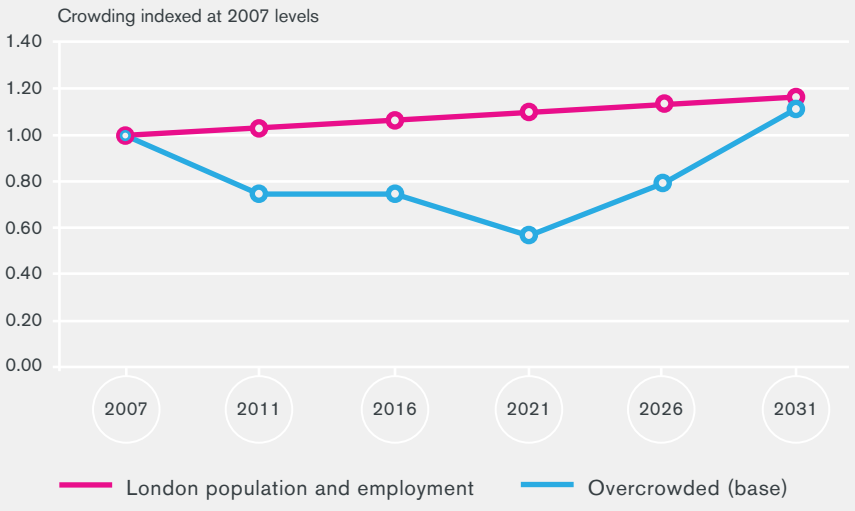
The success of Canary Wharf following the opening of the Jubilee Line extension helped demonstrate that this was possible. Jones Lang La Salle estimated that in Canary Wharf 30,000 sq metres per year of construction could be attributed to the JLE and that this approximated to 20-25,000 jobs over 5 years. Interestingly, the scale of this success was not originally predicted.



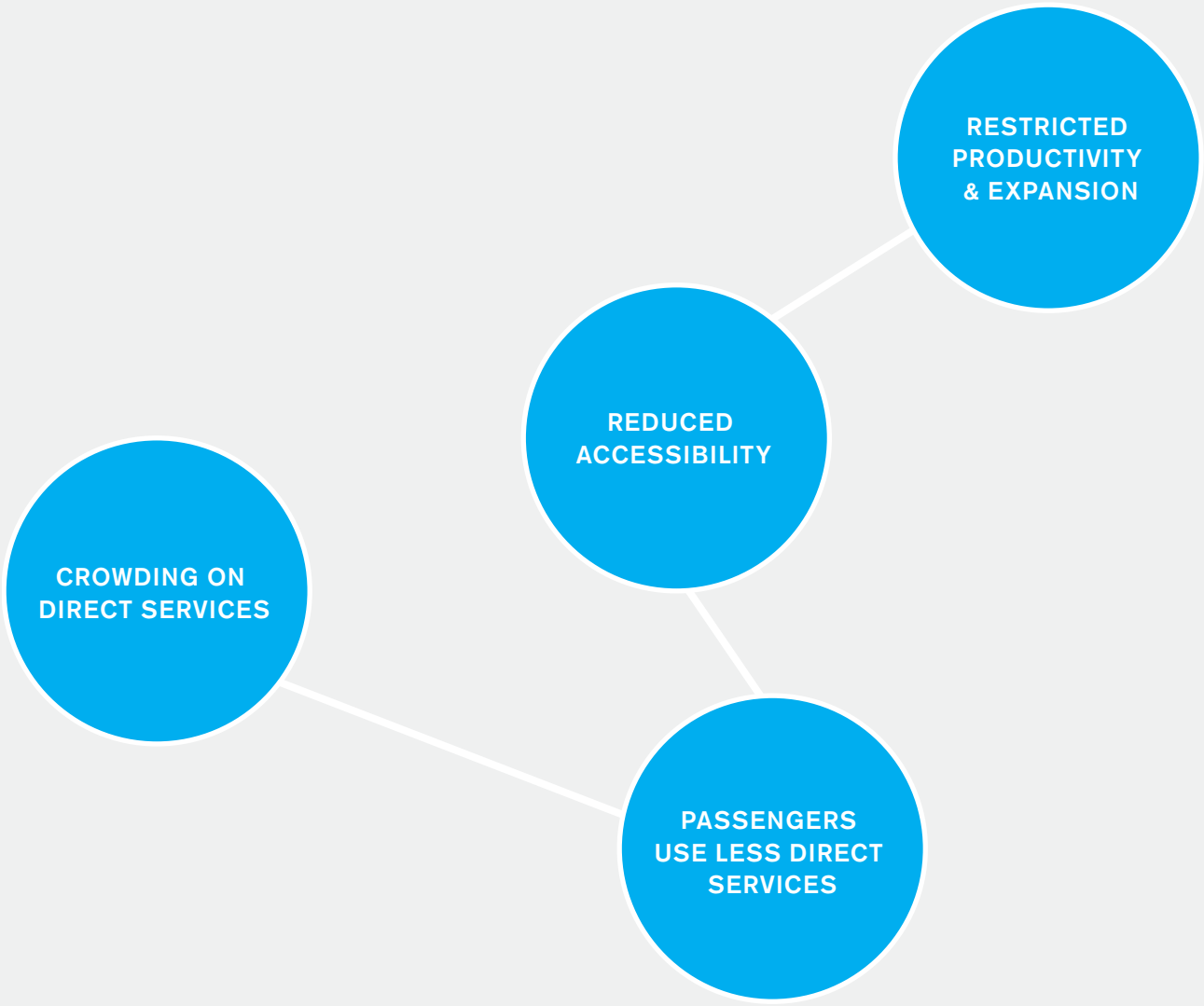
Current infrastructure investment in Crossrail, together with the Tube Upgrade Programme and Thameslink will together increase rail capacity serving central London in the AM peak by around 30 per cent between 2011 and 2019. These programmes – alongside targeted schemes such as the NLE - are currently enabling the CAZ to grow.

However, while the investments underway help deal with today's growth, they will not address the challenges into the future. By the late 2020s crowding is expected to have returned to previous levels, with levels of crowding on national rail increasing in particular.

Crowding levels on rail–based public transport in AM peak



On some parts of the rail network, the system would be unable to meet demand for large parts of the travelling day and there would be negligible resilience. As transport links become more crowded they become less attractive to potential users and some users are forced to take less direct routes. This damages the accessibility of the areas they serve and constrains economic benefits.



Roads to support a growing CAZ

While rail forms the backbone of the transport system serving central London, the road network also plays a vital role, with buses and, increasingly, cycling supporting many commuter journeys from within London. The streets also have to cater for very high volumes of pedestrians. Servicing and logistics requirements are also increasing as the density of central London increases.

Central London's competitiveness increasingly depends on offering a great quality of place that is attractive to skilled workers who operate in a global talent pool; this is particularly important for many of the high tech and creative sectors that are expanding such as film production and gaming. These will be increasingly important for London's future growth, helping build a more diversified economy.

Fringe locations around the CAZ such as Old Street and King's Cross are particularly driven by these industries.

However, the impacts of traffic and the current road layout in many of these areas around the Inner Ring Road, undermine their quality of place.

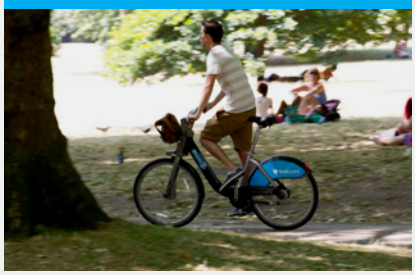
But London also needs an efficient city centre ring road to cater for essential vehicle access to the area. Meeting these conflicting requirements will not be possible without strategic measures to manage demand, provide additional space, or both.

A better road system across London

An efficient road network is key to supporting employment and economic vitality more widely across London. The majority of Londoners work outside the CAZ and are reliant on the road network to access work and other opportunities (by car or bus for example). While the aim is to embed more sustainable travel patterns in outer London (as explored later in this section), road travel will continue to play a vital role, particularly for freight and servicing and business travel.

Millions more people

Extra space for walking and cycling



Movement of people and goods by private vehicle

Place making and a better quality of life

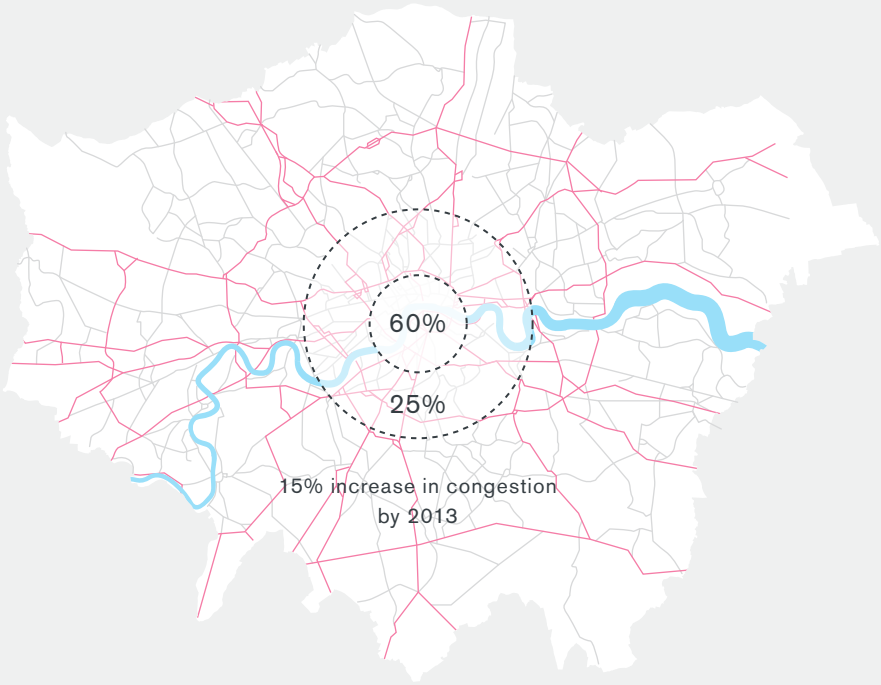
London's strategic road network in particular is essential, with the busiest parts of the A12 catering for more than 100,000 vehicles a day and the North Circular exceeding 120,000. Overall, the road network carries 80 per cent of people's journeys and 90 per cent of freight. Already each day in London it caters for around 10 million car trips, more than 4 million bus trips, more than 6 million walking trips and 500,000 cycle trips.

It is inevitable in the context of the population growth that these pressures will continue to grow, even if we continue to drive the downwards trend in car use.

The road network also accounts for 80 per cent of public space in our city. London's success increasingly depends on offering a great quality of place and life and transforming conditions for walking and cycling across the city, not just in central London. The road network is therefore facing many competing - and increasing - pressures and demands, as illustrated above.

Over the past ten years congestion on London's roads has increased by around 10 per cent despite falling traffic levels. This is in part due to the reallocation of roadspace to support walking, cycling and improvements to the urban realm. Analysis and recent evidence suggests that London is fast approaching the limits of what can be achieved via reallocation alone. If reallocation continues without mitigation, congestion would increase significantly further by 2031, as shown below.

Projected increase in AM peak congestion in central, inner and outer London (given continued road space reallocation)



Major investment will be needed to ensure that improvements can continue to be made to transform places across the city and to support a step change in the proportion of journeys by sustainable modes, while also maintaining a well functioning road network for essential journeys.

(B) Helping to house a growing London

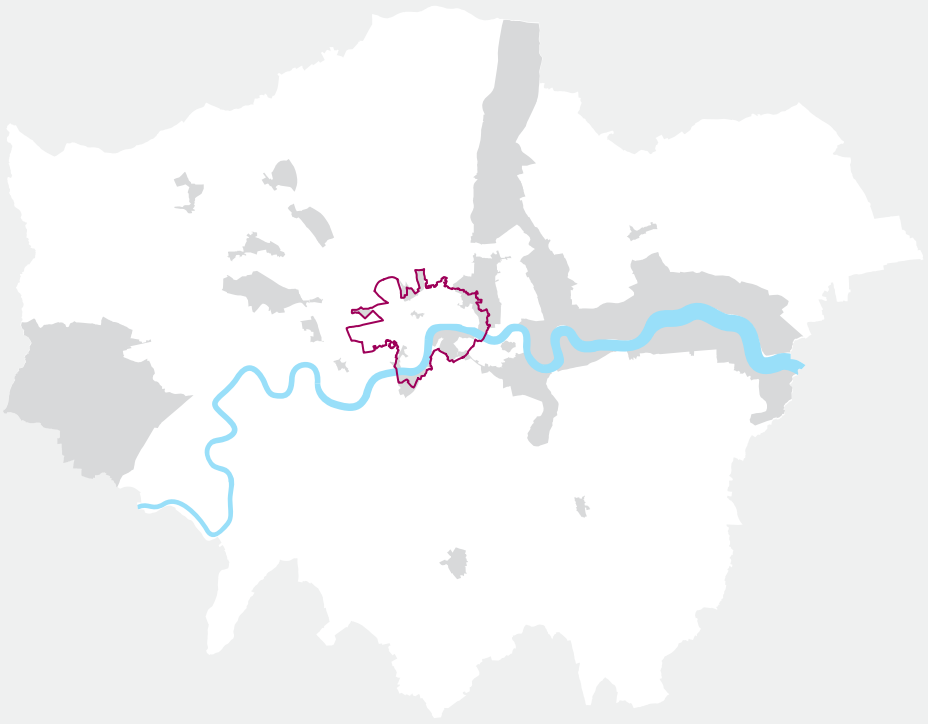
Perhaps the clearest threat to the ongoing success of London is the shortage of good quality housing for people working in the city and the impacts this has on the quality of life that London offers its inhabitants. As in previous generations, the transport system offers the key to unlocking the housing needed to accommodate the growth.

If we are to house a population of 11.3 million people as projected in our central case for 2050, around 1.3 million homes will be needed by that time. To achieve this, housing delivery will need to continue at a higher rate than current delivery. A major strategic challenge will be accommodating this growth in a sustainable way.

A balance will need to be found between continuing densification of the city itself and growth beyond the existing boundary. In general, growth outside London will generate more car trips and be less sustainable while accommodating as much of London's growth as possible within London's boundaries, if properly planned, offers a far more sustainable solution.

Maximising the role of London's Opportunity Areas

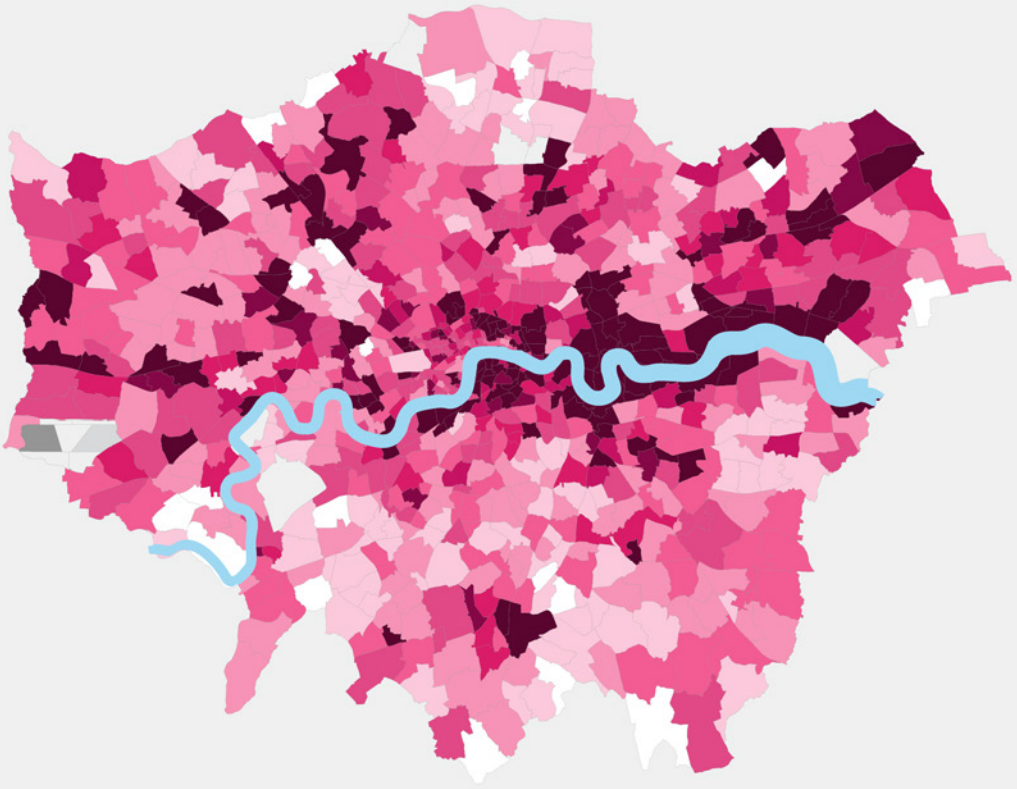
Opportunity areas in London



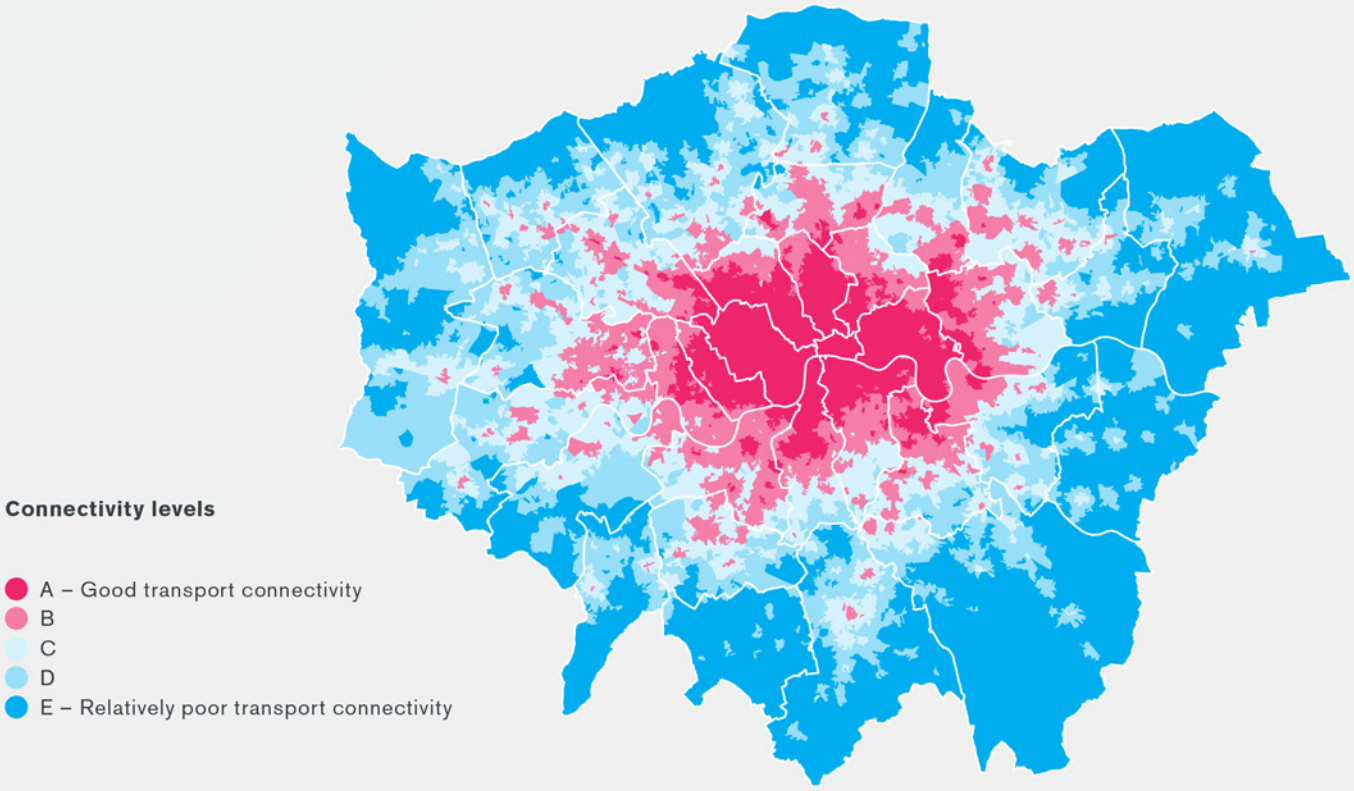
A range of Opportunity Areas and Areas of Intensification have already been identified which have the capacity to accommodate significant numbers of new homes and jobs. Many of these are in east London, where there are significant opportunities associated with land that was in previous industrial use. These growth areas offer London's greatest scope for creating major new sustainable neighbourhoods and also for addressing the persistent social and economic underperformance of east London relative to the rest of the city.

Some of these areas are already rapidly evolving into new city quarters, for example the Royal Docks. The densities of development taking place are often above London Plan standards. This demonstrates that higher densities than have traditionally been assumed can be delivered successfully. But it also highlights the crucial role that transport capacity and connectivity play in achieving this alongside high quality design and urban realm investment.

The new forecasts show increased public transport demand across London, particularly in these growth areas.



Currently, however, many of the areas with capacity for development have poor transport connectivity.

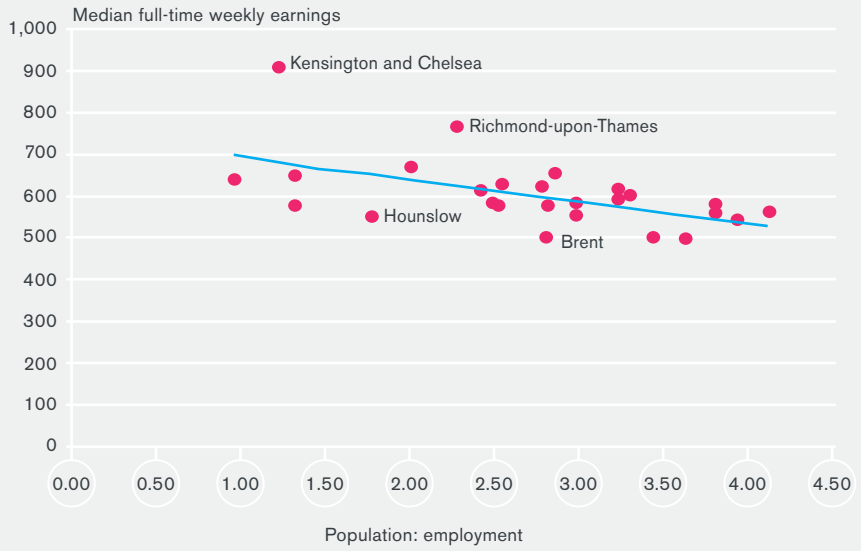


If we are to fully exploit the potential of these areas it is imperative that we make the most of the Mayor's powers to plan transport and housing together. Failing to do so - and failing to invest in additional transport and other infrastructure - risks new development that is car dominated and 'soulless' and/or hamstrung by wider network constraints, or that the development doesn't happen.

To this end, comprehensive transport infrastructure needs to be put in place together with a broader programme of local place-making to integrate London's growth areas into the city's transport system. This will help support an extra 350,000 homes and ensure access to jobs and opportunities across the city.

Better integration into the transport network should also help drive local employment opportunities in these areas. Areas with more people who work in central London, who have incomes that are significantly above the average, tend to generate greater local employment, as there is high demand for local services in the areas in which they live. This relationship is shown in the graph below.

Median income compared with the availability of local employment



This strengthens the case for ensuring there are good transport connections between the main employment hubs and these areas of regeneration.

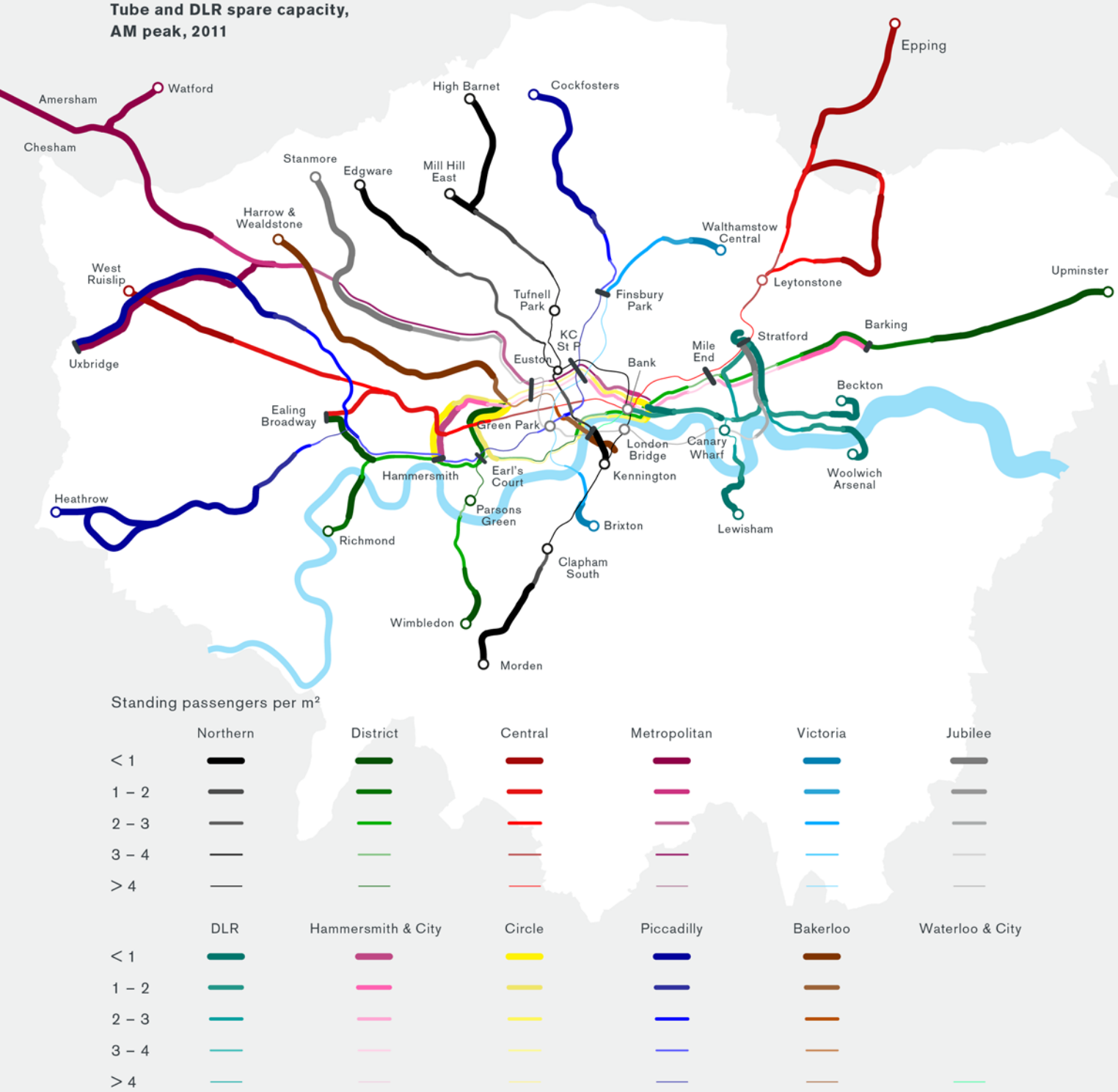
It makes sense to maximise development opportunities where transport capacity and links are already available or may be easier to provide (see overleaf). For example, there may be opportunities close to parts of existing transport corridors such as the Piccadilly and Central Lines which will be benefitting from the significant capacity upgrades already planned on these routes. The Piccadilly line, for example, will see a 60 per cent uplift in capacity as part of the Tube Upgrade Programme.

Proximity to public transport is important for housing whereas successful industrial and commercial locations generally depend on good strategic road connections. Good quality industrial land is key to providing the warehousing, logistics, food and other functions that support London's economic success and keep our city going and adequate supplies of such land must be retained overall.

However there may be some scope for a more integrated approach. For example, new river crossings in east London may help unlock and intensify Strategic Industrial Locations (SILs) on both sides of the river through improving strategic road access. In turn this could allow SILs in areas near good public transport to be released for sustainable housing. For example, the DLR branch from Stratford to Canning Town runs through the Lower Lea Valley, which could support a substantial number of additional homes.

Source: Volterra (July 2014), London, growth and opportunity

Tube and DLR spare capacity, AM peak, 2011



Standing passengers per m²

	Northern	District	Central	Metropolitan	Victoria	Jubilee
< 1						
1 – 2						
2 – 3						
3 – 4						
> 4						

	DLR	Hammersmith & City	Circle	Piccadilly	Bakerloo	Waterloo & City
< 1						
1 – 2						
2 – 3						
3 – 4						
> 4						

Linked to this, there are some examples of rail depots that have been constructed or planned in locations that have excluded opportunities for much needed housing and other commercial development and this can have repercussions for the regeneration of entire neighbourhoods. Clearly, land is still needed to support the operation of the transport system but the case for relocating or developing over some depots should be examined, particularly where development could unlock

sufficient value to pay the full costs of relocation. An example of this could be the Crossrail Depot at Old Oak Common. It is also important that future rail depots, eg for Crossrail 2, are planned strategically.

The build out of all the currently designated Opportunity Areas, however, will not accommodate all the additional homes that are needed. Transport infrastructure needs to support a growing London not just by connecting newly emerging areas of the city but also through supporting densification of London's multiplicity of existing neighbourhoods and help Londoners access jobs and services right across the city.

There is a range of ways in which London can be 'densified'. It is imperative that we make the most use of areas with existing transport and where the need for travel is less (or trips tend to be shorter) eg town centres, inner London and around transport nodes.

A growing housing role for town centres

London's town centres remain vital to the city's economy, however the role of many is changing. While 'destination' shopping locations are expected to continue to prosper it is likely that there will be consolidation around a reduced number of highly attractive centres. Lower order major centres and district centres are facing the most significant challenge to their traditional retail roles. The decline in the office market also poses challenges for the future of some town centres.

There are, however, major opportunities arising from the release of land and property in these locations. Town centres usually have relatively good public transport connections and provide access to important services, including health, education and civic facilities. They therefore offer a sustainable and affordable means of accommodating significant housing growth through transit oriented development. Higher residential populations will also support local services, eg leisure facilities and convenience retailing, generating local employment opportunities.

There is therefore a good case for planning proactively to support changes of use in line with emerging property market trends in these areas. The GLA core projection reaches a population of 11.27 million, with similar growth between 2031 and 2050 in inner and outer London at 16 per cent and 14 per cent respectively. The town centre intensification scenario we have looked at supports a population of 11.21 million, with inner London population growing by 11 per cent and outer London growing by 16 per cent.

Intensification cannot just be about increasing housing density. Redevelopment and re-provision of key non-residential uses such as Low Threshold Enterprise Spaces (which may be vulnerable to conversion) will be equally important. Therefore we have retained existing assumptions on employment and other services.

Compared to the trend-based projection there are only small changes in transport demand. But given that there would be an increase in the proportion of the population living in outer London, this could lead to higher growth in car use and more congestion in the absence of pro-active measures to ensure more sustainable travel patterns.

There is no one size fits all solution but, in all cases, there will need to be a focus on delivering sufficient public transport capacity (not just connectivity) and ensuring high quality environments within the centres, increasing the attractiveness for users and residents.

An inner London focus

Since 2000, inner London has been more successful economically than outer London and it has more sustainable and efficient transport patterns and behaviours. For example, compared to outer London:

– There are half as many car trips across people of all income bands despite a slightly higher total trip rate by all modes

– The rate of car traffic reduction has been twice as fast over the past 10 years

– There has been a greater increase in cycle mode share in last 5 years

– There are more than twice as many cycle trips per person

– There are lower car ownership levels, reducing pressures on space

– There are 40 per cent more walk trips per person

Our scenario which focuses more development in inner areas with higher public transport accessibility could support an equivalent population but the balance of growth between inner and outer London would be at 30 per cent and 4 per cent respectively.

Increasing densities at such locations offers the most positive outcome of the within London scenarios considered. Compared with the trend-based scenario, this scenario leads to a slight increase in demand by public transport, and a slight reduction in car use (about 1 per cent fewer car kilometres). Despite this, there is slight easing of public transport crowding, largely as a result of a reduction in average travel distances.

There are however already some key capacity constraints on inner London rail and bus services and some connectivity gaps which will need to be addressed if higher density development in such areas is to be both acceptable and successful.

While there is high potential for walking and cycling, there are many challenges in relation to perceived safety and the quality of infrastructure and the urban environment. And the quality of design and development will become ever more important as densities increase.

A denser Outer London

If London is to accommodate as much as possible of its future growth within its boundaries, outer London - which accounts for 60 per cent of the city's population at present - will also need to accommodate more people. This could be achieved through a wide variety of means.

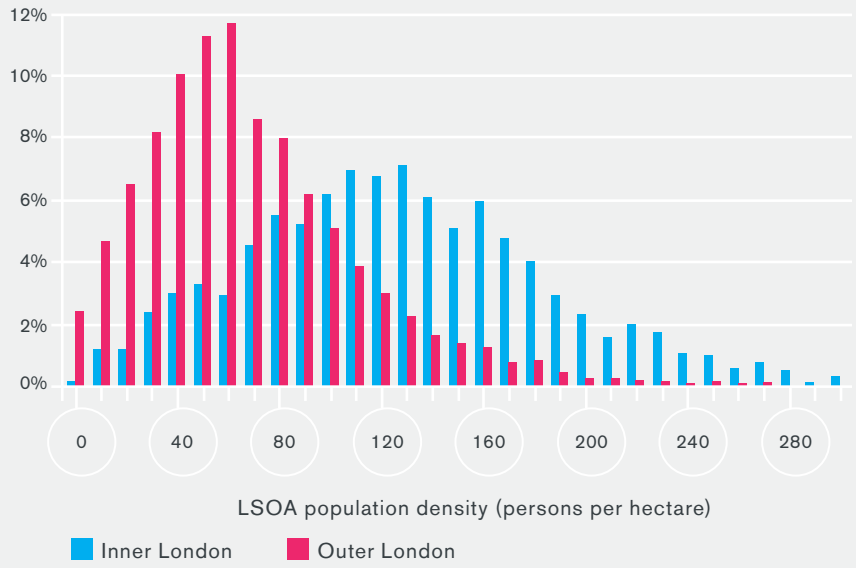
In principle there is scope for accommodating a substantial proportion of London's growth through densification in outer London. The Supurbia project[7], for example, calculated that if 10 per cent of semi-detaching housing was redeveloped at twice the density this could accommodate a total of 400,000 new homes and would be within the London Plan sustainable residential quality density matrix.

Currently, 70 per cent of inner London neighbourhoods[8] have population densities greater than 100 persons per hectare (pph) while 80 per cent of neighbourhoods in outer London have densities less than 100 pph. The most commonly found density in inner London (130 pph) is double that in outer London (60 pph).

7 - HTA Design (2014) Supurbia – A study of urban intensification in Outer London

8 - Lower Super Output Areas (LSOAs)

Distribution of population density in inner and outer London



Our outer London scenario considered the impacts of an uplift in densities in inter-war suburbs[9] with currently very low densities - even with the increase the densities may still not be above the lowest London Plan standards. The density uplift assumed enables London to accommodate the 2050 central population projection of 11.3 million, with inner London population growing by 6 per cent and outer London growing by 21 per cent.

It is clear that this would bring particular challenges. For many people, part of the attraction of outer London is the individual homes on their own plots. However, as Peter Hall highlighted, some suburbs will not last forever and will degenerate further offering the opportunity for rebuilding and intensification[10] and parts of outer London have been performing more poorly than inner London economically[11]. Densification also offers the potential to help promote economic activity, improve local service provision, support town centres and enhance value.

Existing patterns of development in outer London suburbs do not generally support comprehensive public transport provision and there are significantly higher levels of car dependency and use than in inner London. For example, journey to work mode shares in outer London are 51 per cent by car, 17 per cent by walking, 16 per cent by bus and only 11 per cent in total by rail-based modes.

Compared to the trend-based population projection, this scenario could lead to extra car trips across London (an estimated 80,000 more car trips per day) in the context of

9 - This is a category of housing that may be vulnerable to potential decline: GLA (2006) City of Villages

10 - Peter Hall (1989) London 2001

11 - Economist (2013) Suburban London: Trouble in Metroland. 24 April 2013

traffic delay rates already potentially increasing by 35-45 per cent over this period. It could also result in a small reduction in public transport trips (around 1 per cent lower growth) and slightly longer average trip lengths, as a result of the more dispersed population.

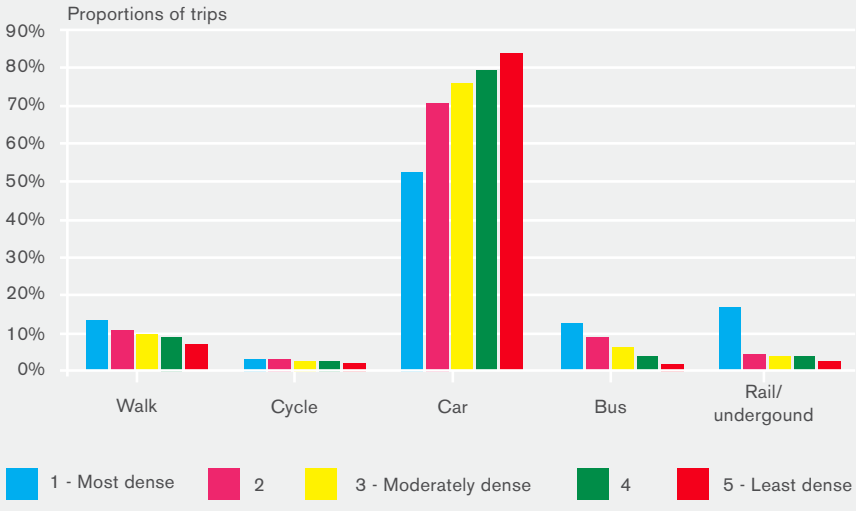
However, if properly planned, developing other parts of London in a way that selectively encourages inner London population densities and transport patterns could actually have some positive transport outcomes, for example:

– This could actually help reduce car use and increase sustainable mode shares – the chart below shows that transport outcomes are more sustainable and efficient in denser areas (if the necessary infrastructure is put in place)

– A smaller number of larger pieces of infrastructure can support the needs (as opposed to requiring a wider spread of less intensive coverage)

– Concentrated development and/or redevelopment may also offer opportunities for securing funding outside public expenditure

Mode share by level of housing density



Densification should therefore focus on areas with existing or future public transport provision. Significant densification in different parts of outer London should also strengthen the case for providing more comprehensive public transport. Indeed, a step change in densification and thus demand may enable a viable case to be made for the creation of more significant new rail-based infrastructure, whether to improve access into key centres or support more 'orbital' movement on particular corridors.

There is a good case for accommodating as much of London's growth within existing parts of the city as possible and this is the expectation of current planning policies.

While there are clearly many practical and political challenges involved that will need to be addressed, a mix of the scenarios considered above could, in theory, accommodate a significant proportion, if not all, of the forecast increase in population. In some cases this could drive wider economic and environmental benefits. But it will be imperative that the appropriate transport infrastructure is in place if this is to be sustainable and acceptable and result in desirable, attractive places to live.

Growth opportunities outside London

In practice, however, even with a combination of all or most of the options discussed above, it is likely that some of the forecast extra population will have to housed outside the existing boundaries of the city. It makes sense to explore opportunities close to London to minimise costs, avoid extending journey times and reduce environmental impacts.

This could be achieved through facilitating 'fingers or nodes of growth' focused on existing, enhanced, extended and new transport corridors and stations. New stations, for example, could offer key foci for sustainable growth. If any development was to be allowed on Green Belt, it must be linked to existing or new rail capacity and where the land is of lower amenity value.

There are also potential options for new 'garden cities' just beyond London's boundary. The only committed scheme to date is at Ebbsfleet. Opportunities for more such schemes could be unlocked through relocating Heathrow Airport to the Inner Thames Estuary. The surface access links to London and beyond would transform connections in the Thames Gateway / North Kent offering potential for new sustainable communities to be developed.

This would help redistribute growth within the wider South East in a way that would help achieve a much needed regional rebalancing, reducing excessive growth pressure on the western side of London and stimulating it in areas with more capacity for expansion to the east. At the same time this could also bring much needed regeneration to areas such as the Medway towns.

This could offer win-wins. Some parts of the South East are relatively deprived eg Kent, Medway and East Sussex has a GVA of £15,766 per head (78.2 per cent of national average). Many of these areas have also experienced population decline. On the other hand they are often located on existing public transport corridors, albeit in need of service improvements.

Apart from in this eastern corridor, opportunities in contiguous areas are likely to be constrained, which means there may be a case to bring larger scale but less well connected growth areas within reasonable commuting times of central London.

There might be economic and regeneration opportunities in this scenario if the additional housing is located in urban areas further afield with relatively high levels of deprivation.

A scenario has been considered which increased densities on residential land in a range of areas outside London considered feasible to enable substantial increased commuting. This scenario supported a population increase of about 1 million in the region surrounding London (correspondingly, London's population growth was reduced by 1 million).

In this scenario, there would be less traffic pressure in London as a result of the lower population growth, but the rail network would face additional crowding pressures as a significant proportion of the dispersed population would commute to London jobs, leading to longer average trip distances and increasing demand on commuter lines.

There would also be challenges in those areas outside London where it will generally be more difficult to embed sustainable travel patterns.

(C) Supporting a better, not just bigger, London

We need to ensure that London becomes not only a bigger city but a better city, offering a high quality of life to its residents and a high quality experience to its workers and visitors.

The way we invest in transport infrastructure can continue to help make London more accessible, cleaner, safer, healthier and more attractive. We should be in a position to set an ambitious vision for the future of London's transport networks.

We need to work towards eliminating death and injury on our roads

We need to make 2/3 of all journeys on public transport accessible

We need to develop a pollution free system

We need to Improve health and make London one of the best cities in the world for walking and cycling

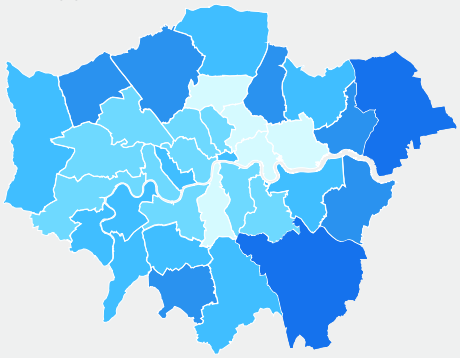
A changing population

Some of the characteristics of London's population are expected to change substantially over the period to 2050. A trend with particular significance to how infrastructure is planned is the rapid growth in the older population in terms of their absolute numbers and also the proportion of the total population that they represent.

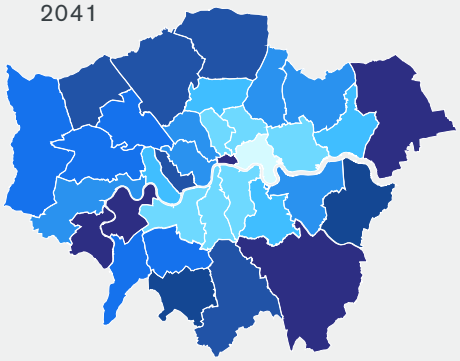
For example, there is expected to be a fourfold increase in the number of Londoners who are over 90 years old by 2050. Alongside this is an increasing age on average when people reduce activity and travel rates, and this means there will be more older people travelling more extensively than in the past. This underlines the importance of improving the accessibility of London's transport system.

Percentage of population aged 65 or over

2001



2041



Population 65+

- 22% to 24%
- 20% to 22%
- 18% to 20%
- 16% to 18%
- 14% to 16%
- 12% to 14%
- 10% to 12%
- 8% to 10%

Engagement with stakeholder groups emphasises that disabled people want to make safe, reliable and accessible journeys and want access to the right information to plan their journey. However, whether they have mobility or other impairments, they face additional barriers to travel, often related to the quality and design of transport infrastructure.

Ensuring the transport system is accessible from the start to the end of the journey, by overcoming the barriers that exist for some users, would enable more 'spontaneous' travel that will benefit the economy and help overcome some pressing social problems, including the increasing isolation of older people.

There may also be affordability issues which could affect people's access to transport and thus opportunities. For example, if people have to travel further to work if affordable housing is not available in London, or in the context of potentially reducing or stabilising incomes for some groups (eg older households running down wealth and nearing full potential of women's participation in labour market).

More active travel

There are also increasing challenges around health, and potential significant divergence in transport requirements.

The latest available records suggest that two-thirds of adults in England do not meet the Chief Medical Officer's recommendation for physical activity, and almost as many are classified as overweight or obese.

The rise of childhood obesity is a particular cause for concern with more than 10 per cent of London's four to five-year-olds being classed as obese, rising to more than 20 per cent of 10 to 11-year-olds. Active travel offers significant opportunities to help tackle this – but conversely there are also risks if car usage, for example, increases.

The table below illustrates the potential impacts on Londoners' health assuming different patterns of travel, for example if Londoners replicated how people in California or the Netherlands travelled in terms of mode choice[12].

Travel scenario	Net health impacts*
Car only	- 50,000
Like Californians	- 27,000
Like other cities in England	- 17,000
Current plans to 2031	+ 4-7,000
Like the Dutch	+ 15,000
Theoretical walking & cycling potential	+ 62,000

* Rounded to the nearest thousand

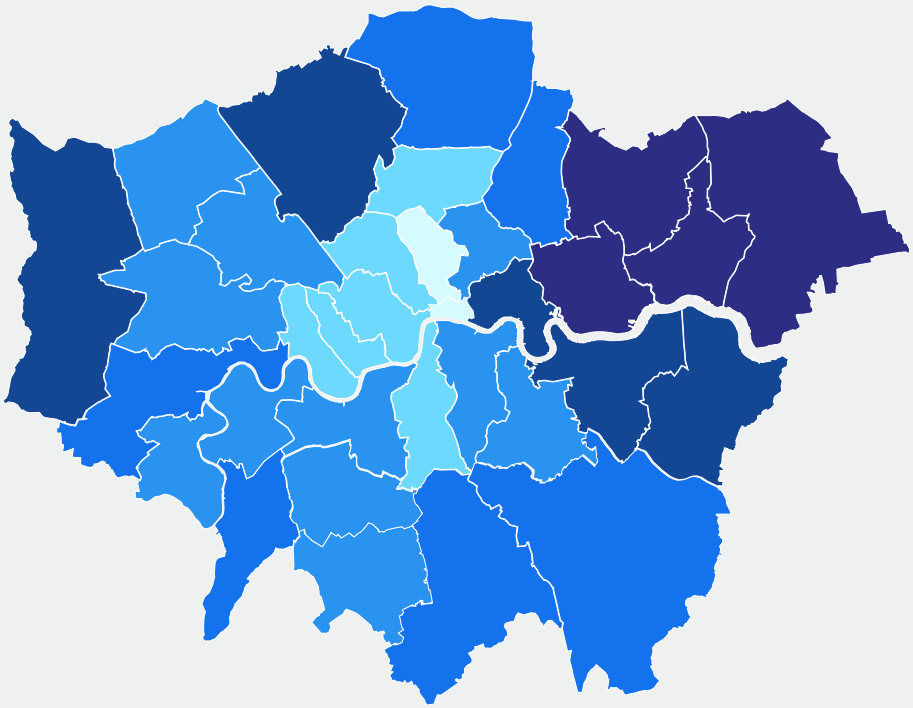
A major challenge is to try to reduce levels of car ownership and usage while maintaining good access for people to jobs, services and opportunities across the city. Otherwise, with a growing population this will cause many problems in terms of congestion, the environment, amenity and space, as well as militating against potential health benefits.

If car ownership rates remain the same as today then the projected growth in population to 2050 would result in nearly 1 million additional cars in London...requiring space for parking equivalent to Richmond Park

We have seen over the past decade a shift in attitudes and behaviour in relation to car usage in central and inner London which suggest some potentially structural changes. This does not seem to have taken root in outer London, however, where traffic has been increasing post-recession.

Even with 'low car' assumptions (with per capita reductions in car usage continuing in central and inner London) car traffic is expected to rise somewhat in inner and more in outer London as the population grows, with more significant increases in particular boroughs.

12 - These are measured in DALYs ('Disability-Adjusted Life Year') which are equivalent to losing / gaining one year of life in perfect health



Percentage difference in car kilometres, 2011-2031, AM peak

- 15 to 20%
- 10 to 15%
- 5 to 10%
- 0 to 5%
- -5 to 0%
- -10 to -15%

However, as highlighted previously, there may be opportunities (and imperatives) to promote more sustainable travel patterns as areas across the city change and densify. Indeed, a recent and pronounced trend has been the growth in cycling alongside continued high levels of walking - a return to more 'human-centred' modes of travel - providing smart but low tech solutions to some of the challenges we face.

A policy-driven shift and pressure on other modes could see an increase in walking relative to population growth, of perhaps 40-45 per cent, while the aims for cycling are to reach levels seen in cities such as Amsterdam and Copenhagen.

Better places

Our transport infrastructure must help support, not undermine, place-making (viz Westway, for example). As a core part of the urban fabric and the heritage of the city, the quality of the transport assets themselves needs to be commensurate with a world city.

Our city needs iconic spaces and welcoming places, thriving high streets and safe, calm, social residential streets and to mitigate the impacts of strategic roads on neighbouring communities.

Reducing transport impacts

The projected increase in population and employment will generate higher numbers of freight and servicing trips and changing patterns of retail distribution will add to the complexity and pressures. Customers expect shorter lead times and this is leading to a more intensive pattern of logistics with increases in the use of smaller delivery vehicles with smaller consignments.

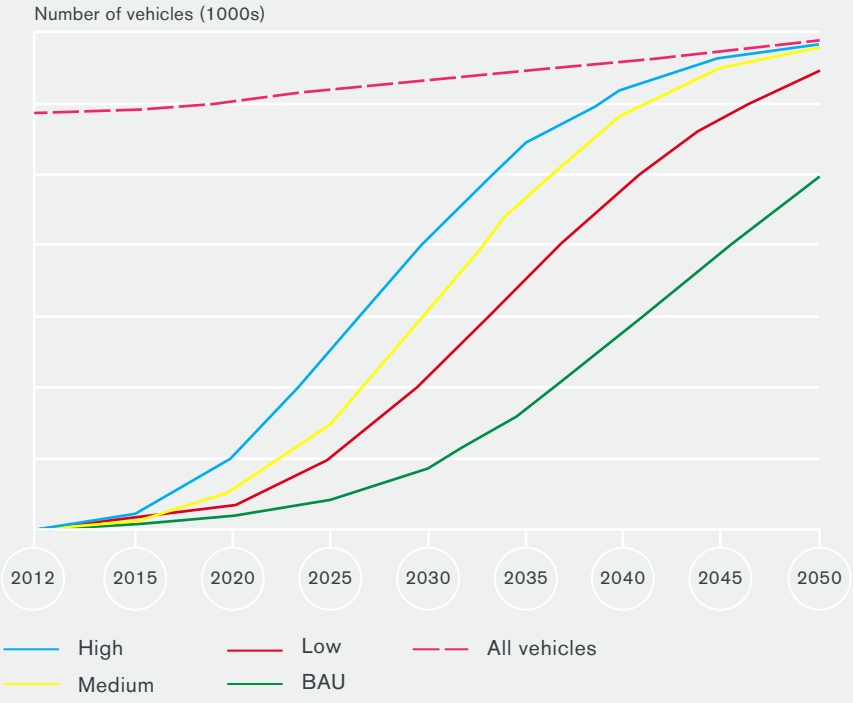
The aim should be for minimal impact freight – to reduce the impacts on the environment, safety, congestion and quality of place – while ensuring that vital deliveries and servicing can continue efficiently. Increasing density of housing must

not circumscribe a shift to out of hours as the norm, but community impacts must be minimised, for example through vehicle technologies and design of developments.

Incorporating the environmental impacts of different transport systems in decision-making will become increasingly important. Transport is responsible for approximately 20 per cent of CO^2 emissions, and around 50-60 per cent of other key air pollutants such as NO^2 and PM^{10} within London. The growth in population is making the trajectory needed to meet 2050 climate change reduction targets ever more challenging and we are already facing significant issues in terms of air quality. Central government has recently indicated that London is unlikely to meet existing NO^2 limits until after 2030.

We have developed high, medium and low scenarios for the uptake of Low Emission Vehicles (LEV) from now until 2050, to illustrate the potential future of LEV technologies.

Illustrative scenarios for take up of low emission vehicles



Even the low uptake scenario represents a significant acceleration over business as usual in terms of advanced electric light vehicles and natural gas fuelled heavy vehicles. The medium uptake scenario goes beyond this and relies upon a rapid early uptake of electrified vehicles and high uptake of low emission vehicle technology for heavier vehicles.

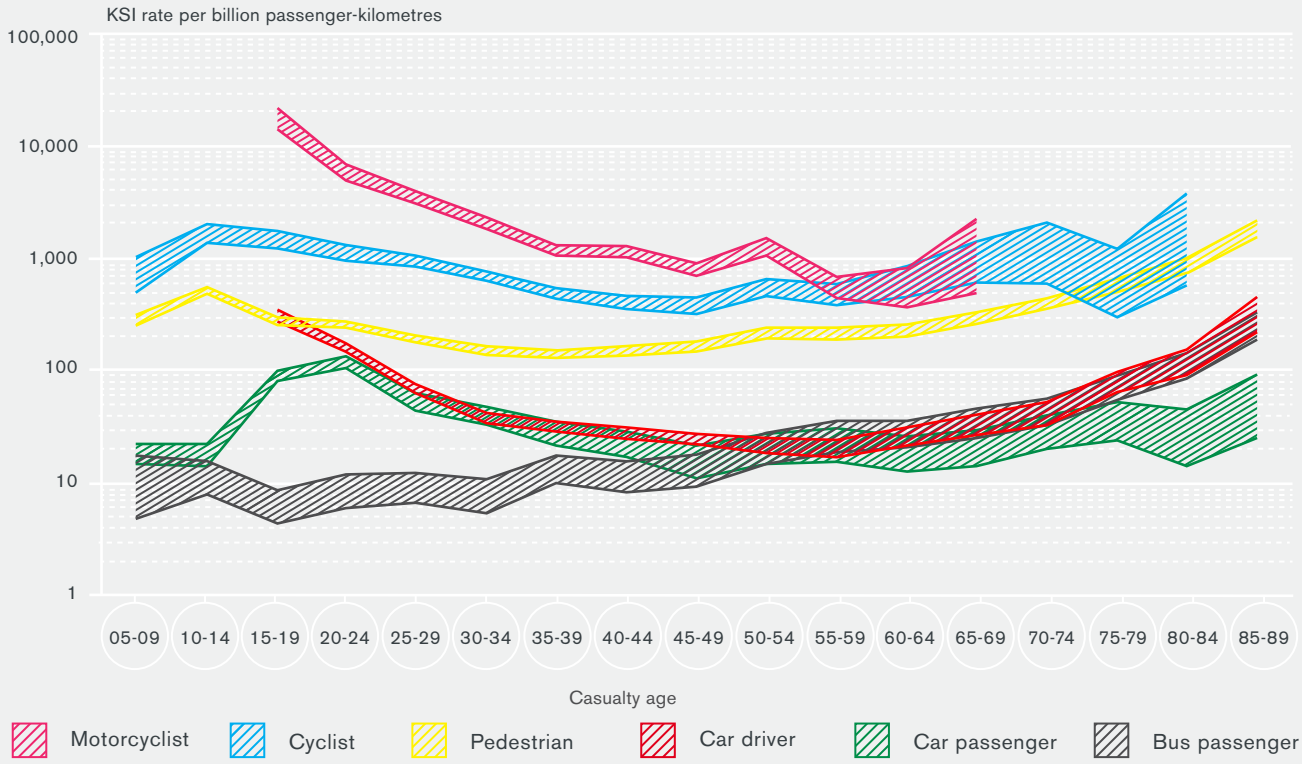
The high scenario is believed to be at the limit of what is achievable with the most significant supporting actions taken

and requires future technology costs and performance to develop fully as anticipated. By 2050, all scenarios envisage only a minimal role for conventional petrol and diesel fuelled vehicles.

A safer transport system

The last decade has seen improvements in reducing deaths and injuries on London's roads. However, the benefits have not been shared equally between communities and different road users, as can be seen in the diagram.

KSI rate by mode (95% confidence interval, logarithmic scale)



Reducing casualties still remains a significant challenge and the aim is to reduce KSIs by 80 per cent by 2040, working towards elimination of death and serious injury beyond this. The additional value of the 80 per cent reduction would be around £3 billion.

(D) Innovating to develop the transport system of tomorrow

This is where the future is even less certain and a crystal ball is needed. There can be dangers of over-estimating the likelihood of change, or 'backing the wrong horse'.

6

However, there is also the risk of missing the potential of significant technological opportunities.

While many aspects of transport have remained remarkably unchanged for many years, even centuries, other aspects such as communications technology have been developing faster than anyone born before 2000 can fully comprehend. Importantly, however, innovation is not just about technology, it is also about policy, processes, behaviour and delivery.

7

How do we try to predict technological or societal change to which we need to respond or that we should seize upon as an early mover? How many might genuinely be game changers and how many might have unexpected or unforeseeable impacts? Today's planners, for example, look back to the 1950s and 1960s with a sense that there was undue optimism about the role of the car in cities.

We need to consider how a broad set of forces are likely to affect customers' needs. Transport is integral to people's lives, and will need to adapt to wider changes in lifestyles. For example, one fast moving area is in retailing and the logistics patterns that support it. The importance of same day delivery is growing and could lead to a further increase in the use of fleets of smaller delivery vehicles or opportunities for more radical alternatives such as drone lorries.

At the same time the transport system itself continues to have profound impacts on people and the environment. The response to many of these evolves over time, for example as we learn more about the damaging consequences of carbon

6 © Neil Kennedy

7 © Tomasz Sienicki

emissions on our climate, or air pollution on our health, there are increasing pressures for change.

"The horse is here to stay but the automobile is only a novelty – a fad." (The president of the Michigan Savings Bank advising Henry Ford's lawyer not to invest in the Ford Motor Co, 1903)

"There is no reason anyone would want a computer in their home." (Ken Olson, president, chairman and founder of Digital Equipment Corp, maker of big business mainframe computers, 1977)

"Heavier-than-air flying machines areimpossible." (Lord Kelvin, Britishmathematician and physicist, president of the Royal Society, 1895)

Different kinds of innovation

All this means that future change and innovation in the realm of transport will be shaped by a complex web of social, economic, technological, cultural and environmental factors. And these will shape all aspects of the way we plan and deliver transport.

We therefore need to consider different kinds of change differently. While some kinds of innovation will bring steady improvements in how we deliver transport or in how it is experienced by our customers, others may lead to the possibility of far more radical change and upheaval in our transport system.

For these in particular, we will need to consider the risks and benefits. An obvious approach is to allow more widespread piloting of new technologies at small cost and scales to test radical new ideas where this is possible.

Clearly, where there is more uncertainty and risk it will be easier to justify investing resources in their development where the potential benefits are higher. In the case of potentially paradigm-shifting changes, such as Autonomous Vehicles (AVs), this may suggest that we should be prepared to invest resources even with high levels of uncertainty.

Our approach to innovation should combine:

– Mainstreaming existing new technology alongside innovative and best practice

– Capitalising on new opportunities and standards coming on stream

– Testing / preparing for more radical new alternatives

Paying for road infrastructure and use

One area in which there is both uncertainty and risk but, in the longer term, potentially significant opportunities is wider road pricing. The Roads Task Force said that this should be investigated given the scale and nature of the challenges. In principle, pricing offers the potential to tackle many of the issues identified by the RTF, including reducing congestion and pollution, helping better balance supply and demand on

the road network and also potentially providing funding to support infrastructure investment.

In our response to the RTF, TfL said that we would help push the national debate on the future means of paying for road infrastructure and use. The wider context of motoring taxation provides an important rationale for this:

– Duty and VAT on fuel currently raise about £32bn annually

– Car fuel efficiency is projected to continue to improve by over 1 per cent a year, a 47 per cent improvement between 2010 and 2040

– Vehicle Excise Duty which raises £6bn annually, is declining as people buy more fuel efficient, cleaner cars

– So, despite a projected growth in traffic nationally, revenue from motoring taxation is set to drop by £13bn a year, or 35 per cent, by 2029

Furthermore advances in communications technology and its application to the road infrastructure will allow a future system to be used in a way that could be powerful as a means of demand management, for example, offering variable pricing in response to real time information and real-time choices to users.

Will vehicles still need drivers?

Communications technology not only offers opportunities for influencing driver choices through tracking and charging road vehicles, but also for controlling the vehicles themselves. This technology has been available in 'closed' systems, such as urban rail and personal rapid transit for decades (viz DLR and airport transit systems). The innovation that could revolutionise the way we use the roads is for autonomous vehicle technology to be able to operate in an 'open' environment, in which there is interaction with the wider surroundings including people.

'Smart' vehicles equipped with technology that supplements the driver's actions with autonomous safety features are already available. These are able to detect safety hazards and override the driver's control in certain situations such as when a possible collision is detected. Google and others are developing further stages of this technology that offers the possibility of fully autonomous vehicles, although this is some way off being proven in all road situations and there are myriad technological, legal and policy issues to resolve before it could be implemented, not to mention questions of public acceptance. These include:

- Verifying the safety of AVs and ensuring they are capable of responding to other road users eg pedestrians and unexpected events
- Creating a legal framework to allow their testing and deployment on public roads and resolving issues around liability
- Managing the interaction between AVs and conventional vehicles in the interim period
- Addressing cultural issues eg perceptions of risk and appeasing those who enjoy controlling the vehicle themselves
- Handling data sensitively
- Embedding the technology into road infrastructure
- Dealing with strategic land use and transport planning issues, such as the impact of AVs on public transport use and land use patterns

In light of these considerations there are important questions about how quickly London should and could implement the technology. In the longer term autonomous vehicles could effect a paradigm-shift in the way we travel, including:

– Helping us reach our goal of eliminating death and injury on the roads

– Optimising the use of limited road capacity and smooth traffic flows, cutting journey times and energy use

– Providing TfL with a rich source of travel data enabling better transport planning as well as help manage demand more precisely

– Allowing large cost savings for buses while delivering a faster more efficient service

– Offering a convenient alternative to private ownership, reducing the demand for parking

– Extending access to opportunities for the young, elderly and those with mobility difficulties

– Increasing the efficiency of goods distribution across the capital

The benefits could thus be great – but only if the technology is harnessed within an effective policy framework. A fundamental challenge is to integrate AVs into a sustainable urban mobility paradigm. For cars the optimal approach may be through shared ownership models. It will be important to develop a trajectory to integrate them into the multi-modal transport system rather than risk a model of individualised ownership with implications for urban sprawl and reverse mode shift.

AV technology could also impact significantly in other areas of road transport in London. In particular new forms of driverless public transport could allow taxi like levels of service at reduced costs. If this were to be integrated to provide high quality interchange with rail based public transport, it could work to encourage sustainable mobility patterns and raise the mode share of public transport.

Autonomous goods vehicles could bring major efficiencies and operational benefits to the logistics industry and could also improve road safety and reduce the need for large vehicles that are often unsuitable for London's roads and streets.

How the technology will develop is not yet clear, but there are already some indications. Increasingly car manufacturers are already introducing elements into their vehicles such as automated safety features or interactive cruise control. Some possible scenarios are shown below.

Examples of possible scenarios for autonomous vehicles

- Near future
- Medium term
- Up to 2050

Safety measures and autonomous modes
Autonomous safety features such as autonomous energency braking is adopted by all new cars. Some vehicles introduce autonomous 'modes' for driving themselves in certain situations, while retaining a responsible driver.

No legalisation of fully autonomous vehicles
The goverment decides against legalising fully autonomous vehicles meaning cars and other vehicles are notable to drive themselves without a responsible driver.

Restricted legalisation of fully autonomous vehicles
The goverment legalises (some types of) fully autonomous vehicles in certain situations and locations eg cheap driverless taxis become popular or 'drone' lorries operate in defined areas or corridors.

Legalisation of fully autonomous vehicles
The goverment legalises fully autonomous vehicles, meaning empty cars and lorries can drive themselves.

'Free market' model
Minimal intervention beyond regulatory frameworks. Increased congestion and pressures on space as people use their vehicles more.

Centrally Controlled Network
Route choice and vehicles speeds are decided centrally, for the benefit of the whole system. Shared ownership models are implemented. Congestion is relieved and journey times cut, while improving road safety.

Road User Charging
Road user charging is introduced, with prices set to maximise the efficiency of the road network. Congestion is relieved on more popular routes, leading to smoother flows.

TRANSPORT REQUIREMENTS

There is a series of transport requirements arising from these challenges and opportunities which are set out in this chapter. These aim, for example, to:

– Mitigate otherwise potential adverse impacts identified eg crowding, congestion

– Shape the growth more pro-actively in terms of where or how it takes place to make most of transport opportunities, reduce costs of provision and achieve better outcomes

– Influence behaviour to embed more sustainable patterns of demand

– Seize opportunities for improvement and innovation

These are linked back to the challenges in chapter 2, although there is clearly overlap since many/most transport schemes tend to deliver benefits across a range of objectives. Many of the requirements are already relatively well specified from work to date and have been evaluated as representing good value for money, for example Crossrail 2. Some are currently being developed in greater detail, for example Bakerloo Line Extension. Others are potential options which may be justified depending on how London develops and demand increases but require significant further assessment, for example orbital rail.

These requirements focus on infrastructure investment rather than overall transport spend (such as operational spend on buses) or policy (such as demand management). They are also taking as read the pre-requisite of basic maintenance and renewal investment. Getting the most from what we've already got and ensuring that our assets are well maintained is absolutely fundamental and must continue to be a cornerstone of our Business Plan and investment programme.

(Ai) WORLD CLASS INTERNATIONAL CONNECTIONS

We believe that the key output to achieve will be an increased range of key international destinations served directly from London.

Transport Requirement 1

A world class four runway hub airport (indicative cost: £18 - 25 billion)

The connectivity that aviation in particular creates is central to many global companies' location decisions. It is essential that London has a world class hub airport.

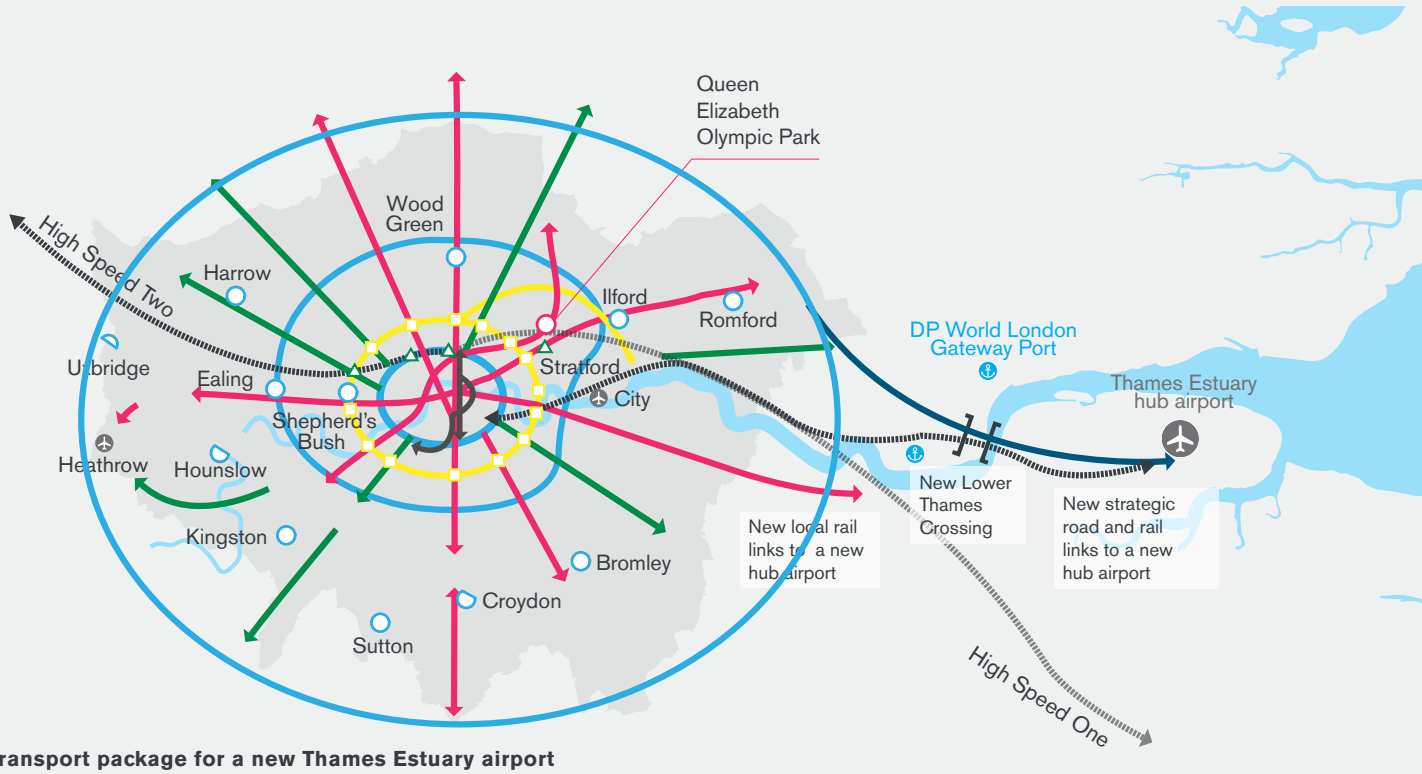
The Mayor strongly believes this should be in the Thames Estuary to provide the capacity required to ensure London has direct connections with the rest of the world. This could:

– Be open by 2029

– Make London & UK the best connected city & country in the world

– Unlock growth across the UK regions

– Make air services reliable and resilient



Transport package for a new Thames Estuary airport

- Strategic interchange
- High-speed/international station
- Metropolitan town centres
- Town centre/sub-regional
- Orbital road
- Orbital rail
- Cross-London
- Radial
- High Speed/international rail
- New road link to new hub airport
- Airport
- Queen Elizabeth Olympic Park
- Thames Estuary hub airport
- Ports
- DP World London Gateway Port

Transport Requirement 2

A new / improved network of road and rail connections to support access to airports (indicative cost: £19 billion)

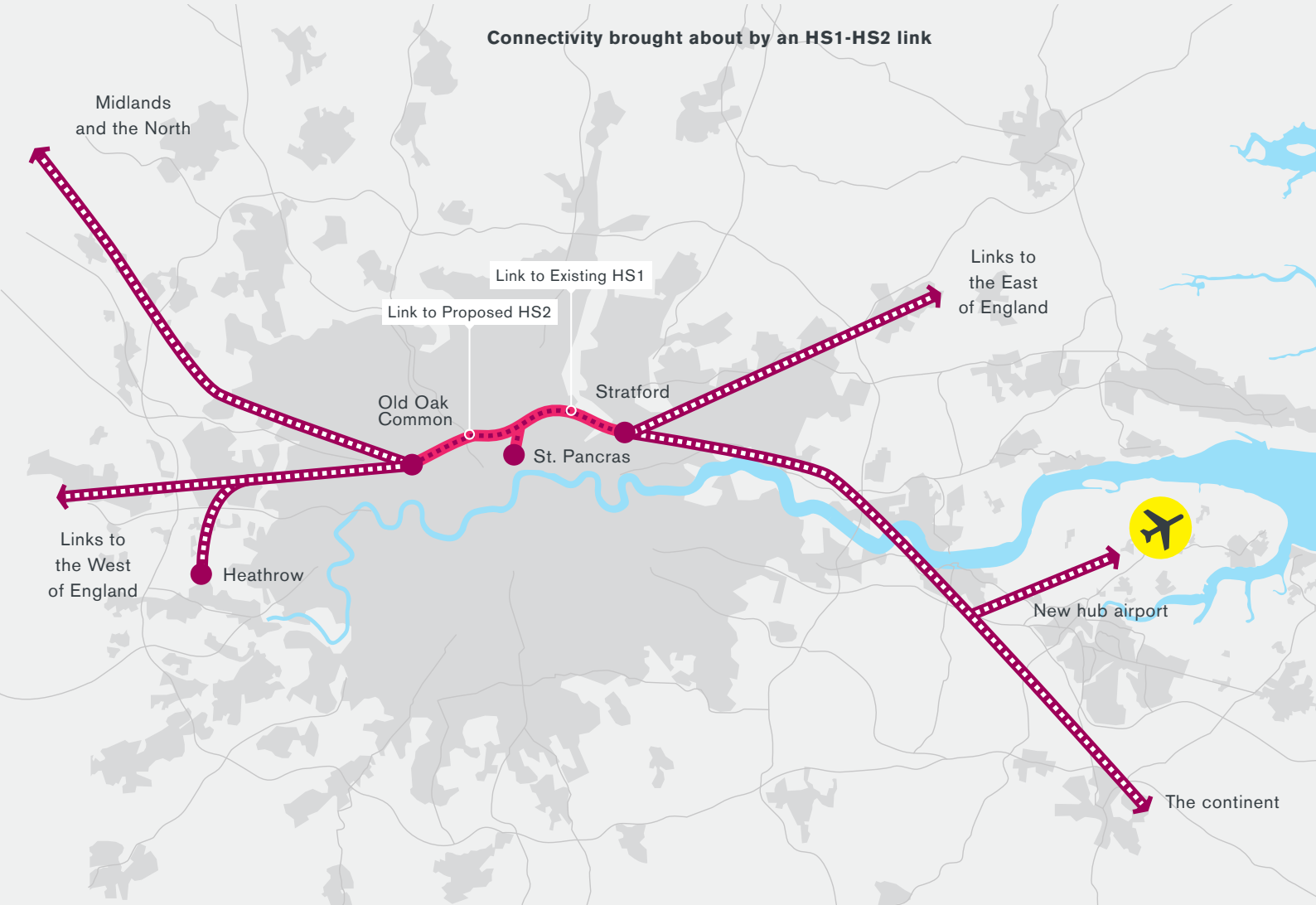
All airport capacity options currently under consideration by the Davies Commission would necessitate substantial new transport infrastructure.

For a new Thames Estuary airport the package would include a high speed link to central London and beyond, a Crossrail extension from Abbey Wood-Ebbsfleet to the airport and strategic road improvements.

This investment would also provide a focal point for development around key nodes in locations such as Barking, Stratford and Canary Wharf and help tackle the regional inequalities that exist between the more prosperous but crowded west and the more deprived east, which contains many opportunities for housing growth.

London's other airports will continue to play a vital supporting role particularly in connecting London to UK and European cities. Airport links are likely to suffer from crowding as demand from airport and other users increases on constrained main lines. Key schemes include 4 tracking along the Lea Valley corridor to serve Stansted.

Connectivity brought about by an HS1-HS2 link



Transport Requirement 3

Provision of an extended network of direct rail connections to mainland Europe for passengers and freight (indicative cost: £1 billion)

High speed rail services can play a key role in meeting international transport requirements with the near Continent. This can also release valuable airport slots for longer distance routes (although this is not an alternative to additional airport capacity, releasing less than 10 per cent of capacity at Heathrow at most).

Key schemes include a fit for purpose link between HS1 and HS2 (ie one that does not adversely affect the Overground) which would not only provide international connections from other UK regions, but also open up further capacity for London and support better regional connections.

Beyond this, the map below shows a possible network of high speed routes to a number of major cities within the traditional economic core of Europe. In the longer-term an additional cross-channel rail tunnel could help support an extended network of direct rail connections to mainland Europe for passengers and freight and provide resilience for the channel rail links[13].

13 This is not included in the cost estimate

Possible future international high speed rail routes from London

(Aii) IMPROVING RADIAL LINKS

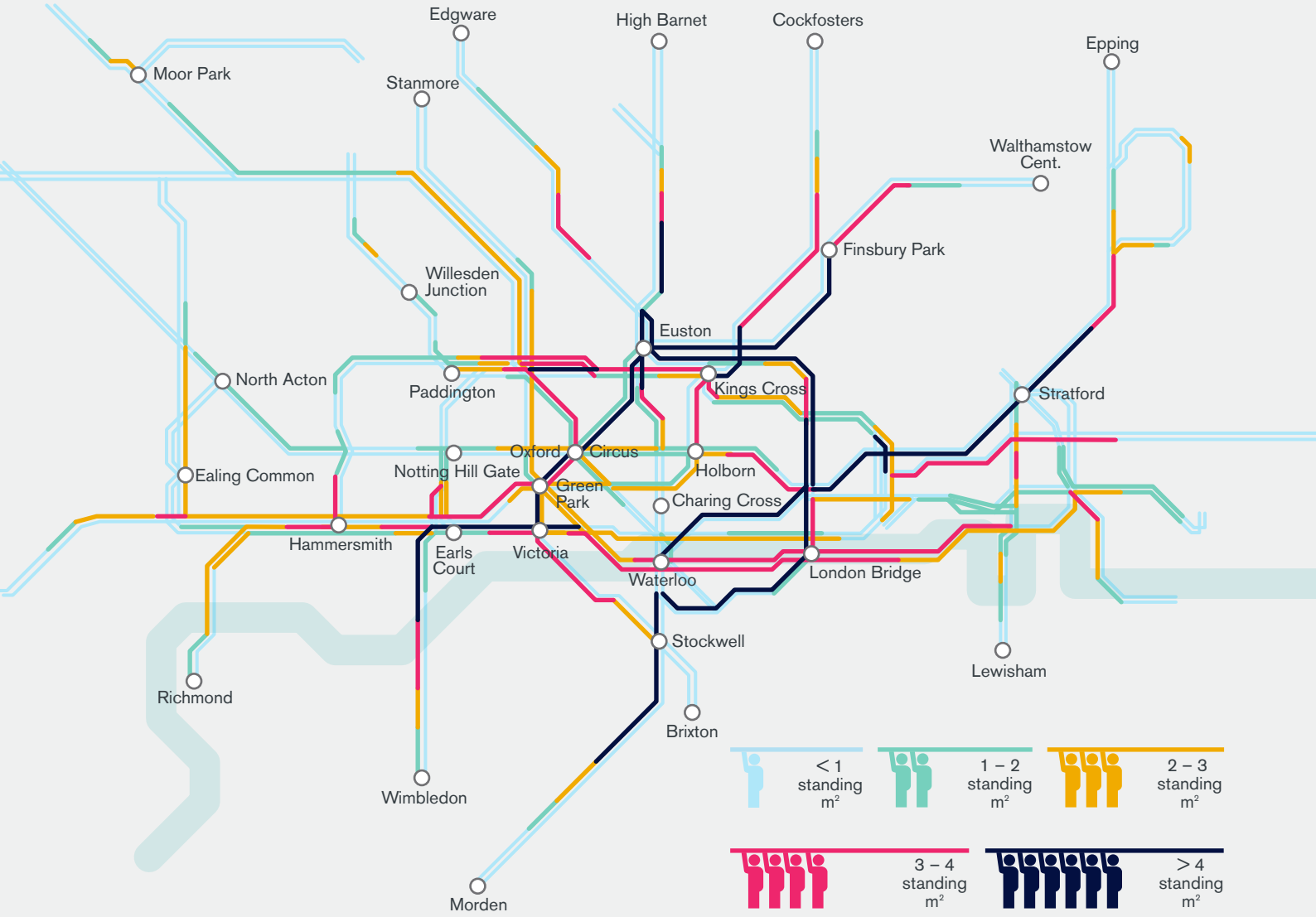
Transport Requirement 4

Maximising performance of the existing Tube network to achieve standards comparable with the best in the world (indicative cost: £12-15 billion)

We believe that the key output to achieve will be around a 70 per cent increase in radial rail peak capacity by 2050 to help meet the forecast increase in demand and prevent worsening crowding.

The vast majority of the trips taken in 2050 will be on lines that form part of the existing transport system and it is thus crucial that the full potential of the existing system is realised.

Crowding levels on the Tube network in 2031, AM peak



The Tube upgrade programme provides capacity to help keep pace with growing demand up to the 2020s, but thereafter continuing demand growth will mean more passengers experiencing crowded conditions.

By the early 2030s we estimate that there will be a 25 per cent increase in the volume of Underground travel in crowded conditions, and a 65 per cent increase by 2050.

Forecast demand levels in 2050 will exceed realistic capacity on sections of several lines, including the Northern, Victoria, Piccadilly and Jubilee lines. This means that, without further capacity increases, London's economic growth potential could be inhibited.

The upgrade programme for the Tube must therefore be continued to reduce crowding and improve reliability on remaining lines. This includes replacement of life-expired assets, automation to reduce operating costs and optimise service operation generation in order to deliver improved journey times, reductions in crowding and people left-behind, congestion relief on adjacent routes, and wider economic benefits.

The aim is to enable frequencies of up to 36 trains per hour across the Jubilee, Piccadilly, Northern and Central lines by 2035. This will increase the peak capacity of these lines by 20-50 per cent (and over 60 per cent on the Piccadilly Line).

Transport Requirement 5

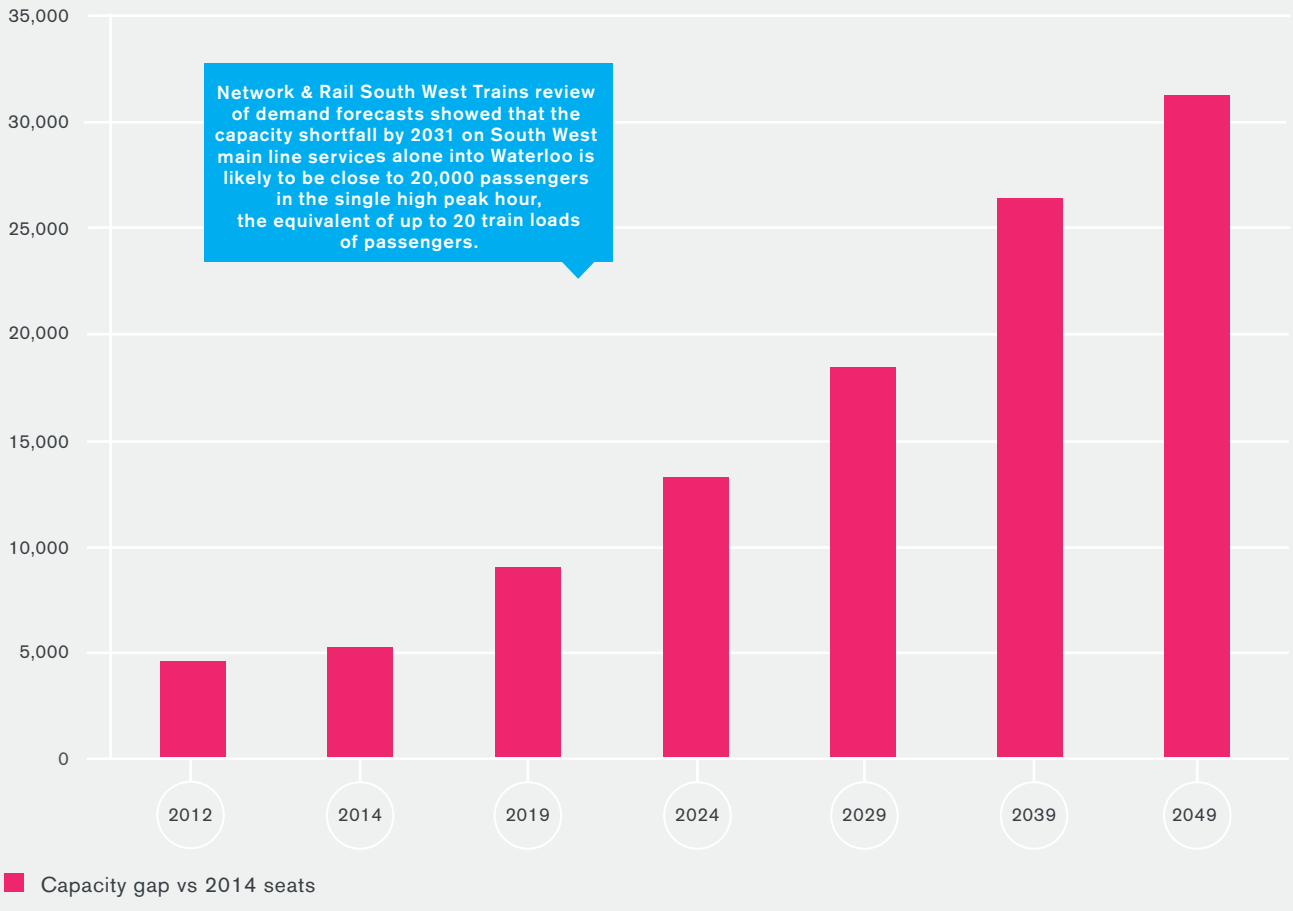
Transform the national commuter rail network through joint investment programme with Network Rail (indicative cost: £15-20 billion)

While an ambitious investment programme is well underway to transform the Underground and bring much of it close to its full potential, much of the commuter rail network remains constrained, with limited capacity and slow journey times, as a result of historic under investment and sometimes compounded by recent growth. Network Rail's processes for prioritising and allocating funding are already well defined and TfL anticipates feeding the Mayor's priorities for rail into these processes.

There is a long-established relationship between the number of jobs in London and the number of commuters crossing London's boundary from the surrounding region. London's jobs growth is likely to attract an extra quarter of a million commuters by 2050. By the early 2030s we estimate that there will be a 35 per cent increase in rail crowding, and more than a doubling by 2050.

The estimates suggest that several lines will experience demand levels well above realistic capacity, for example lines from south-west London into Waterloo.

Forecast capacity gap on the South West Main Line



In effect this means that some of the potential demand could not be accommodated on the rail network and, with similar pressures on the Underground network, there would be no clear alternative for these journeys.

Upgraded commuter routes are therefore vital to continue to underpin the breadth and depth of the South East labour market. In the timeframe to 2050 the aim should be to deliver upgrades to each key National Rail corridor coming into central London.

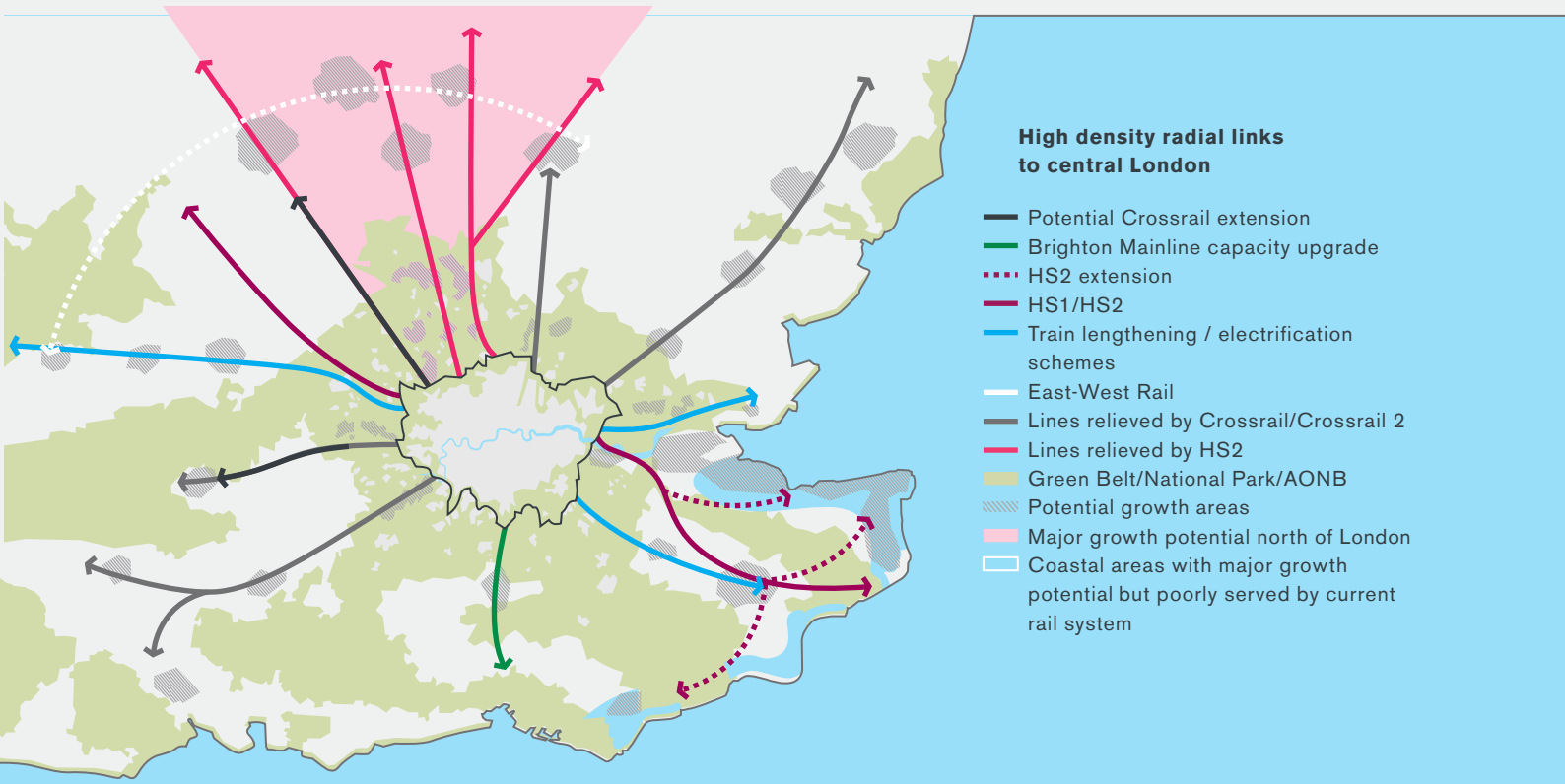
National Rail corridor upgrades

London's rail network has the capability, with investment, to carry nearly twice the number of passengers it does now and to provide equivalent capacity to a second Underground network while continuing to enable longer distance and other services. This enhanced role will be particularly important for south London which is heavily reliant on the rail network for access to central London.

We must also look beyond the traditional commuter belt. Faster and higher capacity links offer the potential to support an expanded labour market. There are particular opportunities associated with the High Speed Lines (HS1 and HS2). While there are significant numbers of medium and long distance commuters in locations served by fast inter-city routes north and west of London, from places like Peterborough, Swindon and Rugby, many areas to the south and south east that are a similar distance from London have fewer such commuters because of relatively poor rail connections.

HS1 has significant unused capacity that could be utilised by trains serving Kent and East Sussex commuters, particularly if better connecting lines were provided beyond Ashford to make journey times more attractive from coastal locations like Ramsgate and Hastings.

HS2 meanwhile will release capacity on the existing inter-city routes to the north that could be used for enhanced commuter services. Additional infrastructure works eg Welwyn Viaduct could unlock additional capacity eg to serve expanded towns linked to the East Coast Main Line such as Northampton. The map below shows some potential opportunities



The national rail network also plays a vital role in providing business and leisure links with other cities and facilitating freight movements. The Mayor and TfL will work with Network Rail to secure London's requirements while recognising its essential role in developing, planning and operating the national rail network to make best use of its overall capacity for these different activities.

Transport Requirement 6

Further 'Crossrails', starting with Crossrail 2 by 2030 and increasing frequency of Crossrail 1 trains (indicative cost: £23-30 billion)

The level of growth, however, is well beyond the limits of what we can get out of the existing (and committed) rail system and further new tunnelled infrastructure through central London will be needed to ensure that the system overall can cope with the demands placed upon it.

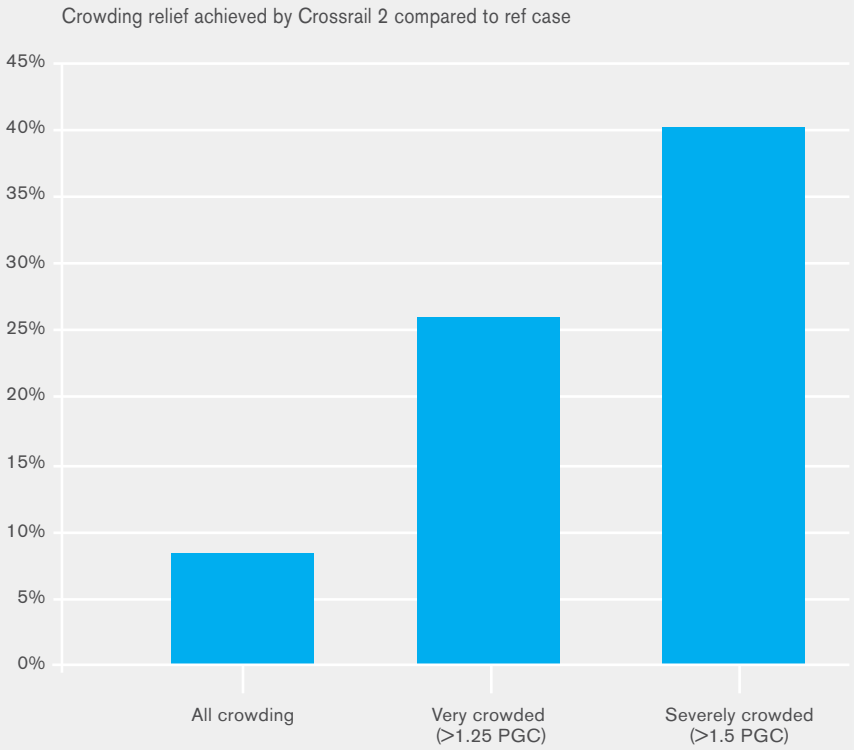
Rail passenger bi-directional flow, 24 hour total, 2011

- < 25,000
- 25,000 – 50,000
- 50,000 – 100,000
- 100,000 – 200,000
- 200,000 – 300,000
- > 300,000

The south west to north east corridor is the busiest rail corridor in London and faces the most severe crowding now and into the future. Our analysis indicates that by the late 2020s it will be at or close to 'breaking point'.

Crossrail 2 is forecast to reduce overall crowding levels on the network in the AM peak period by 8 per cent. Passenger kilometres travelled in 'severely crowded' conditions is expected to reduce by 40 per cent.

Crossrail 2 crowding relief impact: reduction in passenger kilometres in crowded conditions



The scheme will deliver a step change in access to jobs and opportunities from many areas of London, for example Ponders End as shown in the diagrams overleaf.

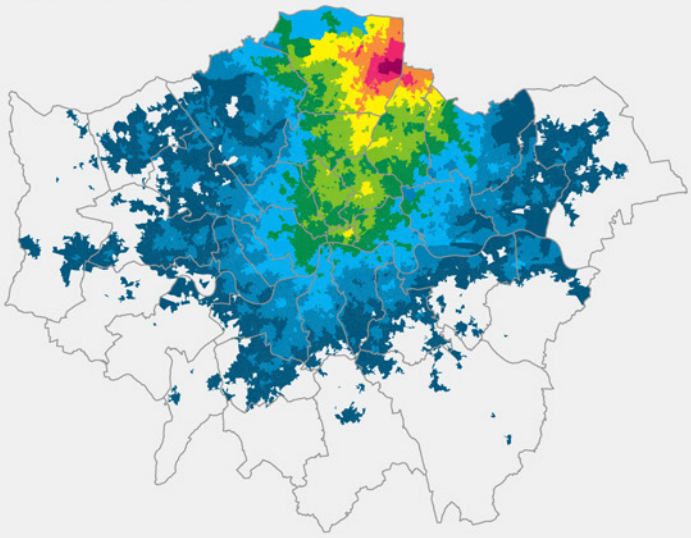
Detailed assessment has been undertaken of potential alternative options but it is clear that there is no convincing alternative to Crossrail 2 that delivers the necessary step-change in capacity on the Victoria, Northern and Piccadilly lines and on the South West Main Line – or that has the wider benefits in terms of unlocking major areas of development.

Crossrail 1 will be operational from 2019 and within the 2020s and beyond there is significant scope to maximise its wider potential through increased frequencies and also extensions, for example to Watford Junction/Tring on the West Coast main line and Ebbsfleet, where a new Garden City is planned. It could be further extended to serve a new Thames Estuary Airport.

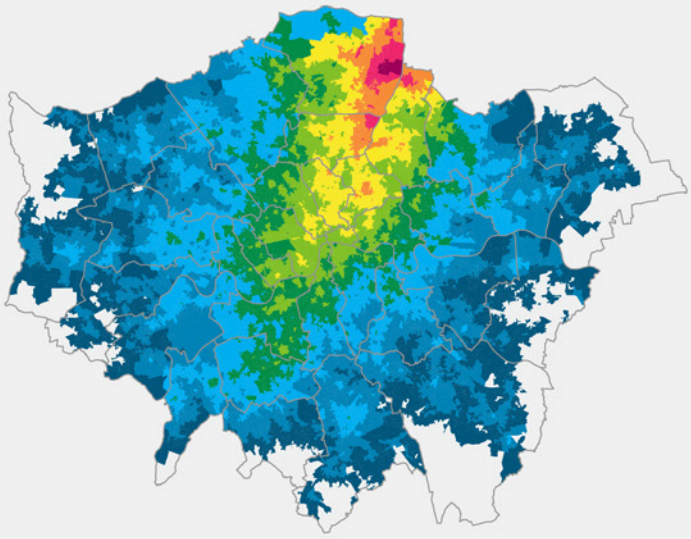
Looking further ahead, continued population and economic growth might suggest that in the 2030s/40s there may be a need for another Crossrail-scale scheme, depending on other projects and the development of the city. This could serve an east west alignment which potentially faces capacity constraints over time (particularly in the context of a new Estuary airport) but there is no specific alignment or proposals at this stage.

Change in journey times from Ponders End with Crossrail 2

Without Crossrail 2



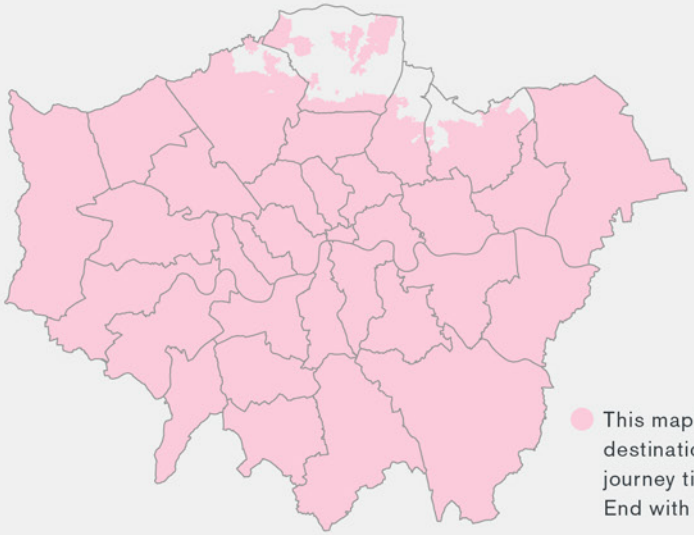
With Crossrail 2



Time (mins)

- 80 to 90
- 70 to 80
- 60 to 70
- 50 tp 60
- 40 to 50
- 30 to 40
- 20 to 30
- 10 to 20
- 0 to 10

Journey time improvements



This map illustrates all destinations with a faster journey time from Ponders End with Crossrail 2

Transport Requirement 7

Upgrading central London stations to enhance capacity and catalyse growth and development in surrounding areas (indicative cost: £2-3 billion)

With increased demand on rail routes coming into central London there will be knock on impacts at stations and their environs and also on the distributing networks within the centre to get people to their destinations.

Upgrading the station and interchange capacity at key locations will be crucial to support this. Priority schemes for early development in the 2020s include Old Street, Paddington, Victoria, and South Kensington.

By 2035, more stations are expected to require significant capacity enhancement schemes, including potentially Baker Street, Piccadilly Circus, Moorgate, Liverpool Street and High St Kensington. In the longer-term, stations such as Earl's Court, Green Park, Warren Street, Embankment and White City are likely to need major upgrades.

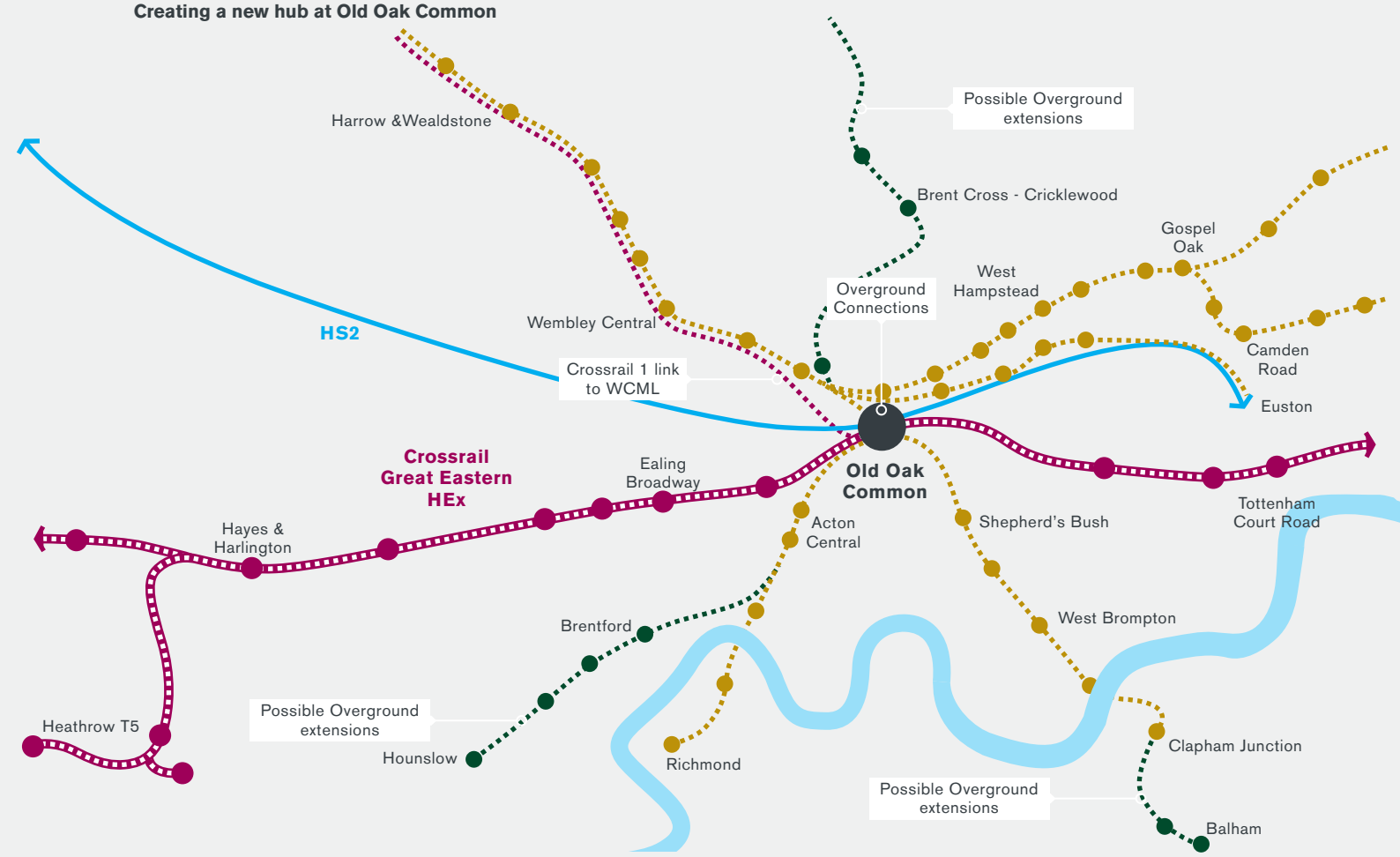
Transport Requirement 8

Integration of new business areas to expand the Central Activities Zone (indicative cost: £500-700 million)

Enhanced interchanges and urban realm schemes at locations such as the City Fringe and Paddington will help continue to expand the productive core of central London.

A key aim beyond this is to integrate Old Oak Common as a Canary Wharf of the future, with around 90,000 jobs and 19,000 homes.

Creating a new hub at Old Oak Common



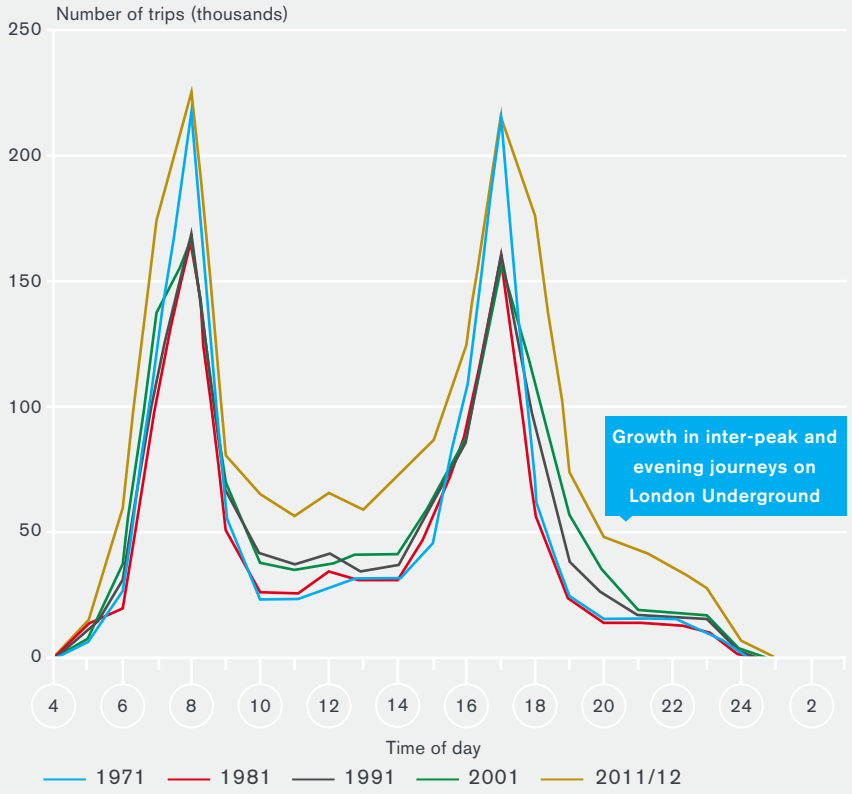
Incorporating an Overground station at Old Oak Common will be essential in ensuring the site is well connected to surrounding areas and areas beyond in north and south London. Together with Crossrail (including a potential extension to West Coast Mainline) and HS2 this will ensure that the area has the connections it needs to provide a labour catchment area and to support effective employment densities comparable to the Central Activities Area. It will also provide a hub for connecting existing Overground stations to Crossrail and for extensions to other areas.

Transport Requirement 9

A transport system to support a 24/7 city (indicative cost: minimal capital investment required)

As demands on the system have intensified, we have seen some temporal changes over the past 40 years. For example the graph below shows changes on the Tube; meanwhile there are almost as many car trips now on a Saturday as an 'average' weekday.

London Underground trips by time of day



These are likely to intensify, with a continued widening of peaks and additional requirements for more 24/7 services as the population grows, working practices evolve, pressures grow within the existing peaks and customer expectations increase.

We need to ensure a transport system that truly supports a 24/7 city, including night-time running on the Tube and rail network.

Off-peak demand is continuing to grow and crowding in the busiest off-peak periods is already similar to the peak. Demand growth will make the case for off-peak service levels in the region of 27-33 trains per hour by the mid-2020s.

Meanwhile growth in the night-time economy will start to make the case for expanding Night Tube services and for higher frequencies (eg in the range of 6-10 trains per hour); a more extensive Night Tube network including Sub-Surface lines, the Overground and DLR and potential operation extended to more nights.

This will present a number of challenges, including less time for maintenance, increased track wear and more heat in tunnels. However, improved services could deliver journey time benefits worth around £50 million per year.

(Aiii) A ROAD NETWORK FIT FOR THE FUTURE

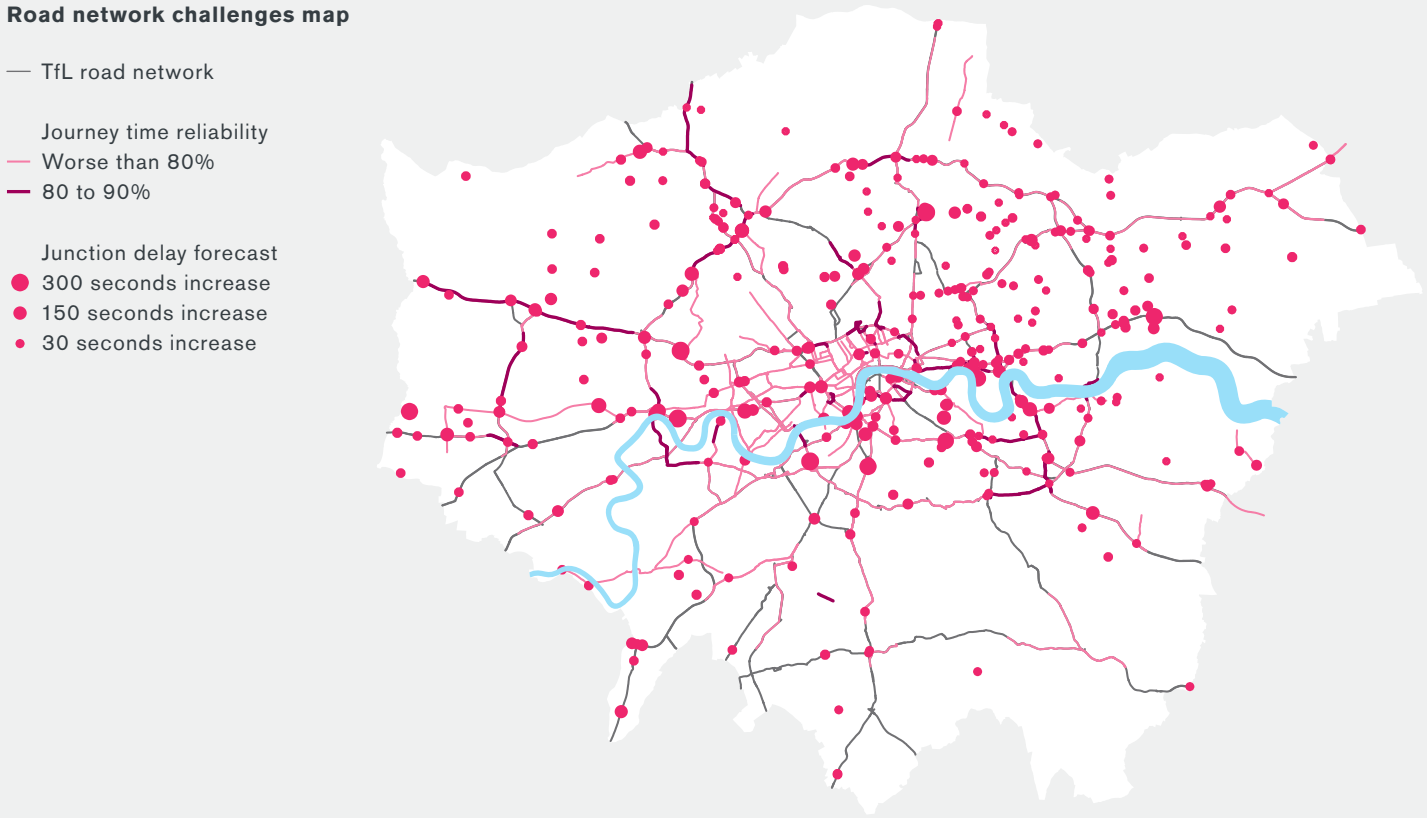
Transport Requirement 10

A congestion-busting programme to support network functioning for essential journeys (indicative cost: £2-5 billion)

We believe that the key output to achieve will be a step change in the quality of this network, with more extensive tunnelling and world leading traffic management that provides for efficient journeys for essential users alongside transformed conditions above ground for walking, cycling and 'living'.

The map below highlights the challenges across the road network in London including congestion hotspots and corridors with poor reliability.

Road network challenges map



Significant investment is needed to tackle these issues, including next generation technological capability in signalling and predictive traffic management. By the early 2020s this should ensure real time operational intelligence across the network and prepare for communication of information to vehicle fleets (eg Autonomous Vehicles).

A key part of the programme should involve enhancements to, and the redesign of, London's major junctions and pinchpoints (eg junctions on the North and South Circulars) and upgrades to the performance of streets - according to their priority functions – across the network. It should also include implementing more innovative junctions which support different

modes, the roll out of Pedestrian and Cycle Scoot across the network (trials of this have reduced KSIs by over 50 per cent) and building pipe subways at key intersections to significantly reduce disruption.

This will aim to protect the functioning of the network, even as London grows, in terms of journey time and reliability for essential journeys while enabling the delivery of continued improvements to places across the city.

Transport Requirement 11

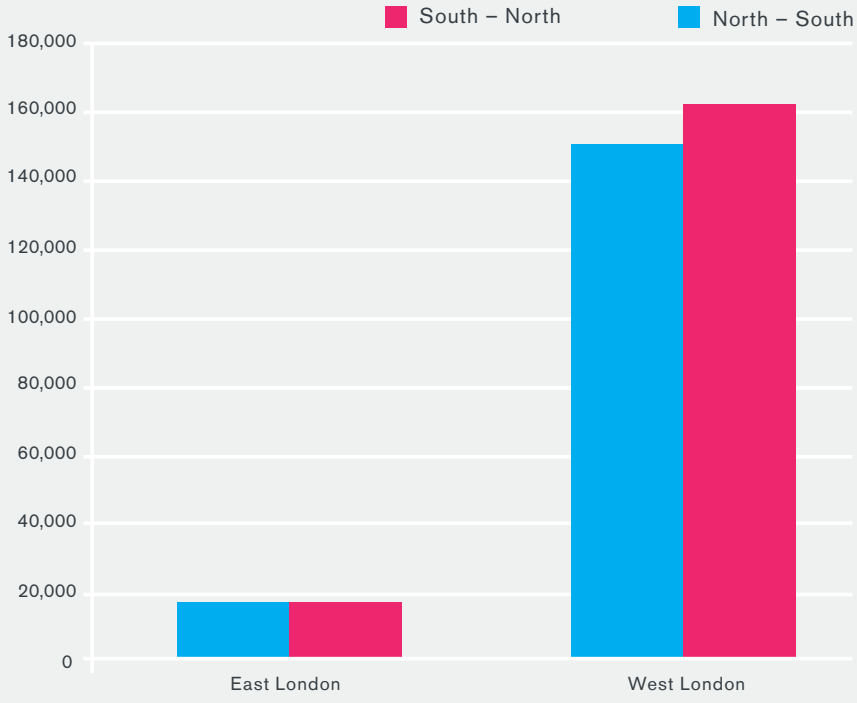
A series of new river crossings in east London to overcome the major barrier effect constraining the potential of this region (indicative cost: £1-2 billion)

A particular constraint in East London is poor cross river connectivity, which inhibits the regeneration of major growth areas, restricts local access, impedes walking and cycling and undermines the effective functioning of the road network.

There are 16 road bridges in the 20 miles west of Tower Bridge to Kew, while in the 20 miles eastwards there is only one road bridge and 2 (lower capacity) road tunnels.

This poorer connectivity is reflected in the relative volumes of travel that takes place between non-central London boroughs on either side of the river between those in the west and those in the east as shown in the diagram below:

Road trips over the Thames, not via central London



These existing crossings are also some of biggest bottlenecks in the UK. For example, the Highways Agency describes Dartford Crossing as the least reliable section of strategic road network nationwide.

A key priority is to deliver a package of river crossings in east London, in addition to the proposed Silvertown tunnel including Gallions-Thamesmead, Belvedere-Rainham shown below and in the longer term also further rail crossings, for example to Thamesmead.

Potential river crossing schemes in east London

Silvertown Tunnel
Woolwich Ferry Replacement
Gallions Reach: Ferry or Bridge
Belvedere Crossing
Four Lane Road
Two Lane Road

Transport Requirement 12

A new inner orbital tolled tunnel and series of mini-tunnels and decking over to help transform places across the city (indicative cost: £15-25 billion)

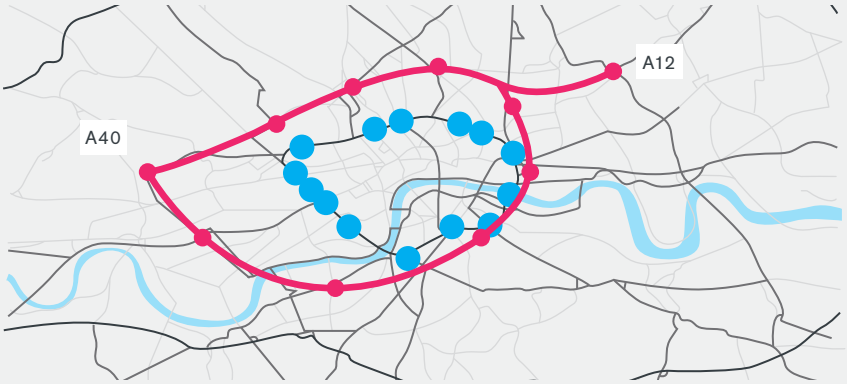
The conclusion of the Roads Task Force was that the provision of more space and/or more radical demand management measures (considered in the Innovation section) would be needed to tackle congestion and achieve other objectives.

The current Inner Ring Road – an amalgam of interwoven disparate roads developed over centuries – is congested and unreliable and is facing increasing pressures for change.

A replacement ring road, in the form of an inner orbital tunnel, could enable more efficient and reliable essential vehicle movement (reducing congestion in central London by up to 20 per cent) while freeing up space on the surface to vastly improve the public realm and significantly improve conditions for the most space efficient and healthy surface transport modes of walking, cycling and bus.

Illustrative inner orbital road tunnel

- City hubs/boulevards and iconic city quarters along the inner ring road
- Potential entry/exit portal locations (precise locations to be determined)

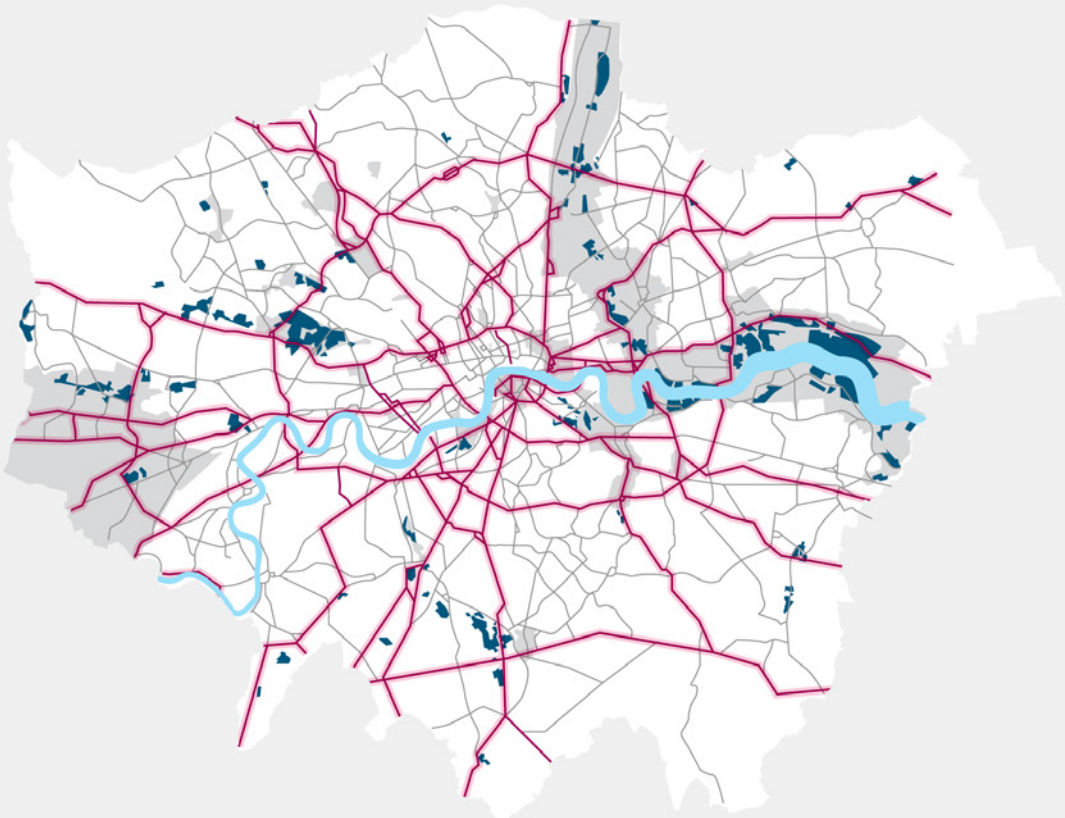


This would help fully unlock the potential of places around the Inner Ring Road like Old Street and Bricklayer's Arms and relieve pressure on Tower Bridge. The development of key areas such as these that straddle the Inner Ring Road could support 170,000 additional jobs and help extend central London agglomeration benefits.

Alongside this, we envisage a programme of enhancements – including flyunders and mini-tunnels – to tackle the worst of the congestion on the network, unlock other key development opportunities and, crucially, mitigate the impact of strategic roads on adjacent communities and create better places. This could include locations such as A2 Old Kent Road, A40 Acton, A503 Woodberry Down. Such an infrastructure programme will need to be accompanied by measures to lock in the benefits and avoid generation of additional traffic volumes.

Areas of the network being looked at for strategic enhancements

- TfL road network
- Borough road network
- Strategic industrial location
- Opportunity areas/ areas for intensification
- Area for further study



Summary of some of the key potential schemes to support the central London economy

	Increased off-peak services across network	Airport access connections	Next generation station schemes	→
	Crossrail 2	Next phase of tube upgrade complete	Congestion busting programme	Crossrail 3 →
	River crossings	HS2 Phase 1	Longer and more frequent Crossrail 1	HS2 Phase 2	Programme of flyunders →
	Updated Commuter Routes	24 hour tube	New hub airport	New tolled Inner Orbital Tunnel →

2020 2050

(Bi) GETTING THE MOST FROM EXISTING OR POTENTIAL GROWTH AREAS

We believe that the key output to achieve will be to deliver transport links that maximise the potential of London's Opportunity Areas, unlocking additional housing capacity equivalent to 10 per cent of London's current population.

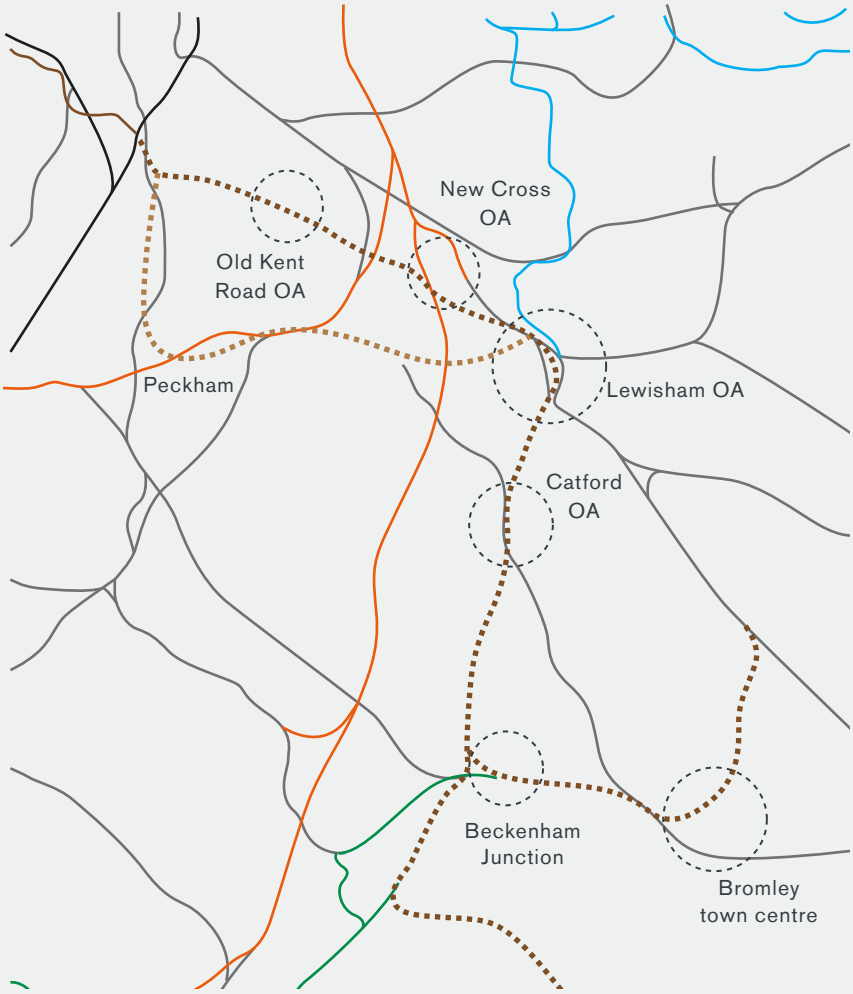
Transport Requirement 13

Extensions to the existing network to connect to areas with major development potential (Indicative cost: £2.5-3.5 billion)

Potential extensions to the existing network to unlock major potential for housing development range from major rail schemes such as the extension of the Bakerloo line, to extensions to the Overground. In unlocking development they also provide opportunities to secure funding towards the cost of their delivery.

An extension of the Bakerloo line will enable regeneration in a swathe of Opportunity Areas in need of regeneration in south east London from Old Kent Road to Catford as well as support development in outer London locations.

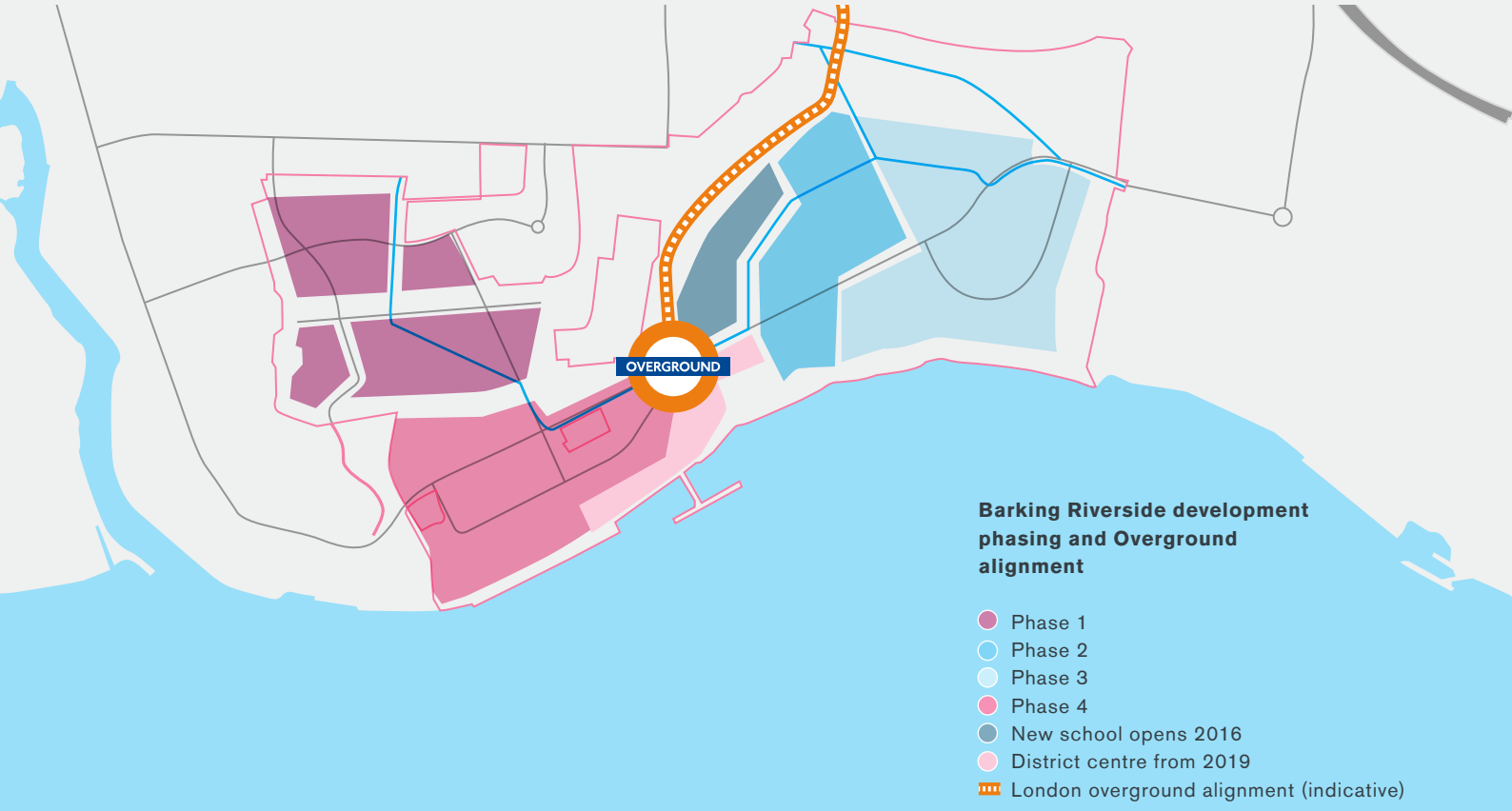
Possible routes for a Bakerloo Line extension



It would also release capacity on national rail lines to support improved rail services into London Bridge, helping deliver much needed wider improvements in south London (see south London Metro section below). The scheme has a Benefit Cost Ratio of 3:1 and it would also generate significant wider economic benefits through improving access to central London. The map above shows potential alignments.

Linked to this, a second phase upgrade to the whole line would support additional demand and could include full automation to reduce operating costs and optimise service operation. This would allow an increase in peak service frequency from 27 trains per hour to between 33 and 36 trains per hour, ie an increase of between 22 and 33 per cent.

Meanwhile there are a number of possible extensions of the London Overground network that could unlock significant development sites. An extension of the Gospel Oak to Barking Line to Barking Riverside is currently being planned to open up development of a major new quarter with 11,500 new homes. A potential further extension could involve crossing the river to Thamesmead and Abbey Wood where there are major regeneration needs and major opportunities for new housing development.



Another opportunity focused more on employment, is the 'Golden Mile' corridor in west London where over 20,000 people are employed in a wide variety of commercial organisations. New public transport links such as an Overground extension could help tackle the area's growing problem of road congestion and reinforce its attractiveness to business.

The Northern Line Extension to Nine Elms and Battersea, which will support 19,000 homes and 25,000 jobs could be further extended to provide a link to Clapham Junction, to provide better connections to this new quarter of London from the south west.

Alongside the development of major brownfield sites is a limited – but potentially significant – number of opportunities on land on the edge of the city where this is of relatively low amenity value and there is existing capacity or there are clear opportunities to provide connections to the existing transport system at a relatively low cost.

A new hub airport and the associated surface access infrastructure could transform development prospects in growth areas in east of London. While the airport itself would act as a major economic growth pole, new surface access links to serve it could catalyse large scale development in growth areas in East London and the Thames Gateway.

Transport Requirement 14

A comprehensive package of investment to maximise the potential of Opportunity Areas and integrate them into the transport network (Indicative cost: £1.5-2.5 billion)

London has a number of otherwise good opportunities for major housing developments that are constrained by poor transport provision. A comprehensive package of measures is needed to unlock these opportunities. They range from new road connections, such as new junctions on corridors such as the A13 to serve development sites like Barking Riverside, to additional carriages required on the DLR and urban realm schemes.

Opportunity Areas are in some cases clustered together in particular areas of London, such as the Lea Valley or former Docklands. Existing transport corridors in these areas are likely to experience substantial growth in demand from the cumulative impact of the growing population and jobs in these new areas and this also needs to be addressed more widely.

The four-tracking of the West Anglia route will be vital to meet the emerging wider needs of the Upper Lea Valley and enable a tripling of services on the corridor. This will also enable Crossrail 2 services to later serve the route, which will vastly improve connections to central London and beyond, and be key

to maximising the contribution of the area to meeting London's strategic growth challenge.

The Docklands Light Railway has been instrumental in unlocking growth and regeneration in east London, but now faces crowding pressures. In order to support further major development opportunities in East London, we propose that by the 2020s all DLR routes should operate with 3 cars. This will provide, for example, a 50 per cent increase in capacity on Stratford to Canary Wharf services, supporting further growth in Bow and around Pudding Mill Lane.

By the 2030s, further increases in capacity and frequency on the cross-river orbital routes from Lewisham and Woolwich to Stratford, and on the Beckton to Stratford route will be needed, for example to provide up to 15 trains per hour on each route. This will support further densification of Stratford as a major metropolitan centre and provide improved feeder connections into Crossrail. It will also support housing and employment expansion on the Isle of Dogs and in the Royal Docks, through providing total capacity in these corridors of 15,000 and 22,000 passengers/hour in each direction respectively on these corridors.

A programme of road corridor and junction improvements will be needed across London to mitigate the cumulative impacts of Opportunity Areas including the A13 in the east, the A406 North Circular, the A40 to serve White City and Old Oak Common and the A23 to serve opportunities in and around Croydon.

It is also vital that sufficient investment is made in more local requirements, in terms of place making and transport links such as bus transit links to surrounding areas. This will help ensure that these areas succeed as new London quarters and that they are properly integrated with – and benefit from – the wider areas of London surrounding them.

Transport Requirement 15

New and improved stations to act as focal points for development (Indicative cost: £500 million)

New railway stations on existing routes will provide vital access to the transport system and will unlock significant amounts of additional housing by improving the viability of sites in the areas surrounding them and acting as catalysts for development. They will also permit such development to take place at higher densities than would otherwise be the case.

Examples of potential new stations to serve development areas are at Cricklewood to serve a Brent Cross Enterprise Zone which could deliver 20,000 jobs and 10,000 homes, at Beam Park in Rainham where 4,000 homes will be unlocked and at Thames Wharf (between Canning Town and West Silvertown) which could support up to 9,000 new homes.

(Bii) Opening up wider opportunities across London for sustainable development

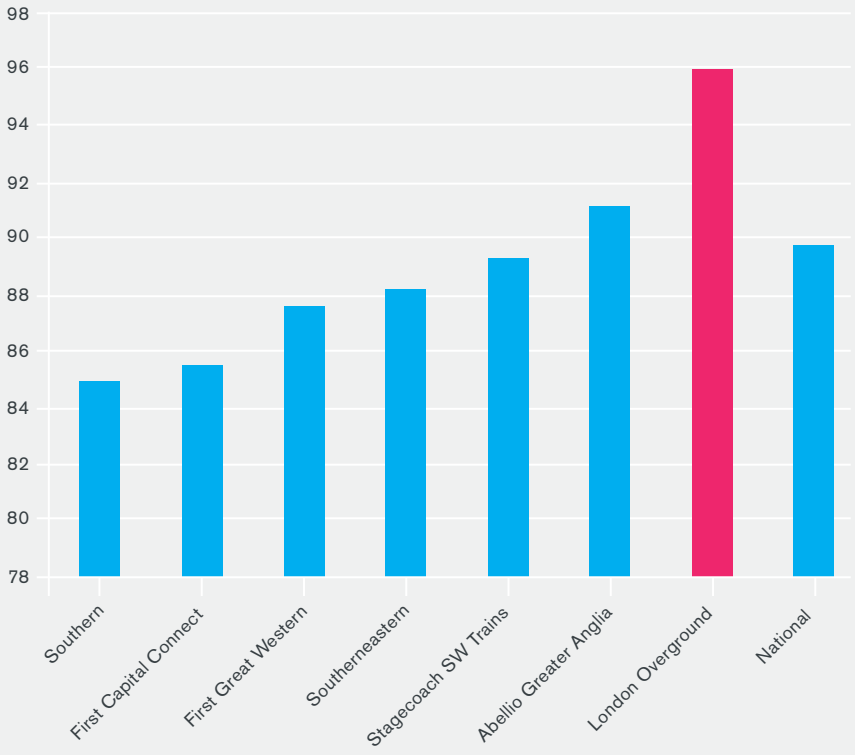
We believe that the key output to achieve will be providing an appropriate mixture of strategic and local transport infrastructure to embed sustainable travel patterns more widely across the city and enable high quality densification of existing areas of London to accommodate potentially over 1 million additional homes.

Transport Requirement 16

Further devolution of suburban rail networks into London (Indicative cost: £500 to £1 billion)

The benefits delivered through partial rail devolution have already helped triple the ridership of the London Overground and transform service quality and customer satisfaction. From being one of the worst performers in the country prior to its takeover, London Overground now significantly outperforms the major London suburban train operating companies on a range of measures. The chart below shows the punctuality performance of key London train operators for example[14].

Rail franchise punctuality performance



14 - Moving annual average per cent of trains meeting public performance measure for year to 21st June 2014.

Services on the West Anglia route are being transferred to TfL control and will become part of the London Overground network in 2015. Further devolution of powers would enable the Mayor and TfL to integrate the planning of rail services to meet the emerging strategic requirements of the city.

For example, devolution of some services currently within the South Central and Southeastern routes could facilitate a transformation in capacity and capability in south London as well as deliver a range of improvements including better station facilities and passenger information (see Transport Requirement 17 below). The Mayor and TfL will work closely with Network Rail and rail industry partners to ensure that network benefits and efficiency are maintained for the benefit of all rail services and users. A programme of devolution covering all of London's main inner suburban rail routes could be completed by 2030.

Transport Requirement 17

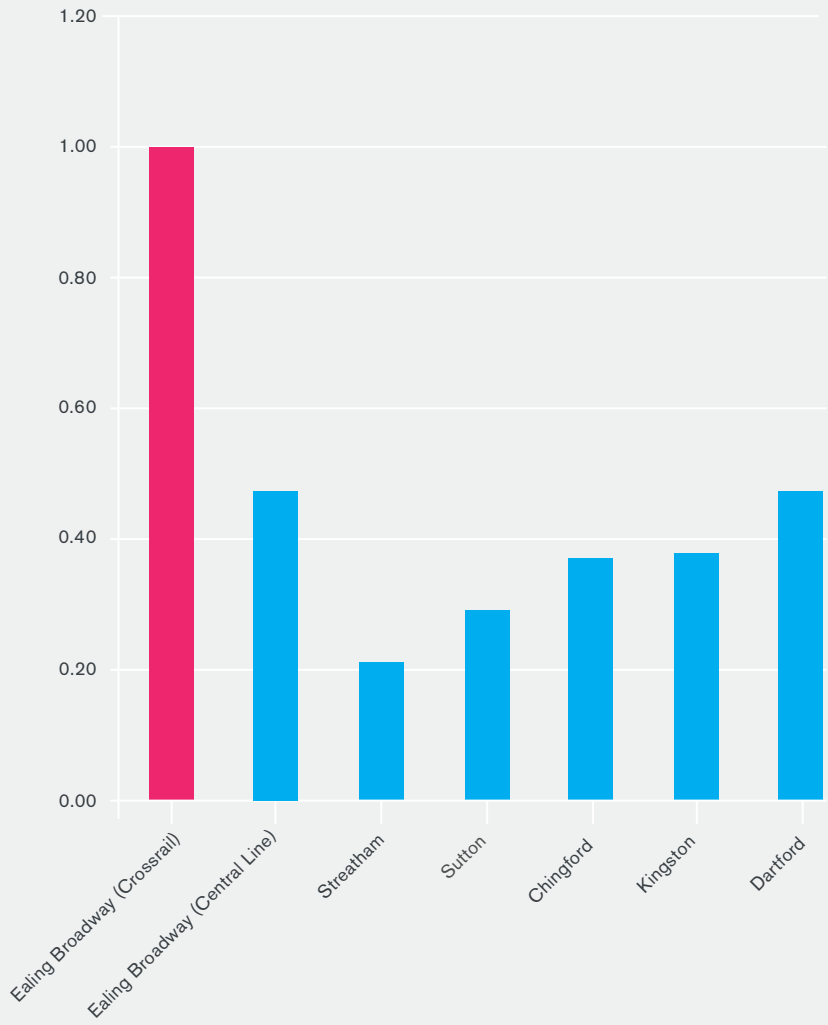
Extend high quality metro style services across the whole city, including a south London Metro (indicative cost: £1-2 billion)

London relies on its rail system for nearby connections as well as those further afield. With sufficient investment, capacity can be expanded to serve both these types of need while also improving reliability. Our aim is to ensure that no area of London is without fast, frequent and high quality metro-style services. While there is a comprehensive geographic spread of rail lines across London, key parts of the network suffer from poor train frequencies and slow journey times together with poor reliability as a result of constrained infrastructure.

The scope for transformation is particularly apparent in south London which is more dependent on its rail services than many areas on the north side of the river. Although there is an extensive and dense rail network in south London, the capability of the system is limited as a result of chronic underinvestment. Connections and journey times are often no better than in the 1930s when the area's railways were electrified. There is therefore significant scope for closing the gap between south London and better served areas in other parts of the city.

The figure below shows the speeds of journeys from selected locations to Tottenham Court Road relative to the speed of the journey, which will be available with Crossrail, from Ealing Broadway.

Average speeds of journeys to Tottenham Court Road (indexed to Ealing Broadway via Crossrail)



By 2030 our aim is that around 70 per cent of rail stations in the capital should offer a service running at least every ten minutes during peak hours.

Major new radial links into central London will play a vital role (including Bakerloo Line Extension and Crossrail 2). Further investment to improve the efficiency and capability of the rail system will however be needed to create a second underground network which caters for a broader range of needs including more orbital travel. This could involve simplifying services to create higher frequency services with key interchange points to allow travel between them, which will also help improve reliability.

This will allow, for example, higher frequency services out of terminals such as Victoria to south London centres such as Croydon and the development of major interchange hubs that act in a similar way to Clapham Junction for the south west eg Camden interchange between Camden Road and Camden Town stations.

Transport Requirement 18

Improved public transport connections and more sustainable travel options to support densification of existing suburbs (indicative cost: £2-3 billion)

There are already some key capacity constraints on inner London rail and bus services and some connectivity gaps which will need to be addressed. Significant additional investment will be required. The scale of this in relation to other requirements will depend on the extent to which the strategy to accommodate London's population growth is through densification in inner London.

Some examples of the types of scheme to help address these issues are an upgrade of the London Overground network to provide 6 car trains and new stations on existing lines, eg at Camberwell, that can plug connectivity gaps and act as development nodes.

It is clear that growth in outer London will bring particular transport challenges. However an approach to housing London's population that involves significant densification in many parts of outer London strengthens the case for providing much more comprehensive public transport, enabling more sustainable patterns of transport to be embedded.

Improvements to existing services will certainly be needed such as enhanced bus priority schemes and increased frequencies on Tramlink. It is also important that the design of developments and wider planning take buses into account at the outset. Depending on the scale of population growth envisaged in outer London, and the change in densities, more significant investment may be needed such as new high capacity rail-based connections including tram / light rail extensions, for example to Sutton, to bring about an overall improvement in the public transport offer in such locations.

In the longer term, there is potential for more significant expansion of the light rail/rail network to support higher densities. For example, there may be a case for providing some new orbital rail based capacity for key links in outer London. An option for doing this could involve an extension of Overground services in stages, creating some new links initially where most feasible and joining up existing routes over time. An indicative network is illustrated below. This is not included in the costings.

It is essential that the above public transport measures are supplemented with a transformation in provision for active travel modes (cycling and walking) including new dedicated infrastructure – see Transport Requirement 23.

Transport Requirement 19

A programme of targeted investment to help town centres adapt to their changing role as locations for city living (indicative cost: £2-4 billion)

Key to this will be the provision of a more diverse transport system with a focus on both large scale and fine grained infrastructure to ensure liveability and sustainable travel options (with space for parking cars likely to be increasingly limited in high density accessible centres). Care will be needed to create environments in town centres capable of attracting a balanced social mixture supporting successful communities.

The scale and nature of investment will need to reflect the scale of ambition in terms of the role of town centres in accommodating London's population growth.

A wide range of measures will be needed to complement major public transport improvements discussed above (Transport Requirements 16 to 18). These should include:

- Improved stations, as planned for example at locations such as Ealing Broadway
- High quality bus priority measures to boost public transport usage and provide seamless connections with rail and other modes
- Urban realm improvements – including a programme of over 100 new or improved public spaces for town centres and high streets
- Removal of gyratories that cause severance and environmental problems, as has happened, for example, at Tottenham Hale could help transform eg Catford
- Provision for active travel, including rolled out cycling "mini-Hollands" to cover at least half of London's main centres

(Biii) Opportunities for growth outside London

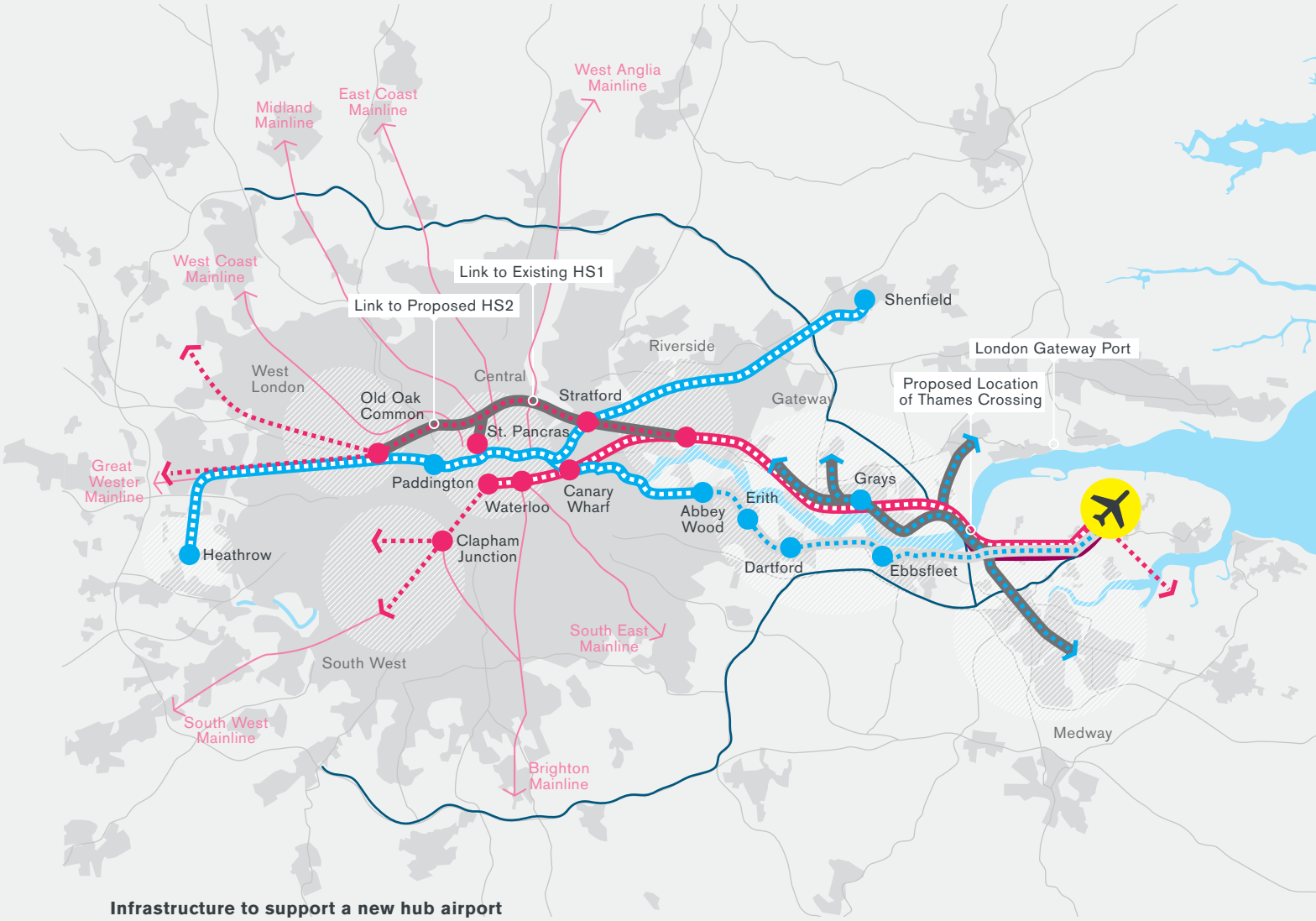
We believe that the key output to achieve will be enhanced rail connections to support population growth beyond London's boundary and promote local regeneration benefits, including around links to a new Inner Thames Estuary Airport

Transport Requirement 20

Maximising the benefits of new airport infrastructure to support population growth on key corridors east of London (costs covered in TR2)

A new hub airport east of London and the associated surface infrastructure would provide for a major rebalancing of the South East economy, helping tackle the regional inequalities that exist between the more prosperous but crowded west and the more deprived east, which contains many of the opportunities for housing growth. The new infrastructure could unlock major new opportunities for large scale development and the creation of new towns and suburbs. In this scenario these areas could play an important role in accommodating London's population growth.

Rick Mather Architects (July 2014), The Transforming City



Infrastructure to support a new hub airport

- Airport Express
- HS1 & HS2 Connections
- Potential Direct Line Connections
- Crossrail Extension
- Crossrail
- Local Rail Connections
- Existing Rail
- New Road
- Widened Road
- Key Development Areas

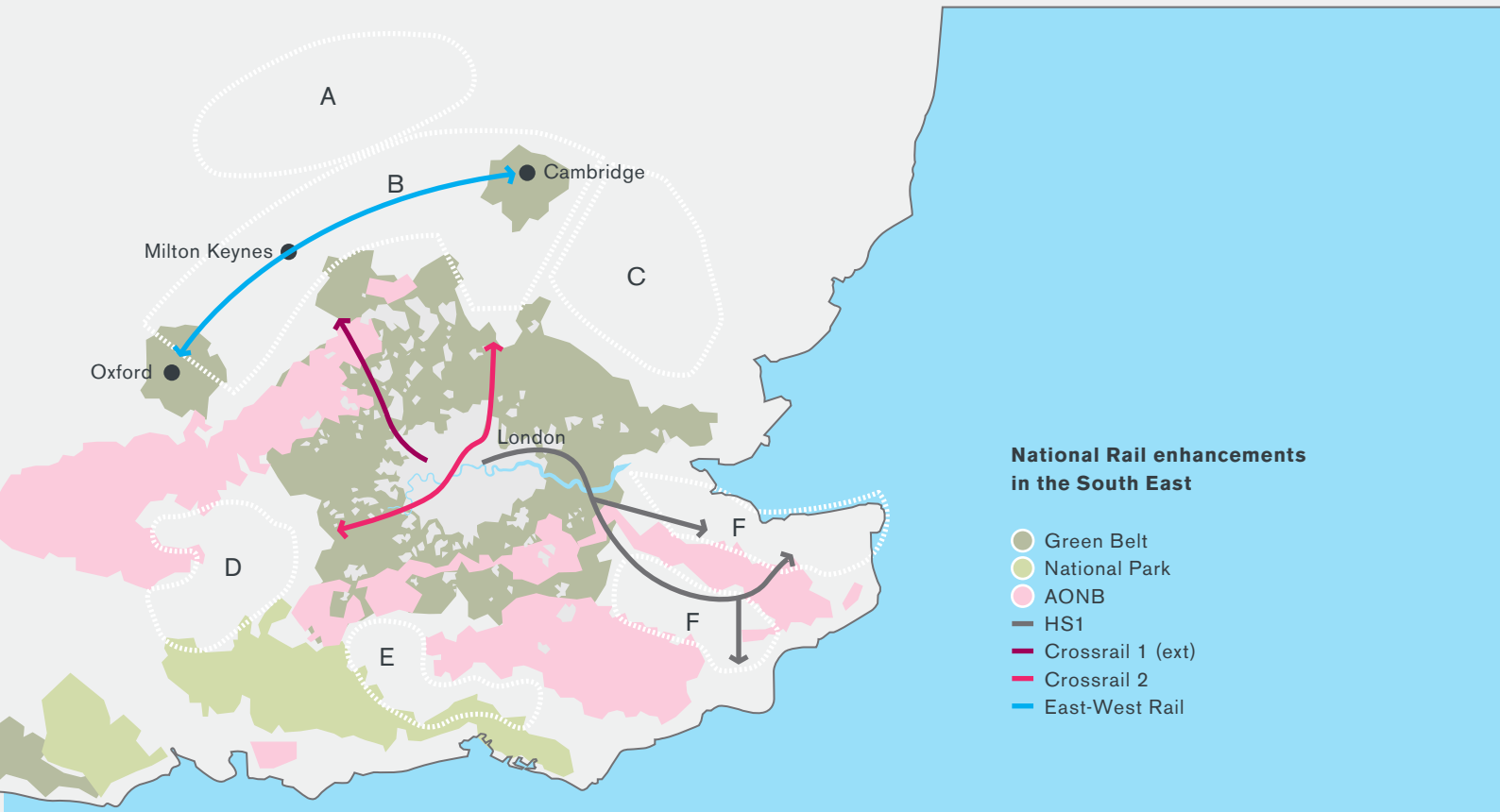
For example, in the case of a new hub airport on the Isle of Grain, supporting infrastructure would have a significant upward effect in terms of land and development values, enhancing viability of large scale projects and stimulating housing markets. It would have a positive impact on the labour market imbalance across London's regions. It would also enable a new Heathrow City with the potential to accommodate 90,000 homes and 80,000 jobs.

The case for schemes such as these will depend on the level of population growth that needs to be accommodated in other areas outside London. There is a range of potential opportunities for urban extensions and regeneration further afield, linked to rail improvements, including opportunities associated with either extensions to high speed lines (HS1 and HS2) or capacity on other rail routes relieved by them

Transport Requirement 21

A series of further national rail enhancements to create faster links or additional capacity to unlock growth in areas beyond London (indicative cost: £2-3 billion)

as highlighted in Transport Requirement 5. Another example is a possible extension of Crossrail east from Abbey Wood to support the development of the Ebbsfleet Garden City. Some of these are shown on the diagram below:



A: Northampton and Peterborough
Good quality land with many large sites already with permission including 5,000 unit urban extension at Corby and Wellingborough, 8,000 unit development u/c at Peterborough.
Potential for rail service improvements on WCML, MML or ECML (post- HS2).

B: The "Arc of Prosperity"
Major developments already around Milton Keynes and Cambridge supporting thriving local economies.
Potential for Crossrail extension to Tring and East-West rail to provide new rail options. Crossrail 2 could serve development between Chesunt and Cambridge.

C: M11 and East
Large are of relatively unconstrained land, some growth planned.
Limited transport opportunities.

D: M3 and M4 corridor
High house prices support urban extensions, good but crowded public transport links to London. Crossrail 2 could support some development.

E: Surrey and Sussex
Many environmental constraints but limited opportunity for additional development, Thameslink and Brighton Mainline improvements offer some potential for public transport improvements.

F: Kent
Fast journey times into London using HS1 but local rail links currently slow, potential line-speed improvements would support additional development especially on North Kent Coast, around Canterbury and towards Hastings.

Summary of some of the key potential measures to help house a growing London

	Overground extensions	Full rail devolution	Mini-Hollands fully rolled out	→
	Further upgrade DLR	London Overground 6 car lengthening	Extensive rail based orbital network	→
	South London Metro	Crossrail 2	Heathrow regional opportunity zone	→
	Gospel Oak to Barking line extension	Tram and light rail extensions	Bakerloo line extension	More extensive road decking	→

2020 2050

(Ci) Making the transport system more accessible

We believe that the key output to achieve will be to ensure the transport system enables all Londoners to access the full range of social and economic opportunities.

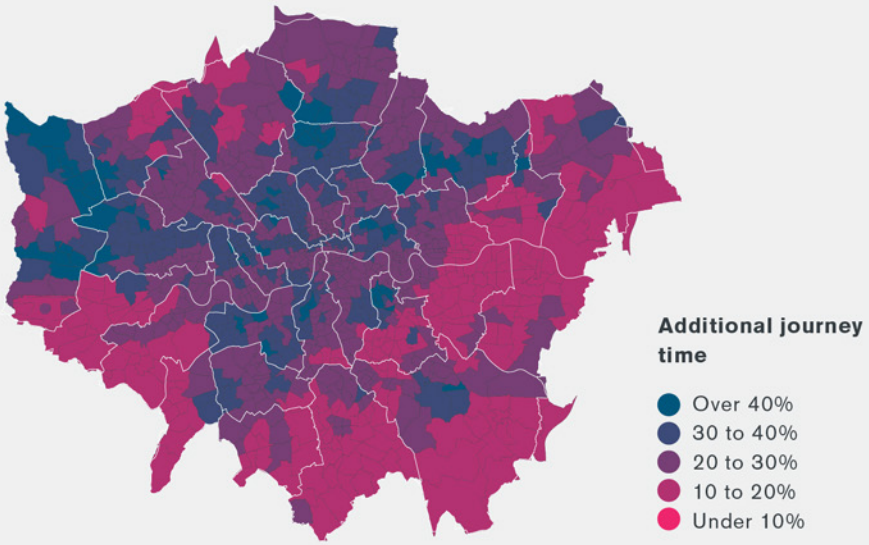
Even with the currently committed investment there remain significant time penalties for step-free journeys:

Transport Requirement 22

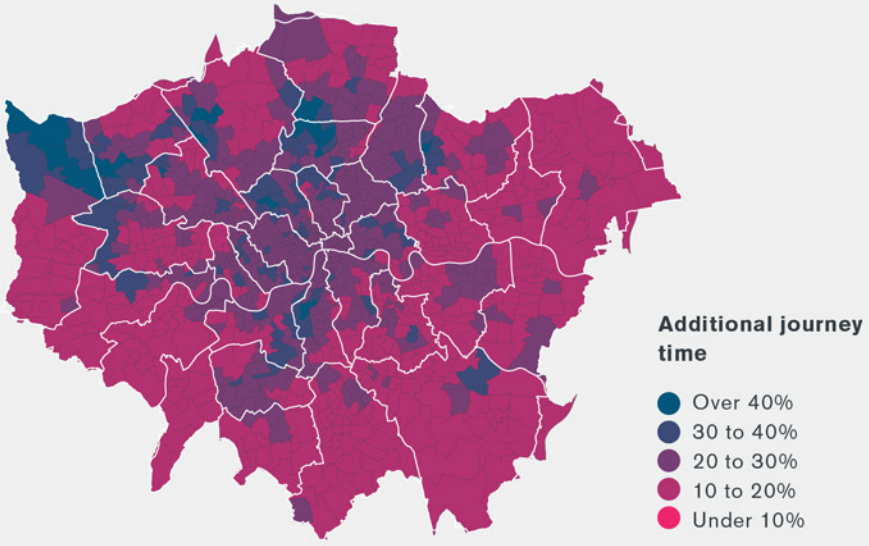
Enhanced accessibility programme to meet the needs of older & younger people, with two-thirds of public transport journeys step free by 2050 (indicative cost: £3-5 billion)

These maps compare...

With existing network

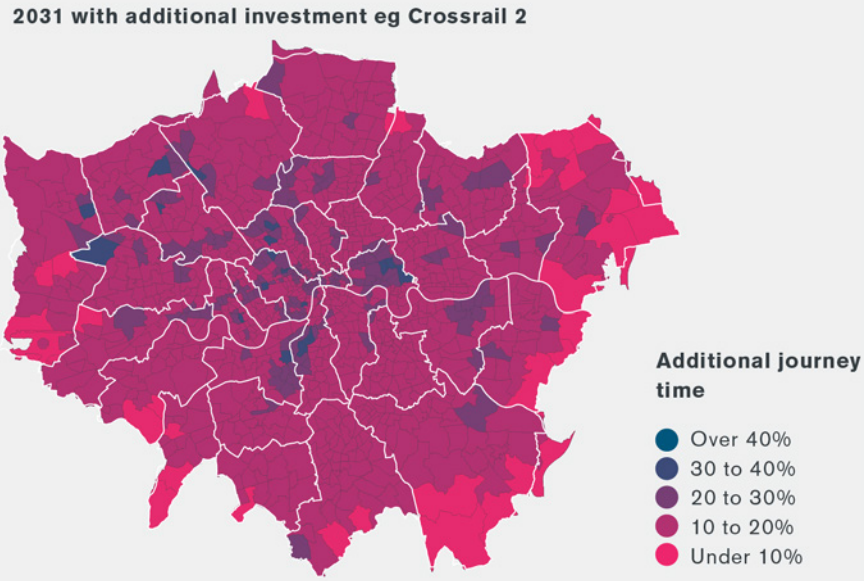


2031 with currently committed investment



These maps compare the avarage travel time from each zone to all others zones in London using (1) the full PT network and (2) the current step-free network.

The difference is mapped as the percentage increase in travel time using the step-free network.



The approach needs to ensure that people's whole journeys are accessible. This means continuing the infrastructure investment programme to make streets, bus stops, stations and interchanges physically accessible. Making the rail and Underground systems accessible is a particular challenge since the infrastructure is often historic and expensive to adapt.

Wherever possible, step free access will be delivered where new infrastructure or capacity enhancement projects are planned. For example, major capacity upgrades to key stations such as King's Cross St Pancras Underground Station have delivered step free access, while Crossrail will transform step free access to the heart of central London.

Beyond this, the plan is to address a series of 'critical gaps' in the system of step free stations. This will reduce typical differences between the time needed for step free and standard journeys across London, and could take the proportion of journeys on the R&U network that are fully step-free to over 40 per cent by around 2040.

By 2050 the aim is for around two-thirds of all public transport journeys in London to be step-free. The programme should continue in perpetuity until all feasible stations are complete.

(Cii) A more active transport system

We believe that the key outputs to achieve will be a city with consistently high quality public realm in which cycling and walking are the usual modes of choice for shorter journeys, with cycling's mode share for all trips increasing to at least 10 per cent.

Transport Requirement 23

A comprehensive network of high quality cycle and pedestrian routes (indicative cost: £2-4 billion)

Infrastructure for the future doesn't need to be high-tech or 'futuristic'. Making London more pedestrian and cycle-friendly is a forward thinking part of any plan, particularly given the potential direct public health benefits, for example in tackling obesity. Promoting higher levels of active travel – walking and cycling – is key to improving Londoners' health.

To enable this, by 2050 London should have a comprehensive, high quality cycle network catering for all journey types and cyclists of all ages. This should include 200 kms of new Dutch-style cycle highways, which will help remove significant barriers to cycling in London. There should also be better links for commuters, including provision for inter-regional cycle corridors, for example linking towns between London and Cambridge.

The proposals for the first substantially segregated Cycle Super Highway, between Belgrave Square and New Cross, remove intimidating and dangerous conflicts with other traffic. The scheme will also increase the footway area across the route by around a square kilometre, delivering significant benefits for walking.

These and other schemes will form part of a comprehensive programme of improvements for pedestrians at key pinchpoints and areas of high footfall that will help increase the sense of London as a permeable, well connected city for walkers.

This will be supplemented by a major increase in active green space in London of around 9,000 hectares and at least 5 new major pedestrian, cycle or green bridges that will help improve relative journey times for people using 'active' modes of transport as well as provide pleasanter routes.

Transport Requirement 24

A programme of iconic place-changing and greening schemes (indicative cost: £3-6 billion)

Addressing the competition between traffic and people for London's constrained roadspace will require a programme of bold, innovative and – in some cases – relatively costly interventions, although this is scalable and can be adjusted as resources become available over time.

In some cases the only realistic option for bringing about radical improvement will be to create new, separate capacity. A series of mini tunnels at key locations will release space on the surface for walking, cycling and 'living'. Some larger scale schemes may also be required, such as the replacement of the Westway with a new tunnelled route, which could be integrated as part of the proposed new inner orbital tunnel, described in Transport Requirement 12.

A programme of decking over and green bridges over arterial roads will reduce community severance, noise and community blight while providing space for eg housing development. Although this approach has not been applied widely to date in London, other cities have made more significant investment in such measures.

London's built and natural environment with its special character and diversity makes a major contribution to people's quality of life. Green spaces in particular provide opportunities for exercise and relaxation and contribute to Londoners' health and wellbeing. As well as a programme to green the city throughmore trees, we should see far more extensive corridors of green walls and network-wide green bus stops, and a series of green bridges in key locations.

(Ciii) Reducing the impacts of the transport system

We believe that the key output to achieve will be dramatic reductions in the negative impacts of London's transport system on people and the environment.

Transport Requirement 25

A pollution free transport system

By 2050 a vast increase in the uptake of Low Emission Vehicles across London and across all vehicle types is needed to replace the conventionally fuelled petrol and diesel fleet. An ultra Low Emission Zone established by 2020 should reduce air pollutant emissions in central London by half. Another stage in the transition to a pollution-free transport system will be the implementation of LEV technology to the entire bus and taxi fleets during the 2020s.

Further infrastructural investment will be required to help achieve challenging emissions targets at the London wide level, for example to support the uptake of ultra-low emission vehicles, based on electricity, hydrogen and other technologies and measures to support a greener Tube.

The levels of uptake required will only be achieved if a range of real and perceived barriers are overcome. A critical factor will be the provision of an adequate infrastructure network for refuelling, at the national as well as the London level.

Transport Requirement 26

'Minimal impact freight', including out of hours, consolidation, last mile bike freight, zero emission vehicles as the norm and increasing the role of rail

Infrastructural investment will also be required to support the development of 'minimal impact' freight and servicing for London. This will include investment in a network of freight consolidation centres so that deliveries into central London, town centres and other areas with highly constrained or sensitive road space can be reduced. For some types of freight and area, the impact of the final leg of the trip can be reduced through the use of last mile bike freight.

We will work with the boroughs, the freight industry and their customers to shift the majority of deliveries, collections and servicing activities to outside peak periods and zero emission vehicles should become standard during the 2020s.

Freight is also an important user of London's rail network. Rail freight makes an important contribution to reducing impacts on the roads and plays an important role in London's economy, traditionally bringing in products such as aggregates and removing waste such as Crossrail spoil. We must plan adequate provision for rail freight facilities to serve London's needs. There is the potential to build on the current LAMILO trial at Euston to bring in deliveries by rail at night to London's termini, with local last mile delivery by road.

The Thames will also continue to play an important role in transporting bulky material and the key network of wharves will be protected and enhanced.

Transport Requirement 27

At least an 80 per cent reduction in KSIs on London's road network by 2040, moving towards the elimination death and serious injury

Londoners and visitors to London deserve safe streets. Infrastructural investment, as part of a wider programme, will be key in taking us towards our longer-term ambition of freeing London's roads from death and serious injury.

The Infrastructure Plan must include a focus on getting road infrastructure right. More will be done to improve standards of cycle safety, including introducing safer and more innovative designs for junctions, roundabouts and traffic signals.

A step-change is also needed in the safety of freight vehicles. As technological capability increases, more possibilities to make London's streets safer will open with Intelligent Speed Adaptation and Autonomous Vehicles. By 2050 London's roads should be largely free from death and serious injury.

Summary of some of the key measures to help support a better, not just bigger, London

	Ultra low emission zone	Low impact freight distribution central London	Place changing road schemes	More extensive network flyunders	2/3 public transport journeys accessible	→
	Zero emission taxis	Electric buses	Green tube	Extensive network of Dutch style cycle highways	Ultra low emission transport system	5 major new pedestrian / cycle / garden bridges	→

2020 2050

(Di) Transforming the customer experience

We believe that the key output to achieve will be a transport system that offers the travelling public a seamless journey from door to door with integrated systems for payment, high quality real time information and more comfortable journeys.

Transport Requirement 28

Provision of seamless information and integrated systems for users

Although customer satisfaction is currently at record levels, our customers can be expected to be ever more demanding. We will need to meet ever increasing expectations in terms of quality, convenience, experience and technological integration.

Communications technology has progressed rapidly over the past 25 years transforming many aspects of daily life, including the provision of information to our customers, as well as in ticketing. Over the coming decades there are likely to be major opportunities for further extending its role and in particular for personalising the travel experience of our customers, widening their choices and increasing their sense of personal control over their travel in the city.

Integrated ticketing has already shown its value in improving public transport services, making them more attractive and driving operational efficiency. More scope exists to deploy existing technology, for example the use of bank cards for all travel (which is already starting to be rolled out on key services).

Providing high quality real-time information to customers and road users is core to making modern cities work. Rising customer expectations, particularly in the area of 'personalised' information, and rapidly advancing technology will continue to drive change in the way information is provided and consumed.

Furthermore as customers increasingly rely on communications technology to personalise their journeys, fine grained information about their travel behaviour will become available to planners, helping them inform the way that transport is provided.

Free, open data from transport providers on the status of transport and on other datasets such as road safety, will continue to power new and innovative products and challenge traditional thinking on solutions to transport challenges.

Transport Requirement 29

Delivering a cooler Tube (indicative cost: £900 million)

Historically the Tube system has been uncomfortable for passengers during hot summer months because it has not been possible to accommodate air conditioning equipment in the confined dimensions of a Tube train. The New Underground 'S' stock trains on the sub surface lines are being fitted with air cooling, while the next generation of deep tube trains (New Tube for London), will be the first to have air cooling – starting with the Piccadilly Line in the late 2020s. Work is also needed to remove excess heat from tunnels generated from higher numbers of trains and their cooling systems, through upgrading ventilation systems and bringing disused ventilation shafts back into use.

(Dii) Developing smarter assets and networks

We believe that the key outputs to achieve will be to embed new innovative technologies, materials, processes and design into London's transport networks and drive innovation in the delivery of new infrastructure.

Transport Requirement 30

Developing and rolling out smarter assets across transport networks and capitalising on wider technological/ business change

Firstly, we will make more widespread use of existing advanced technology. This includes:

– Continued development in the use of 'big data' and open data platforms enabling the current use of infrastructure systems to be analysed and future patterns of use to be predicted and potentially influenced

– 3D visualisation techniques in planning and designing infrastructure systems and in speeding up clearance after incidents

– Greater use of subterranean mapping, 'keyhole surgery' and other techniques to better plan and maintain infrastructure beneath the ground

– World leading traffic signal and traffic management technology which could help reduce congestion and revolutionise real time and predictive communication with vehicles and drivers

– Parking sensor technology which allows vehicles and fixed parking infrastructure to communicate, providing real time information about parking space and reducing traffic driving around searching and enabling more effective enforcement

We will also test emerging technologies and best practice, for example:

– 'Solar highways', which could be constructed to generate sustainable energy from embedded panels in the road surface, making use of the several hundred square kms of roadspace in London for additional purposes

– Kinetic pavements which can 'harvest' the energy expended by pedestrians and turn it into electricity. This technology is already in use in shopping centres and could in principle be applied elsewhere where there is heavy footfall

– Innovation in construction techniques, technologies and materials that may make possible the delivery of transport projects than we cannot necessarily envisage today and helping to reduce disruption and costs

– Capitalising on opportunities from eg 3D printing to reduce pressures on the transport system

Policy and regulatory responses will also be needed in response to opportunities and challenges associated with broader technological developments.

(Diii) Developing new ways of using and paying for transport

We believe that the key outputs to achieve will be a set of policy and regulatory frameworks to maximise the benefits and minimise the negative impacts of potential paradigm shifts in the way London's transport system is used and paid for by its customers.

Transport Requirement 31

New ways of paying for road infrastructure and use

The case for implementing a different user charging system for road use is likely to increase during the period to 2050. This will be driven partly by an increasing need to allocate the available road space more efficiently as the population and demands outpace capacity but also a need to find alternative sources of revenues as vehicle efficiencies and new fuel sources lead to declines in receipts from fuel duty and VED.

London's transport users are set to be benefit from the raised levels of ambition set out in this plan and a legitimate expectation will be that means are found for them to make a fair contribution to the costs. In this context the political acceptability of new forms of charging, eg distance related road user charging, may increase.

Transport Requirement 32

Development of a clear policy framework for the implementation of autonomous vehicle technology in London

As highlighted in chapter 2, vehicles able to drive themselves offer potentially promising solutions to some of London's strategic issues, such as constrained road capacity and parking space. However, a clear legal and policy framework will be vital if the potential benefits of this are to be maximised and potentially negative impacts avoided.

In order to permit the widespread adoption of AV technology on public roads a wide range of challenges will need to be overcome around technology, public perceptions and legislation and policy.

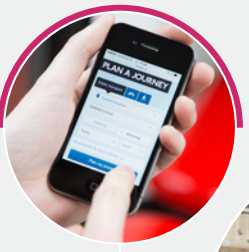
There could also be major opportunities for improving safety and operational efficiency and reducing costs in logistics by applying AV technology to goods vehicles.

New hybrid forms of public transport could be developed that bridge the gap in terms of service flexibility and user costs between buses and taxis.

Work is needed now to understand the potential policy implications alongside developing a programme to implement the required smart infrastructure to enable AV operation. There is likely to be a need for a central traffic control authority such as TfL to actively regulate and manage issues such as route choices, vehicle speeds and other day to day operational issues (and in this way ensure benefits are realised). Broader policy frameworks will also be needed, for example to deal with strategic land use and transport planning issues.

In light of these considerations there are important questions about how quickly London should and could implement the technology. The higher costs of early adoption could potentially be justified if AVs lead to comparatively high benefits in London due to higher values of time, poor air quality and congestion.

Summary of some of the key innovations to help develop the transport system of tomorrow



Click and Collect services | New logistics models | Limited driverless vehicles | Fully autonomous vehicles mainstream →

Seamless customer information | Autonomous features in vehicles | Fully integrated ticketing | Cooler tube | Changing road financing & funding | Smart assets eg kinetic pavements →

2020 2050

APPENDIX

1 – ANALYSIS OF SPATIAL SCENARIOS

2 – TABLE OF RAIL BASED SCHEMES

Introduction

This Appendix describes potential spatial scenarios that have been considered to support development of the Infrastructure Investment Plan 2050 (IIP).

The scale and distribution of jobs and population are important determinants of the scale of infrastructure provision across London, and this is especially the case for transport. As this extends well beyond the planning horizon of the London Plan there is uncertainty about how the growth will emerge spatially. There is a particular question about how London will accommodate 3 million more people by 2050, and the outcome to that question could make a significant difference to the infrastructure needed.

Given this uncertainty, we have considered various alternative spatial scenarios in order to determine whether these lead to significantly different infrastructure challenges, particularly as a result of variations in the distribution of London's population. These alternative spatial scenarios are, in effect, a series of 'what if' scenarios in order to identify the broad range of possible spatial outcomes.

We also considered a scenario in which some of the projected growth in London's population takes place outside the city's boundaries - this is described later in the paper.

Given the key role that the Central Activities Zone (CAZ) has within the London economy, we have not considered significant variations from the geographic structure of employment projected by the GLA, which reflects the spatial pattern set out in the London Plan projected out to 2050. However, we have considered the potential role of new hubs which might support CAZ-type functions.

The case for growing the central London Economy

It is clear that ongoing expansion of the CAZ will require major new investment in transport infrastructure. However, we recognise that the costs of these types of scheme to grow the central London employment market are particularly high, for example Crossrail alone is costing around £16 billion.

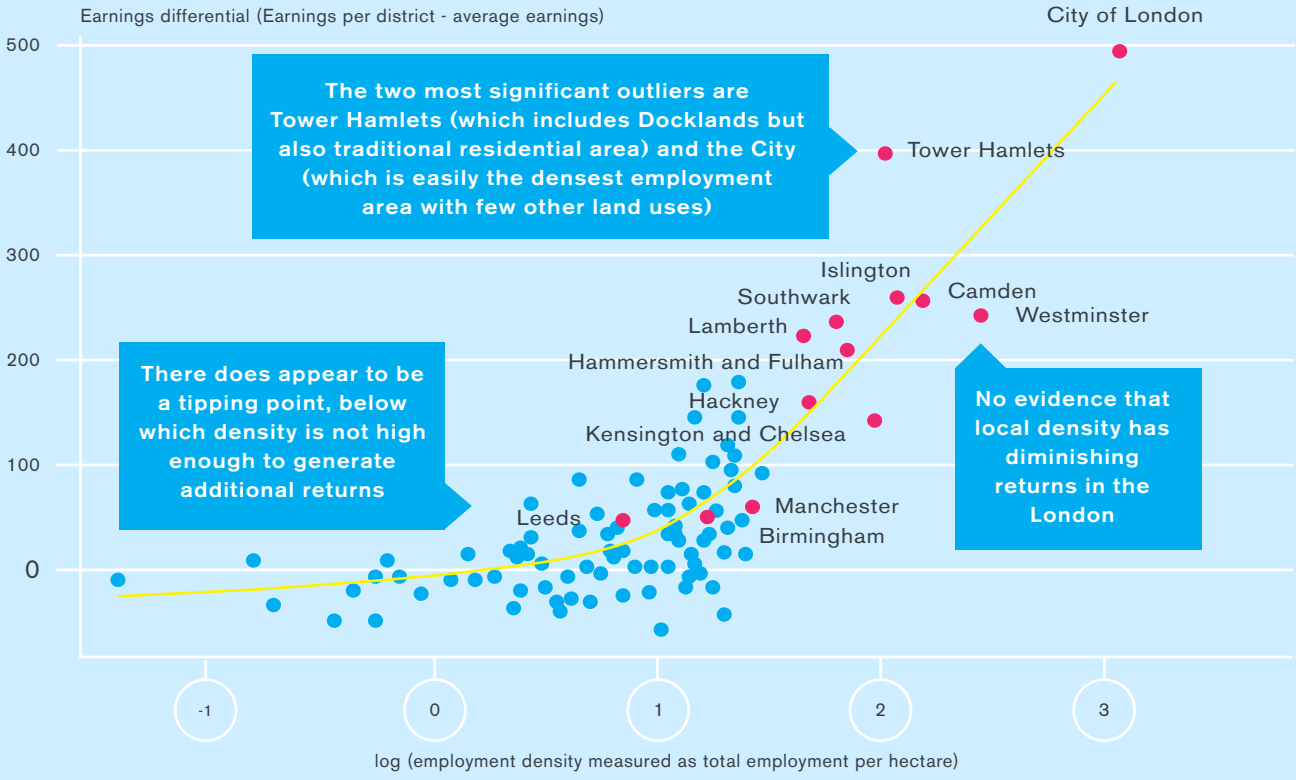
We have therefore looked at whether a more decentralised model of economic growth would offer any savings and benefits. This work (by Volterra) suggests that even if it was in theory achievable (which is highly questionable given the

trends of declining demand for office space in outer London and the realities of business locational decisions) there would be negative economic consequences with the loss of productivity from reduced agglomeration economies.

These would significantly (particularly over time) outweigh any savings from lower costs of infrastructure. There would also be adverse environmental effects with lower densities and more diverse patterns of transport that are more difficult to serve through public transport and higher car mode shares.

They also concluded that while the costs of infrastructure investment to support central densities are high, investment is still good value for money. Taking a simple calculation of the economic benefit of an additional job in central London and what it would cost to relieve the likely constraint on supplying

Earnings differential vs log employment density (top 100 UK districts by employment size)



it implies that at a constant wage differential that results from the central London location there is a ten year payback period for rail infrastructure investment[15].

In the chart above, returns are measured by wages, since this data is directly available and is a good proxy for productivity, particularly in services industries which are most concentrated in city centres.

15 - Different projects clearly have a variety of costs, but a mid-point of cost of rail infrastructure to support each additional work trip is around £150,000. This is entirely a cash calculation, with no allowance for inflation, discounting or productivity growth. In practice these on balance net out, so this is a fairly good rule of thumb.

A simple estimate of economic benefit can be based on earnings, which are the largest element in value added (GVA) although in principle profit should also be included[16].

Taking a weighted median for the central London boroughs which are part of the CAZ and Tower Hamlets gives an annual wage differential of just under £15,000 per year. This differential represents the benefit in wages in London compared to the median for the 150 largest UK centres in total, and is therefore based on urban wages.

As part of the initial development of the 2011 London Plan and 2010 Mayor's Transport Strategy, we examined the transport impact of relocating some CAZ jobs, together with additional housing, to four hubs: Stratford, Ealing, Croydon and Brent Cross/Cricklewood. We have updated that analysis in the light of the additional growth to 2050, though we have included a western hub at Old Oak Common rather than Ealing as the potential role of that site has evolved since the London Plan and Mayor's Transport Strategy were published.

The analysis was run as a 'what if' scenario, and is not offered as a scenario which is being promoted or expected to emerge under current trends and policy. The analysis was based on the following assumptions:

– Half of 2021-2050 central London job growth outside the Opportunity Areas is redistributed to the hubs, though Old Oak Common jobs were assumed to increase by 100k additional jobs with some redistributed from rest of London

– Population redistribution to Stratford, Brent Cross, Croydon of a quarter 2021-2050 population growth in the sub-region within which each hub is located. Half of the 2021-50 west sub-region growth was reallocated to Old Oak Common

The following main transport impacts were noted:

– Increases in highway congestion around the hubs, influenced by higher car mode share outside central area

– Small impact on network statistics London-wide:

  • Public transport demand slightly reduced compared with London Plan land use, with passenger km down 0.5 per cent

  • Small impact on central London cordon flows

16 - Using earnings as the proxy will underestimate the benefits of densification to the extent that profit margins are also higher in denser locations. There will be pressures in both directions. Innovation and scale will be pushing them up, while rents and competition will be pushing down. This will be a dynamic process, and one which creates significant measurement problems, and so the assumption has been made that there is no additional profit benefit.

– No significant changes to rail and LU crowding overall. Crowding increases on Croydon Tramlink

These conclusions were consistent with the findings of the earlier work carried out in support of the London Plan and Transport Strategy.

Given the important economic role of CAZ, as described above, and if it is assumed that role will remain just as strong in 2050, as reported by Volterra, then a potentially more plausible hub scenario would include only locations which are close to the fringes of CAZ. Significantly increasing the density of jobs at Stratford and Old Oak Common could in these circumstances have the effect of extending the CAZ and enhancing its economic strength, so long as the transport infrastructure is in place to ensure good fast connections which link these hubs to the central area public transport network.

Alternative Spatial Scenarios for Housing in London

We have examined a number of alternative scenarios for locating housing across London. The main purpose was to identify whether there would be significant variations in the transport infrastructure requirements.

All the spatial population scenarios reported below used 2031 as the base year, as it was considered reasonable to plan on the basis that London's spatial development would reflect the London Plan up to the 2030s. The analysis reported below therefore assumed a base population of 9.84 million, reflecting the GLA population projection to 2031. We have considered the following alternative means of increasing housing provision across London in 2050:

– Increasing densities in areas with good public transport provision

– Increasing densities in town centres with good public transport

– Renewal of suburban housing in areas with good public transport

Increasing Densities in Areas with Good Public Transport Provision

The London Plan encourages higher density housing provision in locations with good public transport accessibility, whilst taking account of local context and character. One of the aims of the Mayor's Transport Strategy is to increase the mode share of public transport, and establishing development in locations with good public transport accessibility will help achieve this aim. Increased densities at locations with good public transport provision brings together both spatial and transport aims, therefore the effect of increasing densities at these locations was explored as one of the scenarios for the IIP.

Method

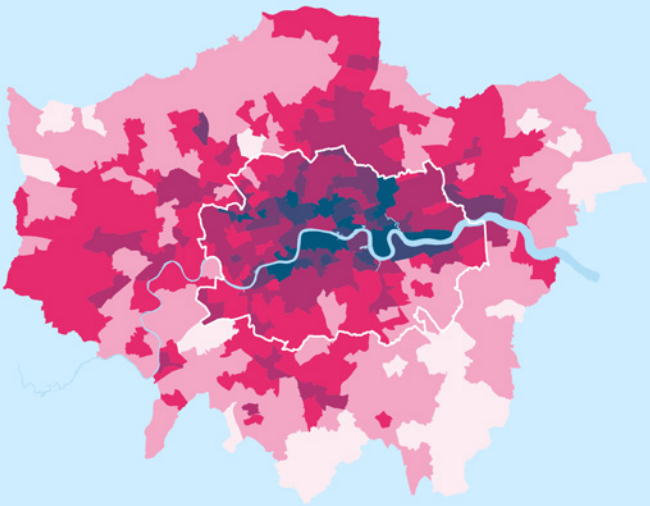
Public Transport Service Levels (PTALs) are used by TfL as a consistent measure of accessibility to the public transport network, taking into account walk access time and service availability. These are also used in the Mayor's London Plan as an indicator of public transport provision, and are a measure which is familiar to many stakeholders.

The analysis was carried out using a GIS system, which brought together housing and PTAL data. The future PTAL values were calculated on the basis of the funded and committed transport network, including, for example, the London Underground upgrade programme, Crossrail 1, and the Department for Transport's (DfT) HLOS2 rail improvements. Areas with PTALs higher than 4 were treated as within scope and housing densities at these locations were increased to comply with the density matrix in Table 3.2 of the London Plan. Target densities were estimated as a mid-point within the Suburban, Urban and Central categories, therefore one mid-level value was applied for each of these categories.

A second version of this scenario was examined in order to assess the impact of additional major schemes currently being planned, including Crossrail 2 and the Bakerloo line southern extension. The effect of this scenario was to improve the PTALs to level 4 and above in areas served by these lines, therefore bringing new areas into scope. It was estimated that this scenario would increase the population level by a further 150,000.

Potential

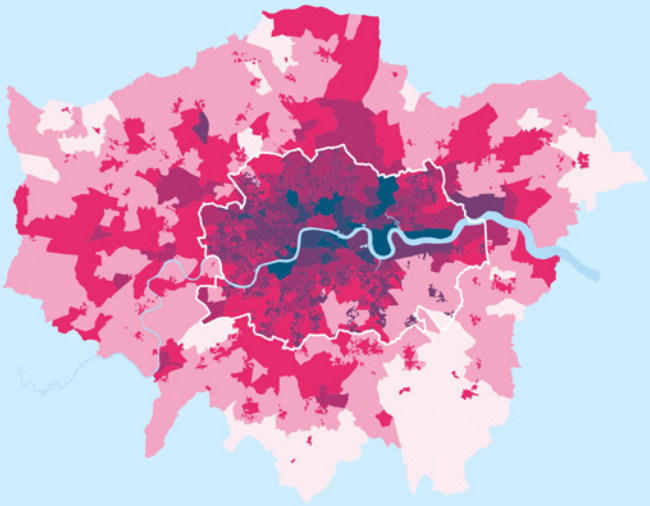
The following maps compare the GLA trend-based spatial distribution, comprising the population projection supplied by the GLA, with the PTALs-based spatial distribution described above. The GLA projection reaches a population of 11.27 million, with similar growth between 2031 and 2050 in inner and outer London at 16 per cent and 14 per cent respectively. The PTAL-based scenario reaches a population of 11.24 million with inner growth at 30 per cent and outer London growth at 4 per cent. The PTALs-based scenario concentrates the post-2031 growth on inner London, reflecting the generally higher level of public transport provision in inner London.



Trend-based 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75



PTALs-based 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75

Transport Impacts

Compared with the trend-based scenario, intensifying housing in areas with good public transport connectivity results in small but positive transport impacts. Public transport demand increases by over 100,000 trips (about 1 per cent higher growth) and a slight reduction in car use (about 1 per cent less car kilometres). Despite the increase in public transport demand, there is a small reduction in crowding, as a result of a small (2 per cent) reduction in average trips lengths by public transport.

Increasing Densities in Town Centres

This section looks at how intensification of uses within London's town centres could increase housing supply.

Planning policy in London emphasises the importance of town centres being a focus for commercial development and intensification. The Further Alterations to the London Plan encourages residential led, high density, mixed-use re-development particularly in centres with a surplus of retail and office floorspace. The Portas Review, government's response to it and the reports of the Outer London Commission, have highlighted the long term challenges facing town centres.

Research suggests that the impact of internet and multi-channel shopping could have a positive effect on attractive, large centres (Metropolitan and some Major centres) where the projected growth in floorspace is expected to be concentrated. Smaller centres (local/Neighbourhood) are best placed to meet the continuing need for convenience goods and services. Centres which are expected to experience the greatest challenges are medium sizes centres – mainly District and some Major centres. While it would be expected that only the smaller Major centres would be experiencing the greatest challenge, the London Plan does not differentiate within the categories. Therefore this analysis focuses on the potential for all District and Major town centres to be intensified through increased residential density.

Town centres often already have good public transport connections and include important services nearby, including health, education and civic facilities together with a retail offering. They therefore provide an opportunity for sustainable development including car-free or car-lite development. An increased resident population will also help support the retail sector within these town centres. High density development will enable the provision of a range of different housing including the private rented sector, smaller households, housing for older people and other specialist housing. There is a particular opportunity for increasing the amount of housing above other uses including retail, car parking, leisure and civic uses.

The decline in the office market in many major town centres offers additional opportunity for intensification. While changes to Permitted Development mean offices can be converted into residential without planning permission, this often results in poor quality housing and does little to improve the urban

environment of town centres. Instead, greater emphasis should be placed on whole-scale redevelopment and increased residential density.

There is therefore substantial opportunity for higher density mixed-use development around town centres in the mid and long term. Many of these locations may be small sites which are sometimes not identified in assessments[17].

Method

This analysis has assumed that all District and Major town centres are within scope for increasing residential density. Due to the varying nature of town centre boundaries the analysis is based on the LSOAs that encompasses the town centre. Dwelling densities are applied to these locations based on PTALs within Table 3.2 of the London Plan. For Major town centres the 'Central' setting is applied and for District Centres the 'Urban' setting is applied – in both cases median level densities for the relevant PTAL are used.

Some town centres already have residential densities at or exceeding London Plan standards – in these locations it is assumed there will not be any additional development.

Practical Considerations

There is no one size fits all solution for all London's town centres so any intensification would have to take account of the particular needs and characteristics of the individual town centre. However, in all cases, there will be an importance in creating high quality environments increasing the attractiveness of the town centres for all users.

Partnership between the community, businesses, property owners and statutory authorities will be particularly important in town centres. Some centres may need to contract their retail offering so development should aim to consolidate rather than divide centres.

Town centres are not just about retail; only about a quarter of town centre employment is retail. Some of the remainder is office and services but Low Threshold Enterprise Spaces (LTES) are also important. LTES are particularly vulnerable to conversion and re-development so care must be taken to protect these uses where appropriate. Due to the substantial variability in characteristics of town centres a detailed understanding of the nature of uses will be required to target development in suitable locations and where necessary

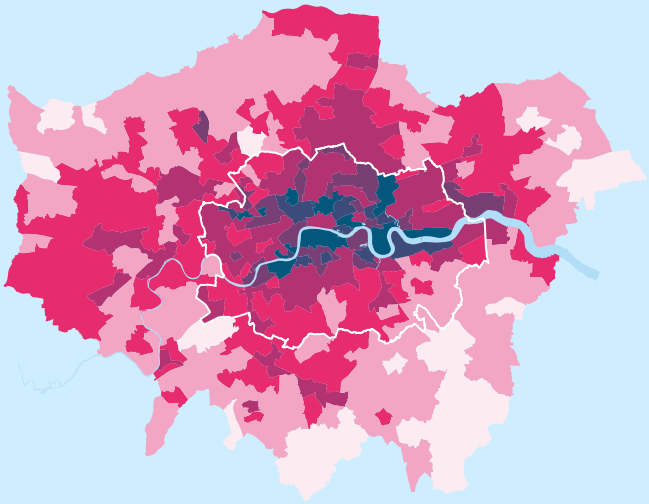
17 - CPRE (2010) Untapped Potential

incorporating or facilitating affordable employment space.

Intensification will be not just about increasing housing density, redevelopment and re-provision of non-residential uses will be equally important. Therefore our analysis has not changed existing assumptions on employment and other services and instead estimates the impact from just increasing town centre resident population.

Potential

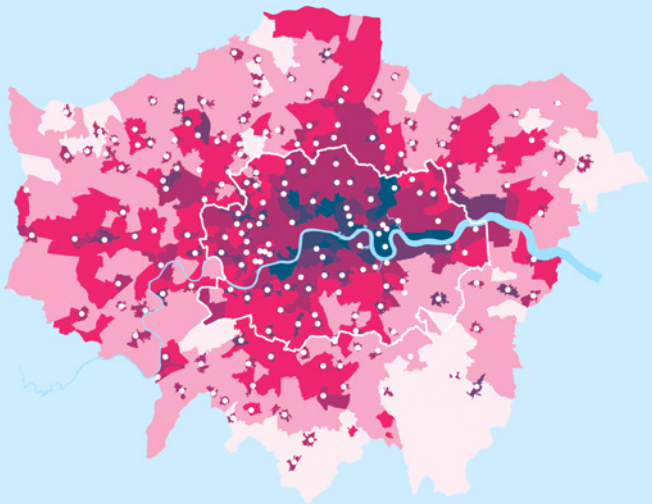
The following maps compare the GLA trend-based spatial distribution with town centre intensification described above. Town centre intensification, as calculated for this study, increases London's population to 11.21 million with inner London population growing by 11 per cent and outer London growing by 16 per cent. This distribution is influenced by the greater number of town centres in outer London.



Trend-based 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75



Town-centre intensification 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75

Transport Impacts

Compared to the trend-based projection there are only small changes in transport demand, with an insignificant slight shift in demand from rail to Underground (a 1 per cent shift in passenger kilometres on rail and Underground), possibly reflecting the location of the Major and District town centres.

Renewal of Suburban Housing

This section looks at how densification of suburban London might contribute to an increase in housing supply.

Much of the reason for London's low population density is the low housing density within outer London often characterised by under-occupancy. Large parts of suburban outer London are of variable quality and have performed less well than inner London economically[18]. Where there is good or improving public transport accessibility, there may be potential for densification which will also help promote economic activity, improve local service provision and enhance value.

Previous work has explored the potential for densification in outer London. The Supurbia project[19] calculated that if just 10 per cent of semi-detached housing in outer London were fully occupied rather than part-occupied that could accommodate an additional 100,000 people. Further, if 10 per cent of semi-detaching housing was redeveloped at twice the density this would accommodate a total of 400,000 new homes. In locations with appropriate public transport, new development, at double the existing density, would be within the London Plan sustainable residential quality density matrix.

Our work has explored how densification of London's suburbs could change the spatial distribution of new development and hence population within London.

Outer London is home to 60 per cent of London's population[20] and has many qualities that are attractive to residents including individual homes on their own plots with often good access to open space. The Outer London Commission identified the benefits of growth in outer London though made clear the importance of 'place shaping' and ensuring new development fits in with local needs and heritage. The Commission recommends encouraging mixed use development and support for high quality design and appropriate development densities. Provision of smaller households is important in outer London and the Commission also recommended a closer look at housing densities and accessibility.

This analysis focuses on housing built between 1930 and 1939. Given the age and scale of the interwar suburbs and the fact that much of the housing was not built or planned to the best standards this may be a category of housing vulnerable to potential decline[21]. Some suburbs will not last forever and there may be future opportunities for rebuilding and intensification[22].

18 - Economist (2013) Suburban London: Trouble in Metroland. 24 April 2013
19 - HTA Design (2014) Supurbia – A study of urban intensification in Outer London
20 - Outer London Commission (2010)
21 - GLA (2006) City of Villages
22 - Peter Hall (1989) London 2001

Increased jobs in outer London should be promoted, though new development would help support existing jobs and also create new jobs – work by Volterra noted the relationship between number of people working in the CAZ and local jobs (230 new locally based jobs for every 1000 extra population). It is assumed that denser populations would result in lower car ownership and increased walking/cycling and use of public transport – in effect outer London becomes more like inner London. Densification of London's suburbs would therefore help support the local economy and particularly town centres.

Method of identifying spatial distribution of densification

Housing units built between 1930-1939 were identified as being within scope for densification. Within this, those locations with a residential density of less than 30 dwellings per hectare were identified as having some scope for densification. This density is below the minimum residential density identified in the London Plan which is 35 units per hectares where PTAL is 0 to 1. Densities were assumed to be increased slightly by 25 per cent across all areas with less than 30 dwellings per hectare. This would result in densities that while higher may still not be within the minimum London Plan standards. The density uplift assumed enables London's total population to achieve the 2050 central population projection of 11.3 million.

Practical Considerations

Ensuring densification and development of sustainable communities is likely to require new delivery models. The Supurbia principle outlined how an area of semi-detached housing could be converted over time dynamically to an area of townhouses, apartments, dedicated older person housing and individual dwellings. Densification could also be achieved through a mixture of less comprehensive methods including infill development and conversions. However, this may raise tensions with existing policy, eg to protect garden land and conversion of single unit houses to flats may not always be practicable/suitable so high quality design, community engagement, fiscal incentives and changes to planning policy would be pre-requisites.

Development must fit with local needs and character – design should be sensitive to ensure that intensification enhances rather than detracts from local character and heritage. Investment in local infrastructure and services would be required to take account of additional population growth

across parts of outer London. Densification should be sensitive to heritage assets including conservation areas, listed buildings and open space.

Compared to inner London, there are higher levels of car dependency and use in outer London, congestion on key sections of the highway network and in many places a lower level of public transport provision. Densification would look to focus on areas with existing or future public transport provision with good PTALs with an aspiration to reduce car ownership through take up of modal shift to sustainable transport. Further transport improvements would be required to support a large population in outer London for example in terms of improving orbital movement.

There is substantial variation within Outer London both in terms of form, demographics, economic performance and relationship with London. Outer London does however offer an adaptable and flexible built form together with opportunity for increased but well considered development. Further work exploring the potential of densification of outer London's suburbs needs to take account of this.

It is clear that all this will bring particular challenges in outer London. Existing patterns of development there do not generally support comprehensive public transport provision and growth could lead to significant increases in congestion and environmental and other impacts eg the traffic delay rate could potentially increase by 35-45 per cent over this period.

Nevertheless if London is to accommodate a large proportion of its future growth within its boundaries, outer London will need to accommodate many more people through densification. This could be achieved through a wide variety of means. In principle there is scope for accommodating a substantial proportion of London's growth. For example:

– If 10 per cent of semi-detached housing in Outer London was fully rather than under-occupied it could accommodate an additional 100,000 people

– If 10 per cent of semi-detached owners took up full development rights (Permitted Development) this could contribute 120,000 new homes[23] (6,000 homes per year)

– 100,000 dwellings could be built on small (micro) sites[24] within London (CPRE, 2010)

23 - Figure is per annum, assumed to be over a 20 year period

24 - Defined as less than 0.5 ha, based on 2007-17

There is also scope for some redevelopment of whole blocks of poorer quality, low density housing in struggling areas of outer suburban London to deliver very large uplifts in provision.

For example, over a twenty year period redeveloping 0.5 per cent of London's semi-detached houses each year to double density could increase supply by 400,000[25] new homes, ie 20,000 new homes per year. Other opportunities for densification include redevelopment of low density retail parks.

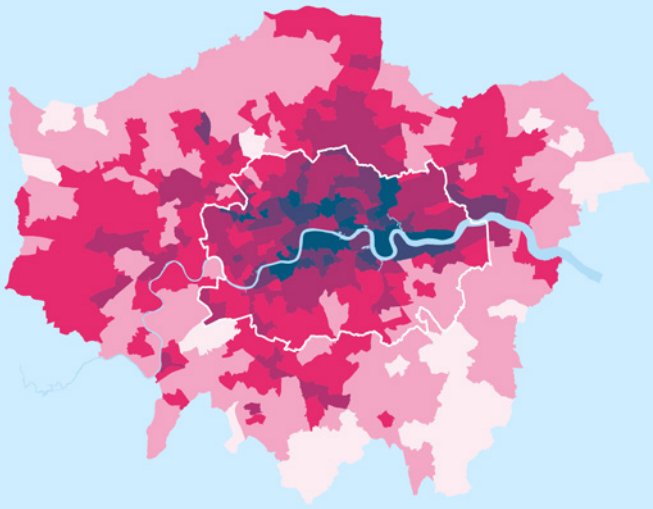
An approach to housing London's population that involves significant densification in much of outer London strengthens the case for providing much more comprehensive public transport, enabling more sustainable patterns of transport to be embedded.

Potential

The following maps compare the GLA trend-based spatial distribution with the spatial distribution resulting from suburban housing renewal described above. Suburban renewal, as calculated for this study could increase London's population to 15.89m, resulting in 2031-2050 growth of 34 per cent in inner London and 79 per cent in outer London, reflecting that much of the housing in scope is located in outer London.

However, as this significantly exceeds the trend-based population estimate, the population total was capped at 11.3 million in line with the central trend projection, and also to provide an alternative distribution on a comparable basis to the other scenarios. This version of the scenario with the population capped at 11.3 million resulted in inner London population growing by 6 per cent and outer London growing by 21 per cent. Therefore this scenario presents an interesting alternative distribution to the other scenarios, with a distinct bias towards population growth in outer London.

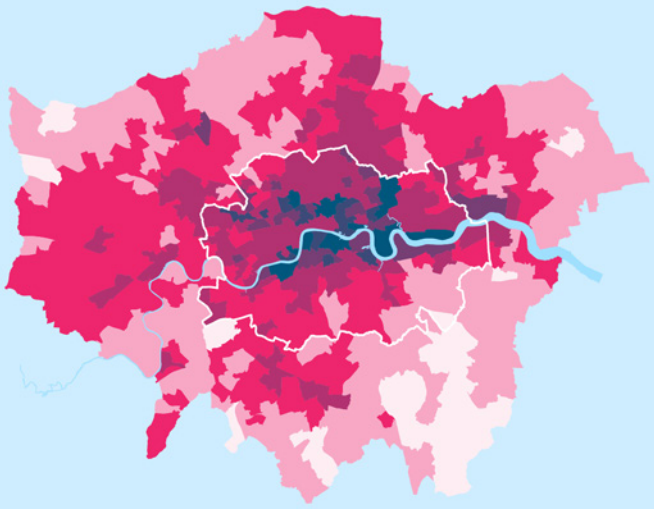
25 - Defined as less than 0.5 ha, based on 2007-17



Trend-based 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75



Suburban-renewal 2050 projection

(Population density per hectare of residential land)

- Over 1,000
- 750 to 1,000
- 500 to 750
- 250 to 500
- 150 to 250
- 75 to 150
- 0 to 75

Transport Impacts

Compared to the trend-based population projection, the increased population in outer London would lead to extra car trips across London (an estimated 80,000 more car trips or 1 per cent higher growth), and a small reduction in public transport trips (less than 1 per cent lower growth). There is slightly more growth in highway demand in outer London and less in inner London (about 1 per cent difference).
There is a small shift in demand from rail to Underground, which could be the effect of less demand in inner London making the Underground relatively more attractive for outer London residents. Average trip lengths on public transport within London are slightly higher, as a result of the more dispersed population.

Beyond London – Increasing Housing Densities in Existing Urban Areas

The above scenarios outline various options for providing a step change in new housing provision in London. It may be the case that individual or combinations of different options will not prove feasible to deliver the amount of new housing London is forecast to need. In line with the National Planning Policy Framework consideration should therefore be given to how housing need could be meet in adjoining areas.

Many local authorities in the Rest of the South East (former South East and East of England regions) are expected to deliver substantial new housing development. Much of this development will be focused on brownfield development sites or urban extensions. While there are other options for providing additional housing in the Rest of the South East (RoSE) including larger urban extensions or garden cities, emerging ideas on this are being led by central Government and we will consider the implications and potential when proposals emerge. We have considered opportunities for densification of existing urban areas, such as South East coastal towns.

Many urban areas in the RoSE have experienced population decline even while new housing has been built in these areas. Population decline has been a result of declining households in more established urban areas especially those that have experienced economic difficulties. Within the RoSE some areas have suffered recent decline: the combined local authorities of East Sussex, Kent and Medway have an economic profile almost identical to the North East region in terms of population and GVA[26]. Similarly, these locations in the RoSE have suffered the effects of declining manufacturing/industry, reliance on the public sector and high levels of deprivation.

Current residential density in many of these urban areas is low, even near public transport or within established centres. By focusing on the more deprived areas there is potential to increase density providing improved accommodation for residents in a wide range of housing types and in different tenures.

Providing better rail journey connections to these locations would support regeneration, for example, of seaside towns on the south coast. Central London commuters would generate local demand for services and local employment just as they do in London. While there are significant numbers of medium and long distance commuters in locations served by fast inter city routes north and west of London, from places like Peterborough, Swindon and Rugby, many areas to the south and south east that are a similar distance from London have fewer such commuters because of relatively poor rail connections.

26 - South East England Councils (2011) Deprivation and public sector reliance in the South East

Assessing the Potential for Housing London's Population in the Region

Locations were identified as within scope for densification based on the following criteria:

- Existing urban area to discount both brownfield and Greenfield sites which may be developed under existing policy

- Low current population density; between 15 and 70 dwellings per hectare – 70 dwellings per hectare is the maximum density for PTAL 0-1 in the suburban setting according to the London Plan

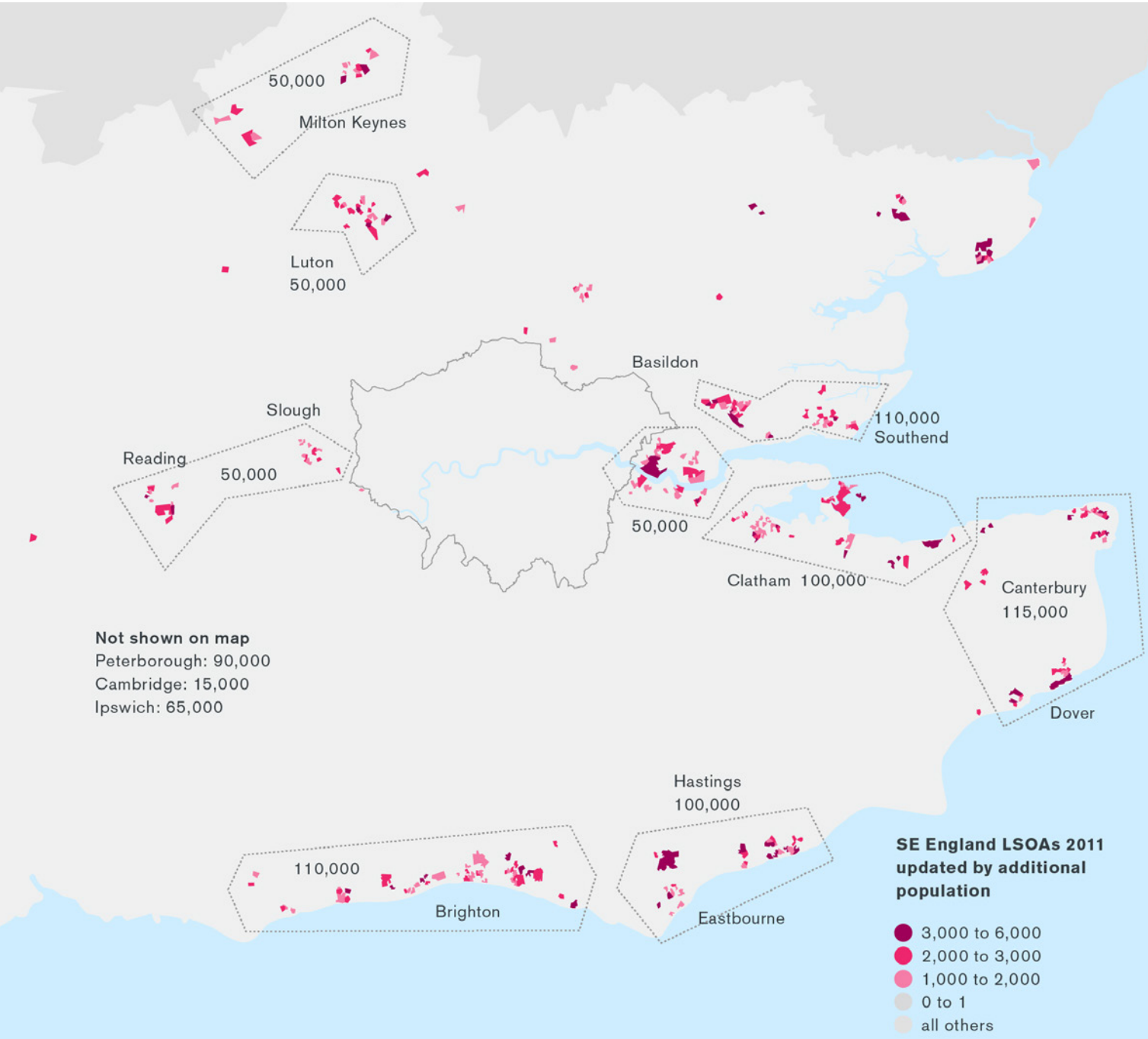
- High levels of deprivation; within the 25 per cent most deprived in the RoSE

- Discounted areas of the RoSE thought to be too far from London to enable substantial increased commuting (i.e. Norfolk, Suffolk, Oxfordshire and South Hampshire)

In order to estimate the potential capacity, it was assumed that housing densities for those locations within scope would be increased to 100 dwellings per hectare – but this was only applied to residential land. 100 dwellings per hectare is in line with London Plan densities of suburban character and good public transport or urban character with moderate public transport.

Potential

The result of increasing density to 100 dwellings per hectare to the areas described was about a 1 million increase in the population in the region surrounding London. The focus of this analysis was to explore the effect of alternative geographic scenarios for accommodating the central trend projection for London, therefore London's population growth was reduced by 1 million in order to counter-balance the additional regional growth. In this scenario London's population was assumed to grow to 10.3 million. The following map shows the locations in London's region where population densities were increased. London's population was scaled evenly to take account of this, with the result that the population distribution was the same as the GLA's central trend-based projection albeit at a lower level.



Conclusions

The analyses described sought to identify possible alternative ways in which London could grow, especially to support the projected population growth. These were then tested using TfL's transport models to assess whether the scenarios led to significantly different infrastructure outcomes. These scenarios have been considered as 'what if' scenarios in order to assess the breadth of spatial variations that might influence transport, and other, infrastructure requirements. These have applied the guideline housing capacities as set out in the London Plan. But it should be emphasised that we have left aside questions

of deliverability and acceptability of these scenarios. The main conclusions arising from this analysis are as follows:

– In the terms set out above, the potential spatial scenarios considered as part of this analysis provide the housing capacity needed to support the projected population growth. The most likely outcome will probably be a mixture of elements of all the scenarios

– As expected, these alternative spatial scenarios lead to variations in the scale and pattern of transport demand and the transport challenges that need to be addressed, but these are detailed and local variations. At a strategic level the differences are relatively small and are not likely to significantly change the overall transport infrastructure requirements. There are thought to be two main reasons for this: firstly, much of the transport demand patterns and challenges will have been established by the 2030s, and subsequent variations in the location of the demand origins represent a marginal change to the underlying transport pressures; secondly, a core assumption underlying London's spatial structure is that central London is retained as high density employment centre, and continues as a dominant trip destination

– The results of our transport analysis indicate that increasing densities at locations which have good public transport provision offers the most positive outcome, of the within London scenarios considered. The scenario leads to a slight increase in demand by public transport, and a reduction in car use, and is therefore consistent with the overall aims of the Mayor's Transport Strategy and London Plan. Despite this, there is slight easing of public transport crowding, largely as a result of a reduction in average travel distances by public transport

– The scenario which considered increased housing densities through renewal of suburban housing is slightly less attractive from a transport perspective than the other scenarios as it leads to a higher growth in car use, due to a greater share of the population in outer London. Average trip lengths are slightly higher due to the more dispersed population

– A consequence of London not being able to house the projected growth could be increasing pressure on areas outside London. There might be economic and regeneration opportunities in this scenario if the additional housing is located in existing urban areas outside London with

relatively high levels of deprivation. There would be less traffic pressure in London as a result of the lower population growth, but the rail network will remain crowded as a significant proportion of the dispersed population would continue to commute to London jobs, leading to longer average trip distances and increasing demand on London's commuter rail network and radial Underground lines

– Dispersing central London economic activities in outlying hubs was considered when the Mayor's Transport Strategy and London Plan were developed. It remains the case for 2050 that this does not offer any significant transport benefits, and such centres would offer less agglomeration benefits than London's central area. However Stratford and Old Oak Common could act as extensions of the central area, and the potential role of these hubs will be explored further

Appendix: detailed list of possible rail-based schemes

This table lists the possible schemes required to meet the objectives of the Infrastructure Investment Plan 2050.

The impact of these in totality is subject to modelling, and individual schemes in some cases need to be tested against value for money criteria.

London Underground

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
World Class capacity Victoria line	2016	200	Improved journey times, reductions in crowding and left-behinds, congestion relief on adjacent routes, generation of Wider Economic Benefits through improved access to the West End. Increase in peak service frequency from 33tph to 36tph; overall increase in peak capacity of c9 per cent; removal of scheduled mid-line reversing – all trains will run to Walthamstow	£30m	1	Capacity case based on London's growth – makes best use of resignalling investment
World Class capacity Jubilee line	2019	214	Improved journey times, reductions in crowding and left-behinds, generation of Wider Economic Benefits through improved access to the Docklands and the West End. Increase in peak service frequency from 30tph to 34-36tph; overall increase in peak capacity of c13-20 per cent.	c£200m	1	Capacity case based on London's growth – makes best use of resignalling investment

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Northern line upgrade 2	2022	252	Improved journey times, reductions in crowding and left-behinds, generation of Wider Economic Benefits through improved access to the City and West End. Increase in peak service frequency from 24tph (post NLU1 service) to 30-36tph; overall increase in peak capacity of c25-50 per cent.	£560m	1	Capacity case based on London's growth – makes best use of resignalling investment
Deep Tube programme (DTP) Piccadilly line	2026 GoA2 2029 GoA4	210	Replacement of life-expired assets, improved journey times, reductions in crowding and left-behinds, congestion relief on adjacent routes, generation of Wider Economic Benefits through improved access to the West End. Full automation to reduce operating costs and optimise service operation. Increase in peak service frequency from 24tph to 33-36tph; overall increase in peak capacity of c60 per cent.	DTP programme cost: £7.7bn at 2012 prices, £12.6bn at outturn.	1	End of life plus capacity case based on London's growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
DTP Central line	2029 GoA2 2032 GoA4	261	Replacement of life-expired assets, improved journey times, reductions in crowding and left-behinds, congestion relief on adjacent routes, generation of Wider Economic Benefits through improved access to the City and West End. Full automation to reduce operating costs and optimise service operation. Increase in peak service frequency from 30tph to 33-36tph; overall increase in peak capacity of c15-25 per cent.	DTP programme cost: £7.7bn at 2012 prices, £12.6bn at outturn.	1	End of life plus capacity case based on London's growth
DTP Bakerloo line	2035 GoA2	111	Replacement of life-expired assets, improved journey times, reductions in crowding, generation of Wider Economic Benefits through improved access to the West End. Increase in peak service frequency from 22tph to 27tph; overall increase in peak capacity of c30 per cent.	DTP programme cost: £7.7bn at 2012 prices, £12.6bn at outturn.	1	End of life plus capacity case based on London's growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Bakerloo upgrade 2 post extension	2045	200	Improved journey times, reductions in crowding and left-behinds, congestion relief on adjacent routes, generation of Wider Economic Benefits through improved access to the West End. 2nd phase upgrade to support demand growth generated by Bakerloo Southern Extension: full automation to reduce operating costs and optimise service operation; increase in peak service frequency from 27tph (post BLU1 service) to 33-36tph; overall increase in peak capacity of c22-33 per cent.	c£200-400m	1	Capacity case based on London's growth – makes best use of extension infrastructure to unlock full potential
Bakerloo Southern extension	2040	200	Extension via Old Kent Road and Lewisham to Hayes and Beckenham Junction, operating a peak service frequency of 27tph as far as Catford Bridge, with 15tph to Hayes and 6tph to Beckenham Junction. Delivers congestion relief on national rail routes into London Bridge, generation of Wider Economic Benefits through improved transport options for areas with development potential in South-East London and improved access to the West End. Conventional journey time benefits total c£400m per annum.	£2.2-2.6bn	2	Long term growth need and potential to maximise capacity from national rail network and support intensification of development

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Northern line extension phase 2 extension	2045	50	Extension to Clapham Junction with full post-NLU2 service level of 30-36tph to facilitate improved connectivity, faster journey times and congestion relief on adjacent routes.	c£300m	1	Case needs assessment in the context of Crossrail 2.

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Platform edge doors	Programme	450	Network wide PEDs roll-out is not value for money. However, PEDs: • are required for full automation on Piccadilly and Central lines (included in NTfL programme); • have a positive business case as stand-alone project on the central sections of the Victoria and Jubilee lines and at some other high-demand platforms (total cost £300-400m); • may support tph increases on other lines where installation could facilitate auto-reversing (included in WCC where applicable). Further research on: • ambience benefit values through 2014 BCDM surveys; • impact on advertising revenues; • platform flows and usable width (current assessments favourable); • impact on door cycle times and therefore dwell times; • Feasibility of PEDs on DLR.	£400m (Current assumption from feasibility is approx £3m to £4m per platform.)	3	Part of the PED programme is essential if full capacity is to be unlocked of some lines

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Long-term off-peak service levels	Programme	735	Off-peak demand continues to grow – crowding in the busiest off-peak periods is already 'peaky': • Demand growth will make the case for off-peak service levels in the region of 27-33tph by the mid-2020s. Growth in the night-time economy will start to make the case for expanding Night Tube services: • Higher frequencies in the range of 6-10 tph. • A more extensive Night Tube network including SSR, Overground and DLR. • Night Tube operation extended to Thursday nights? Improved services could deliver journey time benefits worth c£50m p.a. and generate additional revenue of c£15m p.a., but will present a number of challenges: • More heavily utilised rolling stock, but less time for maintenance. • Increased track wear but shorter windows for maintenance due to Night Tube. • Power systems operating closer to capacity for longer.	Opex £35m p.a.	3	Case based on demand growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
			• More heat in tunnels, necessitating additional cooling infrastructure • Managing closures more difficult, as alternative routes have less spare capacity.			
Phase 2 Future Stations Programme (Phase 1)	Programme	300	Included in the current plan: • Tottenham Court Road (2017): major upgrade including additional capacity and step free access, new ticket hall, entrances and access to LU platforms and to Crossrail. • Vauxhall (2017): capacity and access upgrade including expanded ticket hall and step free access to LU. • Bond Street (2018): major upgrade including additional capacity and step free access, new ticket hall, entrances and additional access to LU platforms and to Crossrail. • Victoria (2019): major upgrade including additional capacity and step free access, new ticket hall, entrances and additional access to LU platforms. • Elephant & Castle (2020): significant upgrade to Northern line entrance including new ticket hall, capacity upgrade and step free access to Northern.		1	Case based on demand growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
			• Bank (2022): new station entrance from Walbrook will provide strep free access from the street to Waterloo & City line trains; a new southbound running tunnel and platform for the Northern line; increased capacity within the station; a new entrance from Cannon Street; improved fire evacuation. • Holborn (2023): new interchange link with step free access and new entrance to north of High Holborn • Camden Town (2024): expanded/new ticket hall, improved access to platform level including step free access and improved low level interchange between branches			
Phase 2 Future Stations Programme (Phase 2)	Programme	300	Priority schemes for future development: • Old Street (2021): major upgrade to provide increased capacity at ticket hall and lower concourse levels alongside over-site development. • Paddington (Bakerloo) (2024): capacity and access upgrade with expanded ticket hall, additional escalators to platform level and step free access, proposals integrated with Crossrail interchange			Case based on demand growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
			proposals and with an adjacent commercial development via passive provision in development design.			
Phase 2 Future Stations Programme (Phase 3)	Programme	300	Expected to require significant capacity enhancement schemes by 2035: • Baker Street • Piccadilly Circus • Moorgate • Liverpool Street • High St Kensington • Harrow-on-the-Hill Expected to require significant capacity enhancement schemes by 2050: • Waterloo • Earl's Court • White City • Green Park • Warren Street • Walthamstow • Embankment	£5-10bn (Several stations have opportunities for 3rd party-funding and/ or associated commercial development.)	3x	Case based on demand growth and economic growth and subject to prioritisation

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Phase 2 Future Stations programme (Accessibility)	Programme	300	Step-free access: • Wherever possible capacity projects will deliver step-free access, and several other stations have 3rd party-funded opportunities to deliver affordable step-free access. • Beyond this the focus will be on the remaining critical 'gaps' in the step-free network where a further 12-15 discreet accessibility schemes would facilitate significant additional numbers of step-free journeys. • Building on the current plan, these station capacity and accessibility schemes could increase the proportion of journeys on the R&U network that are fully step-free to 40 per cent by around 2040.		3	Subject to prioritisation

Notes to the table

GoA1: Manually driven train

GoA2: Automatic Train Operation (ATO), with driver in cab to undertake procedures such as door open / close.

GoA3: Commonly known as Attended operations. Effectively ATO with mobile Passenger Service Agent on train (DLR style), undertaking some procedures such as door close.

GoA4: Commonly known as Driverless operations. Fully automated operations with staff performing no function regarding train movements, including door closures.

Crossrail and Crossrail 2

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Crossrail 1 - HEx merger and serves T5	2030	5	Improves connectivity of Crossrail network and access to Heathrow. Could enable 6tph semi-fast service to T5, 50 per cent more on this route.	£20 million to upgrade relief lines. Assume 5 extra rolling stock required, £65m.	1	Case based on maximising benefits of the Crossrail infrastructure
Crossrail 1 to WCML Watford Jn / Tring	2026	18	Congestion relief at Euston, better use of Crossrail capacity. No additional capacity by itself through central area or along WCML itself.	£150m	2	Case based on demand growth and supporting economic and population growth and addressing HS2 construction impacts at Euston
Crossrail 1 - 30tph	CP7 / 2029	243	Congestion relief on Crossrail. Adds 25 per cent capacity in central area. Enables additional destinations such as WCML.	£100 million to buy new trains	1	Case based on demand growth and supporting economic and population growth
Crossrail 1 to Dartford/ Ebbsfleet (and new airport in case of ITE)	CP8 / 2030	9	Improves connectivity of Crossrail network, reduces crowding on routes into London Bridge. Extension of current Abbey Wood services so no additional capacity in central area.	£100m plus r/s	2	Case based on demand growth and supporting economic and population growth

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Crossrail 2	Early 2030s	269	Relieves LU congestion and provides additional capacity on SW inner suburban services and Lea Valley route. 24 tph on Crossrail 2 plus enhancement to the mainline enables 100,000 new trips into central London in the peak period.	£12-20bn	1	Case based on demand growth and supporting economic and population growth

Docklands Light Railway

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
DLR – Royal Docks capacity enhancements	2022	59	30 additional railcars to increase capacity for large new developments (15,000 jobs at ABP Royal Albert Dock, and 11,000 jobs at Silvertown Quays), and station upgrades at Custom House, Canning Town, Royal Albert, Beckton Park and Pontoon Dock. 100% increase in capacity on the Beckton branch (15tph), 20 per cent increase on the Woolwich branch (all 3-car) and 200% increase on the Stratford International branch (15tph). More direct services between the Royal Docks and Stratford.	£140m	1,2	Case based on demand growth and supporting economic growth – also, Crossrail feeder service
DLR – all three car	2026	23	50 per cent increase in capacity, to 8,000/hr/direction, on Stratford-Canary Wharf services (over and above committed improvements due in 2015), supporting further growth in Bow and around Pudding Mill Lane.	£40m	1	Case based on demand growth and supporting economic growth – also, Crossrail feeder service

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
DLR – enhanced frequencies	2031	45	Further increases in capacity and frequency on cross-river orbital routes from Lewisham and Woolwich to Stratford, and on Beckton to Stratford, e.g. up to 15tph on each route. Supports further densification of Stratford as a major metropolitan centre and provides more connections into Crossrail. Supports further brownfield redevelopment for housing/ jobs on the Isle of Dogs and in the Royal Docks. Total capacity of 15,000/hr/ direction on the Isle of Dogs and 22,000/hr/direction across the Royal Docks.	£125m	1	Case based on demand growth and supporting economic growth – also, Crossrail feeder service
B92 stock replacement	2024	95	New fixed-formation trains to replace old rolling stock, offering faster journey times, up to 10 per cent more capacity and lower maintenance costs.	£250m	1	End of life argument and need for additional capacity
DLR station upgrades	Programme		Capacity upgrades to deal with demand arising from new developments, e.g. expansion of Canary Wharf tall buildings cluster towards Poplar and Crossharbour.	Varies	1,2	Case based on supporting development
New Station at Thames Wharf	2020s		New station at Thames Wharf (between Canning Town and West Silvertown) supporting up to 9,000 new homes.	£20m	2	Case based on growth – post Silvertown tunnel

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Off-peak service levels	Programme	269	Incremental programme of raising offpeak services to maximum 4 minute intervals (as per peak).	Operational cost only	3	Case based on demand growth and supporting economic growth – also, Crossrail feeder service
Night services	2020s	5	New night time services starting with Bank-Lewisham and Bank-Woolwich.	Operational cost only	3	Case based on demand growth and supporting economic growth – also, Crossrail feeder service
Close Tower gateway and construction station underground on Bank branch with direct link to Tower Hill	2050	34	Currently, 90 per cent of DLR City passengers use Bank, but only 75 per cent of services go there; this would increase service to Bank from 23tph to 30tph. This would unlock more capacity on Bank branch.	£80m	1	Business case required.

Croydon Tramlink

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Western capacity package (Wandle Flyover doubling, Phipps Bridge doubling, Additional trams, Reeves Corner westbound tramstop, South Wimbledon spur)	2023-26	15	Potential for 50-100 per cent increase in service from 12tph to 18-24tph, providing significant crowding relief and with potential to support significant new housing around South Wimbledon, Mitcham and Purley Way. New journey opportunities between Tooting, Colliers Wood, South Wimbledon and Mitcham, Purley Way and Croydon.	£100m	2	Case based on demand growth and supporting economic growth in Croydon – unlocks more capacity of the system
Eastern capacity package	2023-26	15	Improvements to allow an uplift in eastern branch services, exploiting opportunities from the Dingwall Road Loop which Westfield are funding. Potential for doubling of service to Beckenham Junction (6 to 12tph).	£50m	2	Case based on demand growth and supporting economic growth in Croydon – unlocks more capacity of the system
Off-peak service levels	Programme		Gradual increase in off-peak service levels (to same levels as peak) to support new leisure demand to central Croydon.		3	Case based on demand growth and supporting economic and population growth and helping to deliver modal shift

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Extension to Sutton	2030	5	New tram service over busy bus corridor between Sutton, St Helier & Morden offering better journey times and 8-12tph. New journey opportunities across Sutton and Merton.	£250m	2	Need already established

London Overground

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
GOB – 4-car electric	Summer 2017	11	68 per cent more capacity, four minute faster journey times	£115m	2	Case made
GOB – extension to Barking Riverside	2020	1	Allows full development in Barking Riverside area. Requires two extra trains over the current fleet of 8	£165m	2	Case made
GOB – 6tph	2040	11	50 per cent more capacity	£20m	2	Case subject to growth but with Barking Riverside and east London growth – highly likley
LOSTAT phase 2	2020	30	Case based on demand growth and supporting economic and population growth and helping to deliver modal shift	£10m pa	3	Business case required
ATO on ELL core section: increase frequencies	2024	53	This could increase frequency as much as 24tph cf 16 tph currently. Case needs to be made for max growth potential on the ELL	£130m	1	Business case required

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
LO off-peak service levels across the network	programme	143			3	Case based on demand growth and supporting economic and population growth and helping to deliver modal shift
Old Oak Common HS2 / LO station	2026 / HS2		Improved accessibility to HS2 from northwest, west and southwest London	C£550m	1,2	Case based on demand growth and supporting economic and population growth
NLL/WLL – 6-car	2027 / HS2	68	Adds 17 per cent to capacity over 5-car fleet.	£100 million – cheaper as avoids platforms extensions into tunnels	1,2	Case based on demand growth and supporting economic and population growth and accessing OOC
ELL – 6-car	CP7 / 2029	53	Adds 17 per cent to capacity over 5-car fleet	£300 million, given need for platform extensions	1,2	Case based on demand growth and supporting economic and population growth
NLL/WLL – 12tph	2040	68	50 per cent increase in capacity over current 8tph peak service		1,2	Not sure how this relates to 12tph service

National Rail line upgrades

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Chiltern electrification and longer trains	CP6 / 2024	21	Improved journey times, extra capacity to meet demand increase of c.50 per cent by 2050	Unknown	1	Case based on demand growth and supporting economic and population growth – but subject to prioritisation
Chiltern: new service Wycombe to West Ealing and/or Old Oak Common via Greenford	CP6 / 2024	8	1 tph at least initially. Not material to capacity, but increases connectivity.	£25 million	2	Dependant on case
Western Rail Access to Heathrow	CP6 / 2021	12	Improved accessibility to Heathrow Airport. Option to route some Crossrail services via Heathrow. Extension of current services so no additional capacity in central area. Case to be re-assessed in context of LHR expansion and future use	£750m?	1	Case to be re-assessed in context of LHR expansion and future use
South London rail link to Heathrow	CP8 / 2030	7	Improved accessibility to Heathrow Airport from south London. Likely to mean 2tph extra into Waterloo over current peak of 14tph on the Windsor lines. Case to be re-assessed in context of LHR expansion and future use	Dependent on option, Airtrack was £700m	1,2	Case to be re-assessed in context of LHR expansion and future use
Wessex capacity: Windsor lines 12-car Windsor lines	2039-44	72	As defined in Wessex route study. Adds 20 per cent to peak capacity. Complementary to Crossrail 2 - prioritisation	£260m		Complementary to Crossrail 2 - prioritisation

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Wessex capacity: Windsor lines move from 16tph to 20tph using WIT, Feltham resignalling, and re-use of Queenstown Road platform 1	2019-24	72	As defined in Wessex route study. Adds 25 per cent to peak capacity. Complementary to Crossrail 2 – prioritisation and next stage beyond 12 car	£300-400m for Wessex package as a whole	1	Complementary to Crossrail 2 – prioritisation and next stage beyond 12 car
Wessex capacity: mainline frequency increase from WIT re-opening, Woking Jn grade separation, plus track capacity freed by XR2	CP6 / 2024	81	As defined in Wessex route study. . Adds 17 per cent to peak capacity. Complementary to Crossrail 2 - prioritisation	See above	1	Complementary to Crossrail 2 – prioritisation and next stage beyond 12 car
BML mainline: Frequency uplift with works to Keymer, Stoats Nest, Windmill Bridge Jn, E Croydon two extra platforms, Clapham Jn platforms, Vic plfm 8, W Croydon, etc.	CP6 / 2024	86	As defined in Sussex route study. Congestion relief on BML through all full length trains and increase frequency. Adds 15-20 per cent to capacity.	£1000m	1	Case based on demand growth and supporting economic and population growth – but prioritisation
More 10-car Southern inners	CP7 / 2029+	57	As defined in Sussex route study. Congestion relief by adding up to 10 per cent more capacity	Rolling stock and stabling only	1	Case based on demand growth and supporting economic and population growth across south London – but prioritisation

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Sussex London suburban routes: extra platforms, better junctions and change route patterns in order to enable higher frequencies	CP7 2029	57	Linked to package of Sussex capacity package in draft route study, BML upgrade more generally This could enable an increase from 12tph to around 20 tph, a 66 per cent increase.	Included elsewhere	1, 2	Case based on demand growth and supporting economic and population growth – but subject to prioritisation
More 12-car Southeastern inners using existing rolling stock cascaded from Thameslink	CP5 / 2019	56	Congestion relief from post TLP cascade. This represents a 20 per cent increase in peak capacity	Rolling stock and stabling only	1	Case based on demand growth and supporting economic and population growth across south east London – but prioritisation
Expansion of the domestic high speed services via HS1	CP6 / 2024	11	More full-length 12-car trains. This could add around 10-20 per cent capacity. Case based on demand growth and supporting economic and population growth across south east London – but prioritisation – link with Estuary Airport	Better use of existing stock	1	Case based on demand growth and supporting economic and population growth across south east London – but prioritisation – link with Estuary Airport
Essex Thameside: more 12-car	CP6 / 2024	37	Congestion relief. Possible to do also or alternatively by changes to interior configuration. This could add around 10-20 per cent capacity.	Rolling stock and stabling only	1	Case based on demand growth and supporting economic and population growth across east London – but prioritisation

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Great Eastern mainline: LST to Southend +2tph 12-car from ETCS level 2 or 3 signalling	CP6 / 2020	11	As defined in Anglia route study. Congestion relief from c.10 per cent increase in capacity	Unknown	1	Case based on demand growth and supporting economic and population growth - complementary to Crossrail 1 – but prioritisation
Great Eastern mainline: +2tph 12-car from remodelling Bow Jn	CP7 / 2029	21	As defined in Anglia route study. Congestion relief from c.10 per cent increase in capacity	Unknown	1	Case based on demand growth and supporting economic and population growth - complementary to Crossrail 1 – but prioritisation
West Anglia: 4-tracking Copper Mill to Broxbourne	CP6 / 2024	28	Congestion relief, improved accessibility to Lea Valley developments. Could enable 8tph before Crossrail 2, compared to frequencies of 1-3tph currently.	>£700m	1, 2	Case based on demand growth and supporting economic and population growth in the Lea Valley - complementary to Crossrail 2
West Anglia: 10-car train capability	CP6 / 2034	19	Reduce peak crowding.. Capacity increase would be 25 per cent	£60m	1	Case based on demand growth and supporting economic and population growth in the Lea Valley - complementary to Crossrail 2

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Great Northern Stevenage / Hertford to Moorgate: high capacity trains	CP6 / 2024	18	TSGN franchise requires renewal of current fleet built 1977. Deep level tunnels limits train length to six-car, but walk-through trains with more standing space ("high capacity") could enable capacity increase. 150 new carriages cf: 132 now, that is a 14 per cent increase		1	Case based on demand growth and supporting economic and population growth

National Rail – Stations and Other Programmes

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Western Rail Access to Heathrow	CP6 / 2021	12	Improved accessibility to Heathrow Airport. Option to route some Crossrail services via Heathrow. Extension of current services so no additional capacity in central area. Case to be re-assessed in context of LHR expansion and future use	£750m?	1	Case to be re-assessed in context of LHR expansion and future use
South London rail link to Heathrow	CP8 / 2030	7	Improved accessibility to Heathrow Airport from south London. Likely to mean 2tph extra into Waterloo over current peak of 14tph on the Windsor lines.	Dependent on option, Airtrack was £700m	1,2	Case to be re-assessed in context of LHR expansion and future use

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Expansion of the domestic high speed services via HS1 (including link to airport if new ITE airport chosen)	CP6 / 2024	11	More full-length 12-car trains. This could add around 10-20 per cent capacity. Case based on demand growth and supporting economic and population growth across south east London, subject to prioritisation. There is also a link with Estuary Airport.	Better use of existing stock	1	Case based on demand growth and supporting economic and population growth across south east London – but prioritisation – link with Estuary Airport
Call International trains at Stratford	ASAP	1	Improved accessibility to international services	£2m	3	Case based on supporting economic growth
New stations for opportunity areas: Beam Park, Brent Cross Cricklewood, etc.	By 2020	2 per station	Enables regeneration at poorly connected sites	Beam Park = £15m Brent Cross = £132m	2	Case based on supporting growth and unlocking development
New links and/ or stations for strategic interchange: Camden Town –Camden Road, Brockley High Level, Brixton High Level, Seven Sisters (GOB), Junction Road (GOB), GOB/XR, Penge, Catford	Programme	1 per station	Enables new connectivity and orbital routes	£25m each	2	Case based on supporting growth and facilitating more orbital movement whilst securing maximum benefit from existing system
Crossrail 3 – Thames Estuary Airport – East London – Central London and Beyond:	2040+	250 per route	Would need to determine this is the most appropriate cross-London route. Could run at a frequency at around 24tph through the central area, with substitution for existing services in outer London.	Up to £20bn	1	Business case untested as yet.

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
New orbital route: Hounslow – Brentford –Acton – Old Oak – Neasden - Brent Cross @ 4tph	2040+	30	Linked to HS2 interchange at Old Oak Common. Improves connectivity in west London.	£300m	2	Case based on improving access to Old Oak Common and the Golden Mile – further work on prioritisation and compatibility with other Overground enhancements to Old Oak Common
Programme – station congestion relief	programme	50	Various	£103m in CP5	3	Case based on rising demand and unlocking growth areas – prioritisation of specific stations
Programme – A4A	programme	50	Programme in perpetuity until all feasible stations complete	£103m in CP5	3	Case based on accessibility and inclusion – prioritisation needed
Line speeds / journey times	programme		Faster journey times on selected routes	£206m in CP5	1	Unlocks capacity from the system

Description	Timescale	Pax (m) affected	Qualitative benefits	Capital cost	IIP objective	Comment
Strategic freight network	programme	n/a	Selected schemes to improve freight capacity/ capability	£206m in CP5	3	Unlocks capacity for passenger trains in London
HS2	2026	114	Phase 1 West Midlands to Euston	£16bn	1	Support based on capacity uplift

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