Urban Transport Analysis: Capacity and Cost

Study Report
July 2018

National Infrastructure Commission

Our ref: 23269801

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Prepared by:

Steer Davies Gleave
28-32 Upper Ground
London SE1 9PD

+44 20 7910 5000
www.steerdaviesgleave.com

Prepared for:

National Infrastructure Commission
11 Philpot Lane 14/04/2018
London
EC3M 8UD
United Kingdom

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1 Introduction

Study overview

1.1 This study, Urban Transport Analysis: Capacity and Cost, provides an order of magnitude estimate of peak hour transport network capacity to the centre of large towns and cities in England. For a number of scenarios, it also establishes order of magnitude costs for increasing that capacity. This study forms part of a suite of three parallel studies, which taken together are seeking to understand the cost of increasing transport capacity into city centres and the likely economic benefits of doing so. The outputs of the three studies will inform recommendations as part of the National Infrastructure Assessment, to be published in July 2018.

1.2 While the outputs of this study provide the National Infrastructure Commission (NIC) with an order of magnitude estimate developed for twenty case study town and city centres (referred to as 'cities' for the remainder of this report), the study approach has been developed to be sufficiently generic to allow its application to other English towns and cities, and the extrapolation of its findings to England as a whole. Also, while the study's outputs are considered representative when aggregated across cities, this is not necessarily so at an individual city level. Variations between our assessment and locally reported data are anticipated. While this study considers potential interventions to achieve a range of transport capacity uplifts, it is not suggested that such interventions are required to meet local policy goals. Specific plans and programmes for individual cities need to be developed at a local level, taking into account local context and need, as well as consideration of deliverability, affordability and value for money.

Study approach

1.3 There are many possible approaches to developing the outputs required of this study. The adopted methodology for this study is based on:

- Utilising publicly available data and information;
- Applying a process that can be repeated consistently across twenty case-study cities;
- Applying a process that allows results to be extrapolated to other non-case-study cities;
- Achieving order of magnitude estimates of transport capacity and costs; and
- Matching effort required to available budget and timeframes.

1.4 This study was conducted in three core stages, each discussed separately in this report:

A. **Urban Transport Capacity Metric** (UTCM);
   i. Determination of available transport network capacity to access city centres during the 0800 - 0900 morning peak hour.

ii. Estimation of utilisation of available morning peak capacity.

B. **Capacity uplift scenarios**; development of five scenarios for increasing transport capacity:
   i. 5% capacity uplift
   ii. 10% capacity uplift
   iii. 20% capacity uplift
   iv. 10% bus focused capacity uplift
   v. 10% active modes focused capacity uplift

C. **Cost estimation** of each capacity uplift scenario including capital, renewal, maintenance and operating costs. For some modes estimates of farebox revenue and subsidy requirements have also been developed.

1.5 Twenty case-study cities are used as a basis for the study. These have been chosen to reflect a range of different city sizes, locations and socio-demographic contexts. The selection does not reflect any assessment of investment priorities, either nationally or in the case-study cities. The case-study cities are:

1. Birmingham
2. Manchester
3. Newcastle
4. Sheffield
5. Leeds
6. Bristol
7. Liverpool
8. Leicester
9. Southampton
10. Reading
11. Preston
12. Middlesbrough
13. Coventry
14. Huddersfield
15. Telford
16. Burnley
17. Plymouth
18. Swindon
19. Exeter
20. Norwich

1.6 Results have also been extrapolated to a further 34 English towns and cities, as discussed in Chapter 3.

1.7 The key outputs of this study that feed into parallel studies within the wider project are:

- UTCM results
- Cost estimates

1.8 The UTCM results also underpin scenario development within this study, and are used as a basis for understanding the scale of a 5%/10%/20% capacity uplift.

Document structure

1.9 The study approach and results are presented in the following sections:

- The Challenge: sets out the challenges of this study and our approach to selecting an appropriate methodology.
- Transport Network Capacity and Utilisation: describes the methodology followed to develop the Urban Transport Capacity Metric results.
- Capacity Uplift Scenarios: describes the methodology followed (and generic scenarios applied) to form a basis for cost estimation.
- Packaging and Cost Estimates: describes the methodology followed in developing packages of interventions within each scenario and the approach to cost estimation. It also presents order of magnitude estimates of the costs required to increase capacity into city centres.
- Summary of Results.

2 The Challenge

Study context

2.1 Transport networks play an important role in supporting the economy and facilitating economic growth. Improved transport connectivity can support and facilitate economic growth through:

- increasing productivity of existing economic assets (land, capital etc.);
- improving the efficiency of the labour market;
- supporting sustainable housing and employment growth; and
- enhancing the attractiveness of places as locations for investment.

2.2 The purpose of this study, reviewing urban transport capacity and the cost of increasing that capacity, is set in the context of a public policy goal to support economic growth. However, growth scenarios for English cities are considered in parallel studies in this project, and are not explicitly considered in this study. The transport capacity uplift scenarios are used in lieu of specific growth scenarios to understand how urban transport networks could be developed to accommodate increased levels of future growth.

2.3 Transport capacity in this study is considered in the context of providing access into city centres only. All analysis is based on trips during the morning peak period (0800 - 0900).

The end goal

2.4 Ultimately the results of this study are structured around answering:

- What is the current capacity of urban transport networks?;
- What could a 5%/10%/20% uplift in transport capacity ‘look like’?; and
- How much would it cost to achieve this?

What is the current capacity of urban transport networks?

2.5 There is no perfect way to determine a single value that represents capacity across an entire urban network. While each individual element of a transport network has a definable capacity, for a system formed of a combination of those elements it is much more difficult to determine a single numeric value of capacity. The way in which the system is used on any given day can change, this affects the overall capacity available to an individual accessing the city centre. For example, a single seat on a bus can provide capacity for multiple people along a route as different passengers board and alight in different locations along the route, or increasing the number of buses travelling into a city centre may reduce the capacity available for private car travel.

2.6 The current capacity of urban transport networks is considered in the development of the Urban Transport Capacity Metric, as discussed in Chapter 3.

What could a capacity uplift look like?

2.7 Providing a representation of what a given uplift could 'look like' is based, for the purposes of this study, on technology and modes that are currently widely utilised in Britain. Technology, and its interface with the transport system, is constantly developing. However, until new technologies are implemented, including the enabling regulations, it is difficult to project how their impact on urban mobility will be manifested.

2.8 Defining how capacity uplifts could be delivered is based, therefore, on current contemporary themes in delivering transport infrastructure. Four core modes are the focus of the scenario building (bus, rail, light rail and private vehicle). Some consideration is also given to active modes; however these modes are only appropriate for relatively short trips and therefore their potential contribution to the provision of capacity for a range of trip purposes and journey lengths is limited.

2.9 Throughout this report, where results and metrics are disaggregated by mode they are colour coded, as set out in Figure 2.1.

Figure 2.1: Core modes considered and colour coding

Contemporary themes in transport planning

2.10 Over time, as the transport knowledge base expands and societal preferences evolve, the way in which transport capacity is delivered is changing. This is most notable in the shift away from prioritising the car as a mode, and is also reflected in a much wider range of decisions. These changes in the focus and delivery of transport capacity are termed 'contemporary themes' in transport planning for the purposes of this report.

2.11 Contemporary themes consider how local authorities and other bodies (e.g. Local Enterprise Partnerships, Sub-National Transport Bodies and Combined Authorities, alongside private companies) are currently approaching the challenge of building transport capacity into urban/built-up environments. The most notable themes considered include:

- Implementation and extension of light rail networks in large cities.
- Light rail/metro aspirations, including commissioning of studies, in medium cities.
- Focus on reducing private vehicle trips, for example with the goal of improving air quality and health.
- Planning for and implementation of integrated BRT networks.
- Investigation of tunnelled metro/public transport infrastructure due to city centre space constraints.
- Continuing decline in bus use.
- Ongoing upgrades to/optimisation of urban road networks to release capacity constraints.

2.12 Further information on contemporary themes is summarised in Appendix B.

How much will it cost?

2.13 The cost of delivering transport capacity uplifts varies by location and can be affected by a range of factors, including:

- Ease/difficulty of implementation;
- Material and transport costs;
- Term contract rates;
- Land-take and compulsory purchase requirements; and
- Impact on the existing, operational transport network.

2.14 Urban transport schemes are likely to become costlier over time. This is anticipated due to a range of factors including changes to minimum standards and exhaustion of 'low hanging fruit', meaning schemes delivered later are often more complex. This potential trend is not considered explicitly within this study; however, the ease of delivery is accounted for to some extent through setting out the scale of change required relative to the existing transport offer to deliver the specified capacity in each scenario. That is, infrastructure requirements in the 20% uplift scenario are considered to be transformational in nature, relative to the 5% scenario where this uplift can likely be achieved through increments to the existing transport offer in a given city.

2.15 Cost estimates developed in this study are intended to be appropriate for scaling across all English cities. However, they are not developed to a level of detail that allows specific local features to be accounted for in the costs. A benchmarking exercise has been undertaken to allow cost estimate outputs of this study to be compared to recent and committed large infrastructure investment in UK cities.

Interpretation of results

2.16 In producing the Urban Transport Capacity Metric, defining the capacity uplift scenarios, and estimating the costs of delivering those capacity uplifts across twenty cities, it has been necessary to make a large number of assumptions. As far as possible we have drawn upon relevant, publicly available datasets and evidence sources to inform and support the assumptions applied, however an element of professional judgement has also been necessary. More detailed commentary related to these assumptions and the data sources used to inform them are included in the subsequent chapters and appendices.

2.17 As a consequence, the results of this study are appropriate for application in the context for which they have been developed. However, it is important to understand the limitations of the results and how these results should be interpreted. The remainder of this section includes commentary regarding appropriate use and application of the study outputs and brief discussion of relevant, but out-of-scope issues.

Application of outputs

Transport interventions

2.18 Where possible, scenarios include the 'lowest cost, realistic' approach to providing the defined capacity uplifts. This, by extension, also requires consideration of the available policy levers at a local level. Generally, considered scenarios include a combination of interventions across all modes, starting from incremental increases to existing transport provision in the 5% scenario, building up to transformational interventions for many modes in the 20% scenario. Packages of interventions are defined for groups of cities, rather than taking a city-by-city approach to defining how capacity could be increased in a specific city. This approach is sufficiently generic to allow the extrapolation of results across all English cities. It is not suggested that the implied mode investments are required, or justified, in each individual city. Specific plans and programmes for individual cities should be developed at a local level, taking into account local context and need, as well as consideration of affordability and value for money.

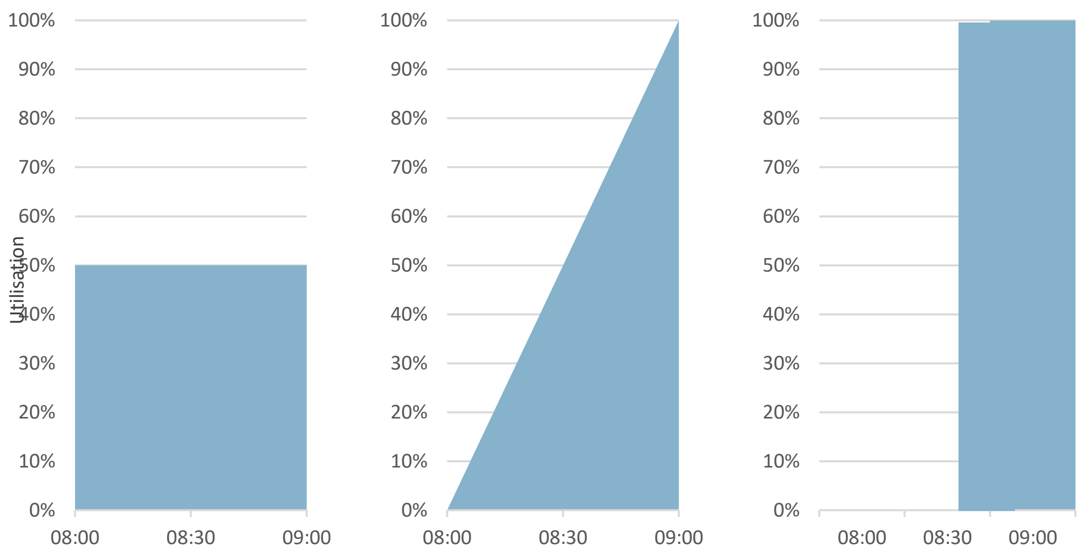
Aggregation of cost estimates

2.19 Cost estimates for the capacity uplift scenarios in this study are intended to be used in aggregate across multiple cities, as opposed to on a city-by-city basis. Assumptions associated with the transport interventions within each scenario are made on the basis that investment in some cities may be overstated, and understated in others. Considering the results in aggregate ensures these over and underestimates countervail each other to provide a representative order of magnitude cost estimate at an aggregate level.

Network utilisation

2.20 Utilisation results, reported as part of the Urban Transport Capacity Metric, represent utilisation over the full peak hour. Many cities experience a 'peak within a peak', where the network is busier for certain periods within the peak hour, but not consistently busy at the same level across the full hour. For example, where an average utilisation value of 50% is reported, this could represent a consistent utilisation of 50% of available capacity across the whole peak hour, or utilisation of 100% of available utilisation for 30 minutes only (50% of the peak hour), as demonstrated in Figure 2.2.

Figure 2.2: '50% Utilisation' example

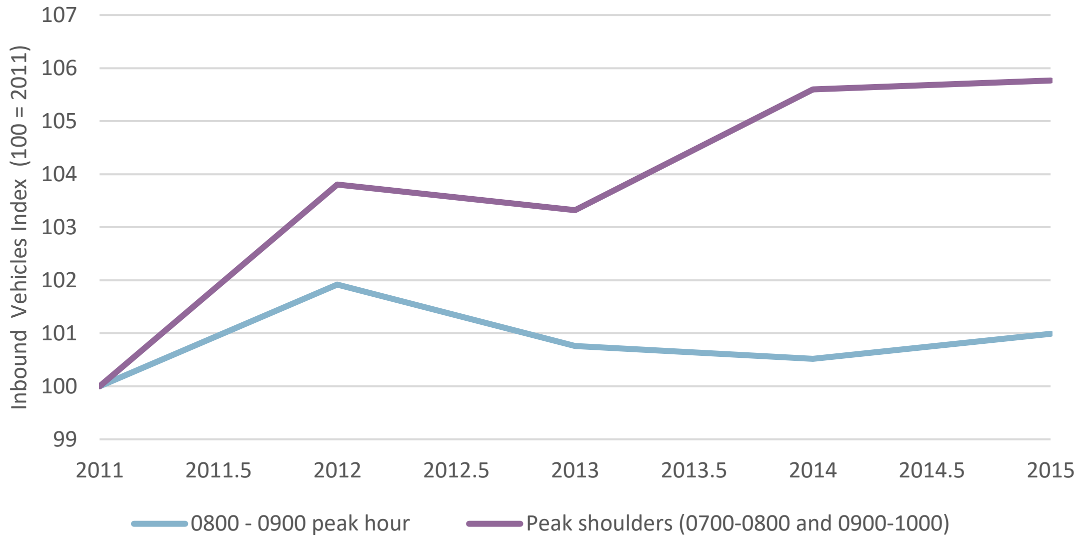


Simplifying assumptions/considerations out of scope

Peak Spreading

2.21 This study assumes that the key trips of interest occur during the morning peak hour (0800-0900) and will continue to occur at this time. In reality, some cities have a propensity for 'peak spreading', where trips that would ideally be undertaken during the peak hour are undertaken during the hours either side of the peak (peak shoulders). An example of this phenomenon, measured in Leeds, is shown in Figure 2.3. Peak shoulder traffic counts are shown to increase over time, showing that overall trip numbers are growing, while morning peak hour counts show negligible change. This is considered to be due to the network operating at capacity in the peak.

Figure 2.3: Peak Spreading across Leeds City Centre Cordon (morning peak)



Source: Leeds Central Cordon: 2015 Traffic Flows

2.22 The results of this study are focused on capacity in the peak hour only, and do not consider propensity for peak spreading.

Delivery timing

2.23 The scope of this project considers transport interventions which could be delivered to 2050. As discussed earlier, transport technology is constantly developing. It is recognised that the intervention options available to transport authorities at the time of planning and delivery may be different to those available at the time of writing. Therefore, the implicit assumption is that a similar uplift in capacity could be achieved with a similar level of investment, albeit the actual interventions delivered may be different.

2.24 The timing of delivery is not explicitly considered in this study. General cost profiles are developed to reflect that not all investment is made in a single year and that there are lead times associated with the implementation of capacity interventions which differ according to the size and nature of the intervention. The accompanying cost model allows the user to select an 'opening year' and costs are inflated and discounted accordingly. However, opening years are not known at the point of handover of the study results and are an output of parallel studies in this project.

Connected and Autonomous Vehicles

2.25 Connected and Autonomous Vehicle (CAV) technology, and frameworks for its widespread adoption, are developing over time. By 2050 it is likely that there will be a significant uptake in Level 4/5 (autonomous driving capability) CAV use, however the impact of CAVs on capacity is uncertain. There is a lot of variability in forecast rates of uptake for CAVs. For example, the Victoria Transport Policy Institute predict that by the 2040s, approximately 40% of vehicle travel will be autonomous, assuming fully automated vehicles become commercially available in the 2020s, see Table 2.1 [1].

Table 2.1: Autonomous Vehicle Implementation Projections

Stage	Decade	Vehicle Sales	Vehicle Fleet	Vehicle Travel
Available with large price premium	2020s	2% to 5%	1% to 2%	1% to 4%
Available with moderate price premium	2030s	20% to 40%	10% to 20%	10% to 30%
Available with minimum price premium	2040s	40% to 60%	20% to 40%	30% to 50%
Standard feature included on most new vehicles	2050s	80% to 100%	40% to 60%	50% to 80%
Saturation (everybody who wants it has it)	2060s	?	?	?
Required for all new and operating vehicles	?	100%	100%	100%

Source: Victoria Transport Policy Institute (2018) *Autonomous Vehicle Implementation Predictions* [2]

2.26 While CAVs will affect network capacity, the extent to which they increase effective capacity will ultimately depend on many factors, including how CAVs are programmed to 'behave'. A study for DfT[3] considered a range of CAV market penetrations and cautious/assertive vehicle behaviour to understand the impact of CAVs on strategic and urban road networks[4].

2.27 Within the DfT study a range of tests, using simple models for various junction and link types, showed capacity increases at junctions could range from 2.2% to 11.6% for vehicle behaviour similar to current driver behaviour and 25% to 50% market penetration, see Table 2.2. The range of capacity change is much broader when a variety of vehicle behaviours is considered. However, given that the fleet is unlikely to be fully autonomous within the timeframes of this study, it is not unreasonable to assume that CAVs would need to behave in a manner that is similar to human driver behaviour.

2.28 In a separate study, Friedrich (2016) estimates that in city traffic, a capacity increase of about 40% could be achieved with 100% uptake of CAVs[5]. Part of this capacity increase could also come from a reduction in road lane width (as less space is needed to accommodate human error). It has been estimated that this reduction could be by as much as 20%[6].

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[1] **https://www.vtpi.org/avip.pdf**

[2] **https://www.vtpi.org/avip.pdf**

[3] **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/530093/impacts-of-connected-and-autonomous-vehicles-on-traffic-flow-technical-report.pdf**

[4] The study results showed, for behaviour similar to current driver behaviour and a 25%-50% market penetration, CAVs could result in a 21%-26% reduction in journey times on urban road networks during peak periods.

[5] **https://link.springer.com/content/pdf/10.1007%2F978-3-662-48847-8_16.pdf**

[6] **https://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf**

Table 2.2: Estimated impact of a 25%-50% CAV market penetration for various road types and links

Test/Model	Capacity Change (Similar Driver Behaviour)
Single-lane Link	+1.1% to +1.9%
Multi-lane Link	+1.0% to +2.2%
Signalised Junction	+2.2% to +4.1%
Roundabout	+3.6% to +6.0%
Multi-lane link with merge	+5.2% to +11.6%

Source: DfT (2016) *Impacts of Connected and Autonomous Vehicles*[3]

2.29 It should be noted that these positive impacts on capacity are uncertain, and there are other factors which will influence traffic flows and the demand for CAVs. These include, but are not limited to:

- Vehicle miles and congestion may increase as people that are currently unable to drive or access public transport can travel in CAVs (e.g. young people, the disabled, the elderly or those who simply don't have access to a car).
- Vehicle miles and congestion may increase due to vehicles re-positioning themselves or driving empty to their next pick up and as travelling by car becomes more pleasurable and accessible.
- Public policy may influence the uptake of CAVS; for example, policies that discourage private vehicle ownership, such as reduced parking supply.
- User preferences for CAV behaviour (cautious/assertive) will affect the changes in network performance resulting from CAV market penetration.
- The provision of Mobility as a Service (MaaS) may change the way in which trips are made.

2.30 The impact of CAVs on Urban Transport Network capacity is considered in a sensitivity test in this study, see Chapter 5 for further information.

Travel Patterns

2.31 In addition to technology affecting the range of modes available, it also has an impact on how we travel. Technology enables more remote working and influences trip timing, mode choice and route choice. This, combined with ongoing changes in societal preferences, means travel patterns are changing over time. This study uses data for current travel patterns and does not extend to consider how these may change in future.

Subsidies

2.32 The provision of additional public transport capacity into many city centres may rely, in part, upon subsidies. Additional rail infrastructure, for example, may be provided through grant funding or, in some cases, through Network Rail borrowing that is subsequently recovered through access charges to train operating companies. Given the complexity of rail industry financial flows[7] it has been assumed that all rail capacity increases are funded by the taxpayer through direct capital grants, there is no impact upon the level of government support

[7] See **http://orr.gov.uk/__data/assets/pdf_file/0006/26439/uk-rail-industry-financial-information-2016-17.pdf**

required to provide services upon the new infrastructure, and no impact on the fare paid by rail users.

2.33 By contrast, in considering the role of buses for providing additional capacity into city centres, it has been assumed that the scale of behaviour change required can only be achieved through offering bus fare subsidies. While there remains a role for softer measures including integrated ticketing, improvements to information provision and safety/security enhancements, these are considered to be complementary to price-based incentive mechanisms. The cost of subsidising bus fares (for both new and existing users) has, therefore, been captured when estimating the cost of increasing bus capacity into city centres.

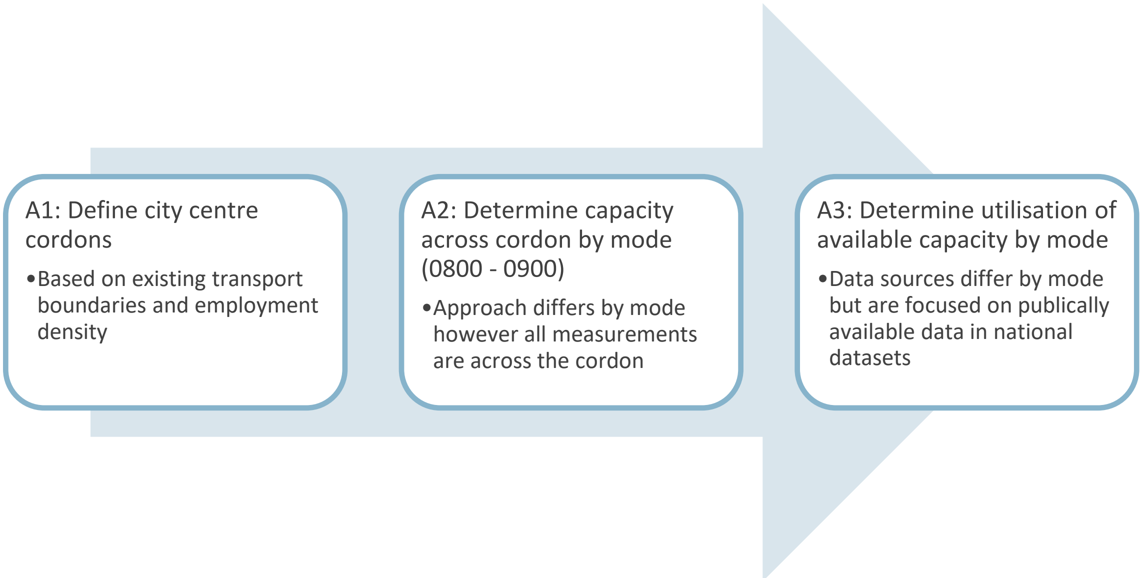
3 A: Transport Network Capacity and Utilisation

Overview

3.1 Current transport network capacity in each of the case-study cities underpins the results for all components of this study, and feeds into parallel studies within the wider project. Current capacity is reported as the Urban Transport Capacity Metric (UTCM) at the end of this chapter. In particular, this study focuses on inbound capacity into city centres in the morning peak hour (0800 - 0900). Capacity is measured across cordons defined around each case-study city centre (see Appendix A).

3.2 An overview of the approach to determining urban transport capacity across modes is summarised in Figure 3.1.

Figure 3.1: Urban Transport Capacity Metric development



3.3 Our approach to estimating capacity and utilisation has been designed to follow a process which:

- uses publicly available data and information;
- can be repeated consistently across twenty case study cities; and
- is appropriate for extension across non-case-study cities;
- is focused on achieving order of magnitude estimates of transport capacity and utilisation only.

3.4 Our approach to estimating inbound capacity is presented in this section for each mode. All capacity and utilisation results are for inbound trips into the relevant city centres between 0800 and 0900. Key capacity metrics are reported in Appendix C for each case-study city.

Methodology rationalisation and limitations

3.5 There is no perfect way to determine a single value that represents capacity across an entire urban network. While each individual element of a transport network has a definable capacity, for a system formed of a combination of those elements it is much more difficult to determine a single numeric value of capacity. The way in which the system is used on any given day can change, this affects the overall capacity available to an individual accessing the city centre. For example, a single seat on a bus can provide capacity for multiple people along a route as different passengers board and alight in different locations along the route, or increasing the number of buses travelling into a city centre may reduce the capacity available for private car travel.

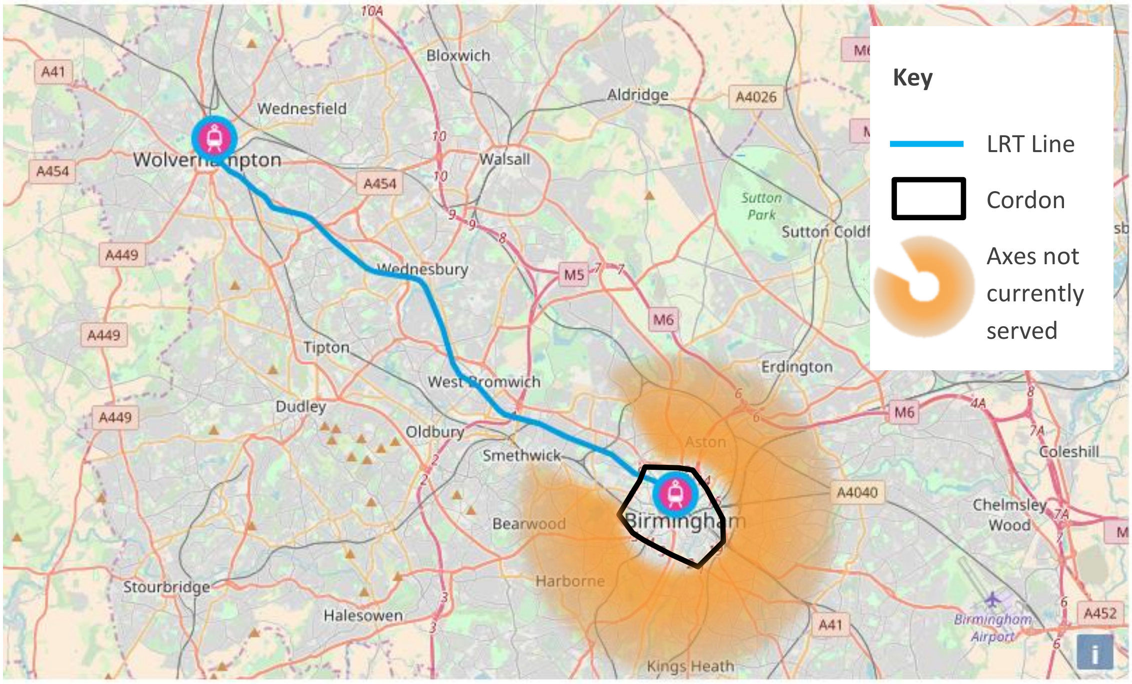
3.6 The approach to understanding capacity, based on measuring capacity across a tightly defined cordon, is therefore rationalised on the basis that:

- measurement of capacity at a single location provides a consistent measure, minimising the impact of travel patterns on capacity;
- consideration of attributes of the transport network at/across the cordon are those most directly relevant to trips into the city centre; and
- the cordon simplifies the requirement to consider inbound trips only.

3.7 It should be noted, however, that services and links crossing each cordon do not exist in isolation; rather, they form part of wider networks. Consequently, constraints away from city centres could, in fact, be the key determinants of capacity in the peak periods.

3.8 Additionally, the measurement of a single value for capacity by city and mode does not provide insight into how the availability of a given mode is distributed across the city. For example, Birmingham currently has a single radial light rail (Midland Metro) line, meaning only city centre bound trips on a single corridor are served and the capacity that light rail offers is only available to a proportion of people who travel into Birmingham city centre (see Figure 3.2). This is an important point to note when considering how capacity is distributed across modes and the potential for available capacity, as reported, to provide for the growth of a city.

Figure 3.2: Existing Midland Metro Network



Methodology Overview

3.9 The following text provides an overview of the approach to developing the UTCM. Further detail is provided in Appendix A (City centre cordon definition and maps), Appendix C (Capacity Methodology and Metrics) and Appendix D (Census Journey to Work Data manipulation).

A1: Cordon Definition

3.10 City centre cordons have been defined with the overarching aim of capturing areas of high employment, while also considering the effect of current transport infrastructure and natural boundaries on the geographic extent of the city centre. Cordon definitions therefore consider both employment and natural/man-made barriers to movement. In most cases the cordons are defined tightly around the central business districts of case-study cities and often exclude city centre fringe activities. City centre cordon maps are included in Appendix A.

A2: Inbound Capacity

3.11 Different methodologies and data sources are used to calculate capacity for each transport mode. Transport capacity has been estimated using different methodologies for private motor vehicles, public transport and active modes (walking and cycling). Walking and cycling 'capacity' represents the number of trips by these modes, rather than available infrastructure capacity.

3.12 A summary by mode is set out in the following text, further information on this process is provided in Appendix C.

Public transport

3.13 Capacity for all public transport modes is calculated following a similar process and uses:

- Service frequency
    - Rail – Current Timetables

  - Tram/Metro - Current Timetables
  - Bus – National Public Transport Access Nodes (NaPTAN) database (7:30-9:30am)
- Assumed average capacity (seating + standing)
  - Developed at a city specific level based on local operators and industry knowledge

3.14 Adjustments are made to remove 'through' rail capacity where a city is located en-route to another city and measured capacity based on service frequency alone would overestimate the rail capacity available to serve the city itself.

Road (private vehicle) capacity

3.15 Private vehicle capacity is based on the hourly vehicle capacity of inbound lanes crossing the cordon. Strategic transport models are widely used to estimate the transport capacity of urban road networks. Undertaking model runs, or sourcing model information, for the twenty case-study cities is not proportionate to the scope of this study. Therefore, only the links crossing the cordon and adjacent junctions are used in the capacity estimation.

3.16 Inbound link capacity is calculated through manually coding the features of each link based on aerial photography. Theoretical capacity values from the Design Manual for Roads and Bridges are then applied to estimate the theoretical capacity of each link. Reduction factors are applied to the theoretical capacity to reflect constraints such as on-street parking, driveways and impacts of adjacent junctions.

3.17 Some adjustment for anomalies is undertaken by exception to remove 'through' capacity to account for large 'through' roads crossing a cordon which predominantly serve traffic not travelling to the city centre.

Active mode capacity

3.18 The capacity of active mode networks (walking and cycling) is defined, for the purpose of this study, to correspond to the current utilisation. This is on the basis that in most UK cities, uptake of walking and cycling tends to be limited by policy and societal preference as opposed to capacity constraints on these modes. The basis for the estimates of the number of people travelling into each cordon by active modes is 2011 census journey to work origin-destination data. National Travel Survey (NTS) 2016 data have been used with census data to:

- Understand daily and weekly travel profiles by purpose and by active mode, in order to quantify the percentage of commuting trips made during the morning peak hour (0800 – 0900)
- Scale-up the number of trips to account for other journey purposes (e.g. education, leisure, business).

Committed capacity increases

3.19 Committed capacity increases are considered in the context of understanding contemporary themes in transport planning and are not included in the UTCM results. Data to inform this consideration is drawn from information provided by local authorities and central government (press releases and *Local road and transport schemes*, 2017, DfT[8]).It is recognised that not all committed capacity improvements are captured in Appendix B, as these are used for information only this does not affect the conclusions drawn from this study.

[8] See http://maps.dft.gov.uk/large-local-road-schemes-2017/index.html

A3: Transport Network Utilisation

3.20 Transport network capacity remains relatively stable throughout the year. Conversely utilisation, in general and by mode, is subject to seasonal effects. In estimating utilisation for this study we have, where possible, attempted to understand utilisation on a typical weekday outside of school holidays. Utilisation in this study refers to trips ending in city centres between 0800 and 0900 only.

3.21 No single resource provides a complete view of utilisation, on a normal day, for all modes and trip purposes, at a national level exists. Therefore, our approach to understanding utilisation involved gathering data from multiple sources and sifting data for each mode to identify the most reliable datasets for each mode. Data sources include:

- Count information published and provided by local authority districts;
- DfT data tables for rail, light rail, bus and traffic counts;
- Highways England WebTRIS;
- 2011 Census journey to work data;
- National Travel Survey; and
- Office of Rail and Road station entries and exits.

3.22 Utilisation values represent 2018 values (current at the time of writing). Where data for 2018 is not available, the most recent data is used and scaled up to 2018 values using:

- DfT rail counts for national rail;
- Population growth from Centre for Cities (PUA) for road, metro/tram and active modes; and
- No growth is applied to bus utilisation due to downward trends in bus use.

3.23 Further detail on the methodology for determining utilisation by mode is provided in Appendix C.

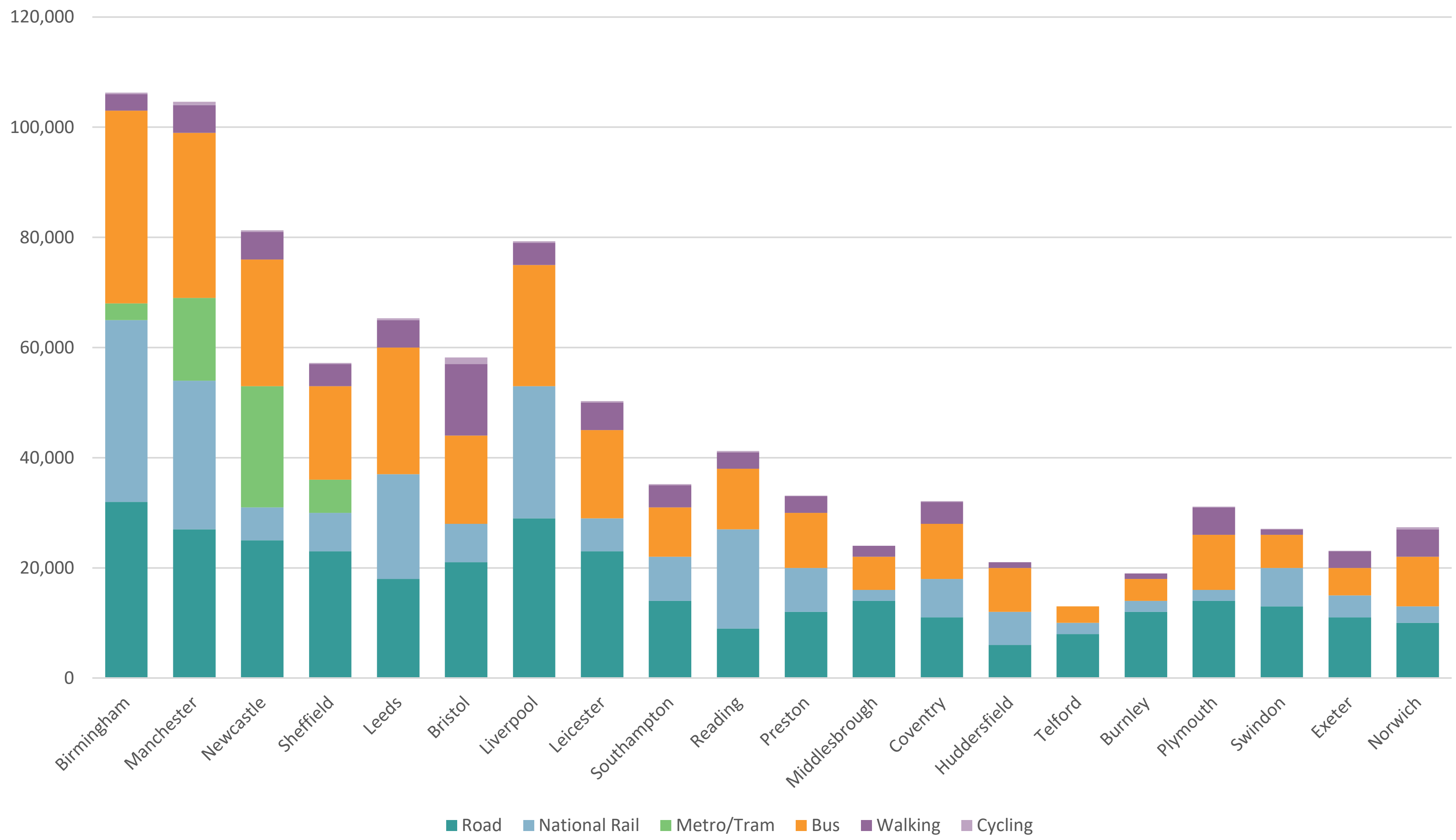
UTCM Results

3.24 The methodology in the preceding text is focused on producing capacity and utilisation results for the twenty case-study cities. These results are summarised in Figure 3.3 and Figure 3.4. The UTCM results represent an estimate of theoretical capacity and should be adjusted (or normalised) to better represent the reasonably useable capacity and subsequent utilisation in each city and for each mode. Normalisation is necessary to account for:

- The difference between theoretical capacity and actual capacity;
- Gaps in geographic coverage and level of service; and
- Recognition that user perception of the theoretical spare capacity on a mode influences travel behaviour in terms of mode choice and the timing of a trip.

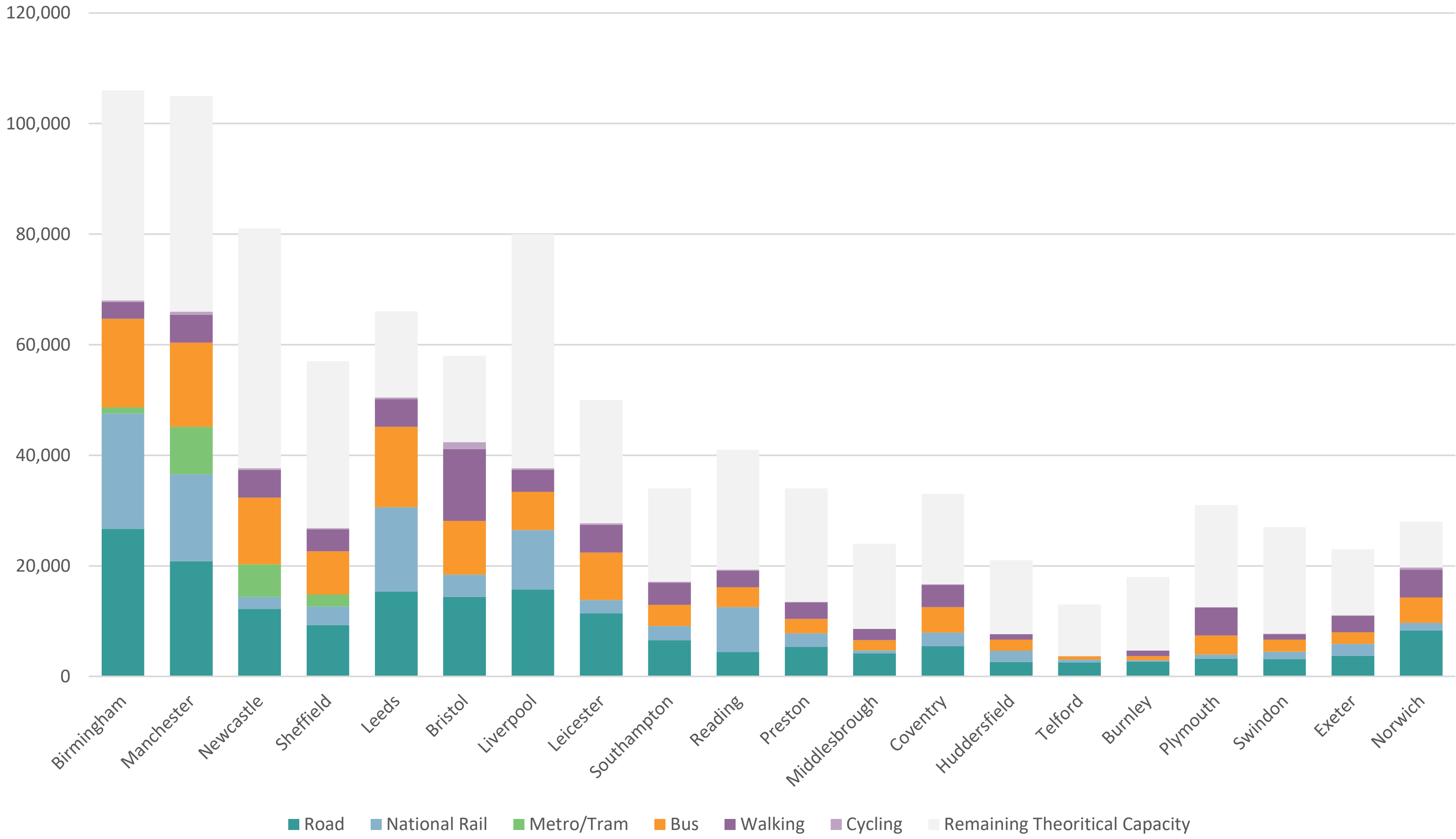
3.25 The results presented in this study are based upon observed capacity and utilisation and have not been normalised. However, the UTCM results have been normalised by the National Infrastructure Commission prior to being applied in parallel studies as part of the wider project.

Figure 3.3: Morning peak theoretical inbound capacity across city centre cordon – case study cities



Source: Steer Davies Gleave

Figure 3.4: Morning peak capacity utilisation across city centre cordon – case study cities



Source: Steer Davies Gleave

Extrapolation of results across a wider range of cities

3.26 While 20 case-study cities are used to develop the core results of this study, the wider project and subsequent recommendations as part of the National Infrastructure Assessment are intended to be representative of all English cities. We have, therefore, used the ONS Output Area Classifications to categorise cities and apply capacity and cost trends across 34 additional cities[9]. Capacity and utilisation results across the 54 cities (20 case-study + 34 additional) are presented in Figure 3.5 and Figure 3.6. Further detail of the scaling methodology is included in Appendix E.

[9] **https://www.ons.gov.uk/methodology/geography/geographicalproducts/areaclassifications/2011areaclassifications**

Figure 3.5: Morning peak theoretical inbound capacity across city centre cordon – scaled to represent all cities

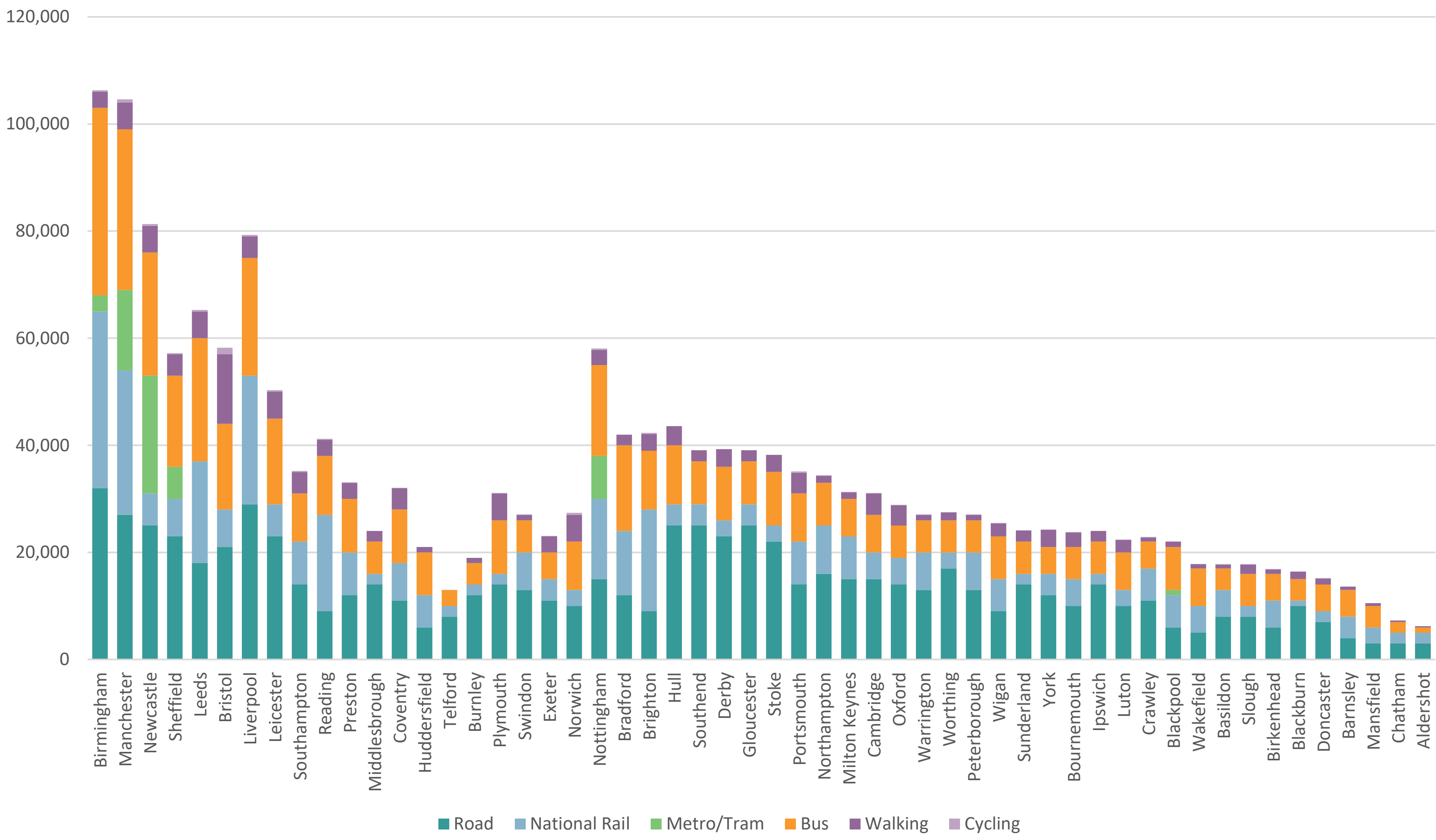
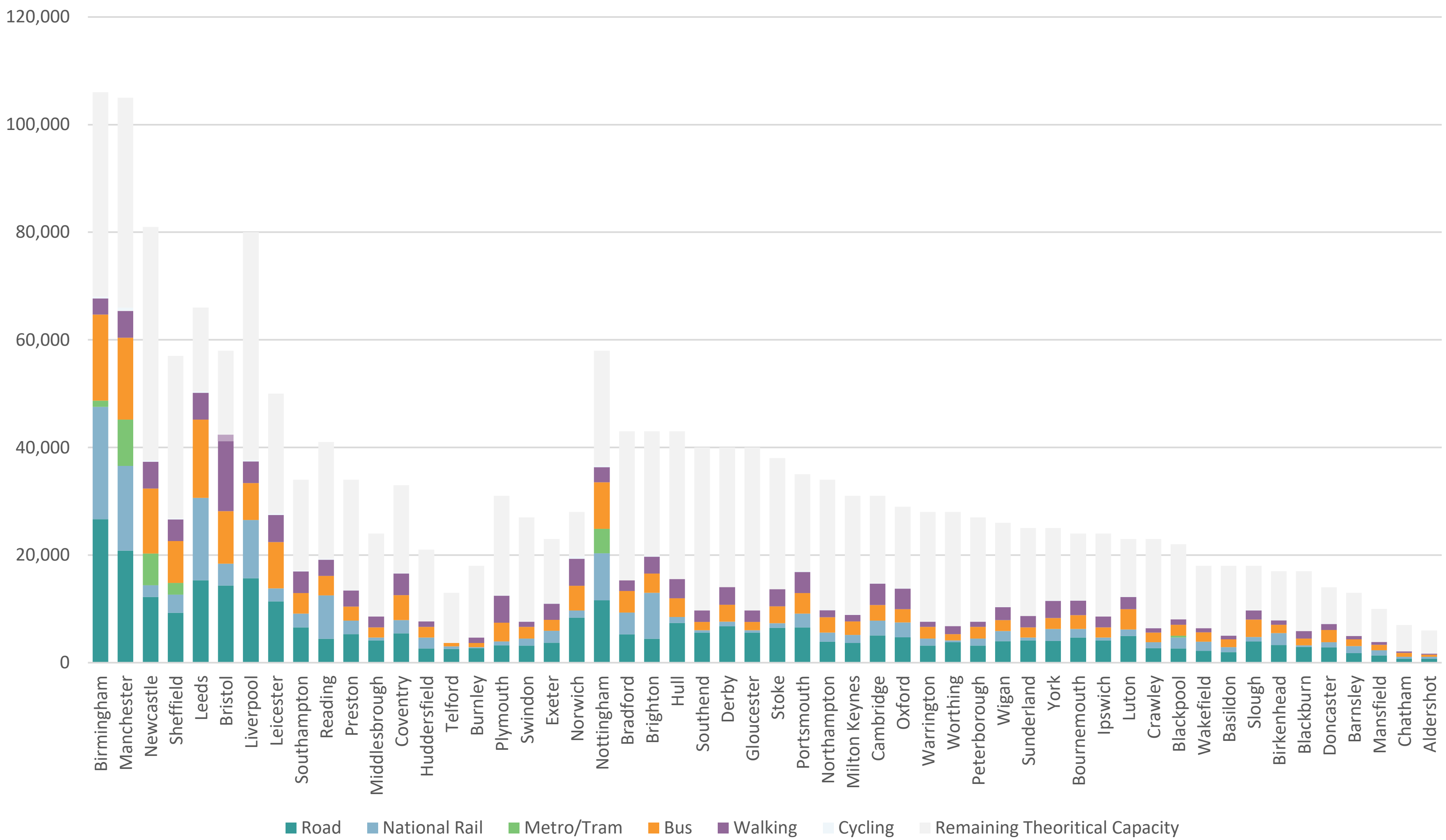


Figure 3.6: Morning peak capacity utilisation across city centre cordon – scaled to represent all cities



4 B: Capacity Uplift Scenarios

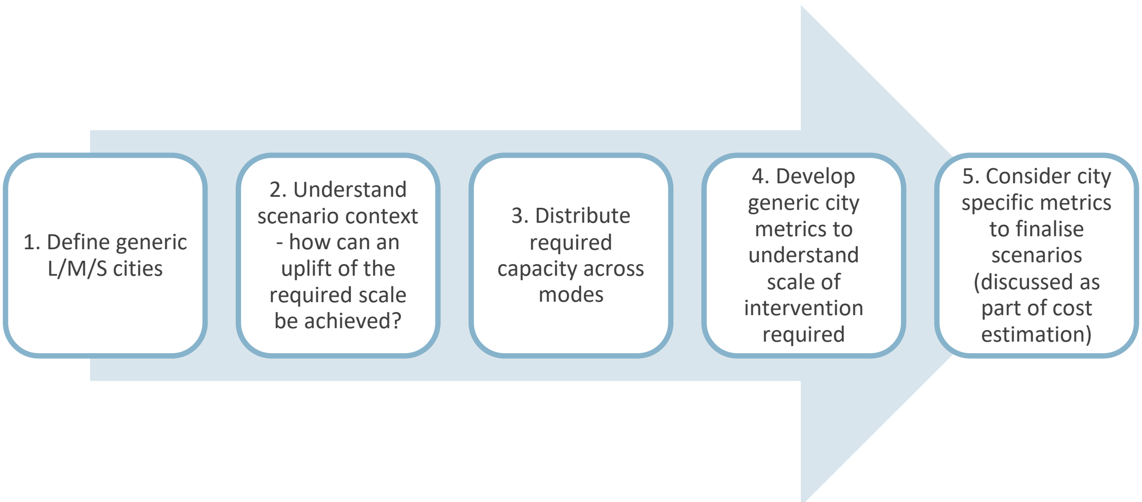
Overview

4.1 Five capacity uplift scenarios have been developed that form the basis for estimating the cost of increasing transport capacity into city centres. Scenarios define how each mode could contribute to additional transport capacity within a city, and paint a picture of what a capacity increase could 'look like'. Scenario definition, the focus of this chapter, refers to determining how the capacity uplift could be distributed across modes only (e.g. 40% of uplift provided by bus, 20% of uplift by road, and the remaining 40% by light rail). The individual interventions required to achieve the capacity uplift are discussed in the cost estimation section.

4.2 Considerations within each scenario are focused on how transport capacity into city centres can be increased, as opposed to more general consideration of capacity for all origin-destination pairs across a city/region. Where possible, scenarios include the lowest cost, realistic approach to providing the defined capacity uplifts. This, by extension, also requires consideration of the available policy levers at a local level.

4.3 An outline of the approach followed is set out in Figure 4.1. This approach is centred on the development of scenarios for generic large, medium and small (L/M/S) cities, before scaling the quantum of each intervention in line with city-specific metrics as part of the cost estimation process.

Figure 4.1: Scenario Development Approach



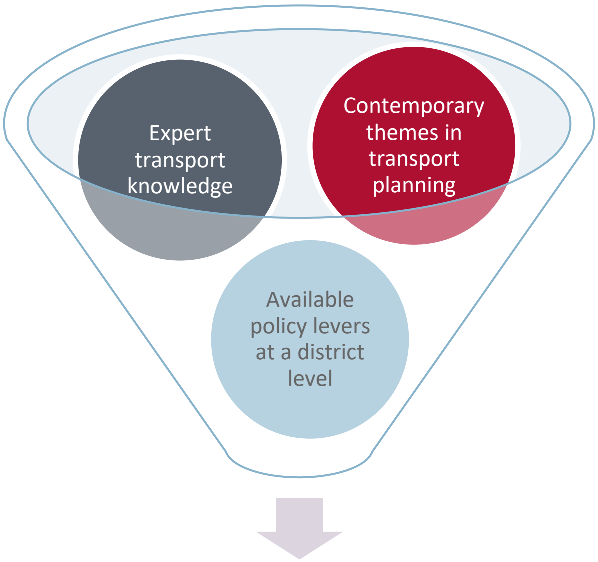
4.4 The UTCM results form the basis of the capacity uplift scenarios. The broad scenario definitions are based on the study scope:

1. 5% capacity uplift

2. 10% capacity uplift
3. 20% capacity uplift
4. 10% bus focused capacity uplift
5. 10% active modes focused capacity uplift

4.5 The distribution of capacity across modes in each scenario is based on drawing together a range of information, as set out in Figure 4.2.

Figure 4.2: Information Feeding into Scenario Development



4.6 The remainder of this chapter discusses:

- The definition of generic cities, used as a basis for defining scenarios;
- Scenario contexts, providing an overview of the scale of change that may be required to deliver the specified capacity uplifts;
- Mode considerations, assumptions specific to each mode that provide an understanding of the markets served by each mode and the extent to which each mode may be appropriate in each scenario; and
- Scenario definition, sets out the scenarios as they relate to the defined 'generic cities'.

Generic City Definitions

4.7 Scenario definitions are prepared for groups of cities (L/M/S), as opposed to individually by city. While the scenarios are scaled and applied to the twenty case-study cities individually to generate cost estimates, grouping provides a sufficiently generic approach to allow the extrapolation of results across all English cities.

4.8 The twenty case-study cities can be broadly grouped into large, medium and small groups based on primary urban area population[10]. For the cities in each group, a range of metrics

[10] It is recognised that primary urban area population covers the full extents of the local authority districts in which a town/city is located. Therefore, it is not necessarily a true representation of the size of a built up urban area.

based upon observations from each of our case-study cities were considered, to understand the scale and nature of an average large, medium and small city. Generic city definitions, based on mean values for groups of case-study cities, are set out in Table 4.1. All capacity uplifts are based on the 'theoretical' capacity calculated as part of the UTCM.

Table 4.1: Generic City Definitions (0800-0900 metrics)

Generic City	Current Capacity	5% of Capacity	10% of Capacity	20% of Capacity	Existing Inbound Traffic Lanes	Current Train Arrivals	Current LRT/Metro Arrivals	Current Bus Arrivals
Large	75,000	4,000	8,000	15,000	36	38	33	283
Medium	31,000	2,000	3,000	6,000	16	19	-	143
Small	23,000	1,000	2,000	5,000	14	8	-	96

Source: Steer Davies Gleave analysis

Scenario Contexts

4.9 In understanding what realistic transport capacity uplifts could 'look like' the potential to provide all required additional capacity through a single mode is considered. This identifies limits on the potential for individual modes to contribute to capacity uplifts.

4.10 The scale of change required to achieve each specified uplift is considered separately.

Delivery of capacity through a single mode

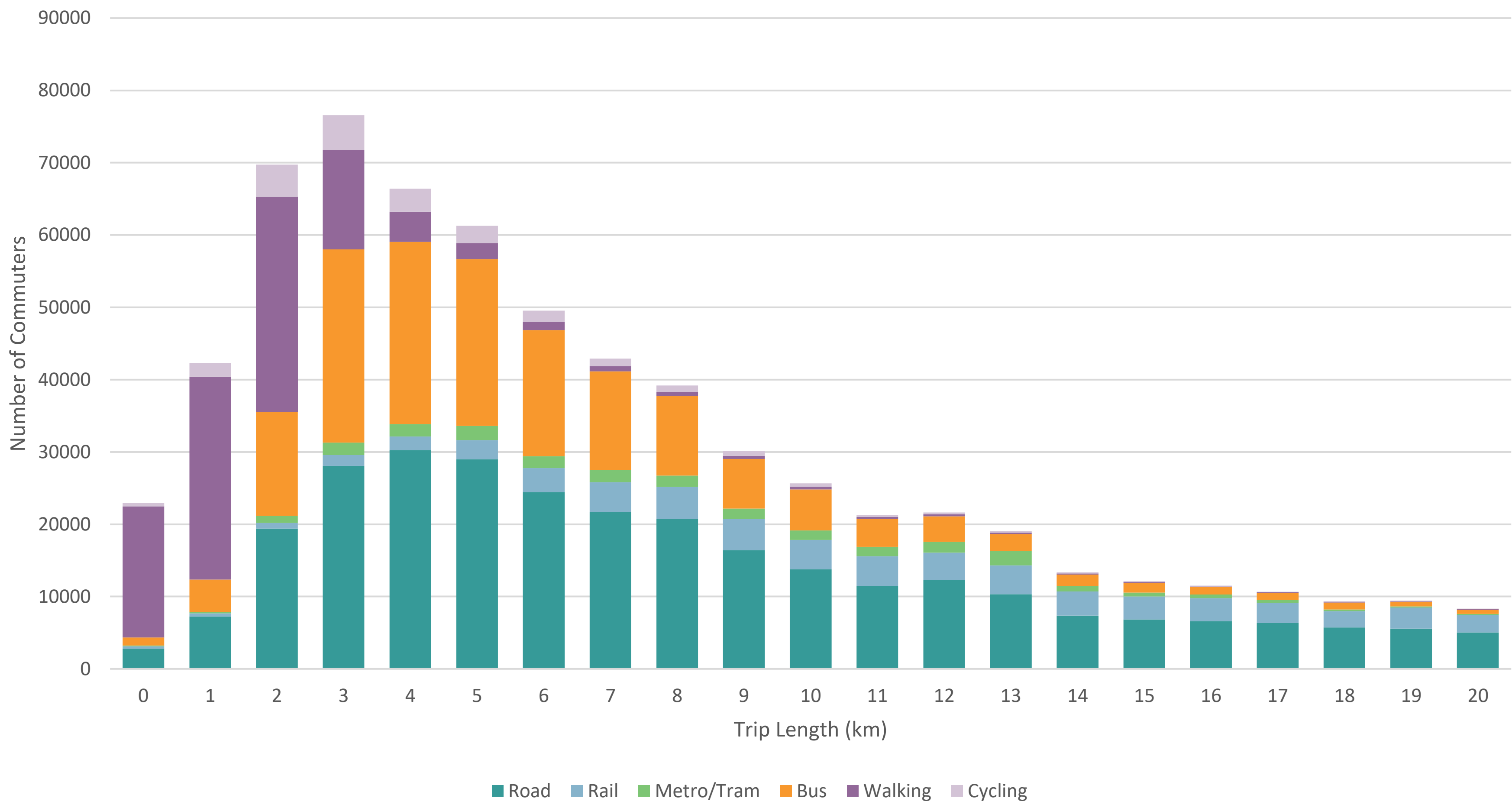
4.11 Representations of the additional services/lanes required if uplifts were delivered by a single mode are set out in Table 4.2 to Table 4.4.

4.12 While for some scenarios it may be possible to deliver all required capacity uplift through a single mode, this is unlikely to be the most effective method of delivery. Different modes serve different markets. One demonstration of this is through disaggregating by trip length, whereby different modes are more convenient or appropriate for different trip lengths. Other travel market segmentations could be based on accessibility of modes due to cost, residential densities at the trip origin, geographic location of infrastructure and physical requirements for use (e.g. ability to drive).

4.13 Furthermore, city centres, by their built-up nature, are space constrained. Modes vary in terms of their space efficiency, which is an important consideration in city centres where multiple routes converge. For example, while a light rail route may only operate with six trams per hour outside the city centre, within the city centre a single length of track can accommodate much higher frequencies where multiple routes converge.

4.14 Figure 4.3 shows distribution of trip length by mode based on journey to work data used for the 20 case-study cities, only trips up to 20km in length are included. Walking and cycling are most predominant for trip lengths up to 3km (slightly longer for cycling). Bus is a common mode for short to medium distance trips, while rail serves medium to long distance trips. Car trips are relatively dominant for all, except very short, trip lengths.

Figure 4.3: Distribution of trip lengths by mode



Source: Census Journey to Work 2011 (for trips to case-study city centres)

4.15 Table 4.2 to Table 4.4 show that delivery of the specified capacity through a single mode would, in most cities, not be possible. For example, for a generic large city delivery of a 10% uplift in capacity would mean either:

- 13 additional road lanes (unlikely to be able to be accommodated within the available space); or
- 150 additional rail carriages, this is approximately equivalent to adding 2 carriages to every existing train, or increasing service frequencies by 30 trains in the peak hour (~80% uplift in frequencies); or
- 27 new trams (>80% uplift in frequency); or
- 93 new buses (>30% uplift in frequency)

4.16 The large uplifts required relative to existing provision by each mode means that the current system would struggle to accommodate the level of change if delivered through a single mode. As already noted, each mode serves different markets, which means a balanced portfolio of capacity increase will be needed if the full benefits are to be realised

4.17 On this basis, an approach to developing scenarios using a combination of modes is considered appropriate.

Table 4.2: 5% scenario – requirements if capacity delivered through a single mode

Size	Units Required (by mode)				Proportion of Existing Capacity			
	Road (inbound lanes)	Rail (carriages)	Metro/Tram (vehicles)	Bus	Road (inbound lanes)	Rail (trains requiring additional carriages)	Metro/ Tram (vehicles)	Bus
L	6.3	36.7	13.5	46.5	18%	98%	41%	16%
M	2.6	15.2	5.6	21.9	17%	82%		15%
S	2.0	11.4	4.2	16.4	14%	145%		17%

Source: Steer Davies Gleave

Table 4.3: 10% scenario – requirements if capacity delivered through a single mode

Size	Units Required (by mode)				Proportion of Existing Capacity			
	Road (inbound lanes)	Rail (carriages)	Metro/Tram (vehicles)	Bus	Road (inbound lanes)	Rail (trains requiring additional carriages)	Metro/ Tram (vehicles)	Bus
L	12.7	73.4	26.9	93.0	35%	195%	82%	33%
M	5.3	30.4	11.1	43.8	33%	164%		31%
S	3.9	22.7	8.3	32.8	29%	290%		34%

Source: Steer Davies Gleave

Table 4.4: 20% scenario – requirements if capacity delivered through a single mode

Size	Units Required (by mode)				Proportion of Existing Capacity			
	Road (inbound lanes)	Rail (carriages)	Metro/Tram (vehicles)	Bus	Road (inbound lanes)	Rail (trains requiring additional carriages)	Metro/ Tram (vehicles)	Bus
L	25.4	146.9	53.8	186.0	71%	390%	164%	66%
M	10.5	60.7	22.3	87.6	66%	328%		61%
S	7.9	45.5	16.7	65.6	58%	580%		68%

Source: Steer Davies Gleave

Scale of change required by capacity uplift

4.18 The following text sets out the scale of change required to achieve the capacity uplifts in each scenario. Contemporary themes in transport planning are drawn upon in developing these contexts as discussed in Chapter 2.

1: 5% Capacity Uplift

4.19 A 5% uplift in capacity is relatively incremental. It can generally be achieved through maintaining a similar transport offer within a city with increases to bus frequencies, train lengths, junction optimisation, and short sections of additional road lanes.

2: 10% Capacity Uplift

4.20 To achieve a 10% uplift in capacity more significant changes to the transport offer are required. For example, in medium and large cities this may mean the introduction of new tram lines (serving new origins), in smaller cities differentiated (i.e. high-quality) bus services may be introduced. Three scenarios are considered for a 10% capacity uplift:

- Standard 10% uplift (Scenario 2)
- 10% uplift with focus on bus capacity (Scenario 4)
- 10% uplift with focus on active mode capacity (Scenario 5)

3: 20% Capacity Uplift

4.21 Transformational change is required to achieve a 20% uplift in capacity. In larger, established cities this may include interventions such as a tunnelled public transport route in the city centre, due to surface level space constraints. For rail services this will likely require major reconstruction of the terminus or main station to accommodate additional services.

Mode Considerations

4.22 Building on the earlier discussion of the differences in markets served and contemporary themes, we have further considered the key attributes of each mode. The following assumptions/assertions are central to the assumed distribution of capacity across modes in each scenario:

Road

- Large cities tend to have better developed public transport networks and actively seek to minimise travel by private vehicle into city centres.
- Large cities have generally maximised the amount of road capacity that can be provided into city centres. A small amount of additional road capacity could be achieved in large cities, however the contribution of road capacity to additional capacity is fixed across scenarios 1-3.
- Small and medium cities have less developed public transport networks and are therefore more car-dependent.
- Due to lower absolute capacity uplifts required, a greater proportion of the required uplift can be achieved by investment in roads in small and medium cities, the contribution of road capacity is fixed across scenarios 1-3.

Rail

- Rail is very efficient at providing high capacity levels, however it is also an expensive mode to implement. The importance of rail capacity is greatest in the higher uplift scenarios.

- Rail network coverage is poorer in smaller cities, with only a selection of trip origins served by rail. The contribution of rail to providing capacity increases in small and medium cities, therefore, is lower.
- Rail is a national network, not necessarily focused on maximising capacity into each and every case-study city. Constraints on the rail network outside of cities may be the limiting factor on the ability to provide additional rail capacity. Light rail is therefore considered a more targeted mode for providing urban transport network capacity in many instances.

Bus

- Large cities are likely to experience kerb space constraints within their city centres for providing bus stops. Moreover, in large cities road capacity constraints are likely to affect bus journey times. For this reason, buses are utilised to a lesser extent in the higher uplift scenarios.
- In small and medium cities, it is assumed there is greater capacity to accommodate additional buses. However, medium cities may also need to extend to higher capacity modes (such as light rail) in the higher uplift scenarios.
- Currently, local authorities have limited ability to influence how bus services are provided, although additional powers are being made available to local decision makers through devolution deals. Bus utilisation, outside of London, has faced long term downward trends. Therefore, any uplift in bus capacity will likely require additional incentives to drive any marked uptake in utilisation.
- Despite long-term downward trends in bus utilisation, buses continue to provide the greatest cumulative capacity of any public transport mode for urban trips, see Figure 4.3.
- Buses are a flexible transport mode. Unlike trams, which require fixed infrastructure on a specified route, bus routes can change over time as origin-destination pairs change.

Metro/Tram

- Light rail is perceived as a more attractive mode than bus and therefore does not face the same issues as bus with attracting passengers who would otherwise use car.
- For the purposes of this study additional Metro/tram capacity is assumed to be light rail, not underground capacity (except where a section of tunnelling may be required).
- Due to the high cost of implementation, and the ultimate need to demonstrate value for money, light rail is considered in this study for large and medium cities only.

Active Modes

- In scenarios 1-3 active modes are not explicitly considered. New transport infrastructure generally has provision for active modes, therefore the costs developed in component C (cost estimation) account for some investment in active modes, however the impact of this on active mode utilisation is not accounted for.
- For the majority of the population, active modes are only attractive for relatively short trips, therefore the ‘market’ for these modes in this study is limited to people living in close proximity to the city centre.
- In scenario 5 (10% active mode focus) active mode capacity replaces bus capacity in scenario 2 (standard 10% scenario). This is justified on the basis that both active modes and buses serve shorter trips and do not require car ownership.

Mode Summary

4.23 As demonstrated in the preceding text, the suitability and effectiveness of investment in each mode varies by city and scenario. Maximum typical capacities for case-study cities are summarised by mode in Table 4.5. Note that values in Table 4.5 refer to infrastructure provided in urban areas outside of city centres to move people into the cordon. They are not intended to represent infrastructure within city centres where multiple routes converge. For example, tram routes in Manchester typically operate with 12 minute headways outside the city centre, however within the city centre various routes converge so that a single tram track accommodates vehicles from several lines at lower headways.

Table 4.5: Maximum typical capacity summary by mode

Mode	Maximum typical capacity per vehicle*	Vehicles per lane/route	Passenger capacity per lane/route	Notes
Car	1.2	600	720	1.2 people per car is typical private vehicle occupancy, as opposed to capacity.
Bus	90	20	1,800	Includes seating and standing capacity for a double decker bus.
BRT	105	20	2,100	Includes seating and standing capacity for an articulated bus.
Tram	240	12	2,880	Based on a 40m tram vehicle, seating and standing capacity.
Rail	450	N/A	N/A	Prototypical 4 car commuter train. Due to rail lines running as part of a complex national network, typical vehicles/route value not calculated. For the purposes of this study rail capacity uplifts driven by service frequency and train length increases only.

*Maximum typical for cities within the scope of the study, actual values vary by city

Scenario Definition

4.24 The scenarios developed for each of the large, medium and small generic cities are summarised in Table 4.6 to Table 4.10. These summaries set out:

- The contribution of each mode to the capacity uplift in each scenario. For example, in the 5% scenario (Table 4.6) for large cities: 10% of the required uplift is assumed to come from road capacity, 25% from national rail, 25% from light rail and the remaining 40% from bus.
- A representation of what this mode contribution could mean in terms of required addition vehicles and lanes. This provides an understanding of the scale of the uplift required and works as a validation point to understand whether the uplift attributed to each mode is achievable.
  - For the 5% scenario for large cities set out above, the required uplift in capacity could be achieved through cumulatively implementing: 1 additional road lane, 10 additional rail carriages, 4 additional light rail vehicles (LRVs) and 19 additional buses in the 0800 - 0900 morning peak.

Table 4.6: 5% Capacity Uplift Scenario (Generic Definition)

Size	Contribution by Mode					Equivalent Additional Units required			
	Road	National Rail	Metro/ Tram	Bus	Active Modes	Road - Lanes	Rail - Carriages	Tram-LRV	Bus-Veh
Large	10%	25%	25%*	40%		1	10	4	19
Medium	40%	15%		45%		2	3	0	10
Small	40%	10%		50%		1	2	0	9

*where a city already has a tram/metro network only, otherwise this proportion of uplift is provided by bus.

Table 4.7: 10% Capacity Uplift Scenario (Generic Definition)

Size	Contribution by Mode					Equivalent Additional Units required			
	Road	National Rail	Metro/ Tram	Bus	Active Modes	Road - Lanes	Rail - Carriages	Tram-LRV	Bus-Veh
Large	5%	25%	25%	45%		1	19	7	42
Medium	20%	20%	40%	20%		2	7	5	9
Small	20%	10%		70%		1	3	0	23

Table 4.8: 20% Capacity Uplift Scenario (Generic Definition)

Size	Contribution by Mode					Equivalent Additional Units required			
	Road	National Rail	Metro/ Tram	Bus	Active Modes	Road - Lanes	Rail - Carriages	Tram-LRV	Bus-Veh
Large	3%	25%	50%	23%		1	37	27	42
Medium	10%	30%	50%	10%		2	19	12	9
Small	10%	10%		80%		1	5	0	53

Table 4.9: 10% Bus Focused Capacity Uplift Scenario (Generic Definition)

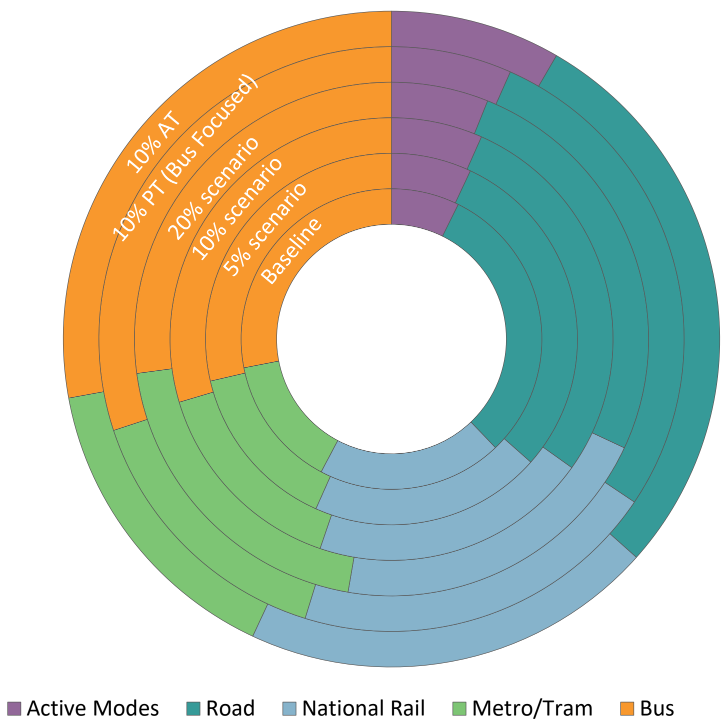
Size	Contribution by Mode					Equivalent Additional Units required			
	Road	National Rail	Metro/ Tram	Bus	Active Modes	Road - Lanes	Rail - Carriages	Tram-LRV	Bus-Veh
Large	-	25%	25%	50%		0	19	7	47
Medium	10%	20%	-	70%		1	7	0	31
Small	10%	10%	-	80%		1	3	0	27

Table 4.10: 10% Active Modes Focused Capacity Uplift Scenario (Generic Definition)

Size	Contribution by Mode					Equivalent Additional Units required			
	Road	National Rail	Metro/ Tram	Bus	Active Modes	Road - Lanes	Rail - Carriages	Tram-LRV	Bus-Veh
Large	5%	25%	25%	26%	19%	1	19	7	25
Medium	20%	20%	-	83%	17%	2	7	0	37
Small	20%	10%	-	444%	26%	1	3	0	15

4.25 The resulting distribution of all capacity across modes, and how this changes by scenario is summarised in Figure 4.4 to Figure 4.6. This shows that for large and medium cities, metro/tram is assumed to become more important as the uplift in capacity required increases. For small cities, bus is assumed to be an appropriate mode for providing large scale increases in capacity. Regardless of mode, capacity increases of 20% would be transformational and require a step change relative to existing transport provision in a city.

Figure 4.4: Mode Share of Capacity for Generic Large City – by Scenario



Source: Steer Davies Gleave

Figure 4.5: Mode Share of Capacity for Generic Medium City – by Scenario

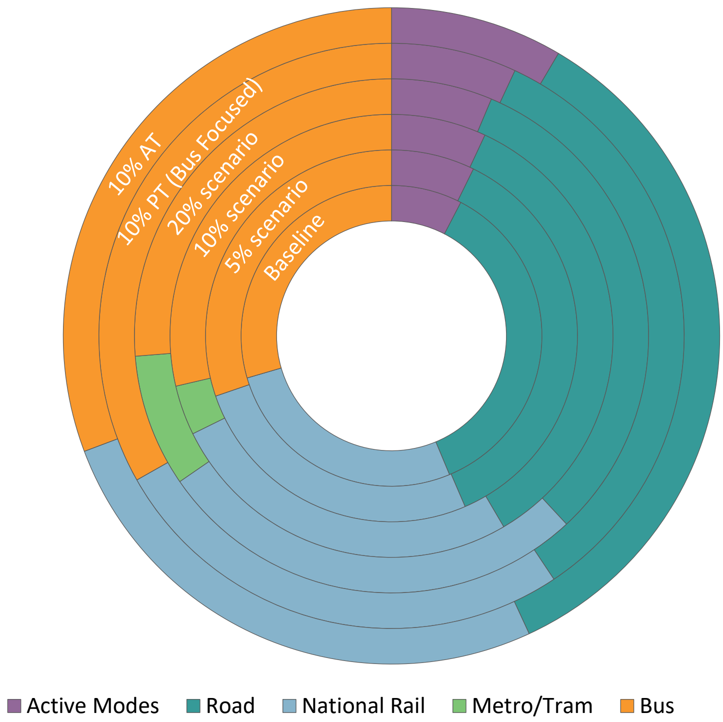
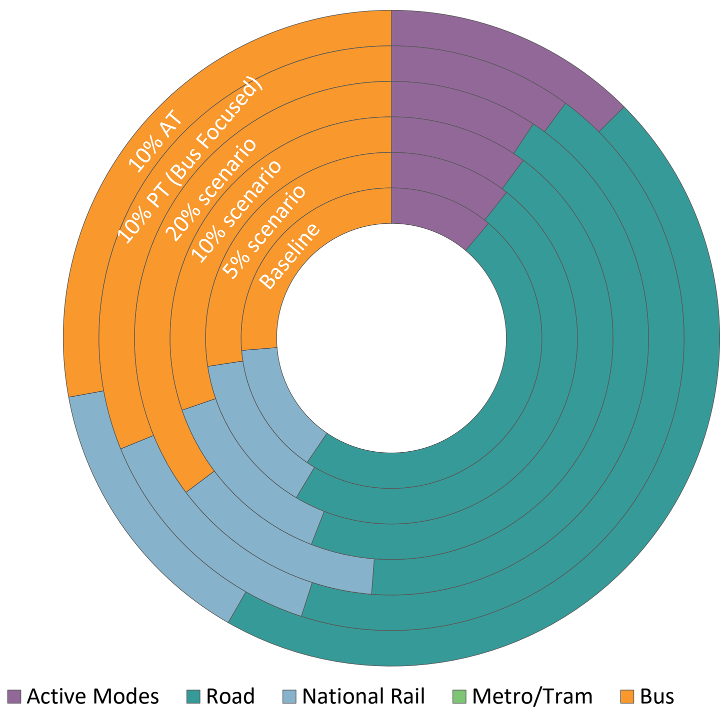


Figure 4.6: Mode Share of Capacity for Generic Small City – by Scenario



Source: Steer Davies Gleave

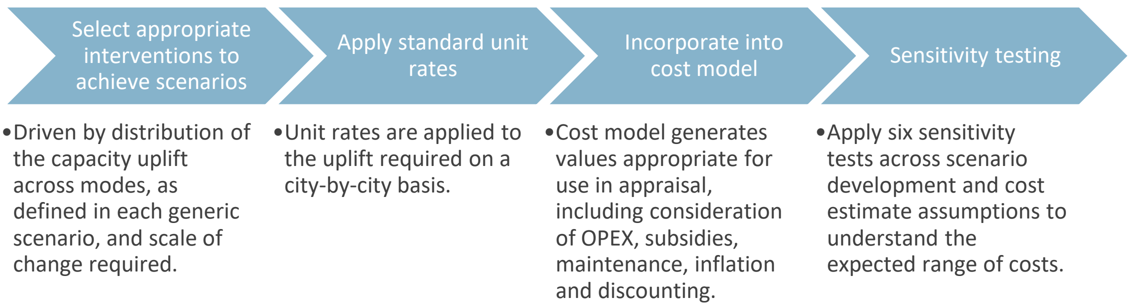
5 C: Packaging and Cost Estimates

Overview

5.1 Order of magnitude cost estimates have been developed for each of the capacity uplift scenarios, for each case-study city. City-specific metrics are used to understand the likely scale of cost, and are not intended to be representative of what a specific city would, or should, implement to achieve the specified capacity uplifts.

5.2 Specific plans and programmes for individual cities should be developed at a local level, taking into account local context and need. The approach to cost estimates is focused on being representative at an aggregate level, variations between reported and actual values/scenarios are anticipated at a city level. An overview of the cost estimation process is provided in Figure 5.1.

Figure 5.1: Cost Estimation Overview



Selection and Packaging of Interventions

5.3 Packages of interventions were developed on a generic city basis (see Chapter 4) for each scenario. Packages were drawn from an initial long-list of interventions, developed as part of a workshop involving a range of transport specialists and representation from the National Infrastructure Commission. Due to the overlapping and complementary nature of many of the interventions on the long list, final packages were developed based on the core interventions required to deliver the bulk of capacity (e.g. additional light rail/tram vehicles) with additional interventions incorporated into the packages where necessitated by scale (e.g. new light rail lines). Further detail on the packaging of interventions is included in Appendix F.

5.4 An overview of the adopted packages is set out in Table 5.1 to Table 5.5. City specific scaling of packages for each of the case-study cities is provided in Appendix F. Note that city specific packages use the UTCM 'theoretical capacity' results. While the underlying UTCM results are theoretical and have not been normalised as part of this study, scenarios are defined as percentage uplifts and can therefore be based on theoretical capacity results.

Table 5.1: Interventions included in 5% Uplift Scenario

	Core Interventions	Complementary Interventions
Large Cities	•Incremental increase in train lengths - 10 additional carriages in the morning peak on average •Use of longer vehicles where metro/tram system exists - 4 additional carriages on average •Increased bus frequencies - 19 additional buses on average (more in cities with no existin tram/metro) •Relief of constraints on road network through provision of additional lanes at pinch points	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure • Bus subsidies • Road junction optimisation and widening, improved driver information
Medium Cities	•Incremental increase in train lengths - 3 additional carriages in the morning peak on average •Increased bus frequencies - 10 additional buses on average •Relief of constraints on road network through provision of up to 2 additional lanes and relief at key pinch points	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure • Bus subsidies • Road junction optimisation and widening, improved driver information
Small Cities	•Incremental increase in train lengths - 2 additional carriages in the morning peak on average •Increased bus frequencies - 9 additional buses on average •Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure • Bus subsidies • Road junction optimisation and widening, improved driver information

Table 5.2: Interventions included in 10% Uplift Scenario

	Core Interventions	Complementary Interventions
Large Cities	• Increase in train lengths and some new services - 19 additional carriages in the morning peak on average • Implementation of new radial light rail lines in all cities - 1 radial route on average • Increased bus frequencies - 42 additional buses on average • Relief of constraints on road network through provision of additional lanes at pinch points (no change from 5% scenario)	• Upgrades at rail stations e.g. increases to platform lengths • BRT infrastructure including bus lanes, expanded depot and branding • Bus subsidies • Road junction optimisation etc (see 5%)
Medium Cities	• Incremental increase in train lengths, possibly some new services - 7 additional carriages in the morning peak on average • Increased bus frequencies - 9 additional buses on average • Implementation of new radial ultra-light rail line in all cities - 1 radial route • Relief of constraints on road network through provision of up to 2 additional lanes and relief at key pinch points (no change from 5% scenario)	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure (see 5%) • Bus subsidies • Road junction optimisation etc (see 5%)
Small Cities	• Incremental increase in train lengths - 3 additional carriages in the morning peak on average • Significantly increased bus frequencies - 23 additional buses on average • Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points (no change from 5% scenario)	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure and investment in integrated system and bus lanes • Bus subsidies • Road junction optimisation etc (see 5%)

Table 5.3: Interventions included in 20% Uplift Scenario

	Core Interventions	Complementary Interventions
Large Cities	•Significant increase in rail service frequencies- 37 additional carriages in the morning peak on average •New cross city light rail lines in all cities - 2-3 cross city lines on average •Increased bus frequencies - 42 additional buses on average (no change from 10% scenario) •Relief of constraints on road network through provision of additional lanes at pinch points (no change from 5% scenario)	• Major upgrade of terminus rail station and infrastructure • Tunnelling for cross city light rail lines in city core • BRT infrastructure (see 10%) • Bus subsidies • Road junction optimisation etc (see 5%)
Medium Cities	•Increased train lengths and service frequencies - 19 additional carriages in the morning peak on average •Increased bus frequencies - 9 additional buses on average (no change from 10% scenario) •Implementation of new cross city light rail lines - 1 cross-city line •Relief of constraints on road network through provision of up to 2 additional lanes and relief at key pinch points (no change from 5% scenario)	• Upgrades at rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure (see 5%) • Bus subsidies • Road junction optimisation etc (see 5%)
Small Cities	•Increased train lengths, possibly some new services - 5 additional carriages in the morning peak on average •Significantly increased bus frequencies - 53 additional buses on average •Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points (no change from 5% scenario)	• Upgrades at rail stations e.g. increases to platform lengths • BRT infrastructure including bus lanes, expanded depot and branding • Bus subsidies • Road junction optimisation etc (see 5%)

Table 5.4: Interventions included in 10% Uplift Bus Focused Scenario

	Core Interventions	Complementary Interventions
Large Cities	•Increase in train lengths and some new services - 19 additional carriages in the morning peak on average •Implementation of new radial light rail lines in all cities - 1 radial route on average •Increased bus frequencies - 47 additional buses on average	• Upgrades at rail stations e.g. increases to platform lengths • BRT infrastructure including bus lanes, expanded depot and branding • Bus subsidies
Medium Cities	•Incremental increase in train lengths, possibly some new services - 7 additional carriages in the morning peak on average •Increased bus frequencies - 31 additional buses on average •Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points (half of 5% scenario)	• Minor upgrades at some rail stations e.g. increases to platform lengths • BRT infrastructure including bus lanes, expanded depot and branding • Bus subsidies • Road junction optimisation etc
Small Cities	•Incremental increase in train lengths - 3 additional carriages in the morning peak on average •Significantly increased bus frequencies - 27 additional buses on average •Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points (half of 5% scenario)	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure and investment in integrated system and bus lanes • Bus subsidies • Road junction optimisation etc

Table 5.5: Interventions included in 10% Uplift Active Modes Focused Scenario

	Core Interventions	Complementary Interventions
Large Cities	•Increase in train lengths and some new services - 19 additional carriages in the morning peak on average •Implementation of new radial light rail lines in all cities - 1 radial route on average •Increased bus frequencies - 25 additional buses on average •Relief of constraints on road network through provision of additional lanes at pinch points (no change from 5% scenario) •Expanded networks of active mode infrastructure	• Upgrades at rail stations (see 5%) • Additional city centre bus stop infrastructure and investment in integrated system and bus lanes • Bus subsidies • Road junction optimisation etc (see 5%) • Travel behaviour change programmes
Medium Cities	•Incremental increase in train lengths, possibly some new services - 7 additional carriages in the morning peak on average •Increased bus frequencies - 37 additional buses on average •Relief of constraints on road network through provision of up to 2 additional lanes and relief at key pinch points (no change from 5% scenario) •Expanded networks of active mode infrastructure	• Minor upgrades at some rail stations e.g. increases to platform lengths • Bus subsidies • Additional city centre bus stop infrastructure and investment in integrated system and bus lanes • Road junction optimisation etc (see 5%) • Travel behaviour change programmes
Small Cities	•Incremental increase in train lengths - 3 additional carriages in the morning peak on average •Increased bus frequencies - 15 additional buses on average •Relief of constraints on road network through provision of up to 1 additional lane and relief at key pinch points (no change from 5% scenario) •Expanded networks of active mode infrastructure	• Minor upgrades at some rail stations e.g. increases to platform lengths • Additional city centre bus stop infrastructure • Bus subsidies • Road junction optimisation etc (see 5%) • Travel behaviour change programmes

Unit Rates and Cost Estimate Assumptions

5.5 Generic unit rates by intervention have been applied to all cities to develop cost estimates. In reality, costs will vary by location due to a range of factors, including:

- Ease/difficulty of implementation;
- Material and transport costs;
- Term contract rates;
- Land-take and compulsory purchase requirements; and
- Impact on the existing, operational transport network.

5.6 Cost estimates are order of magnitude estimates only. For this reason, unit rates are high level and have not been developed using detailed bills of quantities. Unit rates draw from a range of sources including information provided by Local Authority Districts during the study inception phase, published outturn and projected costs for similar schemes, and project experience. Unit Rates and further detail on the cost estimation methodology are provided in Appendix G.

5.7 Values for risk are applied to the cost estimates as is standard practise within the industry. In lieu of a quantified risk assessment, risk proportions are based on optimism bias rates in the DfT's Transport Analysis Guidance.

5.8 All capital costs have been increased by 10% to account for planning and design costs.

Bus Subsidies

5.9 Bus utilisation, outside of London, has faced long term downward trends. There are a variety of measure that can be deployed to influence bus demand. However, in the context of this study, we have assumed that bus subsidies will be required to achieve the large uplift in bus demand required. Bus subsidies have been calculated assuming the uplift in demand is equivalent to the proportional uplift in bus capacity provided, using fare elasticities. Further detail is provided in Appendix G.

Cost Model

5.10 Cost estimates have been processed through a model consistent with the treatment of costs in a DfT WebTAG appraisal. The model spans an appraisal period of 60 years, includes discount rates in line with Green Book guidance and includes inflation using a tender price index. Assumptions within the cost model are summarised in Appendix H.

Scenario Costs

5.11 As stated previously, cost estimates presented in this chapter are intended to be used in aggregate across cities, rather than on a city-by-city basis. Order of magnitude capital costs of each scenario are presented in Figure 5.2 to Figure 5.4 for the generic cities, defined in Chapter 4. Costs do not have a linear relationship to the increase in capacity. Larger increases in capacity will require more transformational change to the transport system, which has a significant impact on cost.

5.12 Cost estimates for each of the case study cities and scaled estimates for the additional cities are detailed in Appendix I.

Figure 5.2: Capital Cost Estimate – Generic Large City

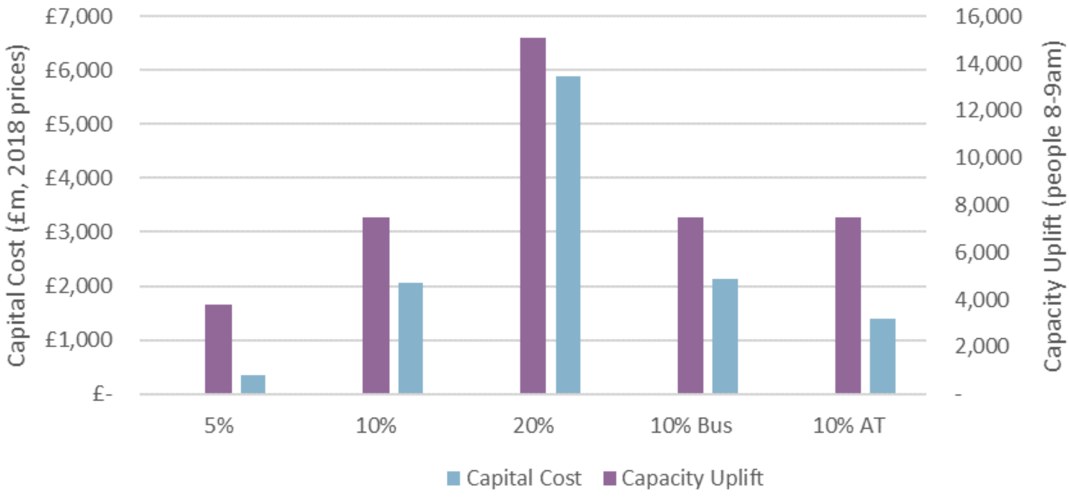


Figure 5.3: Capital Cost Estimate – Generic Medium City

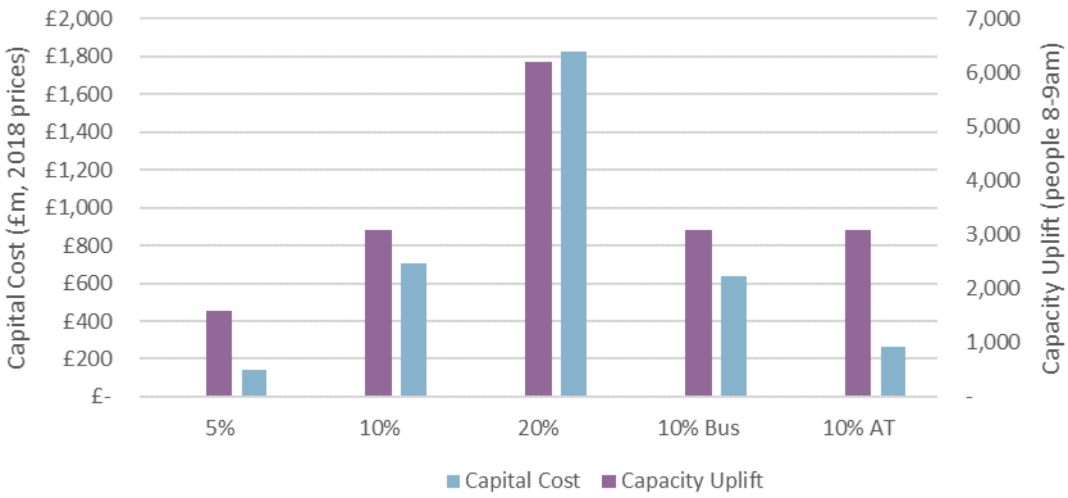
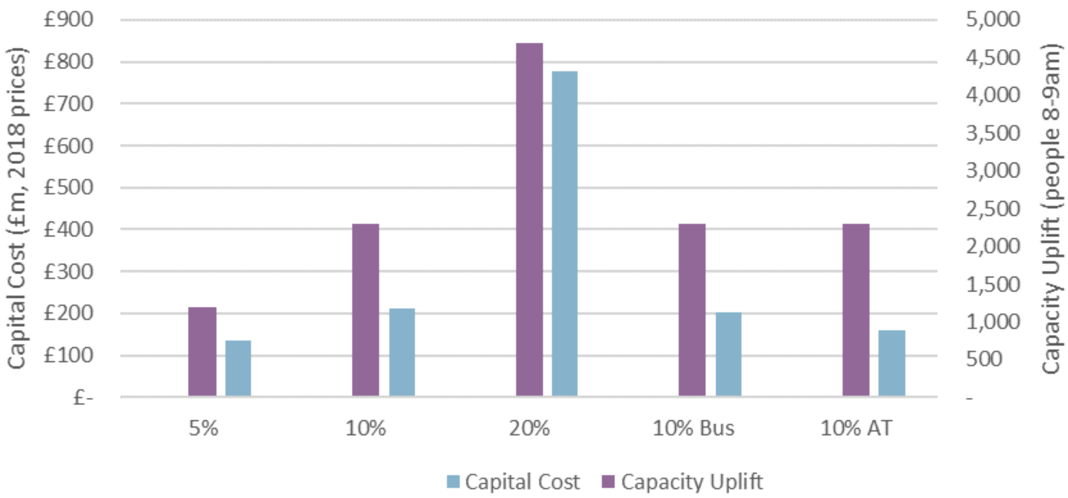


Figure 5.4: Capital Cost Estimate – Generic Small City



Source: Steer Davies Gleave

Cost Benchmarking

5.13 A benchmarking exercise has been undertaken to allow cost estimate outputs of this study to be compared to other large infrastructure investment in the UK. A single scheme per mode has been selected to form the basis of the benchmarking comparisons in this chapter. An overview of each selected scheme is provided in Table 5.6.

Table 5.6: Selected schemes for use in benchmarking comparisons

Scheme	Description	Opening Year	Cost (£m)*
Manchester Metrolink Trafford Park Line[11]	Tram route extension of 5.5.km calling at 6 stops	2021	£350
Reading Station Redevelopment[12]	5 new platforms, 2 entrances, a new link bridge and retail outlets. Does not include any additional vehicles or route upgrades away from the station	2014	£1,130
Bristol Metrobus[13]	BRT system with 51km of mixed and segregated busway, with 3 routes	2018	£230
Hull A63 Castle Street Improvement[14]	Creation of a new junction in Hull by lowering the level of the A63, widening of the eastbound carriage between Princes Dock Street and Market Place to 3 lanes and 2 new bridges	2025	£390

*Costs converted to 2018 price base. Assumptions in converting price base necessary as not all original costs are reported with information regarding the price base. Costs in this table are therefore representative of order of magnitude costs only.

Source: See footnotes

5.14 Cost benchmarking results are presented in Table 5.7 to Table 5.9 These results represent the scale of average costs for S/M/L cities relative to benchmark schemes for each scenario. For example, Table 5.7 shows the average cost of £350m to uplift capacity by 5% for large cities is broadly equivalent to the cost of the Metrolink Trafford Park line and approximately 30% of the cost of the Reading Station redevelopment.

5.15 As discussed earlier in this report, cost estimates in this study do not increase linearly with capacity, due to the differences in the scale of transformation between scenarios. Therefore, the number of schemes that could be afforded for each scenario and city size is provided for context, and is not a precise estimate. That is, if, for example, 8.2 Bristol Metrobus schemes were to be implemented in a city, the average cost per scheme would be significantly higher than the £230m reported for a single scheme. This is due to the added complexity for later schemes as the simplest route options are exhausted, as discussed in Chapter 2.

[11] http://www.constructionenquirer.com/2016/10/14/350m-manchester-metrolink-approved/

[12] http://www.bbc.co.uk/news/uk-england-berkshire-28334188

[13] Information provided by Bristol City Council, http://www.route-one.net/articles/Bus_routes/A_fresh_start_for_Bristol

[14] https://highwaysengland.co.uk/projects/a63-castle-street-improvement/

Table 5.7: Cost benchmarking of average large city costs against selected schemes (£m)

		5% Scenario	10% Scenario	20% Scenario
		£350	£2,060	£5,900
Metrolink Trafford Park Line	£350			
Reading Station Redevelopment	£1,130			
Bristol Metrobus	£230			x 26
Hull A63 Castle Street Improvement	£390			

Table 5.8: Cost benchmarking of average medium city costs against selected schemes (£m)

		5% Scenario	10% Scenario	20% Scenario
		£140	£710	£1,820
Metrolink Trafford Park Line	£350			
Reading Station Redevelopment	£1,130			
Bristol Metrobus	£230			
Hull A63 Castle Street Improvement	£390			

Table 5.9: Cost benchmarking of average small city costs against selected schemes (£m)

		5% Scenario	10% Scenario	20% Scenario
		£140	£210	£780
Metrolink Trafford Park Line	£350			
Reading Station Redevelopment	£1,130			
Bristol Metrobus	£230			
Hull A63 Castle Street Improvement	£390			

Sensitivity Testing

5.16 Sensitivity tests have been carried out on the assumptions underpinning scenario development and cost estimates. In total six tests are considered, with tests organised into four categories as set out in the following text. Summary results are presented in this Chapter, with full results reported in Appendix J.

Sensitivity Tests

1. Unit Costs

5.17 In the central case, medium/average costs are used across all cities. There is potential for these to be higher or lower dependent on city-specific variables and the nature of the location where infrastructure is planned. Two tests on unit cost assumptions are considered:

- 1a: High unit cost estimates, and fixed cost elements increased by 20%
- 1b: Low unit cost estimates, and fixed cost elements decreased by 20%

2. Development Patterns

5.18 Dependent on the development patterns within a city, and the commuting catchment for a given city centre, shorter or longer infrastructure lengths may be required. Compact versus dispersed development patterns are considered in these tests through varying the assumed infrastructure lengths relative to the central case, as shown in Table 5.10 and Table 5.11.

Table 5.10: Assumed Infrastructure Lengths by Mode (km) – Sensitivity Test 2a: Dispersed Development

City Size	Road (Per lane)	National Rail	Metro/Tram	Bus (Cumulative length Per City)
L	3	N/A	15	15
M	3	N/A	12	12
S	3	N/A	N/A	10

Table 5.11: Assumed Infrastructure Lengths by Mode (km) – Sensitivity Test 2b: Compact Development

City Size	Road (Per lane)	National Rail	Metro/Tram	Bus (Cumulative length Per City)
L	2	N/A	6	6
M	2	N/A	5	5
S	2	N/A	N/A	4

5.19 It should be noted that these tests assume the same quantum of routes and vehicles as the central case. Dependent on how development eventuates, additional impacts on costs are possible. For example, in a very dispersed scenario additional routes (with lower service frequencies) may be necessary to serve all markets spatially. Conversely in a very compact scenario, shorter route lengths could mean fewer vehicles are required to provide the assumed frequencies.

3. Scenario Development Assumptions

5.20 This test considers the impact of assumptions surrounding mode contribution and scale of transformation required in achieving the capacity uplifts. A single test is applied based on a varied set of assumptions for each scenario, see Table 5.12 to Table 5.14 and further detail in Appendix J. Generally, this test assumes a larger scale of transformation is required to achieve the specified capacity uplifts:

- **Large Cities**: it is assumed that current bus provision is at the limit of available capacity (in terms of space), therefore no further investment in bus/BRT is considered in the uplift scenarios. Instead a greater focus is placed on light rail and to some extent National rail.
- **Medium Cities**: Similar to the assumptions for large cities in the central case it is assumed that medium cities will move away from providing for private vehicle capacity. Greater investment in bus networks and light rail is assumed.
- **Small Cities**: maintains the same mode contributions towards capacity in each scenario, however, the fixed costs associated with implementing the assumed infrastructure are increased to account for e.g. greater transformation required at rail stations.

Table 5.12: Sensitivity Test 3: 5% Scenario Mode Contributions

City Size	Road	National Rail	Metro/Tram	Bus
L	10.0%	45.0%	45.0%	
M	10.0%	15.0%		75.0%
S	40.0%	10.0%		50.0%

Table 5.13: Sensitivity Test 3: 10% Scenario Mode Contributions

City Size	Road	National Rail	Metro/Tram	Bus
L	5.0%	50.0%	45.0%	-
M	5.0%	20.0%	55.0%	20.0%
S	20.0%	10.0%	-	70.0%

Table 5.14: Sensitivity Test 3: 20% Scenario Mode Contributions

City Size	Road	National Rail	Metro/Tram	Bus
L	2.5%	25.0%	72.5%	-
M	2.5%	30.0%	57.0%	10.0%
S	10.0%	10.0%	-	80.0%

4. Connected and Autonomous Vehicles (CAVs)

5.21 As set out in Chapter 2, the development and increased market penetration of CAVs could affect road capacity. Sensitivity test 4, builds on the information in Chapter 2 and assumes that a 25-50% market penetration by 2050 could increase road capacity by c.5% in urban areas on average. This assumption is consistent with the ranges of capacity impacts reported at junctions in the DfT study[15] on the basis that junction capacity generally drives overall road network capacity in urban environments, see ranges in Table 2.2.

5.22 There is an additional cost, over and above the current supply of road infrastructure, to accommodate CAVs on the road network. Different CAV technologies require different infrastructure to operate safely in the road environment. Therefore, dependent on the technologies that come to the fore in mainstream CAV uptake, associated infrastructure costs will differ. CAV infrastructure requirements could include[16]:

- Enhanced communications technology and digital mapping;
- Well defined and maintained road markings and signage;
- Enhanced temporary traffic management measures;
- CAV parking areas;
- Pick-up and drop-off areas;
- Strengthened long-span bridges due to increased loading if vehicles are travelling closer together.

5.23 In lieu of published values for the cost of upgrading and implementing infrastructure to safely accommodate widespread CAV use in the UK, this sensitivity test considers the potential

[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/530093/impacts-of-connected-and-autonomous-vehicles-on-traffic-flow-technical-report.pdf

[16] https://s3-eu-west-1.amazonaws.com/media.ts.catapult/wp-content/uploads/2017/04/25115313/ATS40-Future-Proofing-Infrastructure-for-CAVs.pdf

impact of CAVs on capacity only, see Table 5.15. The results of this sensitivity test show that if CAV uptake uplifts urban road network capacity by 5%, the uplift to total transport capacity into city centres would be in the range of 1.2% - 3.3%. Smaller cities would experience a larger uplift (by percentage) than larger cities due to the dominance of private vehicle travel on these networks. The uplifts resulting from this sensitivity test show that further investment, over and above that required to accommodate CAVs on the network, is anticipated to be required in order to achieve the specified capacity uplifts.

Table 5.15: Capacity impact of CAVs

City	Road Capacity (8-9am)	Total Capacity (8-9am)	Additional Capacity due to CAVs*	% Capacity uplift across all modes due to CAVs
Birmingham	32,000	106,000	1,600	1.5%
Manchester	27,000	105,000	1,400	1.3%
Newcastle	25,000	81,000	1,300	1.6%
Sheffield	23,000	57,000	1,200	2.1%
Leeds	18,000	66,000	900	1.4%
Bristol	21,000	58,000	1,100	1.9%
Liverpool	29,000	80,000	1,500	1.9%
Leicester	23,000	50,000	1,200	2.4%
Southampton	14,000	34,000	700	2.1%
Reading	9,000	41,000	500	1.2%
Preston	12,000	34,000	600	1.8%
Middlesbrough	14,000	24,000	700	2.9%
Coventry	11,000	33,000	600	1.8%
Huddersfield	6,000	21,000	300	1.4%
Telford	8,000	13,000	400	3.1%
Burnley	12,000	18,000	600	3.3%
Plymouth	14,000	31,000	700	2.3%
Swindon	13,000	27,000	700	2.6%
Exeter	11,000	23,000	600	2.6%
Norwich	10,000	28,000	500	1.8%

*Assumes 5% increase in urban road network capacity

5.24 It should be noted that the availability of CAVs may generate additional travel demand, as discussed in Chapter 2. Therefore, the additional capacity generated may not be available to accommodate the morning peak person trips that are the focus of this project. Note also, no bespoke analysis on the impact of CAVs has been undertaken as part of this study. Assumptions in this sensitivity test rely on published research at the time of writing.

Sensitivity Testing Results

5.25 Results for sensitivity tests 1 to 3 are set out in the following figures (Figure 5.5 to Figure 5.7). Varying unit costs (Sensitivity Test 1) was generally found to have the largest impact on results across all scenarios and city sizes. Overall, the test results show costs for a given city and scenario could range from -45% to +127% relative to the reported central case. There are two scenarios where potential cost ranges are greater still;

- Test 3 for large cities in the 5% scenario shows costs could be up to 307% (+£1,180m) greater than those reported in the central case due to the high cost of investing in light rail.
- Test 3 for small cities in the 10% scenario shows costs could be up to 157% (+£540m) greater than those reported in the central case largely driven by assumptions around the level of investment at stations and signalling to accommodate additional rail services.

5.26 For the above scenarios, test 3 (scenario development assumptions) was found to have the largest impact on results.

5.27 Figure 5.5 to Figure 5.7 set out the impact of the assumptions described in this section on capital costs. Figures show the average capital cost for each test and scenario, by city size. Error bars are used to represent the range of costs for all cities within a given size category.

Figure 5.5: Large city sensitivity test results (CAPEX, £m 2018 Prices)

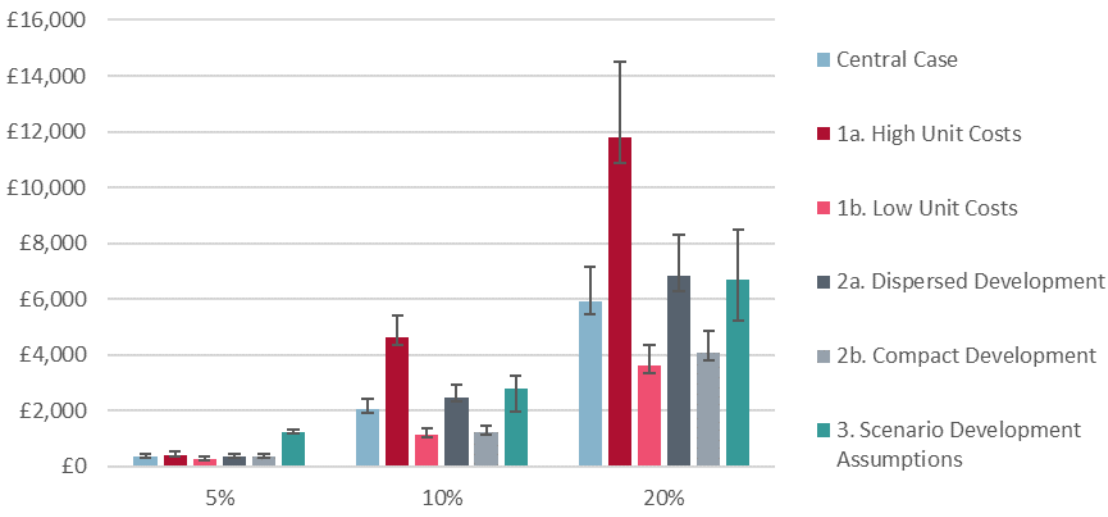


Figure 5.6: Medium city sensitivity test results (CAPEX, £m 2018 Prices)

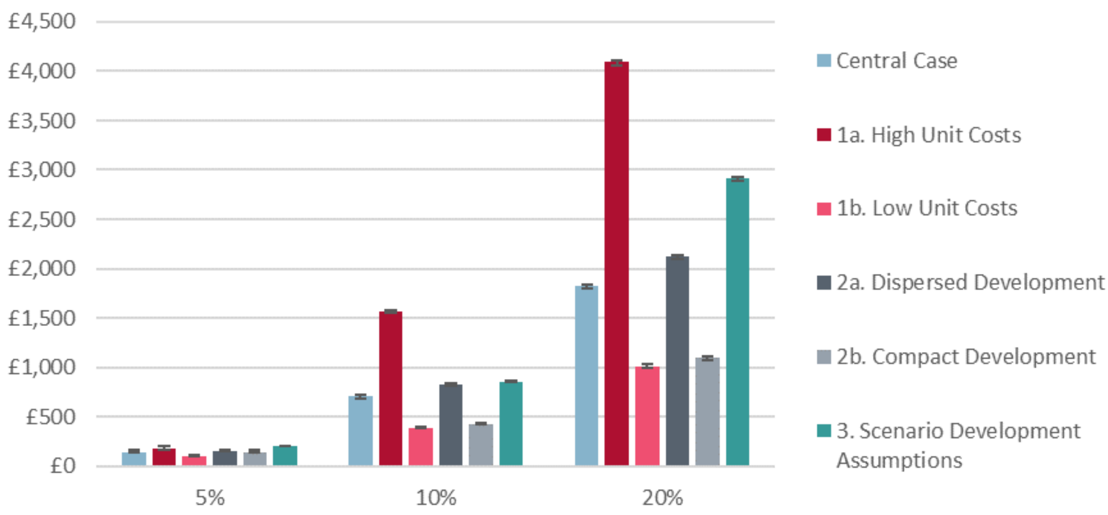
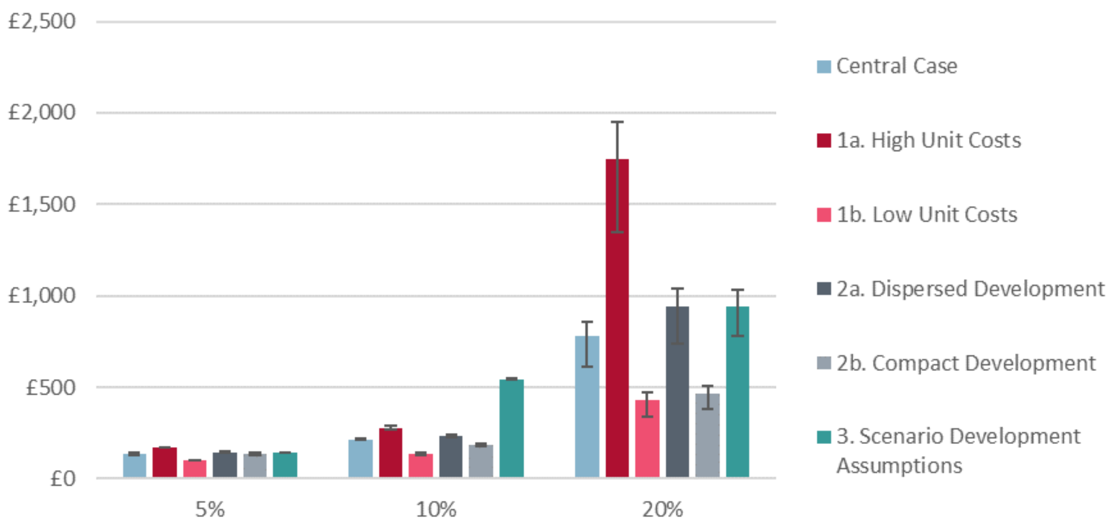


Figure 5.7: Small city sensitivity test results (CAPEX, £m 2018 Prices)



6 Summary of Results

6.1 Ultimately, the results of this study are structured around answering:

- What is the current capacity of urban transport networks?;
- What could a 5%/10%/20% uplift in transport capacity 'look like'?; and
- How much would it cost to achieve this?

6.2 The above questions are answered through developing order of magnitude estimates of peak hour transport network capacity, providing access to the centre of large towns and cities in England (UTCM results). UTCM results form the basis of the analysis to define capacity uplift scenarios and develop cost estimates. Transport capacity in this study is considered in the context of providing access into city centres only. All analysis is based on trips during the morning peak period (0800 - 0900).

6.3 There are many possible approaches to developing the outputs required of this study. The adopted methodology is based on:

- Utilising publicly available data and information;
- Applying a process that can be repeated consistently across twenty case-study cities;
- Applying a process that can be extended to other non-case-study cities;
- Achieving order of magnitude estimates of transport capacity and costs only; and
- Matching effort required to available budget and timeframes.

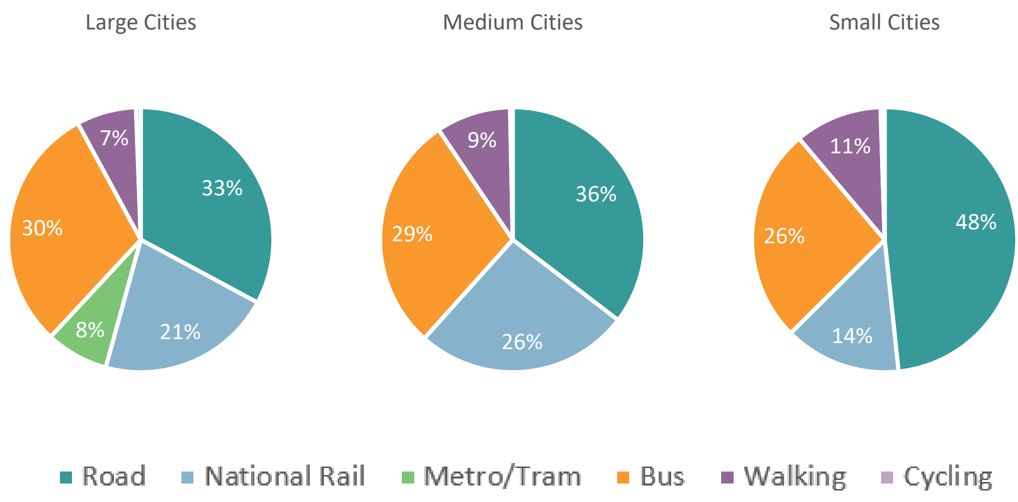
6.4 Results are based on consideration of twenty case-study cities. These cities have been chosen to reflect a range of different city sizes, geographic locations and socio-demographic contexts. The selection does not reflect any assessment of investment priorities.

What is the current capacity of urban transport networks?

6.5 UTCM results are provided in Chapter 3. Overall smaller cities tend to have less developed public transport networks, with a greater proportion of capacity provided by the road network. Larger cities provide more developed public transport networks, however private vehicle capacity into large city centres is still a significant proportion of all capacity. Capacity distribution by mode is shown in Figure 6.1.

6.6 Overall the theoretical capacity to access city centres ranges from 13,000 to 119,000 people per hour in the morning peak across the case study cities. Utilisation of available theoretical capacity ranges from 21% (small cities) to 63% in the 0800-0900 peak hour. The UTCM results represent an estimation of theoretical capacity only and should be normalised to better represent the reasonably useable capacity and subsequent utilisation in each city, for each mode.

Figure 6.1: Summary of mode contribution to capacity into city centres



What could a 5%/10%/20% uplift in transport capacity 'look like'?

6.7 A range of scenarios are used to define the types of investment that could be applied to increase capacity of urban transport networks providing access to city centres. Scenario definitions are prepared for groups of cities (L/M/S), as opposed to individually by city. Scenario contexts assumed for the purposes of this study are described in the following text.

1: 5% Capacity Uplift

6.8 A 5% uplift in capacity is relatively incremental. It can generally be achieved through maintaining a similar transport offer within a city with increases to bus frequencies, train lengths, junction optimisation, and short sections of additional road lanes.

2: 10% Capacity Uplift

6.9 To achieve a 10% uplift in capacity more significant changes to the transport offer are required. For example, in medium and large cities this may mean the introduction of new tram lines (serving new origins), in smaller cities differentiated (i.e. high-quality) bus services may be introduced. Three scenarios are considered for a 10% capacity uplift:

- Standard 10% uplift (Scenario 2)
- 10% uplift with focus on bus capacity (Scenario 4)
- 10% uplift with focus on active mode capacity (Scenario 5)

3: 20% Capacity Uplift

6.10 Transformational change is required to achieve a 20% uplift in capacity. In larger, established cities this may include interventions such as a tunnelled public transport route in the city centre, due to surface level space constraints. For rail services this will likely require major reconstruction of the terminus or main station to accommodate additional services.

6.11 Scenario definitions are provided in detail in Chapter 4.

How much would it cost to achieve this?

6.12 Order of magnitude cost estimates have been developed for each of the capacity uplift scenarios, for each case-study city. City-specific metrics are used to understand the likely scale of cost, and are not intended to be representative of what a specific city would, or should, implement to achieve the specified capacity uplifts.

6.13 Specific plans and programmes for individual cities should be developed at a local level, taking into account local context and need. The approach to cost estimates is focused on being representative at an aggregate level, variations between reported and actual values/scenarios are anticipated at a city level.

6.14 Order of magnitude capital costs for each scenario are presented in Figure 6.2 to Figure 6.4 for the generic cities, defined in Chapter 4. Costs do not have a linear relationship to the increase in capacity. Larger increases in capacity will require more transformational change to the transport system, which has a significant impact on cost. Sensitivity testing results show capital costs for a given city and scenario could range from -45% to +307% relative to the reported central case.

Figure 6.2: Capital Cost Estimate – Generic Large City

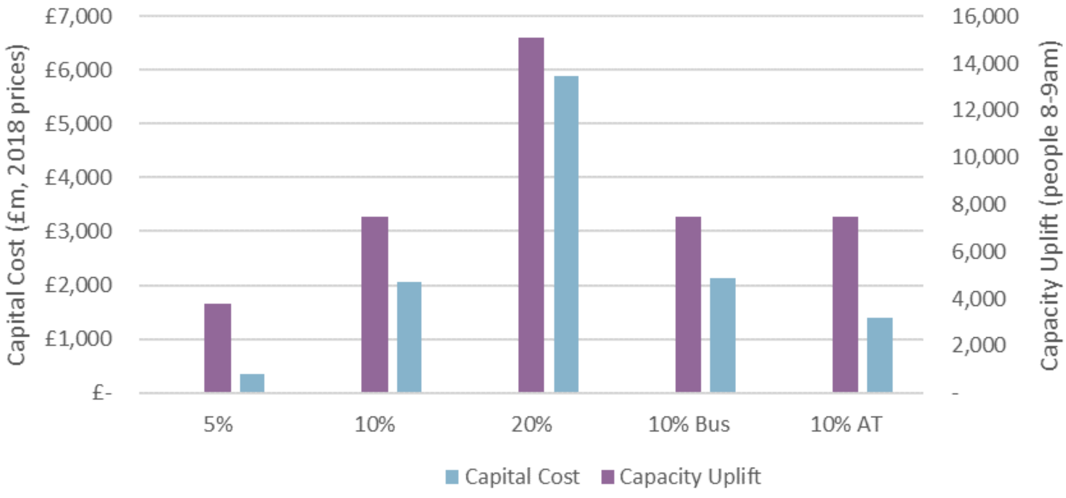


Figure 6.3: Capital Cost Estimate – Generic Medium City

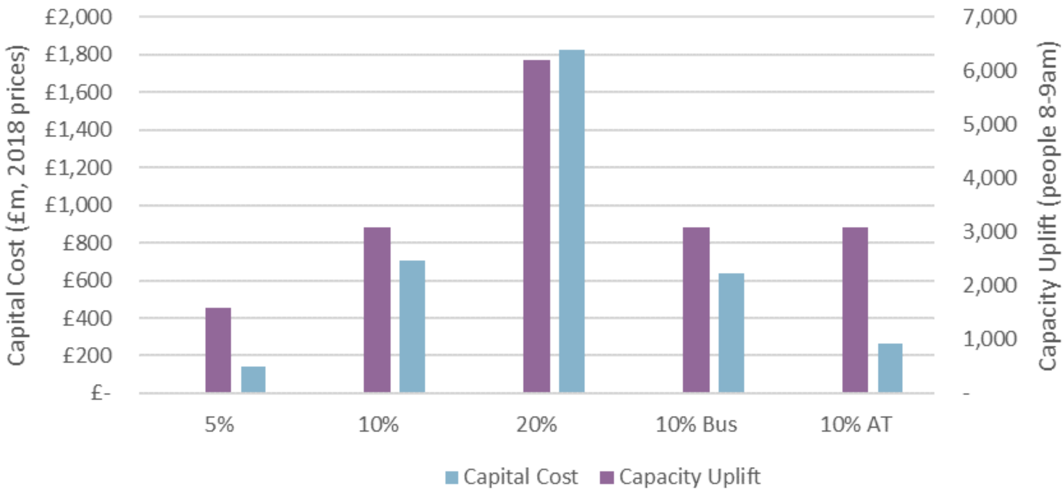
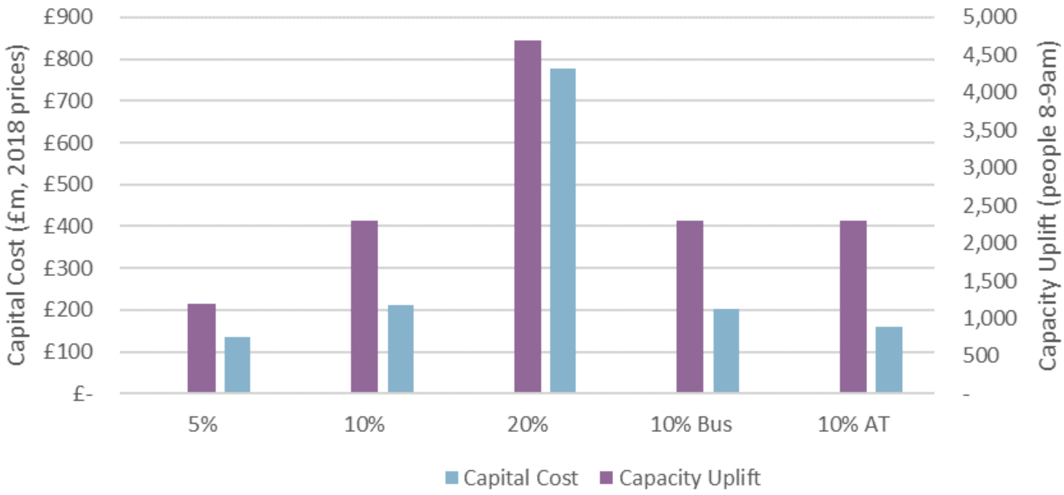


Figure 6.4: Capital Cost Estimate – Generic Small City



Source: Steer Davies Gleave

A City centre cordon definition and maps

Cordon definition

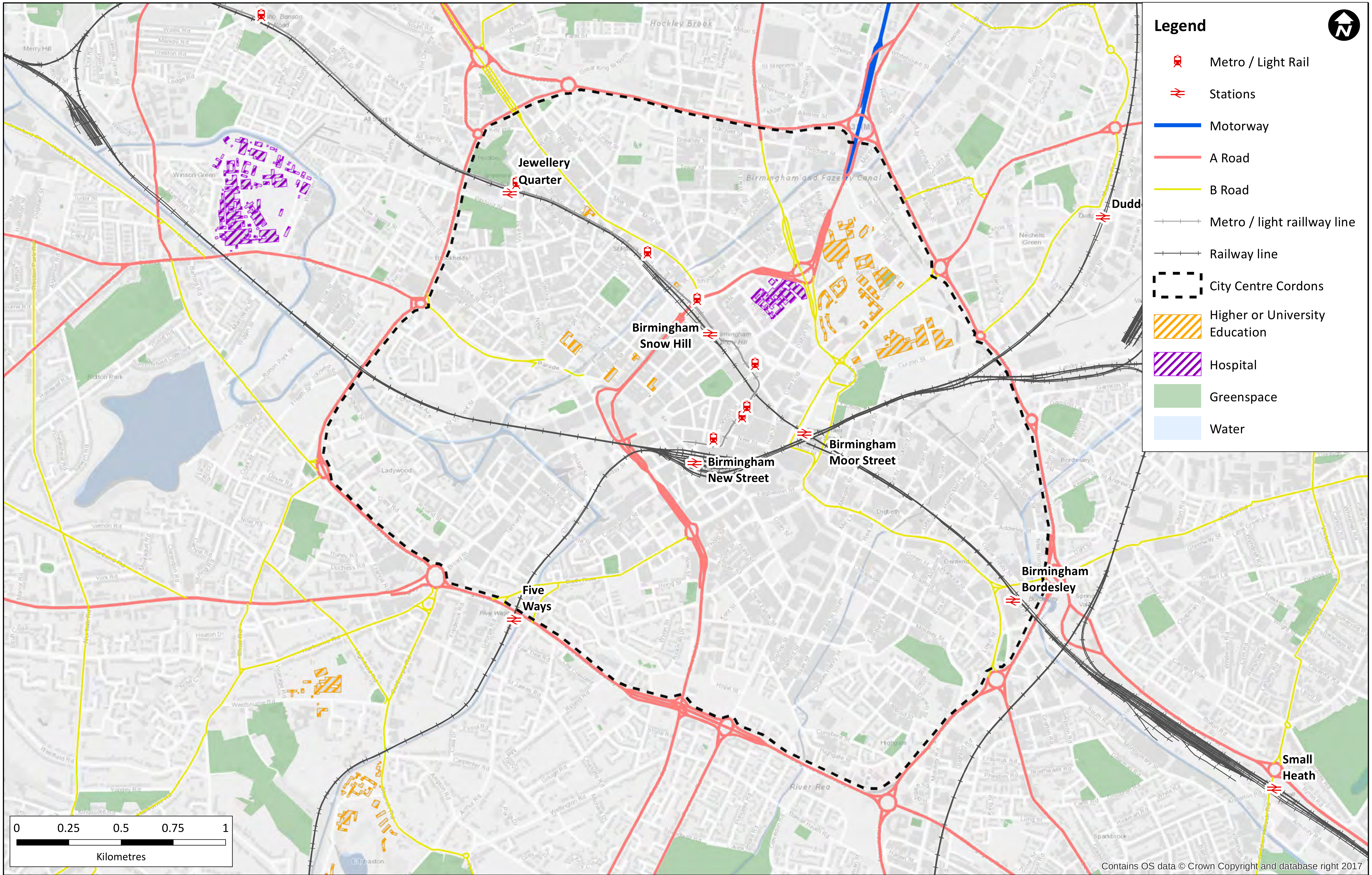
A.1 City centre cordons have been defined with the overarching aim of capturing areas of high employment while also considering the effect of current transport infrastructure on the boundaries of the city. Cordon definitions therefore consider both employment and natural/man-made barriers to movement. In most cases, the cordons are defined tightly around the central business districts of case-study cities.

A.2 Census workplace population data is used to identify areas with the highest concentration of employment. Barriers to movement result in limited crossing points and include, for example, railways, rivers, canals, ring roads, grade-separated roads, parks, etc.

A.3 Some consideration has been given to aligning city centre cordons with ONS geographic boundaries, however this is not always appropriate as ONS geographic boundaries (e.g. MSOAs) are defined such that they have similar levels of population, not employment, which means that they can be large in areas of low residential population density such as city centres.

Cordon maps

A.4 City centre cordon maps are provided on the following pages. Note that where a city's principal rail station falls outside the cordon, rail capacity to the station has been included within the capacity calculations. All case-study cities have rail stations.



National Infrastructure Commission Capacity Review

Birmingham

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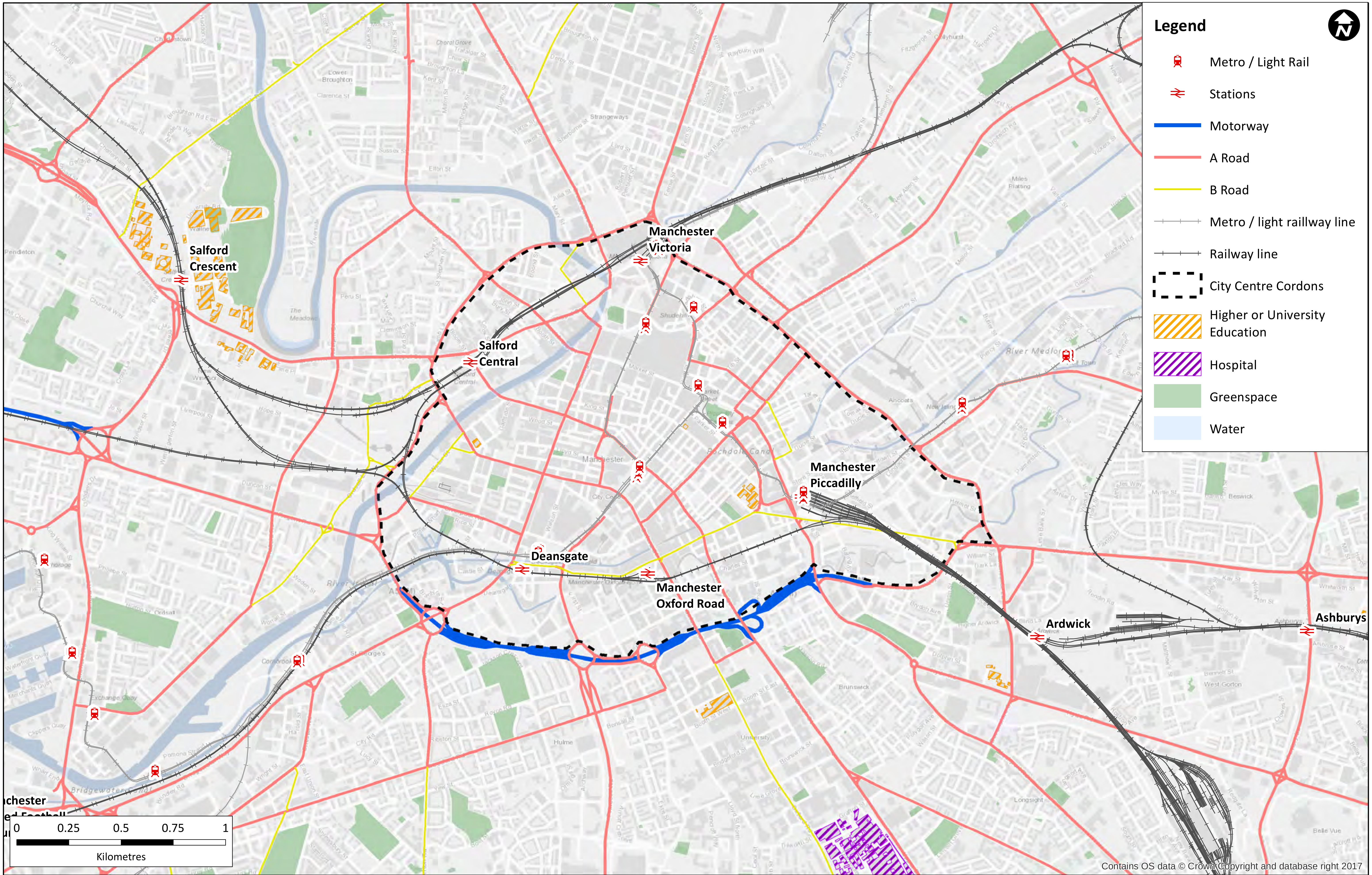

National Infrastructure Commission Capacity Review

Manchester

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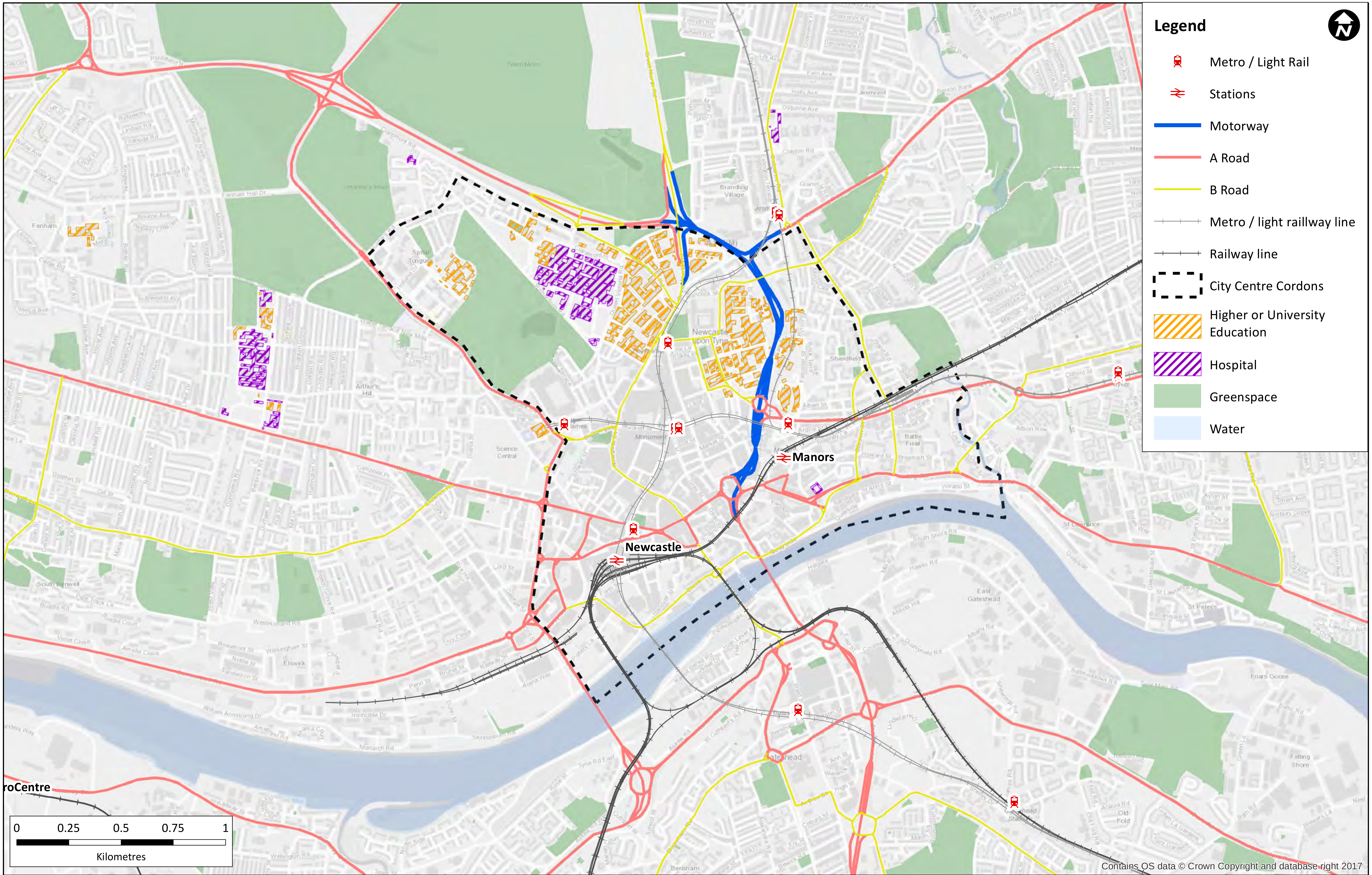

National Infrastructure Commission Capacity Review

Newcastle

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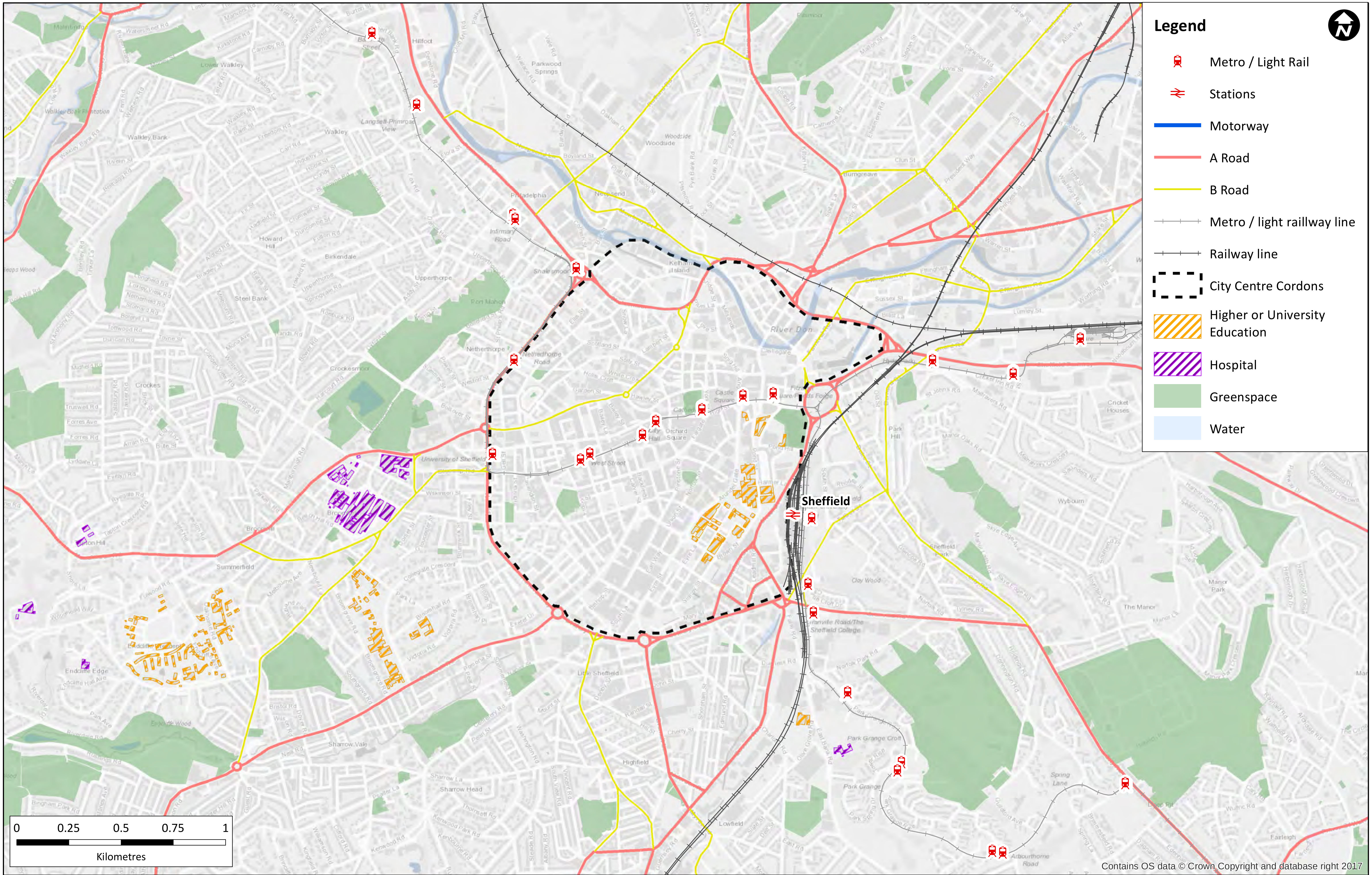

National Infrastructure Commission Capacity Review

Sheffield

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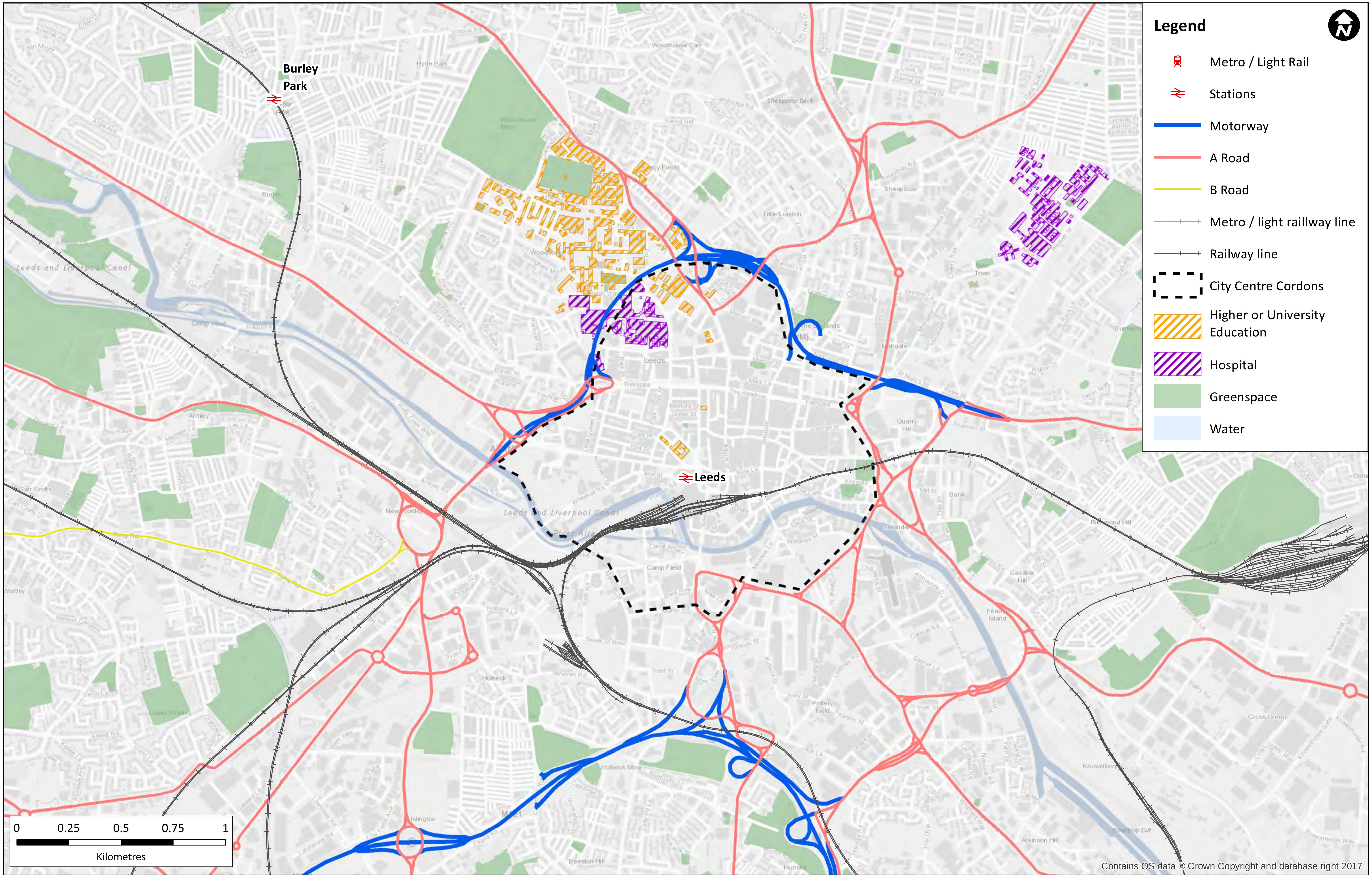

National Infrastructure Commission Capacity Review

Leeds

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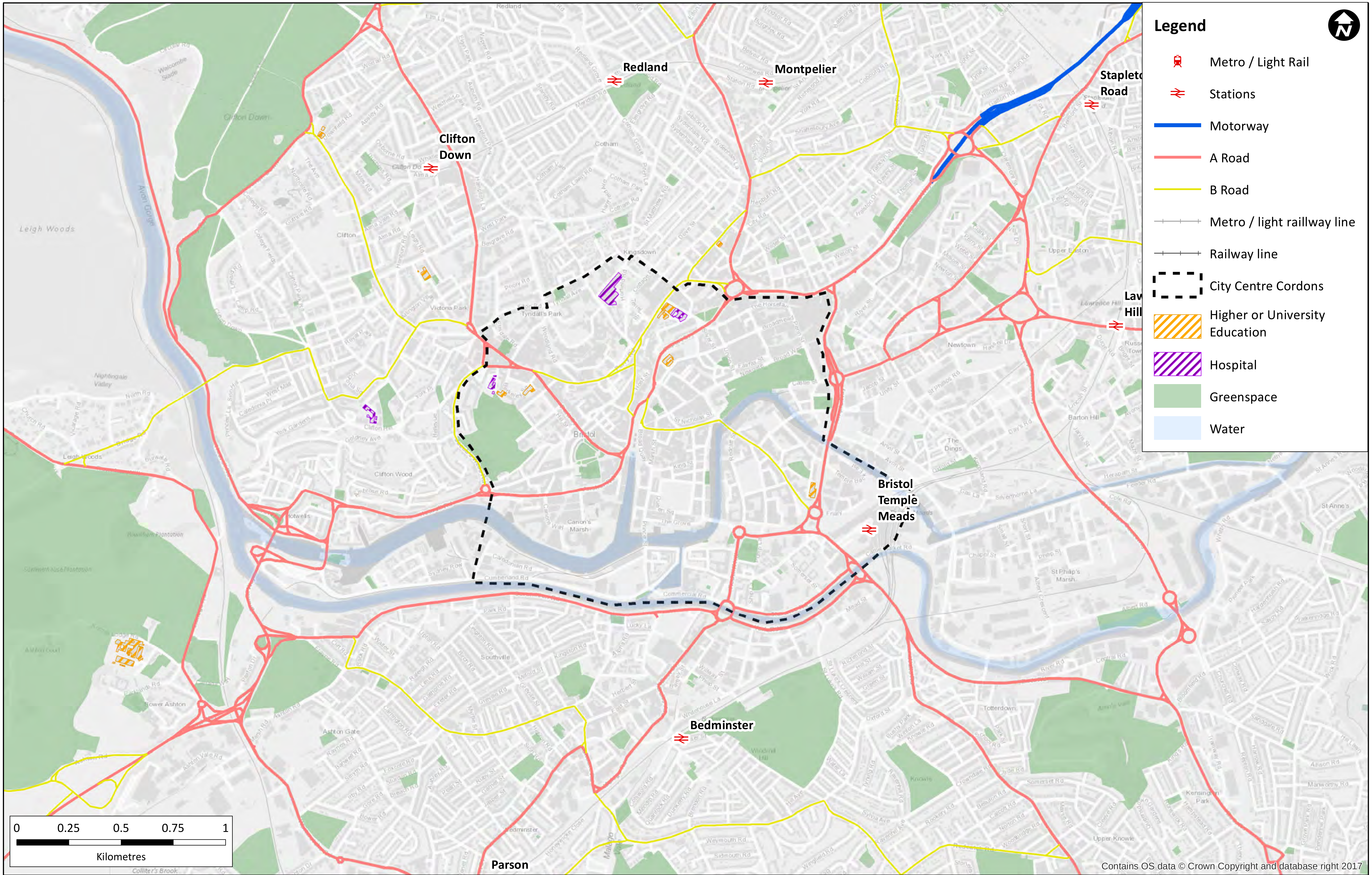

National Infrastructure Commission Capacity Review

Bristol

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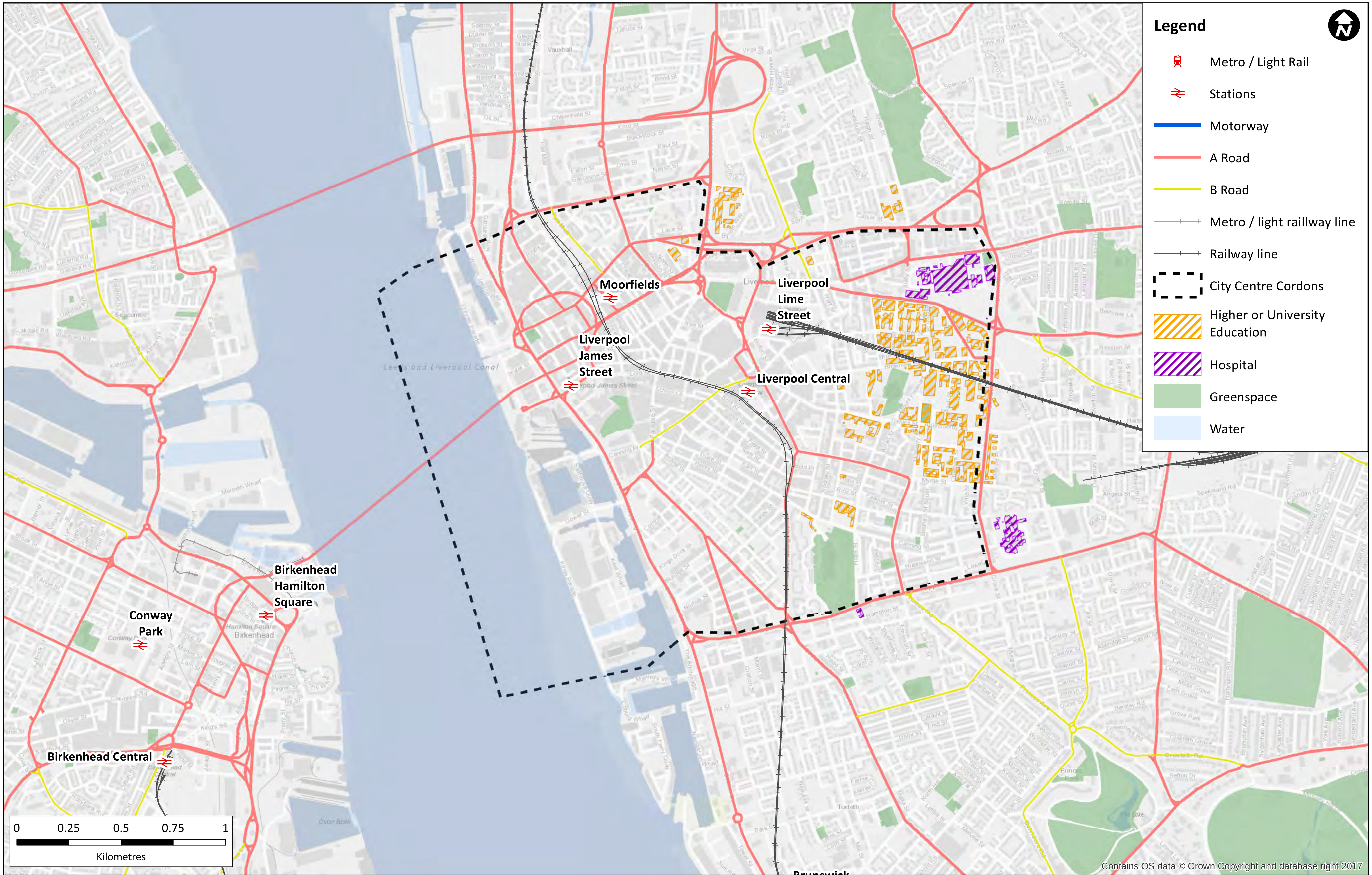

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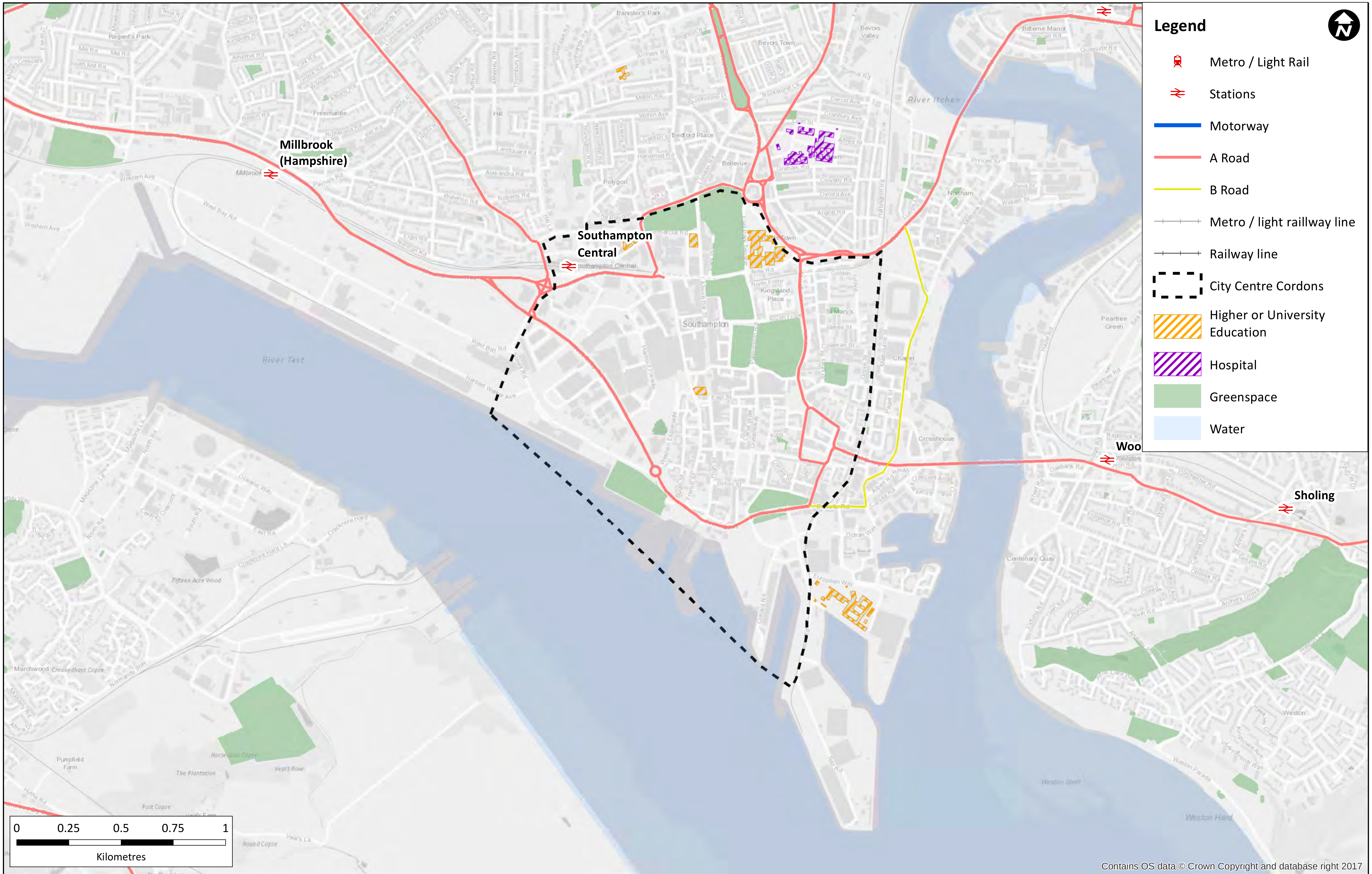

National Infrastructure Commission Capacity Review

Southampton

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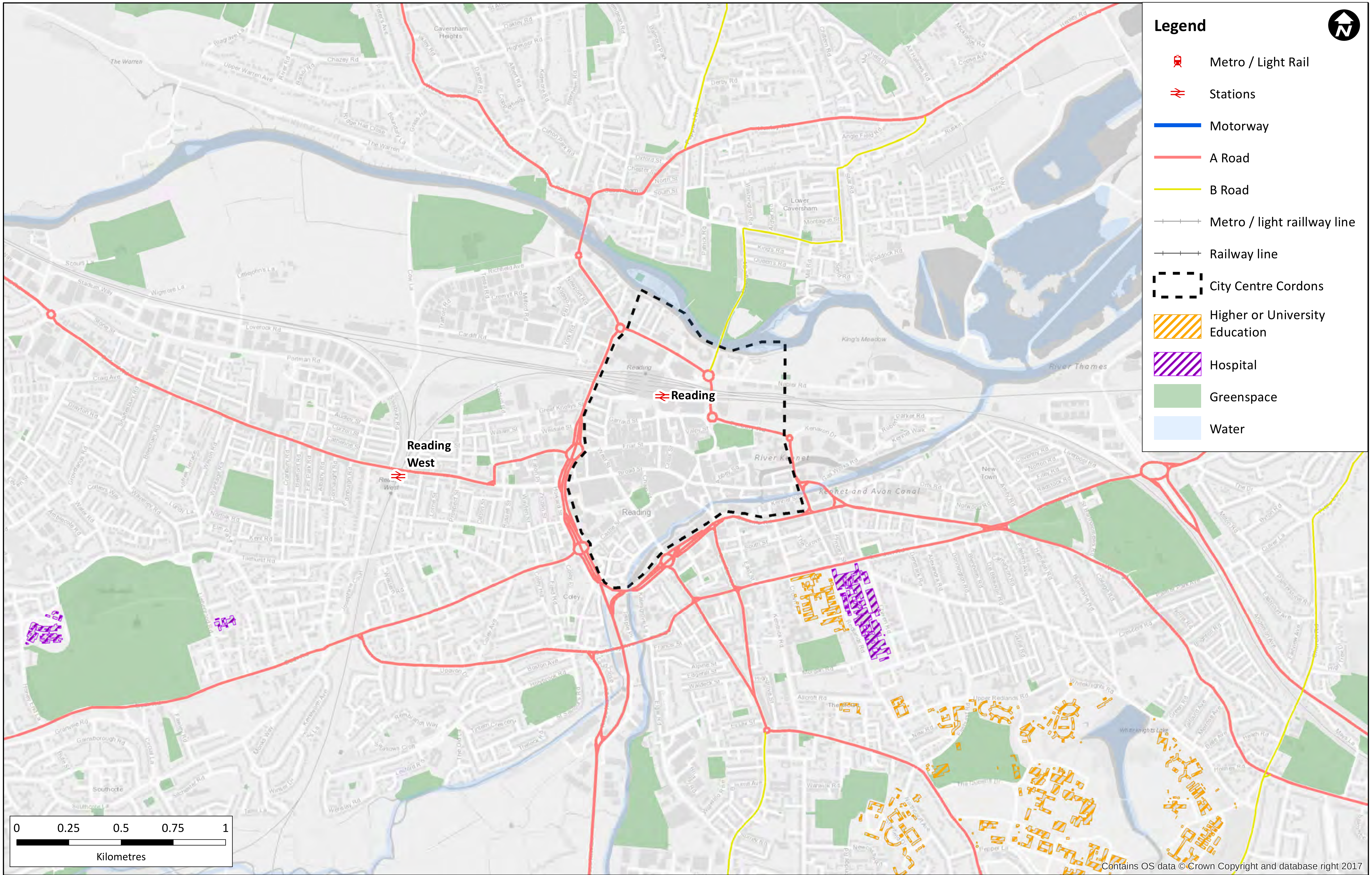

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Reading

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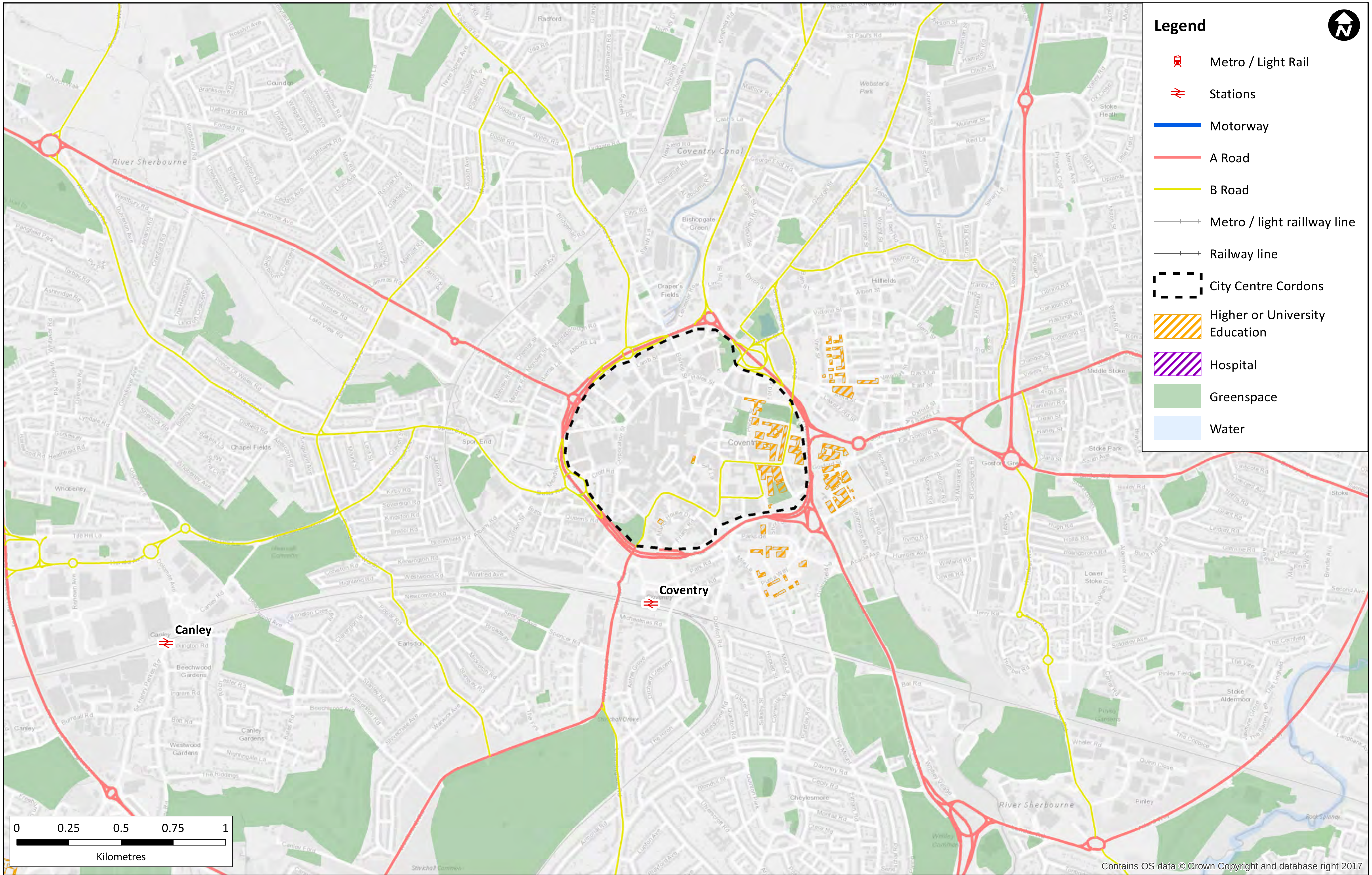

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Coventry

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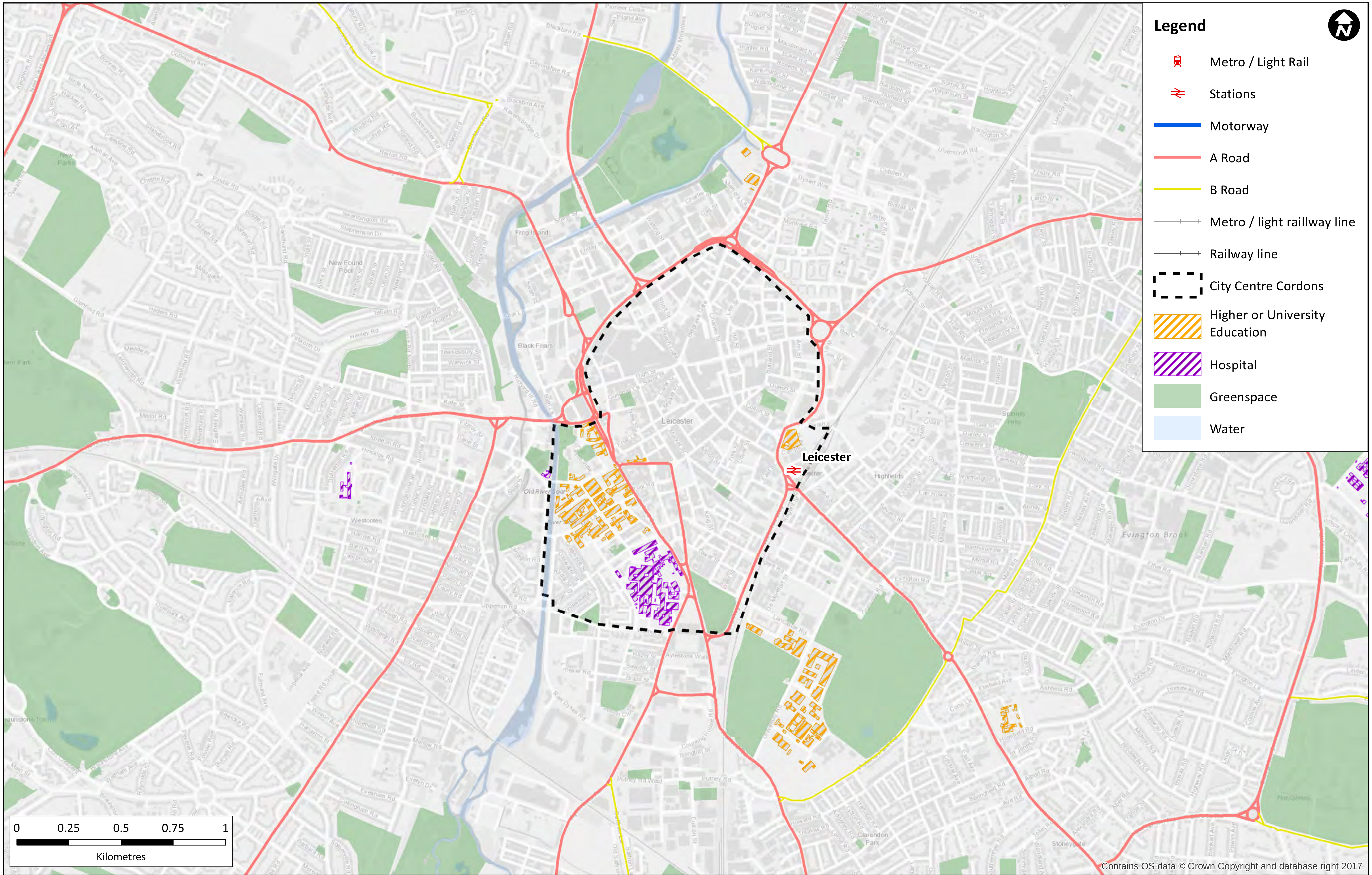

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Leicester

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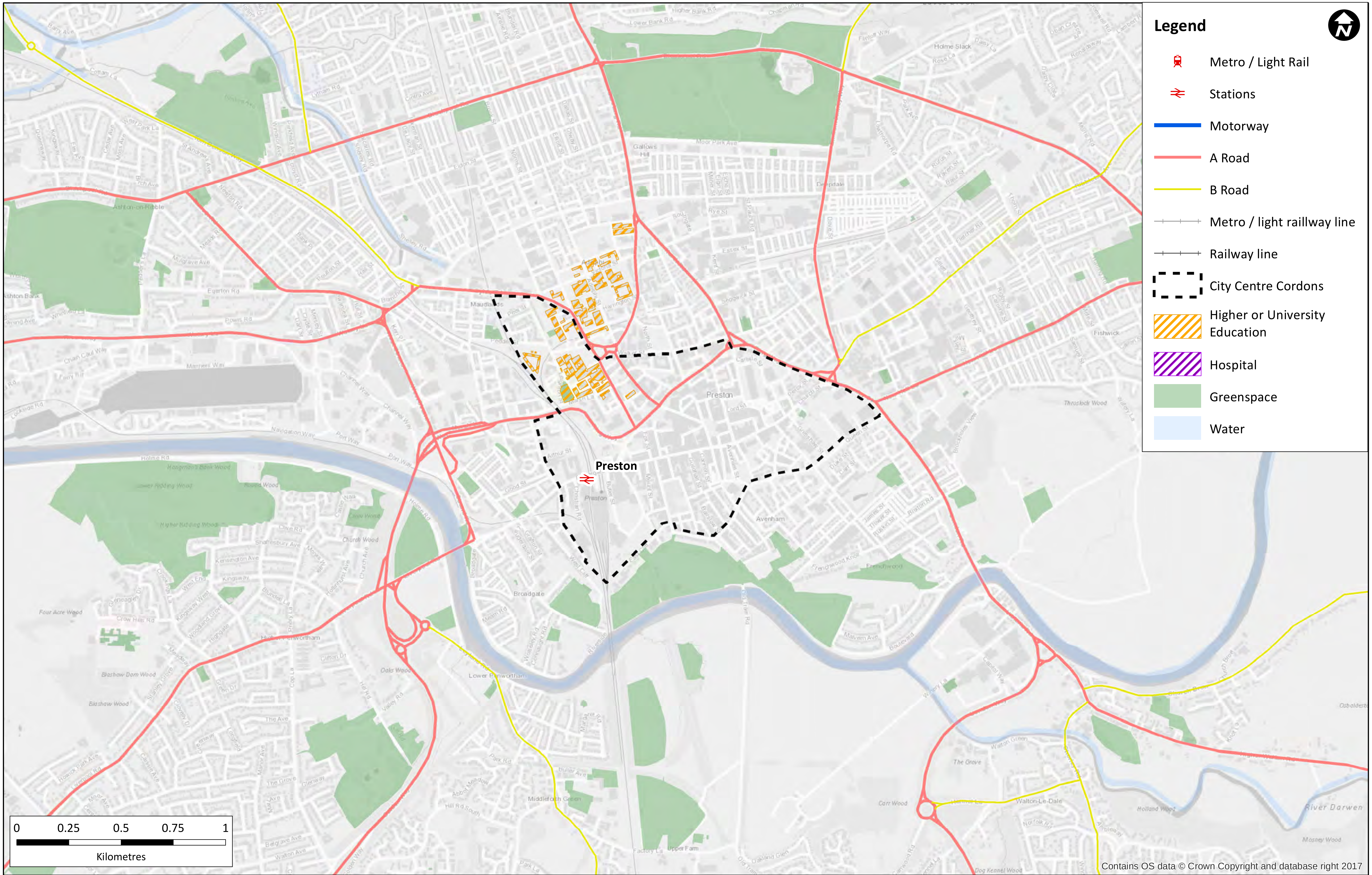

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Preston

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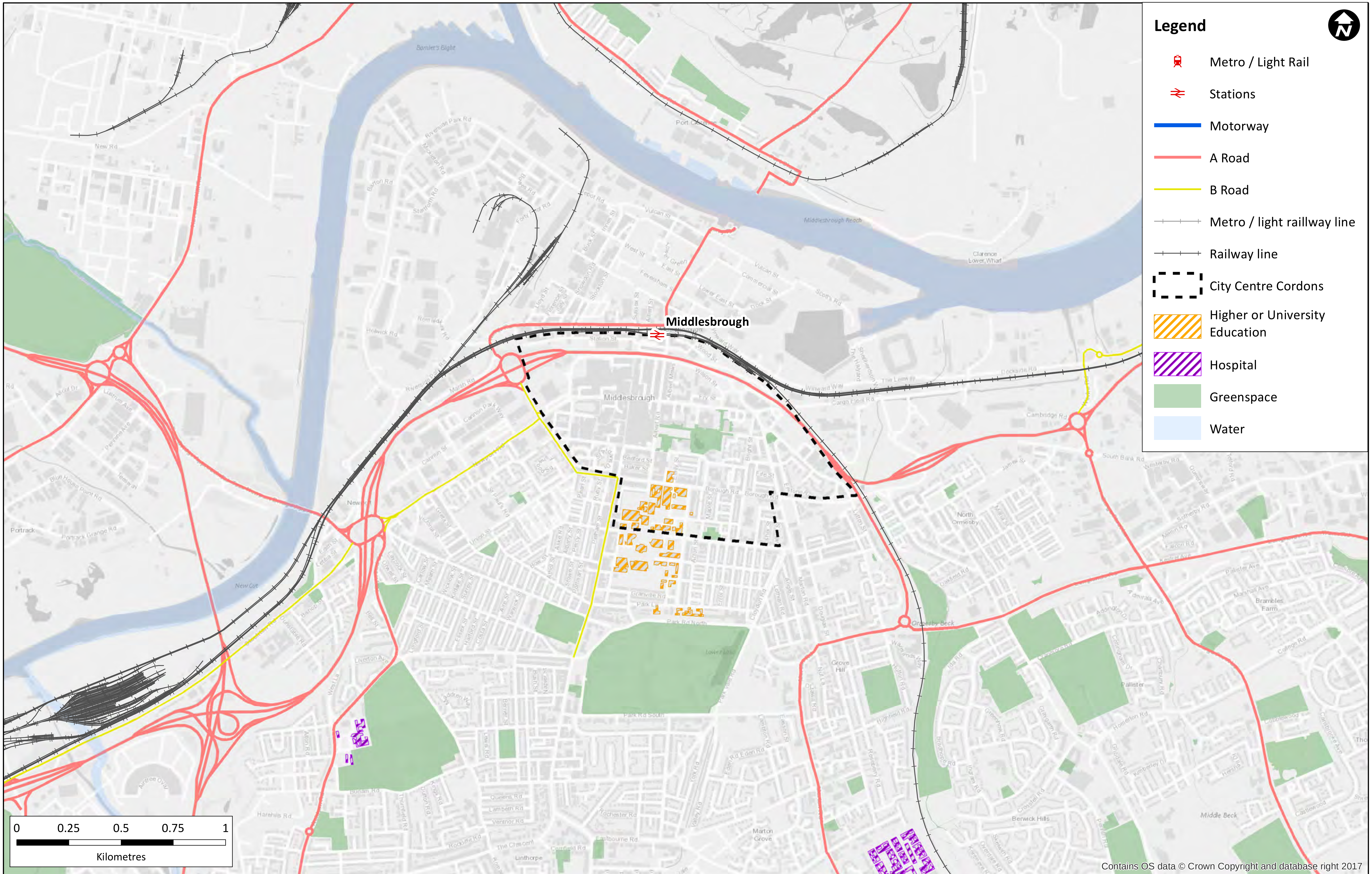

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Middlesbrough

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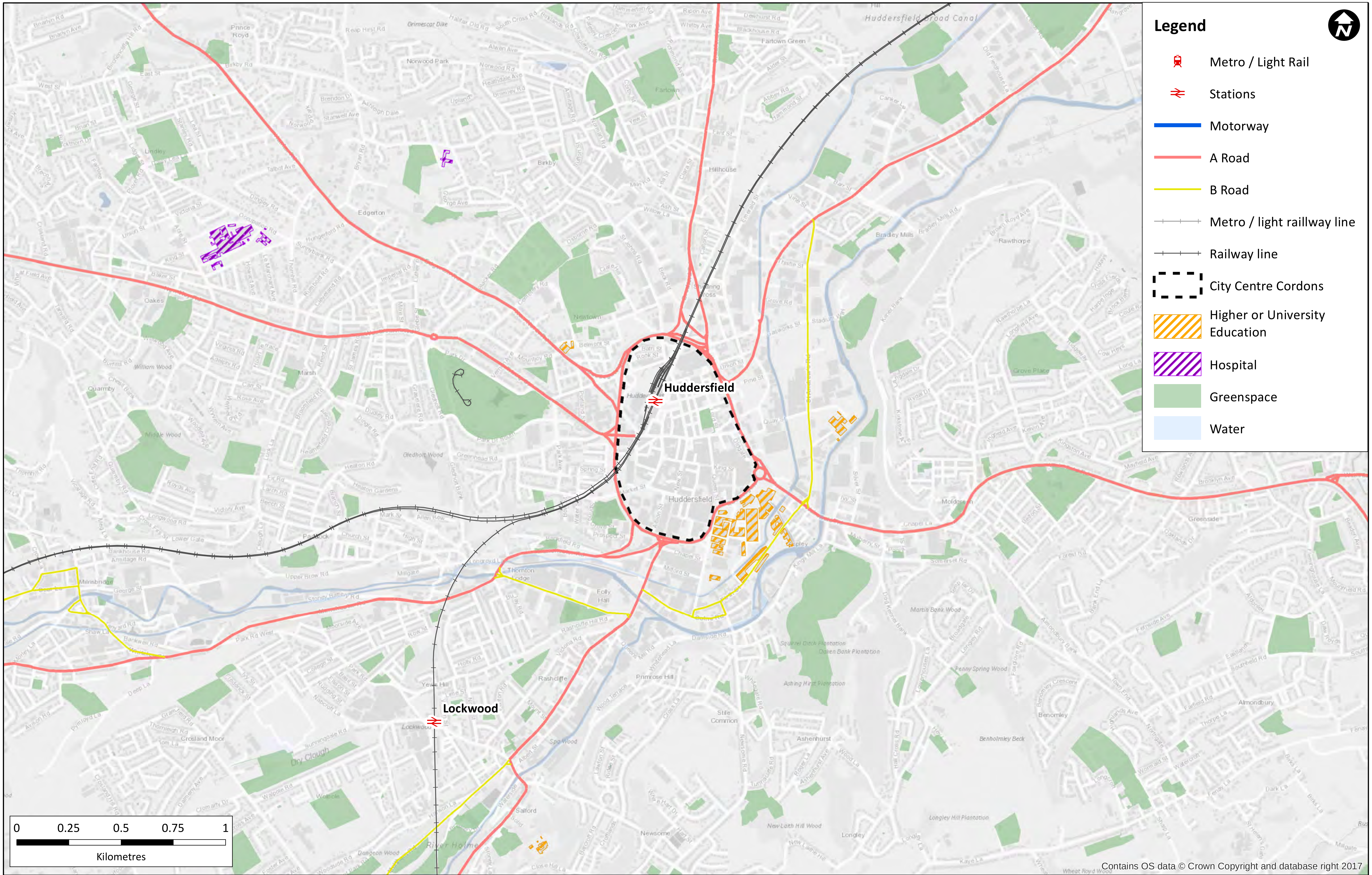

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Huddersfield

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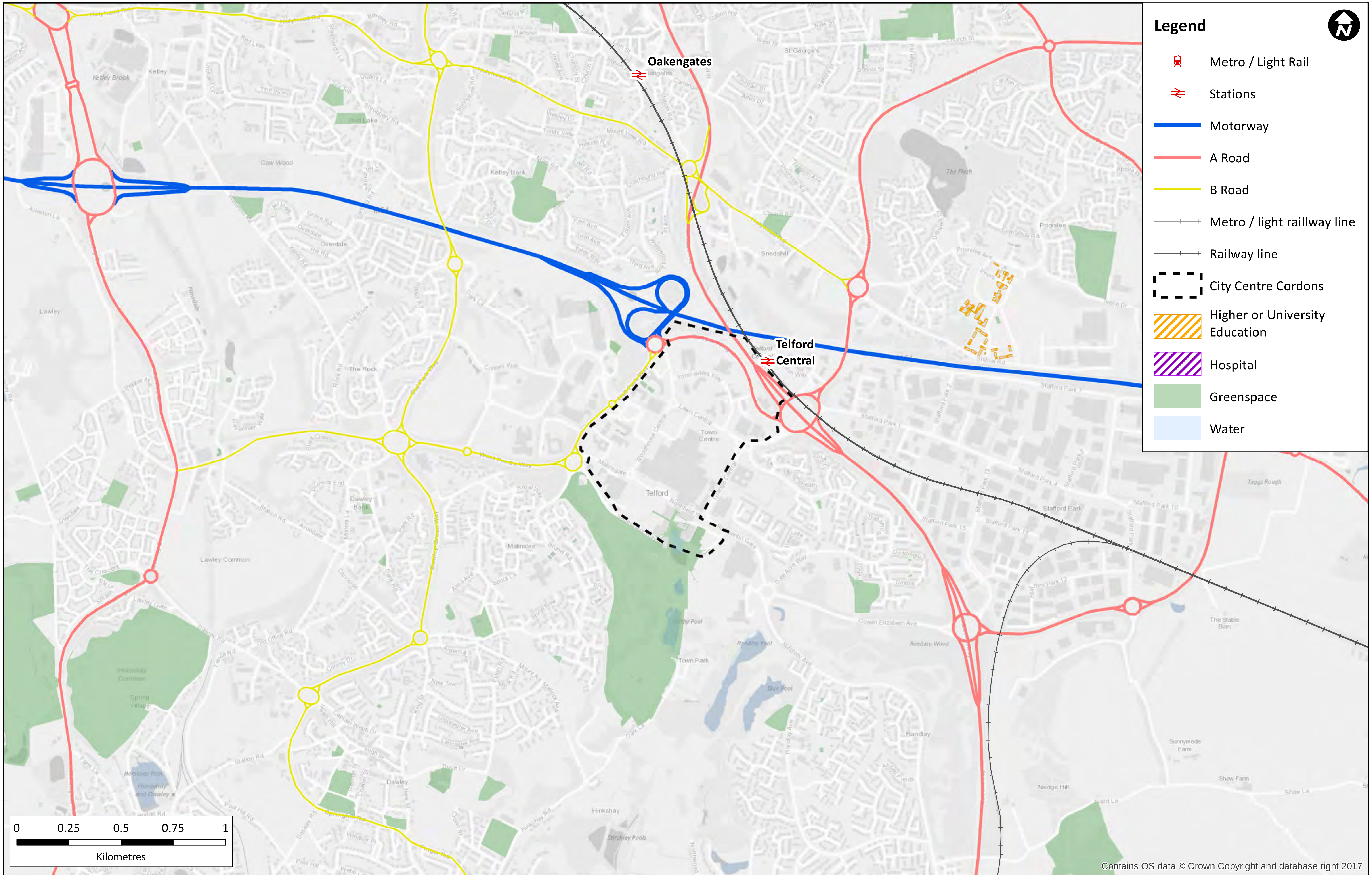

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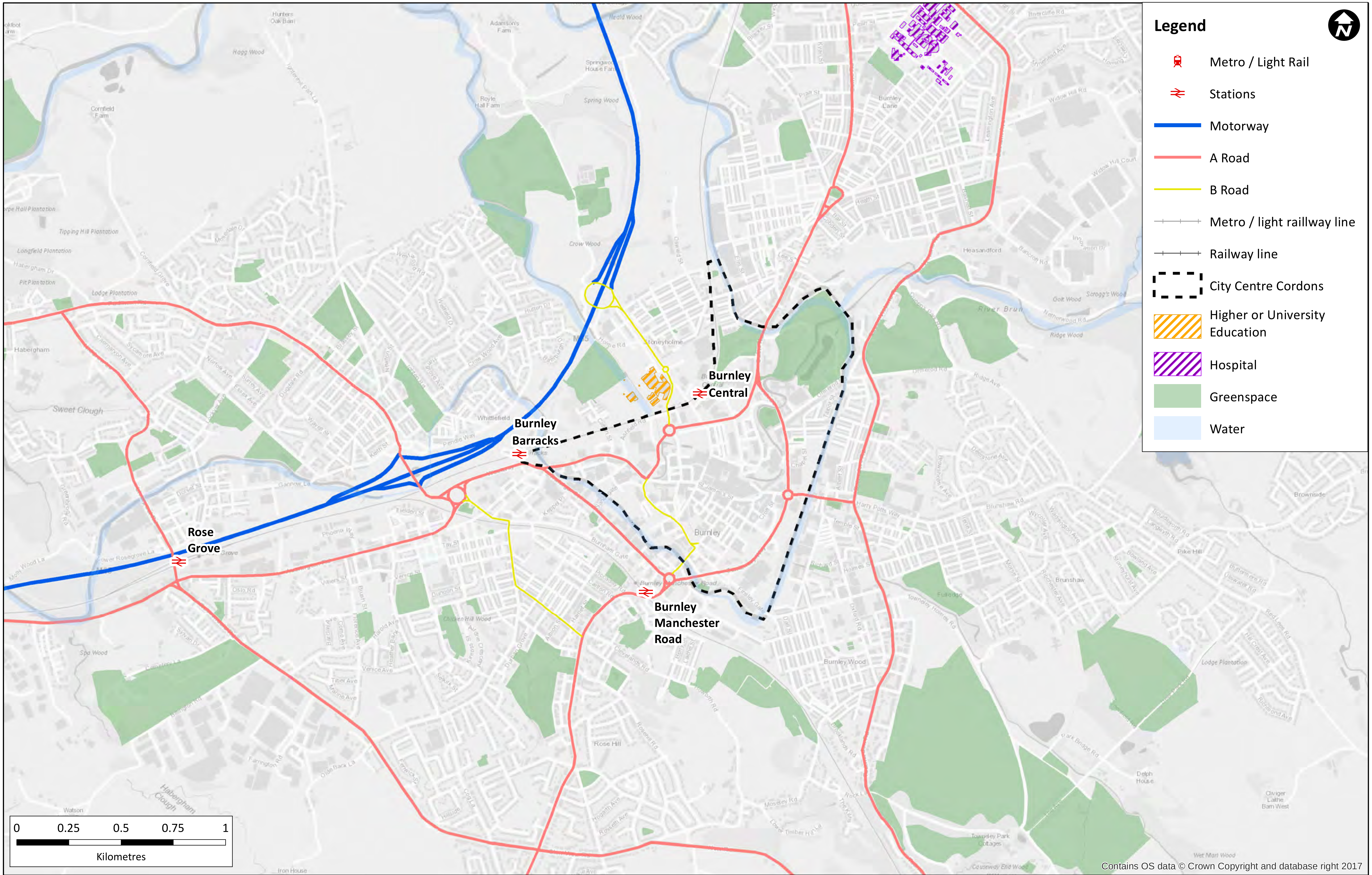

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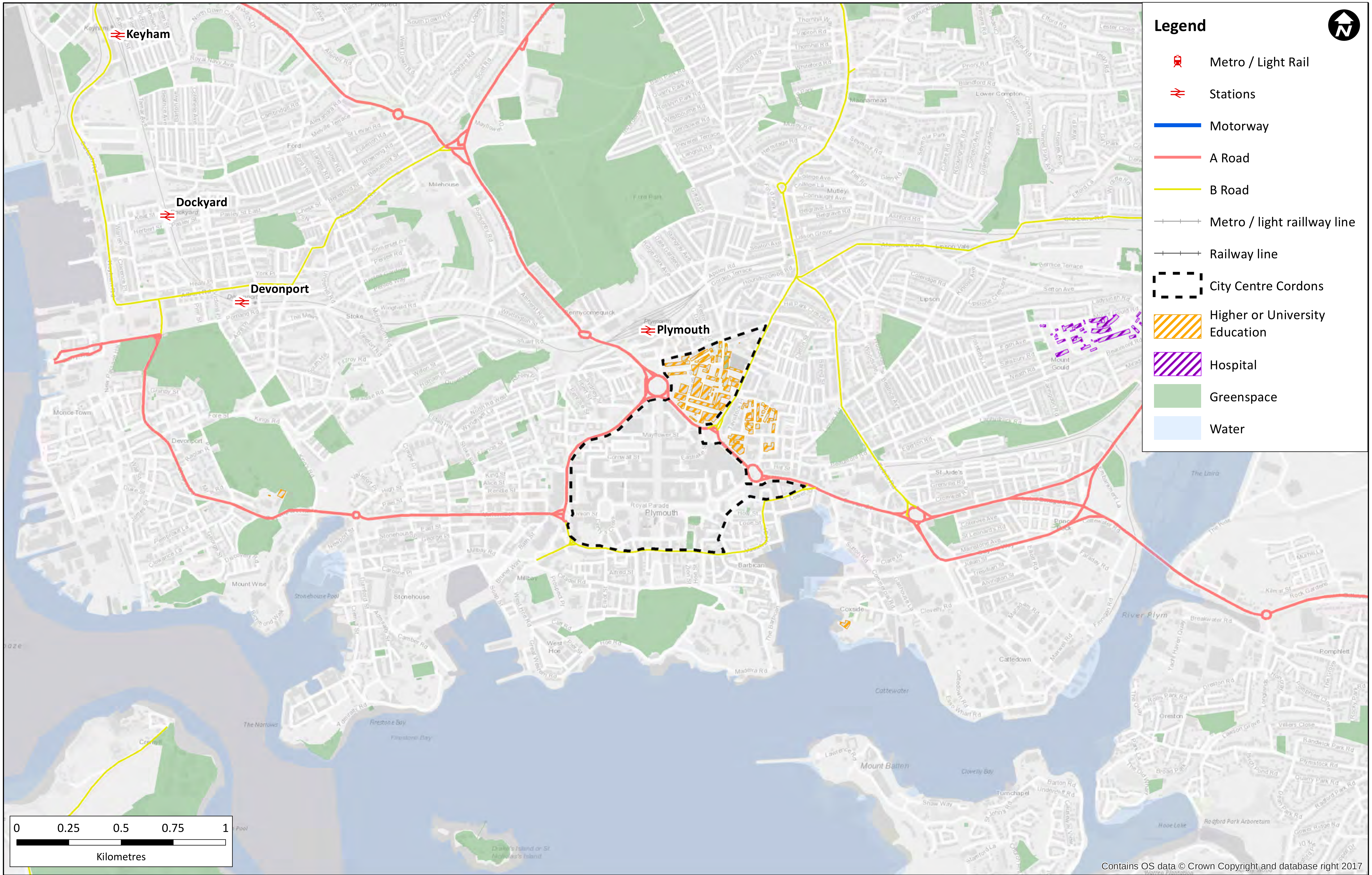

National Infrastructure Commission Capacity Review

Plymouth

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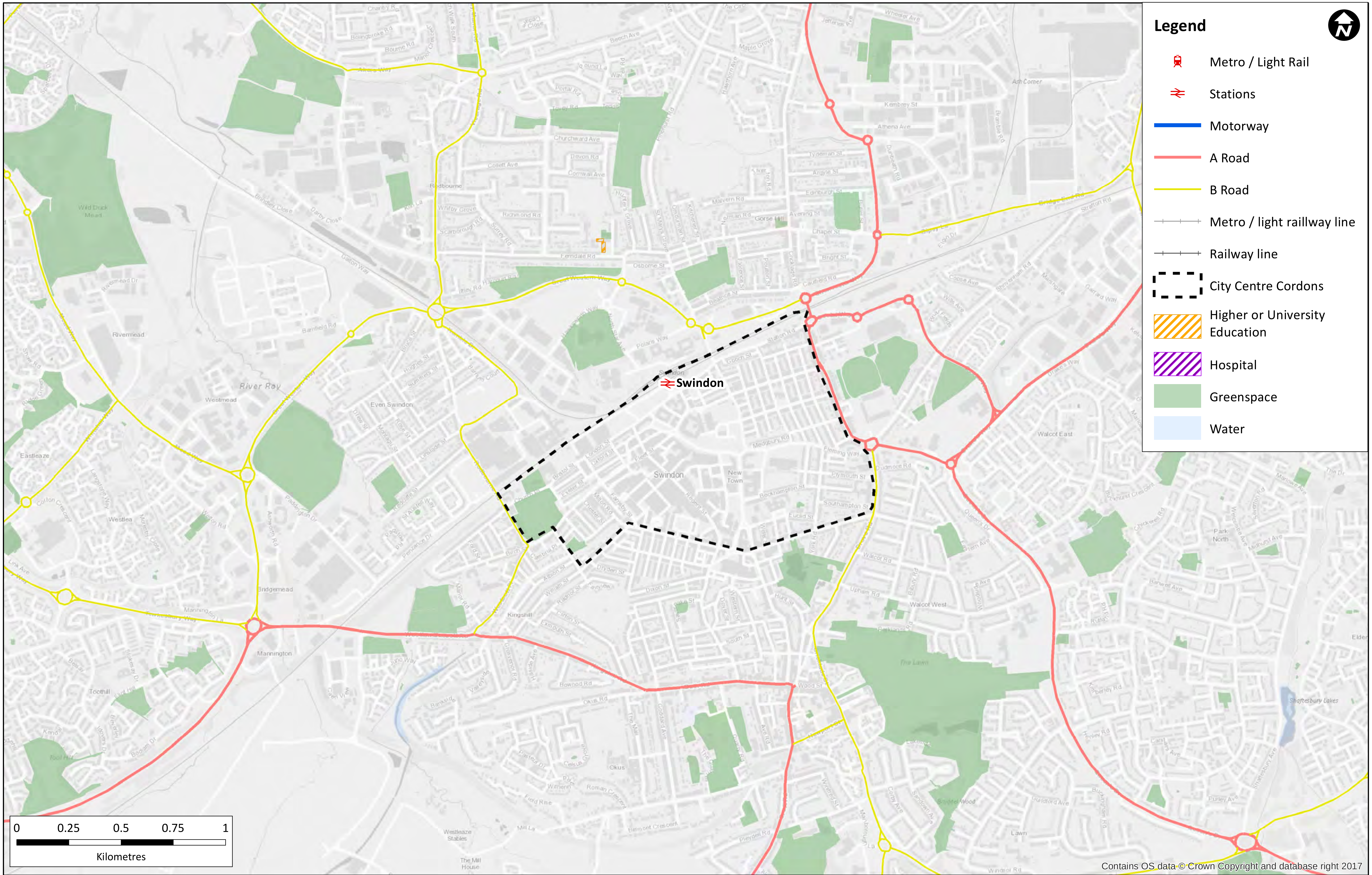

National Infrastructure Commission Capacity Review

Swindon

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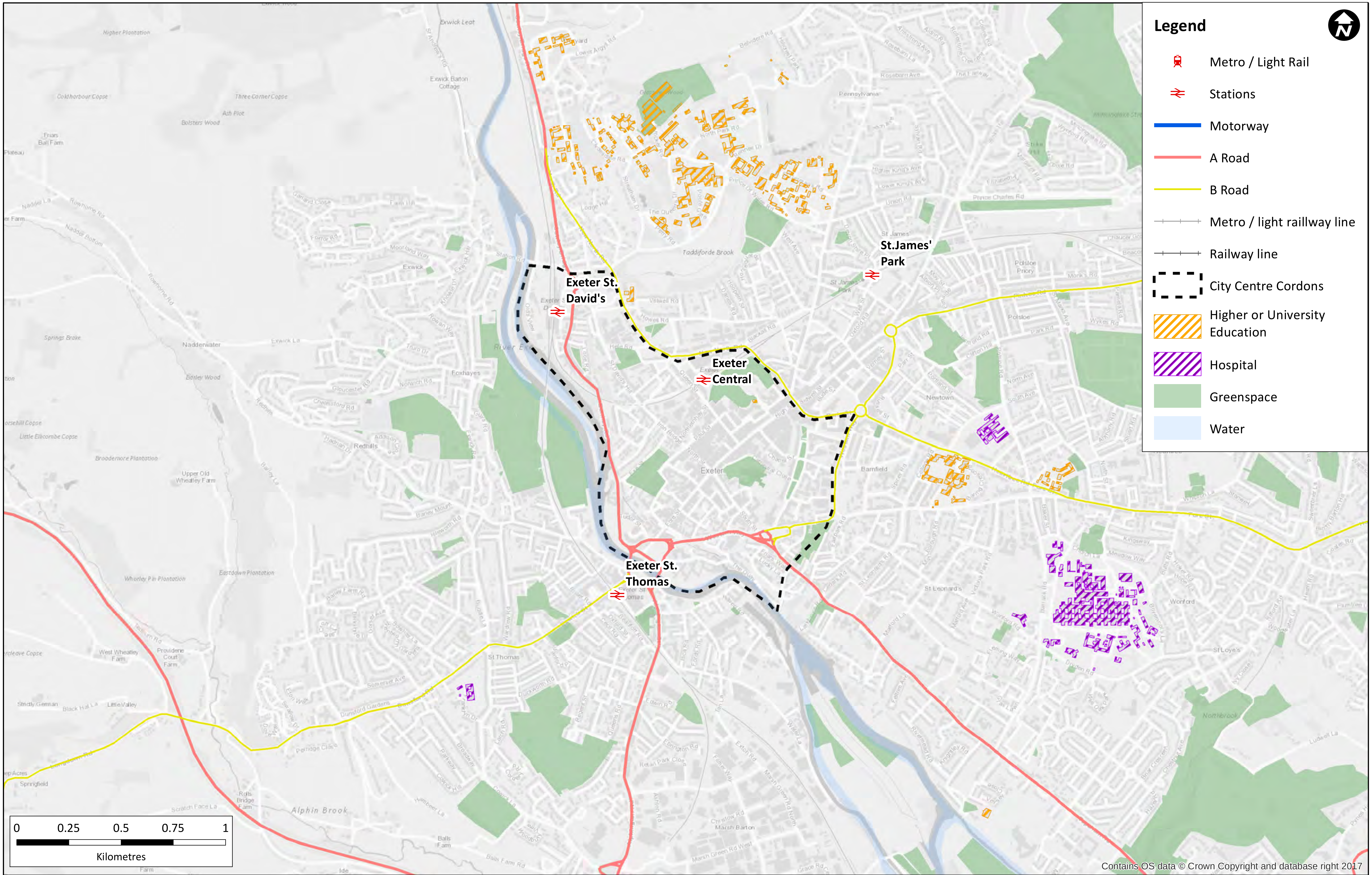

National Infrastructure Commission Capacity Review

Exeter

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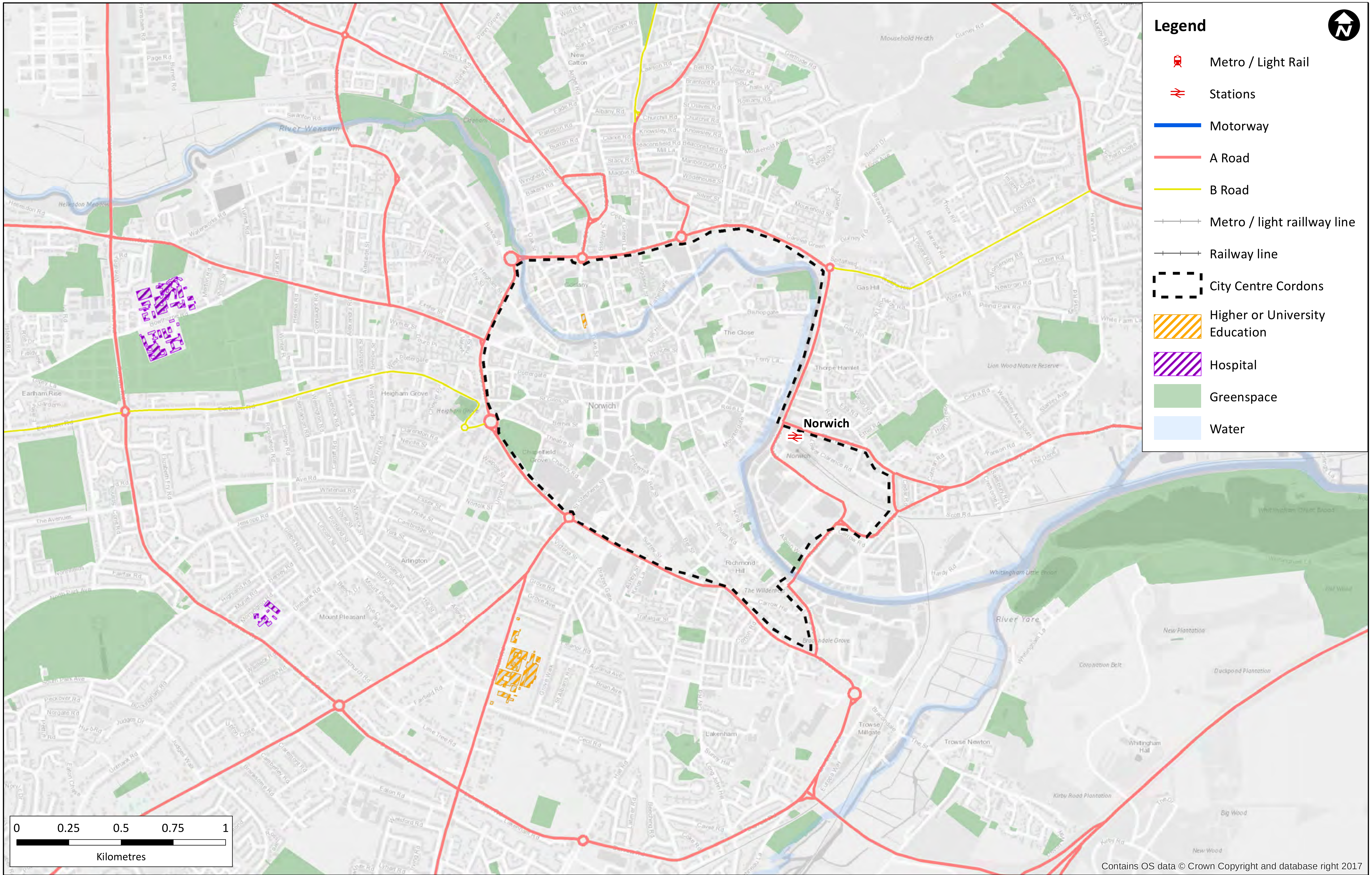

National Infrastructure Commission Capacity Review

Norwich

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B Contemporary Themes in Transport Planning

Overview

B.1 Over time, as the transport knowledge base expands and societal preferences change, the way in which transport capacity is delivered is changing. This is most notable in the shift away from prioritisation of the car, but is also reflected in a much wider range of decisions across the transport industry. These changes in the focus and delivery of transport capacity are termed 'contemporary themes' in transport planning for the purposes of this report. Contemporary themes consider how local authorities and other bodies (e.g. Local Enterprise Partnerships, Sub-National Transport Bodies and Combined Authorities) are currently approaching the challenge of building transport capacity into urban/built up environments. The most notable themes considered include:

- Implementation and extension of light rail networks in large cities.
- Light rail/metro aspirations, including commissioning of studies, in medium cities.
- Focus on reducing private vehicle trips, including drivers such as improving air quality and health.
- Planning for and implementation of integrated BRT networks.
- Investigation of tunnelled metro/public transport infrastructure due to city centre space constraints.
- Ongoing decline in bus use.
- Ongoing upgrades to urban road networks to release capacity constraints.

B.2 Contemporary transport themes in this study are derived from:

- Industry knowledge;
- Committed improvements to infrastructure in case-study cities; and
- Other planned or proposed capacity increases in the case study cities.

Identified themes

B.3 The following tables set out information gathered from Local Authorities and published planning documents to inform contemporary themes used in this study. It is recognised that the following tables do not represent a complete list of all schemes under consideration. Due to the purpose of these tables for information only, however, omitted schemes do not affect the results of the study.

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Future Capacity Schemes in Case-Study Cities

City	Scheme	Description	Opening Year	Road	National Rail	Metro/Tram	Bus	Walking	Cycling
Birmingham	Hagley Road A45 Sprint	Increased bus capacity from the West into Birmingham	2017-2020				✓		
	A34 Sprint	Increased bus capacity from the north into Birmingham	2017-2020				✓		
	Strategic cycle network: A34 Perry Barr to Birmingham	Increased cycle capacity into Birmingham from the North	2017-2020						✓
	Sutton Coldfield to Birmingham Sprint	Increased bus capacity from the North East into Birmingham	2017-2020				✓		
	A45 Sprint	Increased bus capacity from the East into Birmingham	2017-2020				✓		
	M40/M42 Interchange	Smart motorway from the South East	2022	✓					
	M42 junction 6 improvement	Capacity increase from the East	2023	✓					
	M6 junction 2 to junction 4	Smart motorway from the East	2020	✓					
Manchester	Manchester and Salford Inner Relief Route improvements	Regent Road and Great Ancoats Street	2019	✓					
	Metrolink fleet expansion and infrastructure enhancements		2019			✓			
	Improved bus network in Bolton-Salford area		2019				✓		
	A new Metrolink line to the Trafford Centre		2020			✓			
	M62 Junctions 10-12	Improved capacity and reliability of motorway from the West	2018	✓					
	M60 Junctions 24-27 & J1-4	Improved capacity and reliability of motorway ring road	2018-19	✓					
	M56 Junctions 6-8	Improved capacity and reliability of motorway from the South	2020	✓					
	M62 Junctions 20-25	Improved capacity and reliability of motorway from the North East	2019	✓					
Newcastle	Various small cycling and walking schemes in the city centre		2018-2021					✓	✓
Sheffield	BRT between Rotheram and Sheffield						✓		
	Inner Ring Road Junction Improvements			✓					
Leeds	East Leeds Orbital Road		2021	✓					
	Bus Network Transformation		2021				✓		
	Simplifying the road layouts to reduce congestion		2021	✓					
Bristol	Metrobus	A new bus rapid public transport system	2018				✓		
	MetroWest Phase 1	Re-opening the Portishead rail line to passenger train services	2019 (Phase 1) and 2021 (Phase 2)		✓				
	Cycle Ambition Fund	New range of cycling and walking networks	2018					✓	✓
	Temple Gate	Removing roundabout and replacing it with signal-controlled junction, new high quality segregated pedestrian and cycle routes as well as improvements to existing routes	2018	✓				✓	✓
Liverpool	Liverpool City Centre Connectivity 1	A package of interventions which seeks to improve the city centre environment for cyclists and pedestrians	2022					✓	✓
	A565 NLKC	Involves 'Dualling' of road link Sefton and Liverpool and city centre cycling improvements	2018-2019	✓					✓
	Baltic Triangle	City centre cycling improvements	2017-2018						✓
	Greenspace Network	City centre cycle improvements	2017-2018						✓
	Liverpool City Centre Conne	The development on a new link road providing relief for commuting from the northern suburbs	2019-2020	✓					
Leicester	North City Centre Accessibility Improvement Programme		2020	✓					
	A50/A6- Leicester North West Major Transport Corridor		2021	✓					
Southampton	Stubbington bypass		2022	✓					
	Junction 8 of the M27		2022	✓					
Reading	South Reading MRT	Bus priority measures on A33 between Basingstoke and Reading	2016				✓		
	East Reading	Bus priority measures on A4 between Thames Valley Park and Reading	2021-22				✓		
	City Centre cycling improvements								✓
Preston	A582 South Ribble Western Distributor	Capacity improvements on the existing roads between Cuerden/Moss Side and Preston City Centre	2023/24	✓					
	Completion of Penwortham Bypass	Capacity improvements along the A582 and Ribble flyover	2019/20	✓					
	Public Transport Priority Network	Comprehensive network of bus rapid transit corridors	2012-2019				✓		
Middlesbrough	A19 Norton to Wynyard		2022	✓					
Coventry	A45 Kenilworth Junction Improvements	Increase road capacity from the South	2017-2020	✓					
	VLR network	Increase PT capacity from the South	2017-2020			✓			
	A46 link road	Increase road capacity from the South	2017-2020	✓					
Huddersfield	A629 Corridor junction improvements		2021	✓					
Telford									
Burnley									
Plymouth	Derriford road capacity increase		2018	✓					
Swindon	New Eastern Village connectivity improvements		2019-21	✓					
Exeter	Exeter Bridge Road		2018	✓					
Norwich	City Centre cycling improvements								✓
	A47 corridor improvement programme		2023	✓					

Sources

https://www.tfwm.org.uk/development/sprint/

Local and Road Authority Data - direct responses as part of project and websites

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Future Rail Schemes and Additional Trains per hour per City

Scheme	Initiative	Birmingham	Manchester	Newcastle	Sheffield	Leeds	Bristol	Liverpool	Leicester	Southampton	Reading	Preston	Middlesbrough	Coventry	Huddersfield	Telford	Burnley	Plymouth	Swindon	Exeter	Norwich	Total
West Midlands Railway	New trains (400 new carriages, extra peak capacity of 85,000)																					
	Walsall – Rugeley: Electrified; more through trains to Birmingham																					
	Lichfield – Birmingham – Redditch (Cross city line): New trains (100 carriages); Extension to Bromsgrove																					
	Kidderminster – Birmingham – Stratford/Leamington: 80 new carriages																					
	Shrewsbury – Telford – Wolverhampton – Birmingham: 80 new carriages (same carriages as above); Service increased from 2tph to 3tph	1																				
	Stoke – Stafford – Wolverhampton – Birmingham: Longer trains																					
	Nuneaton – Coventry: New trains (3 coaches instead of 1); Service increased from 1 tph to 2 tph													1								
	Leamington – Coventry: Service increased from 1 tph to 2 tph; New station at Kenilworth													1								
Trans Pennine Express	New trains (220 carriages)																					
	Manchester: 56% more seats in the morning rush hour																					
	Newcastle: More than treble the number of seats in the morning peak; Service to and from Manchester increased from 1tph to 2tph; Service to and from Edinburgh increased from 1tph to 2tph		1	1																		
	Sheffield : Double the number of seats in the morning peak																					
	Leeds: More than 60% increase in seats in the morning peak																					
	Liverpool: More than double the number of seats in the morning peak																					
	Preston: No net change in train length (most rise from 4 to 5 carriages, but some reduce from 8 to 5)																					
	Huddersfield - Leeds: Service increased by 1tph					1									1							
Greater Anglia	Replacement of entire fleet (1144 additional weekday services)																					
	London – Norwich: Service increased from 2tph to 3tph																				1	
	Norwich – Cambridge: Service extended to Stansted Airport																					
	Norwich: Longer local trains																					
South Western Railway	Replacement of London suburban fleet (releasing additional carriages for services elsewhere)																					
	London – Southampton: Faster services																					
	Portsmouth – Southampton: Service enhanced from 2 tph to 3 tph									1												
	London – Reading: Service increased from 2tph to 4 tph; Trains lengthened from 8 carriages to 10										2											
Great Western Railway	Replacement of Inter City fleet; Electrification; New London suburban electric trains; Cascade of diesel trains to benefit non-London services																					
	London – Bristol: Service increased from 2tph to 4tph (serves Reading and Swindon); Peak train lengths increased from 8 to 9 or 10 carriages (though based around London peak)						2												2			
	London – Reading – Didcot/Newbury: Most trains to be provided by electric trains; Many train lengths increased from 5 to 8 carriages																					
	London – Exeter – Plymouth – Cornwall: Some peak train lengths increased from 8 to 9 or 10 carriages (though based around London peak)																					
	Reading – Gatwick: Service increased from 1tph to 2tph										1											
	Cardiff – Bristol – Southampton – Portsmouth: Peak train lengths increased from 3 to 5 carriages																					
	Worcester – Gloucester – Bristol: Pacer units replaced by full length 2 carriage trains																					
	Severn Beach – Avonmouth – Bristol: Peak train lengths increased from 2 Pacer carriages to 3 full length carriages																					
	Taunton – Bristo; Additional trains; Longer trains																					
	Exmouth – Exeter: Peak train lengths enhanced from 4 Pacer carriages to 4 full length carriages																					
	Barnstaple – Exeter: Peak train lengths enhanced from 2 Pacer carriages to 2 full length carriages																					
	Paignton – Newton Abbot – Exeter: Service increased from 1tph to 2tph; Peak train lengths enhanced from 4 Pacer carriages to 4 full length carriages																			1		
	Gunnislake – Plymouth: Train length increased from 1 carriage to 2																					
	Penzance – Truro – Plymouth: Service increased to 2tph in all hours; Some trains lengthened from 2 carriages to 4																					
Northern Rail	281 new carriages; Carriages brought in from other franchises; Complete withdrawal of Pacer trains																					
	Newcastle – Middlesbrough: Service increased from 1tph to 2tph			1									1									
	Bishop Auckland – Middlesbrough: Service increased from 0.5tph to 1tph												0.5									
	Whitby – Middlesbrough: AM peak service to be provided												1									
	Carlisle – Newcastle: Service increased from 1tph to 2tph			1																		
	Sheffield – Hull: New trains																					
	Leeds – Hull: Service increased from 1tph to 2tph					1																
	Leeds – Selby: Service increased from 2tph to 3tph					1																
	Leeds – Harrogate: Service increased from 2tph to 4tph					1																
	Leeds – Ilkley/Skipton/Bradford: Peak train lengths increased from 4 to 6 carriages																					
	Leeds – Sheffield – Nottingham: Faster service; New trains																					
	Sheffield – Huddersfield: Peak train lengths enhanced from 2 Pacer carriages to 2 full length carriages																					
	Lincoln – Sheffield: Faster service																					
	Retford/Worksop – Sheffield: Service increased from 1tph to 2tph				1																	
	Leeds – Pontefract – Knottingley: Service increased from 1tph to 2tph					1																
	Bradford – Manchester: Service increased from 2tph to 3tph		1																			
	Glossop/Hadfield – Manchester: Peak train lengths enhanced from 3 to 4 carriages																					
	New Mills Newton – Manchester: Service increased from 1tph to 2tph		1																			
	Hazel Grove – Manchester: Service increased from 3tph to 4tph		1																			
	Macclesfield – Manchester: Service increased from 3tph to 4tph		1																			
	Northwich – Altrincham – Manchester: Service increased from 1tph to 2tph		1																			
	Wigan – Atherton – Manchester: Service increased from 3 or 4tph to 4tph		1																			
	Chester – Warrington – Manchester: Service increased from 1tph to 2tph		1																			
	Ormskirk – Preston: Service increased to 1tph											1										
	Blackpool – Preston – Manchester: New electric trains																					
HS2	2tph to Birmingham	2																				
Assumed Additional TPH		**3**	**8**	**3**	**1**	**5**	**2**	**0**	**0**	**1**	**3**	**1**	**2.5**	**2**	**1**	**0**	**0**	**0**	**2**	**1**	**1**	**36.5**

Sources
http://maps.dft.gov.uk/west-midlands/
http://maps.dft.gov.uk/transpennine-express/index.html
http://maps.dft.gov.uk/east-anglia-franchise/
http://maps.dft.gov.uk/south-western-franchise/
http://maps.dft.gov.uk/first-great-western/index.html
http://maps.dft.gov.uk/northern/index.html

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Contemporary Themes in Transport Planning

	Bus	BRT	LRT/Metro	Road	Walking and Cycling	Rail
Upcoming Schemes and Priorities	• Manchester and Liverpool considering increased regulation of the bus network e.g. franchising or enhanced partnership • Leeds aim to double their bus patronage over 10 years through a package of corridor measures	• SPRINT network currently under development in Birmingham • Manchester considering BRT routes to improve HS2 and Airport access • MetroBus opening in 2018 in Bristol	• Midland Metro Extensions proposed or currently under development in Birmingham • Proposal to complete the airport loop and a potential tunnelled metro in Manchester • A major corridor study involving four strategic LRT/Metro corridors underway in Bristol • Solent Metro proposed by Solent LEP's Strategic Transport Investment plan	• A focus on the M60 in Manchester with studies on the North West Quadrant underway and the construction of the A6 to Manchester Airport Relief Road and the Western Gateway Infrastructure Scheme • A focus on the Strategic Road Network in Leeds • Orbital highway improvements around Bristol to mitigate congestion and to provide space for sustainable transport modes • Strategic schemes such as Mersey Gateway and Thornton Link in Liverpool • Norwich Northern Distributor Road currently under construction • Dualling of the M6/M61/M65 in Preston	• Manchester and Leeds aim to create a network of on and off-road walking and cycling routes as part of their 2040 strategies • Planned improvements to walking and cycling facilities in Liverpool as part of Merseytravel's Transport Plan for Growth • £14.1m of investment in cycle networks and a 2020 strategy for active travel modes in Norwich • Traffic management measures and reallocation of road space to improve cycle networks in Bristol	• Significant overhaul of services to and from Birmingham City Centre following the introduction of HS2 • Proposals for three new rail stations and an upgrade of Leeds City Station • Proposals to re-open rail lines, increase train services and to open new stations as part of MetroWest Phase 1 and Phase 2 in Bristol • New rolling stock in Liverpool and potential devolution to improve station facilities • Proposed rail based local network in Solent LEP's Strategic Transport Investment Plan • Electrification between Preston and Blackpool and amended services following the introduction of HS2 • Replacement of Greater Anglia's rolling stock towards the end of 2020 in Norwich • Prioritisation of strategic rail corridors underway in Manchester

Contents of this table are an excerpt only, based on industry knowledge. This does not represent all themes in all cities, however it does provide context to the contemporary themes used in scenario development

C Capacity Methodology and Metrics

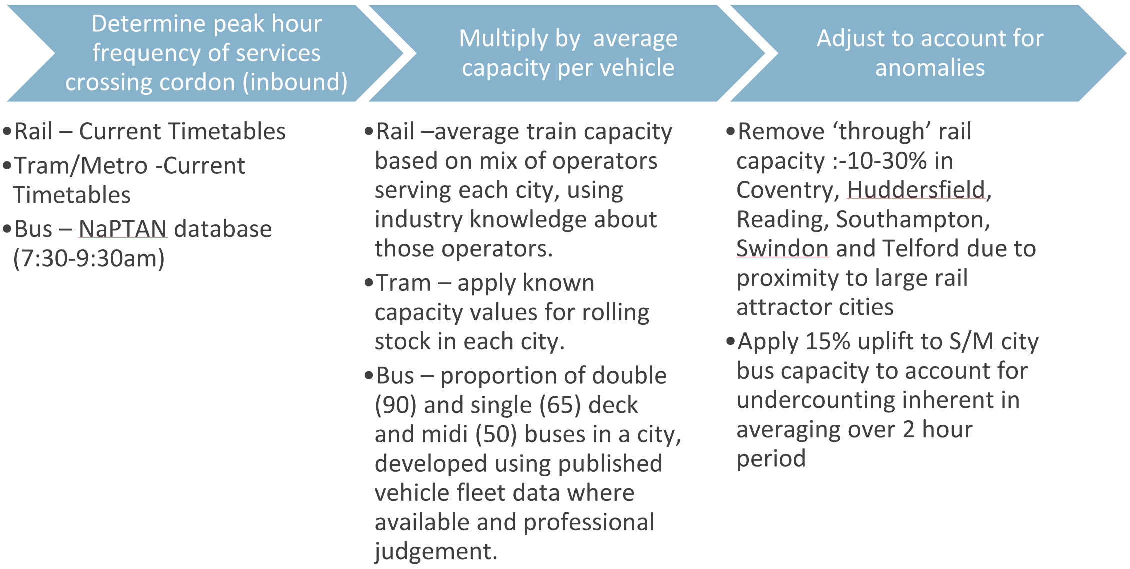
Overview

C.1 This appendix builds on the information provided in the main body of the report regarding the UTCM calculation methodology. Key metrics are provided here to give context to the reported capacity values. The methodology is presented on a mode-by-mode basis.

Public Transport Capacity

C.2 Capacity for all public transport modes is calculated following a similar process, set out in the figure below. Key areas of uncertainty are summarised in the following text.

Figure C.1: Public transport capacity estimation process



National rail

C.3 National rail capacity is based on timetable information at the time of analysis. That is, May 2018 timetable changes are not accounted for in the capacity. The number of rail arrivals in each city centre is based on all city centre stations although, in locations with multiple city centre stations, each train is only counted once.

C.4 Assumed train capacities are based on industry knowledge and evidence of the rolling stock used by train operating companies serving each city. Therefore, carriage capacities and train lengths vary by case-study city. Train capacities include both seating and standing capacity, noting that official standing capacities do not exist for train carriages in the same way they are specified for buses.

C.5 Rail services operate on a national network, therefore it can be misleading to consider all capacity on all trains serving a city to be attributable to that city. This is because the rail network also provides many long distance, inter-city services and not all cities are terminal nodes on the network i.e. many cities receive through-services destined for other cities. To account for this, rail capacity is reduced for cities in close proximity to larger cities where many services are merely 'passing-through' (see table below).

Table C.1: Rail Capacity Reduction Factors

City	Adjoining Major Location	Approximate Distance (miles)	Applied Reduction in Rail Capacity
Coventry	Birmingham	10	30%
Huddersfield	Leeds	17	10%
Reading	London	36	30%
Southampton	London	80	20%
Swindon	London	77	20%
Telford	Birmingham	28	10%

Source: Steer Davies Gleave

C.6 The relative proportions of inter-city and shorter distance services calling at each case-study city are summarised below. There is no absolute definition that defines inter-city (long distance) and short distance (commuter) services. Therefore, the table below is indicative and is based on an understanding of the services operated by each train operating company in each city.

Table C.2: Inter-city and short distance services by city (0800 – 0859)

City	Inter-city	Short Distance
Birmingham	30%	70%
Manchester	44%	56%
Newcastle	-	100%
Sheffield	41%	59%
Leeds	20%	80%
Bristol	56%	44%
Liverpool	26%	74%
Leicester	62%	38%
Southampton	13%	88%
Reading	21%	79%
Preston	-	100%
Middlesbrough	50%	50%
Coventry	33%	67%

City	Inter-city	Short Distance
Huddersfield	33%	67%
Telford	30%	70%
Burnley	54%	46%
Plymouth	52%	48%
Swindon	47%	53%
Exeter	92%	8%
Norwich	-	100%

Tram/Metro

C.7 Few English cities currently have tram or metro networks. Of the case-study cities the following cities have operational tram/metro infrastructure:

- Manchester (Metrolink)
- Birmingham (Midland Metro – the current network is a single line)
- Newcastle (Tyne and Wear Metro)
- Sheffield (Supertram)
- Liverpool has a comprehensive local rail network (Merseyrail) this is included in the National Rail estimates in this study.

C.8 Due to the small number of networks, service patterns and capacity metrics have been calculated for each system separately using available information online and industry knowledge.

Bus

C.9 Bus data is difficult to obtain as bus services are privately operated in a competitive market. Detailed information regarding bus operations is, therefore, considered to be commercially sensitive.

C.10 The National Public Transport Access Nodes (NaPTAN) database is owned by the Department for Transport (DfT) and is a nationally consistent source of bus frequency, route and stop data. NaPTAN provides morning peak bus frequencies for the 0730 to 0930 two-hour period only. In developing peak hour estimates, these two-hour frequencies have been halved to provide a single hour estimate. In small and medium sized cities, a 15% uplift is applied to single hour frequencies, to account for the lower frequencies occurring early in the morning.

C.11 The NaPTAN database is dependent on input data from bus operators.

C.12 Bus capacities are calculated based on an assumed fleet mix of double deck, single deck and midi buses. Where possible these have been calibrated against publicly available fleet data for relevant bus operators. Assumed capacities for each bus category are presented in the following table.

Table C.3: Assumed bus capacities

	D/Deck	S/Deck	Midi
Assumed Seating + Standing Capacity	90	65	50

Table C.4: Key Public Transport Metrics for Case-Study Cities

City	Train Arrivals	Average Train Capacity (including Standing)	LRT/Metro Arrivals	Tram/ Metro Capacity	Bus Arrivals	D/Deck	S/Deck	Midi
Birmingham	67	485	9	280	423	75%	25%	-
Manchester	70	385	55	280	367	66%	30%	4%
Newcastle	14	433	41	544	298	51%	37%	12%
Sheffield	21	347	26	243	217	48%	52%	-
Leeds	50	383			283	67%	33%	-
Bristol	18	391			190	74%	25%	1%
Liverpool	48	497			284	55%	44%	1%
Leicester	13	479			200	53%	43%	4%
Southampton	15	693			143	19%	81%	-
Reading	37	681			161	60%	30%	10%
Preston	18	437			166	45%	32%	23%
Middlesbrough	8	211			108	1%	95%	4%
Coventry	17	617			149	53%	41%	5%
Huddersfield	16	388			130	28%	72%	-
Telford	4	431			52	6%	76%	18%
Burnley	6	268			68	30%	62%	8%
Plymouth	6	384			143	48%	47%	5%
Swindon	12	716			108	12%	82%	6%
Exeter	10	426			80	38%	47%	14%
Norwich	9	382			127	70%	29%	1%

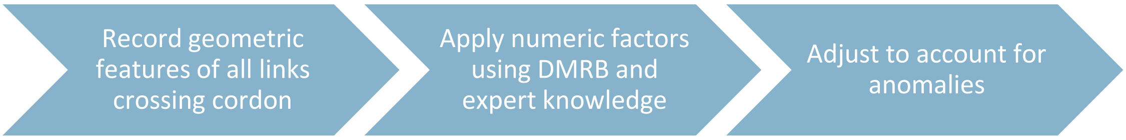
Private vehicle (road) capacity

C.13 Private vehicle capacity was calculated following the process summarised in Figure C.2. Private vehicle capacity is based on the hourly vehicle capacity of inbound lanes crossing the cordon. It should be noted that where a city has an inner ring road, the cordon is generally defined to fall within the ring road such that ring road capacity is not included in the capacity estimate.

C.14 Strategic transport models are widely used to estimate the transport capacity of urban road networks. Undertaking model runs, or sourcing model information, for the twenty case-study cities is not proportionate to the scope of this study. Therefore, only the links crossing the cordon and adjacent junctions are used in the capacity estimation.

C.15 It should be noted that roads crossing each cordon do not exist in isolation; rather, they form part of wider road networks. Consequently, constraints away from city centres could, in fact, be the key drivers of capacity in the peak periods.

Figure C.2: Private vehicle capacity estimation process



- Use GIS to identify links
- Manually record features using aerial photography:
  - Number of lanes
  - Design standard
  - Bus, Cycle, HOV lanes
  - Parking, driveways
  - Upstream and Downstream Junctions (within 250m)

- Initial theoretical lane capacity directly from DMRB
- Applied reduction factors based on manually observed features
  - Reduction factor developed using expert knowledge/rules of thumb, refined through an iterative process
  - Minimum of junction and midblock factors applied

- Remove 'through' capacity to account for large roads dissecting cordon which serve large volumes of traffic not travelling to the city centre:-10 - 50% in Birmingham, Middlesbrough, Newcastle, Norwich, Plymouth, Preston, Reading, Sheffield and Telford.
- High level parking analysis – no further reductions to road capacity

Record geometric features

C.16 The core input to road capacity is the number of lanes and road features. Features of each inbound link across city centre cordons were recorded. This methodology uses a manual approach to identifying road attributes based on publicly available aerial photography. An iterative approach to the development of the methodology was taken to remove as much subjectivity as possible.

C.17 Roads with no inbound capacity, or no access to the city centre are excluded from the analysis.

Apply numeric factors

C.18 Once an inventory of the features of the roads crossing the city centre cordons had been compiled, numeric factors were applied to estimate capacity.

Base capacity value

C.19 The base capacity value of each road in vehicles per hour was estimated based on values in the Design Manual for Roads and Bridges[17]. This represents an ideal/theoretical capacity value for each road in free flow conditions. It does not account for the many other features which affect capacity, accounted for through the use of reduction factors and normalisation of utilisation results.

C.20 The relevant DMRB excerpts are provided in the following tables.

[17] Design Manual for Roads and Bridges (DMRB) (Volume 5, Section 1, Part 3, Table 2) http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol5/section1/ta7999.pdf

Feature	ROAD TYPE				
	Urban Motorway	Urban All-purpose			
	UM	UAP1	UAP2	UAP3	UAP4
General Description	Through route with grade separated junctions, hardshoulders or hardstrips, and motorway restrictions.	High standard single/dual carriageway road carrying predominantly through traffic with limited access.	Good standard single/dual carriageway road with frontage access and more than two side roads per km.	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings.	Busy high street carrying predominantly local traffic with frontage activity including loading and unloading.
Speed Limit	60mph or less	40 to 60 mph for dual, & generally 40mph for single carriageway	Generally 40 mph	30 mph to 40 mph	30mph
Side Roads	None	0 to 2 per km	more than 2 per km	more than 2 per km	more than 2 per km
Access to roadside development	None. Grade separated for major only.	limited access	access to residential properties	frontage access	unlimited access to houses, shops & businesses
Parking and loading	none	restricted	restricted	unrestricted	unrestricted
Pedestrian crossings	grade separated	mostly grade separated	some at-grade	some at-grade	frequent at-grade
Bus stops	none	in lay-bys	at kerbside	at kerbside	at kerbside

**Table 1 Types of Urban roads
and the features that distinguish them**

		Two-way Single Carriageway- Busiest direction flow (Assumes a 60/40 directional split)									Dual Carriageway			
		Total number of Lanes									Number of Lanes in each direction			
		2				2-3	3	3-4	4	4+	2		3	4
Carriageway width		6.1m	6.75m	7.3m	9.0m	10.0m	12.3m	13.5m	14.6m	18.0m	6.75m	7.3m	11.0m	14.6m
Road type	**UM**	**Not applicable**										4000	5600	7200
	UAP1	1020	1320	1590	1860	2010	2550	2800	3050	3300	3350	3600	5200	*
	UAP2	1020	1260	1470	1550	1650	1700	1900	2100	2700	2950	3200	4800	*
	UAP3	900	1110	1300	1530	1620	*	*	*	*	2300	2600	3300	*
	UAP4	750	900	1140	1320	1410	*	*	*	*	*	*	*	*

Table 2 Capacities of Urban Roads
One-way hourly flows in each direction

Notes
1. Capacities are in vehicles per hour.
2. HGV ≤ 15%
3. (*) Capacities are excluded where the road width is not appropriate for the road type and where there are too few examples to give reliable figures.

Source: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol5/section1/ta7999.pdf

C.21 DMRB values were supplemented with an additional value to for the capacity of minor roads. During the initial step, small non-A or B roads were identified as having consistently low capacity, not represented in the DMRB due to its focus on more major roads. Through an iterative process using industry knowledge and available count data a capacity of 350 vehicles per hour was determined appropriate for application to minor roads across the cordon.

Reduction factors

C.22 Reduction factors are a numerical representation of road and junction features which affect the capacity of a road link. These include:

6. Road feature factors such as on-street parking, bus lane and cycle lane reduction factors etc.; and
7. Junction feature factors such as number of phases, signalisation of junctions, type of pedestrian crossing etc.

C.23 Reduction factors were produced for the adjacent upstream junction, downstream junction and road features. The single lowest reduction factor is then applied to each link to reduce the base capacity.

C.24 A 15% reduction was also applied to all capacities to remove capacity ‘allocated’ to HGVs. This is consistent with DMRB values as set out in the earlier excerpt.

Parking supply as a constraint

C.25 There is no readily available, comprehensive data source on the quantity of parking in all case study cities. A high-level review of the available information did not provide sufficiently robust evidence that private vehicle capacities should be reduced due to parking supply. Despite this, parking availability and cost may constrain private vehicle capacity for some cities.

Reported capacity value

C.26 The **reported capacity value** of vehicles per hour is calculated as follows:

$$Theoretical\ Capacity\ Value \times Reduction\ factor = Reported\ Capacity\ Value$$

C.27 Capacity values (vehicles per hour) were developed individually by link and summed across all links crossing the cordon. The aggregate city vehicle capacity was converted to person capacity through applying a factor of 1.2 people per vehicle, based on values in the DfT WebTAG databook Table A1.3.3. It should be noted that Table A1.3.3 car occupancy values across trip purposes between 0700-1000 range from 1.17 to 1.68 per trip. The value of 1.2 applied is at the lower end of this range.

Table C.1: Road Capacity Reduction Factors

Variable Name	Value	Location Applied to	Notes and application
Road Feature Factor	Between 0 and 1	All roads	Road features were surveyed for features which would affect capacity to calculate a reduction factor
Junction Factors	Between 0 and 1	All roads	Upstream and downstream road junction features were surveyed for characteristics which would affect capacity to calculate a reduction factor. The junction which reduced capacity the most was seen as the limiting factor and selected.
Estimated capacity	Ideal capacity * lowest of junction / factor factors	All roads	Ideal capacity after the reduction factors of the road features and junctions were applied. Only the lowest of the 3 factors is applied. (Two junction factors and the one feature factor)
Minor Road Capacity Value	350	All cities, predominately large	This value is an estimated value applied to smaller side roads, (non A or B roads / non motorway roads). Expectations were made where roads clearly possessed a higher carrying capacity due to physically characterises or due to the neighbouring complementary junction design (such as, if the road was very wide/ a dual carriage way or if the road was a feeder to the centre from a large junction). *Values are one-way flows of road in inbound direction
Feature Factor: On-Street Parking/ Loading Reduction Factor (one side)	0.9		Applied to a link where loading bays/ on-street parking / on street bus stops will affect the capacity of the sections of road
Feature Factor: On-Street Parking/ Loading Reduction Factor (both side)	0.6		Applied to a link where loading bays/ on-street parking / on street bus stops are on both side of the link and will have a greater affect the capacity of the road

Variable Name	Value	Location Applied to	Notes and application
Feature Factor: Bus lane reduction factor	$\frac{No.\ of\ lanes - 1}{No.\ of\ lanes}$		Applied to a link where bus lanes occupy a lane of traffic and will affect the capacity of the section of road
Feature Factor: Cycle lane reduction factor	0.9	All roads with a cycle lane	Applied to a link where cycle lanes are present and will affect the capacity of the section of road
Feature Factor: Through traffic	Between 0 and 1	Major roads which carry through traffic	Applied as part of the road features factor to road which carry traffic into and out of the city centre area. This accounts for the reduction capacity due to traffic which has a destination outside of the city but still travels through it.
Junction factor: Upstream Junction is within to 2km			If the upstream junction is not within two 2km of the downstream junction, it is assumed the junction will not influence the capacity and returns the junction factor as 1.
Junction factor: Rule of reduced capacity cause by neighbouring junctions			As a crude estimate, we might say number of stages equals number of lanes and capacity is reduced by (1/no. lanes) – again we can review on a site by site basis at the end. Rules of use: Select number of stages the upstream junction runs. If a signalised interchange, this will be number of arms, if a signalised roundabout, assume it's the equivalent of a 2 arms/ stages and enter "2", If the downstream junction is not signalised or will not affect flow, select "Not signalised"
Junction Factor: Reduction Factor for Pedestrian Crossing at, or near a Junction	0.9	Any road with Pedestrian crossings	Applied as part of the junction factor, if a pedestrian crossing is present, or if there is a pedestrian crossing is present on the link. Also, has been applied at the discretion of the surveyor to zebra crossings which would be likely to affect capacity.

Table C.2: Road Capacity – Key Metrics

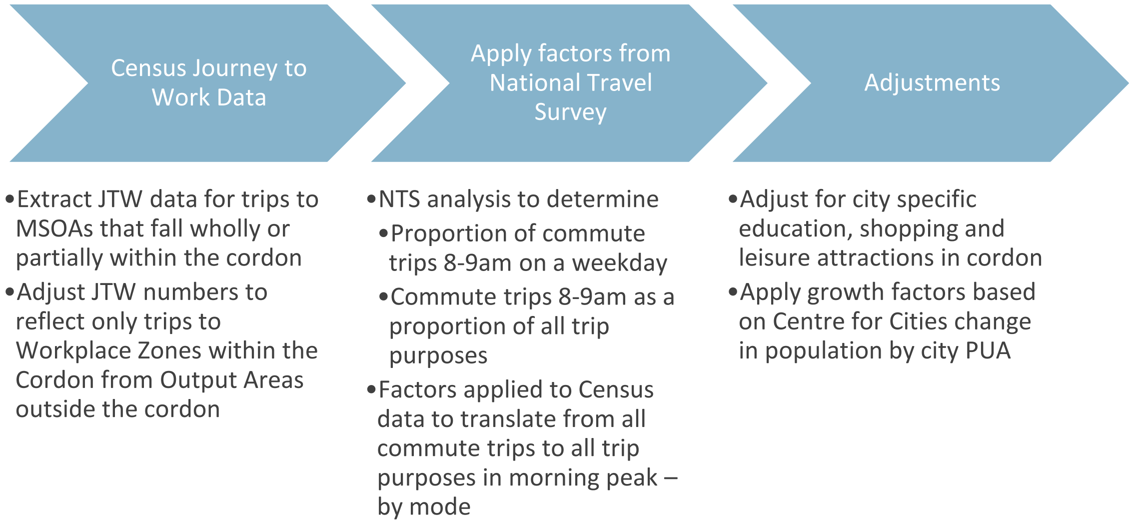
City	No. of roads	No. of roads with > 1 lane	No. of roads with 1 lane	No. of Lanes	Estimated Capacity (Veh./ Hour)
Birmingham	37	10	27	50	26,000
Manchester	28	9	19	37	23,000
Newcastle	27	6	21	34	21,000
Sheffield	23	8	15	31	19,000
Leeds	19	6	13	27	15,000
Bristol	22	7	15	32	17,000
Liverpool	32	11	21	45	24,000
Leicester	24	6	18	32	19,000
Southampton	13	7	6	21	11,000
Reading	9	3	6	12	8,000
Preston	17	2	15	19	10,000
Middlesbrough	15	5	10	20	12,000
Coventry	8	3	5	11	9,000
Huddersfield	10	2	8	12	5,000
Telford	6	0	6	6	7,000
Burnley	9	2	7	11	10,000
Plymouth	13	4	9	17	12,000
Swindon	13	3	10	16	11,000
Exeter	11	2	9	14	9,000
Norwich	17	1	16	18	8,000

Active modes

C.28 The capacity of active mode networks (walking and cycling) is defined, for the purpose of this study, to correspond to the current utilisation. Therefore, the methodology described in the following paragraphs is aimed at determining the number of cycling and walking trips currently crossing the cordons during the morning peak.

C.29 Active mode capacity was calculated using the following three steps:

Figure C.1: Active mode capacity estimation process



Census journey to work origin-destination data

C.30 The basis for the estimates of the number of people travelling into each cordon by active modes is 2011 Census Journey to Work origin-destination data. This data provides a matrix of journeys from home location to work location. At the time of analysis, this data was only available at Middle Super Outputs Area (MSOA) level, which does not match the defined city centre cordons. We have therefore made a number of adjustments to the MSOA level origin-destination data as described in Appendix D.

National Travel Survey 2016

C.31 National Travel Survey (NTS) 2016 data have been used to:

- Understand daily and weekly travel profiles by purpose and by active mode, in order to quantify the percentage of commuting trips made during the morning peak hour (0800 – 0900); and
- Quantify the number of non-commuting trips as a proportion of commuting trips, differentiating both by mode and by time of the day.

C.32 The diurnal profile of active mode commute trips, which forms the basis of factors applied to all commute trips from the census journey to work data is shown in Figure C.2. Note that the commute trip peak is used in developing factors (i.e. for cyclists the peak occurs at 0700-0800, this value is assumed to be representative of trips arriving in the city centre at 0800-0900. In factoring up commute trips to represent all trips, education and shopping/leisure trips were considered in more detail. This is due to the large proportion of active mode trips made for these purposes. Active mode education trips are particularly prevalent during the morning peak period. A detailed overview of these considerations is provided in Appendix D.

Figure C.2: Profile of commute trips by time of day (times represent trip start time)

Source: National Travel Survey (2016)

Table C.3: Active Modes – key metrics

City	Census JTW Data – Walk (across cordon)	Census JTW Data – Cycle (across cordon)	Walk JTW 8-9am (across cordon, average day)	Cycle JTW 8-9am (across cordon, average day)	Ratio Students to Workers	Growth (2011-2018)
Birmingham	3,736	1,620	567	210	0.151	5%
Manchester	8,098	2,789	1,229	362	0.004	5%
Newcastle	4,414	1,585	670	206	0.454	4%
Sheffield	4,555	998	691	130	0.214	5%
Leeds	6,773	1,406	1,028	182	0.139	6%
Bristol	14,050	5,853	2,132	760	0.238	8%
Liverpool	3,956	1,247	600	162	0.384	5%
Leicester	5,054	1,482	767	192	0.259	7%
Southampton	3,680	1,068	559	139	0.295	9%
Reading	4,021	814	610	106		7%
Preston	2,378	389	361	50	0.654	4%
Middlesbrough	1,290	249	196	32	0.449	2%
Coventry	2,362	439	358	57	0.694	16%
Huddersfield	1,214	107	184	15		5%
Telford	435	76	66	10		5%
Burnley	942	66	143	9	0.021	1%
Plymouth	3,329	314	505	41	0.680	4%
Swindon	1,876	456	285	59	0.059	6%
Exeter	3,368	622	511	81	0.225	16%
Norwich	6,297	1,880	956	244	0.116	6%

Utilisation Methodology

C.33 Transport network capacity remains relatively stable throughout the year. Conversely utilisation, in general and by mode, is subject to seasonal effects. In estimating utilisation for this study we have, where possible, attempted to understand utilisation on a typical weekday outside of school holidays. Utilisation in this study refers to trips ending in city centres between 0800 and 0900 only.

C.34 No single resource providing a complete view of utilisation, on a normal day, for all modes and trip purposes, at a national level exists. Therefore, our approach to understanding utilisation involved gathering data from multiple sources and sifting data for each mode to identify the most reliable datasets for each mode. Data sources include:

- Count information published and provided by local authority districts;
- DfT data tables for rail, light rail, bus and traffic counts;

- Highways England WebTRIS;
- 2011 Census journey to work data;
- National Travel Survey; and
- Office of Rail and Road station entries and exits.

C.35 Utilisation values represent 2018 values (current at the time of writing). Where data for 2018 is not available, the most recent data is used and scaled up to 2018 values using:

- DfT rail counts for national rail;
- Population growth from Centre for Cities (PUA) for road, metro/tram and active modes; and
- No growth is applied to bus utilisation due to long-term downward trends in bus use.

C.36 Data sources by mode are presented in the following text.

National Rail

C.37 DfT publishes detailed count information for passengers arriving by rail in large cities. Where this database aligns with the case study cities it is used as the sole source of national rail utilisation data. These data were also used to factor the Office of Rail and Road station entries and exits data from annual counts to a single morning peak hour in order to provide rail utilisation metrics for the remaining case study cities.

Tram / metro

C.38 The majority of case study cities containing a tram/metro system provided utilisation counts during the inception phase of the study. Where available these counts were used as the sole source of utilisation data. These counts were also used to factor the light rail statistics published by DfT from annual counts to a single morning peak hour to provide a value for tram systems where local counts were not available.

Bus

C.39 Bus utilisation data is commercially sensitive and generally not held by local authority districts. DfT data tables published for this mode provide annual counts at the local authority level only, which do not necessarily bear resemblance to inbound trips into the city centre. For this reason, bus utilisation was determined based on Census journey to work data, factored using the National Travel Survey, similar to the approach to estimating active mode trips.

C.40 It should be noted that, while generally the transport network experiences a morning peak between 0800 and 0900, bus utilisation follows a different trend. Concessionary fares for eligible older and disabled people provide free local bus travel from 0930. For this reason, bus use in a city is generally observed to peak after 0930, after the morning commute peak. Lower bus utilisation in the 0800 to 0900 period is therefore expected.

Private vehicle utilisation

C.41 Many local authority districts collect cordon count data around their city centres on a regular (e.g. annual/biannual) basis. Where available this data has been used to understand total trips into city centres. City centre cordons defied by Local Authority Districts are not identical to those defined for this study, however they were generally found to cover similar extents.

C.42 Where local data was not available, Census Journey to Work data was used to inform our estimates of private vehicle utilisation using an approach similar to that used for estimating active mode trips.

DfT traffic counts

C.43 The Department for Transport maintains a database of traffic counts on A and B roads across Great Britain. This database is useful for understanding traffic volumes on specific roads, but is not sufficiently complete to provide a full view of road utilisation in any of the case-study cities. DfT traffic counts have, therefore, been used to calibrate our approach to the estimation of road capacity.

Congestion index

C.44 Based on in-vehicle GPS data, INRIX compiles a congestion index for each road. Whilst this is not a direct measure of utilisation, it is reasonable to expect that all other things being equal, roads with a higher level of utilisation would have a higher level of congestion, and vice-versa. As such, we have used the INRIX congestion index as a point of comparison to sense check the relative levels of road utilisation in each city.

D Census Journey to Work Data Manipulation

D.1 Census journey to work origin-destination data is used as the basis for our estimates of the number of people travelling into each cordon by active modes, private vehicle and bus. This data is based on the 2011 census, and provides an origin-destination matrix of journeys to work from home location to work location. These locations are disaggregated into Middle Super Outputs Areas (MSOAs), and are split by mode of travel. However, as this data is only available at MSOA level, and as discussed in Appendix A, the boundaries of the cordons do not match those of MSOAs. A number of adjustments have therefore been made to the MSOA level origin-destination data, as described below.

D.2 The first step of this process for each city centre cordon was to split all MSOAs across the country into three categories:

a. MSOAs falling entirely outside the cordon;
b. MSOAs straddling the cordon boundary; and
c. MSOAs falling entirely within the cordon.

D.3 Based on the classification, all journeys to work starting from a home location in a MSOA in category (a) going to a work location in an MSOA in category (c) were considered to be in-scope. This is because they represent journeys starting from outside the cordon and finishing inside it.

D.4 The next step was to deal with the MSOAs in category (b), which straddle the boundary of the cordon. We initially considered apportioning the journeys to work starting and/or ending in these MSOAs based on the proportion of each of these MSOAs that fall within the cordon as opposed to outside the cordon. However, this approach was discounted, as it is unlikely that there is a uniform spatial distribution of residents and jobs in these MSOAs. In general, the portions of these MSOAs within these cordons would be expected to have higher employment densities than the portions outside the cordon. Conversely, the portions of these MSOAs within these cordons would be expected to have lower residential densities than the portions outside the cordon.

D.5 As such, we turned to Journey to Work data relating to more fine-grained census geographies, namely Output Areas (OAs) and Workplace Zones (WZs). These smaller areas map to MSOAs.

D.6 However, the disadvantage of using these smaller areas is that journey to work OD data is not available for them. Rather, for each OA there is data on the number of residents living in that area who commute to work by each mode (but not where their workplaces are located).

Similarly, for each WZ there is data on the number of employees working in that area who commute to work by each mode (but not where their homes are located).

D.7 Therefore, for each MSOA straddling the cordon, the following process was followed. First, adjustment factors were calculated as follows:

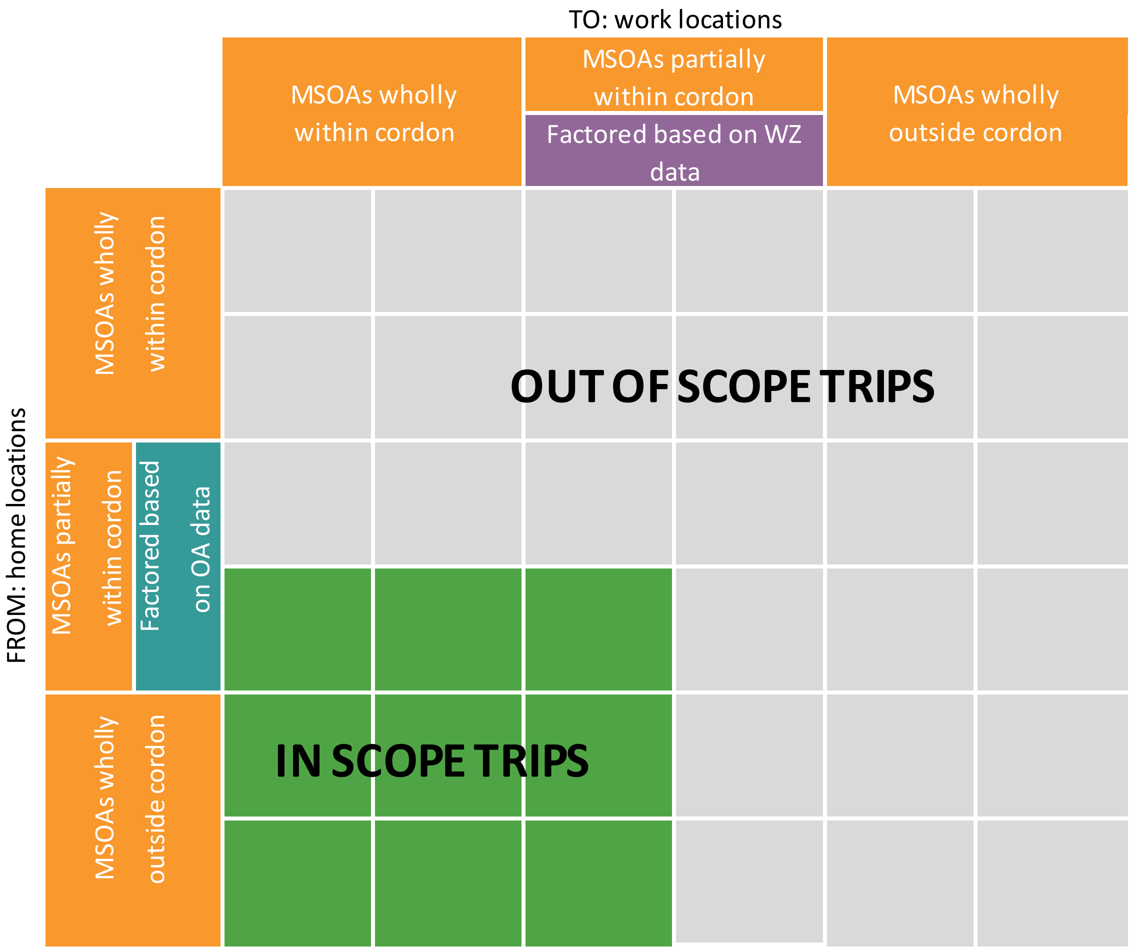
- The sum of all journey to work trips starting in OAs that are outside the cordon (but within an MSOA straddling the cordon boundary) was calculated
- The sum of all journey to work trips starting in OAs that are inside the cordon (but within an MSOA straddling the cordon boundary) was calculated
- Journey to work trips starting in OAs that straddle the cordon boundary were added to the above two categories, based on the proportion of the area of each of these OAs falling outside and inside the cordon respectively

D.8 The numbers above were then used to factor the journey to work trips starting at home locations in these MSOAs, and this process was completed separately for each mode.

D.9 A similar process was then followed for the WZs in each MSOA straddling the cordon, except that the factors were applied to journey to work trips ending at work locations in these MSOAs.

D.10 This process is summarised diagrammatically below.

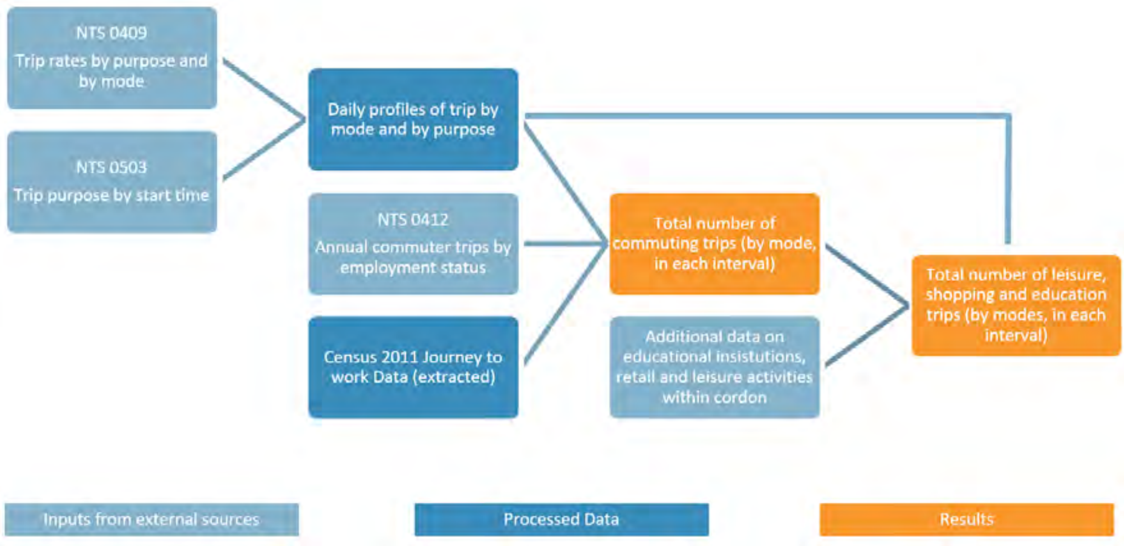
Figure D.1: Diagrammatic summary of in scope and out of scope trips based on census journey to work data



D.11 The outputs of this process provide an estimate of the number of people commuting from a home location outside each cordon to a work location inside each cordon, by mode.

D.12 The analytical methodology of factoring Journey to Work data is summarised below.

Figure D.2: Methodology for estimation of current active modes networks capacity



Commuting trips

D.13 National Travel Survey data includes information on trip purpose by mode and start time. We derived the percentage of trips made in each time interval, by mode and purpose. The diurnal profile of commute trips is shown below.

Figure D.1: Diurnal profile of commute trips

Source: NTS

D.14 Data on average annual trips by employment status (NTS0412) was used to factor into the estimate different travel patterns based on work arrangements (part-time workers, home-workers etc.).

D.15 Combining this analysis with the data extracted from the Census Journey to Work data, we were able to estimate the total number of commuting trips made within each of the two intervals on an average weekday by active mode, for all cities.

Shopping and leisure trips

D.16 A comparative analysis of the daily profiles of different trip purposes enabled us to estimate the number of shopping and leisure trips as a proportion of commuting trips. As each travel purpose has distinct daily profile, different ratios between leisure and shopping trips and commuting trips have been used to capture the relative variability of the two purposes in the two investigated intervals.

D.17 Given that NTS statistics are based on average national data, a coefficient based on the density of leisure and retail activities within the cordon has been applied to the estimated number of trips, in order to take into account the character of each city centre.

Education trips

D.18 A different methodology was used to estimate the number of trips related to education (including education escort trips). The daily profile of education trips was determined using NTS data, using an approach similar to the other travel purposes. This profile was then applied to the number of students enrolled in education institutions located inside the cordon or in the immediate proximity, which was determined from Ofsted data.

D.19 An attendance factor, based on the level of education (i.e. nursery, primary, secondary, further/university) was also applied, to take into account trips that are not made every day due to absence, part time studies, etc.

Bus trips

D.20 The education and shopping/leisure analyses described above are specific to the area within the defined city centre cordons. However, the availability of bus capacity may depend on the utilisation of trips to activities outside the city centre, e.g. a large university just outside the city centre could mean buses are fully occupied right up to the cordon but not across it. For this reason, the city centre-specific shopping/leisure and education analysis is not applied to bus user calculations. These are developed on a simplified basis:

$$Bus\ Users_{8-9am} = \frac{Census\ JTW}{2} \times pCommute_{8-9am} \times mPurpose_{8-9am}$$

Where:

- $Census\ JTW$ is equivalent the journey to work number extracted for other modes;
- $pCommute_{8-9am}$is the proportion of all commute trips by bus that happen during the morning peak hour (NTS); and
- $mPurpose_{8-9am}$ is a multiplier that factors up the number of commute trips to represent all trips undertaken by bus between 8 and 9am.

E Extrapolation of Results to Additional Cities

Scaling results across a wider range of cities

E.1 While 20 case-study cities are used to develop the core results of this study, the wider project and subsequent recommendations as part of the National Infrastructure Assessment are representative of all English cities. We have used the ONS Area Classifications[18] to categorise cities and inform the application of capacity and cost trends across 34 additional cities.

E.2 Area classifications place each of the 391 UK local authority districts into different groups (clusters) based on their 2011 Census characteristics – using census results covering demographic, household, housing, socio-economic and employment topics, with similar local authorities grouped together. This allows local authorities across the UK to be compared and classified. Area Classifications are applied to local authorities in three tiers:

- Supergroups, the highest tier e.g. ‘Affluent England’;
- Groups, the middle tier e.g. ‘University Towns and Cities’; and
- Subgroups, the lowest tier e.g. ‘Mining Legacy’.

E.3 We have matched each of the additional cities to one of the 20 in-scope cities based on the lowest possible tier of Area Classification. We have assumed that a similar package of interventions are appropriate for areas in the same groups, as they are likely to have similar trip-making characteristics.

E.4 Cordons have been defined for each of the additional cities, and shared with team undertaking parallel studies as part of the wider project. Capacities and expansion costs are scaled up by the relative difference in workplace population within the city centre cordons. Utilisation is assumed to be equivalent to the percentages reported for the relevant in-scope city(s).

E.5 City ‘pairs’ and factors used for scaling, scaled UTCM results and scaled cost results are presented in the following tables.

[18] **https://www.ons.gov.uk/methodology/geography/geographicalproducts/areaclassifications/2011areaclassifications**

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	City	Supergroup name	Group name	Subgroup name	Matched to	BUASD Workplace Population (2011)	Scaling Factor (applied consistently to all modes except Tram)	Notes
Case-study cities	Birmingham	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living		484,990		
	Manchester	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities		309,185		
	Newcastle	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		160,886		
	Sheffield	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		251,445		
	Leeds	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		288,356		
	Bristol	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		274,466		
	Liverpool	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		261,559		
	Leicester	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living		209,744		
	Southampton	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		119,615		
	Reading	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities		115,191		
	Preston	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		61,682		
	Middlesbrough	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic		74,602		
	Coventry	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		154,746		
	Huddersfield	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic		73,373		
	Telford	Urban Settlements	Manufacturing Traits	Urban Living		73,286		
	Burnley	Urban Settlements	Manufacturing Traits	Urban Living		34,714		
	Plymouth	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		115,847		
	Swindon	Urban Settlements	Suburban Traits	Expanding Areas		93,875		
	Exeter	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		81,625		
	Norwich	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities		109,979		
Additional Cities	Nottingham	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities	Manchester	171,732	0.56	
	Portsmouth	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities	Southampton	117,385	0.98	
	Bradford	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Huddersfield	148,895	2.03	
	Bournemouth	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities	Southampton	81,590	0.68	
	Stoke	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Middlesbrough	119,315	1.60	
	Southend	Urban Settlements	Manufacturing Traits	Urban Living	Burnley	72,411	2.09	
	Brighton	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities	Reading	119,247	1.04	
	Wakefield	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Manufacturing Legacy	Huddersfield	61,163	0.83	Manufacturing theme used
	Wigan	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Manufacturing Legacy	Preston	48,466	0.79	Manufacturing theme used
	Birkenhead	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Service Economy	Liverpool	54,932	0.21	Matched to Liverpool due to proximity
	Doncaster	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Manufacturing Legacy	Sheffield	71,169	0.28	Manufacturing theme used
	Chatham	Urban Settlements	Suburban Traits	City Periphery	Swindon	24,979	0.27	
	Sunderland	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Mining Legacy	Middlesbrough	76,594	1.03	Manufacturing theme used
	Milton Keynes	Urban Settlements	Suburban Traits	Expanding Areas	Swindon	108,952	1.16	
	Hull	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Middlesbrough	132,453	1.78	
	Derby	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Middlesbrough	124,591	1.67	
	Barnsley	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Manufacturing Legacy	Huddersfield	44,676	0.61	Manufacturing theme used
	Mansfield	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Manufacturing Legacy	Huddersfield	34,729	0.47	Manufacturing theme used
	Northampton	Urban Settlements	Suburban Traits	Expanding Areas	Swindon	118,244	1.26	
	Blackpool	Services and Industrial Legacy	Services, Manufacturing and Mining Legacy	Service Economy	Huddersfield	71,214	0.97	Judgement applied, tram utilisation based on Birmingham (single line network)
	Luton	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Leicester	94,891	0.45	
	Warrington	Town and Country Living	Town Living	Prosperous Towns	Swindon	97,339	1.04	Judgement applied
	York	Business, Education and Heritage Centres	Larger Towns and Cities	Larger Towns and Cities	Exeter	87,964	1.08	
	Peterborough	Urban Settlements	Suburban Traits	Expanding Areas	Swindon	93,507	1.00	
	Aldershot	Urban Settlements	Suburban Traits	Expanding Areas	Swindon	21,877	0.23	
	Basildon	Urban Settlements	Suburban Traits	City Periphery	Swindon	61,040	0.65	
	Oxford	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities	Exeter	102,648	1.26	Matched to Exeter due to historic nature
	Slough	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Ethnically Diverse Metropolitan Living	Leicester	73,048	0.35	
	Blackburn	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Middlesbrough	53,927	0.72	
	Ipswich	Urban Settlements	Manufacturing Traits	Industrial and Multi-ethnic	Middlesbrough	74,473	1.00	
	Cambridge	Business, Education and Heritage Centres	University Towns and Cities	University Towns and Cities	Exeter	107,863	1.32	Matched to Exeter due to historic nature
	Gloucester	Urban Settlements	Manufacturing Traits	Urban Living	Burnley	72,338	2.08	
	Crawley	Urban Settlements	Suburban Traits	Expanding Areas	Swindon	78,265	0.83	
	Worthing	Urban Settlements	Manufacturing Traits	Urban Living	Burnley	50,604	1.46	

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UTCM Results

		Morning Peak Hour (8-9am)													
									Utilisation (%)						
	City	Road	National Rail	Metro/Tram	Bus	Walking	Cycling	TOTAL	Road	National Rail	Metro/Tram	Bus	Walking	Cycling	TOTAL (Excl Walking
Case-study cities	Birmingham	32,000	33,000	3,000	35,000	3,000	300	**106,000**	83%	63%	37%	46%	N/A	N/A	63%
	Manchester	27,000	27,000	15,000	30,000	5,000	600	**105,000**	77%	58%	57%	51%	N/A	N/A	61%
	Newcastle	25,000	6,000	22,000	23,000	5,000	300	**81,000**	49%	36%	27%	52%	N/A	N/A	42%
	Sheffield	23,000	7,000	6,000	17,000	4,000	200	**57,000**	40%	48%	36%	46%	N/A	N/A	43%
	Leeds	18,000	19,000	0	23,000	5,000	300	**66,000**	85%	80%		63%	N/A	N/A	75%
	Bristol	21,000	7,000	0	16,000	13,000	1,200	**58,000**	68%	58%		61%	N/A	N/A	64%
	Liverpool	29,000	24,000	0	22,000	4,000	300	**80,000**	54%	45%		31%	N/A	N/A	44%
	Leicester	23,000	6,000	0	16,000	5,000	300	**50,000**	50%	40%		54%	N/A	N/A	50%
	Southampton	14,000	8,000	0	9,000	4,000	200	**34,000**	47%	32%		43%	N/A	N/A	42%
	Reading	9,000	18,000	0	11,000	3,000	200	**41,000**	49%	45%		33%	N/A	N/A	42%
	Preston	12,000	8,000	0	10,000	3,000	100	**34,000**	44%	31%		26%	N/A	N/A	34%
	Middlesbrough	14,000	2,000	0	6,000	2,000	0	**24,000**	29%	28%		31%	N/A	N/A	30%
	Coventry	11,000	7,000	0	10,000	4,000	100	**33,000**	50%	35%		46%	N/A	N/A	45%
	Huddersfield	6,000	6,000	0	8,000	1,000	0	**21,000**	44%	34%		25%	N/A	N/A	33%
	Telford	8,000	2,000	0	3,000	0	0	**13,000**	32%	25%		21%	N/A	N/A	28%
	Burnley	12,000	2,000	0	4,000	1,000	0	**18,000**	22%	11%		20%	N/A	N/A	21%
	Plymouth	14,000	2,000	0	10,000	5,000	100	**31,000**	23%	37%		35%	N/A	N/A	29%
	Swindon	13,000	7,000	0	6,000	1,000	100	**27,000**	24%	19%		36%	N/A	N/A	26%
	Exeter	11,000	4,000	0	5,000	3,000	100	**23,000**	34%	55%		41%	N/A	N/A	40%
	Norwich	10,000	3,000	0	9,000	5,000	400	**28,000**	83%	46%		51%	N/A	N/A	64%
Additional Cities	Nottingham	15,000	15,000	8,000	17,000	2,800	300	**58,000**	77%	58%	57%	51%	N/A	N/A	61%
	Portsmouth	14,000	8,000	0	9,000	3,900	200	**35,000**	47%	32%		43%	N/A	N/A	42%
	Bradford	12,000	12,000	0	16,000	2,000	0	**43,000**	44%	34%		25%	N/A	N/A	33%
	Bournemouth	10,000	5,000	0	6,000	2,700	100	**24,000**	47%	32%		43%	N/A	N/A	42%
	Stoke	22,000	3,000	0	10,000	3,200	0	**38,000**	29%	28%		31%	N/A	N/A	30%
	Southend	25,000	4,000	0	8,000	2,100	0	**40,000**	22%	11%		20%	N/A	N/A	21%
	Brighton	9,000	19,000	0	11,000	3,100	200	**43,000**	49%	45%		33%	N/A	N/A	42%
	Wakefield	5,000	5,000	0	7,000	800	0	**18,000**	44%	34%		25%	N/A	N/A	33%
	Wigan	9,000	6,000	0	8,000	2,400	100	**26,000**	44%	31%		26%	N/A	N/A	34%
	Birkenhead	6,000	5,000	0	5,000	800	100	**17,000**	54%	45%		31%	N/A	N/A	44%
	Doncaster	7,000	2,000	0	5,000	1,100	100	**14,000**	40%	48%		46%	N/A	N/A	43%
	Chatham	3,000	2,000	0	2,000	300	0	**7,000**	24%	19%		36%	N/A	N/A	26%
	Sunderland	14,000	2,000	0	6,000	2,100	0	**25,000**	29%	28%		31%	N/A	N/A	30%
	Milton Keynes	15,000	8,000	0	7,000	1,200	100	**31,000**	24%	19%		36%	N/A	N/A	26%
	Hull	25,000	4,000	0	11,000	3,600	0	**43,000**	29%	28%		31%	N/A	N/A	30%
	Derby	23,000	3,000	0	10,000	3,300	0	**40,000**	29%	28%		31%	N/A	N/A	30%
	Barnsley	4,000	4,000	0	5,000	600	0	**13,000**	44%	34%		25%	N/A	N/A	33%
	Mansfield	3,000	3,000	0	4,000	500	0	**10,000**	44%	34%		25%	N/A	N/A	33%
	Northampton	16,000	9,000	0	8,000	1,300	100	**34,000**	24%	19%		36%	N/A	N/A	26%
	Blackpool	6,000	6,000	1,000	8,000	1,000	0	**22,000**	44%	34%	37%	25%	N/A	N/A	33%
	Luton	10,000	3,000	0	7,000	2,300	100	**23,000**	50%	40%		54%	N/A	N/A	50%
	Warrington	13,000	7,000	0	6,000	1,000	100	**28,000**	24%	19%		36%	N/A	N/A	26%
	York	12,000	4,000	0	5,000	3,200	100	**25,000**	34%	55%		41%	N/A	N/A	40%
	Peterborough	13,000	7,000	0	6,000	1,000	100	**27,000**	24%	19%		36%	N/A	N/A	26%
	Aldershot	3,000	2,000	0	1,000	200	0	**6,000**	24%	19%		36%	N/A	N/A	26%
	Basildon	8,000	5,000	0	4,000	700	100	**18,000**	24%	19%		36%	N/A	N/A	26%
	Oxford	14,000	5,000	0	6,000	3,800	100	**29,000**	34%	55%		41%	N/A	N/A	40%
	Slough	8,000	2,000	0	6,000	1,700	100	**18,000**	50%	40%		54%	N/A	N/A	50%
	Blackburn	10,000	1,000	0	4,000	1,400	0	**17,000**	29%	28%		31%	N/A	N/A	30%
	Ipswich	14,000	2,000	0	6,000	2,000	0	**24,000**	29%	28%		31%	N/A	N/A	30%
	Cambridge	15,000	5,000	0	7,000	4,000	100	**31,000**	34%	55%		41%	N/A	N/A	40%
	Gloucester	25,000	4,000	0	8,000	2,100	0	**40,000**	22%	11%		20%	N/A	N/A	21%
	Crawley	11,000	6,000	0	5,000	800	100	**23,000**	24%	19%		36%	N/A	N/A	26%
	Worthing	17,000	3,000	0	6,000	1,500	0	**28,000**	22%	11%		20%	N/A	N/A	21%

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Scaled Costs

					CAPEX (£m, 2018 prices)					PVC (£m, 2010 prices)				
Orig	Match pa	City	City Siz	SCALE FACT	5%	10%	20%	10%PT	10%AT	5%	10%	20%	10%PT	10%AT
Y	A	Birmingham	L		460	2,440	7,150	2,420	1,520	490	2,540	6,630	2,510	1,590
Y	B	Manchester	L		450	2,430	7,130	2,410	1,510	490	2,530	6,610	2,520	1,590
Y	C	Newcastle	L		340	1,950	5,510	2,280	1,380	340	1,930	5,030	2,280	1,400
Y	D	Sheffield	L		330	1,940	5,480	1,920	1,360	310	1,870	4,960	1,850	1,340
Y	E	Leeds	L		300	1,940	5,480	1,920	1,360	400	1,990	5,070	1,950	1,410
Y	F	Bristol	L		300	1,930	5,470	1,910	1,360	370	1,950	5,030	1,950	1,400
Y	G	Liverpool	L		310	1,950	5,500	2,280	1,380	370	1,940	5,040	2,260	1,390
Y	H	Leicester	L		290	1,930	5,460	1,910	1,350	320	1,860	4,950	1,850	1,340
Y	I	Southampton	M		160	720	1,840	740	280	160	670	1,660	820	360
Y	J	Reading	M		140	710	1,840	740	270	160	670	1,670	830	360
Y	K	Preston	M		140	710	1,830	740	260	140	650	1,640	800	330
Y	L	Middlesbrough	M		140	700	1,810	440	260	130	630	1,610	460	300
Y	M	Coventry	M		140	710	1,830	740	260	150	660	1,650	830	350
Y	N	Huddersfield	M		140	690	1,800	430	250	130	620	1,590	450	290
Y	O	Telford	S		130	210	610	190	150	110	200	640	200	180
Y	P	Burnley	S		130	210	620	200	160	110	200	660	200	180
Y	Q	Plymouth	S		140	220	860	210	160	130	260	1,010	260	220
Y	R	Swindon	S		140	210	860	210	160	120	230	930	230	200
Y	S	Exeter	S		140	210	860	200	160	130	250	990	240	210
Y	T	Norwich	S		140	210	860	210	160	150	300	1,110	300	240
N	B	Nottingham	L	0.56	290	1,930	5,460	1,910	1,350	310	1,860	4,950	1,850	1,340
N	I	Portsmouth	L	0.98	290	1,930	5,460	1,910	1,350	310	1,860	4,950	1,850	1,340
N	N	Bradford	L	2.03	290	1,930	5,460	1,910	1,350	310	1,860	4,950	1,850	1,340
N	I	Bournemouth	M	0.68	140	690	1,800	505	250	130	620	1,590	559	290
N	L	Stoke	M	1.60	224	1,120	2,895	704	416	208	1,008	2,575	736	480
N	P	Southend	M	2.09	271	690	1,800	430	334	229	620	1,590	450	375
N	J	Brighton	M	1.04	145	735	1,905	766	280	166	694	1,729	859	373
N	N	Wakefield	M	0.83	140	690	1,800	430	250	130	620	1,590	450	290
N	K	Wigan	M	0.79	140	690	1,800	581	250	130	620	1,590	629	290
N	G	Birkenhead	M	0.21	140	690	1,800	479	290	130	620	1,590	475	292
N	D	Doncaster	M	0.28	140	690	1,800	543	385	130	620	1,590	524	379
N	R	Chatham	S	0.27	130	210	610	190	150	110	200	640	200	180
N	L	Sunderland	S	1.03	144	719	1,858	452	267	133	647	1,653	472	308
N	R	Milton Keynes	S	1.16	162	244	998	244	186	139	267	1,079	267	232
N	L	Hull	S	1.78	249	1,243	3,214	781	462	231	1,119	2,858	817	533
N	L	Derby	S	1.67	234	1,169	3,023	735	434	217	1,052	2,689	768	501
N	n	Barnsley	S	0.61	130	420	1,096	262	152	110	378	968	274	180
N	n	Mansfield	S	0.47	130	327	852	204	150	110	293	753	213	180
N	R	Northampton	S	1.26	176	265	1,083	265	202	151	290	1,171	290	252
N	N	Blackpool	S	0.97	136	670	1,747	417	243	126	602	1,543	437	281
N	H	Luton	S	0.45	131	873	2,470	864	611	145	841	2,239	837	606
N	R	Warrington	S	1.04	145	218	892	218	166	124	238	964	238	207
N	S	York	S	1.08	151	226	927	216	172	140	269	1,067	259	226
N	R	Peterborough	S	1.00	139	210	857	209	159	120	229	926	229	199
N	R	Aldershot	S	0.23	130	210	610	190	150	110	200	640	200	180
N	R	Basildon	S	0.65	130	210	610	190	150	110	200	640	200	180
N	S	Oxford	S	1.26	176	264	1,081	252	201	163	314	1,245	302	264
N	H	Slough	S	0.35	130	672	1,902	665	470	111	648	1,724	644	467
N	L	Blackburn	S	0.72	130	506	1,308	318	188	110	455	1,164	333	217
N	L	Ipswich	S	1.00	140	699	1,807	439	260	130	629	1,607	459	299
N	S	Cambridge	S	1.32	185	278	1,136	264	211	172	330	1,308	317	278
N	P	Gloucester	S	2.08	271	438	1,292	417	333	229	417	1,375	417	375
N	R	Crawley	S	0.83	130	210	717	190	150	110	200	775	200	180
N	P	Worthing	S	1.46	190	306	904	292	233	160	292	962	292	262

F City Specific Transport Capacity Uplift Scenarios

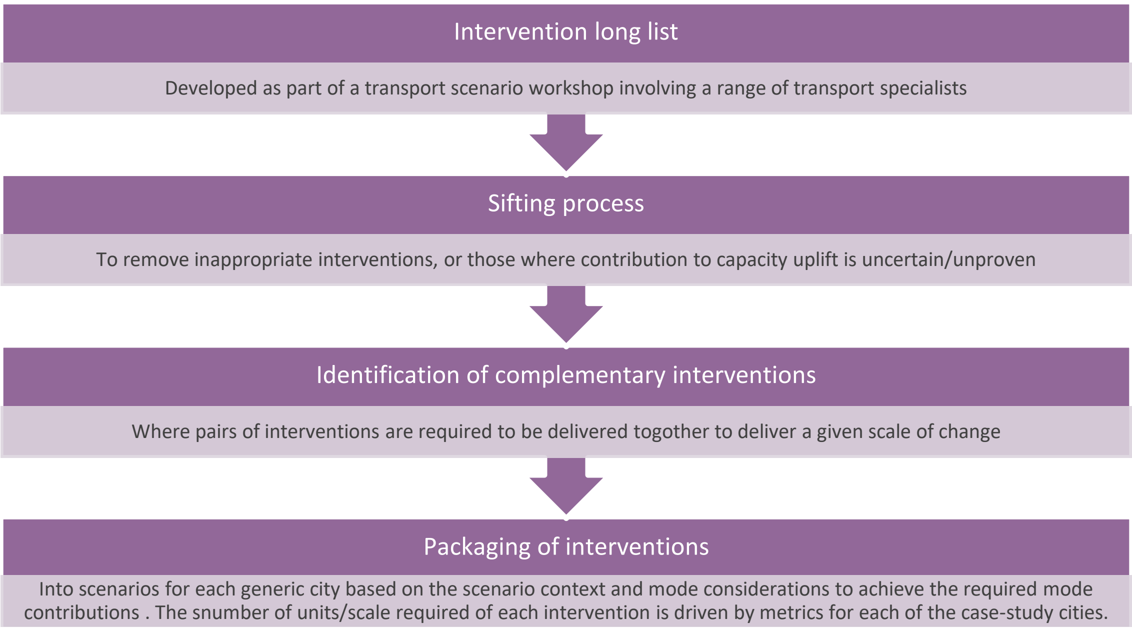
Selection and Packaging of Interventions

F.1 Packages of interventions were developed on a generic city basis for each scenario, as set out in the main body of the report. Packages were drawn from an initial long-list of interventions (see following table). The long list of interventions includes over 50 items, categorised as:

- More efficient/intensive use of existing infrastructure;
- Reallocating space on existing infrastructure to more space efficient modes (high occupancy vehicle lanes, bus lanes, bus rapid transit, cycle lanes, etc.);
- Addressing bottlenecks (optimisation and coordination of traffic signals, increasing railway terminal capacity, etc.);
- Expanding existing infrastructure links (additional lanes, additional railway tracks, etc.);
- New infrastructure (footways, cycleways, busways, roads, etc.); and
- Removing non-passenger trips (i.e. freight trips) from the morning peak hour.

F.2 Due to the overlapping and complementary nature of many of the interventions on the long list, final packages were developed based on the core interventions required to deliver the bulk of capacity (e.g. additional light rail vehicles) with complementary interventions incorporated into the packages where necessitated by scale (e.g. new light rail lines).

Figure F.1: Intervention Identification and Packaging Process



F.3 While this study considers potential interventions to achieve a range of transport capacity uplifts, it is not suggested that the implied interventions are required, or justified, in each individual town/city. Specific plans and programmes for individual towns/cities should be developed at a local level, taking into account local context and need, as well as consideration of affordability and value for money. This approach is intentionally generic to allow scaling of results across all English cities.

City Specific Scenarios

F.4 The following tables set out the additional units required to achieve the capacity uplift in each scenario on a city-by-city basis.

Table F.1: Capacity Uplift in 5% Scenario

	Mode Share of Uplift				Unit Uplift						
City	Road	Rail	Metro/Tram	Bus	Road (Lane Equivalents)	Rail (Carriages)	Tram (LRV)	Bus (Vehicles)	Tram-Lines (10tph)	Bus-Lanes (10bph)	Trains
Birmingham	0.10	0.25	0.25	0.40	1	14	5	26			
Manchester	0.10	0.25	0.25	0.40	1	13	5	26			
Newcastle	0.10	0.25	0.25	0.40	1	11	2	22			
Sheffield	0.10	0.25	0.25	0.40	1	8	3	15			
Leeds	0.10	0.25	0.00	0.65	1	8	0	27			
Bristol	0.10	0.25	0.00	0.65	1	8	0	23			
Liverpool	0.10	0.25	0.00	0.65	1	10	0	34			
Leicester	0.10	0.25	0.00	0.65	1	7	0	21			
Southampton	0.40	0.15	0.00	0.45	2	3	0	11			
Reading	0.40	0.15	0.00	0.45	1	3	0	12			
Preston	0.40	0.15	0.00	0.45	1	3	0	11			
Middlesbrough	0.40	0.15	0.00	0.45	1	2	0	9			
Coventry	0.40	0.15	0.00	0.45	1	3	0	10			
Huddersfield	0.40	0.15	0.00	0.45	1	2	0	7			
Telford	0.40	0.10	0.00	0.50	1	1	0	6			
Burnley	0.40	0.10	0.00	0.50	1	1	0	7			
Plymouth	0.40	0.10	0.00	0.50	1	2	0	11			
Swindon	0.40	0.10	0.00	0.50	1	2	0	11			
Exeter	0.40	0.10	0.00	0.50	1	2	0	8			
Norwich	0.40	0.10	0.00	0.50	1	2	0	9			

Table F.2: Capacity Uplift in 10% Scenario

	Mode Share of Uplift				Unit Uplift						
City	Road	Rail	Metro/Tram	Bus	Road (Lane Equivalents))	Rail (Carriages)	Tram (LRV)	Bus (Vehicles)	Tram-Lines (10tph)	Bus-Lanes (10bph)	Trains
Birmingham	0.05	0.25	0.25	0.45	1	28	10	57	1	6	6
Manchester	0.05	0.25	0.25	0.45	1	25	10	59	1	6	7
Newcastle	0.05	0.25	0.25	0.45	1	21	4	49	1	5	5
Sheffield	0.05	0.25	0.25	0.45	1	16	6	34	1	3	5
Leeds	0.05	0.25	0.25	0.45	1	16	6	37	1	4	5
Bristol	0.05	0.25	0.25	0.45	1	15	6	32	1	3	4
Liverpool	0.05	0.25	0.25	0.45	1	20	4	46	1	5	5
Leicester	0.05	0.25	0.25	0.45	1	13	5	30	1	3	3
Southampton	0.20	0.20	0.40	0.20	2	7	5	10	1	1	2
Reading	0.20	0.20	0.40	0.20	1	8	6	11	1	1	2
Preston	0.20	0.20	0.40	0.20	1	7	5	10	1	1	2
Middlesbrough	0.20	0.20	0.40	0.20	1	5	4	8	1	1	3
Coventry	0.20	0.20	0.40	0.20	1	7	5	9	1	1	2
Huddersfield	0.20	0.20	0.40	0.20	1	4	3	6	1	1	2
Telford	0.20	0.10	0.00	0.70	1	2	0	15	0	2	1
Burnley	0.20	0.10	0.00	0.70	1	2	0	18	0	2	1
Plymouth	0.20	0.10	0.00	0.70	1	4	0	29	0	3	2
Swindon	0.20	0.10	0.00	0.70	1	3	0	29	0	3	1
Exeter	0.20	0.10	0.00	0.70	1	3	0	23	0	2	1
Norwich	0.20	0.10	0.00	0.70	1	3	0	24	0	2	1

Table F.3: Capacity Uplift in 20% Scenario

	Mode Share of Uplift				Unit Uplift						
City	Road	Rail	Metro/Tram	Bus	Road (Lane Equivalents)	Rail (Carriages)	Tram (LRV)	Bus (Vehicles)	Tram-Lines (10tph)	Bus-Lanes (10bph)	Trains
Birmingham	0.03	0.25	0.50	0.23	1	55	38	57	4	6	0.03
Manchester	0.03	0.25	0.50	0.23	1	50	38	59	4	6	0.03
Newcastle	0.03	0.25	0.50	0.23	1	41	15	49	2	5	0.03
Sheffield	0.03	0.25	0.50	0.23	1	31	24	34	3	3	0.03
Leeds	0.03	0.25	0.50	0.23	1	32	24	37	3	4	0.03
Bristol	0.03	0.25	0.50	0.23	1	29	21	32	3	3	0.03
Liverpool	0.03	0.25	0.50	0.23	1	39	13	46	3	5	0.03
Leicester	0.03	0.25	0.50	0.23	1	26	18	30	3	3	0.03
Southampton	0.10	0.30	0.50	0.10	2	19	13	10	2	1	0.10
Reading	0.10	0.30	0.50	0.10	1	24	15	11	2	1	0.10
Preston	0.10	0.30	0.50	0.10	1	20	13	10	2	1	0.10
Middlesbrough	0.10	0.30	0.50	0.10	1	15	9	8	2	1	0.10
Coventry	0.10	0.30	0.50	0.10	1	20	12	9	2	1	0.10
Huddersfield	0.10	0.30	0.50	0.10	1	12	8	6	2	1	0.10
Telford	0.10	0.10	0.00	0.80	1	3	0	33	0	3	0.10
Burnley	0.10	0.10	0.00	0.80	1	4	0	41	0	4	0.10
Plymouth	0.10	0.10	0.00	0.80	1	7	0	66	0	7	0.10
Swindon	0.10	0.10	0.00	0.80	1	6	0	65	0	7	0.10
Exeter	0.10	0.10	0.00	0.80	1	6	0	51	0	5	0.10
Norwich	0.10	0.10	0.00	0.80	1	6	0	55	0	6	0.10

Table F.4: Capacity Uplift in 10% PT Scenario

	Mode Share of Uplift				Unit Uplift						
City	Road	Rail	Metro/Tram	Bus	Road (Lane Equivalents)	Rail (Carriages)	Tram (LRV)	Bus (Vehicles)	Tram-Lines (10tph)	Bus-Lanes (10bph)	Trains
Birmingham	0.00	0.25	0.25	0.50	0.0	28	10	64	1	6	0.00
Manchester	0.00	0.25	0.25	0.50	0.0	25	10	65	1	7	0.00
Newcastle	0.00	0.25	0.25	0.50	0.0	21	4	54	1	5	0.00
Sheffield	0.00	0.25	0.25	0.50	0.0	16	6	38	1	4	0.00
Leeds	0.00	0.25	0.25	0.50	0.0	16	6	41	1	4	0.00
Bristol	0.00	0.25	0.25	0.50	0.0	15	6	35	1	4	0.00
Liverpool	0.00	0.25	0.25	0.50	0.0	20	4	51	1	5	0.00
Leicester	0.00	0.25	0.25	0.50	0.0	13	5	33	1	3	0.00
Southampton	0.10	0.20	0.00	0.70	0.6	7	0	35	0	4	0.10
Reading	0.10	0.20	0.00	0.70	0.5	8	0	37	0	4	0.10
Preston	0.10	0.20	0.00	0.70	0.5	7	0	33	0	3	0.10
Middlesbrough	0.10	0.20	0.00	0.70	0.3	5	0	26	0	3	0.10
Coventry	0.10	0.20	0.00	0.70	0.4	7	0	30	0	3	0.10
Huddersfield	0.10	0.20	0.00	0.70	0.4	4	0	21	0	2	0.10
Telford	0.10	0.10	0.00	0.80	0.1	2	0	17	0	2	0.10
Burnley	0.10	0.10	0.00	0.80	0.2	2	0	21	0	2	0.10
Plymouth	0.10	0.10	0.00	0.80	0.4	4	0	33	0	3	0.10
Swindon	0.10	0.10	0.00	0.80	0.4	3	0	33	0	3	0.10
Exeter	0.10	0.10	0.00	0.80	0.3	3	0	26	0	3	0.10
Norwich	0.10	0.10	0.00	0.80	0.5	3	0	28	0	3	0.10

Table F.5: Capacity Uplift in 10% AT Scenario

	Mode Share of Uplift				Unit Uplift						
City	Road	Rail	Metro/Tram	Bus	Road (Lane Equivalents)	Rail (Carriages)	Tram (LRV)	Bus (Vehicles)	Tram-Lines (10tph)	Bus-Lanes (10bph)	Trains
Birmingham	0.05	0.25	0.25	0.26	1	28	10	33	1	3	6
Manchester	0.05	0.25	0.25	0.26	1	25	10	34	1	3	7
Newcastle	0.05	0.25	0.25	0.26	1	21	4	28	1	3	5
Sheffield	0.05	0.25	0.25	0.26	1	16	6	20	1	2	5
Leeds	0.05	0.25	0.25	0.26	1	16	6	22	1	2	5
Bristol	0.05	0.25	0.25	0.26	1	15	6	19	1	2	4
Liverpool	0.05	0.25	0.25	0.26	1	20	4	27	1	3	5
Leicester	0.05	0.25	0.25	0.26	1	13	5	17	1	2	3
Southampton	0.20	0.20	0.00	0.43	2	7	0	21	0	2	2
Reading	0.20	0.20	0.00	0.43	1	8	0	23	0	2	2
Preston	0.20	0.20	0.00	0.43	1	7	0	20	0	2	2
Middlesbrough	0.20	0.20	0.00	0.43	1	5	0	16	0	2	3
Coventry	0.20	0.20	0.00	0.43	1	7	0	19	0	2	2
Huddersfield	0.20	0.20	0.00	0.43	1	4	0	13	0	1	2
Telford	0.20	0.10	0.00	0.44	1	2	0	9	0	1	1
Burnley	0.20	0.10	0.00	0.44	1	2	0	12	0	1	1
Plymouth	0.20	0.10	0.00	0.44	1	4	0	18	0	2	2
Swindon	0.20	0.10	0.00	0.44	1	3	0	18	0	2	1
Exeter	0.20	0.10	0.00	0.44	1	3	0	14	0	1	1
Norwich	0.20	0.10	0.00	0.44	1	3	0	15	0	2	1

G Cost Estimate Assumptions and Unit Rates

Cost Estimate Assumptions

G.1 Generic unit rates by intervention have been applied to all cities to develop cost estimates. In practice, costs will vary by location due to a range of factors, including:

- Ease/difficulty of implementation;
- Material and transport costs;
- Term contract rates; and
- Impact on the existing, operational transport network.

G.2 Cost estimates are order of magnitude estimates only. For this reason, unit rates are high level and have not been developed using a detailed bill of quantities. Unit rates draw from a range of sources including information provided by Local Authority Districts during the study inception phase, published outturn and projected costs for similar schemes, and project experience.

G.3 Unit rates are applied in the cost estimates to a range of different unit types:

- For rates applicable to number of vehicles/carriages (e.g. train carriage costs) the unit rate was applied to the number of vehicle units required to achieve the uplift on a per city basis. Vehicle units generally form the core capacity uplift intervention for a given mode.
- For rates applicable to a specified length, identical infrastructure length assumptions were applied by city size, see table below.
- Fixed costs were also developed for each mode in each scenario to account for complementary interventions required at a city unit level, e.g. the cost for a major reconstruction of the terminal national rail station.

Table G.1: Assumed Infrastructure Length requirements by City Size (km)

City Size	Road (per lane) (assumes only short lengths are provided at pinch-points)	Metro/Tram	Bus (cumulative length per city)
Large	2	12	12
Medium	2	10	8
Small	2	-	4

Risk

G.4 Values for risk are applied to the cost estimates as is standard practise within the industry. In lieu of a quantified risk assessment, risk proportions are based on optimism bias rates in the Department for Transport's Transport Analysis Guidance, set out in the table below.

Table G.2: Risk factors included in cost estimates

	Road	National Rail	Metro/Tram	Bus
Proportion	44%	66%	66%	66%

Planning and Design

G.5 All costs have been increased by 10% to account for planning and design costs.

Capital Cost Estimates

G.6 Capital cost estimates are made up of two core input types:

- Unit rates by number of vehicles/length of infrastructure; and
- Fixed cost estimates per city, per scenario which capture costs which do not vary linearly with the scale of capacity uplift and may include, for example, upgrading junction optimisation software.

G.7 Unit cost inputs are summarised in the table below.

Table G.3: Unit cost inputs included in cost estimates

Intervention	Unit	Low Cost Unit Cost £m /unit	Medium Cost Unit Cost £m /unit	High Cost Unit Cost £m /unit	Comments
Use longer trains	carriage	£2.0	£2.0	£2.0	Additional carriages only
Increase LRT frequency	LRV	£2.0	£3.0	£4.0	Only used in 5% scenario
Increase bus frequency	bus	£0.1	£0.2	£0.3	Additional buses only
Convert traffic lanes to bus lanes	lane km	£0.1	£0.1	£0.1	Assumes existing road space is available
New roads	km	£2.0	£4.0	£6.0	Addressing 'pinch points' only
New Light Rail Line	km	£20.0	£40.0	£100.0	Includes horizontal infrastructure, depot and vehicle costs
New Very Light Rail Line	km	£15.0	£30.0	£75.0	Includes horizontal infrastructure, depot and vehicle costs
New BRT Line	km	£8.0	£16.0	£40.0	Infrastructure only

G.8 Fixed cost inputs are presented in the table below.

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Fixed Costs (by Scenario) (£m)

5% Scenario

City Size	Road		National Rail		Metro/Tram		Bus		Walk/Cycle	
L	£ 5	Junction optimisation and improved user information	£ 130	Platform lengthening at city centre and at some intermediate stations, some resignalling	£ 10	Depot Expansion	£ 2	New city centre bus stop infrastructure	£ -	Assumed to be included within interventions for other modes
M	£ 3	Junction optimisation and improved user information	£ 60	Platform lengthening at city centre and at some intermediate stations, some resignalling	N/A		£ 1	New city centre bus stop infrastructure	£ -	Assumed to be included within interventions for other modes
S	£ 2	Junction optimisation and improved user information	£ 60	Platform lengthening at city centre and at some intermediate stations, some resignalling	N/A		£ 1	New city centre bus stop infrastructure	£ -	Assumed to be included within interventions for other modes

10% Scenario

City Size	Road		National Rail		Metro/Tram		Bus		Walk/Cycle	
L	£ 5	Junction optimisation and improved user information	£ 150	Additional (relative to 5% scenario) platform lengthening at city centre and at some intermediate stations, resignalling	£ -	New/Expanded Depot included in unit costs	£ 5	BRT implementation, branding, integrated ticketing etc	£ -	Assumed to be included within interventions for other modes
M	£ 3	Junction optimisation and improved user information	£ 60	See 5% Scenario	£ -	New/Expanded Depot included in unit costs	£ 1	New city centre bus stop infrastructure	£ -	Assumed to be included within interventions for other modes
S	£ 2	Junction optimisation and improved user information	£ 60	See 5% Scenario	N/A		£ 5	Additional city centre bus stop infrastructure and investment in integrated system	£ -	Assumed to be included within interventions for other modes

20% Scenario

City Size	Road		National Rail		Metro/Tram		Bus		Walk/Cycle	
L	£ 5	Junction optimisation and improved user information	£ 500	Major upgrade of terminus station including additional platforms[1]	£ 600	Tunelling of route under city centre	£ 5	BRT implementation, branding, integrated ticketing etc	£ -	Assumed to be included within interventions for other modes
M	£ 3	Junction optimisation and improved user information	£ 150	Additional (relative to 10% scenario) platform lengthening at city centre and at some intermediate stations, resignalling	£ -	New/Expanded Depot included in unit costs	£ 1	New city centre bus stop infrastructure	£ -	Assumed to be included within interventions for other modes
S	£ 2	Junction optimisation and improved user information	£ 60	Platform lengthening at city centre and at some intermediate stations, some resignalling	N/A		£ 5	BRT implementation, branding, integrated ticketing etc	£ -	Assumed to be included within interventions for other modes

10% PT

City Size	Road		National Rail		Metro/Tram		Bus		Walk/Cycle	
L	£ -	Junction optimisation and improved user information (50% of 10% scenario investment)	£ 150	See 10% Scenario	£ -	New/Expanded Depot included in unit costs	£ 5	BRT implementation, branding, integrated ticketing etc	£ -	Assumed to be included within interventions for other modes
M	£ 3	Junction optimisation and improved user information (50% of 10% scenario investment)	£ 60	See 10% Scenario	N/A		£ 5	BRT implementation, branding, integrated ticketing etc	£ -	Assumed to be included within interventions for other modes
S	£ 2	Junction optimisation and improved user information (50% of 10% scenario investment)	£ 60	See 10% Scenario	N/A		£ 5	Additional city centre bus stop infrastructure and investment in integrated system	£ -	Assumed to be included within interventions for other modes

10% AT

City Size	Road		National Rail		Metro/Tram		Bus		Walk/Cycle	
L	£ 5	See 10% Scenario	£ 150	See 10% Scenario	£ -	New/Expanded Depot included in unit costs	£ 2	New city centre bus stop infrastructure	£ 30	New active modes infrastructure/ network implementation
M	£ 3	See 10% Scenario	£ 60	See 10% Scenario	N/A		£ 5	BRT implementation, branding, integrated ticketing etc	£ 15	New active modes infrastructure/ network implementation
S	£ 2	See 10% Scenario	£ 60	See 10% Scenario	N/A		£ 1	New city centre bus stop infrastructure	£ 10	New active modes infrastructure/ network implementation

Notes

1 This cost could vary over a large range, assumed cost is only ~25% of Reading Station Redevelopment

Bus Fare Subsidy Calculation Methodology

G.9 Bus utilisation, outside of London, has faced long term downward trends. Therefore, any uplift in bus capacity will likely require additional incentives, such as subsidies, to ensure it is effective. Bus subsidies have been calculated assuming the uplift in demand is equivalent to the proportional uplift in bus capacity provided, using fare elasticities. Note, this methodology does not consider the impact of increased bus frequencies on demand.

G.10 The New Bus Demand for each of the 20 cities was calculated for the 5%, 10% and 20% uplift scenarios, using the following calculation:

$$New\ Bus\ Demand = (Total\ Mode\ Capacity\ x\ Total\ Mode\ Utilisation)\ x\ Uplift\ \%\ x\ Bus\ Mode\ Share\ of\ Uplift$$

G.11 The New Bus Fare needed to achieve this New Bus Demand for each city was then calculated by solving the following formula:

$$\left(\frac{Existing\ Bus\ Demand}{New\ Bus\ Demand}\right) = \left(\frac{Existing\ Bus\ Fare}{New\ Bus\ Fare}\right)^{\varepsilon}$$

G.12 Where ε = bus fare elasticity. A review of the literature on bus fare elasticities was carried out to identify a suitable value for ε. Dargay and Hanly's (1999) estimate of the long-run bus fare elasticity in Metropolitan areas (-0.43) was used as this was the most relevant and recent estimate[19].

G.13 The Existing Bus Fare used for the calculation was £1.32, the operating revenue per passenger journey on local bus services in English Metropolitan areas for 2016/17 (DfT Annual Bus Statistics, 2017)[20].

G.14 The subsidy required for each city was then found by calculating the revenue lost through the change in fares, using the following formula:

$$Subsidy = (Existing\ Bus\ Demand\ x\ Existing\ Bus\ Fare) - (Existing\ Bus\ Demand\ x\ New\ Bus\ Fare)$$

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[19] See Dargay, J. and Hanly, M. (1999), *Bus Fare Elasticities*. ESRC Transport Studies Unit, University College London**.**

[20] See Department for Transport Bus Statistics (2017), Table BUS0402a (Operating revenue per passenger journey (at current prices) on local bus services by metropolitan area status and country: Great Britain. (*link:* **https://www.gov.uk/government/statistical-data-sets/bus04-costs-fares-and-revenue**)

H Cost Model Assumptions

Economic Assumptions

H.1 The cost model follows guidance for a DfT WebTAG appraisal. Assumptions/factors include:

- Market price adjustment of 19% added to all capital investment.
- Opening year between 2018 and 2050 for all interventions.
- Appraisal period of 60 years from opening.
- Discount rate of 3.5% for years 0 to 30 and 3.0% thereafter, in line with the Treasury Green Book and Departmental guidance.
- All discounted costs and benefits have been converted to 2010 prices and values, in line with DfT guidance.
- Capital expenditure is inflated in line with a tender price index[21], all other costs and revenue follow RPI.

OPEX and Maintenance

H.2 Operating, maintenance and renewals costs have been estimated based on the following assumptions:

- Heavy maintenance and renewals costs are equivalent to a proportion of the capital cost, included in the model as an annual equivalent value. In reality these will be incurred periodically, not annually.
- Operating expenditure is calculated by mode on a per journey basis for the new journeys in each scenario. No operational or annual light maintenance is considered for roads due to the incremental nature assumed for road interventions relative to the do-minimum.

H.3 Operational expenditure and maintenance assumptions are included in the following tables.

Table H.1: Operational expenditure assumptions

Mode	OPEX	Unit	Price base	Source
National Rail	£5.72	£ / pax / peak hour	2016/17	ORR[22]
Bus	£1.39	£ / pax / peak hour	2016/17	DfT[23]
Tram / Metro	£0.34	£ / pax / peak hour	2016/17	DfT[24]

21 http://www.costmodelling.com/construction-indices

22 http://orr.gov.uk/__data/assets/file/0017/26441/uk-rail-industry-financial-information-2016-17.ods

23 https://www.gov.uk/government/statistical-data-sets/bus04-costs-fares-and-revenue

Table H.1: Heavy maintenance expenditure assumptions

Mode	Renewals/ Heavy Maintenance as a % of CAPEX	Cost recurrence assumption (years)
Road	2.0%	1
National Rail	0.5%	1
Metro/Tram	1.0%	1
Bus	2.0%	1

Fares and Subsidies

H.4 Revenue estimates have been calculated using the fares set out in Table H.2 below.

Table H.2: Fares used in the cost model

Mode	Fare
Rail	£3.77
Metro / Tram	£1.44
Bus	£1.32
Walking	£0.00
Cycling	£0.00

These fares were used to calculate the amount of bus subsidy required in each scenario and for each city, shown in Table H.3 below.

Table H.3: Subsidies per journey used in the cost model

City	5%	10%	20%	10% PT	10% AT
Birmingham	£0.23	£0.44	£0.44	£0.48	£0.29
Bristol	£0.35	£0.45	£0.45	£0.48	£0.29
Burnley	£0.37	£0.74	£1.04	£0.79	£0.55
Coventry	£0.22	£0.20	£0.20	£0.54	£0.37
Exeter	£0.34	£0.69	£1.01	£0.75	£0.51
Huddersfield	£0.23	£0.21	£0.21	£0.56	£0.39
Leeds	£0.29	£0.38	£0.38	£0.41	£0.24
Leicester	£0.27	£0.36	£0.36	£0.39	£0.23
Liverpool	£0.42	£0.53	£0.53	£0.57	£0.35
Manchester	£0.23	£0.45	£0.45	£0.48	£0.29
Middlesbrough	£0.27	£0.24	£0.24	£0.63	£0.45
Newcastle	£0.17	£0.35	£0.35	£0.38	£0.22
Norwich	£0.28	£0.60	£0.92	£0.65	£0.43
Plymouth	£0.24	£0.54	£0.86	£0.59	£0.38
Preston	£0.30	£0.27	£0.27	£0.68	£0.49
Reading	£0.31	£0.28	£0.28	£0.69	£0.50
Sheffield	£0.19	£0.38	£0.38	£0.41	£0.24

City	5%	10%	20%	10% PT	10% AT
Southampton	£0.26	£0.24	£0.24	£0.62	£0.44
Swindon	£0.24	£0.54	£0.87	£0.59	£0.38
Telford	£0.36	£0.73	£1.04	£0.78	£0.55
Total	£5.56	£8.59	£10.50	£11.45	£0.00

Cost Profiles by Scenario

H.5 The cost profiles for each scenario and each city are presented below.

Figure H.1: Cost profiles – 5% Scenario (£000, 2018 Prices)

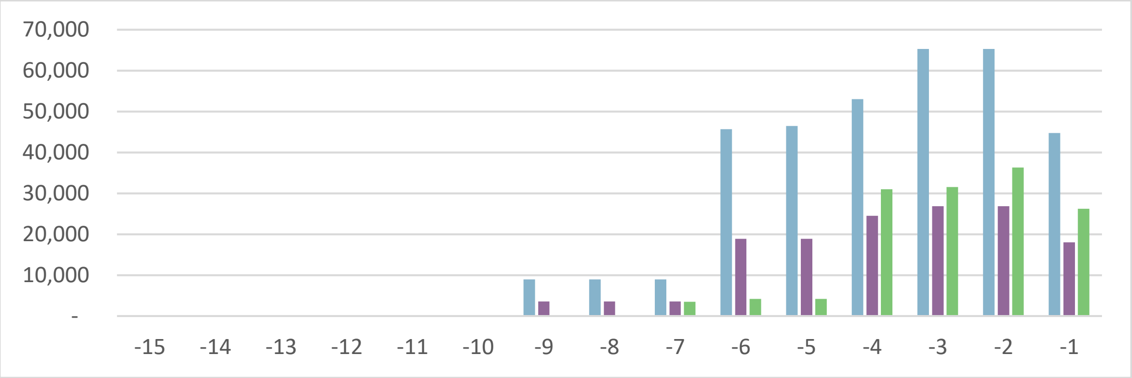


Figure H.2: Cost Profiles – 10% Scenario (£000, 2018 Prices)

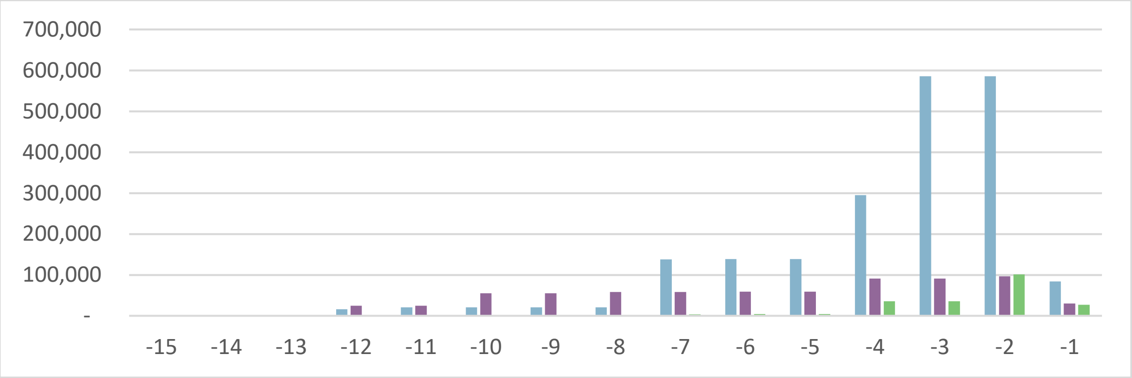
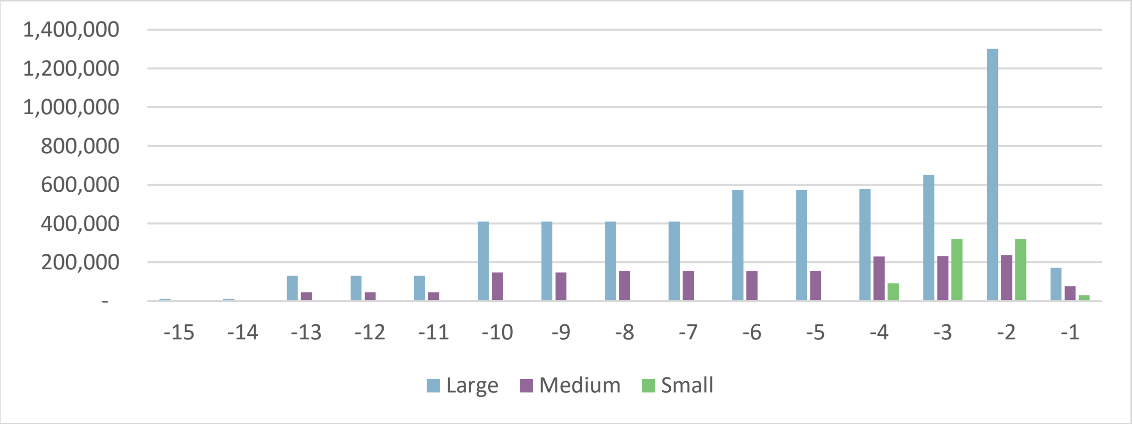


Figure H.3: Cost Profiles – 20% Scenario (£000, 2018 Prices)



I Cost Estimates

I.1 Cost estimate results by city and scenario are provided in the following tables. Costs represent both capital costs and all costs included in the cost model.

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E: 2 OK

National Infrastructure Commission
NIC Urban Transport Network Capacity
NIC Urban Transport Capacity_Cost model timeline V0.2.xlsx

Outputs

Notes:
Subsidies calculated for two peak hours per weekday only
OPEX represents difference between current and uplift in rail/tram/bus in each scenario
Revenue represents difference between current and uplift in rail/tram/bus in each scenario across entire year

5%		Present Value (PV) Costs (2010 Price Base) (£m)						CAPEX (Undiscounted) (Excl maintenance) (£m)		Annual Costs (Revenue Spending) (2018 Price Base) (£m)			Renewals (2018 Price Base) (£m)
	City	PV CAPEX	PV OPEX/ Light	PV Renewals/ Heavy Maintenance	PV Farebox Revenue	PV Subsidies	PVC	CAPEX (2018 Price Base)	CAPEX Nominal	OPEX	Farebox Revenue	Subsidies	Renewals
1	Birmingham	£300	£300	£50	£190	£27	£490	£460	£790	£15.5	£13.5	£1.9	£2.7
10	Manchester	£300	£290	£50	£180	£26	£490	£450	£780	£15.0	£13.1	£1.9	£2.7
12	Newcastle	£220	£170	£40	£110	£15	£340	£340	£580	£8.5	£7.6	£1.1	£2.1
17	Sheffield	£220	£120	£40	£80	£11	£310	£330	£570	£6.1	£5.4	£0.8	£2.1
7	Leeds	£200	£260	£40	£130	£32	£400	£300	£520	£13.5	£9.4	£2.3	£1.8
2	Bristol	£200	£220	£40	£110	£26	£370	£300	£510	£11.3	£7.6	£1.8	£1.8
9	Liverpool	£210	£200	£40	£90	£22	£370	£310	£530	£10.1	£6.5	£1.6	£1.9
8	Leicester	£200	£140	£30	£70	£18	£320	£290	£510	£7.4	£5.2	£1.2	£1.8
18	Southampton	£100	£60	£20	£30	£8	£160	£160	£270	£3.0	£2.1	£0.5	£1.2
16	Reading	£100	£70	£20	£30	£8	£160	£140	£250	£3.4	£2.3	£0.6	£1.0
15	Preston	£100	£50	£20	£20	£6	£140	£140	£250	£2.3	£1.6	£0.4	£1.0
11	Middlesbrough	£90	£30	£20	£10	£4	£130	£140	£240	£1.5	£1.1	£0.3	£1.0
4	Coventry	£100	£60	£20	£30	£8	£150	£140	£250	£2.9	£2.1	£0.5	£1.0
6	Huddersfield	£90	£30	£20	£10	£3	£130	£140	£240	£1.3	£1.0	£0.2	£0.9
20	Telford	£90	£10	£20	£10	£2	£110	£130	£240	£0.6	£0.4	£0.1	£0.9
3	Burnley	£90	£10	£20	£10	£2	£110	£130	£240	£0.8	£0.5	£0.2	£0.9
14	Plymouth	£90	£40	£20	£20	£6	£130	£140	£250	£2.0	£1.5	£0.4	£0.9
19	Swindon	£90	£20	£20	£10	£4	£120	£140	£250	£1.2	£0.9	£0.3	£0.9
5	Exeter	£90	£30	£20	£20	£5	£130	£140	£240	£1.8	£1.2	£0.4	£0.9
13	Norwich	£90	£60	£20	£30	£10	£150	£140	£240	£3.1	£2.3	£0.7	£0.9
							£4,710						

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10%		Present Value (PV) Costs (2010 Price Base) (£m)						CAPEX (Undiscounted) (Excl maintenance) (£m)		Annual Costs (Revenue Spending) (2018 Price Base) (£m)			Renewals (2018 Price Base) (£m)
	City	PV CAPEX	PV OPEX/ Light	PV Renewals/ Heavy Maintenance	PV Farebox Revenue	PV Subsidies	PVC	CAPEX (2018 Price Base)	CAPEX Nominal	OPEX	Farebox Revenue	Subsidies	Renewals/ Heavy Maintenance
1	Birmingham	£1,610	£630	£580	£330	£55	£2,540	£2,440	£4,230	£32.4	£23.5	£3.9	£29.8
10	Manchester	£1,600	£610	£580	£320	£53	£2,530	£2,430	£4,210	£31.5	£22.8	£3.8	£29.8
12	Newcastle	£1,300	£350	£440	£190	£32	£1,930	£1,950	£3,370	£17.9	£13.5	£2.3	£22.8
17	Sheffield	£1,290	£250	£440	£130	£23	£1,870	£1,940	£3,340	£12.8	£9.5	£1.6	£22.8
7	Leeds	£1,290	£470	£440	£250	£42	£1,990	£1,940	£3,340	£24.1	£17.9	£3.0	£22.8
2	Bristol	£1,290	£390	£440	£210	£34	£1,950	£1,930	£3,330	£20.2	£14.6	£2.4	£22.7
9	Liverpool	£1,300	£350	£440	£180	£29	£1,940	£1,950	£3,360	£18.0	£12.6	£2.1	£22.8
8	Leicester	£1,280	£260	£440	£140	£23	£1,860	£1,930	£3,320	£13.2	£9.9	£1.7	£22.7
18	Southampton	£500	£110	£120	£70	£7	£670	£720	£1,170	£5.7	£5.0	£0.5	£6.3
16	Reading	£500	£130	£120	£80	£8	£670	£710	£1,160	£6.5	£5.6	£0.5	£6.0
15	Preston	£500	£90	£120	£60	£5	£650	£710	£1,150	£4.5	£3.9	£0.4	£6.0
11	Middlesbrough	£490	£60	£120	£40	£3	£630	£700	£1,140	£2.9	£2.5	£0.2	£6.0
4	Coventry	£500	£110	£120	£70	£7	£660	£710	£1,150	£5.6	£4.9	£0.5	£6.0
6	Huddersfield	£490	£50	£120	£30	£3	£620	£690	£1,130	£2.6	£2.3	£0.2	£5.9
20	Telford	£130	£30	£40	£10	£4	£200	£210	£370	£1.5	£0.7	£0.3	£2.1
3	Burnley	£130	£40	£40	£10	£5	£200	£210	£370	£1.9	£0.9	£0.4	£2.2
14	Plymouth	£140	£100	£40	£40	£15	£260	£220	£390	£5.1	£3.0	£1.1	£2.3
19	Swindon	£140	£60	£40	£30	£9	£230	£210	£380	£3.2	£1.8	£0.7	£2.3
5	Exeter	£140	£90	£40	£30	£12	£250	£210	£380	£4.6	£2.3	£0.9	£2.2
13	Norwich	£140	£160	£40	£60	£23	£300	£210	£380	£8.0	£4.4	£1.6	£2.2
		£14,760					£21,950						

20%		Present Value (PV) Costs (2010 Price Base) (£m)						CAPEX (Undiscounted) (Excl maintenance) (£m)		Annual Costs (Revenue Spending) (2018 Price Base) (£m)			Renewals (2018 Price Base) (£m)
	City	PV CAPEX	PV OPEX/ Light	PV Renewals/ Heavy Maintenance	PV Farebox Revenue	PV Subsidies	PVC	CAPEX (2018 Price Base)	CAPEX Nominal	OPEX	Farebox Revenue	Subsidies	Renewals
1	Birmingham	£4,980	£1,080	£1,320	£810	£55	£6,630	£7,150	£11,780	£55.4	£57.1	£3.9	£68.2
10	Manchester	£4,970	£1,050	£1,320	£780	£53	£6,610	£7,130	£11,750	£53.9	£55.4	£3.8	£68.1
12	Newcastle	£3,850	£590	£1,010	£450	£32	£5,030	£5,510	£9,050	£30.6	£32.0	£2.3	£51.9
17	Sheffield	£3,830	£420	£1,010	£320	£23	£4,960	£5,480	£8,990	£21.9	£22.8	£1.6	£51.8
7	Leeds	£3,830	£800	£1,010	£600	£42	£5,070	£5,480	£8,990	£41.1	£42.8	£3.0	£51.8
2	Bristol	£3,820	£670	£1,000	£500	£34	£5,030	£5,470	£8,980	£34.5	£35.5	£2.4	£51.8
9	Liverpool	£3,850	£600	£1,010	£440	£29	£5,040	£5,500	£9,040	£30.7	£31.2	£2.1	£51.9
8	Leicester	£3,820	£440	£1,000	£330	£23	£4,950	£5,460	£8,960	£22.6	£23.6	£1.7	£51.7
18	Southampton	£1,290	£270	£300	£200	£7	£1,660	£1,840	£2,990	£13.7	£14.5	£0.5	£15.5
16	Reading	£1,300	£300	£300	£230	£8	£1,670	£1,840	£3,000	£15.5	£16.3	£0.5	£15.3
15	Preston	£1,290	£210	£300	£160	£5	£1,640	£1,830	£2,970	£10.8	£11.3	£0.4	£15.3
11	Middlesbrough	£1,280	£130	£290	£100	£3	£1,610	£1,810	£2,940	£6.9	£7.3	£0.2	£15.2
4	Coventry	£1,290	£260	£300	£200	£7	£1,650	£1,830	£2,970	£13.4	£14.1	£0.5	£15.3
6	Huddersfield	£1,270	£120	£290	£90	£3	£1,590	£1,800	£2,920	£6.2	£6.5	£0.2	£15.1
20	Telford	£390	£70	£180	£10	£7	£640	£610	£1,090	£3.4	£1.0	£0.5	£9.5
3	Burnley	£400	£80	£180	£20	£9	£660	£620	£1,090	£4.3	£1.3	£0.6	£9.5
14	Plymouth	£550	£220	£270	£60	£28	£1,010	£860	£1,530	£11.4	£4.5	£2.0	£13.8
19	Swindon	£550	£140	£270	£40	£17	£930	£860	£1,520	£7.1	£2.8	£1.2	£13.8
5	Exeter	£550	£200	£270	£40	£21	£990	£860	£1,520	£10.1	£3.2	£1.5	£13.8
13	Norwich	£550	£340	£270	£90	£41	£1,110	£860	£1,520	£17.8	£6.4	£2.9	£13.8
		£43,660					£58,480						

10% PT		Present Value (PV) Costs (2010 Price Base) (£m)						CAPEX (Undiscounted) (Excl maintenance) (£m)		Annual Costs (Revenue Spending) (2018 Price Base) (£m)			Renewals (2018 Price Base) (£m)
	City	PV CAPEX	PV OPEX/ Light	PV Renewals/ Heavy Maintenance	PV Farebox Revenue	PV Subsidies	PVC	CAPEX (2018 Price Base)	CAPEX Nominal	OPEX	Farebox Revenue	Subsidies	Renewals
1	Birmingham	£1,600	£660	£570	£380	£60	£2,510	£2,420	£4,190	£33.9	£26.6	£4.3	£29.4
10	Manchester	£1,590	£640	£570	£340	£58	£2,520	£2,410	£4,170	£33.0	£24.3	£4.1	£29.4
12	Newcastle	£1,510	£360	£560	£190	£35	£2,280	£2,280	£3,960	£18.7	£13.7	£2.5	£28.8
17	Sheffield	£1,270	£260	£430	£140	£25	£1,850	£1,920	£3,300	£13.4	£9.9	£1.7	£22.4
7	Leeds	£1,270	£490	£430	£290	£46	£1,950	£1,920	£3,300	£25.2	£20.5	£3.3	£22.4
2	Bristol	£1,270	£410	£430	£200	£37	£1,950	£1,910	£3,300	£21.1	£14.5	£2.6	£22.4
9	Liverpool	£1,510	£370	£560	£210	£32	£2,260	£2,280	£3,950	£18.8	£14.7	£2.2	£28.8
8	Leicester	£1,270	£270	£430	£150	£26	£1,850	£1,910	£3,280	£13.8	£10.5	£1.8	£22.3
18	Southampton	£480	£170	£230	£70	£20	£820	£740	£1,310	£8.7	£5.0	£1.4	£11.6
16	Reading	£480	£190	£230	£90	£21	£830	£740	£1,310	£9.8	£6.4	£1.5	£11.6
15	Preston	£480	£130	£230	£50	£15	£800	£740	£1,310	£6.8	£3.6	£1.0	£11.6
11	Middlesbrough	£280	£80	£120	£40	£10	£460	£440	£770	£4.4	£2.9	£0.7	£6.2
4	Coventry	£480	£160	£220	£60	£20	£830	£740	£1,300	£8.5	£4.2	£1.4	£11.6
6	Huddersfield	£280	£80	£120	£40	£9	£450	£430	£770	£3.9	£2.5	£0.6	£6.2
20	Telford	£130	£30	£40	£0	£4	£200	£190	£350	£1.7	£0.2	£0.3	£2.0
3	Burnley	£130	£40	£40	£20	£5	£200	£200	£350	£2.1	£1.2	£0.4	£2.0
14	Plymouth	£140	£110	£40	£40	£17	£260	£210	£380	£5.7	£2.9	£1.2	£2.2
19	Swindon	£130	£70	£40	£20	£10	£230	£210	£370	£3.5	£1.6	£0.7	£2.1
5	Exeter	£130	£100	£40	£40	£13	£240	£200	£360	£5.1	£2.9	£0.9	£2.1
13	Norwich	£130	£170	£40	£70	£25	£300	£210	£370	£8.9	£4.9	£1.8	£2.1
		£14,560					£22,790						

10% AT		Present Value (PV) Costs (2010 Price Base) (£m)						CAPEX (Undiscounted) (Excl maintenance) (£m)		Annual Costs (Revenue Spending) (2018 Price Base) (£m)			Renewals (2018 Price Base) (£m)
#	City	PV CAPEX	PV OPEX/ Light	PV Renewals/ Heavy Maintenance	PV Farebox Revenue	PV Subsidies	PVC	CAPEX (2018 Price Base)	CAPEX Nominal	OPEX	Farebox Revenue	Subsidies	Renewals
1	Birmingham	£1,020	£620	£250	£330	£34	£1,590	£1,520	£2,590	£31.7	£23.3	£2.4	£13.0
10	Manchester	£1,010	£600	£250	£310	£33	£1,590	£1,510	£2,570	£30.9	£21.8	£2.4	£13.0
12	Newcastle	£930	£380	£240	£180	£20	£1,400	£1,380	£2,350	£19.7	£12.4	£1.4	£12.4
17	Sheffield	£920	£300	£240	£130	£14	£1,340	£1,360	£2,310	£15.5	£8.9	£1.0	£12.3
7	Leeds	£920	£480	£240	£250	£26	£1,410	£1,360	£2,310	£24.8	£17.6	£1.8	£12.3
2	Bristol	£910	£420	£240	£190	£21	£1,400	£1,360	£2,300	£21.6	£13.6	£1.5	£12.2
9	Liverpool	£930	£380	£240	£180	£19	£1,390	£1,380	£2,340	£19.8	£12.9	£1.3	£12.4
8	Leicester	£910	£310	£240	£130	£14	£1,340	£1,350	£2,290	£15.9	£9.4	£1.0	£12.2
18	Southampton	£180	£170	£60	£60	£13	£360	£280	£490	£8.6	£4.4	£0.9	£3.2
16	Reading	£170	£180	£60	£80	£14	£360	£270	£480	£9.5	£5.3	£1.0	£3.0
15	Preston	£170	£140	£60	£50	£10	£330	£260	£470	£7.2	£3.2	£0.7	£3.0
11	Middlesbrough	£160	£100	£60	£30	£7	£300	£260	£460	£5.3	£2.4	£0.5	£2.9
4	Coventry	£170	£160	£60	£60	£13	£350	£260	£470	£8.4	£3.9	£0.9	£3.0
6	Huddersfield	£160	£100	£60	£30	£6	£290	£250	£450	£5.0	£2.1	£0.4	£2.9
20	Telford	£100	£60	£20	£0	£3	£180	£150	£270	£3.1	£0.2	£0.2	£1.2
3	Burnley	£100	£70	£20	£10	£4	£180	£160	£270	£3.4	£0.9	£0.2	£1.2
14	Plymouth	£110	£110	£30	£30	£10	£220	£160	£290	£5.7	£2.2	£0.7	£1.3
19	Swindon	£100	£80	£30	£20	£6	£200	£160	£280	£4.3	£1.3	£0.4	£1.3
5	Exeter	£100	£100	£20	£30	£8	£210	£160	£280	£5.3	£2.1	£0.6	£1.3
13	Norwich	£100	£150	£20	£50	£15	£240	£160	£280	£7.7	£3.8	£1.1	£1.3
		£9,170					£14,680						

END

J Sensitivity Testing

J.1 Sensitivity test results by city and scenario are presented in the following tables.

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5% Scenario Sensitivity Tests (£m)

	Central Case	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	£460	£560	£360	£460	£460	£1,320
Manchester	£450	£550	£360	£450	£460	£1,310
Newcastle	£340	£410	£260	£340	£340	£1,200
Sheffield	£330	£400	£260	£330	£330	£1,180
Leeds	£300	£370	£230	£300	£310	£1,190
Bristol	£300	£360	£230	£300	£310	£1,180
Liverpool	£310	£380	£240	£310	£320	£1,200
Leicester	£290	£360	£230	£290	£300	£1,180
Southampton	£160	£200	£110	£160	£170	£210
Reading	£140	£180	£110	£140	£150	£210
Preston	£140	£180	£110	£140	£150	£210
Middlesbrough	£140	£170	£100	£140	£150	£210
Coventry	£140	£180	£110	£140	£150	£210
Huddersfield	£140	£170	£100	£140	£150	£210
Telford	£130	£170	£100	£130	£140	£140
Burnley	£130	£170	£100	£130	£140	£140
Plymouth	£140	£170	£100	£140	£150	£140
Swindon	£140	£170	£100	£140	£150	£140
Exeter	£140	£170	£100	£140	£140	£140
Norwich	£140	£170	£100	£140	£140	£140

5% Scenario Percentage Change Check

	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	22%	-22%	0%	0%	187%
Manchester	22%	-20%	0%	2%	191%
Newcastle	21%	-24%	0%	0%	253%
Sheffield	21%	-21%	0%	0%	258%
Leeds	23%	-23%	0%	3%	297%
Bristol	20%	-23%	0%	3%	293%
Liverpool	23%	-23%	0%	3%	287%
Leicester	24%	-21%	0%	3%	307%
Southampton	25%	-31%	0%	6%	31%
Reading	29%	-21%	0%	7%	50%
Preston	29%	-21%	0%	7%	50%
Middlesbrough	21%	-29%	0%	7%	50%
Coventry	29%	-21%	0%	7%	50%
Huddersfield	21%	-29%	0%	7%	50%
Telford	31%	-23%	0%	8%	8%
Burnley	31%	-23%	0%	8%	8%
Plymouth	21%	-29%	0%	7%	0%
Swindon	21%	-29%	0%	7%	0%
Exeter	21%	-29%	0%	0%	0%
Norwich	21%	-29%	0%	0%	0%

10% Scenario Sensitivity Tests (£m)

	Central Case	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	£2,440	£5,430	£1,370	£1,470	£2,930	£3,240
Manchester	£2,430	£5,420	£1,360	£1,460	£2,920	£3,230
Newcastle	£1,950	£4,400	£1,080	£1,170	£2,350	£2,830
Sheffield	£1,940	£4,380	£1,070	£1,150	£2,340	£2,790
Leeds	£1,940	£4,380	£1,070	£1,150	£2,340	£2,800
Bristol	£1,930	£4,370	£1,070	£1,140	£2,330	£2,790
Liverpool	£1,950	£4,390	£1,080	£1,160	£2,350	£1,950
Leicester	£1,930	£4,360	£1,060	£1,140	£2,330	£2,780
Southampton	£720	£1,580	£400	£440	£840	£860
Reading	£710	£1,570	£400	£440	£830	£860
Preston	£710	£1,560	£390	£430	£820	£860
Middlesbrough	£700	£1,560	£390	£420	£810	£850
Coventry	£710	£1,560	£390	£430	£820	£860
Huddersfield	£690	£1,550	£380	£420	£810	£850
Telford	£210	£270	£130	£180	£230	£540
Burnley	£210	£270	£130	£180	£230	£540
Plymouth	£220	£290	£140	£190	£240	£550
Swindon	£210	£280	£140	£180	£230	£540
Exeter	£210	£280	£140	£180	£230	£540
Norwich	£210	£280	£140	£180	£230	£540

10% Scenario Percentage Change Check

	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	123%	-44%	-40%	20%	33%
Manchester	123%	-44%	-40%	20%	33%
Newcastle	126%	-45%	-40%	21%	45%
Sheffield	126%	-45%	-41%	21%	44%
Leeds	126%	-45%	-41%	21%	44%
Bristol	126%	-45%	-41%	21%	45%
Liverpool	125%	-45%	-41%	21%	0%
Leicester	126%	-45%	-41%	21%	44%
Southampton	119%	-44%	-39%	17%	19%
Reading	121%	-44%	-38%	17%	21%
Preston	120%	-45%	-39%	15%	21%
Middlesbrough	123%	-44%	-40%	16%	21%
Coventry	120%	-45%	-39%	15%	21%
Huddersfield	125%	-45%	-39%	17%	23%
Telford	29%	-38%	-14%	10%	157%
Burnley	29%	-38%	-14%	10%	157%
Plymouth	32%	-36%	-14%	9%	150%
Swindon	33%	-33%	-14%	10%	157%
Exeter	33%	-33%	-14%	10%	157%
Norwich	33%	-33%	-14%	10%	157%

20% Scenario Sensitivity Tests (£m)

	Central Case	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	£7,150	£14,500	£4,350	£4,870	£8,300	£8,480
Manchester	£7,130	£14,480	£4,330	£4,860	£8,280	£8,470
Newcastle	£5,510	£10,940	£3,400	£3,850	£6,350	£6,130
Sheffield	£5,480	£10,900	£3,380	£3,810	£6,320	£6,100
Leeds	£5,480	£10,900	£3,380	£3,810	£6,320	£6,100
Bristol	£5,470	£10,890	£3,370	£3,800	£6,310	£6,090
Liverpool	£5,500	£10,930	£3,400	£3,840	£6,340	£5,250
Leicester	£5,460	£10,880	£3,360	£3,790	£6,300	£6,960
Southampton	£1,840	£4,110	£1,020	£1,110	£2,140	£2,910
Reading	£1,840	£4,110	£1,030	£1,110	£2,140	£2,930
Preston	£1,830	£4,100	£1,020	£1,100	£2,130	£2,920
Middlesbrough	£1,810	£4,080	£1,000	£1,080	£2,110	£2,900
Coventry	£1,830	£4,100	£1,020	£1,100	£2,130	£2,920
Huddersfield	£1,800	£4,060	£990	£1,070	£2,100	£2,890
Telford	£610	£1,350	£340	£380	£740	£780
Burnley	£620	£1,350	£350	£380	£740	£780
Plymouth	£860	£1,950	£470	£510	£1,040	£1,030
Swindon	£860	£1,940	£470	£510	£1,040	£1,020
Exeter	£860	£1,940	£470	£510	£1,040	£1,020
Norwich	£860	£1,940	£470	£510	£1,040	£1,020

20% Scenario Percentage Change Check

	High Unit Costs	Low Unit Costs	Compact Development	Dispersed Development	Scale of transformation
Birmingham	103%	-39%	-32%	16%	19%
Manchester	103%	-39%	-32%	16%	19%
Newcastle	99%	-38%	-30%	15%	11%
Sheffield	99%	-38%	-30%	15%	11%
Leeds	99%	-38%	-30%	15%	11%
Bristol	99%	-38%	-31%	15%	11%
Liverpool	99%	-38%	-30%	15%	-5%
Leicester	99%	-38%	-31%	15%	27%
Southampton	123%	-45%	-40%	16%	58%
Reading	123%	-44%	-40%	16%	59%
Preston	124%	-44%	-40%	16%	60%
Middlesbrough	125%	-45%	-40%	17%	60%
Coventry	124%	-44%	-40%	16%	60%
Huddersfield	126%	-45%	-41%	17%	61%
Telford	121%	-44%	-38%	21%	28%
Burnley	118%	-44%	-39%	19%	26%
Plymouth	127%	-45%	-41%	21%	20%
Swindon	126%	-45%	-41%	21%	19%
Exeter	126%	-45%	-41%	21%	19%
Norwich	126%	-45%	-41%	21%	19%

CONTROL INFORMATION

Prepared by	Prepared for
Steer Davies Gleave 28-32 Upper Ground London SE1 9PD +44 20 7910 5000 www.steerdaviesgleave.com	National Infrastructure Commission 11 Philpot Lane 14/04/2018 London EC3M 8UD United Kingdom

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Author/originator	Reviewer/approver
Courtney Groundwater	Jake Cartmell and Neil Chadwick

Other contributors	Distribution
Andrew Montgomery, Steve Oliver, David Sutanto, Matteo Novati, Tony Walmsley, David Mack, Chloe Cook, Mariana Ruiz Worth	*Client:* Greg McClymont *SDG*: Project Team

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Our offices

Bogotá, Colombia
+57 1 322 1470
colombiainfo@sdgworld.net

Bologna, Italy
+39 051 656 9381
italyinfo@sdgworld.net

Boston, USA
+1 (617) 391 2300
usainfo@sdgworld.net

Leeds, England
+44 113 389 6400
UKInfo@sdgworld.net

London, England
+44 20 7910 5000
UKInfo@sdgworld.net

Los Angeles, USA
+1 (213) 337 6790
usainfo@sdgworld.net

Madrid, Spain
+34 91 541 8696
spaininfo@sdgworld.net

Manchester, England
+44 161 261 9140
UKInfo@sdgworld.net

Mexico City, Mexico
+52 (55) 5615 0041
mexicoinfo@sdgworld.net

New Delhi, India
+91 124 441 8650
Indiainfo@sdgworld.net

New York, USA
+1 (617) 391 2300
usainfo@sdgworld.net

Rome, Italy
+39 06 4201 6169
italyinfo@sdgworld.net

San Juan, Puerto Rico
+1 (787) 721 2002
puertoricoinfo@sdgworld.net

Santiago, Chile
+56 2 2757 2600
chileinfo@sdgworld.net

São Paulo, Brazil
+55 (11) 3151 3630
brasilinfo@sdgworld.net

Toronto, Canada
+1 (647) 260 4860
canadainfo@sdgworld.net

Vancouver, Canada
+1 (604) 629 2610
canadainfo@sdgworld.net

Washington DC, USA
+1 (703) 788-6500
usainfo@sdgworld.net

steer davies gleave

Technical Note

To	National Infrastructure Commission		
From	Steer Davies Gleave	Version: 3.0	
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Marginal External Cost and Active Modes Benefits Calculations

Introduction

1. This technical note complements the analysis in our report 'Urban Transport Analysis: Capacity and Cost' and work undertaken by other organisations delivering parallel workstreams.

2. This note describes the methodology used to calculate the marginal external cost and active mode benefits associated with increasing employment in city centres (relative to a counterfactual scenario), and presents high-level results from the analysis.

3. All analysis is driven by high and low city centre employment growth estimates provided by the National Infrastructure Commission. Results are presented as a 2050 single year benefit in 2018 prices. No discounting is applied to the reported benefits.

4. This technical note is structured as follows:

- Underlying assumptions
- Marginal External Costs calculation methodology
- Active Mode Benefit calculation methodology
- Results

Underlying assumptions

5. The rationale for estimating marginal external cost benefits (from reduced congestion outside city centres) and health benefits (from uptake in active modes) is provided separately below.

Marginal External Costs

6. Marginal external cost benefits have been estimated on the following basis:

- In some cities the National Infrastructure Commission is proposing the delivery of additional city centre capacity, enabling more people to work in city centres. This additional transport capacity is not assumed to reduce congestion or improve journey times for people travelling into city centres. Equally there is no increase in congestion, because the interventions identified as part of the Urban Transport Analysis: Capacity and Cost study are assumed to provide sufficient new capacity to absorb all additional commuting trips.
- Because employment is displaced from outlying areas into city centres, it is assumed that demand for car-based trips in those outlying areas reduces, and they are replaced by city centre-focused trips accommodated within the additional capacity identified as part of the Urban Transport Analysis: Capacity and Cost study. This generates external benefits, particularly reduced congestion.

London | 28-32 Upper Ground London SE1 9PD
UKInfo@sdgworld.net | +44 20 7910 5000

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- The benefits arising from air quality and reduced greenhouse gas emissions have not been included, as the National Infrastructure Commission considers that in the long-term, the adoption of electric vehicles will reduce emissions across all scenarios.

Health Benefits

7. Health benefits from active travel have been estimated on the following basis:

- Some of the additional city centre transport capacity could be delivered by policies to increase cycling and walking. This means more people travelling by these modes than otherwise would have been the case, and thus generating health benefits.
- New transport infrastructure generally has provision for active modes, therefore the capital cost estimates developed as part of the Urban Transport Analysis: Capacity and Cost study account for some investment in active modes.
- Existing active mode networks in many locations are centred on the city centre, therefore active mode trips to the city centre can take advantage of existing facilities/infrastructure.

8. While it is anticipated the active mode share will increase slightly in the 'city centre employment growth' scenario, many active mode trips into the city centre will be displaced from other parts of the network, as opposed to being new trips.

Marginal External Cost calculation methodology

9. The primary method for estimating decongestion benefits in the absence of a multi-modal model is based on marginal external costs (MECs), which estimate the change in external costs arising from additional or removed vehicle kilometres on the network. For car use, these external costs include congestion, air pollution, noise, infrastructure and accident costs. For the purpose of this exercise, we have only estimated congestion, infrastructure and accident costs.

10. We have used the standard WebTAG methodology and values for our estimations[1]. The three steps followed to implement the methodology are outlined below.

Step One: Estimate the change in car kilometres

11. The change in car kilometres is dependent upon the extent to which employment is displaced from outlying areas into city centres. For each city, the increase in city centre employment was provided by the parallel workstream considering the potential for employment growth in city centres, which is delivered by the University of Leeds. The employment forecasts distinguish between the number of employees displaced from the same Local Authority District (LAD) as the city centre or from the wider Primary Urban Area (PUA)).

12. In order to estimate average car commuting trip lengths for each LAD and PUA, we have used Census Travel to Work data (which is available at Middle Layer Super Output Area (MSOA)) to understand commuting patterns[2].

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[1] WebTAG Unit A5.4 *Marginal External Costs*

[2] https://www.nomisweb.co.uk/census/2011/wu03ew

13. The distance between each MSOA was calculated on a centroid to centroid basis. We have assumed that the average distance for journeys within the same MSOA is 1 km. A weighted average car commute distance was then calculated based upon the number of people who drove to work between each MSOA

14. Based upon the assumptions set out in paragraph 6, the resulting average car commute distance was used to estimate the reduction in car kilometres resulting from the displacement of trips from outlying areas into city centres, for both the high and low growth scenario.,

15. Data on the average number of commuting trips per person, and the ratio between AM peak commuting trips and trips across all journey purposes were then used to uplift the results so that they represent the annual change in vehicle kilometres for all trip purposes. These factors are based on National Travel Survey analysis undertaken as part of the Urban Transport Analysis: Cost and Capacity study.

Step Two: Analyse the characteristics of car journeys removed

16. WebTAG MEC values differ depending on the broad geographical characteristics of where the reduction in vehicle kilometres is observed, distinguishing between London, Inner and Outer Conurbation, Urban or Rural areas. All of the cities were defined as Urban apart from the largest cities, which were defined as Conurbations.

17. Department for Transport statistics were used to identify the proportion of road type (Motorways, A-roads and other roads) for each city LAD and for each PUA[3]. Where data for a LAD was not available, data for the corresponding county was used.

18. The INRIX Global Traffic Scorecard was used to determine the level of congestion in each city, based on the percentage of peak time spent in congestion for each city[4]. Data for Slough and Birkenhead were not available and therefore it was assumed, based upon proximity, that Slough has the same level of congestion as Reading and that Birkenhead has the same level of congestion as Liverpool. Using the range for all UK cities, each city was allocated into a congestion band on a scale of 1-5.

19. The MEC values for decongestion, infrastructure and accidents (in pence per km) for each city LAD and PUA was then identified depending on the characteristics above.

Step Three: Marginal External Costs results

20. The pence per km MEC values for each city LAD and each PUA (calculated in Step Two) were multiplied against the corresponding change in car km (calculated in Step One), to provide the total net impact to 2050, for both the high and low growth scenario.

Notes

- The net impact in 2050 has been deflated to 2018 prices.
- The WebTAG MEC Values were extrapolated from 2035 to 2050 using an index of average GDP per person extracted from the WebTAG databook[5].

[3] https://www.gov.uk/government/statistics/road-lengths-in-great-britain-2016**,** Table RDL0202a

[4] http://inrix.com/scorecard/

[5] https://www.gov.uk/government/publications/webtag-tag-data-book-may-2018

Health benefits calculation methodology

21. In the Urban Transport Analysis: Capacity and Cost core scenarios, active modes are not explicitly considered. New transport infrastructure generally has provision for active modes, therefore the cost estimates developed account for some investment in active modes. However, no major investment in increasing active mode share is considered.

22. In calculating active mode benefits the Department for Transport's Active Mode Appraisal Tool (May 2018)[6] has been used. The key inputs required for this tool are the numbers of new and existing trips by active modes. Only health benefits of active mode uptake are considered. Decongestion and journey quality benefits are excluded due to no explicit consideration of new active mode infrastructure in the cost estimates and to avoid double counting with the MECs.

Trip numbers

23. In calculating existing walking and cycling trip numbers to city centres, current commuting mode share data, based on 2011 Census Travel to Work data, is used. Commute trip numbers are factored up to account for all trip purposes, based on the values in Table 1 below.

Table 1: Commute trips to all trip purposes factors

Mode	Commute trips to All City Centre Trips Factor	Notes
Cycling	1.47	Based on the National Travel Survey for trips in England outside of London during the morning peak hour. Note that an all-day factor would be larger, however this would account for many recreational trips etc that are unlikely to be associated with city centre trips. Therefore, this factor is considered a conservative assumption.
Walking	5.32	Based on average of peak hour factors used in the Urban Transport Analysis: Capacity and Cost study. As for cycling this represents a peak hour factor and is considered a conservative assumption.

24. In estimating the number of new active mode trips the factors in Table 2 have been used.

Table 2: Assumptions applied to generate 'new' active mode trip numbers

Mode	New trip numbers assumption
Cycling	It is assumed that the mode share of cycling trips into the city centre will grow in proportion with employment growth. 70% of this cycle trip growth is assumed to be displaced from other parts of the network.
Walking	Due to walking being an attractive mode for very short trips only it is not anticipated that the proportional impact on trip numbers will be as significant as for cycle trips. However, walking accounts for significantly higher mode shares than cycling. A simple assumption that 1% of displaced commute trips into city centres will result in new walking trips is made for the purposes of this analysis.

25. Daily trips are assumed to occur on 143.5 days per annum on average, based on National Travel Survey analysis as part of the Urban Transport Analysis: Cost and Capacity study. This is consistent with the MEC calculation assumptions. Commute trips on 143.5 days on average per employee reflects:

[6] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/712871/active-mode-appraisal-toolkit.xlsx

- Absences (e.g. sick days and annual leave)
- Employees who work from home
- Part-time employees not commuting every day

Benefit Calculation

26. Generally, the default values within the active mode tool are used. Table 3 sets out notable default values and where they have been altered for the purposes of this analysis.

Table 3: Notable Tool Variables

Variable	Default Value	Value Used	Notes
Average Cycling Trip Length (km)	5.60	5.60	
Average Walking Trip Length (km)	1.18	1.18	
Number of Days Scheme Data is Applicable	220	143.5	Based on NTS analysis in Urban Transport Analysis: Cost and Capacity study.

27. It is noted that the 143.5 days per annum used in the calculation is significantly lower than the 220 default value within the tool. This is because the two figures have been estimated for different purposes on a different basis. The default value of 220 days is a factor derived to be applied to the number of trips on a given day. By contrast our trip numbers are estimated on the basis of an average mode share applied to the total number of commuters (not commuting trips on a given day). Therefore, the lower factor accounts for the fact that not all people travel everyday as set out in Paragraph 25.

28. The tool reports values in 2010 prices, these are converted to 2018 prices using the GDP deflator index within the tool.

Results

29. Results of the analysis described in this technical note are presented in Table 4 and Table 5.

Table 4: Marginal external benefits and health benefits, high employment growth scenario (2050 annual benefit, 2018 prices)

	Congestion	Infrastructure	Accident	Active mode benefits	Total
Total	**£178,282,000**	**£386,000**	**£11,600,000**	**£2,827,000**	**£193,095,000**

Table 5: Marginal external benefits and health benefits, low employment growth scenario (2050 annual benefit, 2018 prices)

	Congestion	Infrastructure	Accident	Active mode benefits	Total
Total	£111,593,000	£232,000	£6,956,000	£1,768,000	£120,549,000