ENGLAND'S ECONOMIC HEARTLAND

Benefits of Smart Junctions

CITY SCIENCE

delivering decarbonisation

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Glossary

Bus Open Data Service (BODS): An open data service that provides timetables, bus locations and fares data for local bus services across England. This includes live locations of buses, so the data can be used to record and analyse bus performance measures, such as speed and journey reliability.

Intelligent Transport Systems (ITS): These involve technology applications and platforms, which are used for the improvement of transport, including efficiency, safety, congestion and emissions. ITS aims to control, manage and improve transport systems.

Machine Vision (MV): The technology and methodologies utilised to deliver imaging-based autonomous inspection and analysis for applications (Javaid, et al., 2022). In the smart junction context, it is usually used to capture and detect traffic movements by vehicle type. The data can then be used to optimise signal timings.

MOVA (Microprocessor Optimised Vehicle Actuation): A strategy for traffic light control signals at isolated junctions only. This strategy has been used since its development in the 1980s and is a common product used across the UK, serving more than half of UK junctions. This product works for low and extremely high traffic density in junctions. The method behind this product consists of a congestion delay minimisation mode for the lower traffic flow and a capacity maximisation for the higher traffic flow. This strategy product also excels in its capacity to operate on a broad range of junctions (TRL Softwares, n.d.). Recent developments of MOVA allow the system to link more than two junctions that are too close to be considered isolated, however it is not designed to optimise the traffic signals across multiple junctions, e.g. at a corridor level.

SCOOT (Split Cycle Offset Optimisation Technique): A software kernel developed by TRL to control and coordinate multiple junctions and is a component of a UTC system. The system collects data from vehicle detectors and then in real-time calculates alternative plans for each signalised junction to reduce vehicle or pedestrian delay. It makes changes rapidly, but changes are kept to a stable state, so fluctuations are smooth for minimal instabilities (TRL Software, n.d.). Historically, SCOOT was only available as a component of Yunex (previously Siemens) and SWARCO (previously Dynniq, Imtech and Peek) UTC systems, but recently TRL have released a UTC with the SCOOT kernel themselves.

Smart Junction: The definition of a smart junction can vary, as detailed in Section 2.1. Smart Junctions products by Computer Vision companies (e.g. VivaCity) use Artificial Intelligence (AI) or learning methods to control specific junctions and are largely looking to outperform traditional alternatives. However, the use of the term “smart junctions” in this report refers to any new algorithms, or combination of algorithms, targeting functional or performance improvements over traditional algorithms. It also includes the use of new data or integration with connected services. Note that the use of the term "smart junctions" in isolation doesn't describe which mode or performance objective is being specifically being targeted, data sources used or whether the process relates to a single junction, cluster of junctions or a wider region.

UTC (Urban Traffic Control): The primary purpose of these systems is to coordinate the operation of signals to allow efficient progression through the network of vehicles. The concept being that once you clear one signal, by the time you get to the next, that signal changes green, minimising stop, start, delay and emissions. In the UK, UTC systems normally use a brain to conduct this optimisation. This is normally the SCOOT kernel (the brain), but Fusion is also now an alternative kernel. UTC forms part of Urban Traffic Management and Control (UTMC).

UTMC: A framework or platform for traffic management systems to work together, to enable improved data management and sharing. This may include network monitoring, parking information provision, environmental monitoring, road user charging, policing (ITS International, 2012).

Vehicle Actuation (VA): Vehicle Actuated (VA) signals use detectors to monitor traffic flows and adjust the lengths of green time to account for traffic flows, in order to reduce delays.

Executive Summary

This Study is an initial strategic and high-level review of the benefits and opportunities of smart junction technology in the England's Economic Heartland (EEH) region, with a focus on priority corridors and upgrading existing signalised junctions. Non-signalised junctions are not included within this Study due to the limited and unknown impacts and possible limited benefits of converting a non-signalised junction to a signalised junction in order to make use of smart junction technology.

This report summarises the current literature outlining the potential benefits of smart junction technology, supplemented by engagement with vendors to understand success stories and opportunities available in the UK market. While conclusive evidence on the full range of potential benefits is still emerging, given the relatively new nature of smart junction technology, the initial results from trials and deployments are promising. The opportunities look encouraging when considering the relatively lower costs and embodied carbon impacts compared to traditional infrastructure upgrades that involve significant construction. With its ability to optimise traffic flow, prioritise sustainable travel modes and improve safety through enhanced detection capabilities, smart junction technology offers an innovative solution to meet EEH's transport priorities.

This Study identifies initial opportunities for implementing smart junction technology at existing signalised junctions on key strategic corridors in EEH. This is based on factors like vehicular demand, congestion, key bus routes and collision data - areas where smart junctions could provide benefits, supported by literature. It also preliminarily identifies urban areas associated with these corridors that could benefit from smart junctions, considering the number of signalised junctions, air quality concerns and collisions involving active modes of transport.

Key Study recommendations include:

- Addressing knowledge gaps about smart junctions across local transport authorities
- Expanding funding sources beyond traditional signal upgrade budgets
- Conducting further localised feasibility studies for high-potential corridors/areas
- Developing business cases following DfT TAG to quantify benefits and costs
- Reviewing use cases and potentially live trials of corridor-level smart junction systems.

This report provides a foundation for understanding the potential of smart junction technology to address EEH's transport priorities in a cost-effective and sustainable way. Further localised analysis is recommended to identify and quantify specific deployment opportunities.

The analysis underpinning this Study, carried out in May 2024, incorporates EEH’s connectivity studies. Since then, connectivity studies that were ongoing at the time of the analysis have since been completed. EEH plans to update this Study with updated connectivity Study work, should funding be available.

1 Introduction

1.1 Background

England's Economic Heartland (EEH) wishes to understand the potential for Intelligent Transport Systems (ITS), in particular smart signalised junctions (hereby referred to as smart junctions) within their region. Trial projects by City Science, VivaCity and others have demonstrated the role that new algorithms could play in easing traffic flow or supporting the shift to alternative modes of transport (e.g. public transport, cycling and walking). Such opportunities are likely to be cost effective in comparison to alternative interventions based on heavy infrastructure (e.g. new roads) and with lower embodied carbon emissions.

City Science has been commissioned by EEH to carry out an initial review and prioritisation Study of smart junction technology, to consolidate the most up-to-date knowledge and undertake an initial assessment of potential benefits and costs within the EEH region. This Study aims to:

1. Consolidate and update knowledge regarding cutting-edge applications of smart junctions
2. Categorise smart junction applications into their respective impacts (e.g. modal shift, congestion etc.)
3. Consolidate regional data and evidence to inform priorities for EEH
4. Prioritise potential interventions to maximise desired impacts (including minimising embodied carbon)
5. Produce clear, evidence-based recommendations for next steps.

A key limitation of this Study is that only existing signalised junctions are considered. Non-signalised junctions are not included within this Study due to the limited and unknown impacts and possible limited benefits of converting a non-signalised junction to a signalised junction in order to make use of smart junction technology.

1.2 Report Purpose

This report aims to give a foundation understanding of existing smart junctions, to assess the benefits and impacts for junctions in EEH. It sets out a review of existing implementations, studies and experiences, associated with smart junctions to understand their impacts, complemented by engagement with Local Transport Authorities (LTAs) and technology vendors. Also included is a draft review of relevant data to understand existing network infrastructure and demand. This report is structured as follows:

- **Chapter 2:** Literature Review
- **Chapter 3:** Engagement
- **Chapter 4:** Data Consolidation
- **Chapter 5:** Network Focus & Typologies
- **Chapter 6:** Congestion Analysis
- **Chapter 7:** Benefits Analysis
- **Chapter 8:** Cost Analysis
- **Chapter 9:** Conclusions & Recommendations.

Appendices are included to support the report with further detail where needed. A Bibliography is also included.

Cadence 360 Enabled Report

We have provided access to our visualisation tool Cadence 360 to support access and interaction with the maps included in this report. Please use this link: Cadence 360

1.3 Geographical Scope

EEH is a sub-national transport body in England and is a partnership of local authorities and local enterprise partnerships, from Swindon and Oxfordshire in the west, to Cambridgeshire in the east, and from Northamptonshire down to Hertfordshire, as shown in Figure 1-1..

Local Transport Authorities & Local Authorities

This report refers to both LTAs and local authorities. LTAs are upper tier local authorities, usually combined authorities and county councils, but also unitary authorities. Combined authorities are local government entities comprising of two or more neighbouring councils wishing to co-ordinate responsibilities, such as transport aspects. This report is mostly interested in and refers to LTAs however this is sometimes interchangeable with “local authorities” and “authorities”.

Figure 1-1: EEH & Local Authority Boundaries

2 Literature Review

2.1 Background

To manage and control conflict of traffic flow at junctions, traffic signalling is employed, which aims to regulate and produce an efficient flow of traffic. The optimisation of traffic signalling has become a popular area of research in recent years and there are several different methods and technologies that have been developed or are in development.

It should be noted that the definition of a smart junction or smart signal control varies. As stated in Manual for Smart Streets (Transport Technology Forum, 2023):

'*Smart signal control involves using new data sources, such as connected vehicle data, new technologies and co-operative and/or connected services to advise the optimisation of the flow of traffic and improve the road user experience.*'

As well as traditionally smoothing traffic flows and reducing delays and congestion for road users, the definition also refers to (Transport Technology Forum, 2023):

- **Extending benefits to all road users**, as opposed to general "traffic"
- **Increasing data sharing** between Authorities and third-party sectors and increasing the quality and availability of information and services to support transport planning and road network operations
- Improving road network efficiency by **improving data monitoring** to reduce reliance on traffic surveys and physical infrastructure.

To expand this definition further based on our engagement and literature review, for the purposes of this report we assume smart junction technology is a technology that can:

- **Detect different modes of transport** and adapt accordingly, for example an extended green signal for a public bus or Heavy Goods Vehicle (HGV), or detection of pedestrians or cyclists at a signalised crossing
- **Prioritise differing needs**, which may include prioritising a specific mode or optimising elements such as air quality or emissions, instead of minimising vehicular delay or stops as has traditionally been prioritised.

Section 2.1.2 seeks to differentiate between and categorise smart signalised technology methods.

2.2 Existing Smart Junction Technology

2.2.1 Traditional Traffic Control Methods

Typical and more traditional traffic control systems, including MOVA and SCOOT, use loop or magnetic detectors and sensors to track vehicles and minimise stops and delays at junctions by synchronising adjacent signals based on either real-time or predicted traffic volumes.

In recent years, SCOOT and MOVA have been the primary Traffic Signal Control (TSC) systems in the UK. SCOOT has been used in scenarios aimed at reducing congestion through the coordination of multiple junctions, while MOVA has been mostly used to optimise individual junctions. Without routine calibration, performance of traffic control mechanisms has been observed to degrade over time; the industry refers to a 5% reduction in performance year on year.

MOVA and SCOOT do not traditionally allow detection of vehicle types (other than by length), but recent developments have improved the systems to be able to extract data from camera/MV based techniques to allow for the classification of vehicle types (e.g. Yunex).

One disadvantage of using loops or detectors to track vehicles and minimise delays is cost efficiency; on top of significant initial implementation costs, these systems need substantial communication infrastructure that can support a centralised control with a high data rate (Tomar, et al., 2022). Moreover, recalibration of traditional systems is time-consuming and can be expensive, so is typically only implemented on priority junctions or when a new scheme or development necessitates it rather than proactively on a rolling programme (as confirmed by LTAs in the survey, see Section 3.2.3.2). One of the potential benefits of AI-based systems is the potential to reduce calibration costs and ensure continuous improvement and performance.

Also, as noted above, traditional methods do not allow detection of vehicle types and non-motorised modes, such as cycling, unless it is integrated with other systems.

2.2.2 Vision-BASED Traffic Control Methods

This group of methods utilise video cameras to track vehicles using advanced techniques such as dynamic Bayesian networks (Chaudhary, et al., 2018; Hadi, et al., 2014), and, similar to the traditional traffic control methods, use algorithms to optimise green time allocation. The obvious advantage of this method is the ability to identify different types of road users (e.g. car, bus, pedestrian); therefore, it has been frequently integrated with traditional systems. However, the speed and accuracy level are the main risks. A sophisticated image recognition technology would be required to be able to process real-time data for TSC.

2.2.3 Sensor-Based Traffic Control Method

Another group of methods rely on GPS data of users or vehicles. GPS can collect data on the speed, position and direction of vehicles approaching signalised junctions, to then adapt traffic lights as required (for example to reduce waiting times). This method has the advantage of relatively low initial installation costs, but the challenge is attaining GPS data from users (Sharma & Sreedevi, 2019). This method can also identify user or vehicle types either by the speed of the GPS trace, through reference to other databases (e.g. DVLA) or by combining with MV technology.

2.2.4 Learning-Based Traffic Control Methods

Differing from the above systems, this is an innovation in the optimisation algorithm rather than in data collection. With the expansion and increasing popularity of Machine Learning and MV methods and AI, many studies have recommended using Reinforcement Learning (RL) to regulate traffic lights (Wei , et al., 2020). Unlike traditional TSC systems which depend mainly on predefined models, RL may learn immediately from inputs and optimise its travel time based on the real-time road conditions.

2.2.5 Co-operative Intelligent Traffic Systems

Co-operative Intelligent Traffic Systems (C-ITS) refer to transport systems where there is cooperation between two or more systems, enables and provides an ITS service that offers better quality and an enhanced service level. For example, the PATH project (Transport Technology Forum, 2023) for traffic signal monitoring uses floating vehicle data across 11 UK authorities. Another example is the Green Light Speed Advisory (GLOSA) project (C-ROADS, 2023) that predicts green phases of traffic signals using various data sources and provides drivers with up-to-date information (for example information on the likelihood of passing the signalised junction within the current green phase).

C-ITS has been trailed in a few cities in the UK such as Birmingham, York, Newcastle and Coventry. However, it is not yet mature enough for products to be available on the open market (Transport Technology Forum, 2023).

Table 2-1 summarises the strategies and methods applied by each of these smart junction technologies, and comments on key challenges and advantages.

Solution	Traffic Signal Control Strategy	Source of Data Collection	Multi-Modal Detection	Key Challenges & Advantages
'Traditional' Traffic Control Methods	Minimises stops and delays at junctions by synchronising adjacent signals	Sensors/ Detectors	Only if integrated with vision or sensor-based data sources	• Significant implementation costs • Degraded effects over time • Cannot detect vehicle types without integration with other systems
Vision-BASED Traffic Control Methods	Real-time prediction of the state of road, improving travel and transit information	Filed Cameras	Yes	• Real-time TSC can be ineffective subject to the accuracy (Tomar, et al., 2022) • Large data storage requirement
Sensor-Based Traffic Control Method	Using floating car data, improve traffic flows on road and signal timings	GPS/DSRC	Depending on the source of data	• The relevant devices need to be installed on vehicle or corridor • Provides robust speed data but can be challenging to obtain accurate traffic volume without a secondary data source
Learning-Based Traffic Control Methods	Utilise mathematical model to minimise vehicular wait time at junctions, giving priority to the junction arm with high traffic density	Various	Only if integrated with vision or sensor-based data sources	• Better performance in complicated traffic situations and multi-junction environment • Can be used with different detection technologies
Co-operative Intelligent Traffic System	Cooperation between two or more sub-systems enables and provides an ITS service	Various	Yes	• Use-case relevant for traffic signal controls is not yet mature enough for products to be available on the open market

Table 2-1: Existing Smart Signal Control Methods

2.3 Impacts of Smart Signal Control

2.3.1 Overview

Traffic optimisation was initially designed to improve the flow of traffic, help reduce delays caused by congested roads and improve overall journey times for users. In recent years, and with the introduction of smart junction technology, the objectives of traffic signalling optimisation have changed. Instead of focusing mainly on traffic flow efficiency, the objectives have shifted towards optimising road usage for different and more sustainable modes of transport, which, in turn, promotes the use of public transport, increases safety for pedestrians and other road users, and reduces air pollution and emissions (Carey, 2020).

A summary of quantitative and qualitative impacts of smart signal control is provided in Table 2-2, as informed by business case guidance from Transport Technology Forum (2023). Subsequent Sections set out further detail where trials or research exist that supports the impacts of smart junctions.

Theme	Impact	Qualitative	Quantitative
Congestion, Emissions & Air Quality	Through optimised signal control and influencing driver behaviour to achieve improved traffic flow and journey time reliability		✓
	Through increased uptake in public transport and active travel		✓
Safety	Improved data supporting planning and design processes, achieved through collection of data such as near misses, turning paths and kerbside pedestrian detection		✓
	Improved road user behaviour, achieved through reduced stopping and starting and more consistent speeds		✓
	Allowing emergency vehicles to pass without disruption		✓
Active Travel Data	Improved data supporting planning and design processes, achieved through collection of active travel data, through detection of pedestrians and cyclists		✓
	Improved connected data services		✓
	Making asset data digitally available to users, either directly or via third parties; improves services for users		✓
Public Bus Reliability & Effectiveness	Increased patronage achieved through increased service reliability		✓
	Achieved through improved availability and fidelity of data for traffic control, integration of signal optimisation with public transport user facilities and implementation of vehicle to infrastructure services	✓	
Physical Infrastructure	Reduces maintenance requirements		✓
	Improves the streetscape	✓	
Reduced Expenditure	Reduced need for manual traffic surveys		✓
	Reduced physical infrastructure and maintenance		✓
Efficient Operations	Improved digitisation and connectivity of equipment	✓	
	Adoption of connected data as an alternative to existing, or legacy, infrastructure sensors for new more efficient or less vulnerable technologies to reduce maintenance operations, costs and migration from ageing, legacy, systems	✓	
Improved Quality & Availability of Traffic Datasets	Improved traffic sensors, subscription to connected data and publication of traffic data to a common database	✓	
	Supporting the Authority's traffic planning activities	✓	

Table 2-2: Summary of Quantitative & Qualitative Impacts of Smart Junctions (Transport Technology Forum, 2023)

2.3.2 Congestion & Emissions

It is widely accepted that vehicle emissions are severe in areas of higher traffic congestion compared to less congested areas (Pérez, et al., 2010). This is largely because emissions are higher when vehicles need to stop and accelerate more frequently compared with free-flowing traffic conditions. Smart junction technology allows congestion to be managed differently from previous signal control. All modes of transport can be detected, and the data can be used to understand changes in traffic patterns or levels of congestion (Paack, 2022). This allows authorities to adjust signal timings accordingly to reduce queues at junctions or manage peak hour flows more efficiently. The adoption of AI in traffic signalling has proven to reduce wait times by 40% and vehicle emissions by 20% compared to traditional algorithms, such as SCOOT, from a study conducted by Carnegie Mellon University (VivaCity, 2022). Further research conducted in the UK found that implementing multimodal prioritisation could result in significant reductions in travel time, fuel consumption and CO_2 emissions (Parsons, 2022). The Yunex traffic system Fusion claimed a reduction in traffic delays (assumed to be all motorised network users) of 25% compared to SCOOT and 40% compared to fixed time control (Yunex Traffic, 2023). However, it is not clear if this is at an individual junction, corridor or network level.

2.3.3 Improving Public Bus Journeys

Smart junctions can also allow vehicles with priority status such as public buses to pass through quickly without disrupting other users' journeys. In turn, this improvement to public bus journey times can encourage a switch from private car due to reduced delay. For example, SWARCO proposes a bus priority where buses are prioritised at junctions with controlled traffic signals, receiving extended green lights or reduced red-light times. Transport for London (TfL) and Bristol City Council have for many years had a bus priority programme that is enabled via SCOOT technology and Sheffield City Council utilise a technology to give priority and coordination to the tram system.

2.3.4 Air Quality

It is widely accepted that traffic congestion causes adverse levels of air pollution (Pérez, et al., 2010). Although research specifically providing evidence as to the extent smart junctions can improve air quality is rare, numerous studies have developed empirical evidence that congestion-relieving interventions (e.g. congestion charging schemes) will significantly improve air quality (Chow, et al., 2013; Beevers & Carslaw, 2005). By reducing congestion across networks, as reviewed in Chapter 6, smart junction technologies will reduce vehicle emissions significantly leading to cleaner air quality within urban areas (Paack, 2022). Additionally, by encouraging active travel, through prioritising pedestrians and cyclists at signalised junctions; these systems can contribute further towards improving air quality within urban areas.

Another example of contributing to improved air quality is the use of smart junction technology to prioritise buses and freight vehicles, such as where there are junctions on an incline, to avoid stopping unnecessarily by providing extended green signals. As well as smoothing their journey time reliability this reduces emissions used to re-start the vehicles on an incline.

2.3.5 Safety & Data

By using advanced technologies like cameras and radar detectors at junctions, smart junctions can identify potential hazards or near misses which can help prevent future collisions from happening (Bhatti, 2020). Smart junctions can also allow vehicles with priority status such as emergency service vehicles to pass through quickly and safely without disrupting other users' journeys.

2.3.6 Walking & Cycling

Walking and cycling detectors have been implemented in Greater Manchester (VivaCityLabs, 2023) and London (Yunex Traffic, 2023). These systems use sensors to record vehicular, walking and cycling flows and their interactions. This data is being used to understand the use of the network and new schemes, as well as in real time to change the signal timings in order to prioritise walking and cycling, and boost cycle safety (Carey, 2020).

3 Engagement

3.1 Vendor Engagement

There are a small number of vendors of smart junction technology in the UK, with the main operators set out in this Section. Appendix A summarises the current detection and control capabilities of several vendors.

3.1.1 TRL Software

TRL are the original developers of the SCOOT which, in the past, was licensed to Yunex and SWARCO within their UTCs. Recently, TRL developed their own UTC platform which utilises SCOOT 7.

Other suppliers that offer multimodal detection or control capabilities, will replicate or use SCOOT as a subcomponent (for example SWARCO uses SCOOT 6 within their own UTC).

3.1.2 SWARCO

SWARCO is a traffic technology company offering traffic management solutions including urban traffic management that covers traffic detection, signal optimisation and adaption, public transport priority and both isolated and fully integrated solutions across corridors or areas. SWARCO makes use of SCOOT 6 kernel within their own UTC.

City Science engaged with SWARCO on the 6th April 2023.

SWARCO products are deployed across a number of locations in the UK and Europe, including:

- **Edinburgh:** Deployment across one large area and two key corridors, including bus priority
- **Derbyshire:** Implementation associated with bus priority along rural corridors for long range and rural buses
- **Oxford:** Signalised cycle junctions
- Other locations including Leicestershire, Hertfordshire, Glasgow, Lincolnshire and Warwickshire.

SWARCO system use detectors/smart cameras from a multitude of suppliers and technology including Loop, Magnetometer, Radar, Lidar ANPR, which can be brought into MyCity UTC and optimised using the SCOOT kernel. MyCity can handle 30 types of vehicles classification.

SWARCO's AI systems connect to existing CCTV cameras and machine learn in order to detect and process different transport modes.

SWARCO traffic controls support Fixed time, VA, MOVA and SCOOT and can support bus priority both in MOVA and SCOOT.

SWARCO discussed a number of challenges of smart junction implementation:

- Prioritising specific modes can cause delays to some vehicles, which can be controversial
- Although SWARCO designs with an open architecture, there is a general barrier in the market where there are multiple operators with incompatible systems
- Older generations of signal operators have a desire to continuously optimise vehicles, however shifting policy is now moving away from this
- Local politics impacts the use of smart junctions, as controversies over priorities mean the smart junctions are not used or not used to their full potential.

SWARCO plan on focussing on the following going forward:

- Identifying bus occupancies to inform priorities
- Understanding how scooters/e-scooters fit into existing controls
- Bus priority implementation, as many LTAs have BSIP funding to support this.

3.1.3 VivaCity

VivaCity offers smart solutions across traffic monitoring, road safety and signal control based on video camera detection with on-device MV technology that classifies different transport modes. This includes collection and monitoring of classified counts and journey times, prioritising specific modes through signal timings and identification of near miss collisions and trajectories. Currently VivaCity implementation can only be provided on isolated junctions and does not offer coordinated signal control.

City Science met with Carl Pittam, Commercial Lead for Signal Control Projects (UK) at VivaCity on the 14th April 2023.

Current or potential implementations include:

- Cambridgeshire (smart junction trials to compare against MOVA, see Section 3.2.2.1)
- Peterborough (smart junction trials, see Section 3.2.3.4)
- Luton (having conversations about potential opportunities)
- Buckinghamshire (use of sensors, see Section 3.2.3.4)
- Oxfordshire
- Hertfordshire (monitoring and sensors)
- Milton Keynes (use of sensors but no data retrieved, see Section 3.2.2.2).

VivaCity's traffic management products are based around their sensors and detection systems, which must be utilised to benefit from the services they offer. Sensors can detect up to ten different classification of modes and have been measured as 97% accurate (in a trial in London). Using VivaCity sensors and detection systems, they can provide:

- Isolated junction optimisation
- Smart traffic monitoring
- Smart road safety (e.g. identifying near misses).

VivaCity detectors can detect and record a number of elements including speed, occupancy, dwell times, turning movements, journey times and origin/destinations. These attributes can then be used to measure the success of the implementation, for example comparing journey times of modes before and after. VivaCity provides a dashboard as part of their service so customers can view and interrogate data.

The technology is generally only used in urban areas or city centres, but sensors are implemented across the country. Infrastructure can be powered by solar or wind power where available.

Decision of control and priority must come from the customer (e.g. the LTA).

VivaCity products can only optimise isolated junctions. Multi-junction coordination is on the horizon for VivaCity but is not currently implemented. VivaCity junction optimisation only works with their traffic detection technology however their traffic detection technology can supply other vendors traffic data for optimisation in their products.

VivaCity uses SUMO simulation software and models to train their signal control products within its trials.

3.1.4 Yunex

Yunex is a traffic technology company offering traffic management solutions including urban traffic management that covers traffic detection, signal optimisation and adaption, public transport priority and both isolated and fully integrated solutions across corridors or areas. Fusion is an adaptive traffic control and signal optimisation solution developed by Yunex in partnership with TfL. Fusion can be considered a modern-day replacement for SCOOT that can be set up to optimise and prioritise traffic based on any modal priority policy. Yunex offer their UTC with either SCOOT 6 or Fusion or both.

Section 3.2.2.3 summarises discussions with TfL regarding the use of Fusion. Engagement with TfL highlighted that Fusion could make parts of the network worse and parts better so is being implemented over time through targeted deployment, to allow continuous monitoring.

3.2 Local Transport Authority Engagement

3.2.1 Overview

Engagement with LTAs comprised of:

- 1:1 meetings with three authorities currently implementing smart junctions
- An online survey distributed to LTAs in the EEH region, where nine LTAs responded.

The aim of the authority engagement is to understand the successes and challenges found by authorities currently implementing smart junction technology. Additionally, engagement with authorities in EEH through the online survey allowed the identification of potential opportunities and collaboration for smart junctions in the region.

3.2.2 1:1 Engagement

3.2.2.1 Cambridgeshire County Council

City Science engaged with officers at Cambridgeshire County Council on 31st March 2023.

VivaCity trials are currently being implemented at four isolated junctions, including two pedestrian controlled junctions, in Cambridge. There are plans for trial implementation also at three coordinated junctions in the near future. At these four junctions, pilot trials are being carried out where there is alternating control between VivaCity and MOVA to compare impact on journey times, flow and ability to prioritise modes. At the time of engagement, no major differences between the existing systems and VivaCity were identified with the LTA reporting that the performance of the MOVA and VivaCity algorithms appears similar (although no quantified data is currently available to support this).

Additionally, Cambridgeshire County Council is also implementing a number of VivaCity detectors across their road network, which includes the detection of different modes (including pedestrians, cyclists, Light Goods Vehicles (LGVs) and HGVs).

The detection at these additional junctions does not involve signal optimisation or mode prioritisation. Note that the classification of e-scooters is not currently available. Detection includes the video capture of 'near miss' collisions and the recording and monitoring of demand, occupancy and journey times (utilising ANPR technology).

The data that is collected will inform the live tweaking of signals at the associated junctions, although this functionality is not yet in place. Cambridgeshire County Council is also looking to trial VivaCity's coordinated junction technology once developed.

The trials include four to five weeks of data collection and VivaCity provide a dashboard (API) to view and interrogate the data.

It is understood that Cambridgeshire are interested in the prioritisation of modes, particularly buses on key bus routes. Prioritisation will be on a junction-by-junction basis and policy-focused. Other future capabilities of interest include kerbside pedestrian detection.

Cambridgeshire discussed that the funding mechanism for smart junctions should consider what the business case is and who benefits. The use of specific funding pots can then be aligned to the business case (for example BSIP funding for buses prioritised at smart junctions), rather than using signals funding which is usually minimal.

Signal timings are reviewed ad hoc, usually due to complaints or where refurbishment is required but there is currently no proactive programme that looks to target all systems over a period of time.

3.2.2.2 Milton Keynes Council

As part of rejuvenating the town centre, Milton Keynes Council is renewing its signalised junctions, focussing on 16 signalised junctions. City Science met with officers from Milton Keynes Council on the 11th April 2023.

The junctions are being updated to MOVA (version 7/8) to generally improve traffic efficiency, although no results in terms of its success have yet been produced. The implementation does not cover pedestrians and cyclists, as they have segregated infrastructure in the town centre. Milton Keynes Council assumes that these junctions have no need for coordination (progression / green wave) at this time. Implementation of MOVA also includes a green extension for buses when detected.

Implementation includes radar detection combined with an induction loop at the junction, which is then verified by a stop line detector.

One main challenge of the MOVA implementation is the cost of working with ageing signal controller stock including problems replacing certain elements such as new cabling.

In the longer-term, Milton Keynes Council would like to integrate MOVA with real time BODS to inform bus priority (for example if a bus is not running to schedule it can be prioritised over a bus running ahead of schedule). Milton Keynes do have a large implementation of VivaCity sensors but due to high data costs, do not actually subscribe to data services to make any benefit or use the data for any purpose (monitoring or detection for signals).

3.2.2.3 Transport for London

City Science engaged with officers at TfL, where Fusion has been piloted and is now being rolled out with the aim of it being used significantly on TfL's road network.

SCOOT technology has been the main technology product used for network management / optimisation by TfL, however policy demand meant that managing a multi-modal, coordinated network was becoming a challenge. Fusion was developed as a solution to this. Pilots have proven the benefit and it is now being rolled out to target corridors, areas and zones where the greatest benefit or need can be realised. The main purpose for its use by TfL is controlling areas of signalised junctions (corridors or groups where coordination is required) as opposed to single isolated junctions.

TfL had a requirement that mandated Fusion's compatibility with existing systems and ability to make use of the existing detectors and loops that exist on the network (around 16,500). It is also future proofed so that when new multimodal detector systems can be deployed (like VivaCity's and others) then the optimisation engine can make greater use of the data.

The functionality of Fusion involves the detection and recording of different modes. These classified counts are used to model and then optimise performance of one or a collective number of modes, depending on priority. This can be optimised based on reducing delay time and choosing priorities by mode (for example bus > cycle > walk).

TRL has the staff and processes that enables it to test the benefits on a traffic model prior to going out on-street and effectively validate the deployment of smart junction technology. VISSIM (a microsimulation transport model) has been used to test and tweak the implementation of smart junctions offline. However, on-street observations didn't always reflect the modelling, creating a challenging cycle of repeated modelling and implementation.

An additional challenge to the implementation of smart junctions is the move away from traditional performance metrics (e.g. traffic flow) to more up-to-date metrics aligned with current policy objectives (e.g. prioritising buses) within the traffic signals team.

Future development of the application of Fusion in London includes identifying the number of people on buses (to inform priority between buses), vulnerabilities of pedestrians and identifying sub-modes.

With over 5,500 signalised junctions over the TfL network, Fusion is not going to be deployed automatically to every junction in London. For some junctions, Fusion can make some parts worse and some parts better so it will be implemented over time through targeted deployment. Balancing global multi modal network demands is difficult due to the sacrifice of road network optimisation for a higher priority to a specific mode.

TfL has a team of key network corridor managers which have now become area based. Their role is to continually review and improve the network in their area in line with TfL's current strategies and policies. This includes reviewing bus delays and priorities. They also must manage a rolling programme of signal timing reviews which proactively looks at junctions to optimise their performance once every three to five years.

3.2.3 Online Survey

An LTA online survey was conducted to collate information to help identify potential opportunities in the EEH region, including where existing or planned trials of smart junctions exist that we can either learn from or coordinate with. The survey also sought to understand local authority views on opportunities for and barriers to smart junction technology.

The survey was completed by 11 respondents across nine LTAs (noting that in some cases multiple respondents represented a single LTA):

- Bedford Borough Council
- Buckinghamshire Council
- Cambridgeshire County Council
- Milton Keynes Council
- North Northamptonshire Council
- Oxfordshire County Council
- Peterborough City Council
- Swindon Borough Council
- Luton Borough Council.

Relevant follow up questions and data requests with LTAs are currently being progressed and this section will be updated as more information becomes available. Subsequent sections summarise survey results and themes. The full survey results are included in Appendix B.

3.2.3.1 Existing Technology

Nearly all authorities use Yunex SCOOT to coordinate signal-controlled junctions. Control at isolated junctions uses a mix of MOVA and VA.

To detect vehicles, most authorities use traditional inductive loops. Additionally, many authorities use overhead or Above Ground Detection (AGD), either through microwave or radar detection. Bedford Borough Council mentions the use of multi modal detection, such as with Smart Video and Sensing (SVS) or ICOMS. To monitor traffic, LTAs use a mix of (in order of most to least used):

- Inductive loops (e.g. within SCOOT)
- Fixed count sites (e.g. Automatic Traffic Count (ATC) or Automatic Number Plate Recognition (ANPR))
- CCTV
- Detection via vendor technology (e.g. Yunex UTC, Yunex Remote Monitoring System (RMS), Telent RMS).

3.2.3.2 Current Signal Policy

Most LTAs review their signal timings ad hoc or when required, with half of these LTAs stating this was less than a year ago. The remainder of authorities updated their signal timings over a year ago, with some expressing that this is rare or hasn't been undertaken at all.

Most respondents state that there is no formal policy regarding which technology should be used for signalised junctions and that technology/strategy is generally decided based on several site-specific factors. Three LTAs state that either MOVA and/or SCOOT is prioritised or the default control approach.

3.2.3.3 Existing Bus Priority Infrastructure

Four of the nine LTAs have bus priority infrastructure on their network. With regards to bus priority technology, implementations includes:

- Use of detection (e.g. inductive profiling / loop detection) on bus lanes, at signalised junctions or where there is priority (Swindon Borough Council)
- VIX Technology Local Bus Priority (TLP), in partnership with Stagecoach, is implemented at 12 junctions but a more strategic system is being explored. This involves GPS detection of buses triggering priority (Peterborough City Council)
- Deployment of bus priority through TRL UTC and MOVA using BSIP funding at six to ten sites (Luton Borough Council).

Buckinghamshire Council also stated that they have bus priority schemes implemented on their network.

3.2.3.4 Smart Junction Experiences

Five of the nine authorities state they have no active consideration of or involvement in smart junction trials. Four authorities state they are either considering or currently implementing smart junctions in some way:

- Cambridgeshire County Council is currently carrying out smart junction trials with VivaCity in Cambridge (see Section 3.2.2.1)
- Peterborough City Council is also trialling smart junctions with VivaCity, to compare optimisation against MOVA on a Siemens controller. This is being trialled at the junction of London Road/Glebe Road/Fletton Avenue J001J
- Buckinghamshire Council is currently in discussions with VivaCity regarding a smart junction trial on a major junction in Aylesbury (A413 Buckingham Road / A4157 Elmhurst Road).

Additionally, Oxfordshire County Council is currently implementing a number of projects including air quality sensors at five signalised junction sites (use of Earthsense Zephry) and Dedicated Short-Range Communications (DSRC) at two sites (part of a Connected and Automated Vehicle (CAV) project).

3.2.3.5 Smart Junction Successes & Challenges

For those currently implementing smart junction trials, the survey asked about successes and challenges that have been experienced.

As discussed in Section 3.2.2.1, Cambridgeshire County Council has been comparing VivaCity implementation to MOVA during their ongoing trials. VivaCity has successfully controlled a stand-alone junction and achieved journey times similar to MOVA. Cambridgeshire County Council identifies that finding a benefit in the use of smart junctions is a challenge, especially as it is more costly than existing technology.

Peterborough City Council stated that although there have been issues concerning the compatibility between new technology and existing equipment, it has allowed an upskilling of signal technology where learnings have then been able to be applied elsewhere on the network.

Oxfordshire County Council has stated that it is a challenge to convert trials into business as usual.

3.2.3.6 Smart Junction Perceptions

Survey responses to the perception of the benefits of smart junctions were generally modest, with most respondents not able to answer the question with evidence. Five LTAs did not respond at all to this question. This raises a key issue that many LTAs may not have the awareness or understanding of the potential for smart junction technology. Additionally, a couple of LTAs, where it is understood that they are not currently involved in smart junction implementation, described that existing adaptive control is smart. Although it is not clear if this is the case, this links back to a possible confusion of the definition of a smart junction (see Section 2.1).

Buckinghamshire Council stated that it was hopeful that forthcoming smart junction trials would cope with high traffic flows better than existing technology, as they can more effectively adapt to changing conditions. Additionally, smart junctions being able detect and adapt to non-motorised users was seen as a key benefit.

However other authorities, not involved in smart junction trials, identified key barriers. One of the main barriers cited is capacity and capability within the LTA to implement such technology, where resource is considered scarce. Additionally, limited knowledge of the technology was apparent including definitions and potential benefits. There were also anticipated challenges to implementing, maintaining and evaluating the technology due to a lack of industry knowledge and expertise within the LTAs.

Another key barrier cited by six LTAs is cost and lack of funding. It was noted that costs include the cost of design, implementation, operation and maintenance which often mean the whole-life costs of systems are much higher than those of the initial trials. Additionally, the interoperability of technology and the need for common standards among systems was viewed as a potential barrier to implementation.

3.2.4 Summary

Table 3-1 summarises the challenges and opportunities found through LTA engagement.

<table>
<tr><th>Challenge</th><th>Opportunity</th></tr>
<tr><td>Lack of authority knowledge and skill including a lack of understanding or awareness of smart junctions and its benefits (see Section 9.2)</td><td rowspan="3">Upskilling workforce and applying knowledge and learnings to other existing technology or infrastructure</td></tr>
<tr><td>Interoperability and compatibility of technology and systems</td></tr>
<tr><td>Reluctance of authorities to new and unknown technology. This includes a change in traditional thinking (e.g. optimising traffic replaced with prioritising other attributes or modes) and controversies regarding possible worsening of vehicular delay</td></tr>
<tr><td>LTA resource</td><td rowspan="2">Expand funding sources where smart junction technology can benefit other modes and aspects (e.g. air quality, bus reliability) (see Section 9.2)</td></tr>
<tr><td rowspan="2">Lack of funding</td></tr>
<tr><td>Calibration of existing signals could deliver cost-effective benefits in the areas where signalised junctions already exist without large costs</td></tr>
<tr><td>Cost of design, implementation, operation and maintenance in comparison to existing technology</td><td>Business case opportunity to highlight smart junction benefits versus costs</td></tr>
</table>

Table 3-1: Summary of LTA Challenges & Opportunities to Smart Junction Technology from Engagement

Moreover, the survey demonstrated that many LTAs do not have a clear understanding of existing signal infrastructure, or at least do not have the data readily available perhaps due to a lack of resource, funding or communication between officers or teams:

- Five of the 11 respondents were able to provide a GIS layer of the signal junctions in their authority, but only one did provide this
- None of the LTAs contacted had a data layer of the technology that currently existed at each signal junction location.

4 Data Consolidation

4.1 Methodology

To understand the potential role of smart junctions in EEH, it is first necessary to understand current network performance and existing network infrastructure, including signalling infrastructure.

Due to funding constraints, this Study was not focused on sites that are not currently signalised and therefore is not an exhaustive exercise of assessing smart junction technology opportunities across the EEH region.

Given the scale of the EEH area, we have used a typology-based approach for our analysis. Figure 4-1 sets out the steps in our method. First, we mapped the existing network and infrastructure, then we mapped demand and performance. In the third step, we classified typologies from this analysis. Finally, we investigated the potential role and impact of smart junctions within each typology.

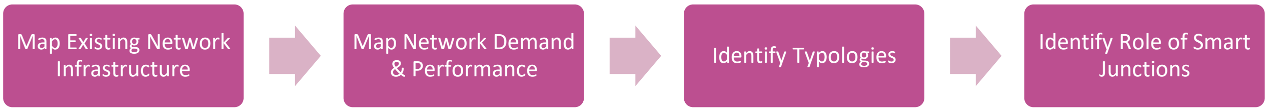

Figure 4-1: Overview of the Task Flow for Data Consolidation, Identify Typologies and Identify the Role of Smart Junctions

4.2 Existing Network Infrastructure

4.2.1 Network Types

Figure 4-2 shows the Major Road Network (MRN) and Strategic Road Network (SRN) in EEH, including typical diversion routes from the SRN enforced by National Highways. The SRN is owned and managed by National Highways and includes all motorways and some A-Roads. The MRN is owned and managed by the respective LTA, with many of these roads spanning multiple LTAs.

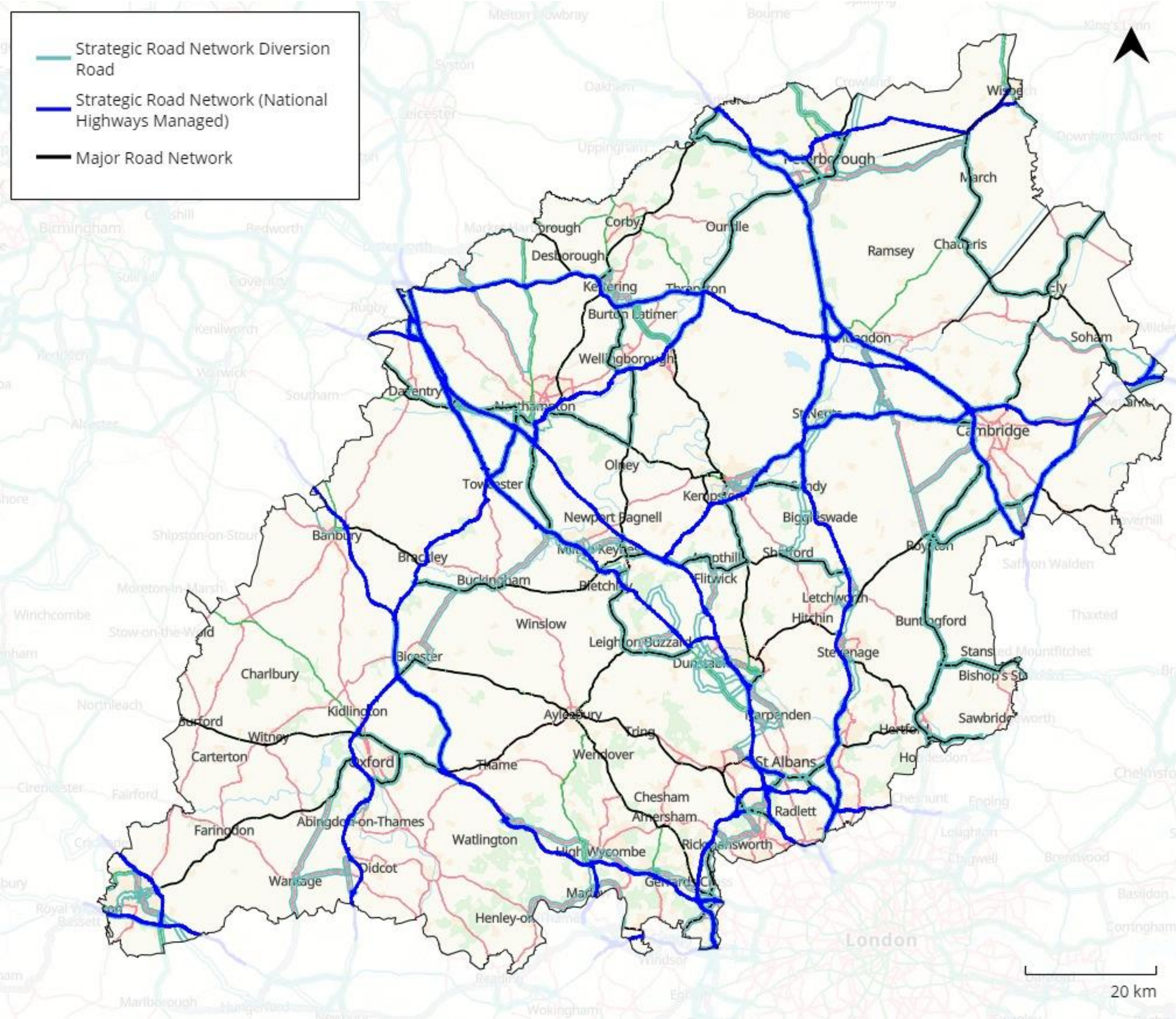

Figure 4-2: Strategic & Major Road Network Types in EEH

4.2.2 Air Quality

There are 73 Air Quality Management Areas (AQMAs) currently enforced in EEH, as shown in Figure 4-3. These have been detailed in Appendix C. Many of the AQMAs exist in urban areas, on local roads, where it is expected to be increased vehicular idling, stopping and starting. However, a number of AQMAs also exist on the SRN (such as the M40 in Buckinghamshire and the A34 outside Oxford) and the MRN (such as the A6 through Bedford and the A414 through Hertford) where there is increased motorised transport demand, including HGVs, and higher speeds.

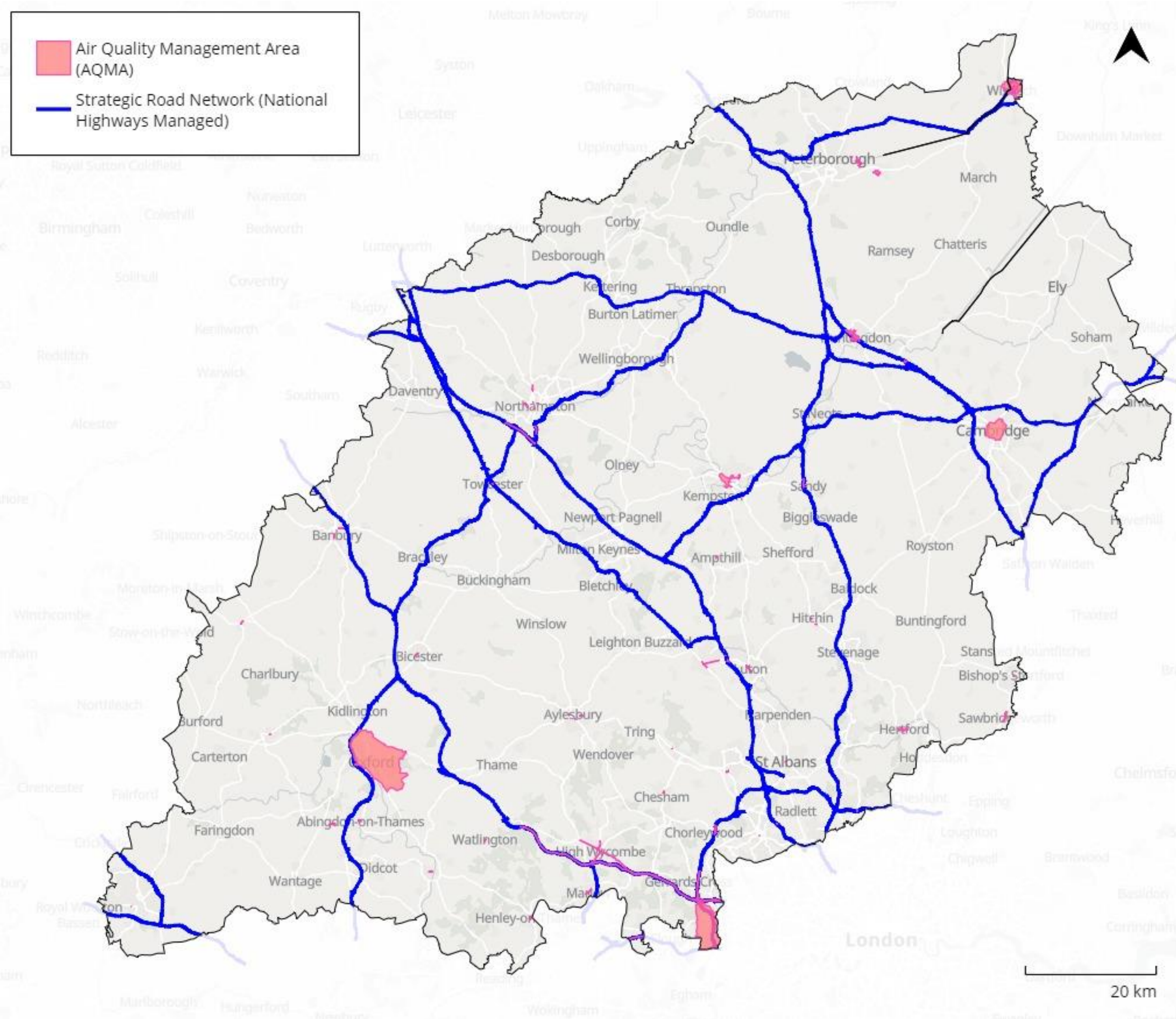

Figure 4-3: AQMAs in EEH (Source: DEFRA)

4.2.3 Signalised Junctions

4.2.3.1 Signalised Junction Locations

Figure 4-4 displays the existing signalised junctions in EEH. As expected, it shows a high concentration of signalised junctions in urban areas, such as Northampton, Peterborough and Swindon. There are also a number of signalised junctions along the MRN and local roads outside of the urban areas.

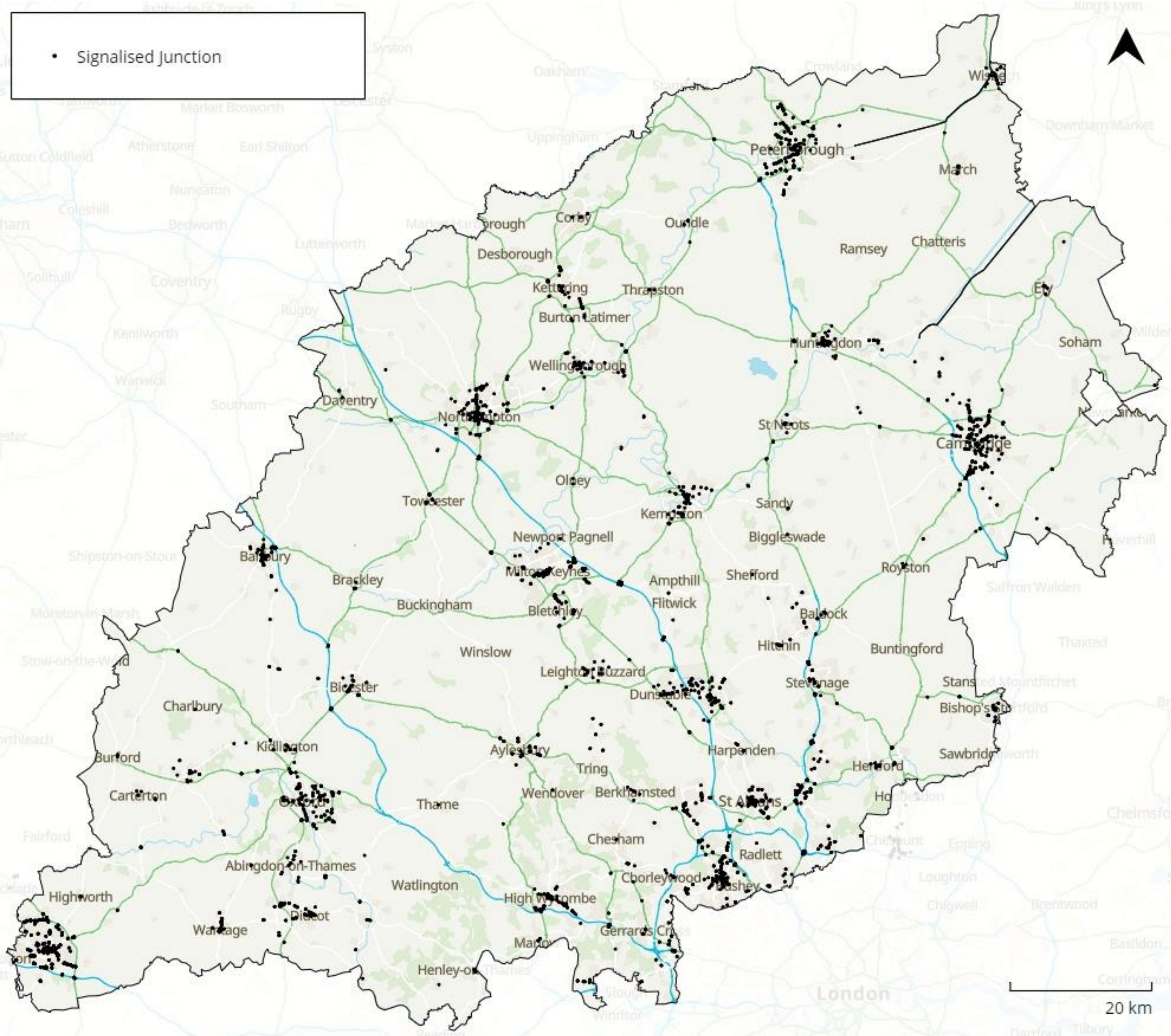

Figure 4-4: Signalised Junctions in EEH (Source: OpenStreetMap)

4.2.3.2 Smart Junctions Involvement

Based on vendor and LTA engagement (see Chapter 3), we have mapped our understanding of current involvement in smart junction technology by LTA.

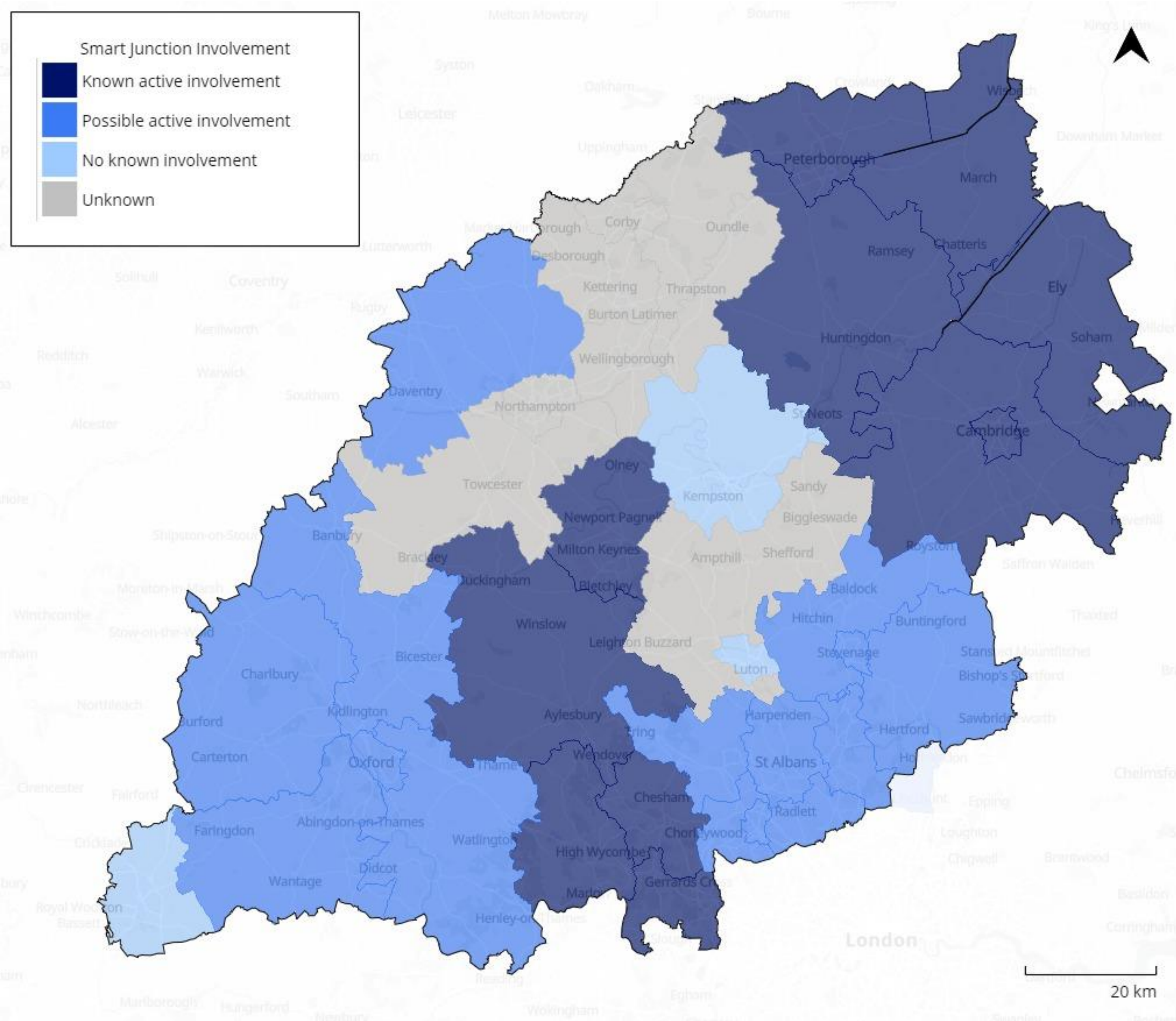

Figure 4-5: Current Known Smart Junction Involvement by LTA in EEH

4.2.4 Corridor Connectivity Studies

4.2.4.1 Current Studies

EEH is currently carrying out several connectivity studies on key corridors in the region (see Table 4-1). These studies consider connectivity solutions for inter-urban corridors to inform future investment.

Corridor Connectivity Study	Status
1: Milton Keynes – Oxford	Complete
2: Peterborough – Northampton – Oxford	Complete
3: Swindon – Didcot – Oxford	Complete
4: Thames Valley – Buckinghamshire – Milton Keynes - Northampton	Ongoing*
5: Southern East West Movements	Ongoing*
6: Luton – Bedford – Corby	Ongoing

*Table 4-1: Status of EEH Corridor Connectivity Studies (Correct May 2024) (*studies have since been completed)*

Figure 4-6 shows the priority corridors identified as a result of Corridor Connectivity Studies 1-3 that have finalised or are near completion.

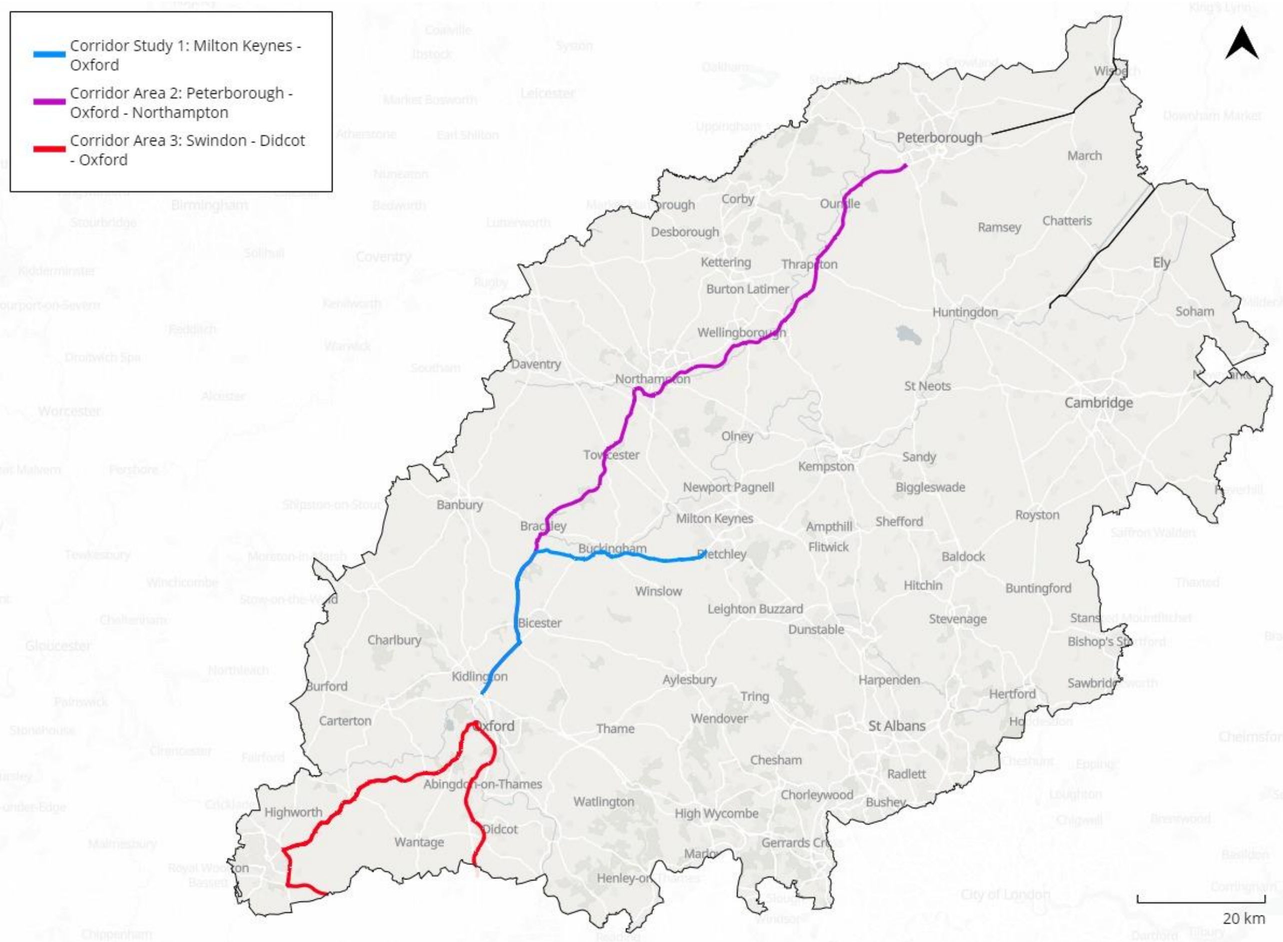

Figure 4-6: Previously Identified Connectivity Study Corridors in EEH (Source: EEH)

As Studies 4-6 are ongoing or commencing at the time of carrying out this Study, priority corridors have not yet been defined. For the purposes of this Study, Section 5.2 sets out the identification of priority corridors for Corridor Studies 4-6.

4.2.4.2 Oxford to Cambridge Connectivity Study

As part of the existing Oxford to Cambridge (OxCam) Connectivity Study, Atkins carried out the 'Oxford to Cambridge Area Connectivity: Roads Study' in 2022 for National Highways. As part of this, Atkins identified "priority areas" which consist of both links and junctions. These priority areas represent areas where there is an identified need for targeted road intervention. Atkins categorised these with three tiers of priority where Tier 1 is of the highest priority and Tier 3 is lowest priority. Priority areas are included in Figure 4-7 (note that lines represent links and dots represent junctions or broader areas). Appendix D details the priority area junction, link and area names.

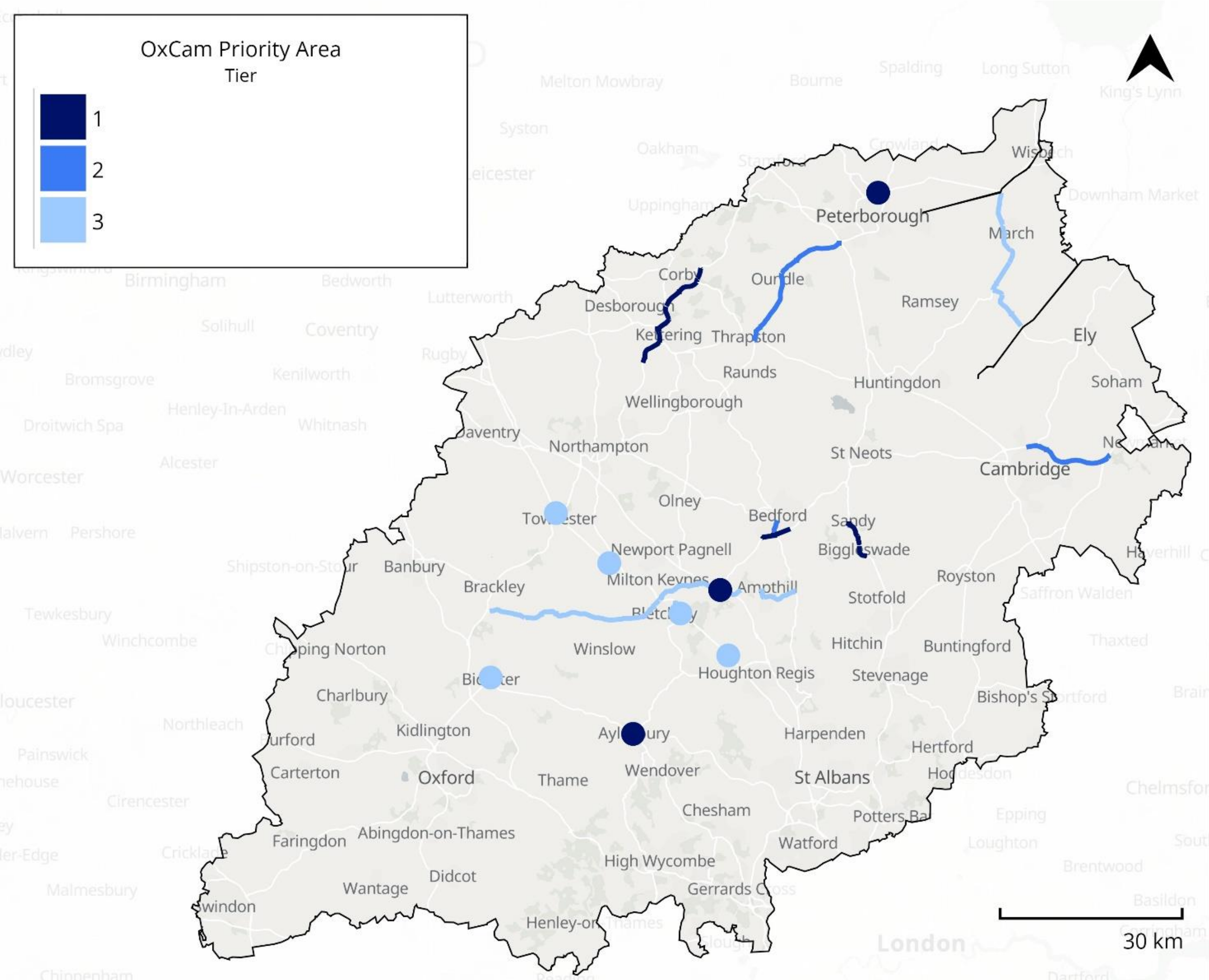

Figure 4-7: OxCam Priority Areas in EEH (Source: EEH, Atkins)

4.2.5 Public Bus

4.2.5.1 Key Bus Route Corridors

Public bus routes in the region have been analysed to understand where potential smart junctions on corridors may support key bus routes. A key bus route has been defined using service frequency but also where it provides more strategic connections between local authority areas.

Figure 4-8 shows where high frequency strategic bus routes exist, using service frequency (buses per hour (bph)) during weekday morning peak hours in 2022. A strategic bus routes has been defined by a bus route that crosses one or more local authority boundaries. A high frequency bus route has been defined using two categories, where the following exists in at least one recorded weekday in the data:

- At least two bph, but less than four buses per hour (a bus at least every 30 minutes, but more than every 15 minutes)
- At least four bph (a bus every at least every 15 minutes).

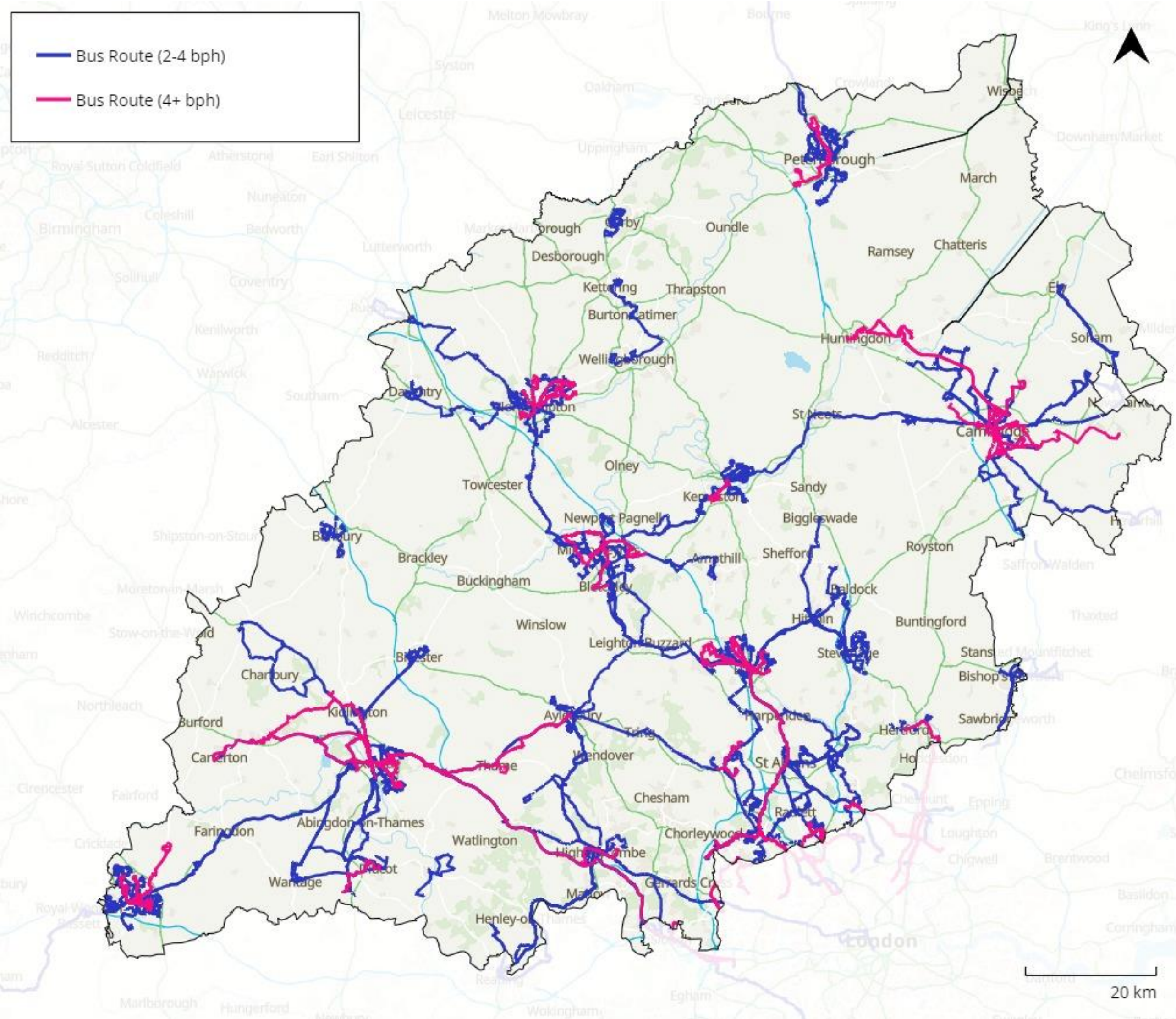

Figure 4-8: High Frequency Strategic Bus Routes in EEH (Provided by AtkinsRéalis sourced from National Public Transport Data Repository)

4.2.5.2 Bus Service Improvement Plan Funding

In April 2022, the Department for Transport (DfT) announced that around half of LTAs in England received Bus Service Improvement Plan (BSIP) funding as part of the National Bus Strategy. More recently, further LTAs were awarded BSIP Plus (BSIP+) funding. All LTAs within EEH have now received

BSIP and/or BSIP+ funding, with approximate total amount awarded (TransportXtra, 2022) (Route One, 2023):

- Bedford Borough Council (£0.5m)
- Buckinghamshire Council (£1.3m)
- Cambridgeshire & Peterborough Combined Authority (£2.3m)
- Central Bedfordshire Council (£0.4m)
- Hertfordshire County Council (£31.27m)
- Luton Borough Council (£19.1m)
- Milton Keynes Council (£0.7m)
- Oxfordshire County Council (£13.7m)
- West Northamptonshire Council (£0.7m)
- North Northamptonshire Council (£0.6m)
- Swindon Borough Council: (£0.4m).

According to the LTA survey response from Luton Borough Council (see Section 3.2.3.3), through BSIP funding, the council is implementing bus priority with the use of signal technology (TRL UTC and MOVA). The scheme is currently at its early stages but will be implemented at a minimum of six sites.

4.3 Network Performance

4.3.1 Methodology & Data Processing

To understand road network performance in EEH, we conducted an analysis of observed vehicular speed and journey time data using INRIX data provided by DfT. INRIX is a GPS data source that records journey time and average speed by vehicle class for network segments on motorways, A roads and B roads. Data was provided for the network in EEH and for 15-minute segments in 2022.

Analysis conducted for this Study uses the weekday morning peak period (i.e. 0700-1000) in June 2022 (chosen to reflect a neutral month outside of school holidays). The vehicle type "car" was analysed as a proxy for understanding network performance.

4.3.2 Speed Variability

To initially understand the overall speed variability, and therefore reliability, on the network, an average speed was calculated for each network segment type and percentile statistics were utilised.

This analysis uses the processed data (see Section 4.3.1) and therefore represents average speeds during the weekday morning peak period. Table 4-2 summaries the average speed at various percentiles for different network types.

Road Type	90%	75%	60%	45%	30%
Single Carriageway	46	36	28	24	20
Dual Carriageway	66	59	43	30	23
Traffic Island Link	41	32	26	23	20
Roundabout	38	33	29	26	23
Traffic Island Link at Junction	36	31	26	22	19
Slip Road	53	45	39	33	24

Table 4-2: Average Speed (mph) for Various Percentiles by Road Type in EEH, Morning Peak Period in June 2022 (Source: DfT INRIX)

The data shows that the lowest speeds are observed at junctions (including roundabouts) rather than on links, and there is a wider range of speeds on dual carriageways compared to other road types.

4.3.3 Level of Service

To help further depict the congestion experienced on the road network in EEH, we adopted a level of service definition with six levels. These are defined as having an observed average speed during the weekday morning peak period that is:

- A: faster than the 90% percentile of the vehicles' speeds (e.g. 46mph on a single carriageway)
- B: between the 75% and 90% percentiles of the vehicles' speeds
- C: between the 60% and 75% percentiles of the vehicles' speeds
- D: between the 45% and 60% percentiles of the vehicles' speeds

- E: between the 30% and 45% percentiles of the vehicles' speeds
- F: slower than the 30% percentile of the vehicles' speeds (e.g. 20mph a single carriageway).

Utilising the processed INRIX data (see Section 4.3.1), level of service on the EEH network has been mapped in Figure 4-9. This data is utilised further in the congestion and benefits analysis (see Chapters 6 and 7, respectively).

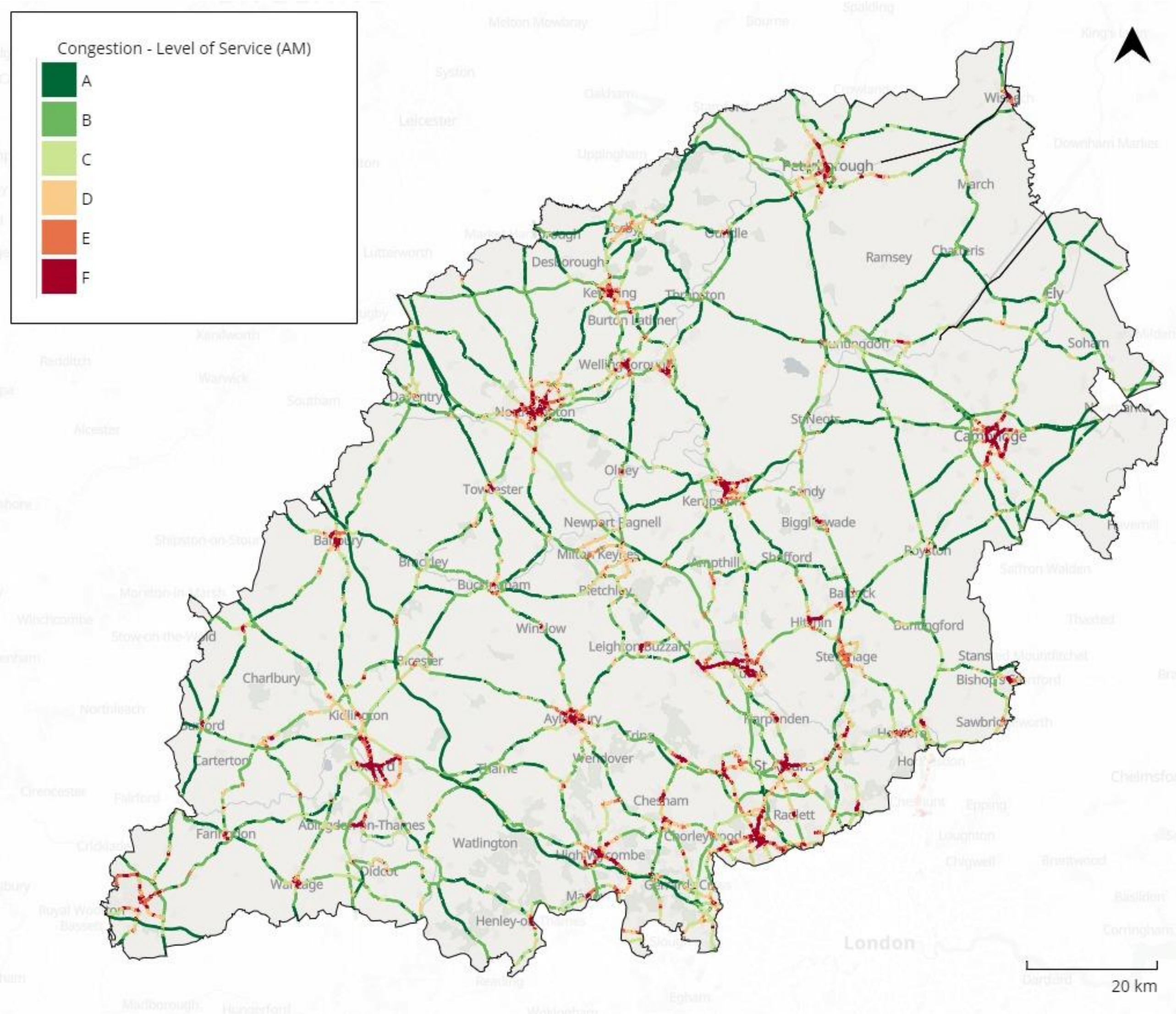

Figure 4-9: Network Level of Service in EEH, Morning Peak Period in June 2022 (Source: DfT INRIX)

5 Network Focus & Typologies

5.1 Typology Definitions

We have identified typologies for existing signalised junctions based on road type and who they are managed by. This allows an identification of potential opportunities at these locations should smart signal technology be deployed. Table 5-1 sets out typologies based on road type (strategic or major road, or an urban area) including who it is managed by.

Typology Junction Type	Managed by	Expected Mode Impact			
		Car/LGV	HGV	Bus	Ped/Cycle
SRN	National Highways	✓	✓		
MRN	LTA	✓	✓	✓	
MRN/SRN	Mix of LTA/National Highways Owned	✓	✓	✓	
Urban		✓		✓	✓

Table 5-1: Typologies & Expected Mode Impacts

5.2 Network Focus

5.2.1 Background & Methodology

This section sets out the areas of focus for this Study, and how these have been developed. In line with the defined typologies (see Section 5.1), focus areas consist of network corridors and urban areas.

There has been a significant volume of work designated to the EEH Corridor Connectivity Studies (see Section 4.2.4) and the prioritisation of routes and corridors in the region. This has been supported by significant data analysis and stakeholder engagement. The corridor studies have therefore been used to geographically focus this Study, making use of existing work to prioritise and identify this Study's corridors of focus (see Section 5.2.2) and urban areas of focus (see Section 5.2.3).

5.2.2 Focus Corridors

5.2.2.1 Completed Corridor Studies

As set out in Section 4.2.4, at the time of writing, Corridor Studies 1-3 have completed and have identified priority corridors. These identified priority corridors have been adopted for this Study's focus corridors. In addition, the OxCam Priority Areas have also been adopted (mixture of identified corridors and junctions). For simplicity, these are hereby referred to as corridors (in the context of focus corridors).

5.2.2.2 Forthcoming Corridor Studies

At the time of carrying out this Study, the remainder of the Corridor Studies (4-6) are forthcoming and, at the time of carrying out the analysis, did not have identified priority corridors. For the purposes of this Study, in using these forthcoming Corridor Studies, focus corridors were identified based on:

- Corridor Study geographical study area (provided by EEH)
- Presence of signalised junctions (see Section 4.2.3) on the corridor links
- Presence of high demand (>30,000 vehicles per day) on the corridor links, based on 2021 DfT Annual Average Daily Flow (AADF)
- Strong commuting demand (>1,000 commuters) between two areas linked by the corridor, established using Census 2011 Travel to Work data.

This resulted in the definition of a further eight focus corridors, as agreed with EEH.

5.2.2.3 Summary of Defined Corridors of Focus

Once the focus corridors were mapped, it was apparent that there was a gap in the east of EEH as well as a lack of east-west corridors, reflecting the current poor east-west road connectivity in EEH. To address this, a further focus corridor was added, Cambridge - St Neots - Milton Keynes, which reflected the above criteria.

Table 5-2 summarises the focus corridors and their segments, including the area of EEH that they are in, and the links that the focus corridors cover.

Ref	Corridor Area	Focus Corridor	Link(s)
A	Oxford - Milton Keynes	Oxford - Milton Keynes	A34/M40/A43/A421
B	Oxford - Northampton - Peterborough	Oxford - Northampton	A34/M40/A43
		Northampton - Peterborough	A45/A605
C	Oxford - Swindon - Didcot	Oxford - Swindon	A420
		Swindon - Didcot	M4/A34
D	Thames Valley - Buckinghamshire - Milton Keynes - Northampton	Hemel Hempstead - Watford	A41
		Northampton - Milton Keynes	A508
		Milton Keynes - Luton	A5/M1
		Dunstable - Luton - Hitchin - Stevenage	A505/A602
E	Southern East West Movements	High Wycombe - Gerrards Cross	A40
F	Luton - Bedford - Corby	Luton - Bedford	A6
		Bedford - Corby	A6/A45/A6116
G	Cambridge - St Neots - Milton Keynes	Cambridge - St Neots	A1303/A428
		St Neots - Milton Keynes	A1/A421
H	Oxford – Cambridge*	A1: Sandy – Biggleswade	A1/A603
		M1 J13	A421/M1/A507
		A1139	A15/A16/A47
		A6/A421	A5141/A6/A421
		Aylesbury	N/A
		A605	A1(M)/A1/A1139/A14
		A43 Corby & A43 Broughton	A14/A6183/A6003/A427
		A14 J33 & J36	A10/A1309/A1303
		A5141	A5140/A5134
		A421	A4421/A413/A4146
		A141/142	A47/A605/
		A43/A5 Roundabout 12	A43/A5
		A5 Old Stratford Roundabout	A5/A508/A422
		A5 Kelly's Kitchen Roundabout	A5/A4146
		A5 Hockliffe	A5/A4012
		Bicester	N/A
		A507	A5120/A6

*Table 5-2: Summary of Focus Corridors for this Study (*due to the nature of the OxCam Priority Areas, a mixture of junctions and corridors are listed for this Corridor Area)*

5.2.3 Focus Urban Areas

In line with the urban area typology (see Section 5.1), Census Built Up Areas were used to define focus urban areas. Those selected for this Study were based on the focus corridors (see Section 5.2.2), using their start and end points. These are set out in Table 5-3.

Urban Area of Focus	Associated Corridor Area Reference
Oxford	A, B, C
Milton Keynes	A, D, G, H
Northampton	B, D
Peterborough	B, H
Swindon	C
Didcot	C
Hemel Hempstead	D
Watford	D
Dunstable	D
Luton	D, F
Stevenage	D
High Wycombe	E
Gerrards Cross	E
Bedford	F, G, H
Corby	F, H
Cambridge	G, H
St Neots	G
Buckingham	A, H
Bicester	H
Aylesbury	H

Table 5-3: Summary of Urban Areas of Focus for this Study

5.2.4 Network Focus Summary

Figure 5-1 displays the resulting focus corridors (shown by corridor areas) and focus urban areas for this Study.

Where corridors and urban areas intersect, the corridor has been retained where the corridor is a strategic through route between focus urban areas. For example, the focus corridor Northampton - Milton Keynes - Luton passes through Milton Keynes and the corridor intersects with the urban area. The corridor has been retained in this case, as it is viewed as a strategic route between urban areas (Northampton and Luton). However, in other cases, the strategic corridor has been ended at the urban area boundary as it does not reflect a strategic through route reflected in the focus corridors.

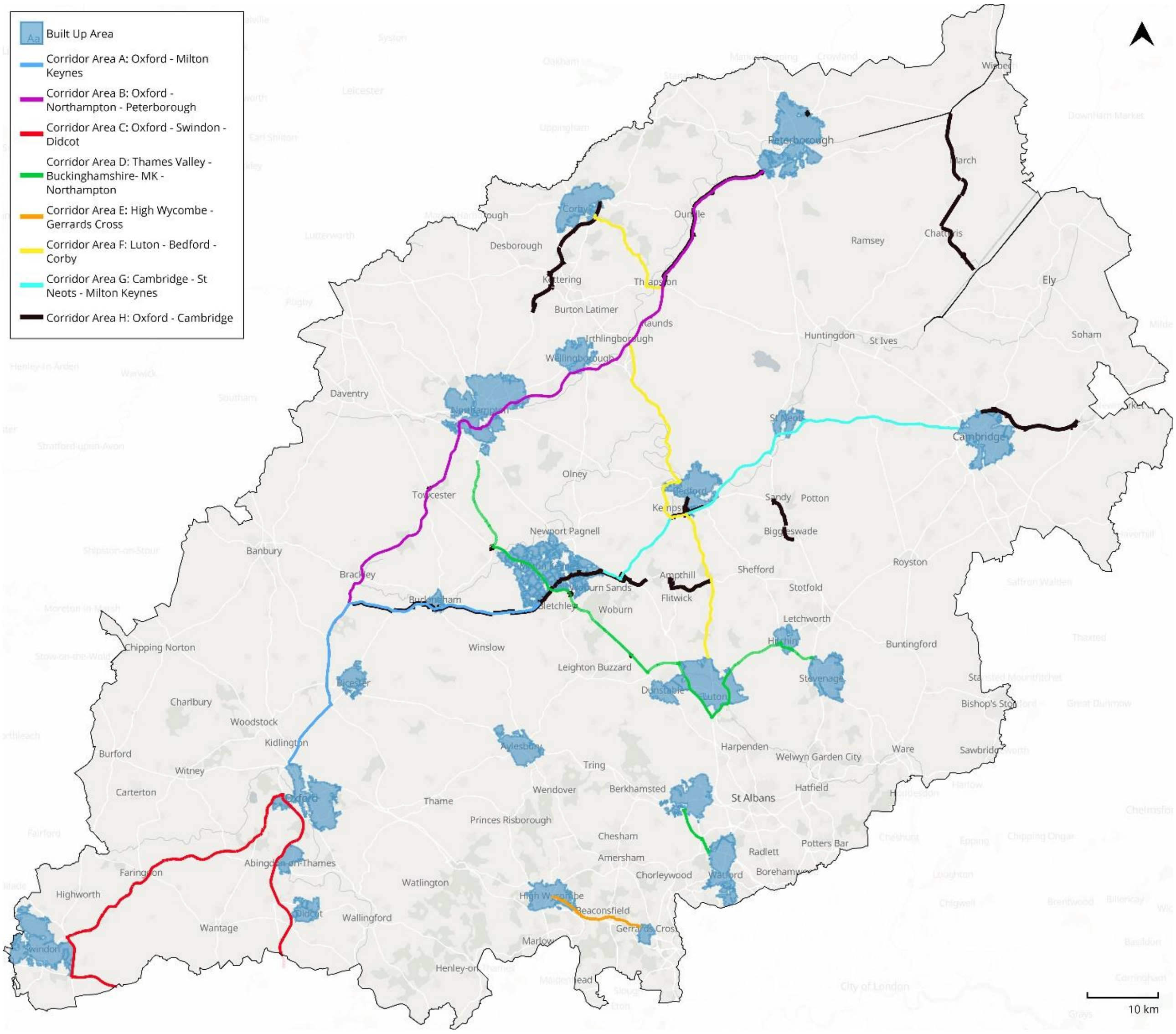

Figure 5-1: Map of Focus Corridors & Focus Urban Areas in EEH (Source: ONS, EEH)

6 Congestion Analysis

One key expected benefit of smart junction technology is its potential to reduce vehicular journey times and alleviate congestion (see Section 2.3). Therefore, this Chapter seeks to understand whether, using the focus corridors, there are congestion issues on the EEH network that could benefit from smart junction technology.

6.1 Corridor Level of Service

Using the focus corridors identified in Section 5.2 and the levels of service defined in Section 4.3.3, congestion has been analysed at a corridor level and is summarised in Table 6-1. Also included is a proportional length of the corridor that is within service levels D, E or F, the slowest proportional speed categories.

The analysis also includes the length of the corridor and the number of signalised junctions on the corridor. This helps evaluate the possible impact smart junction technology could have based on the potential frequency of smart junction technology.

Ref	Corridor Area	Corridor	Approx. Length (km)	Average Level of Service	Length of Level of Service D-F (%)	Signalised Junctions
A	Oxford - Milton Keynes	Oxford - Milton Keynes	87	C	11%	2
B	Oxford - Northampton - Peterborough	Oxford - Northampton	132	C	11%	2
		Northampton - Peterborough	89	B	5%	3
C	Oxford - Swindon-Didcot	Oxford - Swindon	83	B	6%	3
		Swindon - Didcot	-	-	-	1
D	Thames Valley - Buckinghamshire - Milton Keynes - Northampton	Hemel Hempstead - Watford	17	D	37%	2
		Northampton - Milton Keynes	58	C	32%	3
		Milton Keynes - Luton	55	C	9%	2
		Dunstable - Luton - Hitchin - Stevenage	59	E	27%	1
E	Southern East West Movements	High Wycombe - Gerrards Cross	22	D	30%	3
F	Luton - Bedford - Corby	Luton - Bedford	47	C	13%	1
		Bedford - Corby	103	B	6%	1*
G	Cambridge - St Neots - Milton Keynes	Cambridge - St Neots	49	B	1%	1
		St Neots - Milton Keynes	77	B	6%	2
H	Oxford - Cambridge	A1: Sandy-Biggleswade	16	C	10%	0
		A6/A421	13	B	3%	1

Ref	Corridor Area	Corridor	Approx. Length (km)	Average Level of Service	Length of Level of Service D-F (%)	Signalised Junctions
		A605	49	B	5%	2
		A43 Corby & A43 Broughton	44	C	16%	4
		A14 J33 to J36	36	B	4%	2
		A5141	5	F	91%	5
		A141/A142	50	A	2%	1
		A421	85	A	20%	1
		A507	15	B	12%	0

*Table 6-1: Average Level of Service by Focus Corridor (*forthcoming signalised junction)*

Corridors where at least approximately a third of the corridor has level of service D, E or F (meaning the morning peak hour speed is at most 60% of the average speed) include:

- Hemel Hempstead - Watford
- Northampton - Milton Keynes
- Dunstable - Luton - Hitchin - Stevenage
- High Wycombe - Gerrards Cross
- A5141 (OxCam Priority Area).

6.1.1 Assumptions

Please note that several assumptions were applied when carrying out this congestion analysis, due to the data that was provided:

- Distances and levels of service calculated for each corridor average over both directions (e.g. Oxford to Milton Keynes and Milton Keynes to Oxford)
- Each corridor extends to the beginning of the built-up area and therefore excludes the corridor distance within the built-up area
- It was found that the provided data generally overestimates the actual length of the corridors due to the detail of the corridor links and possible inclusion of additional links in roundabouts and junctions
- The absence of data for the Swindon - Didcot corridor is due to some of the corridor (part of the M4) being outside of the EEH region.

6.2 Inter-Urban Journey Time Analysis

Another area of investigation into vehicular congestion is understanding the congestion experienced in urban areas. To determine this, we analysed journey times between urban areas through a comparison between journeys that start/end in an urban area's centre, compared to its outskirts.

In all cases, the journey time is greater for journeys to and from an urban area's centre compared to its outskirts. However, this analysis seeks to identify where the journey time is proportionally much greater for the portion of the journey that is entering or existing an urban area. For example, a journey may be 9 miles between two urban centres but 6 miles between their outskirts. For this 33% increase in journey distance, we would expect a similar increase in journey time. However, in most cases, the journey time increase is proportionally greater than the distance increase, denoting that slower speeds, and perhaps greater congestion, is experienced entering and exiting an urban area.

The analysis was carried out for the urban focus areas and can be found in Appendix E. The analysis also included a note as to whether a P&R exists, which could suggest the tackling of outer to inner urban area congestion. The analysis broadly suggests:

- The greatest differences in journey time and distance variability between the two journey types (denoting the greatest urban congestion and slower speeds) occur for:
  - Oxford to Northampton
  - Swindon to Didcot
  - Northampton to Milton Keynes
  - Stevenage to Luton
- P&Rs are available at two of these destinations (Milton Keynes and Luton)
- Nearly half of the corridor journeys analysed (14 out of 30) have relevant P&Rs available at the outskirts of their respective urban area destinations.

7 Benefits Analysis

7.1 Methodology

7.1.1 Appraisal Framework

Drawing on the literature review (see Chapter 2), we identified several known or anticipated key overarching benefits of smart signalised junction technology ("Themes"). These themes are central to the development of a benefits appraisal framework that appraises the focus corridors and focus urban areas, with a view to identify and prioritise opportunities for potential smart junction technology.

Based on available spatial data, we developed several metrics to represent and appraise against each identified theme (see Table 7-1). The table also denotes whether the metric is applicable to corridors and/or urban areas. The analysis assumes only the upgrade of existing signalised junctions with smart junction technology, as opposed to identifying non-signalised junctions that could be signalised with smart junction technology.

As some technology vendors are not able to offer the functionality of linking smart junction technology, this has been excluded from the scoring for corridor signal junctions. Instead, it has been included as additional information in the results.

Theme	Potential Benefit	Metric	Data Source	Criteria	Corridor	Urban Area
Safety	Reduction in collisions	Number of collisions	DfT STATS19	Number of collisions in junction buffer	✓	
Congestion	Reduction in vehicular congestion /increase in vehicular journey time	Observed congestion	DfT INRIX (see Section 4.3)	Average level of service on junction arms	✓	
Air Quality	Reduction in air pollutants due to smoother driving behaviours and less idling due to reduced congestion	AQMA	DEFRA AQMA boundary	Presence of an AQMA		✓
	Reduction in occurrences of HGVs stopping and starting at signals	Proportion of HGVs	DfT INRIX (see Section 4.3)	Average HGV proportion on junction arms	✓	
Active Travel Safety	Improve active travel safety through mode specific identification and prioritisation	Collisions involving active modes	DfT STATS19	Collisions involving a pedestrian or cyclist (proportional to number of junctions)		✓
Public Bus Reliability	Prioritise public buses at junctions and improve reliability	Key Bus Corridors	Map of high frequency strategic bus routes	Presence of key bus corridor	✓	
Impact	Number of vehicles impacted by the smart junction technology	Vehicular demand	DfT AADF (2021)	Total daily junction throughput	✓	

	Potential scale of impact based on number of signalised junctions	Number of signalised junctions	OSM (see Section 4.2.3)	Count of current signalised junctions		✓
	Potential for integrated technology along a corridor or within an urban area			Presence of multiple signalised junctions along corridor*	✓	

*Table 7-1: Summary of the Benefits Appraisal Framework (*included but does not contribute to scoring)*

7.1.2 Scoring Methodology

Scores were developed to identify where there is the **greatest opportunity to address issues at existing signalised junctions** and the potential impact that smart junction technology could have to address these, reflecting the Literature Review.

High scores therefore reflect that there is both a greater need for smart junction technology at these locations but also the potential for greater impact.

7.1.2.1 Focus Corridors

For the assessment of each corridor, the relevant spatial data was obtained, mapped and intersected with the corridor and its signal locations (or for Corridor Area H, the identified junction if this is currently signalised). This resulted in data against each of the criteria in Table 7-1 for each of the signal locations along the focus corridors.

For each criterion, we developed a score between 0 and 4. Scores provided for signalised junctions on focus corridors are out of a possible total of 20, reflecting that five metrics (each with a potential to score 4) have been used to score these signalised junctions.

7.1.2.2 Focus Urban Areas

For the assessment of each urban area, the relevant spatial data was obtained, mapped and intersected with the focus urban areas. This resulted in data against each of the criteria in Table 7-1 for each of the urban areas.

Scoring was carried out at an urban area level, as opposed to at a junction level, due to the vast number of signalised junction locations in the urban areas.

To prevent the size of urban areas leading to a bias for higher scores, the land area was used to scale the number of recorded collisions involving a pedestrian or cyclist and the number of signalised junctions in the focus urban area. This means that focus urban areas with a low ratio of existing signalised junctions and/or collisions per unit measure of land area will score poorly compared to those with higher ratios.

Similar to focus corridors, we developed a score between 0 and 4 for each criterion. Scores provided for focus urban areas are out of a possible total of 12, reflecting that three metrics (each with a potential to score 4) have been used to score these focus urban areas.

7.1.2.3 Combining Scores

Once scores have been obtained for each signal junction on the focus corridors and for each focus urban area, they were added to combine them. No weightings were applied to the metrics and are equally weighted across all themes.

7.2 Results & Opportunities Scan

7.2.1 Focus Corridors

7.2.1.1 Highest Scoring Signalised Junctions

Table 7-1 summarises the top scoring signalised junctions on the focus corridors, alongside the LTA it resides in, the score and the reason for the high score. As stated in Section 7.1.2, scores were developed to identify where there is the greatest opportunity to address issues at existing signalised junctions and the potential impact that smart junction technology could have to address these. High scores therefore reflect that there is both a greater need for smart junction technology at these locations but also the potential for greater impact.

Junction	Corridor	LTA	Typology	Score (/20)	Reason for High Score
A1/A602	Dunstable - Luton - Hitchin - Stevenage	Hertfordshire County Council	MRN/ SRN	15	• Very high junction collisions • High congestion • High demand • Supports very high frequency strategic bus routes
A1/A421	Cambridge - St Neots	Bedford City Council	SRN	13	• Very high HGV proportion • High congestion • Supports high frequency strategic bus routes
M25/A41	Hemel Hempstead - Watford	Hertfordshire County Council	MRN/ SRN	12	• Very high demand • High junction collisions
M40/A41	Oxford - Milton Keynes	Oxfordshire County Council	MRN/ SRN	12	• Very high junction collisions • High demand
M4/A419	Swindon - Didcot	Swindon Borough Council	MRN/ SRN	12	• Very high junction collisions • High congestion • High demand
M1 J13	St Neots – Milton Keynes	Central Bedfordshire	MRN/ SRN	12	• Very high HGV proportion • High congestion
M40/A43	Oxford - Milton Keynes	Oxfordshire County Council	SRN	11	• High HGV proportion • High congestion • High demand
A45/ A5076	Oxford - Northampton	West Northampton-shire Council	MRN	11	• High junction collisions • High congestion • High demand
A34/ A420	Oxford - Swindon	Oxfordshire County Council	MRN/ SRN	11	• Very high congestion • High demand • Supports high frequency strategic bus routes
A420/ Thornhill Rd		Swindon Borough Council	MRN	11	

Junction	Corridor	LTA	Typology	Score (/20)	Reason for High Score
A421/ A5130 (Newport Road)	St Neots – Milton Keynes	Milton Keynes Council	MRN	11	• Very high congestion • Supports high frequency strategic bus routes

Table 7-2: Summary of Highest Scoring Signalised Junctions on Focus Corridors

7.2.1.2 Summary of Opportunities

Table 7-3 summarises the scores for these top scoring signalised junctions on the focus corridors. The scores are given against each of the benefits previously identified in the framework (see Table 7-1). High scores therefore reflect that there is both a greater need for smart junction technology at these locations but also the opportunity for greater impact.

It is recognised that there are junctions outside of the top scoring junctions and those identified that would also see benefits from the use of smart junction technology, including benefits that may not be captured in the appraisal methodology utilised for this Study. These junctions and a broader methodology could be incorporated into further or more localised studies on the benefits of smart junction technology.

Theme	Benefit	A1/ A602	A1/ A421	M25/ A41	M40/ A41	M4/ A419	M1 J13	M40/ A43	A45/ A5076	A34/A420	A420/Thornhill	A421/A5130
Safety	Reduction in collisions	4	2	3	4	4	2	1	3	1	0	2
Congestion	Reduction in vehicular congestion/increase in vehicular journey time	3	3	2	2	3	3	3	3	4	4	4
Air Quality	Reduction in air pollutants due to smoother driving behaviours and less idling due to reduced congestion*	3	3	2	2	3	3	3	3	4	4	4
	Reduction in occurrences of HGVs stopping and starting at signals	2	4	2	2	2	4	3	1	1	2	1
Active Travel Safety	Improve active travel safety through mode specific identification and prioritisation	N/A										
Public Bus Reliability	Prioritise public buses at junctions and improve reliability	3	2	1	1	1	1	1	1	2	2	2
Impact	Number of vehicles impacted by the smart junction technology	3	2	4	3	3	2	3	3	3	3	2
	Potential for integrated technology along a corridor or within an urban area**			✓	✓		✓	✓	✓	✓	✓	

*Table 7-3: Summary of Opportunities for Highest Scoring Signalised Junctions on Focus Corridors (*assumed based on score for Congestion theme) (**does not contribute to final scores)*

7.2.2 Focus Urban Areas

7.2.2.1 Highest Scoring Urban Areas

Table 7-4 summarises the top scoring focus urban areas, alongside the LTA it resides in, the score and the reasoning for the high score.

All top scoring urban areas are within an AQMA. The majority of the high scores reflect the greater number of signalised junctions in the urban area and the therefore the opportunity for smart junction technology.

Alongside Oxford and Cambridge, Abingdon-on-Thames was also identified has having a relatively high number of collisions involving a pedestrian or cyclist (proportional to its size). However, the high propensity of walking and cycling in these urban areas is likely distorting the assessment for these focus urban areas.

Urban Area	LTA	Number of Signalised Junctions	Score (/12)	Reasoning
Cambridge	Cambridgeshire County Council	214	12	• Very high number of collisions involving a pedestrian or cyclist • Very high number of signalised junctions • Presence of an AQMA
Oxford	Oxfordshire County Council	168	10	• High number of collisions involving a pedestrian or cyclist • High number of signalised junctions • Presence of an AQMA
Swindon	Swindon Borough Council	238	8	• Very high number of signalised junctions • Presence of an AQMA
Watford	Hertfordshire County Council	171	7	• High number of signalised junctions • Presence of an AQMA

Table 7-4: Summary of Highest Scoring Focus Urban Areas

7.2.2.2 Summary of Opportunities

Table 7-5 summarises the scores for these top scoring urban areas. The scores are given against each of the benefits previously identified in the framework (see Table 7-1). High scores therefore reflect that there is both a greater need for smart junction technology in these areas but also the opportunity for greater impact.

Theme	Benefit	Potential Scale of Impact by Priority Urban Area			
		Cambridge	Oxford	Swindon	Watford
Safety	Reduction in collisions	N/A			
Congestion	Reduction in vehicular congestion/increase in vehicular journey time	N/A			
Air Quality	Reduction in air pollutants due to smoother driving behaviours and less idling due to reduced congestion	4	4	4	4

Theme	Benefit	Potential Scale of Impact by Priority Urban Area			
		Cambridge	Oxford	Swindon	Watford
	Reduction in occurrences of HGVs stopping and starting at signals	N/A			
Active Travel Safety	Improve active travel safety through mode specific identification and prioritisation	4	3	1	1
Public Bus Reliability	Prioritise public buses at junctions and improve reliability	N/A			
Impact	Number of vehicles impacted by the smart junction technology	N/A			
	Potential scale of impact based on number of signalised junctions	4	3	4	3

Table 7-5: Summary of Opportunities for Highest Scoring Urban Areas

Focus urban areas have been selected based on their potential to support focus corridors. This reflects how smart junctions can support corridor movements where they involve connections into and out of these urban areas. However, it is likely that there are areas not identified as being high scoring in this Study that would be suitable for and benefit from smart junctions, including those where smart junctions can support strategic movements. For example, several urban or built-up areas in the region, such as Aylesbury, have strategic inner ring roads which support strategic transport demand. Smart junction technology can therefore look to distinguish and prioritise between local and strategic or through movement demand or between local modes such as public bus, walking and cycling and all other traffic.

7.2.3 Results Summary

Figure 7-1 spatially displays the highest scoring signalised junctions on the focus corridors and the highest scoring urban areas.

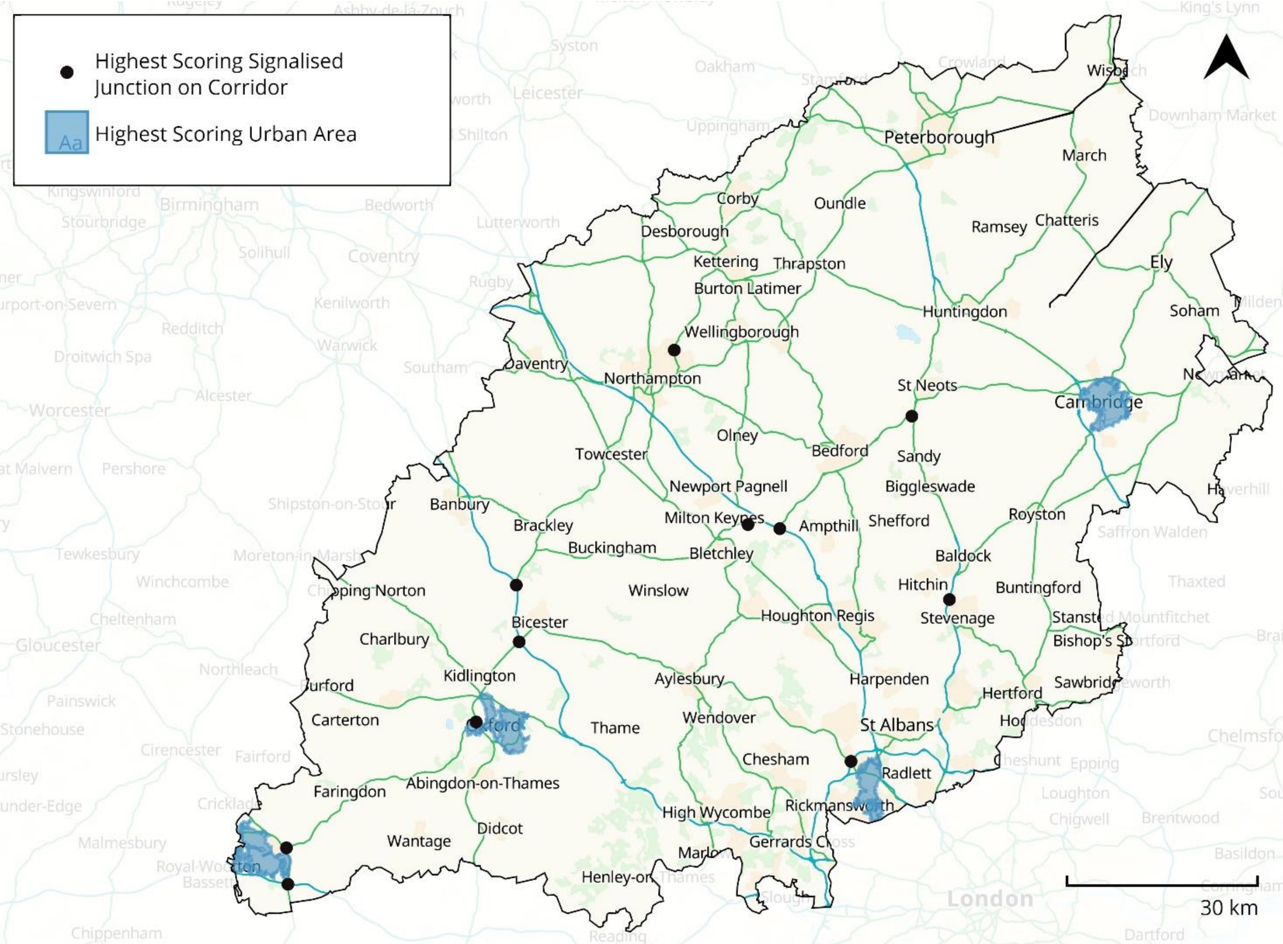

Figure 7-1: Map of Highest Scoring Signalised Junctions and Urban Areas in EEH

8 Cost Analysis

Through engagement with a technology vendor, an initial analysis of the cost of smart junction technology has been carried out. As the identified opportunities are currently in their early stages, costs are high level and have several dependencies and assumptions but are provided as a general guide for next steps. It is recommended that further cost consultation is carried out as opportunities are further developed.

Through this Study, we have assumed only opportunities for upgrading existing signalised junctions to include smart junction technology. This assumption has been reflected in the engagement summarised in this Chapter.

8.1 Vendor Engagement

Costs vary depending on the complexity of the junction, dictated by factors including:

- The number of junction arms and approach lanes
- Sensor functions e.g. ANPR capabilities, safety features
- Data outputs required i.e. classified counts, speed and dwell times
- Number of modes involved and required to be detected.

There is also an economy of scale at play; the cost per junction is reduced as further junctions are included, partly due to shared hardware.

The vendor quoted a price of £25,000 - £40,000 depending on the above factors. There are also ongoing plans to reduce the cost as technology develops and efficiencies are made, as well as the need to remain competitive on the market.

This cost includes installation, ongoing maintenance, a five-year warranty and ongoing data and support.

8.2 Cost vs Benefit Analysis

8.2.1 Cost of Traditional Road Infrastructure

The cost of major or strategic road infrastructure schemes varies but is significant and can easily run into the hundreds of millions for upgrades and billions for new roads such as bypasses or capacity increases such as dualling. For example:

- Capacity upgrades at M42 J6 at £282 million (National Highways, 2023a)
- Grade separation on the A46 at £61 million (National Highways, 2023b)
- A46 Newark Bypass at £400-500 million (National Highways, 2023c)
- A9 and A96 dualling at £3 billion (Scottish Construction Now, 2021).

8.2.2 Cost vs Benefit of Traditional Road Infrastructure

For traditional road infrastructure schemes, the cost will need to be outweighed by its economic benefit to be viable. The economic benefit will comprise of (and in many cases be significantly dominated by) journey time saving benefits to its users.

For example, the current value of time for a car driver who is commuting (non-working time) is £9.95 per hour (market price, 2010 prices, 2010 values) (Department for Transport, 2023). Put simply, to calculate the economic benefit of a journey time saving of a scheme, the journey time saving will be multiplied by the number of people or vehicles benefitted per day, the number of days in a 60-year appraisal period and the value of time for each trip purpose type. To demonstrate the scale of economic benefit that journey time savings can bring, a 30-second saving that benefits 30,000 commuters per day (assuming commuting daily and 260 working days in a year) would bring about approximately a £38 million benefit.

Additional economic cost savings that could be included in a business case include:

- Safety improvements resulting in a reduction in collisions
- Air quality improvements resulting in an improvement in health
- Wider economic impacts including improved access to markets and agglomeration impacts.

8.2.3 Potential Cost vs Benefit of Smart Junction Technology

Although the likely journey time savings due to smart junction technology is yet to be fully evidenced, the scale of the cost compared to traditional road infrastructure makes it much more likely that the journey time economic benefit will outweigh the lower costs.

It's important to note here that, as found as part of our LTA engagement (see Section 3.2.4), the calibration of existing signals could deliver cost-effective journey time saving benefits in the areas where signalised junctions already exist, without employing smart junction technology, and could offer a 'quick win'.

9 Conclusion & Recommendations

9.1 Conclusion

This Study is an initial strategic and high-level review of the benefits and opportunities of smart junction technology in EEH, with a focus on priority corridors and existing signalised junctions.

This report summarises the current literature outlining the potential benefits of smart junction technology, supplemented by engagement with vendors to understand the current opportunities in the UK market. Although many potential benefits are discussed, little is proven as the technology is still relatively new. However, the opportunities for smart junction technology look promising when considering the relatively lower costs and carbon impacts compared to traditional infrastructure upgrades (as there is a reduced reliance on large new infrastructure).

This Study identifies initial opportunities for smart junction technology for existing signalised junctions on key strategic corridors in EEH. This is based on vehicular demand, including for HGVs, congestion, key bus routes and collisions, as aligned with literature regarding benefits of smart junction technology. It also initially identifies urban areas associated with these corridors that could benefit, based on the number of signalised junctions, air quality and active mode collisions.

As a key limitation of this study, it is very likely that there are opportunities outside of those focus corridors and focus urban areas that have been identified for assessment. For example, there will likely be other urban areas, outside of those that support the focus corridors, that have the potential to benefit from smart junction technology.

Outside of smart junction technology, the calibration of existing signals could deliver cost-effective benefits in the areas where signalised junctions already exist.

The analysis underpinning this Study, carried out in May 2024, incorporates EEH's connectivity studies. Since then, connectivity studies that were ongoing at the time of the analysis have since been completed. EEH plans to update this Study with updated connectivity study work, should funding be available.

9.2 Recommendations

Addressing LTA Knowledge Gaps to Highlight Opportunities

There is an opportunity to improve the understanding of smart junction technology and its benefits across LTAs. There is also a need to improve current data and information held by LTAs, such as signalised junction locations, technology and signal timings. This will allow a greater understanding of the current situation on which to identify opportunities for smart junction technology or other junction solutions.

Expanding Funding Sources

As the benefits of smart junction technology are wide ranging, there are opportunities to utilise funding pots and opportunities outside of often restrictive signal junction funding sources. This could include public bus, air quality or active travel funding opportunities, relative to the benefit that smart junction technology may bring.

Further Smart Junction Feasibility Studies & Modelling

As this Study sets out a strategic-level understanding of potential smart junction technology opportunities across the region, it is recommended that further work is localised and undertaken for specific geographical opportunities, for example corridors or areas. This could also incorporate a review of opportunities at existing junctions that may not already be signalised. Further studies could help understand the detailed benefits and costs of such opportunities, as well as further knowledge on specific technical and logistical hurdles. It could use more detailed data and models to understand the impact of the technology.

Business Case Opportunities

Once specific opportunities are identified, we recommend building a business case for the solution. Although there is no specific guidance for this, we recommend this follows the DfT TAG wherever possible, such as the typical benefit themes that comprise a major transport scheme. It should quantify the likely key benefits of the solution and draw on relevant data, evidence and case studies to support the case. This can then be compared to the cost of the solution (and with a comparison to traditional solutions) to understand an initial Benefit vs Cost Ratio (BCR).

Further Understanding of Corridor Solutions

Use cases of smart junction technology on corridors should be reviewed as further work is developed and published. Further, microsimulation and/or the observation of live trials of smart signal junction technology on corridors could be considered, which would support the development of a business case (see previous Recommendation).

10 Appendix A: Vendor Detection & Control Capabilities

Vendor	Detection Capabilities	Control Capabilities		
		Network/Coordinated Control Method	UTC	Isolated Control Method
Yunex	Provider of Loop, Magnetometer, Radar, Video	SCOOT 6 or Fusion (or both)	UTC-UX PRO	Fixed Time, VA, Licensed MOVA
SWARCO		SCOOT 6	MyCity	
TRL	Use Industry Standards	SCOOT 7	TRL UTC	MOVA developer
Telent		N/A	N/A	Fixed Time, VA, Licensed MOVA
VivaCity	Provider of Video with On Edge MV	N/A	N/A	Smart Control

Table 10-1: Summary of Current Vendor Detection & Control Capabilities

11 Appendix B: Local Transport Authority Survey Results Summary

11.1 Existing Infrastructure

Respondent	LTA	What technology and brand do you use to coordinate the control of your signalised junctions?	What traditional technology do you use for control at isolated signalised junctions?	What technology do you use for traffic control detection at signalised junctions?	What technology do you use for traffic monitoring over your network?	Do you have a policy over which technology you use for signalised junctions?	How often are your signal timings reviewed?	When were your signals last reviewed/updated?	Do you have any bus priority schemes?	Please give an overview of your existing and/or planned bus priority schemes (number, location, type)
A	Buckinghamshire Council	Yunex SCOOT	MOVA	Loops, Multi-lane Radar	ANPR, CCTV, loop detection	No formal policy, signals specification has a hierarchy for complex junctions, SCOOT-MOVA-CLF-VA-Fixed time with fail over capability	Regularly (E.g yearly)	We review on a 5-year rotation	Yes	Implemented bus priority scheme on A41 Bicester Road in 2022 and currently evaluating. Will then be rolled out to other corridors
B	Swindon Borough Council	Yunex SCOOT	MOVA	Loops, Multi lane radar	Loop detection	Yes, all new signal junctions should operate either MOVA or SCOOT control	Ad hoc or when required	When required	Yes	Local bus priority, using inductive profiling
C				Loops, Above ground microwave & radar detection		All new junctions should be adaptive control - either MOVA or SCOOT control		More than a year ago		Loop detection of buses within bus lanes at junctions.
D*	North Northamptonshire Council	Yunex SCOOT	VA	Loops, Above ground radar	Loop detection	No	Never	Not answered	Not answered	Not answered
E	Cambridgeshire County Council	Yunex SCOOT	MOVA	Loops, Overhead detection	Yunex RMS and Yunex UTC	Not a strict policy, depends on suitability of site.	Ad hoc, but very rarely due to lack of resource	More than a year ago	No and not committed to any	Unknown
F	Milton Keynes Council	Unknown	MOVA	Loops, AGD	Telent remote monitoring	We are in the process of updating our Traffic Signal specification	Ad hoc or when required	In the last year	No and not committed to any	Unknown
G	Oxfordshire County Council	Unknown	Unknown	Unknown	ATCs, City Radar, VivaCity, traffic signals loops, CCTV for traffic monitoring. Use real time floating vehicle data and same weeks each year for O&D and routing data.	Unknown	Unknown	Unknown	Yes	Unknown
H	Peterborough City Council	Yunex SCOOT	MOVA	Loops, AGD	Vivacity sensors	Decision based on a site by site basis - we have developed a Smart Cities Strategy as well.	Ad hoc or when required	In the last year	Yes	VIX Technology Local Bus Priority in partnership with Stagecoach. TLP at about 12 junctions - GPS triggers to demand priority. Exploring a strategic TLP system moving forwards.
I	Bedford Borough Council	Yunex SCOOT	VA	Radar - AGD, SVS, ICOMS	All sites connected to UTC	No	Ad hoc or when required	In the last year	No and not committed to any	Unknown
J	Luton Borough Council	TRL fixed time control, some linked MOVA	MOVA	Loops, AGD	CCTV	Default is MOVA control at junctions. Other forms of control are then given consideration depending on factors.	Ad hoc or when required	In the last year	Yes	BP being deployed through TRL UTC and MOVA. Scheme at early stages through BSIP funding. Likley between 6 and 10 sites.
K	Unknown	Yunex SCOOT	VA		Fixed Count Sites, Bluetooth Journey Time Sensors	No	Ad hoc or when required	More than a year ago	No and not committed to any	Unknown

*Table 11-1: LTA Survey Responses for Existing Infrastructure Questions (*Incomplete Survey Response) Note: Some answers have been reworded*

11.2 Smart Junction Experiences & Perceptions

Respondent	LTA	Have you carried out or are you planning any smart signal junction (e.g. Fusion, VivaCity) trials or implementations?	Please provide detail of any trials or implementations (existing and/or planned) including: scale and location of the trial/implementation	What have been the main successes of the existing/current smart signal junction trials/implementations (or the planning of these, if relevant)?	What have been the main challenges of the existing/current smart signal junction trials /implementations (or the planning of these, if relevant)?	How do you think smart signal junctions can best support the network demand in your authority? Please name specific junctions, modes and use cases where possible.	What are the major barriers to moving to smart junction technology, in order of priority?
A	Buckinghamshire Council	Currently planning or committed to implementation/trials	We are in discussions with VivaCity to trial a smart junctions solution on a major junction in Aylesbury (A413 Buckingham Road / A4157 Elmhurst Road (Horse & Jockey)), it will use their video detection system	It is hoped that the junction will cope better with the high traffic flows that can change quickly and also better accommodate non-motorised users who crisscross the junction.	The condition of the existing infrastructure to accommodate the new technology, traditional thinking	We have a number of new junctions in the pipeline to facilitate large development areas, most infrastructure will go in near the start but the developments may take 10years+ to build out before full traffic is using the junctions meaning traffic flows will be changing constantly.	Funding and reluctance to commit to new technology
B	Swindon Borough Council	No active consideration or involvement				There are already a wide selection of "smart signals", SBC are mostly using combined MOVA7 / MOVA8 with SCOOT and allowing the signals to switch between control methods based on the traffic conditions.	Industry knowledge, Good technology already within the market place, resources at local authorities to invest in technology.
C						Not something we have investigated.	Capacity and capability within the Council (a single member of staff covers all signal issues) to look at such initiatives.
E	Cambridgeshire County Council	Currently carrying out a trial or currently implementing	VivaCity	VivaCity have managed to control a stand-alone junction with no linking. They have achieved journey times similar to MOVA	Cost and the benefit the product provides over existing, much cheaper technology.	We consider all of our junctions to be smart as they all run on adaptive modes of control and not fixed time modes.	Cost, Resource to implement
F	Milton Keynes Council	No active consideration or involvement				I can see the benefit of smart signal technology and I believe it's something we will be looking to introduce to new or retrofit to existing sites.	Money, Resource
G	Oxfordshire County Council	Have been encouraging that these should be trialled. DSRC at 2 sites installed for a CAV project.	NEFVMA project installed Earthsense Zephry AQ sensors at 5 traffic signal sites to feed into project.	Unknown	Getting things that we are trialling into business as usual.	Unknown	Funding including Opex, training of maintenance staff
H	Peterborough City Council	Currently carrying out a trial or currently implementing	Trialling Vivacity Smart Junction Technology to compare optimisation against MOVA control on a Siemens controller. This is being trialled at the junction of London Road/Glebe Road/Fletton Avenue J001J.	We have come across issues related to the site/technology/compatibility with the existing equipment that have then allowed further investigation and fixes that have been implemented on other trials being implemented on other projects.	Working with a live site and gradually reducing supervision when trials take place. The trial has potentially taken much longer than we originally anticipated.	We need to review junctions such at Oundle Road/London Road in the city centre where the river crossing is, to also balance ped and cycle demand and limited queue space over the Town Bridge, working with the East Station Road junction. Another junction that needs review is Oundle Road/ Shrewsbury Avenue and Oundle Road/Sugar Way.	Budget to design, implement and maintain/validate, Resource and knowledge to implement, Access to skills and resources to maintain the technology and strategies when in place
I	Bedford Borough Council	No active consideration or involvement				'Smart' signals not under consideration, we use SCOOT, MOVA, VA	Not currently under consideration
J	Luton Borough Council	No active consideration or involvement				A key benefit would be the ability to rebalance demand/priority at signal junctions in favour of active / non-motorised transport.	The primary barrier is currently resource in terms of the size of the signals team. If this were overcome, we would need to understand the clear benefits vs disbenefits of smart junction technology in order to build it into our forward programme/policies.
K	Unknown	No active consideration or involvement				Unknown	Cost and Interoperability. There needs to be a common standard applied to these systems.

Table 11-2: LTA Survey Responses for Smart Junction Experiences & Perceptions Question

12 Appendix C: AQMAs by Location

Local Authority	AQMA Title	Description/Location	Pollutant
Bedford Borough Council	Bedford Town Centre AQMA	An area encompassing the majority of properties within Bedford Town Centre, and incorporating the 2 previous AQMAs in the Town Centre.	NO2
Broxbourne Borough Council	Extension to AQMA 1	Arlington Crescent to Abbey Road	NO2
	AQMA No.4 Eleanor Cross Road / Monarchs Way	Roundabout	NO2
	AQMA 6 Great Cambridge Road (A10)	The designated area incorporates the junction of Great Cambridge Road and College Road in Cheshunt, including the Great Cambridge Road (A10) near Theobalds Lane junction up to the Brookfield Centre (B156 Flyover and B156/A10 Slip Road).	NO2
Buckinghamshire	Chesham AQMA	An area encompassing buildings along parts of Broad Street and Berkhampstead Road in Chesham.	NO2
	Stoke Road AQMA	An area encompassing the junction of the A413 Wendover Road, Walton St, and B4443 Stoke Road in Aylesbury.	NO2
	Friarage Road AQMA	An area encompassing a number of properties along the A418 (Friarage Road and Oxford Road) in Aylesbury.	NO2
	Tring Road AQMA	An area encompassing a stretch of the A41 Tring Road and properties bordering it between the Oakfield Road/King Edward Avenue Junction and Queen Street in Aylesbury.	NO2
	AQMA No.2 (High Wycombe)	Main arterial roads of High Wycombe including; West Wycombe Road, Oxford Street, Hughenden Road, Abbey Way, Marlow Hill, Bridge Street, Crendon Street, Queen Victoria Road, Easton Street, London Road and Amersham Hill (part of). Area also includes proper	NO2
	AQMA No.3 (Marlow)	Area incorporates the High Street (between Station Road/ Pound Lane roundabout and West Street/ Spittal Street roundabout), West Street (between High Street/ Spittal Street roundabout and Westwood Road), Spittal Street, Chapel Street, Little Marlow Road	NO2
	AQMA No.1 (M40)	Along the M40 Motorway throughout District. Area includes land and property to each side of the carriageway that were modeled to have exceeded national air quality objectives for Nitrogen Dioxide (Annual mean).	NO2
	South Bucks District Council AQMA No 2	The AQMA boundary follows the Iver Parish boundary	NO2
	South Bucks AQMA	An area comprising the M4, M25 and M40 and adjacent land.	NO2
Cambridge City Council	Cambridge AQMA	An area encompassing the inner ring road and all the land within it (including a buffer zone around the ring road and its junctions with main feeder roads).	NO2
Central Bedfordshire	South Bedfordshire AQMA	The AQMA incorporates Dunstable Town Centre, the A505 (from the town centre to the junction of PoyntersRoad/Dunstable Road), the A5 (from Union St to Borough Road), and the B489 - West St from the town centre to St Marys Gate.	NO2
	Air Quality Management Area No 4 Sandy	The designated area incorporates 10 metres from the kerbside of both sides of the A1 at the Georgetown exit, then south along the London Road A1 to the Bedford Road junction.	NO2
	Air Quality Management Area No 3 Ampthill	The declared area incorporates part of Bedford St between Market Sq Brewers Lane on both sides of the road	NO2
Cherwell District Council	Cherwell District Council Air Quality Management Area (no. 1)	The designated area incorporates Hennef Way between the junctions with Ermont Way and Concorde Avenue.	NO2
	Cherwell District Council Air Quality Management Area no. 2	The designated area incorporates sections of Oxford Road, Bloxham Road, South Bar, High Street, Horsefair, North Bar, Warwick Road and Southam Road, Banbury.	NO2
	Cherwell District Council Air Quality Management Area no. 3	The designated area incorporates a section of Bicester Road, Kidlington to the north of its junction with Water Eaton Lane.	NO2
	Air Quality Management Area No.4	The designated area incorporates sections of Kings End, Queens Avenue, Field Street, St Johns Street, Bicester.	NO2
Dacorum Borough Council	AQMA No 2 (Apsley)	Incorporating part of London Road Apsley between the junction with Featherbed Lane travelling south east along London Road Apsley to the junction with Avia Close Apsley.	NO2
	AQMA No 1 (Hemel Hempstead)	Incorporating part of Lawn Lane between the junctions of Durrants Hill Road and Deaconsfield Road travelling south east along Lawn Lane to the junction with Belswains Lane, Hemel Hempstead.	NO2
	AQMA No 3 (Northchurch)	Incorporating part of High Street Northchurch A4251 between the northern boundary junction of Darrs Lane travelling south east to the southern boundary of Dunscombe Road. Extended to include 84-96 High Street.	NO2
East Hertfordshire District Council	Bishops Stortford AQMA	An area encompassing a number of properties around the junction of Dunmow Road, Hockerill Street, London Road and Stanstead Road in Bishops Stortford.	NO2
	Hertford AQMA	A number of properties in central Hertford	NO2
	AQMA Sawbridgeworth	London Rd and Cambridge Rd and the adjoining roads.	NO2
Fenland District Council	Wisbech AQMA No.3 (NO2)	An area extending along the B198 Lynn Road between Freedom Bridge Roundabout and Mount Pleasant Road and along the A1101, from Sandylands, along Churchill Road to just past Westmead Avenue.	NO2
	Whittlesey AQMA No.1 (SO2)	An area along roads and cycle routes to the west and northwest of Whittlesey brickworks and an area covering roads, footpaths, dwellings, schools and public open spaces to the east of Whittlesey brickworks.	SO2
	Wisbech AQMA No.1 & No.2	An area in central Wisbech surrounding the HL Food site.	SO2, PM10
Hertsmere Borough Council	Hertsmere AQMA No. 1	An area comprising the domestic properties 23-27 Dove Lane and caravan site off A1000 Barnet Road.	NO2
	Hertsmere AQMA No. 2	An area comprising the domestic property known as Charleston Paddocks, St Albans Road, South Mimms, Potters Bar.	NO2
	Hertsmere AQMA No. 3	An Area comprising the domestic properties 31-39 Blanche Lane, South Mimms.	NO2

Local Authority	AQMA Title	Description/Location	Pollutant
	Hertsmere AQMA No. 4	An area comprising the domestic properties 12 Grove Place, Hartspring Lane, Aldenham and caravans numbered 1, 2, 3, 4, 7, 8, 55, 56, 57, 58, 59, 60 within Winfield Caravan site, Hartspring Lane.	NO2
	Hertsmere AQMA No. 5	An area encompassing a number of houses on the eastern side of Watling Street, either side of the junction with Barnet Road.	NO2
	Hertsmere AQMA No. 6	An area encompassing a number of domestic properties on the east side of the High Street, opposite the Potters Bar bus station.	NO2
Huntingdonshire District Council	Brampton AQMA	An area encompassing properties at Wood View, Nursery Cottages, Thrapston Road, Bliss Close and Flamsteed Drive close to the A14 in Brampton and Hinchingbrooke	NO2
	Hemingford to Fenstanton (A14) AQMA	An area encompassing a number of properties either side of the A14 between Hemingford and Fenstanton.	NO2
	Huntingdon AQMA	An area encompassing the southern part of the town centre, bounded largely by the A141 to the west, A14 to the south and the river to the east.	NO2
	St Neots AQMA	An area encompassing the junction of the High Street, St Neots, with New Street and South Street.	NO2
Luton Borough Council	Luton AQMA No.1	24 dwellings in the vicinity of the M1 motorway.	NO2
	Luton AQMA No.2	An area encompassing 431 premises in the vicinity of the M1 motorway either side of Junction 11.	NO2
	Luton AQMA No.3	From Dunstable Road by Kenilworth Road through to Stuart Street and Chapel Viaduct by Latimer Road, including Castle Street to Holly Street and Telford Way.	NO2
Milton Keynes Borough Council	Olney AQMA	An area in Olney encompassing all properties fronting Bridge Street and High Street South, and also including part of Market Place.	NO2
North Hertfordshire District Council	North Hertfordshire District Council Air Quality Management Order No.1 2012	Properties on the south side of Stevenage Road, Hitchin, fronting on to the road, between the Hitchin Hill (Three Moorhens PH) roundabout and 94-98 Stevenage Road.	NO2
	NHDC AQMA Order No.2 2016 - Paynes Park Roundabout, Hitchin	One residential property located adjacent to the Paynes Park Roundabout. The south east faade of which is exposed to nitrogen dioxide concentrations above the annual mean Air Quality Objective	NO2
Oxford City Council	The City of Oxford	The area covered is described as the city of Oxford and is detailed on a map supplied with the Order creating the AQMA.	NO2
Peterborough Council	AQMA No.1	Two rural areas near Flag Fen, to the east of Peterborough between the City and Whittlesey. Declared due to emissions from the brickworks outside the Local Authority area at Whittlesey.	SO2
Reading Borough Council	Reading AQMA	An area covering Reading Town Centre, areas along the major radial road routes into Reading (including J11 of the M4) and along the railway lines where they pass through built-up areas.	NO2
Slough Borough Council	Slough AQMA No.1	An area encompassing land adjacent to the M4 motorway along the north carriageway between junctions 5 and 7, and along the south carriageway between junction 5 and Sutton Lane.	NO2
South Oxfordshire District Council	Wallingford AQMA	An area extending either side of Wallingford High Street from just west of Wallingford Bridge to the junction with Croft Road/St Georges Road.	NO2
	Watlington AQMA	An area encompassing Brook Street, Watlington from the Gorwell junction to the Watcombe Road junction, and the length of Counching Street and Shirburn Street.	NO2
	Henley AQMA	The AQMA covers the length of Duke Street including the junctions at either end.	NO2
St Albans City & District Council	St Albans AQMA No. 1	The area comprising of odd numbers 1-7 London Road, 1-11c Holywell Hill and even numbers London Road, St Albans.	NO2, PM10
Swindon Borough Council	Kingshill Road, Swindon AQMA	Section of A4289 highway eastwards from GR 414635E 183838N on Kingshill Road, to its junction with Okus Road.	NO2
Three Rivers District Council	Chorley Wood NO2 AQMA	Along the M25 from just south of Junction 18 to just north of where the motorway crosses the River Chess extending 74m either side of the centreline.	NO2
	Chorleywood PM10 AQMA	A slightly narrower area from just north of Junction 18, along the M25 to just north of where the motorway crosses the River Chess extending 38m either side of the centreline	PM10
Vale of White Horse District Council	Abingdon AQMA	An area encompassing properties along the main road system in the centre of Abingdon. This includes part or all of Stert Street, Bridge Street, High Street, Stratton Way, Vineyard, West St Helens Street, Ock Street and Bath Street.	NO2
	Botley AQMA	An area encompassing a number of properties in Westminster Way, Coles Court, Stanley Close and along the Southern Bypass.	NO2
	Marcham AQMA	This comprises an area along the A415 and includes part of Abingdon Road, Packhorse Lane and Frilford Road from the western village boundary sign to the eastern village boundary sign, all within the village of Marcham, Oxfordshire.	NO2
Watford Borough Council	AQMA 3A Chalk Hill and Pinner Road	304 and 304a Lower High Street, 123 Pinner Road and the section of Attenborough Court on Pinner Road, 41-55 Pinner Road (odds).	NO2
	AQMA No.2 (Vicarage Rd)	An area encompassing a number of properties along Vicarage Rd, St Albans.	NO2
West Northamptonshire	Northampton AQMA No.8	An area encompassing a number of properties along St Michael's Road and close to the junction on Kettering Road.	NO2
	Northampton AQMA No.6	An area encompassing a number of properties in or near Campbell Square at the junction of the A4500 (Grafton Street0 and Regent Street in central Northampton.	NO2
	Northampton AQMA No.1	The area of land which runs alongside the southbound carriageway of the M1 motorway within the boundaries of Northampton Borough Council. The area varies in depth from between 40 and 54 metres when measured from the central reservation on the M1.	NO2
	Towcester AQMA	An area encompassing Watling Street (A5) from the Saracens Head crossroads to Silverstone Brook (adjacent to 131 Watling Street) in Towcester	NO2
	Northampton AQMA No.2	An area encompassing a number of properties along Bridge Street, Victoria Promenade and Victoria Gardens, including the Plough Hotel.	NO2
	Northampton AQMA No.4	An area encompassing roads and propertied fronting parts of Kingsthorpe Grove, Harborough Road, Cranford Terrace, Alexandra Terrace and Boughton Green Road.	NO2
	Northampton AQMA No.5	An area encompassing properties in Wootton Hall Park, Cottesbrooke Gardens, Hermitage Way, Stratford Drive and Chestnut Drive close to the A45 London Road.	NO2
	Northampton AQMA No. 3	An area encompassing a number of properties along St James Road, Weedon Road, Harlestone Road and adjoining streets.	NO2
West Oxfordshire District Council	Chipping Norton AQMA	An area incorporating Horse Fair, High Street, Market Place (A44) and part of West Street in Chipping Norton, Oxfordshire.	NO2
	Witney AQMA	An area incorporating Bridge Street, Witney and the junctions with New Yatt Road, Newland, Mill Street and High Street.	NO2

Table 12-1: Detail of AQMAs in EEH

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13 Appendix D: OxCam Priority Areas

ID	Priority Area Name	Tier
1	A1: Sandy - Biggleswade	1
2	M1 J13	
3	A1139	
4	A6/A421	
5	Aylesbury	
6	A605	2
7	A43 Corby & A43 Broughton	
8	A14 J33 & J36	
9	A5141	
10	A421	3
11	A141/142	
12	A43/A5 Roundabout	
13	A5 Old Stratford Roundabout	
14	A5 Kelly's Kitchen Roundabout	
15	A5 Hockliffe	
16	Bicester	
17	A507	

Table 13-1: OxCam Priority Areas by Tier

14 Appendix E: Inter-Urban Journey Time Analysis

Ref	Corridor Area	Corridor	Centre-Centre Length (miles)	Centre-Centre Time (mins)	Outskirts-Outskirts Length (miles)	Outskirts-Outskirts Time (mins)	Additional Length (miles)	Journey Time Variability (%)	Distance Variability (%)	P&R Availability on Route
A	Oxford - Milton Keynes	Oxford to Milton Keynes	40	65	33	45	7	31%	18%	×
		Milton Keynes to Oxford	42	75	35	55	7	27%	17%	✓
B	Oxford - Northampton - Peterborough	Oxford to Northampton	44	75	37	45	7	40%	16%	×
		Northampton to Oxford	42	70	37	60	5	14%	12%	✓
		Northampton to Peterborough	44	65	31	45	13	31%	30%	×
		Peterborough to Northampton	44	70	32	50	12	29%	27%	×
C	Oxford - Swindon -Didcot	Oxford to Swindon	33	60	25	40	8	33%	24%	✓
		Swindon to Oxford	33	65	25	40	8	38%	24%	✓
		Swindon to Didcot	37	55	35	40	2	27%	5%	×
		Didcot to Swindon	38	55	31	35	7	36%	18%	✓
D	Thames Valley - Buckinghamshire - Milton Keynes - Northampton	Hemel Hempstead to Watford	9	30	6	18	3	40%	33%	×
		Watford to Hemel Hempstead	10	20	5	9	5	55%	50%	×
		Milton Keynes to Northampton	20	30	13	16	7	47%	35%	×
		Northampton to Milton Keynes	21	35	13	12	8	66%	38%	✓
		Milton Keynes to Luton	22	40	16	26	6	35%	27%	✓
		Luton to Milton Keynes	23	40	13	20	10	50%	43%	✓
		Luton to Stevenage	15	35	9	20	6	43%	40%	×
		Stevenage to Luton	14	35	8	12	6	66%	43%	✓
		Dunstable to Stevenage	19	50	16	40	3	20%	16%	×
		Stevenage to Dunstable	18	45	17	35	1	22%	6%	×
E	Southern East West Movements	High Wycombe to Gerrards Cross	10	22	6	9	4	59%	40%	×
		Gerrards Cross to High Wycombe	10	22	6	9	4	59%	40%	✓
F	Luton - Bedford - Corby	Luton to Bedford	21	50	13	22	8	56%	38%	✓
		Bedford to Luton	20	45	13	22	7	51%	35%	×
		Bedford to Corby	33	55	31	50	2	9%	6%	✓
		Corby to Bedford	33	55	31	50	2	9%	6%	×
G		Cambridge to St Neots	19	35	14	20	5	43%	26%	×
		St Neots to Cambridge	19	50	14	28	5	44%	26%	✓

Ref	Corridor Area	Corridor	Centre-Centre Length (miles)	Centre-Centre Time (mins)	Outskirts-Outskirts Length (miles)	Outskirts-Outskirts Time (mins)	Additional Length (miles)	Journey Time Variability (%)	Distance Variability (%)	P&R Availability on Route
	Cambridge - St Neots - Milton Keynes	St Neots to Milton Keynes	31	55	23	35	8	36%	26%	✓
		Milton Keynes to St Neots	31	50	23	28	8	44%	26%	×

Table 14-1: Comparison of Centre & Outskirt Inter-Urban Journey Times by Focus Corridor

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