Economic and Technical Report

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Best endeavours / efforts were made to ensure the accuracy of the report, however users should be aware that the environment operated in can change quickly and if there are any queries on particular points of the report please contact: contact@eastwestrail.co.uk.

Abbreviations & Glossary

Term	Description
A428 Improvement Scheme	The scheme promoted by Highways England to upgrade the A428 between Black Cat roundabout east of Bedford and Caxton Gibbet roundabout west of Cambourne.
Active Travel	Making journeys in physically active ways - like walking, wheeling (using a wheelchair or mobility aid), cycling, or scootering.
Affordable Connections Project	This is a review of the strategic need for the Project and to investigate solutions which could deliver the majority of the original scheme benefits and outcomes at a lower cost.
Air Quality Management Area	An area designated by a local authority, where it believes the Government's objectives for air quality will not be achieved without additional interventions.
Assessment factors	The factors used to assess and compare different options for the Project.
At-grade junction	A railway junction where tracks cross at the same level. Also known as a flat junction.
Bat gantries	Purpose-built structures designed to act as linear features that will guide echolocating bats over transport corridors at a safe height above traffic.
Biodiversity Net Gain (BNG)	An approach to development that leaves biodiversity in a better state than before the development took place.
Blight	The term blight used in this document refers to generalised blight. Generalised blight is typically used to describe the actual or assumed depreciation in value of property which may be attributable to a proposed infrastructure scheme.
Blockade	The closure of a rail route for an extended period (typically more than two to three days).
Bridleway	A route over which the public have rights to pass on foot, cycle and on horseback.
Cambourne North	The preferred option for a new station to the north of Cambourne.
Cambourne South	Option for a new station to the south of Cambourne.

Term	Description
Capital costs	Cost incurred during delivery of a project in purchasing buildings, land, construction works, and equipment as opposed to the costs of operating, maintaining or decommissioning the project.
Clean Air Strategy	The government's clean air strategy sets out how it intends to reduce particulate matter emissions.
Clock-face timetable	A timetable arranged so that trains arrive or depart at the same times in the hour, every hour (for instance at 10, 30 and 50 minutes past the hour).
Concept	Referred to as the ways the line could be upgraded in various sections.
Code of Construction Practice	A public document which sets out the environmental management requirements for construction.
Compulsory acquisition	A legal mechanism by which certain bodies (known as 'acquiring authorities') can acquire land without the consent of the owner.
Connection stage	Work will be divided into three connection stages which relate directly to a full journey and not just a piece of track: Connection Stage One (CS1): Oxford - Bletchley and Milton Keynes (services may be first opened to Bletchley in a two-phased approach) Connection Stage Two (CS2): Oxford – Bedford Connection Stage Three (CS3): Oxford – Cambridge.
Conservation area	An area of notable architectural or historic interest or importance in relation to which change is managed by law.
Construction Environmental Management Plan	A working document that defines how a project will mitigate its potential impacts on the environment and local community during construction.
Cutting	A passage that has been dug through high ground for a railway or road.

Term	Description
Development Consent Order	Order made by the relevant Secretary of State to authorise the construction, operation and maintenance of a nationally significant infrastructure project (NSIP). In relation to East West Rail, this would be the Secretary of State for Transport.
Department for Environment, Food & Rural Affairs (Defra)	UK Government department responsible for safeguarding our natural environment, supporting our world-leading food and farming industry, and sustaining a thriving rural economy.
Department for Transport (DfT)	Government department responsible for the English transport network and a limited number of transport matters in Scotland, Wales and Northern Ireland that have not been devolved.
Department for Levelling Up, Housing and Communities (DLUHC)	UK government department responsible for responsible for housing, communities, local government in England and the levelling up policy. Formerly Ministry of Housing, Communities & Local Government (MHCLG).
Door to door connectivity	This includes local connectivity, smart ticketing and transport accessibility – all areas of significance when considering the door-to-door journey.
Earthworks	General term for the excavation and placement of soil, rock and other material; or for existing cuttings and embankments.
East Coast Main Line (ECML)	Railway line running from London King's Cross to Edinburgh through Sandy and St Neots.
Environmental Statement (ES)	A document produced to support an application for development consent that is subject to Environmental Impact Assessment (EIA), which sets out the likely impacts on the environment arising from the proposed development.
East West Rail (EWR)	A proposed new rail link, which would connect communities between Oxford, Milton Keynes, Bedford and Cambridge. This is the project.

Term	Description
East West Railway Company Ltd (EWR Co)	Company set up by the Secretary of State for Transport to develop East West Rail. This is the Company, so we use "we, us and our".
Electrification	The development of powering trains and locomotives using electricity instead of diesel or steam power.
Embankment	A construction that allows railway lines to pass at an acceptable level and gradient through the surrounding ground that is composed entirely of soil or rock.
Embedded carbon	The greenhouse gas emissions arising from the manufacture, transportation, installation, maintenance, and disposal of materials used in construction.
Environmental Impact Assessment	A process by which information about environmental effects of a proposed development is collected, assessed and used to inform decision making. For certain projects, EIA is a statutory requirement, reported in an Environmental Statement.
Fleet	The rolling stock vehicles described in or required by Schedule 1.7
Flood plain	An area of low-lying ground adjacent to a river, which is subject to flooding.
Flood risk / assessment	An assessment of the risk of flooding from all flooding mechanisms, the identification of flood mitigation measures, and identification of actions to be taken before and during a flood.
Freight	Goods transported in bulk by truck, train, ship, or aircraft.
Freight operating companies	Companies which use the rail network in order to transport goods to their destination.
Grade-separated junction	A railway junction where tracks cross at different levels
Govia Thameslink Railway (GTR)	Govia Thameslink Railway, a train operating company
Green belt	A designation for land around certain cities and large built-up areas, which aims to keep this land permanently open or largely undeveloped.

Term	Description
Green bridge	An artificial structure over road or rail infrastructure which is either vegetated or provides some other wildlife function.
Green corridor	A thin strip of land that provides sufficient habitat to support wildlife, often within an urban environment, thus allowing the movement of wildlife along it.
Greenhouse gas	Gases able to absorb infrared radiation emitted from Earth's surface and re-radiate it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapour are the most important greenhouse gases.
Highways England (HE)	The Government body responsible for managing the Strategic Road Network in England.
HS2	High Speed 2, the new railway line under construction between London and the West Midlands, and beyond.
Impact Risk Zone (IRZ)	A zone around a Site of Special Scientific Interest used to make an initial assessment of the potential risks posed to that Site by development proposals.
Indicative alignment	The indicative, concept alignment within each Route Option used for the comparison of Route Options A to E in the previous stage of design.
Infrastructure maintenance depot	A depot at which staff and equipment involved in maintaining rail infrastructure are based and from which maintenance operations are coordinated.
Interchange	A station at which passengers may change between trains serving different routes and destinations.
km	Kilometres
Level crossing	A location at which vehicles and pedestrians may cross railway tracks at grade (at ground level). This definition includes accommodation crossings which provide access to specific properties; and crossings which are operated by their users rather than automatically.
Line speed	The maximum speed at which trains can run on a given railway line, or section of line.

Term	Description
Listed building	A building placed on a statutory list, because of its special architectural or historical interest, in relation to which change is managed by law.
London & North Western Railway (LNWR)	Historic British railway company, an ancestor of the West Coast Main Line.
Local Representative Group (LRG)	These 15 groups were established by EWR Co along the route and include councillors, parish and town councils, and representatives from EWR Co. They offer an open forum for discussions – a place to share information and informative content on key parts of the development process, ask questions and discuss local opportunities or emerging concerns.
M	Metres
Marston Vale Line (MVL)	The existing line and services operating between Bletchley and Bedford.
Ministry of Housing, Communities & Local Government (MHCLG)	UK government department responsible for housing, community and local government matters in England.
Midland Main Line (MML)	The main railway route between London St Pancras, Nottingham and Sheffield.
mph	Miles per hour
National Highways	The government body responsible for managing the Strategic Road Network in England. Formerly Highways England.
National Infrastructure Commission (NIC)	Executive agency responsible for providing the Government with impartial, expert advice on major long term infrastructure challenges facing the UK.
National Networks National Policy Statement (NN NPS)	Sets out the need for, and the Government's policies to deliver, development of nationally significant infrastructure projects (NSIPs) on the national road and rail networks in England, and will be the primary basis against which the Secretary of State for Transport will assess and determine a DCO application for a new railway pursuant to section 104 of the 2008 Act.

Term	Description
Nationally Significant Infrastructure Project (NSIP)	A large-scale development (relating to energy, transport, water, or waste) of national significance that meets the thresholds set in Part 3 of the Planning Act 2008.
Need to Sell Property scheme	A scheme available to eligible property owners who have a compelling need to sell but have been unable to do so other than at a substantially reduced value because of the EWR project.
Network Rail (NR)	Network Rail Infrastructure Limited, the organisation which owns the majority of the railway infrastructure in England.
Net zero carbon	Net zero refers to achieving a balance between the amount of greenhouse gas emissions produced and the amount removed from the atmosphere.
Nitrogen dioxide (NO2)	One of a group of gases called nitrogen oxides. One source of NO2 is from traffic emissions, as a result of burning fossil fuel in internal combustion engines.
Noise barrier	Exterior structure designed to protect sensitive receptors from noise pollution.
Non-motorised users	People travelling on foot, by cycle or on horseback; or by any other means which is not motorised.
Office of Rail and Road (ORR)	A non-ministerial Government department which is the economic and safety regulator for Britain's railways.
Off-line option / Offline	When the new junction is constructed outside of the footprint of the existing railway, which means we wouldn't have to close the existing railway for a long period of time to construct the new junction.
Overhead Line Equipment (OLE)	The Overhead wires above railway lines, along with their supporting infrastructure, that typically carry electricity at 25,000 volts to power electric trains.
Operating costs	Costs incurred in the day-to-day running of the railway.
Option	In this report, 'option' is used to refer to a possible solution that has been considered and is being taken forward for further design and/or assessment.

Term	Description
Oxford- Cambridge Arc (the Arc)	A region defined by the Government and the National Infrastructure Commission covering local authorities across the counties of Northamptonshire, Cambridgeshire, Buckinghamshire and Oxfordshire and the unitary authorities of Bedford, Central Bedfordshire, Luton, and Milton Keynes.
PA 2008	Planning Act 2008
Patronage	Refers to the number of people using a transit service.
Passing loop	A section of track used to allow one train to be passed by another train travelling behind it in the same direction.
Permitted Development Rights	Development that may be carried out by certain categories of (for example) statutory undertaker (such as Network Rail) under deemed planning permission ("Permitted Development Rights"), for certain types of work. Permitted Development Rights also benefit other statutory undertakers.
Particulate Matter (PM10 and PM2.5)	Fine particulate matter with an aerodynamic diameter of 10 microns or less and 2.5 microns or less, respectively.
Platform dwell times	The amount of time a train spends at a scheduled stop without moving.
Points	A junction between two railway lines, that can be set to guide a train to or from either of those lines. Can also be referred to as a switch.
Possession	Restriction of access to a section of railway for the purposes of maintaining or renewing infrastructure, at a particular location and for a particular period of time.
Preferred Route Option E	The route option previously selected as the preferred area between Bedford and Cambridge in which to seek alignments in this phase of developing the project.
Preliminary Environmental Information Report (PEIR)	A report to inform the statutory consultations on the likely significant environmental effects of the Project, so far as available to date.
Programme- Wide Output Specification (PWOS)	A document containing detailed requirements for the project, agreed with the Department for Transport.

Term	Description
The Project	The infrastructure, systems, rolling stock and organisational arrangements which need to be created or modified to deliver East West Rail and its intended outcomes.
Project section	One of six geographical areas used to present infrastructure proposals for consultation.
Public Rights of Way (PRoWs)	A way over which the public have a right to pass and repass.
Reference alignment	The alignment option against which the performance of other alignment options is assessed.
Rolling stock	Any vehicle that operates on, or intends to operate on, or uses a railway track, including any loading on such a vehicle, but excluding a vehicle designed for both on- and off-track use when not operating on the track. Rolling stock is a collective term for a large range of rail vehicles of various types, including locomotives, freight wagons, passenger cars, track machines and road-rail vehicles.
Route corridor, Route option and Route alignment	Route Corridors are the broad areas within which the new railway might be located, identified as part of the initial 'sift' of possibilities in 2016. Within the preferred Route Corridor, several narrower Route Options were identified and a Preferred Route Option was announced in 2020. The Project is now at the stage of selecting a Route Alignment.
Safety risk	The risk of unsafe practices or situations occurring on the railway that may lead to accidents
Scheme	A project or a group of projects being promoted or undertaken by a party or parties other than EWR Co with objectives which do not directly facilitate, but may be related to, East West Rail.
Scheduled Monument	A historic building or site considered to be of national importance, placed on a list kept by the Government and requiring Government approvals for any works which might affect the Scheduled Monument.

Term	Description
Shepreth Branch Royston (SBR) Line	The line that connects Cambridge to Hitchin via Shepreth.
Siding	A short track at the side of and opening on to a railway line. They are usually used for stabling trains.
Source Protection Zone (SPZ)	A defined area around groundwater sources such as wells, boreholes and springs used for public drinking water supply. The purpose of SPZs is to provide additional protection to safeguard drinking water quality through constraining the proximity of an activity that may impact upon a drinking water abstraction.
Site of Special Scientific Interest (SSSI)	The land notified as a SSSI under the Wildlife and Countryside Act 1981, as amended, as being of special interest by reason of its flora, fauna or geological or physiological features.
Special Area of Conservation (SAC)	A designation under EU Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, also known as the Habitats Directive. The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds)
Statutory blight	The term used to describe a situation where a property is blighted in a legal sense, such as where it is in a development plan or within land safeguarded for a specific purpose, for example the railway, or included within a compulsory purchase order.
Statutory consultation	A stage of consultation which a promoter of a nationally significant infrastructure project is required to undertake, under section 42 the Planning Act 2008.
Stopping Pattern	The order of station calls that are made by a train service in each direction along a route.
St Neots Option A station	Option for a new station in the St Neots area. Both St Neots station options would be located to the south of St Neots. This would be in addition to the existing St Neots station.

Term	Description
St Neots Option B station	Option for a new station in the St Neots area. Both St Neots station options would be located to the south of St Neots. This would be in addition to the existing St Neots station.
Strategic Road Network	The core road network in England managed by National Highways.
Tempsford Option A station	Option for a new station in the Tempsford area. Both Tempsford station options would be located to the northeast of Tempsford.
Tempsford Option B station	Option for a new station in the Tempsford area. Both Tempsford station options would be located to the northeast of Tempsford.
Thameslink	Train operator running services between the south coast of England, Bedford and Cambridge.
Theory of change	A theory of change is a method that explains how a given set of interventions, is expected to lead to specific change in future outcomes, drawing on a causal analysis, based upon available evidence.
Track layout / track configurations / trackworks	The number of railway lines that are present at a location including any sets of points that allow a train to move between different tracks.
Traction power	The source of energy used for the movement of railway vehicles. This power source may be self-contained within the train such as diesel fuel or batteries, or may be provided externally such as electricity provided via Overhead Line Equipment.
tph	Trains per hour
TWA 1992	Transport and Works Act 1992
Transport and Works Act Order (TWAO)	A Transport and Works Act Order made by the Secretary of State under the TWA 1992 alongside a deemed planning permission, allowing works to a railway or other transport project to be undertaken.

Term	Description
Upfast platform Utility company	A platform that serves a faster running train service. A company that owns equipment which carries and distributes water, electricity, gas or telecommunications. These commodities are collectively known as 'utilities'.
West Anglia Main Line (WAML)	The main railway route between London Liverpool Street and Cambridge.
West Coast Main Line (WCML)	The main railway route between London Euston and Glasgow.
Wildlife corridors	An area of habitat connecting wildlife populations, often used as bat flyways.

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Executive Summary

In December 2021, the Department for Transport (DfT) and the East West Railway Company (EWR Co) agreed that the Affordable Connections Project (ACP) should be undertaken in response to (1) increasing affordability pressures on Government funding, particularly in the aftermath of Covid; and (2) a change in the policy landscape regarding the Oxford to Cambridge (Ox-Cam) area, with transition towards local rather than central government leadership. The ACP therefore considered whether there were solutions which could deliver most of the benefits of East West Rail (EWR) at a lower capital cost than that presented at the 2021 non-statutory consultation, as well as testing whether there remained a strategic case for investing in EWR given the changed policy context.

This exercise also sought to address concerns raised during the 2021 consultation, which included calls for EWR Co to re-evaluate the strategic case for the Project, associated cost estimates and the results of previous optioneering processes.

The ACP undertook a root and branch review of the potential options for connecting Oxford, Milton Keynes, Bedford and Cambridge. When EWR Co consulted in 2021, proposals were based on parameters set out in the DfT's Sponsor's Requirements and EWR's response to them, known as the Programme Wide Output Specification. Together, these formed the Project Objectives. As part of the ACP, Project Objectives were relaxed, to allow consideration of a wide range of alternatives.

Identification of a long list

A long list of potential transport solutions for EWR was developed through a collaborative workshop of EWR staff and its consultants. The approach was to be as exhaustive as possible. Different options were identified in respect of the following variables: mode choice, alignment choice, service level and service pattern. The exercise identified 170 options to deliver affordable transport connectivity between Oxford and Cambridge. Among this long list were light rail, heavy rail, and guided bus options as well as emerging technologies, for example Advanced Very Rapid Transit (AVRT) system. The AVRT engineering solution has been specifically advocated by Professor John Miles with the Cambridge region in mind.
The long list was then sifted to identify viable options, firstly, through a Credibility Test (was the option feasible?) and then considered by the application of an Affordability Test (would it be likely to offer a cost saving over previous estimates?). The remaining options were then subjected to a Strategic Sift against a range of criteria that were derived from the strategic drivers for transport connectivity in the Ox-Cam region, such as connectivity and attractiveness to passengers.

At this early stage it was identified that cost savings were likely in comparison with previous designs for a new railway between Bedford and Cambridge as there was a broad range of alternatives (modes, routes and service levels) that could be considered. However, on the existing network between Oxford and Bedford, the opportunity for alternatives was thought to be lower as the alignment would most likely make use of the existing railway.

Testing the case for a New Transport Link

In parallel with the identification of viable options, work was undertaken to test the strategic case for EWR as a whole. A Theory of Change analysis was undertaken alongside traditional business case modelling to better capture the transformational benefits of a new transport link. Analysis highlighted that Cambridge in particular has been growing very fast and, given global trends in the sectors where it has particular strengths – for example life sciences – this momentum has the potential to continue. However, it also identified that this growth was likely to be constrained as there was insufficient space for businesses to expand to create new jobs and there was insufficient access to the labour market to fill these roles. The Theory of Change identified that improved connectivity to the rest of the region would help address this. It would also help spread prosperity along the line of the route, including opportunities for regeneration, and ensure the region continued to attract international profile and investment.

Identification of Option Families

Following the initial sifting of options, the remaining options were considered further and clustered into Option Families, grouped by the route served and the proposed transport mode. Some of the remaining options were excluded at this stage after reflecting upon their performance in relation to the sifting process and other considerations.
The Option Families were tested against the Theory of Change to see whether they could support the economic opportunities of the Project and, if so, how.

This resulted in the elimination of all Option Families reliant on modes other than heavy rail. It was found that only heavy rail Option Families could deliver the capacity and capability at the scale required to meet the transport need as articulated in the Theory of Change. In addition, heavy rail Option Families whose routes utilise the route of the former Varsity Line into Cambridge via an alignment through Sandy were eliminated. This was because the alignment does not serve areas designated under current or emerging planning policy as suitable for supporting growth, which is key to the strategic case for EWR, and, based on an assessment of local plans and each Local Authority's position, a change in planning policy in these areas is not considered credible. Further, these Option Families would not perform as well on environmental grounds.

The potential for AVRT was explored separately, and similarly appraised in relation to other strongly performing modes and options studied within the ACP. AVRT has been assessed to be less beneficial than heavy rail in achieving the outcomes of EWR's Theory of Change, so was not recommended for further consideration.

This enabled the list to be down-selected to a shortlist of four heavy rail (HR) Option Families: HR1, HR2, HR3 and HR5, which are depicted in Figure 14 on page 121 of this report. All would serve the St Neots/Tempsford area and Cambourne North with the central stretch of each being roughly the same. However, they presented choices of alignment at Bedford and on approach to Cambridge: to use the Midland Main Line (MML) (HR1 and HR5) or re-use variants of the historic Varsity alignment in the vicinity of Bedford town (HR2 and HR3); a

northern approach via Cambridge North station (HR1 and HR2) or a southern approach via the new Cambridge South station (HR3 and HR5).

Application of the Assessment Factors

The four remaining Option Families were then subject to further development and assessment against EWR Co's Assessment Factors, which were used in the 2021 consultation. This enabled a more informed understanding and a review of the emerging propositions within the context of consultation feedback, as well as allowing a comparison to be made between them. The differentiating Assessment Factors, against which more detailed analysis was carried out, were approached in two stages; Stage 1, looking at Cost (Assessment Factors 3, 4 and 5) and Environment (Assessment Factor 14); and Stage 2, looking at Rail Delivery and Operations (Assessment Factors 6, 7, 8, 9, 10, 11 and 12); and Delivering the Theory of Change and Unlocking Economic Growth (Assessment Factors 1, 2, 15).

Cost estimates were developed for four shortlisted scheme options, for the purpose of comparing the relative costs of these solutions. To do this, EWR Co assessed their relative affordability at base cost level (i.e. the direct cost of construction works plus the associated indirect costs of delivery such as design and project management) with estimates of risk and uncertainty added. Due to the uncertainty around inflation, it has been excluded in the costs produced by the ACP.

Opportunities for phased construction and the phased introduction of services were considered. It was concluded that there was little scope for geographical phasing of services as terminating trains at an interim point between Oxford and Cambridge (Bedford) would not connect the key markets that underpin the Theory of Change. While capital cost could be reduced through phased construction, this would result in higher costs overall. The Theory of Change also indicated that, within a reasonably foreseeable period, EWR would need to deliver at least four trains per hour between Bedford and Cambridge to satisfy forecast demand for the majority of growth scenarios. Delivering that future level of capacity was accordingly an assumption for the purposes of comparing each shortlisted option by reference to the Assessment Factors.

The results of this first stage of assessment indicated that: HR2 (Varsity Hybrid – Cambridge North) performed best on capital cost followed by HR3 (Varsity Hybrid – Cambridge South), but both had significant potential environmental issues associated with the reuse of the Varsity Line. HR1 (Bedford MML – Cambridge North) performed best in respect of the environment with a northern approach to Cambridge being considered to perform better than a southern approach as proposed by HR5 (Bedford MML – Cambridge South).

To provide further differentiation between Option Families, the second stage of assessment was undertaken. This reviewed their performance against the following criteria: Rail Delivery and Operations, Delivering the Theory of Change and Unlocking Economic Growth.

The results of this second stage indicated that in Bedford, routes using the MML (HR1 and HR5) performed better than routes re-using the former Varsity alignment (HR2 and HR3) in terms of both Rail Delivery and Operations and the Theory of Change and Unlocking Economic

Growth. At Cambridge, routes approaching from the north (HR1 and HR2) would not unlock the constraints that need to be addressed to realise the growth opportunity established in the Theory of Change as effectively as routes approaching Cambridge from the south (HR3 and HR5). Operationally, the southern approach was expected to have a more robust and resilient timetable, closer to regular 15-minute service intervals than the northern approach, which is more attractive to users as well as imposing lesser constraints on the future development of the railway network.

Identification of a preferred Option Family

It was concluded that Option Family HR5 (heavy rail between Bedford and Cambridge via the Midland Main Line (MML), St Neots/Tempsford, Cambourne and Cambridge South) performed best overall against EWR Co's Assessment Factors, notwithstanding the likely higher upfront capital cost compared to other Option Families and its potential environmental impact. In environmental terms, HR5 performed better than options utilising the Varsity Line alignment east of Bedford.

The above process validated the optioneering undertaken to date, which had led to nine potential route alignments between Bedford and Cambridge being identified in the 2021 consultation. Following consideration of the feedback from the consultation, and through the ACP, it was confirmed that Alignment 1, equating with Option Family HR5 (Bedford MML-Cambridge South) performed best overall and should be selected as the preferred alignment.

Identification of a preferred route alignment between Bedford and Cambridge

The performance of Option Family HR5 enabled an alignment between Bedford and Cambridge, via the MML St Neots/Tempsford, Cambourne and Cambridge (Alignment 1) to be identified as the preferred route alignment for the new section of railway. Further work was also undertaken to determine whether it was possible to run EWR services on the four existing Midland Mainline (MML) tracks at Bedford. However, this was not found to be viable from an operational perspective. Therefore, the six-tracking option at Bedford also remained the preferred solution.

Concerns were raised in response to the 2021 consultation about the likely impact of Alignment 9 on the village of Roxton. In addition, there was a desire to investigate whether EWR Co's preferred alignment would be able to serve a new station at Tempsford, noting particular support for it in comparison with a St Neots South station in respect of placemaking and economic growth. A variant to Alignment 1 was therefore developed alongside the ACP to address these points. The new alignment, known as Alignment 1 (Tempsford variant), passes to the south of the A428 Black Cat roundabout to serve a new station at Tempsford and has been identified as the preferred alignment.

Confirming the train service pattern

The requirement to deliver the jobs and growth envisaged in the Theory of Change established the need to provide an updated service specification for EWR, compared to that presented at the 2021 consultation. Whereas previously a '4-4-4' trains per hour (tph) service was proposed (2tph Oxford to Milton Keynes, 2tph Oxford to Cambridge, 2tph Bletchley to

Cambridge), the strategic work undertaken by EWR Co indicated that a '4-3-4' tph service (see Figure 17 on page 153) would meet the anticipated demand. This would comprise four trains per hour from Oxford, two of which would progress to Milton Keynes and two of which would continue to Cambridge. A further two trains per hour would travel between Bedford and Cambridge, plus a service between Bletchley and Bedford, which could be replaced by extending one of the Bedford-Cambridge trains to Bletchley to further improve connectivity for the Marston Vale.

Identifying a single preferred solution between Oxford and Cambridge

On the basis of the train service pattern established through the Theory of Change, and having regard to relaxed Project Objectives, the level of infrastructure intervention for the on-line section of EWR between Oxford and Bedford was also re-assessed in parallel with the detailed review on Bedford to Cambridge. This was a 'desk-top' exercise reflecting the process undertaken in relation to the Bedford-Cambridge section of EWR. This allowed assumptions to be made on infrastructure provision and for these to be included with an overall cost estimate for the Project.

Through the combination of work done to consider the alignment between Bedford and Cambridge, and consideration of infrastructure interventions between Oxford and Bedford, the ACP was able to confirm a single preferred solution for the Project. In addition to the new route between Bedford and Cambridge, via the MML, Tempsford, Cambourne and a southern approach to Cambridge, improvements between Oxford and Bedford were also identified. These included upgrades at Oxford which can be integrated with the longer term industry plans for the area; the potential closure and diversion of London Road Level Crossing at Bicester, whilst maintaining pedestrian connectivity; interventions on the Marston Vale Line of a more limited scale than those proposed at the 2021 consultation, including the retention of some level crossings; and upgrades to Bedford St Johns and Bedford stations.
The estimated cost of the Project presented at the 2021 consultation was £5.93bn to £6.33bn. Through the ACP work, the estimated cost of the Project has been revised to £4.46bn to £5.34bn. These figures exclude inflation, electrification, the cost of obtaining statutory authority to construct and operate the Project and EWR Co's operating expenditure but include an estimate of risk.

1. Introduction

1.1 East West Rail

1.1.1 East West Rail (EWR) is a proposed new rail link which would connect communities between Oxford, Milton Keynes, Bedford and Cambridge. By increasing connectivity across the Oxford to Cambridge region and boosting the local economy, the new railway line is part of the Government's ambition to create a range of opportunities for people across the area and spread prosperity across the UK.

1.1.2 The Sponsor of the Project is the Secretary of State for Transport who, through his Department, owns the Project and has overall responsibility for its success. The East West Rail Company Limited (EWR Co) is a government-owned company set up by the Secretary of State for Transport in 2018 to:

- Oversee and further develop work already underway between Oxford and Bletchley (delivered by the East West Rail Alliance).
- Develop all aspects of the Project between Bletchley and Cambridge.

1.1.3 In undertaking this role, EWR Co has been given a remit by the Government to challenge industry norms, such as conventional delivery and operational models.

1.1.4 Although they are sometimes referred to as being part of EWR, proposals by the East West Main Line Partnership to improve the railway between Cambridge, Ipswich and Norwich, and in doing so enable EWR services to continue eastwards, and to improve capacity for freight, are not part of this Project and are not in the remit of EWR Co.

1.2 Context of this Report

1.2.1 EWR Co has worked to develop a rail-based transport solution connecting Oxford, Milton Keynes, and Cambridge.

1.2.2 Construction is already underway between Oxford and Bletchley to enable a train service to run between Oxford and Milton Keynes. This is known as Connection Stage (CS) 1.

1.2.3 Following a public consultation in 2019, a route option was identified for the new section of the line between Bedford and Cambridge. Route alignments within this option were subsequently developed and presented at a non-statutory consultation in 2021, together with proposals for the railway between Oxford and Bedford.

1.2.4 These route alignments were developed in accordance with a Programme Wide Output Specification (PWOS), which set out the standard of the railway infrastructure and level of service to be provided. The PWOS was developed by EWR Co to respond to Sponsor's Requirements specified by the Department for Transport (DfT).

1.2.5 The project between Bletchley and Cambridge (and including additional interventions required at Oxford and Bicester London Road Level Crossing) was estimated to cost in the region of £6bn[1] . This figure was in addition to the £1bn capital investment already committed to CS1.

1.2.6 In December 2021, EWR Co and the DfT agreed to undertake an assessment of the phases of the EWR programme not yet in construction. The purpose of this was to assess the viability and potential benefits to the economy, to businesses, and to the community in the Oxford to Cambridge (Ox-Cam) region of a project which could be delivered at a reduced capital cost compared to the solution presented at the 2021 consultation. This exercise was referred to as the Affordable Connections Project (ACP).

1.2.7 This work followed the 2021 consultation and further initial development work undertaken since the consultation, which helped inform some elements of ACP. Since the consultation, there have been two strategic changes that have impacted the EWR project, which form the background to the ACP reported in this Economic and Technical Report.

1.2.8 The objectives of the ACP were:

Objectives (January 2022)	Comment
Objective One: to engage with local and regional government and businesses in order to understand their ambitions and strategies for delivering housing and business growth in the Oxford to Cambridge area and how EWR supports these, gain a better understanding of the specific needs, constraints and opportunities of these groups, and to align these interests to achieve anticipated benefits.	This engagement has been carried out by EWR Co but is not reported here. Please refer to the Consultation Feedback Report for a summary of stakeholder engagement since the 2021 consultation.
Objective Two: to re-evaluate the strategic case for the Project, considering the purpose of the railway and its ability to serve local, regional, and national needs and to balance the need for housing and local connectivity with the needs of industry and commerce throughout the corridor.	The strategic case for EWR is described in Chapter 6 of this document.
Objective Three: to develop a more comprehensive understanding of the journeys EWR Co is enabling and the associated economic and demand modelling (and its interaction with housing growth) that will underpin decisions around the prioritisation of a railway that is likely to connect some or all of the following:	Please refer to Chapter 6 and Chapter 7 of this document.

[1] At 2021 prices

Objectives (January 2022)	Comment
• Oxford • Milton Keynes • Bletchley • The Marston Vale Line • Bedford • Tempsford / St Neots • Cambourne • Cambridge • Aylesbury[2] However, in setting the terms of reference for this review, EWR Co does not wish to overly constrain our thinking if other, more effective solutions emerge, and further connections opportunities emerge.	
Objective Four: to expand the sources of funding for the Project, including the way in which private and public sector capital can be accessed and combined in the most advantageous way to benefit housing, jobs, and transportation across the Ox-Cam region. EWR Co wants to understand how to be able to leverage its approach to land assembly to create value as the Project develops. Also, to consider the way in which future railway operations would be funded, as a combination of customer fares, central government contributions, local authority contributions, and business contributions.	This is being considered by EWR Co as an ongoing and separate exercise – it is not addressed in this report. While EWR remains a centrally-funded project, opportunities for alternative sources of funding will continue to be explored.
Objective Five: to identify, analyse and estimate the cost of options which offer best value for money by connecting the aforementioned towns and cities, and which are capable of being delivered in phases for a reduced initial capital investment (for example, for less than £3 billion) recognising that the Project will comprise elements which might be delivered sequentially and at lower incremental cost.	Please see Chapter 7 and Appendix 8 of this document.

[2] *Although solutions addressing connectivity with Aylesbury, which does not lie on the core EWR alignment continue to be considered, they are not addressed in this report and do not form part of EWR Co's preferred route alignment.*

Objectives (January 2022)	Comment
Objective Six: to prepare an appraisal report to the Government …[3] which provides a credible strategic and economic case for an affordable railway that can be delivered in incremental phases to meet the existing and emerging needs of the corridor, recommending one or more solutions that should be considered in the next stages of the Project and outline what needs to be true for the business case to succeed.	The appraisal report is this document. Please refer specifically to Chapters 2 to 7. Although the objective refers to "an affordable railway", EWR Co has been open-minded as to the engineering solution and has considered other transport modes as set out in this report.
Additional Objective (July 2022)	
Objective Seven: to recommend the optimal emerging preferred option(s) to be progressed. Three key areas require further development to deliver this objective: A. Clarifying the outputs from Affordable Connections, demonstrating that supporting evidence is robust. This will be conducted by: • Further assessment of environmental impacts, key assumptions, including the potential new options proposed under ACP, to confirm feasibility at this stage and ensure that these are sufficiently robust to support decision making (noting that the Project is in its early stage). Focus will be placed on Bedford North and Varsity alignments; Cambridge North and South. • Consolidation of existing information at Oxford, Bicester London Road, Marston Vale Line and Tempsford/St Neots South. B. Determining the optimal service proposal, considering capacity, demand and operational strategy (including train length, service level and end-to-end routing). C. Assessment and validation of operational assumptions to test robustness of proposals and	Please refer to Chapters 9 to 13 of this document.

[3] The original terms of reference specified a given delivery date of March 2022. In practice, this period was extended when an additional objective was added to the Terms of Reference in July 2022. This report also summarises the further work undertaken in accordance with this, to enable a preferred single option between Oxford and Cambridge to be identified.

Objectives (January 2022)	Comment
increase confidence in the CAPEX and OPEX (and therefore overall total cost estimates).	

Table 1 - ACP Objectives and how they have been addressed

1.2.9 These objectives required EWR Co to set aside previous assumptions which were identified as *Project Objectives* in the 2021 consultation, including the infrastructure and service level constraints set out in the Sponsor's Requirements and the corresponding PWOS. Setting these assumptions aside enabled the scope of the project to be considered afresh. In response, the ACP considered alternative transport solutions to those previously developed, including a reassessment of transport mode, service level options and route alignments based on an understanding of demand requirements and affordability.

1.3 Purpose and contents of the report

1.3.1 The purpose of this report is to review the strategic case for government investment in EWR and to present lower cost, more affordable route alignment solutions than those considered previously, which remain capable of delivering some, or all of the benefits of EWR. Based on the work undertaken for the ACP, a single preferred solution between Oxford and Cambridge is presented as far as is possible at this stage in the Project's development.

1.3.2 The report is structured as follows:

Chapter No.	Chapter Title	Purpose	Page No.
1	Introduction	Explains the role of EWR Co, the background to the project and the purpose of the ACP	6
2	Methodology	Explains the approach to how a preferred option was selected	13
3	Early Sift of Long list – Oxford to Bedford Results	Describes the outcomes from the sifting of a long list of options between Oxford and Bedford	26

Chapter No.	Chapter Title	Purpose	Page No.
4	Early Sift of Long list – Bedford to Cambridge Results	Describes the outcomes from the sifting of a long list of options between Bedford and Cambridge	36
5	Option Families	Explains how options were grouped into families, each with a single infrastructure option and considering different service levels and patterns	54
6	The Case for EWR	Introduces the Theory of Change, an accepted approach to analysing transformational change. This explains the transformational opportunity in the Ox-Cam region and the transport interventions required to enable it	73
7	Application of the Theory of Change to Bedford – Cambridge Option Families	Explains how the Option Families performed against the Theory of Change	98
8	Identifying a Single Preferred Route	Provides an assessment of the remaining four Option Families and determines a single preferred Oxford to Cambridge route	121
9	East West Rail Service Pattern	Explains how the preferred train service along the route was determined	151
10	Infrastructure Decisions between Oxford and Bedford	Describes how outstanding decisions on a number of the Project elements were made	158
11	Conclusion	Summarises the findings of the ACP and describes the preferred options for each element of the programme,	178

Chapter No.	Chapter Title	Purpose	Page No.
		including the preferred route alignment	

Table 2 - Report Contents

2. Methodology

2.1 Introduction

2.1.1 To respond to Objectives 2, 3, 5, 6 and 7 (see Table 1), a staged methodology was adopted; first identifying a long list of potential options, and then refining this over several subsequent stages and through detailed analysis to identify an end-to-end solution for EWR.

2.1.2 A long list of potential solutions was developed through a series of collaborative workshops involving EWR staff and its consultants. The objective was to be as exhaustive as possible. Different options were identified in respect of the following variables: mode choice, alignment choice, service level and service pattern. The exercise identified 170 options to deliver affordable transport connectivity between Oxford and Cambridge.

2.1.3 At this early stage, it was identified that the new section of railway between Bedford and Cambridge presented the greatest potential for material cost savings as there was a broad range of alternative options that could be considered to provide the required connectivity. The opportunity for alternatives was lower on the section between Oxford and Bedford as the alignment would most likely make use of the existing railway.

2.1.4 Next, the process was to determine the most viable options from the long list of 170 potential solutions, to deliver affordable transport connectivity between Oxford and Cambridge. Sections 2.2 to 2.5 below describe the approach to sifting the options, first through a Credibility Test and considered against an Affordability Test. The remaining options were then subjected to a Strategic Sift against a range of criteria that were derived from the strategic drivers for transport connectivity across the region. This process generated a short list of options, which was sense-checked to inform which options should progress for further assessment. The results of this process are addressed in Chapters 3 and 4 of this Report. It was concluded early on that heavy rail remained the most appropriate means to provide connectivity between Oxford and Bedford, whereas greater mode options remained for the Bedford to Cambridge section.

2.1.5 In parallel with the identification of viable options, work was undertaken to review the strategic case for EWR as a whole. The remaining options were considered further and sense-checked against the criteria and supporting strategic work, and subsequently clustered into *Option Families* (a range of service options each with consistent infrastructure and mode solutions).

2.1.6 This strategic work focused on the development of connectivity beyond Bletchley, once CS1 was in place. This highlighted the Cambridge economy as a focus area which requires particular interventions if it is to deliver the benefits identified in the strategic case, and which would have a positive ripple effect on the rest of the region. This is known as the Theory of Change and is described in Chapter 6. The process of applying the Theory of Change to inform the selection of a single route option is described in Chapter 7.

2.1.7 As part of this work, an updated service specification for EWR of 4-3-4 trains per hour (tph) was confirmed as being needed to meet the anticipated demand. This differed from the service specification presented in the 2021 consultation. The revised specification of 4-3-4tph would comprise four trains per hour from Oxford, two of which would progress to Milton Keynes and two of which would continue to Cambridge; a further two trains per hour would travel between Bedford and Cambridge; plus a service between Bletchley and Bedford, which could be provided by extending one of the Bedford-Cambridge trains to Bletchley to further improve connectivity for the Marston Vale.

2.1.8 The Theory of Change findings determined the outputs, such as the transport mode and an updated service specification, needed to achieve the identified benefits. These were applied to the Option Families, reducing the number of Option Families that remained.

2.1.9 The remaining Option Families were then subject to further development and assessment against EWR Co's Assessment Factors. This enabled a more informed understanding of the options and a more detailed comparison to be made between them. At this stage, opportunities for phased construction and a phased introduction of services were considered.

2.1.10 Cost estimates were developed for four shortlisted Option Families for the purpose of comparing the relative costs of these solutions. To do this, EWR Co assessed their relative affordability at base cost level (i.e. the direct cost of works plus the associated indirect costs of delivery, such as design and project management). Estimates also included risk and uncertainty and inflation in order to determine the expected range of total cost for each shortlisted option. Appendix 8 provides more detail on how these costs were derived and a summary of the estimates.

2.1.11 This methodology resulted in a single preferred solution to be identified between Oxford and Cambridge.

2.2 Strategic Objectives

2.2.1 When EWR Co consulted in 2021, the proposals were based on parameters set out in the DfT's Sponsor's Requirements and EWR's response to them, known as the Programme Wide Output Specification (PWOS). Together, these formed the Project Objectives. For the ACP, the review of the strategic case set aside these parameters.

2.2.2 The Project Objectives were set out in the 2021 consultation Technical Report. They included:

- Improve east-west public transport connectivity between key urban areas.
- Stimulate economic growth, housing and employment.
- Provide a sustainable and value for money transport solution to support economic growth in the area.

2.2.3 The work on the strategic case undertaken as part of the ACP sought to test these objectives. A review of the most up-to-date (at that time) local, regional, and national policies and plans,

including on planning, growth, transport and environment were examined, which confirmed that the objectives have not fundamentally changed, and that a transport project between Oxford and Cambridge remains key to enabling economic growth.

2.3 Options Long list

2.3.1 A Scheme Option is defined as a transport solution for a specific route section incorporating mode, route geography and service level descriptors such as stopping pattern and frequency per section. By developing solutions unconstrained by the Sponsor's Requirements and PWOS, EWR Co was able to investigate a wide range of options through a long listing exercise undertaken by experts from EWR Co and its technical consultant, Arup. Collaborative optioneering workshops were held, at which attendees considered potential transport solutions to connect the key locations across the region as per the Terms of Reference for the ACP. The approach was to be as exhaustive as possible. Different options were identified in respect of the following variables:

- Mode choice.
- Alignment choice.
- Service specification – note that options which delivered a service level (number of passenger services) in excess of four trains per hour for a heavy rail solution were not considered, as such options were assumed to not reduce costs. This cap was not applied to other modes, to enable comparable levels of capability to be assessed.

2.3.2 The Project team divided the route into two route sections when identifying options: Oxford to Bedford and Bedford to Cambridge. The rationale for this was that there were distinctive comparable characteristics of each section that would be easier to assess against criteria if the sifting was undertaken separately.

2.3.3 Different modes were considered using professional engineering judgement, noting that railway infrastructure already exists between Oxford and Bedford. Therefore, an opportunity to replace this for use by another mode at a reduced cost was less likely. It was also recognised that Connection Stage 1 (CS1) between Bicester and Milton Keynes is currently under construction. Consequently, the Oxford to Bedford route section focussed on operationally-led solutions with minimum levels of enhancement work.

2.3.4 Because a direct railway connection between Bedford and Cambridge no longer exists, a greater range of operational, infrastructure and mode options was available for this section. This allowed a wider range of alternatives to be considered.

2.3.5 After further analysis, the solutions proposed for the two route sections have been combined to provide an end-to-end transport solution between Oxford and Cambridge via Bletchley and Bedford.

2.3.6 This approach, alongside the nature of the long-listing exercise and the ability to consider options in an unconstrained manner meant that over 170 options were identified. Each of the long list of Scheme Options was given a code to enable it to be identified during the appraisal of options and the sifting process. The codes were produced in the format set out in Table 3.

Route Section	Mode	Identifier
CS2 – Oxford-Bedford	HR – Heavy Rail	S*n* – CS2
CS3 – Bedford-Cambridge	LR – Light Rail	A*n* – CS3
	TT – Tram/Train	
	GB – Guided Bus	
	R – Road	
	HL – Hyperloop	
	ML – Maglev	
	CC – Cable car	

Table 3- Alignment ID Codes

2.3.7 For example, the third listed heavy rail solution under consideration in the route section between Oxford and Bedford would be identified as: CS2-HR-S3.

2.3.8 For each Scheme Option, there is a corresponding description, which enables its components to be understood. For CS2-HR-S3, this is "Existing - Oxford to Milton Keynes 2 trains per hour (tph)/Oxford to Bedford1tph + existing freight", which means that the Scheme Option uses the existing alignment of the railway between Oxford and Bedford and would accommodate three trains per hour of which two would be between Oxford and Milton Keynes Central Station with one train per hour between Oxford and Bedford and existing freight services.

2.3.9 The full long list is set out in Appendix 1 to this Report. To provide some context, Figure 1 below depicts a simplified indicative diagram of the EWR routes that were considered in the assessment with possible calling points.

2.3.10 While a connection to Aylesbury is not currently within the core scope of EWR, the identification of long list options for the connection between Oxford and Cambridge, as well as potential stopping points between the cities, included consideration of how a connection to Aylesbury might be achieved so as not to preclude such options. The strategic work also reviewed the opportunities for connectivity to Aylesbury and concluded that Aylesbury should continue to be viewed separately from the core scope of EWR. As a consequence, it is not considered further in this report.

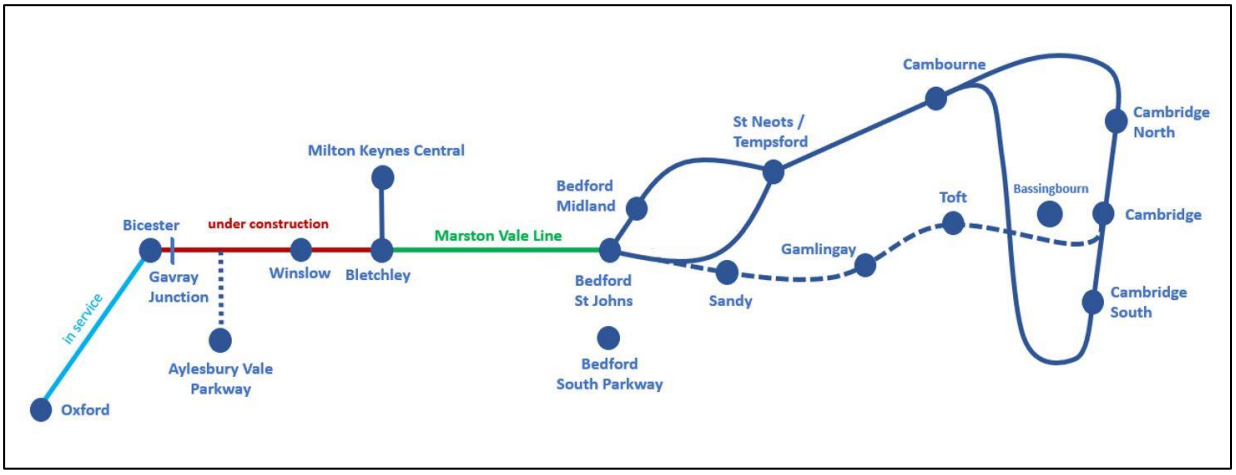


Figure 1 - Simplified diagram of possible calling points - route alignments for illustrative purposes only. Options developed covered two sections: Oxford to Bedford, and Bedford to Cambridge.

2.3.11 The long list was then subjected to Credibility, Affordability and Strategic criteria, to produce a list of viable options to be developed in greater detail.

2.3.12 In addition to the more conventional solutions identified, EWR Co considered an emerging mode known as Affordable Very Rapid Transit (AVRT) in relation to the Bedford-Cambridge route section. This is included in the long list but was the subject of a parallel review, which appraised the AVRT scheme(s) in relation to other strongly performing modes and options studied within this report. The study concluded that AVRT would not unlock the economic opportunity identified in EWR's Theory of Change, so was not recommended for further consideration. The report on AVRT is included in Appendix 10.

2.4 Credibility Test

2.4.1 The first review of the long list was against a Credibility Test, which was designed to remove all options that were not technically suitable or were out of scope for ACP or EWR. The results of this test are summarised in Chapters 3 and 4. This included solutions in the following categories:

- Technically novel, unproven or inappropriate transport modes for a connection between Oxford and Cambridge (e.g. hyperloop, maglev, cable car).
- Modes that reduce capacity on the existing rail network due to poor interoperability with heavy rail (e.g. light rail / tram / bus on the West Coast Mainline); notwithstanding the options where existing network services may be substituted to deliver EWR services.
- Rail options triggering additional significant enhancements to the national railway network beyond those identified in the 2021 consultation as a result of capacity constraints on the network, which were not considered plausible.
- Modes that are inconsistent with current policy (such as recommencing promotion of the Oxford-Cambridge Expressway, which was cancelled) or road improvement proposals which are properly to be considered by National Highways.

2.5 Affordability Test

2.5.1 Affordability has not been defined in absolute terms in this report. In the circumstances of this review and based upon the cost of the scheme presented as an emerging preference in the 2021 consultation, it was initially assumed that a £6 billion capital investment at 2021 (including risk and inflation allowances, and which equates to circa £3bn in base cost) provides a notional cost ceiling. Therefore, as a working assumption, it was concluded that the initial capital cost will need to be significantly less than this. Having regard to longer-term

affordability, the longer-term value for money that this investment would deliver has been considered and the customer benefits accrued in relation to their cost.

2.5.2 The Affordability Test considered the principal cost-driving infrastructure interventions for the Scheme Options in each route section that remained following the application of the Credibility Test. This test also considered service elements (such as service level and stopping patterns) which were driving those infrastructure requirements and, therefore, were leading to higher capital costs. The results of this test are summarised in Chapters 3 and 4.

2.5.3 Scheme options requiring significant segregated track and platforms or other extensive interventions on the existing rail network[4] to create the extra capacity (both light and heavy rail) were discounted on the basis of cost at this stage. These are summarised below[5]:

- Rail scheme options with more than three trains per hour over Bicester London Road level crossing.
- Rail scheme options with more than two trains per hour to Milton Keynes, Bedford Station or Cambridge (whether approaching Cambridge from the north or south).

2.5.4 As part of this sifting stage, a sensitivity was applied by taking account of two factors, which resulted in the retention of options with two trains per hour into Cambridge from the south and options utilising most of the original Varsity Line alignment between Bedford and Cambridge via Sandy:

- For scheme options with a southern approach to Cambridge, options which would have been discounted on affordability owing to the need to four-track the West Anglia Mainline (WAML), were retained on the assumption that two existing WAML services per hour could be replaced to deliver the EWR services, thereby avoiding four-tracking the WAML.
- Varsity Line options, which had initially been excluded as too expensive due to the requirement for a tunnel to address the topography of the area and to traverse the built-up Sandy area, were retained by substituting a viaduct for a tunnel, making these Varsity Line options affordable in principle.

2.6 Strategic Drivers

2.6.1 The process described above excluded Scheme Options that were considered unlikely to be credible as a way of providing enhanced transport connectivity on the two route sections between Oxford and Bedford and between Bedford and Cambridge, and those which it was anticipated would exceed the cost envelope of an EWR project with a notional minimum affordability. Next, it was necessary to consider how to identify those remaining Scheme Options which were most likely to achieve the strategic objectives and provide a cost-

[4] including the West Coast Mainline, Midland Mainline and West Anglia Mainline

[5] Prices below in base construction costs (reference Project Taskforce 2021)

effective transport solution, linking settlements within the Oxford to Cambridge area. This analysis was considered to require a more detailed understanding of the aims of the Project and the performance of Scheme Options in relation to those aims.

2.6.2 To enable the performance of Scheme Options to be assessed consistently in both the Oxford-Bedford and Bedford-Cambridge route sections, a series of "Strategic Drivers" were identified. The performance of the Scheme Options was considered against the Strategic Drivers and the sifting criteria that sit beneath these:

1. Does the Scheme Option meet the strategic need, in terms of access to population, employment and potential housing growth, demand, and does the option have the capacity and ability to meet the demand?

2. Is the Scheme Option attractive to users, from the perspective of journey time, need to interchange, and service frequency?

2.6.3 Once the options had been sifted, consideration was also given to their overall alignment with relevant policies such as on decarbonisation or the ability to support modal shift in freight. Whilst these considerations were noted at this stage, performance against such factors was taken into account in later comparisons of transport solutions.

2.7 Strategic Test

2.7.1 The Strategic Drivers were used to sift affordable and credible Scheme Options and identify those which were most likely to meet the strategic objectives. The aim of this sifting exercise was to identify those credible and affordable Scheme Options that could be subject to further appraisal in terms of their ability to address geographical and economic issues within the Oxford to Cambridge region.

2.7.2 Each Scheme Option (regardless of mode) was considered against the Sifting Criteria using a scoring system of 1 (low) to 3 (high). Any Scheme options where any Sifting Criterion scored 1 were initially discounted. The results of the sifting process are summarised in Chapter 4.

Strategic Need

2.7.3 The Strategic Need was considered against three sifting criteria:

- Does it connect the right places? Three supporting criteria were examined for each option:
    - Existing Population; allowing an understanding of the best opportunity to achieve modal shift and connect existing populations to employment.
    - Existing Jobs; connecting existing jobs provides the best opportunity to achieve modal shift and connect existing populations to employment.

- Future Growth; as a key strategic aim of EWR is to maximise the potential for economic growth in the Oxford to Cambridge region.

- Does it attract enough demand?
- Does it have enough capacity to meet that demand?

Attractiveness to Users

2.7.4 The Attractiveness to Users sifting criterion included three supporting criteria:

- Journey Time; as the shortest journey times would best encourage modal shift and use of the scheme option, with lower journey times generally leading to higher demand for transport.
- Interchanges required in each section; as changing transport modes influences demand through the effect it has on time spent waiting, time spent transferring between vehicles and the inconvenience and risks to the journey involved.
- Service frequency; as a higher frequency is assumed to encourage more travel and demand as individuals would more likely be able to depart at their chosen time and would be less impacted should they miss a service. It would also increase capacity.

Journey time

2.7.5 Lower journey times generally lead to higher demand for transport. This is because, irrespective of mode, the lower the journey time, the more likely someone is to undertake the journey. This is particularly the case with commuting, where a worker's choice of residence and/or workplace is influenced by the transport options available, and the journey time between destinations.

2.7.6 A 45-minute journey time is frequently used in transport planning to mark the boundaries of a medium sized city's commuting catchment and most workers' willingness to travel. The analysis carried out by EWR Co. suggests the point at which fewer than 1% of residents will commute to the city aligns approximately with 45-minutes by rail for Oxford and Cambridge and 45-minutes by car for Milton Keynes. This figure is important to understand the issues concerned in the decision-making for the approach into Cambridge, explained in section 8.4.

2.7.7 The journey time thresholds which were applied during the sifting process differed depending on relevant sections of the route. All of them are in the region of 45 minutes.

Interchange

2.7.8 Changing transport modes influences demand through the effect it has on time spent waiting, time spent transferring between vehicles and the inconvenience and risks involved. Hence, interchanging not only takes time but also imposes a psychological barrier on travellers greater than the actual time required to interchange. Transport research shows that in Great

Britain, rail demand, in particular, significantly rises when interchanges are removed. This is particularly the case for short-distance journeys.

Frequency

2.7.9 It has been assumed that a higher frequency of service encourages more travel / demand as individuals would more likely be able to depart at their chosen time and would be less impacted should they miss a service.

2.7.10 The long listing process aspired to a minimum frequency of two trains (heavy or light rail) per hour with the potential to upgrade to four trains per hour. This position would be revisited later in the process, once the Theory of Change had been established – see paragraph 2.8 below and Chapters 6 and 7. For other modes, a minimum of four services per hour was considered to provide a comparable alternative to a two trains per hour heavy rail service level.

2.7.11 Table 4 below summarises how each of the performance criteria in the strategic sift were scored.

		Strategic driver 1: Strategic Need					Strategic driver 2: Attractiveness to Users		
		Does it connect the right places?			Does it attract 'enough' demand?	Does it have capacity to meet that demand?	Is it attractive to users?		
	Score (1-3)	Existing Population (No.)	Growth opportunity ranking*	Existing Jobs (No.)	Demand Compared to Base (inc. planned development)	Demand over Capacity (% modelled)	Journey Time (Total mins, modelled)	Interchanges (No. required)	Service Frequency (No. of tph)
Oxford to Bedford	1	<222,052	Low	<208,062	<0.7	>140%	>64	>1	<3
	2	222,053 - 239,497	Medium	208,062 - 223,105	0.7 - 0.77	100- 140%	56 - 64	1	3
	3	>239,497	High	>223,105	>0.77	<100%	<56	0	>3
Bedford to Cambridge	1	<86,473	Low	<37,202	<0.56	<140%	>50	>1	<3
	2	86,473 - 122,575	Medium	37,202 - 67,201	0.56 - 0.72	100- 140%	50 - 41	1	3
	3	<122,575	High	>67,201	>0.72	<100%	<41	0	>3

Table 4 – Levels of performance against each parameter used to arrive at the relevant scores for each criterion

* The growth opportunity ranking was calculated on the basis of a high-level assessment of land availability using GIS Data / Desktop research, based on:

LOW: <30% Available Land
MEDIUM: 30-60% Available Land
HIGH: >60% Available Land

2.8 Creation of Option Families and the Theory of Change

2.8.1 The sifting process created a short list of options to be considered further.

2.8.2 For the Oxford to Bedford section, this stage of the process involved converging on a single, heavy rail Scheme Option based on a high-level analysis of benefits and costs. In contrast, there remained significant differentiators between Bedford and Cambridge and therefore by fixing on a single mode option between Oxford and Bedford, these differentiators could then be compared on a like-for-like basis.

2.8.3 To make the assessment manageable, it was necessary to limit the number of options between Bedford and Cambridge that were taken forward to detailed modelling and economic appraisal. The shortlisted options were consolidated into Option Families, grouped by the alignment served and proposed transport mode.

2.8.4 In parallel, EWR Co used a Theory of Change approach to assess the Option Families for transport connectivity between Oxford and Cambridge. A Theory of Change is a tried and tested methodology for planning and evaluation that is used in commercial, not-for-profit and government sectors to promote social change. It defines long-term goals and then maps backwards to identify the necessary preconditions for outcomes to be achieved. The Theory of Change developed for the Project is explained in Chapter 6 along with its methodology and its outputs.

2.8.5 The outputs of the Theory of Change were used to reassess the strategic case for a transport project between Oxford and Cambridge and to identify particular regional constraints that a successful option would need to tackle. It also determined the capacity that a successful transport option would ultimately need to provide, and hence the level of service necessary for each mode to deliver that capacity. The evidence gathered through the use of a Theory of Change analysis (supplemented by traditional transport modelling and appraisal techniques) was applied to the Option Families (explained in Chapter 7). This allowed further shortlisting of the option families, retaining those that were most likely to deliver growth. Four rail option families remained the focus of further analysis with different approaches to Bedford and Cambridge, but with a common alignment in-between. These four rail option families were then analysed to identify risks and opportunities. This assessment is explained in Chapter 9.

2.8.6 Cost estimates were developed for the four heavy rail option families, for the purpose of comparing the relative costs of these solutions. This was done by assessing their relative affordability at base cost level (i.e. the direct cost of works plus the associated indirect costs of delivery such as design and project management) and by also considering the expected range of total costs in terms of risk and uncertainty for these options.

2.9 Assessing the short-list

2.9.1 EWR Co assessed the performance of the shortlisted Option Families by using the Assessment Factors used in previous decision-making for EWR. The Assessment Factors are set out in the

2021 consultation Technical Report. In a first stage, the following topics were identified as potential differentiating considerations:

- Cost (Assessment Factors 3, 4 and 5).
- Environment (Assessment Factor 14).

2.9.2 A second stage of EWR Co's assessment then looked again at the previous optioneering decisions on key elements of infrastructure, particularly in relation to the approaches to Bedford and Cambridge. To facilitate these comparisons, additional topics from the existing Assessment Factors were identified as potential differentiating considerations:

- Service delivery and operations (Assessment Factors 6, 7, 8, 9, 10, 11 and 12).
- Delivering the Theory of Change and unlocking economic growth (Assessment Factors 1, 2, 15).

2.9.3 The opportunities for phased construction and a phased introduction of services for the shortlisted options families, and the implications of this for the service pattern, were also considered.

2.10 Identifying the final recommendation

2.10.1 The conclusions of the assessment process validated the optioneering undertaken to date, and allowed a single, most appropriate Scheme Option to be identified for the section of the railway between Bedford and Cambridge. This then enabled other aspects of the route to be defined, particularly:

- Confirming the proposed EWR service pattern between Oxford, Milton Keynes, Bedford and Cambridge.
- Outcomes needed at Oxford.
- Narrowing of options at the Bicester London Road level crossing.
- Outcomes required for the Marston Vale Line.
- Preferred options at Bedford and Cambridge.

3. Early Sift of Long list – Oxford to Bedford Results

3.1 Introduction

3.1.1 This chapter considers the long list of Scheme Options between Oxford and Bedford and explains how options were discounted to identify a shortlist of potential solutions. The methodology for this is set out in Chapter 2.

3.1.2 To establish the long list of options, a group of experts from EWR Co and its supply chain of engineering consultancies considered transport solutions that could provide enhanced links between Oxford and Cambridge. Unconstrained by the Project Objectives contained in the Sponsor's Requirements and the PWOS, it was possible to identify a large number of means of providing transport for passengers between the two cities and locations in between. The process identified 170 Scheme Options, of which 57 related to the route section between Oxford and Bedford and 113 related to the route section between Bedford and Cambridge. The Bedford to Cambridge options long list sift is summarised in Chapter 4.

3.1.3 As described in Chapter 2, the long list of Scheme Options was considered for each route section. This was undertaken first in terms of technical suitability (or credibility) to provide a transport connection between the relevant end points and then in terms of affordability in the context of the Terms of Reference for the ACP. It should be noted that cost estimates provided in relation to infrastructure interventions at this stage were based on professional judgement and were used to make a high-level comparison between options to enable an early sift.

3.1.4 After the initial Credibility and Affordability tests (or sifts), the remaining Scheme Options were subject to a Strategic Sift. This considered Strategic Drivers, which are summarised as: the ability of the Scheme Options to meet the strategic need for the project, and the attractiveness of the Scheme Options to users.

3.1.5 These tests/sifts and their outcomes for the Oxford-Bedford section are described below.

3.2 Results of Credibility Test – Oxford to Bedford

3.2.1 Of the 57 Scheme Options for this section, the test of whether an option was technically suitable or out of scope for further consideration resulted in 7 options being discounted from the long list.

3.2.2 This was for the following reasons:

- The use of a Light Rail solution on a four light rail vehicles (LRVs)-per-hour basis between Oxford and Milton Keynes Central or between Oxford and Bletchley stations was discounted. This was for several reasons, including

that to achieve shared running on the West Coast Main Line (WCML) of LRVs and existing/planned services was considered likely to be highly technically complex. The tram vehicles used in a light rail solution are fundamentally different to high speed (>100 mph) mainline rail vehicles for passenger trains and heavy freight trains. To mitigate the risk posed by different vehicle standards, there would need to be enforced separation between light rail and heavy rail services because of the different crashworthiness characteristics of the rolling stock. This mitigation would require changes to WCML signalling, which would reduce capacity on the main line by 25%, meaning that additional infrastructure would be required in the form of new track on the WCML. While the introduction of a European (electronic) Train Control System (ETCS) might provide an alternative mitigation, longer overrun protection would still be needed due to the different crashworthiness standards, and capacity would still be constrained on the WCML. These solutions would be very expensive to introduce (in excess of £300M). Consequently, these two Scheme Options (Light rail between Oxford and Milton Keynes, and between Oxford and Bletchley) were excluded.

- The replacement of the existing railway by a Guided Bus between Oxford and Bletchley and then extending to Milton Keynes Central station on a six bus-per-hour basis was discounted. Similarly, the replacement of the existing railway by a new road between Oxford and Bedford was discounted. This is because the loss of the existing railway would be expensive and result in the loss of existing rail services. Because the existing railway, particularly its overbridges, is built to traditional railway standards, it is narrower than the cross-section needed for modern bus rapid transit vehicles or road vehicles, meaning that capacity would be constrained to a single lane in each direction. There would be particular constraints at bridges where vehicles could not pass one another. The solution would result in constraints on capacity, impacts on the environment and have material cost implications.

- A Hyperloop solution was discounted as unsuitable because of its technical complexity, the risk of deploying new technology, and high capital and operating costs. The distance involved was also not considered appropriate for a Hyperloop solution (Hyperloop, to maximise the top speed benefit, needs approximately at least 50km+ between portals to get to top speeds, using aircraft take-off acceleration speeds).

- A Maglev constructed on the existing railway alignment was discounted as being unsuitable because of its technical complexity, high capital and operating costs, and capacity limitations. The distance involved was also not considered appropriate for a Maglev solution.

- A replacement of the railway with a cable car was discounted as it would result in long journey times and restrict capacity. The replacement of the railway would reduce passenger capacity and result in the loss of freight capacity.

3.3 Results of Affordability Test (Oxford to Bedford)

3.3.1 The test of whether a Scheme Option was affordable in the context of the Terms of Reference for the ACP resulted in a further seven options being discounted from the long list. The majority of these are heavy rail options, which can be grouped as a series of single infrastructure solutions with multiple service levels.

3.3.2 The first set of Scheme Options discounted were as follows:

- Two trains per hour between Oxford and Milton Keynes Central and two trains per hour between Oxford and Bedford with existing freight services. EWR trains would stop twice on the Marston Vale Line between Bletchley and Bedford.
- Two trains per hour between Oxford and Milton Keynes Central and two trains per hour between Oxford and Bedford with existing freight services. EWR trains would stop five times on the Marston Vale Line between Bletchley and Bedford.
- Two trains per hour between Oxford and Milton Keynes Central and two trains per hour between Oxford and Bedford with existing freight services. EWR trains would stop twice on the Marston Vale Line between Bletchley and Bedford and existing services would stop ten times.

3.3.3 These Scheme Options would require the new facilities at Oxford station and the closure and replacement of Bicester London Road level crossing, each of which would result in material project risk and significant capital cost. Based on the need to consider affordability, such provision and its associated costs were discounted at this stage.

3.3.4 A second set of Scheme Options that used part of the WCML was then considered and discounted. These were as follows:

- A two train per hour service between Oxford and Milton Keynes Central, with a one train per hour stopping service. EWR trains would stop twice on the Marston Vale Line between Bletchley and Bedford.
- A two train per hour service between Oxford and Milton Keynes Central, with a one train per hour stopping service. EWR trains would stop five times on the Marston Vale Line between Bletchley and Bedford.
- A two train per hour service between Oxford and Milton Keynes Central, with a one train per hour stopping service. EWR trains would stop twice on the Marston Vale Line between Bletchley and Bedford and existing services would stop ten times.

3.3.5 These Scheme Options were discounted because of the complexity and cost of integrating more services on the WCML and resulting capacity constraints. These Scheme Options result

in 3tph between Bletchley and Milton Keynes on the WCML. The existing WCML is at capacity and there are platform constraints at Milton Keynes that affect the ability to turn services. These Scheme Options are likely to require the construction of additional platform capacity to enable trains to turn. Furthermore, the existing WCML signalling is conventional, and no further capacity can be provided unless additional infrastructure (track) or migration to ETCS with traffic management is provided. The cost is considered to be in excess of £500m, having regard to infrastructure alterations/land acquisition or the provision of ETCS traffic management for the Rugby Regional Operations Centre desk (including the cost of rolling stock fitment with ETCS apparatus).

3.3.6 The final discounted Scheme Option was the provision of a tram/train service from Oxford to Bletchley along the existing railway. The railway would continue to operate as heavy rail on the Marston Vale Line east of Bletchley. This was discounted because of the cost of altering track to light rail standards. Also, achieving shared running on the WCML of tram/train vehicles and existing/planned services on the WCML was considered likely to be highly technically complex. The vehicles used in a tram/train solution are different in character to high speed (>100 mph) mainline rail vehicles for passenger trains and heavy freight trains. As for light rail, to mitigate the risk, there would need to be enforced separation between light rail and heavy rail services due to the different crashworthiness characteristics of the rolling stock. This mitigation would result in changes to WCML signalling, which would reduce capacity on the main line by 25% meaning that additional infrastructure would be required – new track on the WCML. While the introduction of an electronic European Train Control System (ETCS) might provide an alternative mitigation, longer overrun protection would still be needed due to the different crashworthiness standards and capacity would still be constrained on the WCML. These solutions would be very expensive to introduce (in excess of £300M).

3.4 Results of Strategic Sift (Oxford to Bedford)

3.4.1 Following the application of ten criteria derived from the Strategic Drivers, options were eliminated on a range of grounds relating to an insufficiency of population served, jobs likely to be created, or growth opportunities.

3.4.2 Table 5 shows that discounting Scheme Options on the basis of the Strategic Drivers resulted in the exclusion of 23 Scheme Options due to the strategic need not being met, and further two Scheme Options on the basis of attractiveness to travellers.

Service/Alignment Options	Mode	Trains / Users PH	MVL Stopping Pattern	Strategic Driver Category not met
Oxf to Mkc 2 tph/ Bletchley to Bed 1tph stopper (Base case) + existing freight	Heavy Rail	2 tph	2 stations	Capacity, Population, Growth Opportunity, Jobs
Oxf to Mkc 2 tph/ Bletchley to Bed 1tph stopper (Base case) + existing freight	Heavy Rail	2 tph	2 EWR + 10 Stopper	Capacity
Oxf to Mkc 2 tph/Oxf to Bed 1tph + existing freight	Heavy Rail	3 tph	2 stations	Demand, Population, Growth Opportunity, Jobs
Oxf to Mkc 2 tph/Oxf to Bed 1tph + existing freight	Heavy Rail	3 tph	5 stations	Capacity
Oxf to Mkc 2 tph/Oxf to Bed 1tph + existing freight	Heavy Rail	3 tph	2 EWR + 10 stopper	Demand
Oxf to Mkc 1tph/Oxf to Bed 2tph + existing freight	Heavy Rail	3 tph	2 stations	Population, Growth Opportunity, Jobs
Oxf to Mkc 1tph/Oxf to Bed 1tph + existing freight	Heavy Rail	2 tph	2 stations	Demand, Population, Growth Opportunity, Jobs
Oxf to Mkc 1tph/Oxf to Bed 1tph + existing freight	Heavy Rail	2 tph	5 stations	Demand
Oxf to Mkc 1tph/Oxf to Bed 1tph + existing freight	Heavy Rail	2 tph	2 EWR + 10 stopper	Demand
Oxf to Mkc 0tph/Oxf to Bed 2tph + existing freight	Heavy Rail	2 tph	2 stations	Population, Growth Opportunity, Jobs
Oxf to Mkc 1tph – Bed to Mkc 1tph	Heavy Rail	1tph	2 stations	Population, Growth Opportunity, Jobs
Oxf to Mkc 2ph – Bed to AYS 1tph stopper	Heavy Rail	2 tph	2 stations	Demand, Growth Opportunity
Oxf to Mkc 2ph – Bed to AYS 1tph stopper	Heavy Rail	2 tph	5 stations	Demand, Population Jobs
Oxf to Mkc 2ph – Bed to AYS 1tph stopper	Heavy Rail	2 tph	2 EWR + 10 stopper	Demand

Service/Alignment Options	Mode	Trains / Users PH	MVL Stopping Pattern	Strategic Driver Category not met
Oxf to Mkc 1tph – Bed to Mkc 1tph stopper – Oxf to Bed 1tph stopper	Heavy Rail	2 tph	2 stations	Population, Growth Opportunity, Jobs
Oxf to Mkc 1tph – Bed to Mkc 1tph stopper – Oxf to Bed 1tph stopper	Heavy Rail	2 tph	2 EWR + 10 stopper	Population, Jobs
Oxf to Bed via Mkc 1ph stopper - Oxf to Bed 1tph stopper	Heavy Rail	2 tph	2 stations	Population, Growth Opportunity, Jobs
Freight only	Heavy Rail	Freight Only	-	No Passenger Service
Oxf to Mkc 1tph - 1 Oxf - Bed 1tph stopper - 1 AYS to Mkc	Heavy Rail	3tph	2 EWR + 10 Stopper	Attractive to Users
Oxford to Milton Keynes Central	Tram/ Train	4 tph	-	Population, Growth Opportunity, Jobs
Bletchley to Bedford (MVL)	Tram/ Train	4 tph	2 stations	Population, Growth Opportunity, Jobs
Bletchley to Bedford (MVL)	Tram/ Train	4 tph	2 EWR + 10 stopper	Attractive to User
Aylesbury to Gavray Junction	Tram/ Train	4 tph	-	Demand, Population, Growth Opportunity, Jobs
Bletchley to Bedford (MVL)	Guided Bus	6bph	-	Demand
Aylesbury to Gavray Junction	Guided Bus	4bph	-	Demand

Table 5 - Oxford to Bedford Scheme Options discarded at strategic sift

3.4.3 There were a number of reasons why options were excluded during the long list sift between Oxford and Bedford. These are summarised below. As all the options shared the same alignment and served the same town and city centre catchments the variance in scores between options was low.

Strategic Need

Connecting the right places (Population, Jobs and Growth Potential)

3.4.4 Service patterns which had only two stops on the Marston Vale Line resulted in smaller population and jobs catchment than those with five stops or a combined express and all-stopper service.

Demand

3.4.5 Options with only one service per hour on the Marston Vale Line, assumed to be in addition to the existing stopping service, performed comparatively poorly in attracting enough demand compared to the original project.

Capacity

3.4.6 Options with only one service on the Marston Vale Line (without a stopper) were also frequently but not exclusively found not to deliver enough capacity for the estimated demand.

Attractiveness to Users

Journey Time, Interchanges, Frequency

3.4.7 The options excluded for this reason was to maintain the proposed service frequency on completion of CS1 as this offered a low frequency (1tph) and long journey time between Oxford and Bedford (70 minutes).

3.4.8 Following the Strategic Sift, 19 Scheme Options remained for EWR between Oxford and Bedford. These were grouped based on service patterns as shown in Table 6 and are considered further in Chapter 0

3.5 Remaining Options (Oxford to Bedford)

3.5.1 Following the sifting process, 19 options remained between Oxford and Bedford. These are summarised in Table 6.

Mode	Alignment ID	Long List Description	MVL Stations	Bicester - Bletchley Frequency (Trains / Users PH)	Bletchley - Bedford Frequency (Trains / Users PH)	Dependency
Heavy Rail	CS2-HR-S1	Oxf to Mkc 2 tph/ Bletchley to Bed 1tph stopper (Base case) + existing freight	5	2	1	none
	CS2-HR-S4	Existing - Oxf to MKC 1tph/Oxf to Bed 2tph + existing freight	5	2	2	
	CS2-HR-S4	Existing - Oxf to MKC 1tph/Oxf to Bed 2tph + existing freight	2 (EWR) + 10 (existing)	2	3	
	CS2-HR-S6	Existing - Oxf to MKC 0tph/Oxf to Bed 2tph + existing freight	5	2	3	
	CS2-HR-S6	Existing - Oxf to MKC 0tph/Oxf to Bed 2tph + existing freight	5	2	3	
	CS2-HR-S6	Existing - Oxf to MKC 0tph/Oxf to Bed 2tph + existing freight	2 (EWR) + 10 (existing)	2	3	
	CS2-HR-S7	Existing - Oxf to MKC 1tph - Bed to MKC 1tph	5	1	1	
	CS2-HR-S7	Existing - Oxf to MKC 1tph - Bed to MKC 1tph	2 (EWR) + 10 (existing)	1	1	
	CS2-HR-S10	Oxf to Mkc 1tph – Bed to Mkc 1tph stopper – Oxf to Bed 1tph stopper	5	2	2	
	CS2-HR-S11	Oxf to Bed via Mkc 1ph stopper - Oxf to Bed 1tph stopper	5	2	2	
	CS2-HR-S11	Oxf to Bed via Mkc 1ph stopper - Oxf to Bed 1tph stopper	2 (EWR) + 10 (existing)	2	2	
	CS2-HR-S13	Existing - Oxf to MKC 1tph - 1 Oxf - Bed 1tph stopper - 1 AYS to MKC	2	2	1	

Mode	Alignment ID	Long List Description	MVL Stations	Bicester - Bletchley Frequency (Trains / Users PH)	Bletchley - Bedford Frequency (Trains / Users PH)	Dependency
	CS2-HR-S13	Existing - Oxf to MKC 1tph - 1 Oxf - Bed 1tph stopper - 1 AYS to MKC	5	2	1	
	CS2-HR-S14	Existing - Oxf to MKC 1tph/Oxf to Bed 2 tph/AYS – MKC 1tph + existing freight	2	3	2	
	CS2-HR-S14	Existing - Oxf to MKC 1tph/Oxf to Bed 2 tph/ AYS – MKC 1tph + existing freight	5	4	2	
	CS2-HR-S14	Existing - Oxf to MKC 1tph/Oxf to Bed 2 tph/ AYS – MKC 1tph + existing freight	2 (EWR) + 10 (existing)	4	3	
Light Rail	CS2-LR-S2	Existing - Bletchley to Bedford (MVL)	2	N/A	4	Bedford to Cambridge is also light rail
Light Rail	CS2-LR-S2	Existing - Bletchley to Bedford (MVL)	5	N/A	4	Bedford to Cambridge is also light rail
Tram Train	CS2-LR-S2	Existing - Bletchley to Bedford (MVL)	5	N/A	4	Bedford to Cambridge is also light rail

Table 6 - Options retained between Oxford and Bedford following strategic sift

3.6 Service Options west of Bedford

3.6.1 As part of the development of initial options, 57 Scheme Options were identified in the long list for the Oxford to Bedford route section. It was assumed that, as an existing railway between Oxford and Bedford will be in place, there was more of a case for utilising the existing railway and looking for service solutions rather than seeking to replace the railway with an alternative mode or a new alignment. This assumption was borne out in analysis. This approach managed costs associated with this section of the route. With the existing railway assumed to be in place, EWR Co therefore sought to optimise the service and infrastructure between Oxford and Bedford by considering the station calling pattern, the service pattern and the minimum infrastructure that could support these options.

3.6.2 Between Oxford (OXD) and Milton Keynes (MKC) it is planned that 2tph will be introduced by mid 2025 under CS1.

3.6.3 In adding services under CS2 between Oxford and Bedford (and later extending to Cambridge) of 1 or 2 tph, several factors come into play that have an associated cost. Key constraints are capacity at Oxford and the number of services that operate over the level crossing at Bicester. These tend to discourage an enhanced level of service unless there is an overarching justification for providing one.

3.7 Aylesbury

3.7.1 Services to Aylesbury formed part of the original EWR scope where it was proposed to run services between Aylesbury and Milton Keynes. However, it was challenging to provide a positive conventional business case to support the cost of the additional infrastructure required and the Aylesbury branch was not taken forward as part of the core project.

3.7.2 The ACP Terms of Reference contained a requirement to reassess the strategic case for EWR's proposals, and this reassessment included the potential to extend EWR services to Aylesbury, to establish where there were more affordable ways to deliver the scheme. Reconsidering Aylesbury connections did not open up more affordable solutions for EWR, and conventional transport modelling analysis continues to suggest that the benefits of extending EWR services to Aylesbury do not justify the costs. As such, Scheme Options serving Aylesbury were not progressed further under the ACP.

3.7.3 Notwithstanding this conclusion, there are local aspirations for an Aylesbury service connecting to EWR and the possibility remains that a strategic case could be made, should a case for growth be identified. EWR Co continues to review the potential for such a service as a separate proposal.

4. Early Sift of Long list – Bedford to Cambridge Results

4.1 Introduction

4.1.1 This chapter summarises the results of the long list sift for options between Bedford and Cambridge. The process followed was the same as that undertaken for the Oxford to Bedford sift and the approach and nomenclature used can be found in Chapter 2 above, with the routes depicted in Figure 2 below.

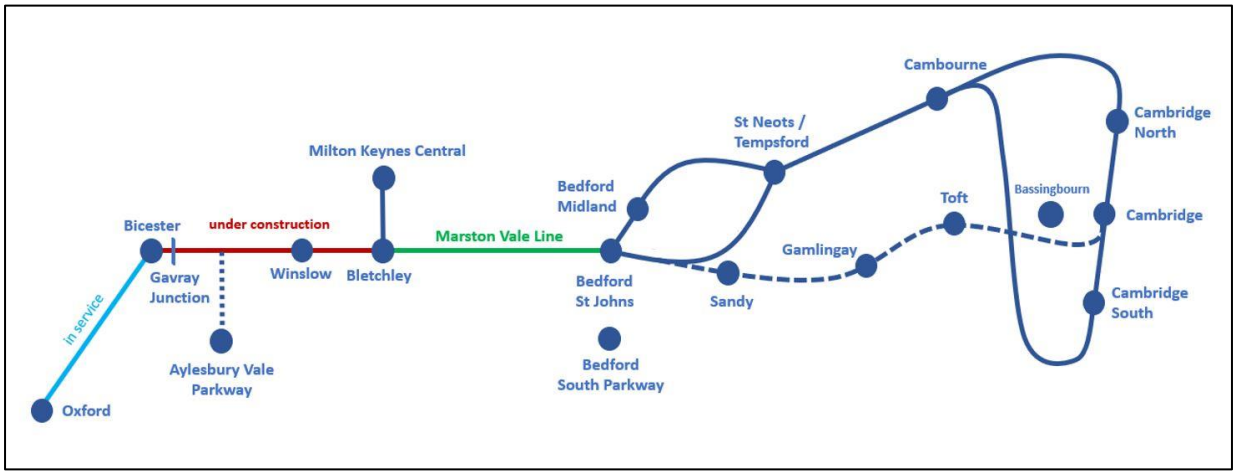


Figure 2- Simplified diagram of possible calling points - route alignments for illustrative purposes only. This section covers the Bedford to Cambridge options.

4.1.2 In total, 113 options were identified between Bedford and Cambridge, varying in alignment, approach to Bedford and Cambridge, and connectivity into main stations or points of termination. They also covered a range of service frequency.

4.1.3 Separately, an option variation was also considered of replacing two existing West Anglia Main Line (WAML) services per hour with EWR services approaching Cambridge from the south. This option would minimise works required on the WAML as part of a southern approach to Cambridge and would therefore make southern approach to Cambridge options more affordable. This was not counted as a separate option but applied at the affordability sifting stage, which meant that these options were retained.

4.2 Results of Credibility Test (Bedford to Cambridge)

4.2.1 An initial sift was carried out to test the suitability of different modes. This considered technical maturity, and development / planning consent risk. Scheme Options meeting the criteria listed below were discounted:

- Those which were considered by EWR Co's consultant experts to be technically novel, immature and unproven or an inappropriate transport mode for the Oxford to Cambridge area – and which would not be ready in time for the demand profile for this business case, when considering the strategic objectives for the Project (e.g. hyperloop).
- Mode Options that were considered at this stage to reduce capacity on the existing mainline rail network due to poor interoperability with heavy rail on intercity routes (e.g. light rail/tram/bus on the West Coast Main Line).
- Rail options which required use of large existing network sections already at capacity, such as the East Coast Main Line (ECML), triggering significant enhancements such as extensive four-tracking, were not considered plausible.
- In addition, road improvement solutions were discounted as strategic investment on linking roads was not deemed to solve the capacity and local congestion issues in town centres which would prevail due to lack of space.

4.2.2 The test of whether an option was technically suitable (credible) or out of scope for further consideration resulted in 13 options being discounted. Although AVRT was considered to be a novel technology, owing to the separate review on its suitability as an option, it was retained as an option in the sifting process.

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
1	CS3-HR-A17	Bedford St Johns - ECML - Hitchin - Royston - Cambridge South	2tph	Heavy Rail	Substantial extensive investment would be required to enable EWR services to operate on existing mainlines, which would be extremely disruptive to existing services. These solutions differ from those considered at non-statutory consultation in 2021 by reason of the extent of necessary
2	CS3-HR-A59	Bedford St Johns - ECML - Royston - Cambridge South	2tph	Heavy Rail	
3	CS3-HR-A23	Bedford South Parkway – Sandy (re-located south) & Bassingbourn - via Cambridge South	N/A	Heavy Rail	
4	CS3-HR-A24	Bedford South Parkway - Tempsford Area - Sandy &	N/A	Heavy Rail	

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
		Bassingbourn - via Cambridge South			interventions on existing busy railway lines.
5	CS3-HR-A25	Bedford North - Tempsford area - Sandy & Bassingbourn - via Cambridge South	N/A	Heavy Rail	
6	CS3-LR-A34	Bedford via Bedford St Johns - A421 & A428 - A14 into Cambridge	4tph	Light Rail	Complexity of operation in urban areas, particularly Cambridge, where there would be significant costs at junctions to enable traffic control. There was also considered to be very limited space on roads in Cambridge for joint running with cars and other vehicles, which would have a significant impact on the existing highway network and would incur significant cost. There would also be significant disruption to traffic, including bus services, during construction.
7	CS3-LR-A35	Bedford A4280 - A421 & A428 - A14 into Cambridge	4tph	Light Rail	
8	CS3-LR-A36	Bedford St Johns - Longholme Way, Newham Ave, A4280 - A421 & A428 - A14 into Cambridge	4tph	Light Rail	
9	CS3-GB-A43	Bedford via Bedford St Johns - A421 & A428 - Cambridge via Northern rail alignment	6bph	Guided Bus	Physical constraints on the West Anglia Main Line, where there would either be a loss of the Heavy Rail network, presumed to be unacceptable, or
10	CS3-GB-A48	Bedford South Parkway – A421 &	6bph	Guided Bus	

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
		A428 – Cambridge via Northern rail alignment			required provision of significant infrastructure (bridges and stations) in excess of £500m.
11	CS3-GB-A50	Bedford A4280 - A421 & A428 - C2C - Cambridge Automated Metro (CAM)	6bph	Guided Bus	Challenge of connection to a new transport system that was not committed and would be too expensive unless the CAM was funded separately.
12	CS3-R-A56	Bedford A4280 - A421 & A428 - A14 into Cambridge	N/A	Existing Road	Strategic investment in road improvements would not resolve local congestion.
13	CS3-HL-A58	Hyperloop Solution	N/A	New	Technical complexity, the risk of deploying new technology, high capital and operating costs, and capacity limitations. The distance involved was also not considered appropriate for a Hyperloop solution.

Table 7 - Options not progressed on grounds of Credibility

4.3 Results of Affordability Test (Bedford to Cambridge)

4.3.1 At the next sifting stage, options that were deemed to exceed the investment envelope set in the ACP Terms of Reference were discounted. Costs were considered in relation to a necessary upgrade of the WAML, including a new grade-separated junction at Hauxton, four-

tracking, new signalling, and significant infrastructure works at Cambridge and the proposed Cambridge South station.

4.3.2 When applying the affordability sift without alternatives, a further 30 options were not progressed. Most of the discounted options are heavy rail Scheme Options, which can be grouped as a series of single infrastructure options with multiple service levels. The route alignments in this section relate to those alignments presented at the 2021 consultation. Nine alignments were presented for the railway between Bedford and Cambridge, with Route Alignments (RA) 1 and 9 identified as the emerging preferred options. Further detail can be found within the Consultation Technical Report[6].

4.3.3 Table 8, below, lists those options which were discounted.

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for Discounting
1	CS3-HR-A1	Bedford North - RA1 - Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
2	CS3-HR-A1	Bedford North - RA1 - Cambridge via South	3tph	Heavy Rail	
3	CS3-HR-A2	Bedford North - RA1 - Cambridge South terminate	2tph	Heavy Rail	Cost of work on Royston Branch and WAML – the early termination would require significant works at Cambridge South station and substitution of services is not an option
4	CS3-HR-A2	Bedford North - RA1 - Cambridge South terminate	3tph	Heavy Rail	
5	CS3-HR-A2	Bedford North - RA1 - Cambridge South terminate	4tph	Heavy Rail	
6	CS3-HR-A3	Bedford North - RA1 - Cambridge via North	4tph	Heavy Rail	Cost of work on WAML from the north, including additional tracks and Cambridge throat area
7	CS3-HR-A3	Bedford North - RA1 - Cambridge via North	3tph	Heavy Rail	

[6] East West Rail | Library

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for Discounting
8	CS3-HR-A4	Bedford North - RA2 - Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
9	CS3-HR-A4	Bedford North - RA2 - Cambridge via South	3tph	Heavy Rail	
10	CS3-HR-A5	Bedford North - RA2 - Cambridge South terminate	3tph	Heavy Rail	Cost of work on Royston Branch and WAML – the early termination would require significant works at Cambridge South station and substitution of services is not an option
11	CS3-HR-A5	Bedford North - RA2 - Cambridge South terminate	4tph	Heavy Rail	
12	CS3-HR-A6	Bedford North - RA6 - Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
13	CS3-HR-A6	Bedford North - RA6 - Cambridge via South	3tph	Heavy Rail	
14	CS3-HR-A7	Bedford North - RA6 - Cambridge South terminate	3tph	Heavy Rail	Cost of work on Royston Branch and WAML – the early termination would require significant works at Cambridge South station and substitution of services is not an option
15	CS3-HR-A7	Bedford North - RA6 - Cambridge South terminate	4tph	Heavy Rail	
16	CS3-HR-A8	Bedford North - RA8 - Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
17	CS3-HR-A8	Bedford North - RA8 - Cambridge via South	3tph	Heavy Rail	

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for Discounting
18	CS3-HR-A9	Bedford North - RA8 - Cambridge South terminate	3tph	Heavy Rail	Cost of work on Royston Branch and WAML – the early termination would require significant works at Cambridge South station and substitution of services is not an option
19	CS3-HR-A9	Bedford North - RA8 - Cambridge South terminate	4tph	Heavy Rail	
20	CS3-HR-A10	Bedford North - RA9 - Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
21	CS3-HR-A10	Bedford North - RA9 - Cambridge via South	3tph	Heavy Rail	
22	CS3-HR-A11	Bedford North - RA9 - Cambridge South terminate	3tph	Heavy Rail	Cost of work on Royston Branch and WAML – the early termination would require significant works at Cambridge South station and substitution of services is not an option
23	CS3-HR-A11	Bedford North - RA9 - Cambridge South terminate	4tph	Heavy Rail	
24	CS3-HR-A12	Bedford North - RA9 - Cambridge via North	4tph	Heavy Rail	Cost of work on WAML from the north, including additional tracks and Cambridge throat area
25	CS3-HR-A12	Bedford North - RA9 - Cambridge via North	3tph	Heavy Rail	
26	CS3-HR-A13	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via North	4tph	Heavy Rail	
27	CS3-HR-A13	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via North	3tph	Heavy Rail	

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for Discounting
28	CS3-HR-NEW2	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via South	4tph	Heavy Rail	Cost of work on Royston Branch and WAML, including Cambridge throat area
29	CS3-LR-A3	Bedford North - RA1 - Cambridge via Northern rail alignment	4tph	Light Rail	Technical complexity of shared running and cost of Light Rail on WAML requiring significant alterations to the existing signalling and 25% of the existing capacity would be lost driving additional infrastructure (track).
30	CS3-R-A57	Bedford - Cambridge new road	N/A	Road	Equivalent to Expressway which was cancelled due to Cost/Benefit assessment

Table 8 - Options not progressed on grounds of Affordability

4.3.4 As discussed in Section 2.5, a sensitivity was applied on account of two factors, which resulted in the retention of options with two trains per hour into Cambridge from the south and options utilising most of the original varsity alignment between Bedford and Cambridge. Table 9, below, lists those options retained as a result.

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode
1	CS3-HR-A1	Bedford North - RA1 - Cambridge via South	2tph	Heavy Rail
2	CS3-HR-A4	Bedford North - RA2 - Cambridge via South	2tph	Heavy Rail
3	CS3-HR-A5	Bedford North - RA2 - Cambridge South terminate	2tph	Heavy Rail
4	CS3-HR-A6	Bedford North - RA6 - Cambridge via South	2tph	Heavy Rail
5	CS3-HR-A7	Bedford North - RA6 - Cambridge South terminate	2tph	Heavy Rail
6	CS3-HR-A8	Bedford North - RA8 - Cambridge via South	2tph	Heavy Rail
7	CS3-HR-A9	Bedford North - RA8 - Cambridge South terminate	2tph	Heavy Rail
8	CS3-HR-A10	Bedford North - RA9 - Cambridge via South	2tph	Heavy Rail
9	CS3-HR-A11	Bedford North - RA9 - Cambridge South terminate	2tph	Heavy Rail
10	CS3-HR-NEW1	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via South	2tph	Heavy Rail
11	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Varsity	4tph	Heavy Rail
12	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	3tph	Heavy Rail
13	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	2tph	Heavy Rail
14	CS3-HR-NEWA15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Cambridge South	2tph	Heavy Rail
15	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	4tph	Heavy Rail
16	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	3tph	Heavy Rail
17	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	2tph	Heavy Rail
18	CS3-HR-A20	Bedford South Parkway – Varsity Hybrid - Cambourne South – Cambridge South	2tph	Heavy Rail
19	CS3-HR-A21	Bedford South Parkway – Varsity Line (shortcut) – via Cambridge South	2tph	Heavy Rail

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode
20	CS3-HR-A22	Bedford South Parkway – Varsity Line (shortcut) – Cambridge South terminate	2tph	Heavy Rail
21	CS3-HR-A30	Cambridge South - Cambourne only	2tph	Heavy Rail
22	CS3-HRGB-A54	Heavy Rail Cambridge South - Cambourne - Guided Bus to Bedford	2tph/4bph	Heavy Rail - Guided Bus
23	CS3-HRB-A54	Heavy Rail Cambridge South - Cambourne - Bus to Bedford	2tph/4bph	Heavy Rail - Bus

Table 9 - Options originally thought to be unaffordable, but found to have affordable variations available so progressed

4.4 Results of Strategic Sift and Attractiveness to Users (Bedford to Cambridge)

4.4.1 Following the application of the criteria derived from the Strategic Drivers, 47 Scheme Options were not progressed on a range of grounds, and these are listed in Table 10.

Connecting the right places

4.4.2 There were two main reasons why 21 options scored comparatively poorly for connecting the right places:

- Options which served only a South Bedford Parkway resulting in a smaller population and jobs catchment due to the lack of a town centre station connectivity, and where growth potential was low.
- Options which did not serve central Cambridge, through the foreshortened termination of the route at either St Neots/Tempsford or Cambourne, or which utilised the C2C corridor, were excluded as they would fail to connect to Cambridge city centre.

Capacity

4.4.3 A further 21 options were discounted on grounds of not providing sufficient capacity as scheme options. Options which relied on bus services operating at lower than six buses per hour, or some options terminating early and outside of main towns, did not provide sufficient capacity.

Demand

4.4.4 There were five options which were excluded for low demand performance compared to the original project, which can be grouped into:

- Heavy rail options with a service level of two trains per hour, which did not serve a central Cambridge or Bedford station.
- Light rail options which terminated at Cambridge North station or Bedford South Parkway, which did not serve either city/town centre and had a comparatively long journey time.
- Guided bus options which did not deliver comparative journey times to Cambridge city centre due to a lack of segregation and had lower frequency scored comparatively poorly. Options which combined a number of modes and long journey times scored comparatively poorly.

Attractiveness to Users

4.4.5 Having sifted on capacity, demand and connecting the right places, all remaining options were found to be attractive to users in terms of journey time, the number of interchanges between Bedford and Cambridge, and the service frequency offered.

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
1	CS3-HR-A5	Bedford North - RA2 - Cambridge South terminate	2tph	Heavy Rail	Population, Employment, Growth opportunity
2	CS3-HR-A7	Bedford North - RA6 - Cambridge South terminate	2tph	Heavy Rail	Population, Employment, Growth opportunity
3	CS3-HR-A9	Bedford North - RA8 - Cambridge South terminate	2tph	Heavy Rail	Population, Employment, Growth opportunity
4	CS3-HR-A11	Bedford North - RA9 - Cambridge South terminate	2tph	Heavy Rail	Population, Employment, Growth opportunity
5	CS3-HR-A19	Bedford South Parkway – Varsity Hybrid - Cambourne North – Cambridge North terminate	2tph	Heavy Rail	Population, Employment
6	CS3-HR-A20	Bedford South Parkway – Varsity	2tph	Heavy Rail	Population, Growth opportunity

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
		Hybrid - Cambourne South – Cambridge South			
7	CS3-HR-A22	Bedford South Parkway – Varsity Line (shortcut) – Cambridge South terminate	2tph	Heavy Rail	Population, Employment
8	CS3-HR-A26	Bedford (North) to Tempsford only	2tph	Heavy Rail	Population, Employment, Growth opportunity
9	CS3-HR-A27	Bedford - Tempsford - Cambourne only	2tph	Heavy Rail	Population, Employment, Growth opportunity
10	CS3-HR-A28	Bedford St Johns to Tempsford only	2tph	Heavy Rail	Population, Employment, Growth opportunity
11	CS3-HR-A30	Cambridge South - Cambourne only	2tph	Heavy Rail	Population, Growth opportunity
12	CS3-LRGB-A37	Light Rail Bedford A4280 to Tempsford - Guided bus A428 & C2C	4 tph/bph	Light Rail - Guided Bus	Population, Employment, Growth opportunity
13	CS3-LRGB-A38	Light Rail Bedford St Johns to Tempsford - Guided Bus A428 & C2C	4 tph/bph	Light Rail - Guided Bus	Population, Employment, Growth opportunity
14	CS3-LRGB-A39	Light Rail Cambridge North - Cambourne - Guided Bus to Bedford	4 tph/bph	Light Rail - Guided Bus	Employment, Growth opportunity
15	CS3-LRB-A39	Light Rail Cambridge North - Cambourne - Bus to Bedford	4 tph/bph	Light Rail - Bus	Employment, Growth opportunity
16	CS3-GB-A46	Bedford A4280 - A421 & A428 - C2C into Cambridge	6bph	Guided Bus	Population, Employment, Growth opportunity
17	CS3-GB-A35	Bedford A4280 - A421 & A428 - A14 into Cambridge	6bph	Guided Bus	Population, Employment, Growth opportunity

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
18	CS3-HRGB-A51	Heavy Rail Bedford (North) to Tempsford - Guided Bus A428 & C2C	2tph/4bph	Heavy Rail - Guided Bus	Population, Employment, Growth opportunity
19	CS3-HRGB-A52	Heavy Rail Bedford via Bedford St Johns to Tempsford - Guided Bus A428 & C2C	2tph/4bph	Heavy Rail - Guided Bus	Population, Employment, Growth opportunity
20	CS3-HRB-A51	Heavy Rail Bedford (North) to Tempsford - Bus A428 & C2C	2tph/4bph	Heavy Rail - Bus	Population, Employment, Growth opportunity
21	CS3-HRB-A52	Heavy Rail Bedford via Bedford St Johns to Tempsford - Bus A428 & C2C	2tph/4bph	Heavy Rail - Bus	Population, Employment, Growth opportunity
22	CS3-HR-A29	Cambridge North - Cambourne only	2tph	Heavy Rail	Insufficient scheme option capacity to 2030
23	CS3-HR-A31	Cambridge North - Cambourne - Tempsford only	2tph	Heavy Rail	Insufficient scheme option capacity to 2030
24	CS3-LRGB-A40	Light Rail Cambridge South - Cambourne - Guided Bus to Bedford	4 tph/bph	Light Rail - Guided Bus	Insufficient scheme option capacity to 2030
25	CS3-LRGB-A41	Light Rail Cambridge North - Cambourne - Tempsford - Guided Bus to Bedford	4 tph/bph	Light Rail - Guided Bus	Insufficient scheme option capacity to 2030
26	CS3-LRGB-A42	Light Rail Cambridge South - Cambourne - Tempsford - Guided Bus to Bedford	4 tph/bph	Light Rail - Guided Bus	Insufficient scheme option capacity to 2030
27	CS3-LRB-A37	Light Rail Bedford A4280 to Tempsford - Bus A428 & C2C	4 tph/bph	Light Rail - Bus	Insufficient scheme option capacity to 2030
28	CS3-LRB-A38	Light Rail Bedford St Johns to Tempsford - Bus A428 & C2C	4 tph/bph	Light Rail - Bus	Insufficient scheme option capacity to 2030

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
29	CS3-LRB-A40	Light Rail Cambridge South - Cambourne - Bus to Bedford	4 tph/bph	Light Rail - Bus	Insufficient scheme option capacity to 2030
30	CS3-LRB-A41	Light Rail Cambridge North - Cambourne - Tempsford - Bus to Bedford	4 tph/bph	Light Rail - Bus	Insufficient scheme option capacity to 2030
31	CS3-LRB-A42	Light Rail Cambridge South - Cambourne - Tempsford - Bus to Bedford	4 tph/bph	Light Rail - Bus	Insufficient scheme option capacity to 2030
32	CS3-GB-A44	Bedford via Bedford St Johns - A421 & A428 - Cambridge North Guided Busway	4bph	Guided Bus	Insufficient scheme option capacity to 2030
33	CS3-GB-A34	Bedford via Bedford St Johns - A421 & A428 - A14 into Cambridge	4bph	Guided Bus	Insufficient scheme option capacity to 2030
34	CS3-GB-A47	Bedford via Bedford St Johns - Varsity (original via Sandy and Potton) - Cambridge via Varsity	4bph	Guided Bus	Insufficient scheme option capacity to 2030
35	CS3-GB-A15	Bedford via Bedford St Johns - Varsity (Shortcut) - Cambridge via Varsity	4bph	Guided Bus	Insufficient scheme option capacity to 2030
36	CS3-GB-A49	Bedford South Parkway – A421 & A428 – Cambridge via North Guided Busway	4bph	Guided Bus	Insufficient scheme option capacity to 2030
37	CS3-HRGB-A53	Heavy Rail Cambridge North - Cambourne - Guided Bus to Bedford	2tph/4bph	Heavy Rail – Guided Bus	Insufficient scheme option capacity to 2030

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
38	CS3-HRGB-A54	Heavy Rail Cambridge South - Cambourne - Guided Bus to Bedford	2tph/4bph	Heavy Rail – Guided Bus	Insufficient scheme option capacity to 2030
39	CS3-HRGB-A55	Heavy Rail Cambridge North - Cambourne - Tempsford - Guided Bus to Bedford	2tph/4bph	Heavy Rail – Guided Bus	Insufficient scheme option capacity to 2030
40	CS3-HRB-A53	Heavy Rail Cambridge North - Cambourne - Bus to Bedford	2tph/4bph	Heavy Rail - Bus	Insufficient scheme option capacity to 2030
41	CS3-HRB-A54	Heavy Rail Cambridge South - Cambourne - Bus to Bedford	2tph/4bph	Heavy Rail - Bus	Insufficient scheme option capacity to 2030
42	CS3-HRB-A55	Heavy Rail Cambridge North - Cambourne - Tempsford - Bus to Bedford	2tph/4bph	Heavy Rail - Bus	Insufficient scheme option capacity to 2030
43	CS3-HR-A18	Bedford South Parkway – Varsity Hybrid - Cambourne North – via Cambridge North	2tph	Heavy Rail	Insufficient demand
44	CS3-HR-A21	Bedford South Parkway – Varsity Line (shortcut) – via Cambridge South	2tph	Heavy Rail	Insufficient demand
45	CS3-LR-A18	Bedford South Parkway – Varsity Hybrid (Cambourne) – Cambridge via North Guided busway	4tph	Light Rail	Insufficient demand
46	CS3-LR-A33	Bedford via Bedford St Johns - Varsity Hybrid - RA1/9 -	4tph	Light Rail	Insufficient demand

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Rationale for discounting
		Cambridge North Guided Busway			
47	CS3-GB-A45	Bedford via Bedford St Johns - A421 & A428 - C2C into Cambridge	4bph	Guided Bus	Insufficient demand

Table 10 - Options not progressed on grounds of not connecting the right places, scheme option capacity, demand, or attractiveness to users.

4.5 Remaining Options (Bedford to Cambridge)

4.5.1 Following the sifting process, 23 options between Bedford and Cambridge remained. These are summarised in Table 11 below.

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Dependency
1	CS3-HR-A1	Bedford North - RA1 - Cambridge via South	2tph	Heavy Rail	Removal of 2 heavy rail services from WAML
2	CS3-HR-A3	Bedford North - RA1 - Cambridge via North	2tph	Heavy Rail	-
3	CS3-HR-A4	Bedford North - RA2 - Cambridge via South	2tph	Heavy Rail	Removal of 2 heavy rail services from WAML
4	CS3-HR-A6	Bedford North - RA6 - Cambridge via South	2tph	Heavy Rail	
5	CS3-HR-A8	Bedford North - RA8 - Cambridge via South	2tph	Heavy Rail	
6	CS3-HR-A10	Bedford North - RA9 - Cambridge via South	2tph	Heavy Rail	
7	CS3-HR-A12	Bedford North - RA9 - Cambridge via North	2tph	Heavy Rail	-
8	CS3-HR-NEW1	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via South	2tph	Heavy Rail	-

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Dependency
9	CS3-HR-A13	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via North	2tph	Heavy Rail	-
10	CS3-HR-A14	Bedford St Johns – Varsity Hybrid - RA6/8 (Cambourne South) – Cambridge via Varsity line guided busway	2tph	Heavy Rail	-
11	CS3-HR-A58	Bedford St Johns - Varsity Hybrid via St Neots - Cambourne North - Cambridge via North	2tph	Heavy Rail	-
12	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Varsity	4tph	Heavy Rail	-
13	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	3tph	Heavy Rail	-
14	CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	2tph	Heavy Rail	-
15	CS3-HR-NEWA15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Cambridge South	2tph	Heavy Rail	-
16	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	4tph	Heavy Rail	-
17	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	3tph	Heavy Rail	-
18	CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	2tph	Heavy Rail	-
19	CS3-LR-A15	Bedford via Bedford St Johns - Varsity -	4tph	Light Rail	Busway converted to light rail

	Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Dependency
		Cambridge via South guided busway			
20	CS3-GB-A51	Bedford St Johns - Varsity (Shortcut) - Cambridge via Varsity - via North Guided Busway, C2C and Southern Guided Busway	12bph	Guided Bus	-
21	CS3-GB-A52	Bedford via Bedford St Johns - Varsity (Shortcut) - Cambridge via Varsity	6bph	Guided Bus	-
22	CS3-GB-A53	Bedford St Johns via northern Alignment corridor into Cambridge via North, South and C2C	12bph	Guided Bus	-
23	CS3-AVRT-01	AVRT - Bedford to Cambridge	20	AVRT	-

Table 11 - Shortlisted options

4.5.2 The list of Scheme Options includes three Scheme Options that were identified for consideration following identification of the shortlist. During the sifting process these were identified as potential options that should have been included in the original long list. These new options were tested against the sifting process described above for completeness, so were included in the respective sifting list (discounted or retained). These three options were:

- CS3-HR-NEW1 Bedford St Johns – Varsity Hybrid – Cambourne North – Cambridge via South, 2tph.
- CS3-HR-NEW2 Bedford St Johns – Varsity Hybrid – Cambourne North – Cambridge via South, 4tph.
- CSE-HR-NEWA15 Bedford St Johns - Varsity Line (shortcut) – Cambridge via Cambridge South, 2tph.

5. Option Families

5.1 The Option Families

5.1.1 Following the sifting process, EWR Co reflected upon the extent to which the down-selection process resulted in options likely to achieve desirable outputs for the new transport link on opening and in relation to its longer-term operation. Given the number of potential options and service permutations, as well as the single-option analysis performed under the sifting process, the Scheme Options were rationalised into Option Families. This enabled a focus on the shortlisted infrastructure solutions as well as an understanding of the potential for solutions to evolve. Option families are derived from Scheme Options and represent groupings using the alignment served and proposed transport mode.

5.1.2 The sifting process was designed so that the broadest possible range of options to improve transport connectivity between Oxford and Cambridge could be considered. To be proportionate, this was necessarily coarse and so a critical review of the sifting process and the shortlisted options demonstrated that certain key proposals did not survive down-selection but merited more detailed consideration. Similarly, a number of the surviving proposals closely resembled each other.

5.1.3 The shortlisted Heavy Rail options all operated at 2tph due to the application of the affordability criterion, which had deemed higher service frequencies to be prohibitively expensive due to a requirement for more significant – and costly – infrastructure interventions. However, EWR Co's work on the Theory of Change (described in Chapter 6 of this report) was being undertaken in parallel, and this had established that there would need to be upwards flexibility in service frequency to enable sufficient capacity for increased commuting to Cambridge, even in conservative growth scenarios.

5.1.4 Alongside this, as the ACP progressed, it became clear that the Option Families needed to consider higher service frequencies of 3-4tph for Heavy Rail options or similarly performing frequencies for other transport modes.

5.1.5 Considering the above, and to facilitate further appraisal and comparison between them, the remaining Scheme Options were consolidated into Option Families. In creating the Option Families, the principal characteristics of each of the Scheme Options were retained. The following consolidation of options was implemented:

1. Heavy rail alignments serving either Tempsford or St Neots were consolidated into St Neots Option Families, for ACP purposes, as this represented the most affordable option serving that location as identified in the 2021 consultation.

2. Heavy rail alignments through Cambourne North and Cambourne South were consolidated to serve Cambourne North, which presents a greater opportunity for growth, would have less environmental impact and was

preferred in feedback received from the 2021 consultation as well as reflecting EWR Co's emerging preferred options at the consultation.

3. A light rail option discounted at the Demand stage was reintroduced to provide an alternative northern approach to Cambridge, leaving Bedford via a Varsity hybrid alignment.

4. The Guided Bus options were consolidated into one option utilising existing roads (online) and one segregated option (offline). This was seen as the key differentiator and would enable a better comparison with the heavy and light rail options.

5.1.6 The Scheme Options considered further in this report and the Option Families that they were grouped into are set out in the tables and diagrams below. For each Option Family, a schematic of the route shows the proposed stopping pattern, with the number of trains per hour stated alongside. The phased increase in capacity is shown through the increase in trains per hour – together these form the range of options within any one family. Further columns summarise the alignment for the different sections of the route, moving from west to east.

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
CS3-HR-A1	Bedford North - RA1 - Cambridge via South	2tph	Heavy Rail	HR5	Alignment chosen as preferred alignment in line with emerging preferred option at the 2021 consultation, and cheaper than RA9.
CS3-HR-A3	Bedford North - RA1 - Cambridge via North	2tph	Heavy Rail	HR1	Alignment chosen as preferred alignment in line with emerging preferred option at the 2021 consultation, and cheaper than RA9

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
CS3-HR-A4	Bedford North - RA2 - Cambridge via South	2tph	Heavy Rail	-	Not progressed on the basis of emerging preferred options at the 2021 consultation.
CS3-HR-A6	Bedford North - RA6 - Cambridge via South	2tph	Heavy Rail	-	Not progressed as the emerging preferred options at the 2021 consultation would perform better.
CS3-HR-A8	Bedford North - RA8 - Cambridge via South	2tph	Heavy Rail	-	Not progressed as the emerging preferred options at the 2021 consultation would perform better.
CS3-HR-A10	Bedford North - RA9 - Cambridge via South	2tph	Heavy Rail	-	Not progressed on the basis that RA1 performs better than RA9 noting that the question on whether RA1 could serve a Tempsford station remained under consideration and is described in Chapter 8 after further assessment of the Option Families.
CS3-HR-A12	Bedford North - RA9 - Cambridge via North	2tph	Heavy Rail	-	Not progressed on the basis that RA1 is more affordable than RA9 noting

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
					that the question on whether RA1 could serve a Tempsford station remained under consideration and is described in Chapter 8 after further assessment of the Option Families.
CS3-HR-NEW1	Bedford St Johns – Varsity Hybrid - Cambourne North – Cambridge via South	2tph	Heavy Rail	HR3	Option identified as missing from the Long List during a backcheck exercise once the original sift took place. It was added upon the generation of the Option Families to provide an alternative Varsity Hybrid route that approached Cambridge from the South.
CS3-HR-A13	Bedford St Johns – Varsity Hybrid – Tempsford - Cambourne North – Cambridge via North	2tph	Heavy Rail	-	This option was not progressed as RA1 was progressed as a preferred alignment instead.
CS3-HR-A14	Bedford St Johns – Varsity Hybrid - RA6/8 (Cambourne	2tph	Heavy Rail	-	This option was not compatible with our recommended

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
	South) – Cambridge via Varsity line guided busway				preferred option for a RA1 to connect Bedford and Cambridge, which was progressed as the preferred alignment.
CS3-HR-A58	Bedford St Johns - Varsity Hybrid via St Neots - Cambourne North - Cambridge via North	2tph	Heavy Rail	HR2	RA1 progressed as preferred alignment, noting that the question on whether RA1 could serve a Tempsford station remained under consideration and is described in Chapter 8 after further assessment of the Option Families.
CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Varsity	4tph	Heavy Rail	HR4	Progressed as a single HR4 Option Family with 2, 3 and 4tph.
CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	3tph	Heavy Rail	HR4	
CS3-HR-A15	Bedford St Johns - Varsity Line (shortcut)- Cambridge via Varsity	2tph	Heavy Rail	HR4	

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
CSE-HR-NEWA15	Bedford St Johns - Varsity Line (shortcut) - Cambridge via Cambridge South	2tph	Heavy Rail	HR6	This option was identified as missing from the Long List during a backcheck exercise, once the original sift took place. It was added upon the generation of the Option Families to provide an alternative approach into Cambridge via the south which did not require the replacement of the existing guided busway, which is necessitated by HR4.
CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	4tph	Heavy Rail	-	Included as geographic phasing sub-options for HR4.
CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	3tph	Heavy Rail	-	

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
CS3-HR-A16	Bedford St Johns - Varsity Line (shortcut) - Cambridge Varsity Trumpington terminate	2tph	Heavy Rail	-	
CS3-LR-A33	Bedford via Bedford St Johns - Varsity Hybrid - RA1/9 - Cambridge North Guided Busway	4tph	Light Rail	LR2A	This option was reintroduced despite failing the Demand Index to provide an alternative Light Rail option to A51 into Cambridge, utilising the opportunities of the previous preferred alignment.
CS3-LR-A15	Bedford via Bedford St Johns - Varsity - Cambridge via South guided busway	4tph	Light Rail	LR2B	N/A
CS3-GB-A51	Bedford St Johns - Varsity (Shortcut) - Cambridge via Varsity - via North Guided Busway, C2C and Southern Guided Busway	12bph	Guided Bus	GB1	This option was amalgamated with CS3-GB-A52 into GB1 as it involved shortlisted Guided Bus options which followed a similar core alignment but variations on approaches to Cambridge which presented similar

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
					characteristics for assessment.
CS3-GB-A52	Bedford via Bedford St Johns - Varsity (Shortcut) - Cambridge via Varsity	6bph	Guided Bus	GB1	This option was amalgamated with CS3-GB-A52 into GB1 as it involved shortlisted Guided Bus options which followed a similar core alignment but variations on approaches to Cambridge which presented similar characteristics for assessment.
CS3-GB-A53	Bedford St Johns via northern Alignment corridor into Cambridge via North, South and C2C	12bph	Guided Bus	GB2	N/A
CS3-AVRT-01	AVRT - Bedford to Cambridge	20	AVRT	-	This option was not considered to perform sufficiently well in achieving to deliver the objectives of a transport solution. It did not progress to be considered alongside Option Families, but

Alignment ID	Alignment	Trains / Users PH	Transport Solution Mode	Progressed to Option Family (Family ID) ID	Rationale for progressing / not progressing / reconsidering / to Option Families
					further work was undertaken separately to substantiate this conclusion. There is a separate report on AVRT which discusses this further and discounts AVRT, which is set out in Appendix 10.

Table 12 - Consolidation of shortlisted options into Option Families

5.1.7 The Option Families were tested against the Theory of Change to consider the extent to which they could support economic opportunities. This provided an understanding of which Option Families could deliver the capacity and capability at scale required to meet the transport need identified to deliver growth, including the prospects of unlocking dependent housing development, along with some environmental considerations. The Option Families are described more fully in Tables 13 to 24, which follow.

HR1: Bedford North – RA1 – Cambridge via North

Alignment

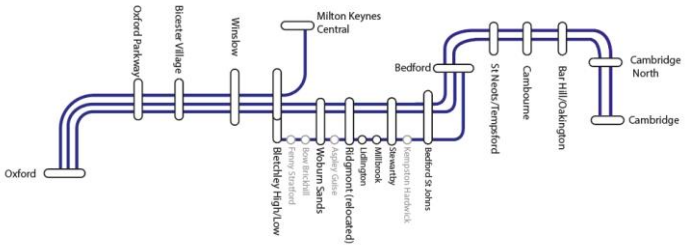
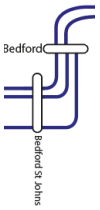
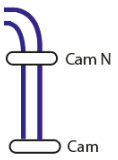
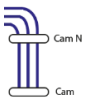
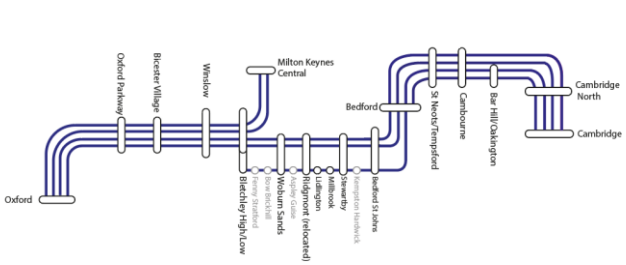
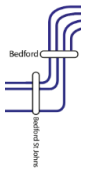
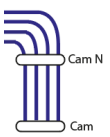
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF – BLY	MVL	Bed	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper		RA1/1A/9 (Bedford MML, St Neots/Tempsford, Cambourne, Bar Hill/Oakington, Cambridge North, Cambridge)	
	plus 1tph Bedford - Cambridge	3	TBC	2tph + stopper	TBC		
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 13 - HR1 Simplified Option Matrix

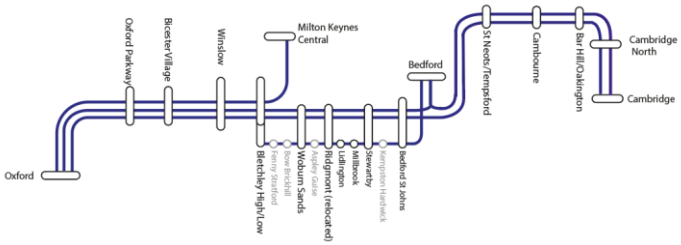
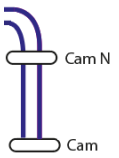
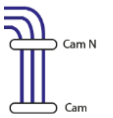
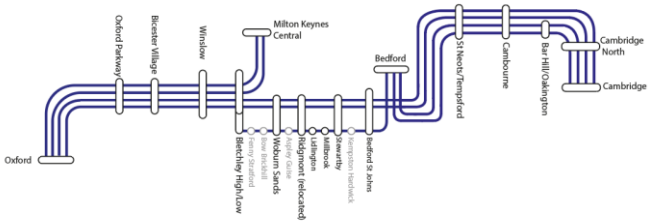
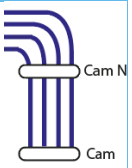
HR2: Bedford Varsity – RA1 – Cambridge via the North					Alignment		
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF - BLY	MVL	Bed	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper	[7] 	Varsity Hybrid (Bedford St Johns, Sandy, Cambourne, Bar Hill/Oakington, Cambridge North, Cambridge)	
	plus 1tph Bedford - Cambridge	3	TBC	2tph + stopper	TBC		
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 14 - HR2 Simplified Option Matrix

[7] This arrangement was revisited in subsequent stages of the ACP to reflect option development, and Bedford St Johns station was moved to the eastern side of the triangular junction.

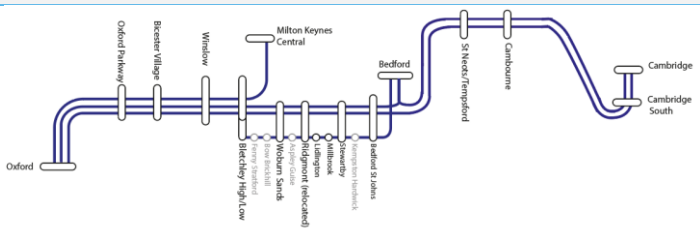
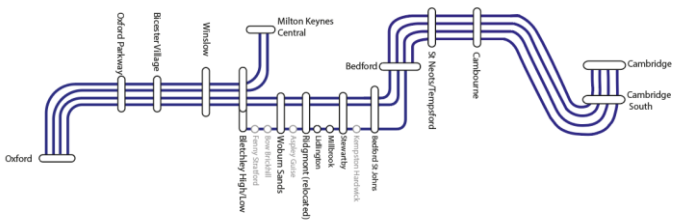
HR3: Bedford Varsity – RA1 – Cambridge via the South			Alignment				
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF - BLY	MVL	Bed[8]	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper		Varsity Hybrid via Cambridge South (Bedford St Johns, Sandy, Cambourne, Cambridge South, Cambridge)	
	plus 1tph Bedford - Cambridge	3	TBC	2tph + stopper	TBC		
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 15 - HR3 Simplified Option Matrix

[8] Further work on this option at the next stage proposed for Bedford St Johns station to be located to the east of Bedford station

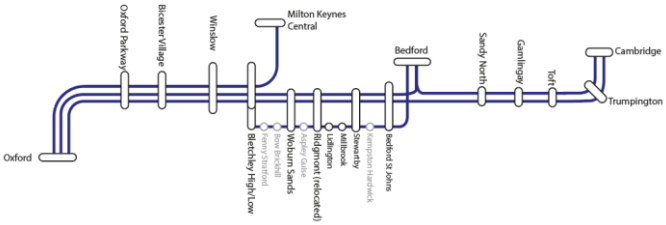
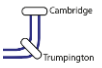
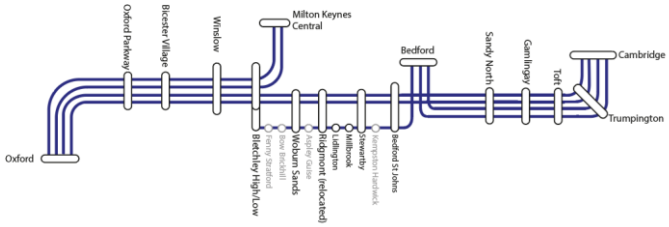
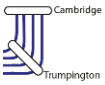
HR4: Bedford Varsity Line – Cambridge via Trumpington					Alignment		
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF - BLY	MVL	Bed[9]	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper		Varsity Line via Trumpington (Bedford St Johns, Sandy North, Gamlingay, Toft, Trumpington, Cambridge)	
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 16 - HR4 Simplified Option Matrix

A further consideration within this Option Family was to truncate services at Trumpington as an initial phase before extending into Cambridge later.

[9] Further work on this option at the next stage proposed for Bedford St Johns station to be located to the east of Bedford station

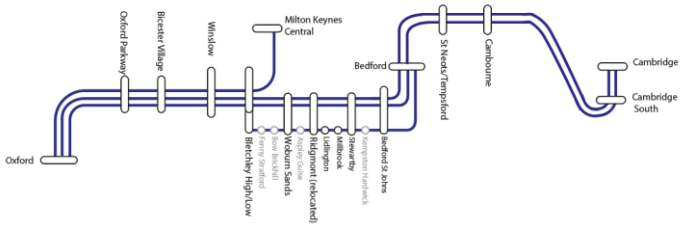
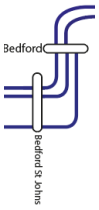
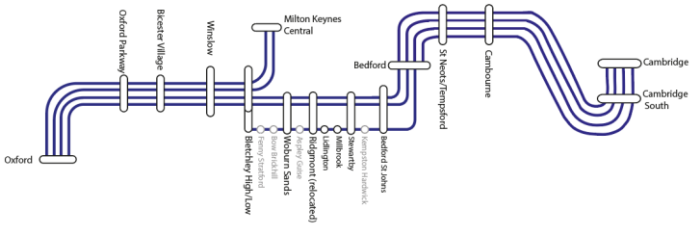
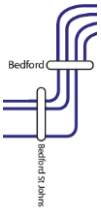
HR5: Bedford North - RA1 - Cambridge via the South					Alignment		
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF - BLY	MVL	Bed	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper		RA1/1A/9 (Bedford MML, St Neots/Tempsford, Cambourne, Cambridge South, Cambridge)	
	plus 1tph Bedford – Cambridge	3	TBC	2tph + stopper	TBC		
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 17 - HR5 Simplified Option Matrix

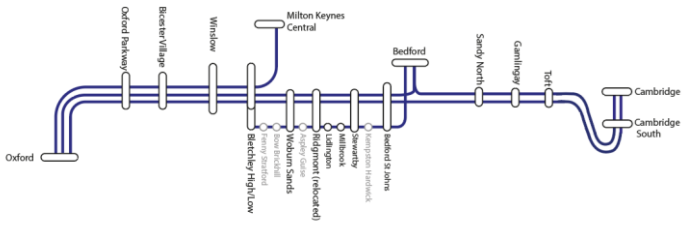
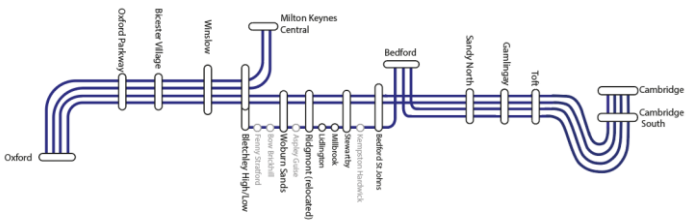
HR6: Bedford Varsity Line – Cambridge via the South					Alignment		
Phasing	Schematic (Indicative Service pattern not infrastructure)	EWR tph	OXF - BLY	MVL	Bed[10]	Core	Cam
Capacity Phasing		2	2tph OXF – CBG + 1tph OXF – MKC	2tph + stopper		Varsity Line via Cambridge South (Bedford St Johns, Sandy North, Gamlingay, Toft, Cambridge South, Cambridge)	
	plus 1tph Bedford – Cambridge	3	TBC	2tph + stopper	TBC		
		4	2tph OXF - CBG + 2 tphh2TPH – MKC	2tph + stopper			

Table 18 - HR6 Simplified Option Matrix

[10] Further work on this option at the next stage proposed for Bedford St Johns station to be located to the east of Bedford station

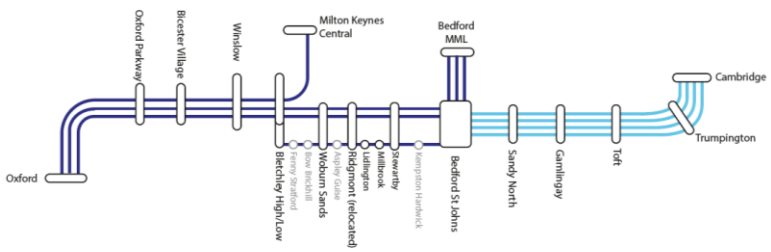
LR1a: Bedford St Johns – Varsity Line – Cambridge via Trumpington *(Heavy Rail Oxford – Bedford)*			Alignment				
Phasing	Schematic (Indicative Service pattern not infrastructure)	tph	OXD - BLY	MVL	Bed	Core	Cam
Capacity Phasing		4	2tph OXF – CBG + 1tph OXF – MKC	2tph + 1 stopper	Bedford St Johns terminating platform with heavy rail	Varsity Line (Bedford St Johns, Sandy North, Gamlingay, Toft, Trumpington, Cambridge)	Existing busway from Trumpington into Cambridge Central Stn

Table 19 - LR1A Simplified Option Matrix

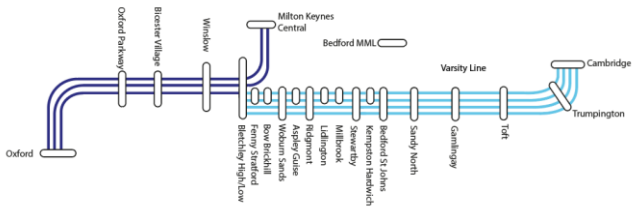
LR1b: Bletchley - Bedford St Johns – Varsity Line - Cambridge via Trumpington *(Heavy Rail Oxford – Bletchley)*			Alignment				
Phasing	Schematic (Indicative Service pattern not infrastructure)	tph	OXD - BLY	MVL	Bed	Core	Cam
Capacity Phasing		4	Heavy Rail 1tph OXF - BLY + 2tph OXF – MKC TBC	Light Rail 2 EWR Stopper 2 EWR Fast	All through trains running via Bedford St Johns	Varsity Line (Bedford St Johns, Sandy North, Gamlingay, Toft, Trumpington, Cambridge)	Existing busway from Trumpington into Cambridge Central Station

Table 20 - LR1B Simplified Option Matrix

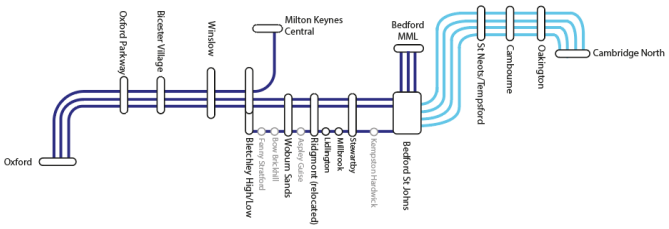
LR2a: Bedford St Johns - Varsity Hybrid – Cambridge North *(Heavy Rail Oxford – Bedford)*				**Alignment**		
Schematic (Indicative Service pattern not infrastructure)	tph	OXD - BLY	MVL	Bed	Core	Cam
	4	2tph OXF – CBG + 1tph OXF – MKC	2tph + 1 stopper	Bedford St Johns terminating platform with heavy rail interchange	Varsity Hybrid (Bedford St Johns, Sandy North, Cambourne, Oakington, Cambridge North)	Existing busway from the North, terminating at Cambridge North Station

Table 21 - LRA and LR2B2 Simplified Option Matrix

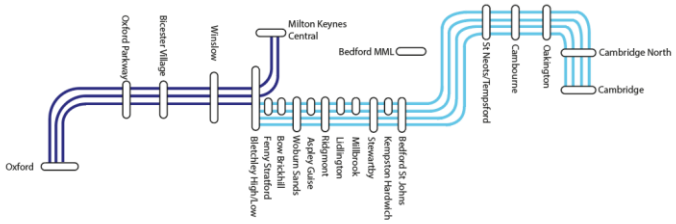
LR2b: Bletchley - Bedford St Johns - Varsity Hybrid – Cambridge North *(Heavy Rail Oxford – Bletchley)*				**Alignment**		
Schematic (Indicative Service pattern not infrastructure)	tph	OXD - BLY	MVL	Bed	Core	Cam
	4	Heavy Rail 1tph OXF - BLY + 2tph OXF – MKC TBC	Light Rail 2 EWR Stopper 2 EWR Fast	All through trains running via Bedford St Johns	Varsity Hybrid (Bedford St Johns, Sandy, Cambourne, Oakington, Cambridge North)	Existing busway from the North, terminating at Cambridge North Station

Table 22 - LRA and LR2B2 Simplified Option Matrix

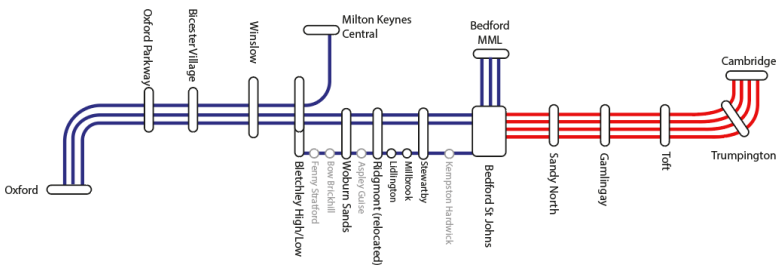
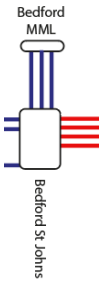
GB1: Bedford St Johns – Varsity Line – Cambridge via Trumpington *(Heavy Rail Oxford – Bedford)*					Alignment		
Phasing	Schematic (Indicative Service pattern not infrastructure)	bph	OXD - BLY	MVL	Bed	Core	Cam
Capacity Phasing		6	2tph OXF - BDM + 1tph OXF – MKC	2tph + stopper		Varsity Line (Bedford St Johns, Sandy North, Gamlingay, Toft, Trumpington, Cambridge)	Existing busway from Trumpington into Cambridge Central Stn

Table 23 - GB1 Simplified Option Matrix

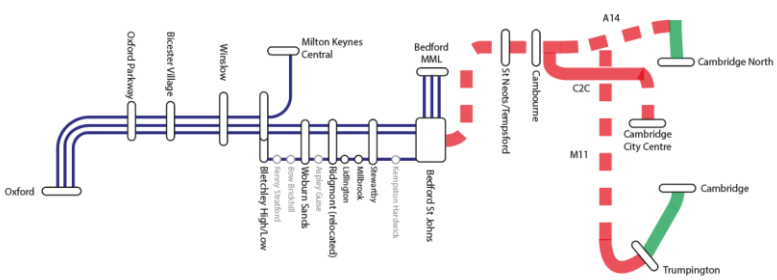
GB2: Bedford St Johns -A421&A428– Cambridge via A14&C2C&M11 *(Heavy Rail Oxford – Bedford)*			Alignment				
Phasing	Schematic (Indicative Service pattern not infrastructure)	bph	OXD - BLY	MVL	Bed	Core	Cam
Capacity Phasing		4	2tph OXF – BDM + 1tph OXF – MKC	2tph + stopper	Interchange at Bedford St Johns. Segregated busway between Bedford St Johns and A421.	A421 & A428	Into Cambridge North Station via A14 & Kings Hedges Road & existing busway
		4					Into Cambridge City Centre via C2C and existing road network
		4					Into Cambridge Central Station via M11 & segregated busway via Trumpington

Table 24 - GB2 Simplified Option Matrix

6. The Case for a New Transport Link

6.1 Introduction

6.1.1 Alongside considering the range of transport options to connect Oxford, Milton Keynes, Bedford and Cambridge set out in Chapters 2-5, EWR Co revisited the strategic case for a new transport link, taking a holistic approach to test whether investment in the Project can be justified as value for money. This included reviewing work previously undertaken, considering new evidence, and considering stakeholder feedback. The approach to testing the case for the Project went beyond traditional appraisal methods, the limitations of which are increasingly recognised when it comes to evaluating investment in complex transformational transport infrastructure.

6.1.2 The approach used established methods including both cost-benefit analysis and broader strategic analysis. This work has improved EWR Co's understanding of the poor connectivity across the Oxford-Milton Keynes-Cambridge region, the urgent need to improve it, and how best that can be achieved, while underlining the need for a strategic transport intervention to transform economic growth across the whole area, create new opportunities and jobs, and bring significant benefits to the wider UK economy.

6.1.3 In August 2022, *The Economist* singled out the Oxford to Cambridge area as a top priority for investment if the UK is to return to economic growth. *The Economist* claimed it has the potential to turbocharge the UK economy, add more than £90billion[11] extra Gross Value Added (GVA), and secure the UK's role as a world leader in science and technology. The region's economic track record also suggests it is a crucial source of economic resilience for the UK[12], making the nation better able to withstand economic shocks when they occur.

6.2 Understanding the transformative benefits of EWR

6.2.1 Traditional economic modelling struggles to identify the full benefits of investment in transformational projects, because of its concentration on journey-time-savings for existing travel patterns and its inability to capture fully the wider (non-transport) benefits associated with building a new transport link. To ensure public money is invested in the best possible way, EWR Co's business case will be compliant with government guidance, ensuring its analysis of the strategic and economic case for the Project considers its wider benefits and lasting impact.

6.2.2 The shortcomings of traditional appraisal models have been recognised by the recent revisions to the HMT Green Book. These highlight the importance of capturing the strategic merits of a project and place a greater emphasis on its strategic benefits, such as its contribution to economic growth and ability to meet wider policy objectives, rather than

[11] The Economist. (July 2022). The life-sciences industry is a jewel in Britain's economy

[12] Cambridge Ahead reference

focusing on an assumption that value for money is solely based on a project's quantified costs and benefits.

6.2.3 EWR Co has developed a more holistic view when considering the value for money of the Project, which will be carried forward to underpin the strategic and economic case. In addition to traditional approaches to modelling, and following guidance set out in the HMT Magenta Book[13], EWR Co has used a Theory of Change methodology to test whether the Project is necessary to enable the economic transformation of the region. This gives a more appropriate assessment of whether the Project provides good value for money. Theories of Change are a well-established approach, and The United Nations describes them as a useful tool that "explains how a given intervention, or set of interventions, are expected to lead to a specific change, drawing on a causal analysis based on available evidence."[14]

6.2.4 To inform its Theory of Change, EWR Co gathered a range of quantitative and qualitative evidence including socio-economic forecasts, data, and insights provided from key stakeholders. This has allowed EWR Co to understand the potential real-world outcomes of a new transport link. EWR Co's hybrid approach, combining traditional modelling with Theory of Change analysis, informs the selection of the single preferred project option and provides a more robust view of the Project than would otherwise be the case if either method were used in isolation.

6.3 The approach

6.3.1 EWR Co's approach to developing the Theory of Change for the Project is based around understanding four logical steps:

- The **transformational opportunity** for the Ox-Cam region and UKPLC
- The **constraints** that could prevent it from being realised
- The **enablers** to overcome those constraints
- The **outcome** of unlocking the Ox-Cam region's potential

6.3.2 Using a range of evidence including internal analysis, engagement with businesses, academia, and local authorities, as well as supplementary information gathered through literature reviews, EWR Co assessed the transformational opportunity for the region, before examining the constraints that inhibit growth, and prevent it realising that opportunity.

6.3.3 The analysis identified enablers necessary to realise the opportunities across the Ox-Cam region, the solution required to deliver the desired outcome, and specifically, how a new transport link could support this. The focus was the Bedford to Cambridge section of the route, given construction work on CS1 is already underway. However, the logic applies route-wide as many of the opportunities, constraints and enablers also apply in the Oxford area.

[13] The HMT Magenta Book is HM Treasury guidance on what to consider when designing an evaluation.

[14] As cited in the Theory Of Change United Nations Development Assistance Framework companion guidance

EWR Co considered Oxford's contribution to the Theory of Change later in the process. As this chapter explains, Oxford is a fundamental contributor to the Ox-Cam region's success and plays a vital role in creating the transformational opportunity for the region and the UK economy.

6.4 The opportunity

Oxford-Milton Keynes-Cambridge is a magnet for investment

6.4.1 The Oxford-Milton Keynes-Cambridge region is a globally significant area[15] and is formed of five counties: Oxfordshire, Buckinghamshire, Northamptonshire, Bedfordshire and Cambridgeshire. The region accounts for 7.1% of England's economic output[16], is home to 3.95m[17] people, and is an economic powerhouse that makes the UK a global leader in science, technology, and innovation. This creates jobs, growth, and wealth for the UK.

6.4.2 Capitalising on its world leading universities in Oxford and Cambridge, the region has an international reputation for life sciences, exemplified by its pivotal role in creating the world's first Covid-19 vaccine. It is also pioneering new technologies in the energy, aerospace, and automotive industries, as well as artificial intelligence, agri-tech, and fin-tech.

6.4.3 In 2021, the region supported over two million jobs and contributed £120bn of annual GVA to the UK economy[18]. The Ox-Cam region has a GDP per head that is 13% higher than the national average[19]. Both Oxford and Cambridge are in the top 25 cities around the world for venture capital investment[20] and research carried out in the Ox-Cam region creates high value development and manufacturing jobs elsewhere in the country.

6.4.4 It is an area of huge potential, home to well-known multinational companies and some of the most innovative high-growth potential businesses anywhere. Nearly 10% of the UK's top 100 (and two of the top 10) high-growth technology firms are based in the region[21].

6.4.5 Together, Oxford and Cambridge are home to 11 'unicorns'[22] with an investment per capita of £2,800, more than double that compared to London and significantly above other European

[15] MHCLG (2021). Oxford-Cambridge Arc. Policy Paper. https://www.gov.uk/government/publications/oxford-cambridge-arc. Accessed 31/05/2022

[16] MHCLG (2021). Oxford-Cambridge Arc. Policy Paper. Planning for sustainable growth in the Oxford-Cambridge Arc: an introduction to the spatial framework

[17] Office for National Statistics (2021) - Census 2021

[18] Office for National Statistics (2021). Regional gross domestic product: Enterprise regions. Gross Domestic Product (GDP) chained volume measures (CVM) annual growth rates.

[19] Office for National Statistics (2022). Regional economic activity by gross domestic product, UK: 1998 to 2020.

[20] Dealroom.co (2020). 2019: A record year for VC investment in the UK. https://dealroom.co/uploaded/2020/01/2019-A-record-year-for-VC-investment-in-the-UK.pdf?x75805.

[21] The Oxford-Cambridge Unit (2020). The Oxford-Cambridge Arc Economic Prospectus. https://www.oxfordshirelep.com/sites/default/files/uploads/Oxford-CambridgeArcProspectus_Approved_1.pdf.

[22] A Unicorn is a company founded since 1990 that reached $1 billion valuation. 11 unicorns recorded in 2019. Dealroom.co (2020).

cities[23]. Underpinning the region's industrial strengths are some 203,000 businesses[24] and a highly skilled workforce which is well-qualified[25].

6.4.6 In 2018, employment in the professional, scientific and technical sector across the region grew by 6.1%. Cambridge is a key driver of growth. Together, the City of Cambridge and South Cambridgeshire saw a 27% increase in professional, scientific and technical employment over the year – an addition of 8,000 new workers in these sectors[26].

High-performing towns and cities with productive business clusters

6.4.7 **Cambridge** is an intellectual powerhouse and a driving force for science and innovation in the UK. It is renowned for its high-tech clusters, with specialisms covering electronics, digital technology, and biosciences. Highly productive sectors include business services, which contains Cambridge's specialised professional, scientific, and technical sector. Cambridge has a significant reputation for innovation, leading the UK in terms of patent applications[27] with 258.5 applications per 100,000 population[28] [29].

6.4.8 Cambridge South (the area around Addenbrooke's and Trumpington), contains the Cambridge Biomedical Campus, the city's biggest employer and the largest centre of medical research and health science in Europe[30].

6.4.9 Bedford is situated between Oxford and Cambridge and is located close to both the M1 and the A1. Its population increased by 17.6%, from around 157,500 in 2011 to around 185,200 in 2021[31]. This is the largest percentage increase in the East of England (8.3% increase in Bedford compared to a 6.6% average for England). There are areas of deprivation as well as space to grow and attract further investment, given the skilled workforce. Availability of commercial premises and excellent north-south road connections have led several major logistics companies and large employers, heavily reliant on logistics, to locate close to Bedford. ASDA (Wal-Mart), Fuji and Argos Direct have all chosen Bedford as their operational base[32].

[23] London: $1,180 (£966). Dealroom.co (2020). 2019: A record year for VC investment in the UK. https://dealroom.co/uploaded/2020/01/2019-A-record-year-for-VC-investment-in-the-UK.pdf?x75805.

[24] Centre for Cities (2018). Cities Data Tool. Business Start-ups and Closures (per 10,000 population) 2019. ONS, Business Demography. ONS, Population Estimates. https://www.centreforcities.org/data-tool.

[25] Office for National Statistics (2021). Census interactive maps. *Education filter applied*

[26] Bidwells (2020). Oxford-Cambridge Arc Beyond the Covid-19 crisis.

[27] 258.5 applications per 100,000 population (compared to a national average of 17.8) Centre for Cities, Cambridge City Fact Sheet, Accessed March 2022

[28] Centre for Cities (2018). Cities Data Tool. Patent Applications (per 10,000 population) 2020..

[29] $0.7bn (£0.56bn) Dealroom.co (2020). 2019: A record year for VC investment in the UK.

[30] Network Rail (2022). East West Main Line Strategic Statement.

[31] How life has changed in Bedford: Census 2021 (ons.gov.uk)

[32] About Bedford Borough | Bedford Borough Council

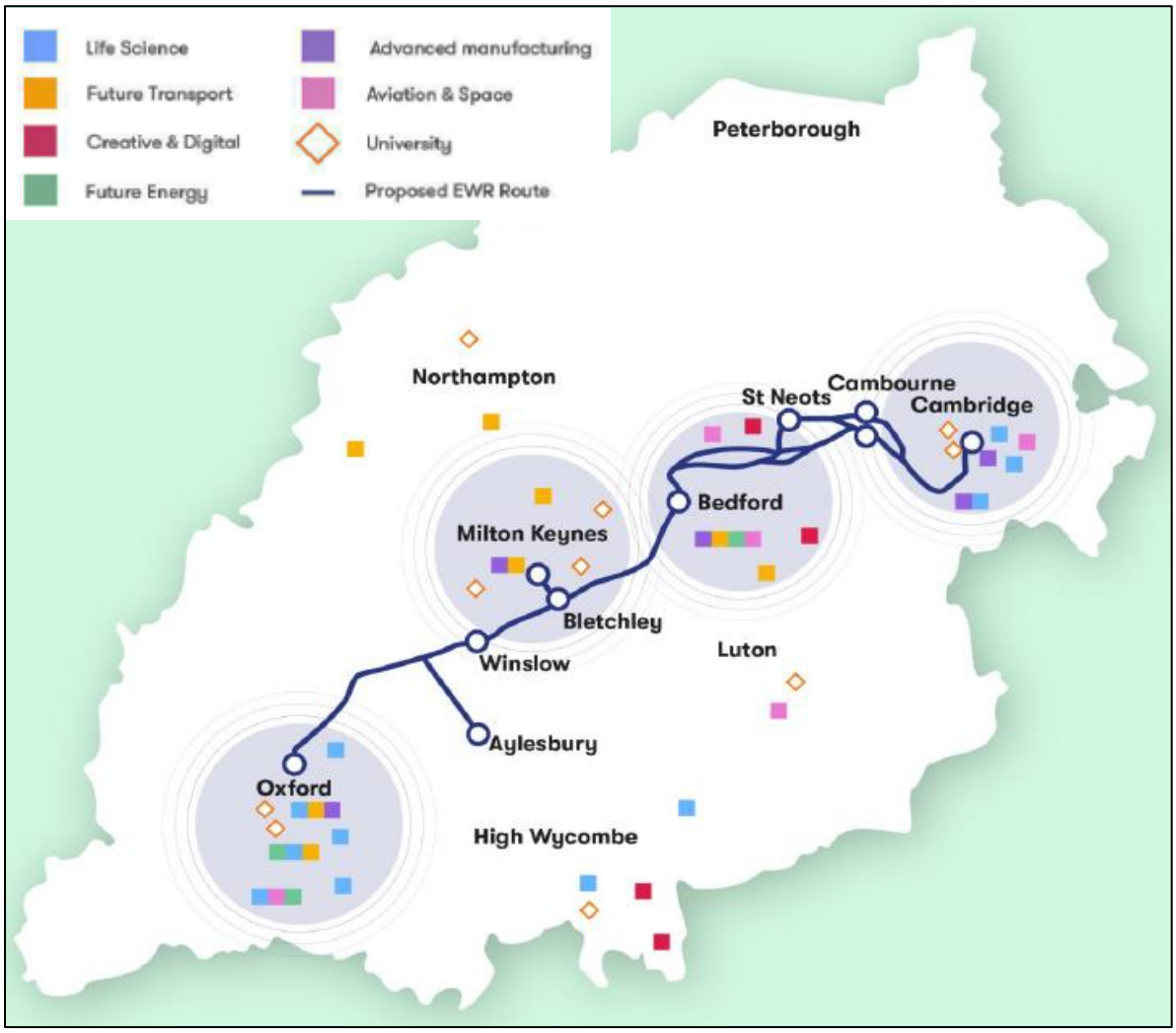


Figure 3 - Depiction of the Ox-Cam region, highlighting the sectors in which each different area is strongest

6.4.10 **Milton Keynes** is one of the most productive economies in the UK, with an estimated GVA of £11.8bn in 2020[33], and an estimated £83,000 per job filled[34]. Milton Keynes hosts offices for highly productive sectors including information, financial and professional services, such as PwC and Mazars. It also contributes to the region's automotive engineering and motorsport cluster. Having recently been afforded city status[35], it is in the top eight cities for start-ups in

[33] Office for National Statistics (2023). UK gross value added (GVA) and productivity estimates for other geographies. At current prices

[34] Office for National Statistics (2023). UK gross value added (GVA) and productivity estimates for other geographies. Milton Keynes GVA per job filled smoothed. ONS built-up area definition for Milton Keynes ("BUASD")

[35] https://www.gov.uk/government/news/record-number-of-city-status-winners-announced-to-celebrate-platinum-jubilee Accessed 01/06/2022

the country[36], with 66.43 start-ups per 100,000 people in 2020[37], in the top 11 for patent applications, and top five for concentration of high tech and digital SMEs[38].

6.4.11 **Oxford** is an historic, high-growth economy. The city's surrounding areas contain several bioscience and medical technology centres, as well as telecommunications, computer hardware, engineering and electronics firms. Highly productive sectors include information and communications, and business services, which contains Oxford's specialised scientific research and development sector. The area, with a population of 151,000 (2021)[39] contributes around £7.1bn GVA alone (2020)[40].

6.4.12 Surrounded by four innovation centres[41]; Oxford is recognised as one of the most innovative regions in the UK, with the third highest level of patent applications at 91.24 per 100,000 in 2019 [42]. The area is experiencing rapid and intensive economic growth, with a consequent increasing pressure on the demand for new homes[43].

A unique opportunity for transformational growth

6.4.13 The opportunity to maximise the potential of the Oxford-Milton Keynes-Cambridge region is well understood. In 2017, the National infrastructure Commission (NIC) found that by increasing the number of high-value jobs and strengthening its international competitiveness, the Ox-Cam region would add £110bn GVA to the UK economy per annum from 2050[44].

6.4.14 The NIC's recommendations formed the basis of the case for investing in EWR and underpinned the investment in the initial phase of the Project, starting at Oxford. More than £1bn investment[45] has been committed to connect Oxford with Bletchley and Milton Keynes under the first phase of EWR (CS1), with construction underway and services scheduled to commence by 2025.

6.4.15 Against the backdrop of global economic shocks, such as the Covid-19 pandemic and international conflict, which have impacted supply chains and increased the cost of living, EWR Co's analysis sought to test and validate the NIC's findings. This analysis found the case to invest in the Project is still compelling and has been bolstered further by the recent

[36] 66.43 start-ups per 100,000 people in 2020. Centre for Cities (2020). Cities Data Tool. Business Start-ups and Closures (per 10,000 population) 2020. ONS, Business Demography. ONS, Population Estimates. https://www.centreforcities.org/data-tool.

[37] Centre for Cities (2020). Cities Data Tool. Business Start-ups and Closures (per 10,000 population) 2020. ONS, Business Demography. ONS, Population Estimates. https://www.centreforcities.org/data-tool.

[38] Bidwells (2022). Radical Capital. Supercharge the Arc.

[39] Office for National Statistics (2021). Population of the United Kingdom by country of birth and nationality

[40] Office for National Statistics (2023). UK gross value added (GVA) and productivity estimates for other geographies. At current prices

[41] the Oxford BioEscalator, the Begbroke Accelerator, Harwell Science and Innovation Campus, and Culham Science Centre

[42] 91.24 per 100,000 in 2019. Centre for Cities (2019). Cities Data Tool. Patent applications (per 100,000 of population) 2019.

[43] Network Rail (2022). East West Main Line Strategic Statement.

[44] Presented in 2021 values uplifted from £85bn (2011 prices) presented in the NIC report using the HMT GDP deflator (from Jan 23 TAG Databook). National Infrastructure Commission (2017). Partnering for Prosperity: A new deal for the Cambridge-Milton Keynes-Oxford Arc. https://nic.org.uk/app/uploads/Partnering-for-Prosperty.pdf

[45] East West Rail. Connection Stage One. Gov.UK (2023)

successes of the UK life sciences sector and the resilience of the region since the pandemic and the war in Ukraine.

Oxford-Milton Keynes-Cambridge as a science supercluster

6.4.16 With its rare combination of complementary specialisms, the Oxford-Milton Keynes-Cambridge region contains a unique set of characteristics which give rise to its global influence and economic potential to become one of the few internationally competitive science superclusters. Areas with the most potential to become successful, high value-added superclusters are found in and around high performing universities with sufficient land to accommodate development, such as science parks, and have access to reliable transport connections. Universities act as incubators for pioneering ideas and provide a flow of highly skilled expertise.

6.4.17 Just as Stanford is at the heart of Silicon Valley in the USA, the Ox-Cam region is anchored by two of the world's top ten universities (Oxford and Cambridge) and their critical research and development (R&D) collaborations with world-leading life sciences and technology companies. Hundreds of new businesses spin out of both universities each year. Oxford is responsible for four times more patents than the UK average, while Cambridge has 19 times more[46]. This makes the region a perfect launch pad for start-ups. Global corporations, such as AstraZeneca and GSK, Unilever and ARM are drawn to the region by its exciting ecosystem of research and technology and the breadth of talent it attracts. The region accounts for four of the top eight ranked cities for new business start-ups in the UK[47]. Not only is there a thriving start-up scene, but companies that start here grow quickly and some become billion-pound businesses, such as Oxford Nanopore and AbCam in Cambridge. Oxford and Cambridge produce the same number of 'unicorns' as leading European capitals such as Berlin and Paris[48].

6.4.18 The Oxford-Cambridge Supercluster board has provided advice that the region can potentially drive increased prosperity and the economic potential of the UK if enabled by a new transport link. The expansion and growth of the high value life science and tech industries in the region is estimated to add £50bn of economic output by 2030 to the national economy, equivalent to over 2% of today's UK economy[49].

Triple Helix: Accelerated Innovation Through Co-operation

6.4.19 The Oxford-Milton Keynes-Cambridge region is further advantaged by its access to a unique 'Triple Helix.' The Triple Helix is an established concept that demonstrates overlapping interactions between academia and universities, industry and business, and government and public sector institutions. The close proximity of these institutions and organisations to each other form overlapping circles or helixes. These accelerate economic and social development,

[46] National Infrastructure Commission (2017). Partnering for Prosperity: A new deal for the Cambridge-Milton Keynes-Oxford Arc. https://nic.org.uk/app/uploads/Partnering-for-Prosperty.pdf

[47] National Infrastructure Commission (2017). Partnering for Prosperity: A new deal for the Cambridge-Milton Keynes-Oxford Arc. https://nic.org.uk/app/uploads/Partnering-for-Prosperty.pdf

[48] Dealroom.co (2020). 2019: A record year for VC investment in the UK. https://dealroom.co/uploaded/2020/01/2019-A-record-year-forVC-investment-in-the-UK.pdf?x75805.

[49] *East West Rail as a Catalyst for Turbocharged Economic Growth*

creating new concepts, such as the knowledge economy, and give rise to new intermediary organisations, such as science parks and technology transfer offices. This in turn drives innovation and powers economic growth, generating more employment opportunities and prosperity within the region and across the UK.

6.4.20 A notable Triple Helix collaboration was formed between AstraZeneca, the University of Oxford and the Government during the Covid-19 pandemic. This accelerated the creation of the vaccine and its subsequent testing. The Triple Helix is also being realised in the interactions between Cambridge University and the Cambridge Biomedical Campus. These interactions are growing – the development of the "Health Zone" or Cambridge University Enterprise Zone[50] is another example of the Triple Helix in action. The Triple Helix is also creating many other new and innovative partnerships, such as that between GSK, the University of Cambridge and Cambridge University Hospitals, which aims to jointly deliver new medicines to patients.

The Silicon Valley Triple Helix

6.4.21 Silicon Valley's Triple Helix has evolved over more than a century through the convergence of multiple double helices (university-industry; university-government; government-industry interactions). Over time, the three helices have built upon and reinforced each other, helping to contribute to the area's growth and prosperity.

6.4.22 Stanford and Berkeley, renowned universities with strong technical research capabilities, have both played a pivotal role in Silicon Valley's development, forging close ties with the commercial world and its activities. Entrepreneurs find access to capital more readily in Silicon Valley, while venture capitalists and investment bankers find it easier to identify promising new investment opportunities.

6.4.23 Additionally, support in helping to attract and facilitate the flow of talent and technology from around the world has been instrumental to Silicon Valley becoming the world innovation hub it is today. Its emphasis on human-capital development and its attractiveness as a place to live and work is another key factor behind the area's success.

The Singapore Triple Helix

6.4.24 Since 2000, Singapore has successfully become a world-leading biotechnology centre thanks to a coordinated, proactive and patient policy that prioritised access to funding, skilled people and infrastructure provision, underpinned by a supportive regulatory environment.

6.4.25 In 2000, the Government of Singapore announced a strategy to develop a biomedical industry. Three years later it launched [42] a purpose-built campus, which has become an example of global best practice in innovation cluster formation. In 2005, increased R&D funding led to the launch of the national Translational and Clinical Research (TCR) programme and the establishment of Research Centres of Excellence, five of which were based in the country's two largest universities. Since the Government's strategy was announced, Singapore's biomedical manufacturing industry has seen dramatic employment growth (7.77% vs. the Singapore [43] average of 3.14%), reflecting its increasing significance. The

[50] University Enterprise Zone aims to drive innovation across Cambridge | University of Cambridge

number of biological drug manufacturing sites in Singapore grew from zero in 2000, to around 18 by 2019.

6.4.26 Talent was also a key focus, with scholarship programmes introduced for human resource formation and a recruitment push to attract the world's leading scientists. Other policies to bolster the biomedical industry have included providing government venture capital for private-sector industrial projects, the holistic integration of research activities, and offering traditional tax incentives and intellectual property frameworks.

6.4.27 Over the last decade, Singapore has attracted top biotechnology experts from leading global institutions, such as the Massachusetts Institute of Technology and the University of California which cited benefits such as enhanced funding, greater organisational freedom, a more liberal research policy, and a heightened appreciation of the benefits of long-term R&D.

6.5 The problem

A constrained region

6.5.1 Oxford, Milton Keynes, and Cambridge have delivered economic growth in recent years that has exceeded even the most ambitious forecasts. Each is also a top UK performer when it comes to growth and productivity, and all three rank highly in global terms. However, in terms of per capita investment, each city still clearly has significant unrealised potential and there are untapped opportunities to work together to greater economic effect. Productivity in Oxford-Milton Keynes-Cambridge is only half that in Silicon Valley. Whereas the Bay Area in California attracts over £35bn of venture capital investment, Oxford and Cambridge secure between £1-£3bn per annum[51].

6.5.2 As discussed above, in 2017 the National Infrastructure Commission highlighted the Ox-Cam region's unique opportunity for growth, but also pinpointed poor transport connectivity as a limiting factor in the region's ability to realise its full potential. The NIC warned inadequate transport connections could exacerbate labour market constraints and reduce the affordability of housing in the fastest growing areas of the region. The NIC concluded that the region's economic potential cannot be achieved without investing in critical infrastructure, including EWR, which it argued would help to overcome its economic constraints [52].

6.5.3 The current constraints hold the region back, limiting opportunities for collaboration and agglomeration that drive innovation and economic growth. In a recent business report about the region, the risks were well highlighted: "…the Ox-Cam region has the potential to be as important as the US centres of innovation but we're just not enabling them…quickly enough and at some point, global money will … give flight and go elsewhere".[53]

[51] Figure converted to £s using 0.8 conversion rate from dollars. Rounded to nearest £Bn. Dealroom.co (2020). 2019: A record year for VC investment in the UK. https://dealroom.co/uploaded/2020/01/2019-A-record-year-forVC-investment-in-the-UK.pdf?x75805

[52] National Infrastructure Commission (2017). Partnering for Prosperity: A new deal for the Cambridge-Milton Keynes-Oxford Arc

[53] Bidwells (2022). Radical Capital. Supercharge the Arc.

6.5.4 The global reputation of the Oxford-Milton Keynes-Cambridge region, the growth potential of its businesses, and its skilled labour force are all attributes that attract investors. However, without addressing the prevailing constraints to growth, investment is likely to reach a ceiling and the Ox-Cam region could struggle to compete on the international stage against rivals, such as Silicon Valley[54].

6.5.5 These constraints are all linked to the region's fundamental problem of poor transport connectivity, highlighted by the NIC, and will be familiar to the businesses, organisations and families who live and work in the region. There are five key constraints:

1. **Lack of space and reduced land availability** – available laboratory and commercial space is almost exhausted in both Oxford and Cambridge. Even the most successful and productive businesses cannot grow if they cannot expand easily. With less than 5% lab availability in both Oxford and Cambridge, and the highest commercial rents outside London, this is a problem today. New companies find it hard to establish a foothold and there are waiting lists for businesses to access start-up, incubation and early-stage growth spaces.

2. **A limited labour market** means businesses cannot access the workforce and skills they need to grow. Despite being a short distance apart, journeys from places, such as Milton Keynes and Bedford, to Oxford and Cambridge take a long time because of congested roads and a lack of fast, reliable and frequent public transport. East-West public transport is limited to a coach service, which takes one hour 50 minutes between Oxford and Milton Keynes at peak times. The bus journey from Bedford to Cambridge takes an average of one-and-a-half hours.

3. **The impact of high living costs on families and businesses.** This affects people already living and working locally, as well as families and businesses considering relocating to the region. Housing costs in Oxford and Cambridge are the highest in the UK outside London, making it difficult for businesses to attract staff and relocate. The region's more affordable areas, such as Bedford and Milton Keynes, are cut off from the Oxford and Cambridge job market by poor transport links.

4. Oxford, Milton Keynes, and Cambridge **miss out on the synergies that accelerate innovation and generate growth**. Cutting-edge businesses and organisations choose to locate where they can be part of a dynamic ecosystem that sparks new ideas and creates exciting opportunities.

[54] In 2019, employment (16 and over) in the Arc was 1,930,400 (NOMIS (2021). Annual Population Survey. T01 Economic activity by age. 12 months to December 2004-2020 and Jul 2020-Jun 2021. https://www.nomisweb.co.uk/datasets/apsnew) and the Gross Value Added was £117,316 (ONS (2021). Regional gross domestic product: enterprise regions. Table 1: Enterprise Regions: Gross Value Added (Balanced) [note 1,2] at current basic prices https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductenterpriseregions), meaning GVA per employee was £60,772. In Silicon Valley, GVA per employee in 2019 was $250,000 (~£199,000 IN 2022 prices). Source: Value Added Per Employee (siliconvalleyindicators.org)

[54] Savills Research (2019). The Oxford-Cambridge Innovation Arc. Savills.

However, poor transport connectivity makes regional collaboration a challenge. While Harvard and MIT jointly invest in each other's start-ups because it benefits their single economic eco-system, Oxford and Cambridge do so only infrequently. Recent research by Savills concluded, "*It is clear that for the life science cluster in the arc region to compete internationally there needs to be greater collaboration between major centres*."[55]

5. **Attracting and retaining the best talent is a growing issue** for investors in the Ox-Cam region. It takes highly skilled technical and commercial talent to turn good ideas into successful businesses, but the individual job markets across the Oxford and Cambridge region are much smaller and more limited than the bigger metropolitan areas that serve rivals in Boston and San Francisco and are therefore not as attractive for people making long-term career and lifestyle decisions for where to locate themselves.

Cambridge: A current example of a constrained city

6.5.6 Many of the constraints highlighted by EWR Co's analysis are already having an impact in the fastest growing cities in the Ox-Cam region. This is particularly acute in the Cambridge area[56] where employment has been growing at a 3.4% per annum, higher than the UK average of 0.8%, and much higher than forecast (1.6%) in the transformational NIC growth scenario[57]. EWR Co has calculated that, if Cambridge's potential is realised, it could grow by 80,000 jobs by 2050, creating a potential total value of £4bn-5bn GVA per annum – over 50% more than its current economic contribution.[58]

6.5.7 Such growth is only possible in the right circumstances, and there are early signs that the constraints on growth are starting to have an impact in and around the city.

6.5.8 Characterised by the medieval city it has grown around, Cambridge, like Oxford, is encircled by a designated green belt that restricts its ability to grow further. In the five years to 2019 commercial rents in Cambridge increased by 32% to £46.50 per square foot (sq ft)[59]. A lack of commercial space can also be evidenced in the low availability rates. According to Savills Q4 2022 figures, vacancy rates for laboratories stand at 0.57%, with just 15,000 sq ft of fitted space available, and 11,518 sq[60]. Without available and affordable space to grow, businesses will not be able to continue creating jobs and the added value at the pace they have been, and they will instead go elsewhere.

6.5.9 The same is true if businesses do not have access to a big enough or skilled enough labour market to fill the jobs. Given Cambridge's spatial growth constraints, such as protecting the city's heritage and the green belt, EWR Co analysis suggests that only around 21% of the 80,000 potential jobs could be filled by development in Cambridge itself. Significant future

[55] Savills Research (2019). The Oxford-Cambridge Innovation Arc. Savills.

[56] Cambridge area [Cambridge] refers to the Urban Cambridge Area, which is defined for the purposes of the ToC as Cambridge local authority and eight Lower-layer Super Output Areas (LSOA) from South Cambridgeshire local authority.

[57] Partnering for Prosperity, NIC 2017

[58] EWR Co Analysis.

[59] Bidwells (2020). Oxford-Cambridge Arc Beyond the Covid-19 crisis.

[60] Savills UK | Cambridge office and lab supply remains critically constrained as take-up drops in 2022, says Savills

jobs growth is therefore based on expanding the labour market through people being able to travel into the city to access jobs.

6.5.10 Commuting to high value jobs is already increasing pressure on the region's stressed transport network, with congestion growing on key routes and little spare capacity on the limited public transport networks that are available.

6.5.11 The existing commuting catchment area into Cambridge limits the size of its labour pool. Based on observed large non-London city commuting trends, a catchment area is assumed to be within a 45-minute journey time. A 45-minute journey west of Cambridge reaches a very limited catchment area owing to congestion and the absence of good public transport. For example, it can take up to 53 minutes to travel 11 miles from Cambourne to the centre of Cambridge during busy periods of the day. Figure 4 shows how limited the current 45-minute Cambridge commuting catchment area is.

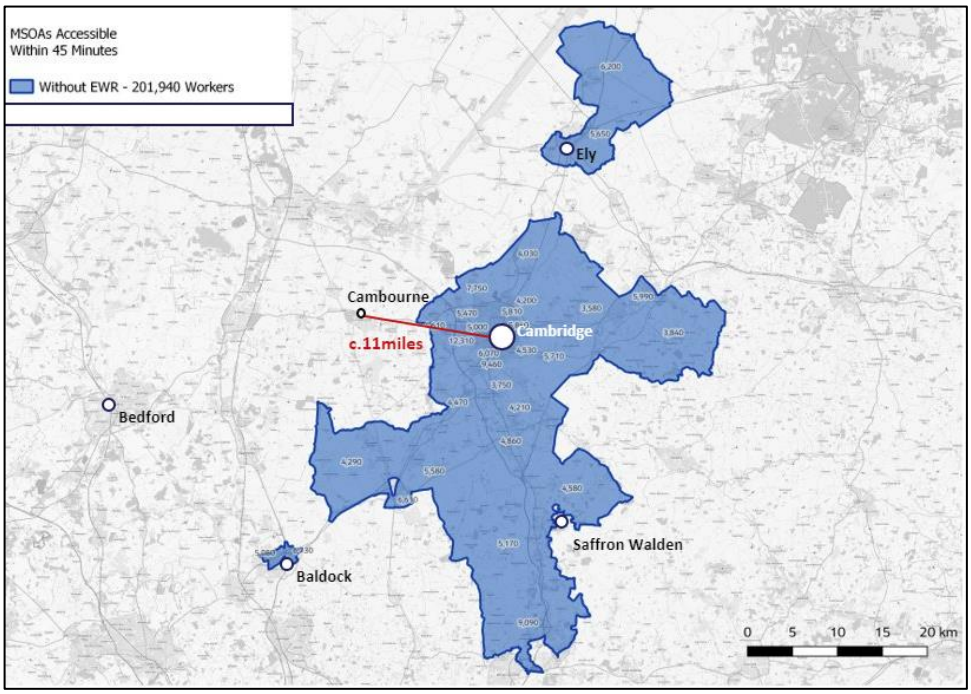


Figure 4 - Map of Cambridge labour market catchment area

6.5.12 Cambridge is highly reliant on the private car for travel to work. More than 40% of commuting journeys are taken by car. Increasing the number of commutes by car would further exacerbate congestion and is neither a viable nor sustainable long-term solution. There has been no growth in peak-hour traffic in Cambridge in the last decade, indicating that road access to Cambridge is 'full'. Traffic congestion impacts negatively on people's quality of life, the environment, and productivity. Congestion has been identified as a major problem in Cambridge and the city experiences the second highest levels of congestion in the UK, costing the average person £600 per annum in delays .

6.5.13 With such congestion and the resulting limited commuting catchment area, house prices have significantly increased. According to the Land Registry, Cambridge is the third worst in the UK affordability indices, just behind London and Oxford[61] [62]. This means that, without action, those businesses seeking to grow in Cambridge are not only facing a constrained labour market, but also higher labour costs and lower productivity. Those who do live within commuting distance of Cambridge, particularly along the main railway lines, have to pay high house prices, which drives up salary costs, whereas there are no transport connections to more affordable locations.

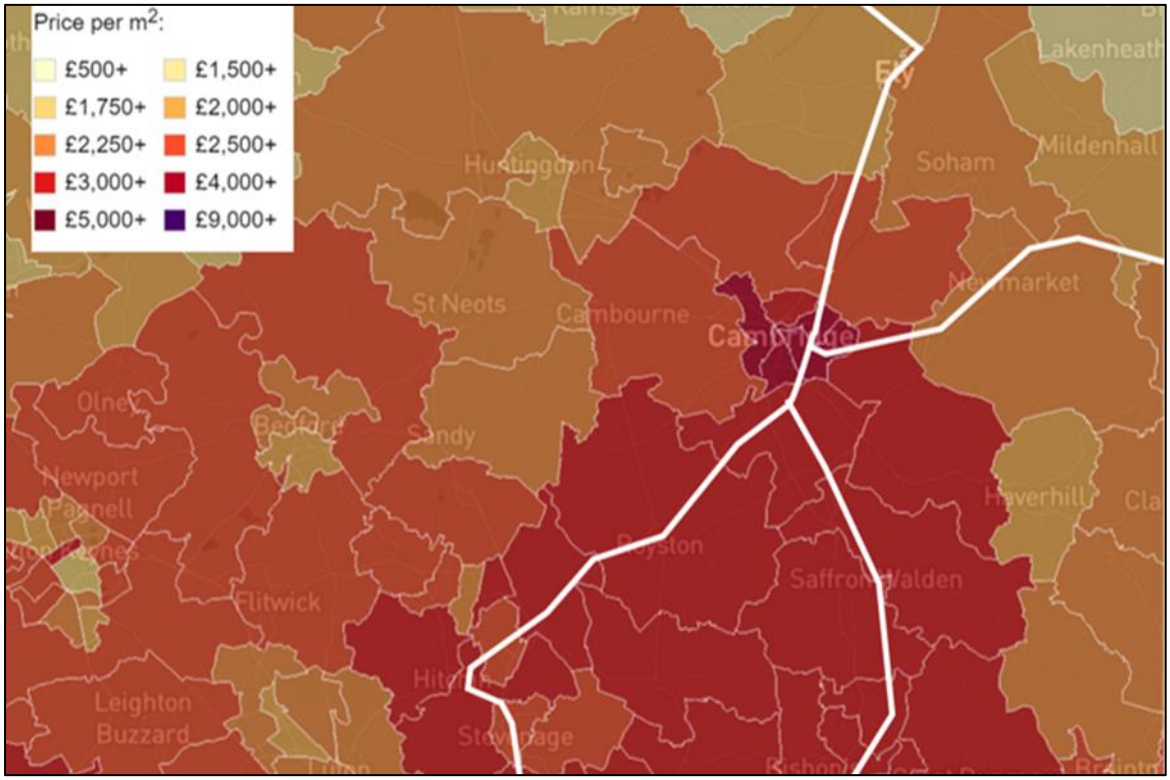


Figure 5 - Heat map showing house price per square metre in Cambridge and surrounding areas. Thicker white lines are existing railway lines.

6.5.14 This affordability issue is particularly acute for the key workers – for example hospital staff at Addenbrookes - on which Cambridge's 'Triple Helix' relies for success.

6.5.15 A constrained labour market and high labour costs are likely to become an impediment to growth and will certainly prevent Cambridge from fulfilling its potential to create 80,000 new high value jobs, and the added value those jobs would contribute to the economy.

[61] Calculated from Land Registry Average House Price. Comparing annual average 2001 to 2022. Comparing the LA of Cambridge to London (region). https://landregistry.data.gov.uk/app/ukhpi/browse?from=2001-01-01&location=http%3A%2F%2Flandregistry.data.gov.uk%2Fid%2Fregion%2Fcambridge&to=2023-01-01&lang=en

[62] ONS (2021). House price (existing dwellings) to residence-based earnings ratio. https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/housepriceexistingdwellingstoresidencebasedearningsratio.

6.5.16 This issue is particularly critical not just to Cambridge but to the UK economy as a whole, because if these jobs are not being created in Cambridge, they are unlikely to be created in the UK at all:

- The Technology Partnership, an innovative technology company, reports, "*one of our clients started in Scotland… They need[ed] to scale their facilities and initially looked to Cambridge as the next step. They eventually chose Switzerland due to better access to the facilities and support*."[63]

- The Cambridgeshire and Peterborough Independent Economic Review (CPIER) report[64] warns that, because Cambridge is the favourite UK location for many knowledge intensive businesses, most would prefer to move abroad rather than seek an alternative UK location. 35.4% of respondents to the CPIER qualitative survey said it was possible, likely, or certain that they would move activity abroad. Of those, who said they were likely to move activity outside of the area, significantly more indicated that they would move abroad (44.2%) than elsewhere in the UK (25.0%). One commented: "*Our reliance on a highly skilled work force, which could not easily be found elsewhere, would make relocation from the (Cambridge and Peterborough) area very difficult*."

6.6 The solution

6.6.1 Separate local interventions are unlikely to address the region's constraints, let alone unlock its full potential. It is only by adding a new transport link that the forces of Oxford and Cambridge can be combined. This enables them to connect with fast growing and less constrained places, such as Milton Keynes and Bedford, releasing the constrains on Oxford and Cambridge, as well as unlocking the potential of the whole Ox-Cam region. Better connectivity will create wealth and jobs for nearly four million people, improving the UK's international competitiveness, and attracting more international investment.

6.6.2 To better understand how a new transport link could provide such a significant boost to the value of goods and services produced in the Oxford-Milton Keynes-Cambridge region, EWR Co analysed the constraints discussed earlier in the chapter and identified that a new transport link could unlock these by:

1. **Expanding the labour market and bringing more jobs within reach of local people**. It currently takes nearly an hour to travel just 11 eleven miles from Cambourne to Cambridge in the morning peak. A new transport link – for example a rail line –- could reduce this to just 14 minutes. Bedford and Cambridge could be just 35 minutes apart. A new transport link would dramatically expand the number of people within commuting distance of

63 Bidwells (2022). Radical Capital. Supercharge the Arc.
64 Cambridge and Peterborough Independent Economic Review (2018)

high-quality jobs and give businesses much improved access to a considerably larger pool of labour.

2. **Improving the quality of life and reducing the cost of living.** Improved public transport creates more choice and better options: less time spent in traffic, more productive time to be able to work, and less carbon emitted from congestion. By bringing more locations within easy reach of good jobs, families could choose to live more affordably, rather than being forced to pay premium prices to live close to work. This would improve their cost of living as well as reducing business costs and boosting productivity. A new transport link could also support new, sustainable communities to grow around stations/stops along the route, serviced by a modern and integrated transport system.

3. **Opening up new areas for businesses to grow**. With space in Oxford and Cambridge becoming increasingly scarce, a new transport link would make it easier for businesses to grow by taking easily accessible, but more affordable, space elsewhere along the line of the route. This would enable more towns such as Bedford to benefit, keep business growth in the UK and also spread prosperity, which is currently focused at either end of the line, all the way along the route.

4. **Creating a dynamic ecosystem that attracts business and drives productivity**. A new transport link would bring people closer to jobs and would also bring businesses closer to their supply chains, research centres, competitors, customers, and other sectors. Businesses, particularly in emerging and innovative sectors, are attracted to locate where they can be part of a broader eco-system from which they can benefit, and which drive overall productivity. This concept of clustering is well established. Vibrant ecosystems already thrive in pockets like the Cambridge Biomedical Campus and the Oxford Science Park. A new transport link would connect these individual clusters, adding to their value and attractiveness for investment; creating new opportunities for cross sector collaboration – for example, between aerospace at Cranfield, advance manufacturing in Milton Keynes and energy research at Oxford; and boosting their productivity benefits for the UK economy.

5. **Attracting top talent with increased opportunities.** Global talent is attracted by places that provide opportunities to build a career, with good connectivity, interesting and fulfilling jobs for partners, and a good choice of education options for children and young people within reach. A new transport link would join up isolated jobs markets, bringing new opportunities from across the Oxford to Cambridge region within reach of more people, and making London and the Midlands more accessible.

The solution in practice - unlocking Cambridge

6.6.3 As explained above, EWR Co's analysis identified that the key constraints in the Oxford-Milton Keynes-Cambridge region - a lack of available labour and high cost of both commercial and residential property – are particularly severe in Cambridge. By better connecting Cambridge to the rest of the Ox-Cam region, a new transport link would alleviate many of these pressures.

6.6.4 It was clear from the analysis in Section 6.5 above that expanding transport connectivity into Cambridge is critical to unlocking the constraints on its growth. Some modes of transport, such as Road are already at full capacity, whilst others are close to capacity and cannot move sufficient people en masse between their homes and workplaces. Projections for future jobs mean transport investment is key to unlocking the constraints upon growth. However, not all transport connections would be effective.

6.6.5 **Rail services** from the North, East, and South bring people into Cambridge from areas such as Ely, Kings Lynn, Norwich and London. They provide capacity for 6,800 passengers to travel into Cambridge in the morning peak hour[65]. The spare rail capacity available from the south is unlikely to encourage more people to travel to Cambridge, because it results from the return journeys of longer trains serving commuters heading into London from Cambridgeshire. An examination of housing affordability shows the housing market to the south, which is also part of the London commuter market, is also saturated. Demand exceeds supply, and it is under the same stresses as those faced by Cambridge. This suggests a substantial number of people are unable to afford to move to areas already served by rail links to commute into Cambridge.

6.6.6 Although localised rail enhancements such as train lengthening, or the proposed Ely Area Capacity Enhancement (EACE) scheme could provide additional capacity to support busy rail services from the North and North-East, this would not be sufficient to carry the number of people required to fill the predicted number of new jobs.

6.6.7 New additional commutes are likely to come from west of Cambridge and rail investment to the north, north-east and south of Cambridge will be unable to overcome the constraints on Cambridge's growth.

6.6.8 **Existing bus services** provide capacity for around 1,600 passengers[66]. Expanding existing bus capacity is not a viable solution on its own, because it would have a limited impact on longer distance commutes due to congestion and long journey times.

6.6.9 Building **new road arteries** to access Cambridge would do nothing to address the congestion facing drivers when they reach the city. A road-based solution would be likely to lead to increased carbon emissions in the short term, because it is expected to take time for road

[65] EWR analysis conducted as part of Theory of Change scenario for ACP.

[66] EWR analysis conducted as part of Theory of Change scenario for ACP.

users to fully transition to electric vehicle usage[67] and would not increase the capacity where it is most urgently required, on the radial routes into central Cambridge.

6.6.10 Cambridge has **five Park and Ride (P&R) sites** and several bus services. The existing transport and parking infrastructure in the city struggles to cope with demand pressures. For example, the current demand at Trumpington Park and Ride exceeds supply[68]. This is likely to become more problematic, as the Southern Fringe, Cambridge Biomedical Campus and Cambridge City Centre continue to grow and develop.

6.6.11 Increasing **Busway services** will have a limited impact over longer distance commutes, further increasing congestion at peak times and impacting negatively on users of other modes.

6.6.12 Although other initiatives, such as the proposed **Cambourne to Cambridge (C2C) guided bus scheme** will help alleviate pressures, they will not address congestion within and around the city. Capacity limitations on a guided busway remain and such an intervention would still be reliant on non-segregated roads to reach the two principal growth areas in Cambridge of Cambridge Biomedical Campus and Cambridge Science Park, suggesting that it can only have a limited impact on relieving congestion.

6.6.13 As noted above, only 21% of the potential job growth can be met from development in Cambridge. Therefore, to make a meaningful contribution to unlocking the full potential Cambridge, it is necessary to open up access to significant additional labour markets, rather than relying on local solutions that make marginal improvements to connectivity within the existing labour market. It is in that context that connecting the cities, towns, and villages between Cambridge and Oxford with a new transport link would be transformative. It would bring significantly more people within 45 minutes of Cambridge. Taking a heavy rail option as an example, it could bring an additional 40,000 people into Cambridge every day. It would expand the labour market so that people in Stewartby, west of Bedford on the Marston Vale Line, would be able to reach high value jobs in Cambridge in just 42 mins, whereas they are currently out of reach with the current 78-minute journey time[69]. Figure 6 below illustrates the changes in journey times from Cambridge that a new transport link could deliver.

[67] The current government policy implications for transitioning away from diesel and petrol cards are:
- to end the sale of new petrol and diesel petrol and diesel vehicles by 2030,
- for all new cars and vans to be fully zero emission at the tailpipe by 2035,

bearing in mind this does not affect the *existing cars* on the road.
DfT (2022). *UK electric vehicle infrastructure strategy.* Source: https://www.gov.uk/government/publications/uk-electric-vehicle-infrastructure-strategy

[68] Cambridge South West Travel Park and Ride Outline Business Case with documents (greatercambridge.org.uk)

[69] A heavy rail solution is assumed in these figures, but as noted elsewhere in this report, EWR Co has taken an open-minded approach to mode choice. In subsequent chapter, the ability of other transport solutions to achieve similar outputs is tested.

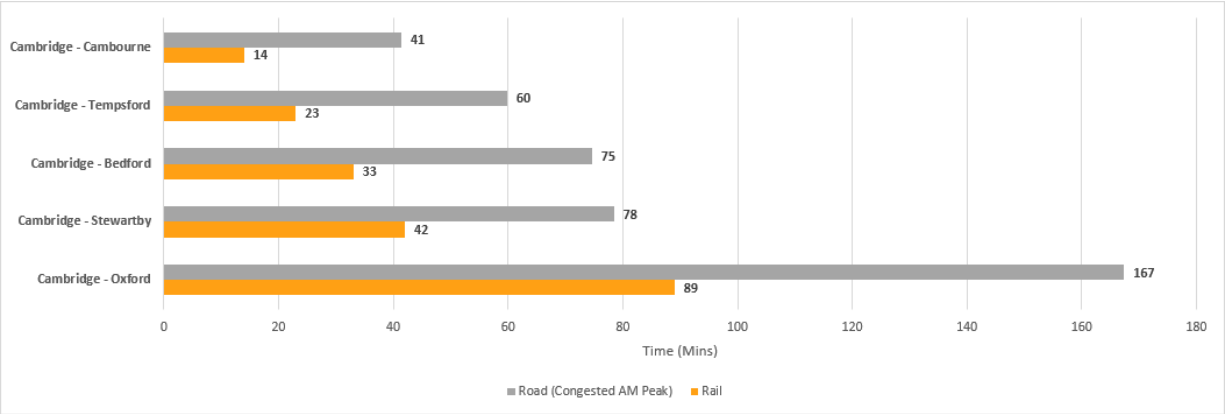


Figure 6 - Journey times from Cambridge before and after EWR (assuming a heavy rail transport solution)

6.6.14 EWR Co's analysis suggests that whilst 21% of the 80,000 potential jobs can be met by development in Cambridge itself, it is possible to unlock a further 22% by connecting Cambridge to additional existing highly skilled labour markets, like Bedford, when the planned growth in those areas is taken into account. On indicative estimates, this would enable a further 28,200 of the job opportunities in Cambridge to be fulfilled.

6.6.15 Despite the new transport link delivering significant value by unlocking additional jobs and growth, it still means that over 35,000 of the 80,000 potential jobs in Cambridge could remain unfulfilled, worth over £1.9bn in lost value to the UK economy every year.

6.6.16 It is important to recognise a new transport link also opens up the opportunity for additional growth by making existing areas more desirable places to live because of their better transport connections and by creating the conditions for new, more sustainable communities in strategic locations, for example at the intersection with other transport links, like the East Coast Mainline.

6.6.17 It is therefore only with the delivery of a new transport link across the Ox-Cam region that it is possible to release the labour market constraints and unlock the otherwise unfulfilled potential jobs and economic growth in Cambridge.

6.6.18 Furthermore, a new transport link not only connects Cambridge to an expanded labour market, but also to more affordable areas. For example, in Milton Keynes and Bedford, homes are 8.93 & 9.50 times the annual salary respectively, compared to 12.21 in Cambridge.[70] A connection to these areas would significantly reduce the cost of living for those who currently pay a premium to live near Cambridge because of their job, but who would be able to commute from more affordable places more easily with a new transport link. This is particularly important for lower paid key workers who are essential to enabling economic

[70] ONS (2021). House price (existing dwellings) to residence-based earnings ratio. *https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/housepriceexistingdwellingstoresidencebasedearningsratio.*
Affordability ratios are calculated by dividing median house prices for existing dwellings, by median gross annual residence-based earnings.

growth in a 'Triple Helix' economy; and it also reduces costs and boosts productivity for businesses, therefore encouraging further investment.

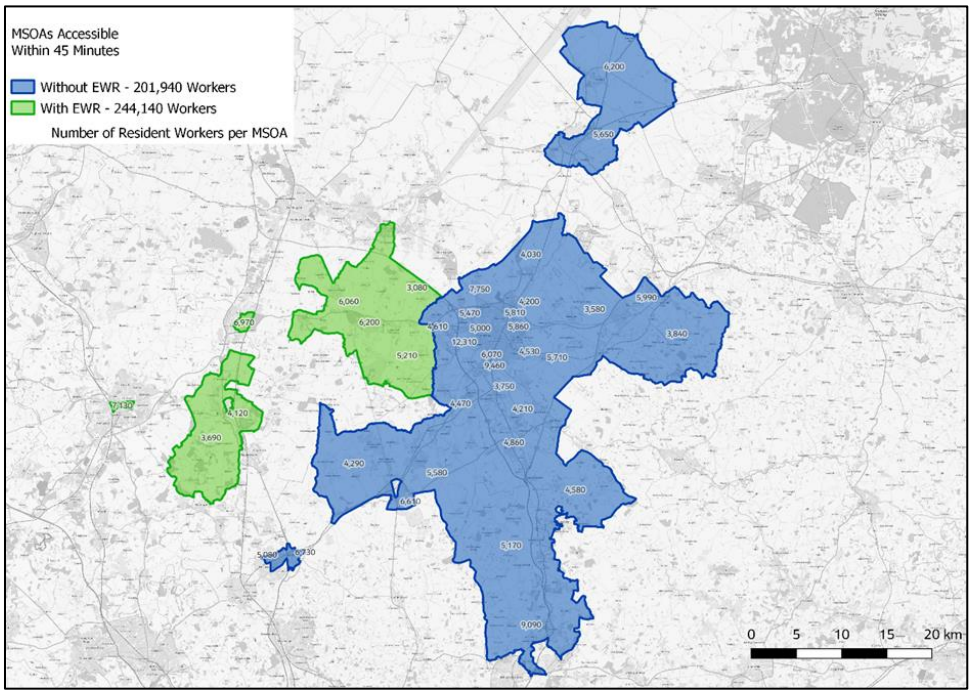


Figure 7 - Areas that could be reached within 45 minutes of Cambridge station by fastest mode

6.6.19 It is important to recognise that by opening up Cambridge to the wider Ox-Cam region, the new transport link not only makes it easier for businesses in Cambridge to access a wider and more affordable labour market, it also makes it easier for businesses to choose to locate or expand elsewhere in the region whilst still having good proximity to Cambridge and being part of the wider eco-system. In recent years, a number of Cambridge based businesses have expanded to commutable locations locally. Indeed, given even a new transport link is unlikely to enable sufficient people to access Cambridge to meet the full 80,000 job opportunities forecast, it is therefore highly likely that businesses will both need and want to create high value jobs in other areas along the line of route where there is a skilled work-force, affordable space and other good transport connections. These are exactly the conditions found already in Bedford and Milton Keynes as well as potentially in Tempsford/St Neots.

6.6.20 In addition to unlocking the constraints in terms of labour market, affordability and giving business space to grow, a new transport link is also essential to unlocking growth in Cambridge in two other ways noted above.

6.6.21 The first is the benefits of clustering in Cambridge itself and across the region. This drives productivity through business collaboration and innovation, and also makes businesses more likely to choose to locate in the region in the first place to be part of such an ecosystem. EWR Co's analysis highlights how businesses, and other institutions and organisations working in sectors such as life sciences, new technology in energy, the aerospace and automotive

industries, artificial intelligence, agri-tech and fin-tech, tend to cluster close to each other to benefit from the increasing returns that accelerate growth, reduce costs and improve efficiency. The benefits of such co-location are known as agglomeration[71] effects. Oxford and Cambridge and their surrounding specialist clusters are powerful examples of this, but their science cluster is not able to realise its full potential because the universities are located at opposite ends of the Ox-Cam region. With better transport links, regional innovation systems are more likely to develop faster and realise the agglomeration benefits of scale. Many areas within the region have their own functions and industrial specialities which, when connected, could achieve more than the sum of their parts. By overcoming the constraints of the individual economies of the Ox-Cam region and connecting their specialities, the potential for it to be a Supercluster can be unlocked. Creating a supercluster would boost UK international competitiveness, creating a magnet for international investment, talent, and business development.

6.6.22 The second is making the area attractive to help bring in and retain talent, particularly in a globally competitive market. EWR Co has heard from venture capital investors that access to talent is a constraint on growth. In part that is because, whilst there are great opportunities to attract talent in Cambridge, the size of the market is small internationally – Cambridge is a city of around 150k[72], compared to Boston Metro Area (4.9m)[73] and Silicon Valley's approximate 3m[74]. To be truly competitive on the international stage, the region needs access to a larger labour pool. Better connectivity between places doesn't simply provide businesses with access to workers. In an environment where success is far from certain, people look not just for one job opportunity but for the opportunities in the employment market overall, to sustain their career in the medium term. This is particularly the case if they have a family and need a stable base for their children's education and also to respect changes in their partner's career too. Given the current transport constraints around Cambridge, the range of opportunities is comparatively limited. So, a better connected area results in an improved offer for skilled workers.

6.6.23 A new transport link across the Ox-Cam area would connect a market of nearly 4 million people, which is comparable with the region's international competitors. This makes the region more attractive to talent, and therefore to investors.

6.6.24 Figure 8 below uses a heavy rail example to demonstrate how a new transport link could bring Oxford, Cambridge, Milton Keynes and Bedford within 45 minutes travel time of places

[71] Agglomeration is defined as a localised economy in which a large number of companies, services, and industries exist in close proximity to one another and benefit from the cost reductions and gains in efficiency that result from this proximity - Miriam Webster Dictionary

[72] ONS (2022). Population and household estimates, England and Wales: Census 2021, unrounded data. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/populationandhouseholdestimatesenglandandwales/census2021unroundeddata#population-and-household-estimates-england-and-wales-data

[73] Statista (2021). Boston metro area population 2021. https://www.statista.com/statistics/815215/boston-metro-area-population/#:~:text=Boston%2DCambridge%2DNewton%20metro%20area,in%20the%20U.S.%202010%2D2021&text=In%202021%2C%20the%20population%20of,also%20about%204.94%20million%20people.

[74] Civic Well (2022). *SILICON VALLEY REGION.* https://civicwell.org/wp-content/uploads/2022/01/Silicon-Valley-Regional-Profile.pdf
Silicon Valley Indicators (2023). Accessed 23/05/2023. https://siliconvalleyindicators.org/about/snapshot/
Official Population statistics unavailable for Silicon Valley. Collation of various sources lead to figure of approximately 3m.

situated in the centre of the region, such as Stewartby, opening up opportunities for people to choose the centre of that area as a good long-term base for themselves and their families. This would open up 70,000 jobs to households within the region, as journey times would be significantly reduced.

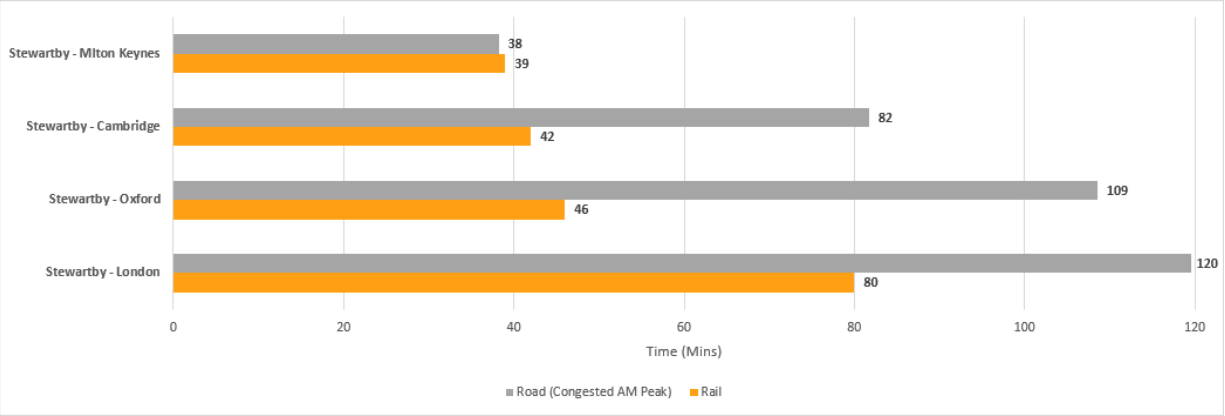


Figure 8 - Journey times from Stewartby before and after EWR (assuming a heavy rail transport solution)

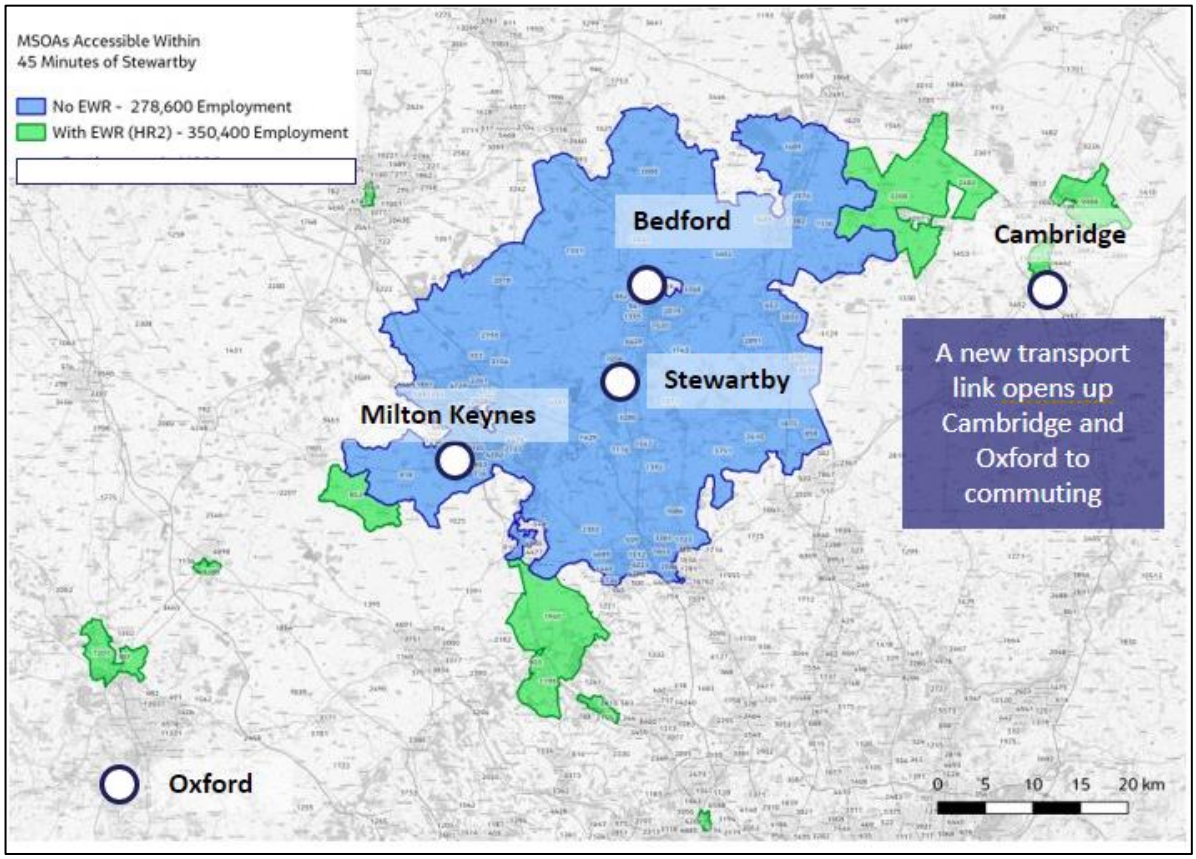


Figure 9 - Map of Stewartby labour market catchment area showing the existing areas within

45 minutes of Stewartby station and what could be reached with a heavy rail transport solution in place

6.6.25 This is a unique characteristic of a new transport link that connects centres across the region, which could not be unlocked by local interventions, to release the constraints on individual towns or cities.

Looking beyond Cambridge

6.6.26 In developing the Theory of Change, EWR Co initially considered the constraints on, and then the enablers of growth in the region as exemplified in Cambridge. That is because the constraints are particularly acute and the opportunities significant there, given the city's international reputation and status. Even considering Cambridge alone, the case for a new transport link is compelling.

6.6.27 However, the benefits are much wider than that.

Oxford and Milton Keynes

6.6.28 EWR Co's analysis suggests that Oxford suffers from similar challenges but is already set to gain improved transport connectivity from the implementation of the first stage of East West Rail (CS1).

6.6.29 Additional analysis was subsequently undertaken on the western section of the Ox-Cam region to explore significant job growth potential in Oxford and Milton Keynes by linking the two cities, overcoming local transport and land constraints. Both Oxford and Milton Keynes are high-performing economies and EWR Co's analysis sought to assess the transformational potential of a new transport link to support their further growth.

6.6.30 EWR would reduce travel time between Milton Keynes/Bletchley and Oxford by approximately 30 minutes compared to driving in the morning peak. This is a significant reduction, which puts both cities within 45 minutes commuting time of each other, increasing opportunities to travel between them.

6.6.31 EWR Co's analysis focused on the constraints in the transport network of Oxford and Milton Keynes (including between the two cities) and their economic performance. EWR Co's conclusion is that a new transport link from Oxford to Cambridge via Bletchley/Milton Keynes would remove some of the barriers that have constrained Oxford's economic growth, such as a congested road network and lack of available land for commercial and residential development. In short, a new link presents Oxford with a significant opportunity to boost its economy and enlarge its labour market, much as it would for Cambridge.

6.6.32 Milton Keynes has a different situation from Oxford in many ways. There is much greater availability of land, homes are cheaper, and are more affordable as a proportion of earnings. Businesses in the area also benefit from cheaper commercial space. The surrounding transport infrastructure is not as congested, although it could be in the future if significant economic growth is delivered. Therefore, Milton Keynes has great potential to attract talent

and business investment. High growth has already been seen in Milton Keynes' strong performance as a centre for new business formation. Global businesses such as Santander have consolidated their operations there, and more could follow. Stimulating economic growth, new east-west connectivity would provide communities with enhanced access to well-paid jobs in Milton Keynes, as well as in Oxford and Cambridge, creating larger and more flexible labour markets.

Milton Keynes to Bedford

6.6.33 The existing MVL, connecting communities between Bletchley and Bedford, is slow and often unreliable. With significant potential development available in the Woburn Sands, Marston Village, and the Bedford Brickworks areas, improved services on the MVL would be required to support this development and enable further sustainable housing and business growth. This in turn would support job growth in the neighbouring economies of Bedford and Milton Keynes, as well as further afield.

6.6.34 Bedford has relatively affordable property prices[75] and 41% of its eligible workforce had a degree or higher education qualification in 2021[76], but there are also pockets of deprivation. There are plans to help stimulate the local economy via £22.6m funds secured to help regenerate Bedford Town Centre[77], and the redevelopment of Bedford station would support this.

6.6.35 Relatively well connected with a direct rail link to London, many people who live in Bedford do not work in the town[78.] The traffic congestion in the centre of Bedford is a by-product of this, as many people drive inwards to the central station to travel outwards to jobs elsewhere.

6.6.36 Access to skilled labour is an issue and was highlighted by the South East Midlands Local Enterprise Partnership (SEMLEP). Businesses report science, engineering and production technicians are the top three occupations they struggled to recruit in 2021 – a change from sales, marketing and related occupations noted in 2019[79].

6.6.37 The Bedford workforce ranks 19th in the East of England and 153rd across England and Wales[80]. There is an opportunity, through better east-west transport connectivity for the workforce in Bedford, to address labour market constraints in the wider Ox-Cam region, and to contribute towards regenerating the town by improving access to local jobs, broadening people's skills and qualifications, boosting growth and helping to 'level up' the town.

6.6.38 Opportunities also exist to provide more homes that are affordable for local people, given the land available for development in Bedford and surrounding settlements, such as Tempsford/St Neots and on the Marston Vale Line. As with Milton Keynes, Bedford also

[75] Land Registry House Price Data (2023). https://landregistry.data.gov.uk/app/ukhpi/browse?from=2001-01-01&location=http%3A%2F%2Flandregistry.data.gov.uk%2Fid%2Fregion%2Fbedford&to=2023-01-01&lang=en

[76] Education, England and Wales - Office for National Statistics (ons.gov.uk)

[77] 'Success as Bedford Borough wins £22.6m for Town Deal' www.bedford.gov.uk [accessed 22nd May 2022]

[78] Bedford's jobs density ratio of 0.78 in 2021, which means that for every 1 working age resident, there are 0.78 jobs available. Source: https://www.nomisweb.co.uk/datasets/jd

[79] SEMLEP Business Survey 2021, November 2021

[80] More than one in 20 Bedford workers have no qualifications | Bedford Today

presents an opportunity to provide space for collaboration, business expansion, and supply chain development.

6.6.39 Maximising Bedford's professional specialisations and bringing together the otherwise constrained economies of Oxford and Cambridge with the fast-growing city of Milton Keynes, and combining it with the opportunities for growth in Bedford, would provide the region with the capacity to become much more than a sum of its parts, turning it into a Supercluster[81], an engine for economic growth, innovation, and a magnet for international investment and talent.

Wider UK

6.6.40 Improved connectivity across the region would have further direct and indirect complementary impacts beyond Cambridge, as the effects of larger scale agglomeration reach into places such as Milton Keynes and Bedford, which are strategically well placed and provide a number of opportunities to deliver growth for the region and the country as a whole.

6.6.41 The complementary nature of the region's clusters mean that improved transport connectivity opens up not only a larger labour pool, but also opportunities for businesses to collaborate, innovate, access supply chains, and reach new markets. Many businesses throughout the region (including some of the UKs best performing companies) have links to other parts of the country, either through day-to-day customer/client relationships or through specialisation and diversification of businesses activities. As the region's high growth businesses scale up, better access to other parts of the country improves the likelihood of retaining these businesses in the UK, the jobs they will provide and the investment they will attract, spreading growth along the length of the line and throughout the country. Indeed, the Oxford-Cambridge Supercluster Board[82], cited AstraZeneca as a case study that shows how national growth can be driven by businesses in the heart of the regions Supercluster. They also highlighted that successful clusters naturally evolve along transport corridors, a pattern observed in many locations globally.

6.7 Conclusion

6.7.1 This chapter has made the strategic case for a new transport link between Oxford and Cambridge, using the latest HMT Green and Magenta Book methodologies, and by developing a Theory of Change to evaluate the Project's value for money.

6.7.2 The Oxford-Milton Keynes-Cambridge region is a magnet for investment. Oxford, Milton Keynes, and Cambridge are top economic performers and, despite being mid-sized cities, overperform on the international stage. The region's potential was identified by the National

[81] Innovation Superclusters are massive innovation systems built around a single theme and designed around industries of the future. They are expected to generate significant value as they develop. Engage Innovate and Strategy Tools. (2019). Building Innovation Superclusters. https://www.engage-innovate.com/reports/building-innovation-superclusters/#reportsignup.

[82] Oxford-Cambridge Supercluster Board (2023). East West Rail as a Catalyst for Turbocharged Economic Growth.

Infrastructure Commission (NIC) in 2017[83]. With world leading universities in Oxford and Cambridge at either end of the region, the area is unique in the UK for being home to a rare Triple Helix and several world leading specialist clusters, such as the life sciences; new technology in energy, the aerospace and automotive industries; Artificial Intelligence; Agri-Tech and Fin-Tech. Together, they give it the ability and attributes to become a globally significant Science Supercluster capable of challenging the few other global Superclusters, most notably in Silicon Valley, Boston, and Singapore.

6.7.3 EWR Co identified several constraints that hold the region back and limit its potential. These include a lack of space, the high and rising cost of living in the fastest growing areas of the region, and crucially, Oxford-Milton Keynes-Cambridge's restricted labour market and poor transport connectivity. The NIC highlighted these constraints in 2017, when it made the investment case for EWR and warned that, without that investment, the region's ability to create new jobs and growth would be severely limited.

6.7.4 EWR Co has set out how a new transport link connecting Oxford to Cambridge, via Milton Keynes and many of the towns in between, would create new opportunities for growth by bringing significant numbers of jobs within reach of more people across the region.

[83] National Infrastructure Commission (2017). Partnering for Prosperity: A new deal for the Cambridge-Milton Keynes-Oxford Arc. https://nic.org.uk/app/uploads/Partnering-for-Prosperty.pdf

7. Application of the Theory of Change to Bedford – Cambridge Option Families

7.1 Introduction

7.1.1 As discussed in Chapter 5, the output of the initial and strategic sifts led to the creation of ten Option Families for the project between Bedford and Cambridge. To demonstrate the real value of the investment in EWR, the Theory of Change was then applied to the ten Option Families to identify potentially viable Option Families. This identified four Option Families for further study, all of which are heavy rail options, as outlined below.

7.1.2 In addition, as explained elsewhere, AVRT was considered in a separate, parallel exercise and is therefore not addressed in detail in this Report. Appendix 10 discusses AVRT in detail.

7.1.3 To deliver a transformational economic change, the Theory of Change, focusing on the need to resolve the constraints facing the economic development of Cambridge and its role in an Oxford-Cambridge region, requires a transport solution between the two cities to have the following characteristics:

- **Location:** The proposed solution would need to serve locations that have large existing populations and contain stations at locations where future housebuilding is planned and also look at areas where there are further opportunities for growth that can take advantage of the new transport link. This would provide the greatest benefit in terms of increasing the available workforce to support Cambridge's employment opportunities.

- **Speed:** The proposed solution would need to be able to operate at a sufficiently high speed to expand the workforce that could be within 45-minutes commuting distance of Cambridge, as well as providing the most job opportunities for workers who live in the centre of the region. Speed is a function of the mode and the route of the Option Family.

- **Capacity:** The proposed solution would need to accommodate the commuting and business demand to support continued jobs growth in Cambridge and elsewhere in the region. It must deliver sufficient passengers to the right places in the key peak commuting periods.

7.1.4 There are two significant differentiators across the ten families:

- **Route:** The families cover two broad route choices between Bedford and Cambridge, each enabling connection to a different set of communities between the crossing with the East Coast Main Line and Cambridge. The routes have alternatives for the approaches to Bedford and Cambridge.

However, there are no potential stations in these approach sections of the routes. The main route choices are:

- a route (termed *Cambourne* in Table 25 25) with potential for stations at Tempsford/St. Neots, Cambourne and the option of a station to the north of Cambridge (potentially at Bar Hill).
- a route (termed *Varsity* in Table 25) with potential for stations at Sandy, Gamlingay, and Toft.

7.1.5 For both *Cambourne* and *Varsity* routes, potential station locations reflect areas of existing population as well as areas with potential for residential growth; this is explained in more detail below.

- **Mode:** the families cover three different modes; heavy rail, light rail and guided bus. Each mode has different characteristics in terms of their speed, frequency, and capacity.

7.1.6 Both *Cambourne* and *Varsity* route choices have been considered for all modes, although the approaches to Bedford and Cambridge are not all considered for each mode.[84] Together, these provide the alignments for the Option Families that are listed in Table 25 25 below.

Option Code	Mode	Route option	Bedford approach	Cambridge approach
HR1	Heavy rail	Cambourne	Northern rail approach	Northern rail approach
HR2	Heavy rail	Cambourne	Eastern approach	Northern rail approach
HR3	Heavy rail	Cambourne	Eastern approach	Southern rail approach
HR4	Heavy rail	Varsity	Northern rail approach	Cambridgeshire Guided Busway (South)
HR5	Heavy rail	Cambourne	Northern rail approach	Southern rail approach
HR6	Heavy rail	Varsity	Eastern approach	Southern rail approach
LR1	Light rail	Varsity	Eastern approach	Cambridgeshire Guided Busway (South)

[84] This is because, for instance, the northern rail approach to Bedford is not useable by bus and is extremely difficult to use for light rail because it entails use of the existing heavy rail corridor.

LR2	Light rail	Cambourne	Eastern approach	Cambridgeshire Guided Busway (North)
GB1	Guided bus	Varsity	Eastern approach	Cambridgeshire Guided Busway (South)
GB3	Guided bus	Cambourne	Eastern approach	Cambridgeshire Guided Busway (North), C2C, Cambridgeshire Guided Busway (South)

Table 25 - Route options for the ten families, images below provided to assist understanding

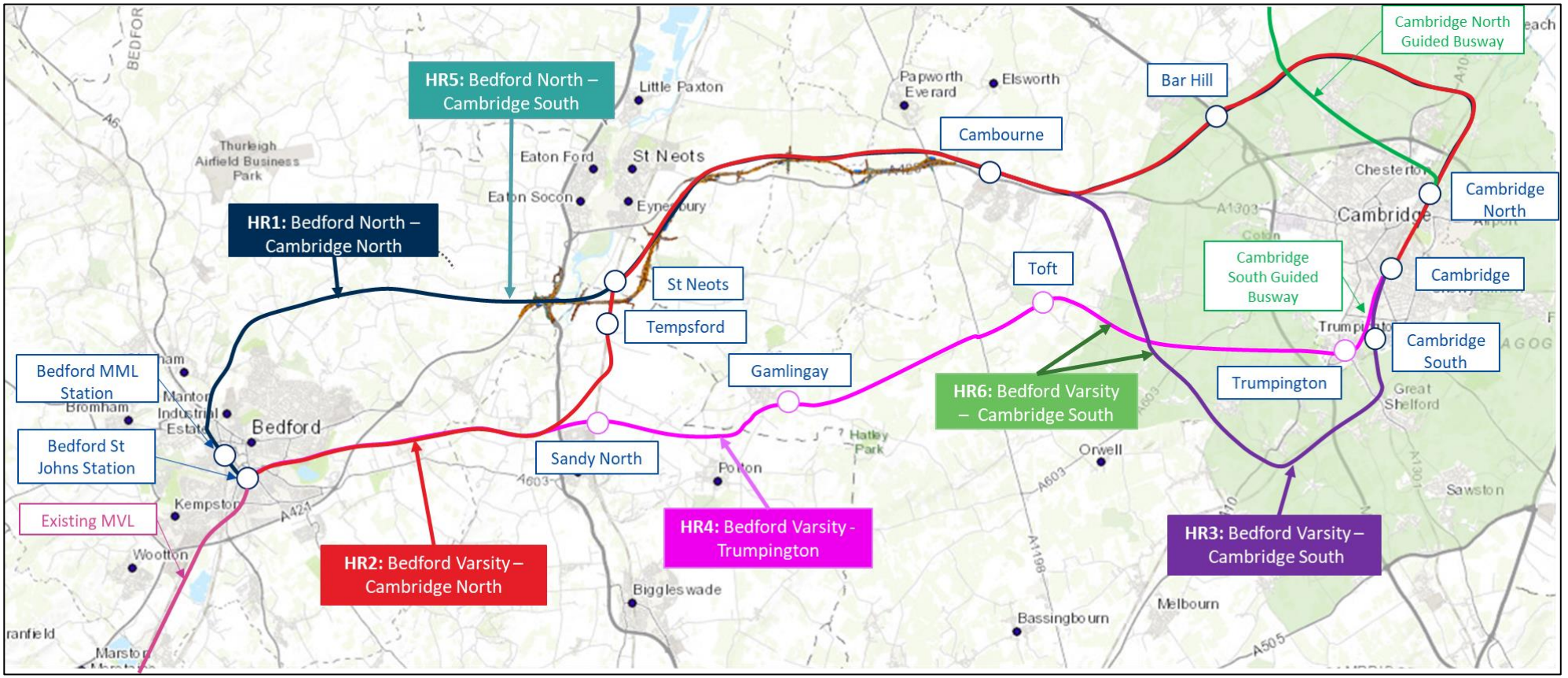


Figure 10 - Map of Heavy Rail options between Bedford and Cambridge (Station locations are indicative)

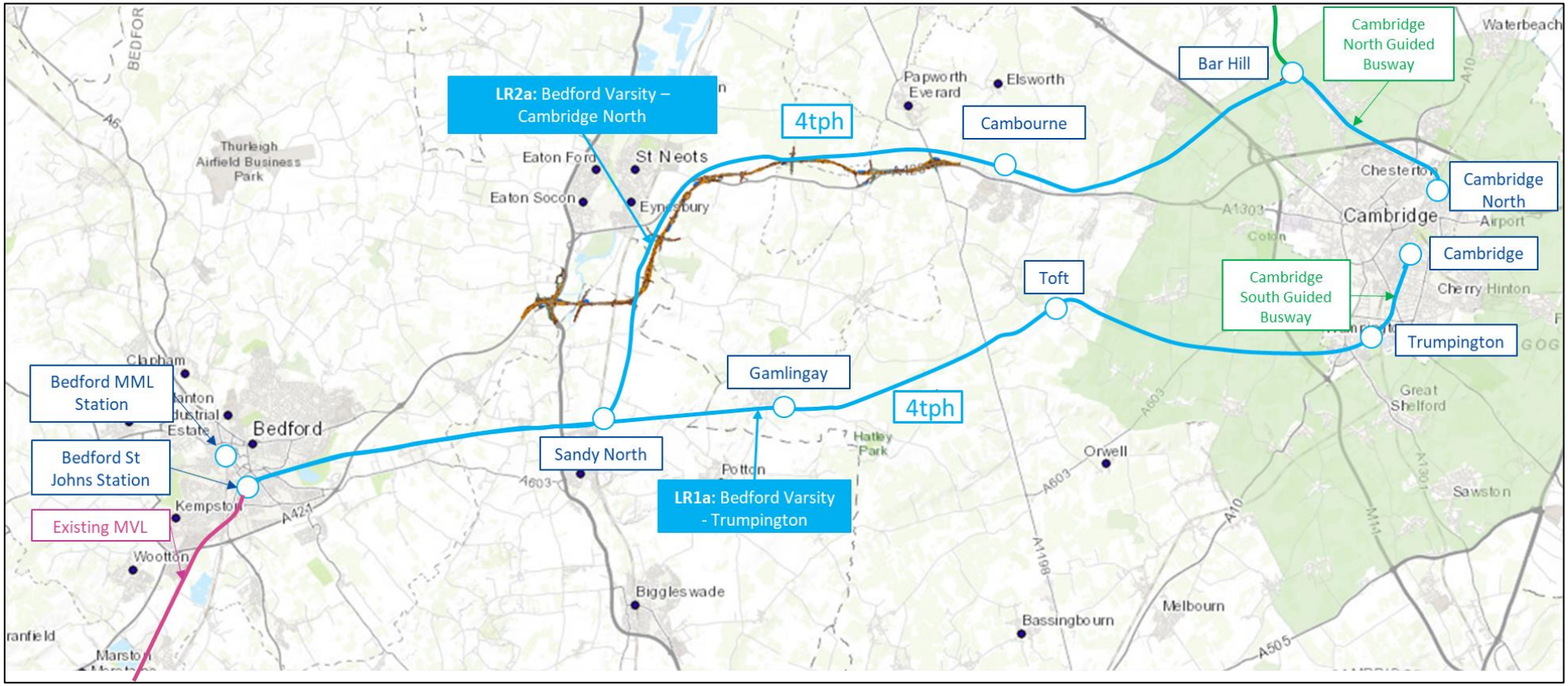


Figure 11 - Map of Light Rail options between Bedford and Cambridge (Station locations are indicative)

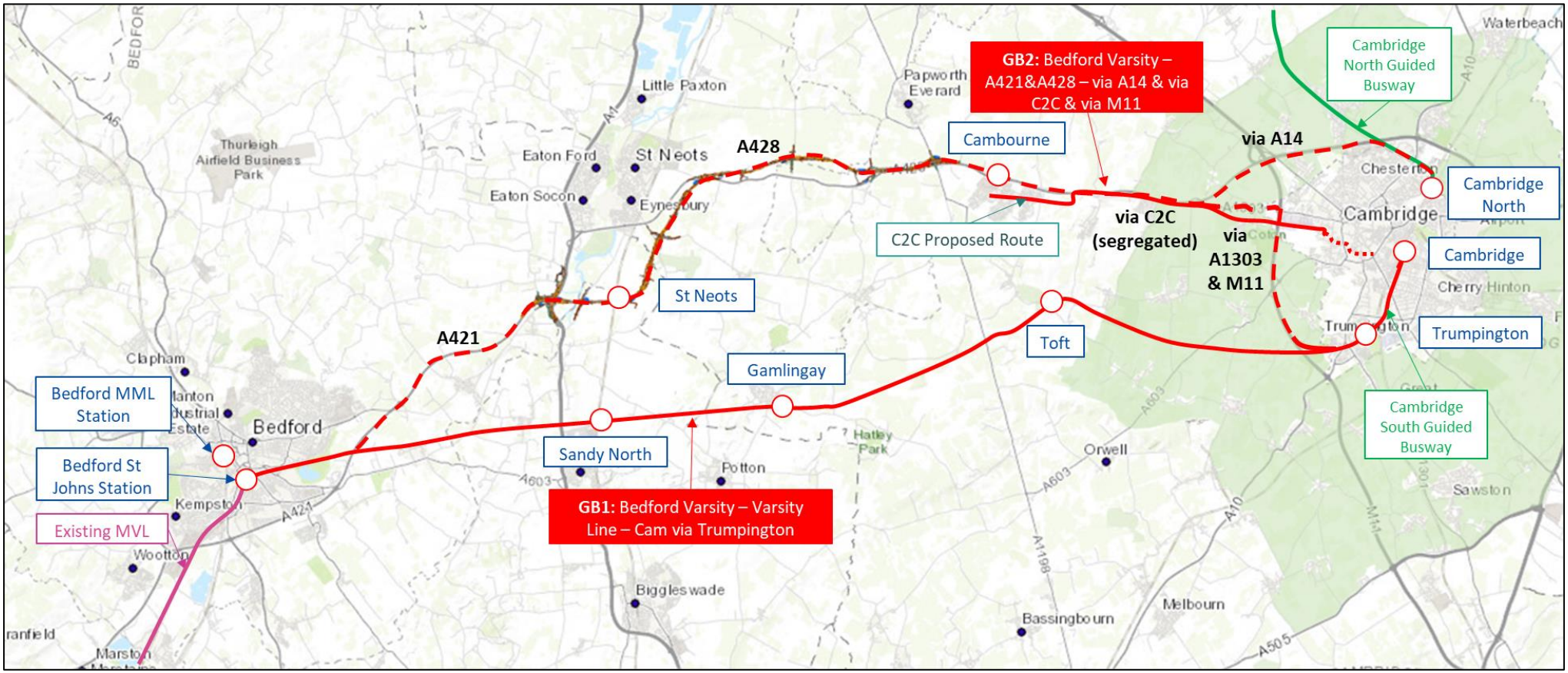


Figure 12 - Map of Guided Bus options between Bedford and Cambridge (Station locations are indicative)

7.2 Assessment of route options by the application of the Theory of Change

Dependent Development

7.2.1 The criteria used to assess route alignment are speed and location. Varsity alignments are shorter in distance and therefore have lower journey times than the Cambourne options. However, the main differentiator between the Varsity and Cambourne route options is the identified potential for dependent development51, especially future house building. As stated above, any successful Option Family would need to serve locations that have large existing populations and contain stations or stops at locations which can serve future planned development and areas where there are further opportunities for growth, including jobs, and homes. Dependent housing is that which would not be built without EWR's new transport link. This is important to the case for the Project because:

- There are additional Land Value Uplift benefits[85] that are associated with future growth that is both dependent on EWR, and additional[86].
- Increased housing growth results in an increased population within station catchment areas which, in turn, will induce additional demand for EWR and increase the labour pool available to the key economies of Oxford and Cambridge in the region.
- Additional housing supply in the area will result in less upwards pressure on the housing market, helping to stabilise prices and make it more affordable to live and work within the key catchment areas.

Growth Potential of the Varsity and Cambourne Alignments

7.2.2 Consideration was given to the likelihood of new stations or stops providing a stimulus for the allocation of significant new housing development along the Varsity alignment in the future emerging Bedford, Central Bedfordshire and Greater Cambridge local plans.

7.2.3 The emerging Bedford Local Plan 2040 has advanced to examination. The focus for large scale strategic growth is at new growth locations focussed on the EWR / A421 transport corridor with the potential for rail-based growth, particularly in the south of Bedford area and at a new settlement at Little Barford.

7.2.4 There is considered little prospect of large scale strategic development along the Varsity alignment to the east of Bedford being supported by Bedford Borough Council as this would lead to the loss of urban open space in Priory Country Park and within the Bedford River Valley Park as well as impacting on objectives to improve, enhance, create and link landscapes, woodland, biodiversity sites, heritage sites, green spaces and paths within the wider designated strategic green infrastructure area of the Park.

[85] TAG UNIT A2.1 Wider Economic Impacts Appraisal (publishing.service.gov.uk)

[86] In appraisal terms, an impact is additional if would not have occurred in the absence of the intervention

7.2.5 Central Bedfordshire District Council has commenced a review of its existing Local Plan but has yet to consult on its proposed future spatial development strategy. The adopted Central Bedfordshire Local plan indicates that the A1 corridor, including Sandy and the area north to Tempsford, may have a greater future potential for large-scale growth as a result of service improvements to the East Coast Mainline (ECML) and also dependent on routing of EWR.

7.2.6 The location of stations/stops on EWR could therefore have a major impact on the scale of future development and growth potential that could be accommodated within Central Bedfordshire.

7.2.7 It is considered that there may be potential for large-scale strategic development to the area to the north and north east of Sandy east of A1 corridor and north to Tempsford, provided any such development is carefully designed to respect environmental constraints in the area including land liable to flood (flood zone 2 and 3) and a county wildlife site. The impact on the character of and identity of Sandy would also need to be mitigated by sensitive design. Land to the east of Sandy and the ECML is more constrained (by a historic park and garden and Nature Improvement Area) and lacks good access to the strategic highway network which would limit future development potential.

7.2.8 Cambridge City Council and South Cambridgeshire District Council ('the Councils') are working together to prepare the Greater Cambridge Local Plan. The plan is at an early stage of preparation but the First Proposals have been consulted on, indicating the emerging preferred development strategy to 2041. The focus of strategic scale growth is to the north east fringe and east of Cambridge City and at the new settlements of Northstow, Waterbeach and Cambourne.

7.2.9 It is considered that there is no likelihood of large-scale development opportunities on the Varsity line in South Cambridgeshire being considered acceptable. Significant strategic development around Gamlingay would substantially change the character of the settlement and its landscape and historic setting and impact a nearby SSSI, and historic park and garden and country wildlife sites. Significant highway and infrastructure improvements would be required to unlock any large-scale development potential.

7.2.10 Comberton is in the green belt. National policy states that green belt boundaries should only be altered where "very special circumstances" are evidenced and justified, and having examined fully all other reasonable options for meeting its identified need for development. The stringent requirements of this test means it is considered unlikely that substantial strategic growth at this location would be supported over the emerging plan period to 2041. Comberton is also within the 'Lord's Bridge Restricted Area' and the risk of inference to the Mullard Radio Astronomy at Lord's Bridge through construction works likely to last up to 10 years and possibly beyond may preclude large-scale strategic growth at this location.

7.2.11 Trumpington is also in the Green Belt and large-scale strategic growth is likely to be constrained for the same reason. The area to the west of Trumpington is in part designated as a country park and has been subject to landscape, biodiversity, recreation and public access improvements making it further unlikely to be designated for strategic development.

7.2.12 Toft and Kingston are small villages in close proximity to the green belt. Large scale development in these locations may also require the release of green belt land. Significant strategic development in this area would substantially change the character and settlement pattern of the area and its landscape and historic setting and risk the coalescence of villages, including with Comberton. Significant highway and infrastructure improvements would also be required to unlock any large-scale development potential with potential long lead in times for delivery. The likelihood of strategic scale growth being promoted in these locations in a future emerging local plan is considered very low should the Varsity alignment proceed.

7.2.13 EWR Co's consideration of the status of local plans led to the conclusion that the Varsity Line alignment would not support the same quantity of new housing as an alignment via Cambourne North. Further analysis of the planned housing numbers presented below reinforces this assessment.

Current Plans for Housing

7.2.14 Local development plans identify 2,781 homes[52] in the planning pipeline within 2km of a potential Cambourne option station, compared to 147 homes[53] within 2km of a Varsity option station.[54] Planning pipeline in this context means sites with planning permission, sites that are currently under construction or likely to be developed in the near future as part of the natural growth of the environment such as strategic site allocations and calls for sites included in local plans.

7.2.15 Planned growth is a useful consideration as it shows current Local Authority appetite to expand existing settlements, as well as increasing the population within the catchment area of potential EWR stations or stops. Such growth would result in higher levels of demand for the new transport link and a higher labour pool to service jobs across the Ox-Cam region. Planned growth and the areas favoured in existing development plan documents also assist in identifying the broad locations favoured or likely to be favoured for material growth in housing provision. The exception to this is the Tempsford/St Neots South area, which currently has no planned growth but local plans state that they are waiting for the EWR alignment to be published before committing to any planned development.[87]

Conclusion

7.2.16 The Cambourne option has significantly higher potential for future growth over the Varsity option based upon current allocations. EWR Co's assessment suggests that, if planning permission were granted for sites within 2km of potential station locations, 27,390 homes could be delivered on the alignment via Cambourne compared to zero homes on existing allocated sites for the Varsity option.[88]

[87] https://centralbedfordshire.app.box.com/s/m0skego6ypqvql90wle3p9jslp0edex3

[88] Detailed analysis and methodology for urban planning analysis can be found in the Wider Economic Impacts Output Report.

7.2.17 In comparison, it was concluded that large scale dependent development around Sandy, Toft, Gamlingay and Trumpington is very unlikely and therefore it was removed from consideration. This also applies to development at Milton and Histon North.

7.2.18 Therefore, when taking current housing in the planning pipeline and the potential for future dependent housing into consideration, the updated Strategic Case strongly suggests that the preferred alignment should be the Cambourne route. This results in discounting of option families HR4, HR6, LR1 and GB1.

7.2.19 To deliver the jobs and growth envisaged, the conclusion of the analysis of route choice through the application of the Theory of Change is that the *Varsity* alignment should be discounted, subject to validation by transport modelling, which is considered below.

7.3 Validation of choice of route option with demand modelling

7.3.1 The choice of route option has been validated by running the different options through the EWR Full Demand Model, which incorporates a gravity model and represents a conventional demand modelling approach (see Appendix 2). This validation exercise aims to demonstrate that demand would follow the top-down analysis based upon anticipated development provided above.

7.3.2 Heavy Rail and Light Rail modes both contain comparable options with similar frequencies. Guided bus does not contain comparable options as the Cambourne option (GB3) runs primarily on road and is significantly slower than the Varsity option (GB1), which is fully segregated.

7.3.3 The demand modelling has been conducted with three growth scenarios:

- Base growth: represents very limited demand growth at all locations, informed by DfT future economic/demographic forecast ("EDGE").
- Non-dependent high growth: represents planned housebuilding currently in local plans to 2031 and partly extrapolated.[89]
- Dependent high growth: as above, and also represents future potential housebuilding enabled by the delivery of a new transport solution.

7.3.4 The Varsity option is a shorter route than the Cambourne option and therefore has lower journey times. This leads to a higher level of demand generated in a conventional transport gravity model.

7.3.5 In a base growth scenario, the Varsity option has a higher level of demand for both heavy rail and light rail modes. However, it is harder for the Varsity option to enable housing growth at stations along the route. Areas around Gamlingay and Toft are considered unsuitable for large

[89] EEH forecast housebuilding to 2031 + additional 50% to 2050.

scale development and therefore there is no development potential as a result of East West Rail around these stations. This means that, once dependent development is considered, the Cambourne option has higher demand for both heavy rail and light rail modes. Although there is no dependent development assumed for the Varsity option, demand continues to increase due to growth elsewhere along the route including west of Bedford.

7.3.6 Therefore, conventional gravity modelling supports the choice of the Cambourne route option to deliver higher demand from dependent development.

7.3.7 Table 26 below summarises the results of the modelling for forecast demand during the busiest 60-minute period on the route section to the east of the East Coast Main Line.

Mode	Option family	Route option	Base Growth	Non-dependent High Growth	Dependent High Growth
Heavy Rail	HR2 or HR5	Cambourne	526	613	921
	HR6	Varsity	596	658	711
Light Rail	LR1a	Varsity	382	409	434
	LR2a	Cambourne, Cambridge North only	238	305	708

Table 26 - Busiest 60-minute period east of the ECML. Conventionally modelled with 4 tph. Highest demand option family within route option chosen. Bus option families were not compared as Varsity route option is guided and Cambourne route option is primarily road-running and hence do not generate sufficient demand.

7.3.8 The demand modelling validated the findings from the Theory of Change analysis that the Cambourne route choice is preferred over the Varsity Line alignment as it demonstrated the attraction of higher demand. This corroborates the analysis in section 7.2. As noted above, this results in Option Families HR4, HR6, LR1 and GB1 being discounted.

7.4 Application of the Theory of Change to mode

7.4.1 The analysis then undertook a comparison between modes for the Cambourne route alignment. The following metrics were considered in this assessment:

- Journey time between Bedford and Cambridge: this indicates whether Bedford can fall within a 45-minute commuting time of Cambridge.
- Increase in working age population within 45-minute travel time of Cambridge: this demonstrates by how much a new transport link can expand the commuting catchment.

- Potential growth: this illustrates whether the option families can deliver new development.
- Passenger capacity: this shows whether the transport link could accommodate the required transformational level of demand indicated by the updated Strategic Case for the Project.

7.4.2 It was decided that, as GB3 was primarily a non-guided option, this would be unlikely to lead to dependent development. There appears to be no available evidence to suggest developers would have the confidence to invest on the basis of unguided bus schemes. However, there is evidence to suggest a fixed mode transport link is far more effective in generating dependent development. The Cambridgeshire Guided Busway is an example of a fixed mode link which has supported housing development at Northstow and Orchard Park in South Cambridgeshire.

7.4.3 The number of passengers within a 45-minute commute of Cambridge is both a function of journey time, which relates in part to distance, and the stations called at in Bedford. Rail has the highest catchment, increasing the commuting catchment by up to 56,000 people who currently live within 45 minutes of Cambridge. Light rail journey times are slower, so the catchment increases by only 22,000 people. Bus is slower still, so the catchment increases by only 4,300. As the light rail options do not cross Bedford with a direct service, entailing an additional interchange time penalty as well as being slower, the mode is limited in its commuting catchment. To unlock the economic opportunity identified by EWR Co, journey time and whether the option families serve Bedford station (which is more accessible by road than Bedford St. Johns) drive the size of the Cambridge commenting area. As heavy rail Option 5 (HR5) has a faster journey time compared to the other heavy rail option families and serves Bedford station, it has the greatest catchment area.

7.4.4 To enable the new jobs and economic growth envisaged, the new transport link would potentially need to be able to carry up to 4,000 people per hour in the long term. See Appendix 2 and Appendix 4 for more information about the trip-end modelling approach that calculates the transformative scenario. Figure 13 sets out the hourly capacity across the different modes and demonstrates that only heavy rail with 4tph can accommodate this scale of capacity.

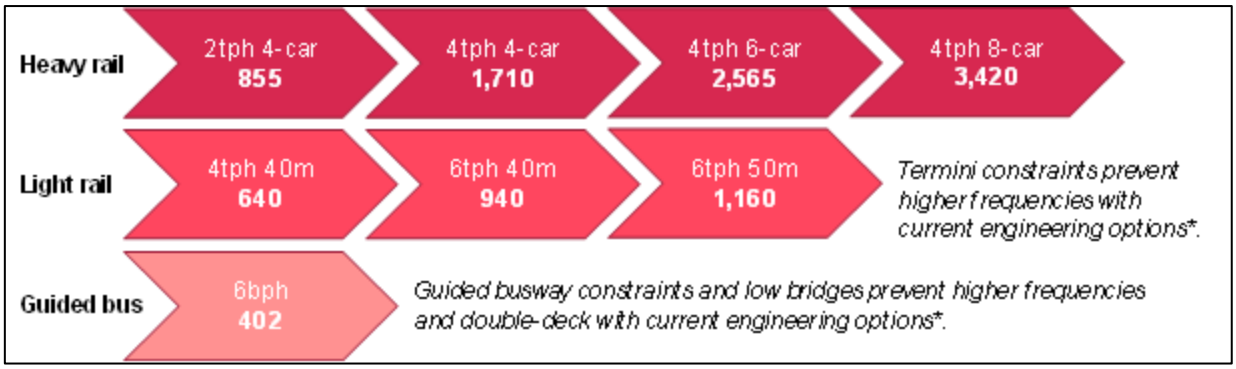


Figure 13 - Capacity (seated and standing) of different Affordable Connections modes where studies have been conducted

7.4.5 The metrics listed above were applied to the remaining Option Families, as shown in Table 27. Heavy rail delivers the fastest journey time between Bedford and Cambridge, which then results in the largest increase in working age population within a 45-minutes travel time, almost twice that of light rail. Both heavy rail and light rail can support a similar level of dependent development as this is supported by alignment and the need for a segregated mode rather than speed.

7.4.6 The capacity of each mode is potentially expandable. The capacity constraint can be overcome to some extent by increasing capacity of services, and it is possible for frequency constraints to be overcome with additional capital expenditure. For example, longer heavy rail trains can be used if platform lengths are increased or, so far as capacity of the network allows, frequencies of services can be increased. Similarly, light rail services can be increased, or vehicles lengthened up to a point. However, no land has been identified at Cambridge for a second light rail platform for higher frequencies. It is also possible for guided bus frequencies to be increased with additional bridges and viaducts but at significant expense – the vehicles are not, of course, scalable.

7.4.7 Only heavy rail with a service of 4tph between Bedford and Cambridge produces a capacity that could be expanded even close to the transformational forecast 4,000 passengers per hour. Based on this assessment, the Light Rail and Guided Bus options were discounted as unable to deliver the real value of investment in EWR.

Option Family	Mode	Journey time between Bedford and Cambridge	Increase in working age population within 45 minutes of Cambridge	Passenger capacity with base assumptions
HR1	Heavy rail	38 mins	+38,500	1,710
HR2	Heavy rail	38 mins	+45,300	
HR3	Heavy rail	31 mins	+48,200	
HR5	Heavy rail	33 mins	+56,400	

LR2	Light rail	48 mins	+22,200	640
GB3	Guided bus	87 minutes (TBC)	+4,300	402

Table 27 - Assessment of different option families (on the Cambourne route option) according to ToC

7.5 Validation of mode differentiation by demand modelling

7.5.1 Traditional demand modelling is a different analytical approach to the analysis underpinning the Theory of Change. Traditional demand modelling is conservative as it is limited to existing behaviours and employment forecasts are conventional. However, reliance on a Theory of Change is also not sufficient alone to provide the depth of analysis required for validation of mode assumptions. The two analytical approaches have therefore been considered alongside each other.

7.5.2 In respect of the traditional demand modelling, the Full Demand Model (FDM) has been developed by EWR Co as a tool to forecast the demand and benefits of the Project. The model has been used to estimate the demand of the Option Families shortlisted and is TAG compliant and endorsed by DfT Centres of Excellence.

7.5.3 FDM is a "fit for purpose" model that incorporates industry best practice and guidance. FDM is a hybrid of an elasticity-based forecasting model and a regression-based gravity model, which presents two options for demand forecasting. The model derives base year (2018/2019) demand patterns for rail. Further explanation of the forecasting assumptions and how the FDM model works can be found in Appendix 2.

7.5.4 The gravity model represents a non-transformational view of the world. That is, annual journey demand is estimated for the Do Something scenario, then uplifted for future years using DfT economic forecast indices. As a result, the forecast hourly peak loads are generally lower, with a maximum of around 1,000, as shown in Table 28.

7.5.5 The gravity model is calibrated against and simulates annual demand. This is not constrained by vehicle capacity. However, to calculate demand by train, the model suite uses MOIRA2 as a train allocation tool with crowding turned on. This does not supress the overall level of demand per day but allocates it to adjacent trains when trains are very full at the preferred time of travel.

7.5.6 Demand modelling results show that heavy rail delivers the highest levels of demand, which is driven by considerably faster journey times. Hence, heavy rail produces 120% more demand than the bus options.

7.5.7 Light rail cannot provide for the potential to continue through Cambridge station to the East, or beyond Bedford as a through service. The inconvenience (modelled as a penalty) associated with interchange results in significantly lower levels of demand. The fastest heavy rail option modelled in this analysis produces 39% more demand than light rail options.

7.5.8 Of the Option Families shortlisted for demand modelling, only the four remaining Heavy Rail option families (HR1, HR2, HR3 and HR5) can accommodate the demand associated with a conventionally modelled high growth scenario.

Option Code	Mode	Busiest 60-minute single direction load and load factor		
		Oxford – Bletchley (4tph HR, 3tph LR/GB)	Bletchley – Bedford (3 tph)	ECML – Cambridge (4 tph; GB 12bph)
HR1	Heavy rail	1,145 (80% loaded)	907 (84% loaded)	911 (63% loaded)
HR2	Heavy rail	1,119 (78% loaded)	912 (84% loaded)	921 (64% loaded)
HR3	Heavy rail	1,111 (77% loaded)	893 (83% loaded)	847 (59% loaded)
HR5	Heavy rail	1,146 (80% loaded)	909 (84% loaded)	857 (60% loaded)
LR2	Light rail	924 (86% loaded)	656 (61% loaded)	708 (295% loaded)
GB3	Bus, partially guided, largely on-road	889 (82% loaded)	561 (52% loaded)	256 (47% loaded)

Table 28 - Number of passengers and load factors in the busiest 60-minute period in each route section (high growth with dependent development, four trains per hour) -2050

7.5.9 As Table 28 demonstrates, the modelling shows that Guided Bus does not generate sufficient demand, especially on the eastern section, and is under-utilised. Light rail is under-utilised between Bletchley and Bedford but is significantly overloaded at the eastern end of the route and is still unable to carry as many passengers as the heavy rail options. Thus, the conventional demand modelling supports the Theory of Change analysis that only the heavy rail options are capable of meeting the forecast demand. This results in the surviving non-heavy rail Option Families (namely, LR2 and GB3) being discounted.

7.6 AVRT

7.6.1 During the long list stage, other modes of transport and alternative technologies were considered. One preliminary concept was Advanced Very Rapid Transit (AVRT) - effectively an Automated Guided Busway. The AVRT proposal had been developed for the Cambridge region and EWR Co decided it merited further consideration. To better understand the concept and to allow sift assessment, EWR Co engaged with the proponent of the technology to develop the concept to a testable level in the context of ACP. As such, this mode was an exception to the sift process explained above in Chapter 3. Although it is not a mature technology and would otherwise have been excluded in the credibility sift, it was agreed that a separate exercise to assess the potential for AVRT should be undertaken.

7.6.2 A separate report was produced on the viability of AVRT within the EWR geographic context. The report concluded that AVRT would be less beneficial than Heavy Rail in achieving the outcomes required to achieve the jobs and growth envisaged in Theory of Change. The report is at Appendix 10.

7.6.3 The key limitations of an AVRT scheme for EWR were concluded to be: like Light Rail or Guided Bus, it would require compulsory interchange at Bedford and Cambridge, with an associated journey time penalty, whereas Heavy Rail can provide services onto the MVL and potentially call at Cambridge North, Cambridge and Cambridge South stations to serve the catchment areas of high value jobs. It would not support freight. Furthermore, significant technology concept development is needed to de-risk and prove AVRT's deliverability in order to make it worthy of investment, leading to uncertainty and a lengthy delay in the delivery of benefits, including economic growth.

7.6.4 The report concluded that, although AVRT was likely to be lower cost than other options, it was also expected to generate significantly lower benefits. When assessed with the upgrade to the MVL included, the AVRT Benefit Cost Ratio was lower than that for Heavy Rail.

7.6.5 Based on the assessment undertaken, AVRT was not therefore recommended for further consideration between Oxford and Cambridge.

7.7 Cost considerations

7.7.1 ACP is concerned with achieving a more affordable and better value for money project. Heavy Rail options HR1, HR2, HR3 and HR5 all deliver well against the updated strategic case for the Project. However, this needs to be considered against affordability, both in terms of capital costs and operating costs, as higher benefits are likely to be delivered by higher cost projects.

7.7.2 The capital cost (excluding risk) for each Cambourne route option for the Bedford-Cambridge section is shown in Table 29. These cost estimates were produced in August 2022. The EWR modelling suite has also calculated the lifetime cost of each option, based on the operating requirements of each option timetable.

7.7.3 In terms of Annual Operating costs, there is very little difference between the four remaining heavy rail options, ranging between £143m and £146m in 2041/42. This is because the train running mileages - which drive traction power and train maintenance costs - are very similar, and the journey times are not sufficiently different to require different vehicle and driver requirements. Operational staff costs in 2041/42 make up 1/3rd of the expenditure, and this proportion increases over time.

7.7.4 Light rail is approximately 12% cheaper to operate at £128m in 2041/42. This is because light rail vehicles are cheaper to lease and operate than heavy rail trains, but the number of vehicles required would be substantially higher than the heavy rail options. This is because the frequency of the Eastern section would be higher at 6tph rather than 4tph and introducing an interchange at Bedford reduces operational efficiency as both heavy and light rail trains spend more time waiting at a terminus and less time in motion.

7.7.5 Bus is 38% cheaper to operate than heavy rail at £90m in 2041/42. This is because the vehicle costs and driver wages are lower, but this is significantly offset but increasing frequency from 4tph to 12bph on the eastern section in option GB3 via Cambourne. As per light rail, this would be less operationally efficient for the remaining rail services, as trains would spend more time waiting at a terminus. It should be noted that the operating costs do not include optimism bias. Year 2041/42 has been selected since it is the first year after the heavy rail option families are assumed in the assessment to have been upgraded to a 4tph service.

Option Family	Mode	Capital base cost, 4tph (£bn)	Operating cost for single year (£m, nominal, year 2041/42)
HR1	Heavy rail	£3.1	146
HR2	Heavy rail	£2.0	146
HR3	Heavy rail	£2.4	143
HR5	Heavy rail	£3.4	146
LR2	Light rail	£1.7	128
GB3	Guided bus	£0.7	90

Table 29 - Capital and operating costs (excluding risk) for each option (4tph- which includes 2tph OXD-MKC, 2tph OXF CMB and 2tph BED-CMB)

7.7.6 Although the capital and operating costs for Light Rail and Guided Bus were substantially lower than those for heavy rail, they were not taken further forward because, as explained above, they were not capable of providing sufficient capacity to deliver the real value of investment in EWR. Further information on capital costs can be found in Appendix 8, in respect of the four remaining Option Families. A breakdown of initial appraisal results is presented in Appendix 5, covering the shortlisted options heavy rail options.

7.8 Conclusion of application of the Theory of Change to the Bedford to Cambridge Options Families

7.8.1 The Theory of Change was applied to the shortlisted Option Families. The analysis concluded that:

- Routes via Cambourne performed better in terms of supporting housing growth.
- For the Cambourne route options, heavy rail outperformed light rail and guided bus in terms of journey times and the size of the population in the new Cambridge commuting catchment area.
- Heavy rail was the only mode that was able to deliver the capacity required to satisfy the Theory of Change demand forecasts. A service pattern of 4tph between Bedford and Cambridge was required.
- These conclusions were confirmed by demand modelling that also demonstrated only heavy rail was capable of accommodating forecast demand.

7.8.2 It was therefore concluded that only four heavy rail Option Families via the Cambourne route should be taken forward for further development. These were compared through the application of EWR Co's Assessment Factors, which were presented and utilised for the 2021 Consultation and contained within the Technical Report that was published for that purpose. This analysis is summarised in Chapter 8.

7.9 Potential for a Phased Approach to Implementation

7.9.1 One of the aims of the ACP was to consider how the majority of the benefits of EWR could be delivered at a lower cost. Accordingly, a phased approach to implementation was considered. This would enable a smaller number of tph to be operated on opening, with frequencies or capacity increasing later to accommodate the growth in demand as forecast in the Theory of Change.

7.9.2 In all cases, the service on the Marston Vale Line (MVL) was assumed for assessment purposes to be 3tph (2 EWR services and the existing stopping service) to provide an end-to-end solution to allow the characteristics of the four remaining option families to be understood[90]. The service level and calling pattern for the MVL will be determined at the next stage of Project development. Note that, should services be increased on the MVL beyond 3tph it would be necessary to carry out significant work, associated with the removal of level crossings and the provision of alternative means of crossing the railway.

[90] The output of the technical review into the performance of different solutions for other parts of EWR is set out at [ ], which describes the preference for the elements adopted.

7.9.3 With regard to the number of trains each hour, the table considers an initial service of 2tph, increasing to 4tph later. An interim position of 3tph could be considered, although at key locations this would require the same level of infrastructure as is needed for 4 tph, and consequently provides no benefit in terms of phasing.

7.9.4 The following sections describe the potential phasing of each Option Family in turn, building on the base position used for the purposes of assessment of a 2tph service between Oxford and Cambridge, 1tph between Oxford and Milton Keynes and the continued operation of the service between Bletchley and Bedford.

7.9.5 In all cases, if additional capacity was to be provided through an increase in trains per hour from 2 to 4 between Bedford and Cambridge, then a range of additional interventions would be needed. There would be a need for additional work at Oxford Station, likely to include a turnback to the south and installation of additional crossovers or partial fifth running line to the north. The level of disruption due to barrier down time at the Bicester London Road level crossing would be likely to require its closure and the provision of an alternative crossing, either a bridge or underpass for pedestrians and an overbridge for vehicles.

7.9.6 For options to approach Cambridge from the North, the following would be required: an additional platform at Cambridge North, additional track from Coldham Lane Junction to Cambridge station (accommodated within the existing Network Rail boundary), structural work at Mill Road and work to platforms at Cambridge station.

7.9.7 For options to approach Cambridge from the South, additional work at Cambridge station would be required, including a new island platform, modification to the station building, a new footbridge and station track works.

HR1: Bedford North, Route Alignment 1, Cambridge North

7.9.8 An increase in capacity from 760 passengers per hour to 1140 through the addition of carriages from four to six for a 2tph service could be achieved through the lengthening of platforms. On the MVL it would be necessary to extend the platform at Woburn Sands and to relocate Ridgmont and Stewartby stations. At Cambridge station it would be necessary to extend platforms, requiring the demolition of a staff building and impacting on the car park, as well as a need to relocate the engine sidings. There is also a potential need for platform lengthening at Winslow and Bletchley.

7.9.9 If train lengths were to be extended to 8 carriages this would have significant impacts on stations, due to the need for extensive platform lengthening. Whilst not quantified, this cost is likely to be material.

HR2: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge North

7.9.10 An increase in capacity from 760 passengers per hour to 1140 through the addition of carriages from 4 to 6 for a 2tph service could be achieved through the lengthening of platforms. On the MVL it would be necessary to extend the platform at Woburn Sands and to relocate Ridgmont and Stewartby stations. At Cambridge station it would be necessary to extend platforms, requiring the demolition of a staff building and impacting on the car park,

as well as a need to relocate engine sidings. There is also a potential need for platform lengthening at Winslow and Bletchley. This option would also require work at Bedford station in the form of the extension of a platform, additional bay platforms and the rebuilding of the station building to accommodate a stopping/ reversing service.

7.9.11 If train lengths were to be extended to 8 carriages this would have significant impacts on stations, due to the need for extensive platform lengthening.

HR3: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge South

7.9.12 An increase in capacity from 760 passengers per hour to 1140 through the addition of carriages from 4 to 6 for a 2tph service could be achieved through the lengthening of platforms. On the MVL it would be necessary to extend the platform at Woburn Sands and to relocate Ridgmont and Stewartby stations. At Cambridge station it would be necessary to extend platforms, requiring the demolition of a staff building and impacting on the car park, as well as a need to relocate engine sidings. There is also a potential need for platform lengthening at Winslow and Bletchley. This option would require work at Bedford station in the form of the extension of a platform, additional bay platforms and the rebuilding of the station building to accommodate a stopping/ reversing service.

7.9.13 It is to be noted that a southern approach to Cambridge requires additional tracks to the WAML. These are required regardless of the level of service and so are within the capital cost for a 2tph 4-car service.

7.9.14 Once again, If train lengths were to be extended to eight carriages this would have significant impacts on stations, due to the need for extensive platform lengthening.

HR5: Bedford North, Route Alignment 1, Cambridge South

7.9.15 An increase in capacity from 760 passengers per hour to 1140 through the addition of carriages from 4 to 6 for a 2tph service could be achieved through the lengthening of platforms. On the MVL it would be necessary to extend the platform at Woburn Sands and to relocate Ridgmont and Stewartby stations. At Cambridge station it would be necessary to extend platforms, requiring the demolition of a staff building and impacting on the car park, as well as a need to relocate engine sidings. There is also a potential need for platform lengthening at Winslow and Bletchley.

7.9.16 It is to be noted that a southern approach to Cambridge requires additional tracks to the WAML. These are required regardless of the level of service and so are within the capital cost for a 2tph 4-car service.

7.9.17 If train lengths were to be extended to eight carriages this would have significant impacts on stations, due to the need for extensive platform lengthening.

Consideration of phasing

7.9.18 There are various advantages and disadvantages of phasing, as presented in Table 30.

	2tph now then upgrade later to 4 tph	
Advantages	Cheaper initial cost. Allows capacity to grow in time as demand increases. Incremental funding opportunities for stakeholders to add capacity to meet their local transport ambitions. Can run the railway and use real data to track passenger behaviours and how to maximise benefits in further phases. Benefits of emerging technologies can be incorporated into upgrades.	Only one intervention needed (minimises abortive cost/duplication/disruption of multiple interventions). Reduces risk of having to build in and around an operational railway. Capacity is there from day one and demand can grow unimpeded. Can better kick start growth and regeneration around stations. Better able to be transformative due to greater immediate impact. Reduces customer disruption later once travel patterns are established.
Disadvantages	Increased costs from multiple mobilisations. Less efficient overall, increasing consent, design and construction costs. Risk of cost escalation/inflation impacting later phases and reducing business case. Working on a live railway will have cost, schedule implications and will impact communities. Risk that demand rises faster than projected and trains become full before second phase can be constructed. More complicated for consenting – difficult to safeguard future land without causing blight. Investors discouraged due to perceived lack of commitment to the full project.	Higher initial cost – full project cost incurred. Reputational risk of empty trains and underutilised stations before demand grows. Changing travel patterns may mean capacity not needed.

Table 30 - Advantages and disadvantages of phasing

7.9.19 The four remaining Option Families are capable of phasing, enabling an increase in capacity in line with increases in demand. Although such an approach would help to reduce the initial capital outlay, the overall cost would be higher if the Project is delivered in phases. There would be a more prolonged period of disruption, and construction of the later phase(s) would carry more challenges and higher risk.

7.9.20 As explained above, 4tph between Bedford and Cambridge are required to deliver the real value of investment in EWR. Given the disadvantages of a phased approach, it was therefore concluded that a railway capable of operating 4tph should be delivered in a single phase.

7.10 Conclusion on remaining Option Families

7.10.1 The assessment concluded that four viable Option Families between Bedford and Cambridge remain which, together with enhancements between Oxford and Bedford, would improve transport connectivity in the region and meet the objectives for jobs and growth identified in the Terms of Reference for this Project.

7.10.2 Option Families which primarily use the Varsity Line in full between Bedford and Cambridge have been discounted as they do not connect with areas of potential growth and so cannot support the objective of increasing the available working population within reach of the key employment centres in the region. To support the jobs and economic growth envisaged in the Theory of Change it requires the new transport link to follow the Cambourne route option. The full alignment of the former Varsity Line via Sandy is not supported by the analysis. However, some sections of the Varsity Line remain under consideration as the alignment west of Sandy provides an option for the approach to Bedford, although it does not include a potential station over this distance.

7.10.3 Transport modes other than heavy rail, have been discounted because they do not meet the strategic need - they are unable to provide the required capacity. Heavy rail delivers the fastest journey time between Bedford and Cambridge, which then results in the largest increase in working age population within a 45-minute travel time; almost twice that of light rail. Only heavy rail produces a capacity that could be expanded even close to the transformational scenario of 4,000 passengers per hour that would be required to deliver the jobs and growth contemplated by the Theory of Change.

7.10.4 To unlock the economic opportunity, a service of 4tph between Bedford and Cambridge is required to meet even relatively conservative estimates of the demand.

7.10.5 A parallel piece of work was undertaken to determine whether AVRT has the potential to meet the Project objectives and concluded that it would not be suitable for deployment on the EWR project.

7.10.6 It was concluded that a phased approach to enable capacity to be increased over time would not be cost-effective. It would also be more challenging to construct than delivering a solution in a single phase. Furthermore, as 4tph between Bedford and Cambridge have been identified as being necessary to maximise the economic opportunity in the region, it was determined that the railway should be delivered in full to allow such operation.

7.10.7 The four remaining Option Families are set out below. They all share the same alignment between Tempsford/St Neots and Cambourne and reflect the Cambourne route option assessed above. Options remain in Both the approaches to Bedford and Cambridge:

- HR1: Bedford North, Route Alignment 1, Cambridge North
- HR2: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge North
- HR3: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge South
- HR5: Bedford North, Route Alignment 1, Cambridge South

7.10.8 These remaining Option Families were subject to further assessment and development in respect of the Cambridge and Bedford approach options to enable a preferred single end-to-end Oxford to Cambridge solution to be identified. The process for this down-selection from four Option Families to a single preferred option is described in Chapter 8.

8. Identifying a Single Preferred Route between Bedford and Cambridge

8.1 Introduction

8.1.1 As explained in Chapter 7, four viable heavy rail Option Families were identified, giving four potential alignments between Bedford and Cambridge. All non-heavy rail options were discounted as well as options that approached Cambridge along the alignment of the former Varsity Line via Sandy, Gamlingay and Toft.

8.1.2 All four remaining Option Families include a common alignment between Tempsford/St. Neots and Cambourne, while choices remained on the routes into and out of Bedford and Cambridge. The four remaining Option Family alignments are as follows:

- HR1: Bedford North, Route Alignment 1, Cambridge North
- HR2: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge North
- HR3: Bedford South, Varsity Hybrid, Route Alignment 1, Cambridge South
- HR5: Bedford North, Route Alignment 1, Cambridge South

These are shown in Figure 14 below.

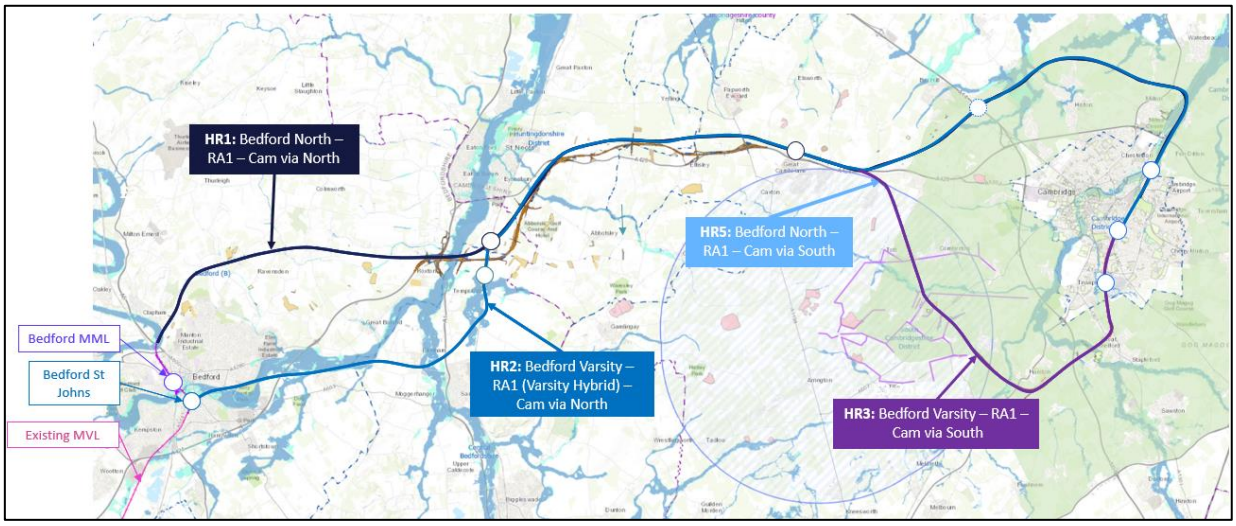


Figure 14 - Map depicting the 4 shortlisted options

8.1.3 In response to the seventh objective within the Terms of Reference for the ACP (see Chapter 1 above), further work was undertaken to seek to identify a single preferred option for the route.

Use of the Assessment Factors

8.1.4 EWR Co carried out an assessment of how the four short-listed Option Families performed against Assessment Factors used previously in the decision-making process for EWR. The following groups of Assessment Factors were particularly relevant in differentiating between Option Families:

- Cost (Assessment Factors 3: capital costs, 4: operating costs and 5: overall affordability)
- Environment (Assessment Factor 14: environmental impacts and opportunities).
- Rail delivery and operations (Assessment Factors 6: short distance connectivity, 7: short distance passenger services, 8: rail passenger connectivity to existing main lines, 9: long distance passenger services, 10: freight demand, 11: performance and 12: alignment with wider railway strategy/ infrastructure)
- Unlocking economic growth (Assessment Factors 1: transport user benefits, 2: contribution to enabling housing and economic growth, 15: consistency with local plans)

8.1.5 When considering the application of Assessment Factors related to economic growth, the four heavy rail options shown above had a traditional appraisal approach applied, estimating the costs and benefits of each option. There was little to differentiate between the monetised benefits of each option, with the costs of each option being the key driver of the appraisal results. The results of this appraisal are set out at Appendix 5. As described in chapter 6 the Theory of Change methodology was also applied to broaden this conventional modelling of the benefits with additional evidence. This culminated in the application of Assessment Factors providing a more holistic understanding of which option would be likely to deliver the transformational growth potential of the region.

8.2 Options for the approach to Bedford

Introduction

8.2.1 The potential approaches for EWR into and out of Bedford are physically constrained by features including; the existing railway, residential and commercial properties, the river Great Ouse, areas of woodland, highways, car parks and several road bridges.

8.2.2 Bedford station is an important transport hub. More than four million railway journeys (2018/9)[91] start or finish at Bedford station each year. However, in 2014 Network Rail declared the Midland Mainline (MML) infrastructure through Bedford as 'Congested Infrastructure' – one of only five locations on the national railway network with that designation. As a result, Network Rail has been unable to accommodate all requests for access of services from train operating companies into the timetable. This position is further

[91] dataportal.orr.gov.uk/statistics/usage/estimates-of-station-usage

complicated by planned future growth of freight (by parties other than EWR Co) along the route.

8.2.3 As explained previously, options for the approaches to Bedford remained amongst the four shortlisted Option Families between Bedford and Cambridge. Further assessment therefore sought to determine a preferred option for the approach, striking an appropriate balance between cost, environmental impact, deliverability and operational performance.

8.2.4 The proposals presented at the 2021 consultation provided for trains to pass through Bedford station and continue to the north before heading eastwards towards Cambridge. This allowed for interchange between EWR and MML/Thameslink services at Bedford station, enabling EWR passengers to access services to London and the South Coast, or to the East Midlands and Yorkshire. To investigate the value of calling at Bedford, EWR Co modelled a case without a Bedford interchange. The modelling showed the impact of this would result in a loss of benefits and revenue of approximately £109m NPV (11% decrease in revenues and 14% decrease in benefits compared to a scenario with trains running through Bedford assuming a base growth scenario)[92].

8.2.5 EWR Co investigated two options for the Bedford approaches as part of the shortlisted Option Families, both of which contain a Bedford interchange at Bedford Station:

- Via Bedford St Johns and Bedford station heading North (as contained in HR1 and HR5); and
- Via Bedford St Johns heading East, to the South of the town (as contained in HR2 and HR3).

Description of the Options

8.2.6 The southern option for the approach to Bedford would partly follow the alignment of the former track bed for the Varsity Line from Bedford St Johns, which was closed in 1968 and is now used over some of its length as a cycleway. The route would run east-west, to the south of Bedford, passing through what is now Priory Country Park.

8.2.7 The southern option would maintain a connection to Bedford station (and therefore the MML) but would require Bedford St Johns to be relocated to serve through services between Oxford and Cambridge. Maintaining 2tph that call at Bedford St Johns (relocated) without going into Bedford station would enable a faster journey time between Oxford and Cambridge, necessary to ensure attractiveness to users. 2tph would travel between Oxford and Cambridge via Bedford St Johns (not calling at Bedford station) and a further 2 EWR tph would travel between Cambridge and Bedford, not calling at a re-located Bedford St Johns. It is assumed that the MVL stopping service would continue to operate between Bletchley and Bedford station.

8.2.8 The northern option would follow the route presented at the 2021 consultation. It would pass out of Bedford station to the North. The railway would diverge to the east near the A6 and

[92] EWR Co analysis

river Great Ouse and head towards St. Neots/Tempsford. Options for making use of the existing four-tracks or increasing to six-tracks were presented.

Application of the Assessment Factors

Cost (Assessment Factors 3, 4 and 5):

8.2.9 The southern options could potentially be delivered at lower cost than northern options as they would not require as much construction within central Bedford. The cost of the southern options between Bedford and a proposed ECML interchange station is estimated at £1.1-1.4bn compared to £1.5-£1.8bn for the northern six-track option. These estimates are based on the section from Elstow Road to the ECML station and include total construction costs and risk, but do not include end-to-end land and property costs to allow direct comparison between options).

Environmental impacts and opportunities (Assessment Factor 14):

8.2.10 A key advantage of the southern option would be the absence of the need for demolition of houses to the north of Bedford Station and the relocation of the electrical substation at Fairhill. The overall number of properties that are likely to be directly affected by the construction of two additional tracks in the northern option is 66 (65 residential properties and one business property). The impact on 66 properties equates to 38 buildings, 37 of which are residential buildings.

8.2.11 However, given the time that has passed since the Varsity Line was decommissioned and its transition to amenity space and habitat, there are significant environmental considerations to be addressed if the alignment is to return to being an operational railway line. The key constraints associated with this area are; the protected status of open space land in and surrounding Priory Country Park (which the line would run through); the proximity to and extent of route within flood zone areas; the presence of scheduled monuments along and near to the route; and the extent of potentially priority and high value habitat which could be lost. The southern alignments would also indirectly impact Grade I listed buildings and their setting in Willingdon Dovecote and Willington Stables. In addition, parts of the former Varsity Line around Blunham have been subject to residential development, which could be at risk of demolition or require diverting the railway around this area. These points are considered further below.

8.2.12 As a public open space, the Priory Country Park has protected status. This means that replacement land would need to be found to compensate for that taken by the Project or that complex additional procedures would be required to secure consent for the Project. The land in the vicinity is either built upon or within the flood plain, making it challenging to acquire replacement land for the railway.

8.2.13 The former Varsity Line lies in the flood plain of the River Great Ouse to the south of Bedford. To bring the line back into use, and to comply with modern regulations, the track would need to be elevated. If constructed as an embankment, this would create a barrier within the flood zone which, without sufficient mitigation, would increase the risk of flooding in Bedford. Our assessments indicate that in an event with a 1% chance of flooding, and allowing for climate

change, there would be an additional 27 properties affected by flooding and a further 35 with an increased impact (the equivalent values for the northern option are 3 additional and 8 increased). Mitigating this risk would require the construction of viaducts in sensitive areas and would have additional potentially significant impacts. For example, the need to create compensatory flood storage would have further impacts on land use, including the possible loss of wildlife habitats. The presence of heavy engineering such as viaducts in the country park would be likely to affect its amenity and character as well as having potential for material visual impacts. The character of the area would inevitably be affected.

8.2.14 Scheduled Monuments on or close to the route include the Site of Newnham Priory, Octagon Farm Neolithic and Bronze Age mortuary complex comprised of 8 Scheduled Monuments, and 'The Docks' medieval moated site and dock at Willington. All of these would be at risk of being materially affected. The southern alignments would also indirectly impact Grade I listed buildings and their setting in Willingdon Dovecote and Willington Stables.

8.2.15 Environmental considerations relevant to a northern approach to Bedford include works within the Air Quality Management Area (AQMA) in Bedford, the crossing of the River Great Ouse and A6 and visual impacts associated with the required infrastructure, and works in proximity to ancient woodlands at Crabtree Spinney and Helen's Wood. The alignment would also affect a solar farm and potentially also areas of public open space at the Alexander Sport Centre playing fields.

8.2.16 To find ways to avoid or reduce the impacts of the Beford approach options, an additional alternative alignment that utilised a southern approach to Bedford was developed. This alternative alignment followed the Varsity Line, as for HR2 and HR3, before turning northeast prior to the A421 and following this road before turning east and crossing the A1 towards the ECML. In doing so, this alignment would avoid impacts on a Grade 1 listed building and a Scheduled Monument at Willington, as well as a further Scheduled Monument at Danish Camp and would avoid potential impacts on communities at Blunham and Willington. However, impacts to the west of the A421 would remain including impacts on the Priory Country Park, the flood plain and several Scheduled Monuments including the site of Newnham Priory, and Octagon Farm Neolithic and Bronze Age mortuary complex.

Rail delivery and operations (Assessment Factors 6, 7, 8, 9, 10, 11 and 12):

8.2.17 Depending on the option chosen for the relocation of Bedford St Johns station, the southern options would result in trains needing to reverse at Bedford station which would significantly increase end-to-end journey times, so reducing the attractiveness of the EWR service for passengers wishing to travel beyond Bedford in either direction on those services. When compared to northern options, southern options were also assessed as presenting poorer connectivity with Bedford town centre due to a reduced train frequency to Bedford Station where services did not call at Bedford station, reducing interchange opportunities with Midland Main Line and Thameslink services.

8.2.18 The northern option with six-tracking, as presented at the 2021 consultation, would provide a robust and resilient 4tph level of service, and maintain interchange with other services for

onward journeys. The northern option benefits from segregation of EWR's services from the congested Midland Main Line.

Delivering the Theory of Change and unlocking economic growth (Assessment Factors 1, 2, 15):

8.2.19 Depending on the location chosen for Bedford St Johns station and as described above, a southern approach to Bedford along the former Varsity alignment would result in fewer direct services between Bedford and Cambridge, and between Oxford and Bedford. A reduced frequency of trains into Bedford station would detrimentally impact the local authority's plans for the regeneration of the area surrounding the station. Similarly, if the site for an eastern Bedford St Johns station is selected, it would be less attractive from a regeneration perspective than the site close to the hospital, as per the emerging preference presented at the 2021 consultation.

8.2.20 Based on the above, EWR Co's preferred alignment remains north of Bedford via the MML route because it would avoid the issues identified as well as maximising the benefits of more resilient and more frequent connectivity direct to Bedford station.

Summary of key risks and issues for options

8.2.21 Table 31 summarises the key risks and issues associated with the different options for the Bedford approaches.

Key Risk/ Issue		
Assessment Factor	**Southern Options**	**Northern Options**
Cost (AF3, 4, 5)	Capital cost estimated at £1.1-1.4bn for the southern options.	Capital cost estimated at £1.5-£1.8bn for the northern six-track option.
Benefits / Disbenefits (AF1, 6, 7, 8, 9)	Journey time penalty for 2 EWR services due to reversing of services to serve Bedford station, negatively impacting project benefits. A small increase in benefits as a result of faster journey times for 2 EWR services that do not call at Bedford station.	Able to accommodate 4tph through Bedford station, whereas the southern option can only provide 2tph and maintain acceptable journey times, thereby not satisfying demand. Robust and even interval 4tph service is possible at Bedford, which is attractive to customers and satisfies demand.
Environment (AF14)	Would pass through and in result in the loss of areas of Priory Country Park, causing noise, visual and air	Would require construction works within the Air Quality Management Area (AQMA) in Bedford.

	Key Risk/ Issue	
	quality impacts as well as loss of amenity. Would pass directly through two Scheduled Monuments and within very close proximity to four more, potentially causing substantial harm or the complete destruction of the significance of these assets. To mitigate flood risk, would involve the construction of new infrastructure raised higher above the flood plain of the River Great Ouse and would need land for flood compensation. It is anticipated that over 60 properties would be impacted by increased flood risks from the necessary mitigation measures. Would result in the loss of high-value and priority habitat for wildlife and several designated County Wildlife Sites would also be at risk of impact and loss, including St John's County Wildlife Site.	The crossing of the River Great Ouse and A6 would result in visual impacts associated with the infrastructure required. Would require works in proximity to ancient woodlands at Crabtree Spinney and Helen's Wood. Would directly affect residential property and other land, resulting in community impacts.
Land acquisition	Priory Country Park is likely to constitute a protected public open space, requiring replacement land to be provided in compensation for any land lost; this could be difficult to secure given suitability and use of nearby land. Potential for loss of properties in Blunham area, although this could be avoided by the "A421 alignment" variant to a southern option.	A six-track option, with two new tracks adjacent to the MML would require acquisition of 66 properties (65 residential, one business, equating to 38 buildings, 37 of which are residential) for additional land needed outside the existing railway corridor. To the north of this area, some land at the UK Power Network substation, Alexander Sports Centre and Anglian Water Solar Farm are likely to be impacted.

	Key Risk/ Issue	
	An eastern Bedford St Johns station associated with a southern alignment would require acquisition of the Bedford bus garage and would negatively impact a retail park.	
Rail delivery and Operations (AF6, 7, 8, 9, 10, 11 and 12)	Freight opportunities marginally improved as route allows access to/from MVL, north onto and south from the MML. The potential reversal of trains at Bedford station would require more management than a through service, impacting operating costs and having a risk to reliability.	Freight opportunities would be reduced if additional tracks are not provided adjacent to the MML (four-tracking option – see section below). Would support opportunities to deliver strategic mixed-use development in Bedford and around Bedford and Bedford St Johns stations. The preferred option for the relocation of Bedford St Johns station would enable easier rail access to Bedford Hospital and provide better connectivity to communities south of the town when compared with an eastern Bedford St Johns station for the southern option.
Economic Growth (AF1, 2, 15)	Reduced services into Bedford, reducing interchange for onward connections. Reduced services would result in lower benefits to town centre businesses and be less conducive to the Local Authority's proposals for regeneration around the station. An eastern Bedford St Johns station would be less able to support plans for economic growth close to the hospital and to the south of the town.	4tph service through Bedford station provides the best opportunity for regeneration in the town centre in the area immediately adjacent to the station, given higher footfall. Northern option enables St Johns station relocation close to Bedford Hospital which would maximise the area adjacent to the station available for redevelopment.

Table 31 - Options for the approach to Bedford – comparison of key risks and issues

Summary

8.2.22 The analysis above shows that the southern approach option has a lower capital cost estimate than the northern option. However, the southern option would present several significant environmental risks which would make it difficult to obtain consent and to deliver the Project. The northern option, however, would have an adverse impact on a number of properties to the north of Bedford station, if a six-track option is selected.

8.2.23 With the southern option, any trains serving Bedford station would need to be turned around in the platform, which would add operational complexity and substantially increase journey times for passengers making through journeys on those services. In comparison, a northern option would provide a frequent and reliable service to both Bedford and Bedford St Johns stations, and would better align with the Local Authority's proposals for regeneration, thereby stimulating economic growth.

8.2.24 Taking all factors into account, the northern approach to Bedford remains EWR Co's preferred option. Therefore, Option Families HR1 and HR5 are preferred over HR2 and HR3.

Bedford North and Six Tracking

8.2.25 A preferred northern option, with a route following the MML gives rise to considerations about the required track layout to the north of Bedford station. A six-track option – with two new tracks constructed on the eastern side of the existing railway - was the preferred solution presented at the 2021 consultation. However, this would affect homes and businesses in the north of Bedford. Consultation feedback was received stating that the demolition of homes was particularly concerning to residents and the wider community in the *Poets* area of Bedford. Therefore, EWR Co investigated whether an alternative, utilising the existing four-track MML infrastructure, with lower impacts on properties adjacent to the existing railway corridor could be delivered whilst also securing the operational benefits of the six-track option presented at the 2021 consultation.

Application of the Assessment Factors

Cost (Assessment Factors 3, 4 and 5):

8.2.26 The cost of the four-track and six-track options would be similar. The cost of building two additional tracks alongside the MML for the six-track option would be offset by the need to provide an Up Fast Platform at Bedford station for a four-track option as well as additional track alterations. This would be disruptive to existing services and incur substantial cost (anticipated to be about the same as the six-track option), and potentially incur additional compensation to train operators.

Environment impacts and opportunities (Assessment Factor 14):

8.2.27 Avoiding the demolition of residential properties north of Bedford is a major advantage of the four-track option. This option would also have less noise and community impacts.

8.2.28 EWR CO has sought to optimise the design of the six-track option since the 2021 consultation to reduce the impact on adjacent properties. Table 32 below summarises the number of properties believed likely to be directly affected by the six-track option and how this has reduced since 2021.

	2021 consultation	2023 design	Difference
Residential properties likely to be acquired and / or demolished	53	37	-16
Residential properties may lose part of their garden or parking area	44	28	-16
Commercial properties likely to be acquired and / or demolished	1	1	0
Total number of properties likely to be acquired/demolished or lose part of land	**98**	**66**	**-32**

Table 32 – Impact of proposals on land and property

8.2.29 Other environmental topics are identical for the four and six track options as they follow the same alignment in the approach to Bedford.

Rail delivery and operations (Assessment Factors 6, 7, 8, 9, 10, 11 and 12):

8.2.30 A high volume of rail traffic currently passes through, or terminates at, Bedford station; long distance East Midlands Railway (EMR) services on the MML, local Thameslink services to London and the south, freight services and trains to and from local depots. The current four-track MML north of Bedford station has been formally designated as 'congested' by Network Rail, the infrastructure manager for Britain's rail network. It is one of very few such designations, which indicates the severity of the congestion.

8.2.31 There is very limited scope for EWR Co to secure major alterations to the current passenger and freight timetable on the current MML infrastructure so as to accommodate EWR services. This is because the existing services from Bedford have to reach other parts of the rail network at the right time in order to interact with other existing services, including on routes through central London and as far away as Yorkshire and the South Coast. It is also considered likely that, due to onward connections, if the lines north of Bedford were shared between EWR and non-EWR services, Thameslink and freight services would be prioritised, limiting the availability of paths for EWR.

8.2.32 This means that EWR services would have to fit between the other services operating on the existing four-track MML north of Bedford, constraining the number of EWR services and how they are distributed across each hour.

8.2.33 It was noted that the current timetable proposals for the new Wixams station to the south of Bedford would further constrain capacity at Bedford station through longer occupancy of the existing platforms by Thameslink services which terminate at Bedford before forming new services back south on the MML.

8.2.34 By making use of the existing four tracks there would be a significant lack of operational resilience as delays in one train service would have a knock-on effect on others, affecting not only Bedford station but other destinations as well. The lack of resilience in this location is particularly acute due to the congested nature of the railway.

8.2.35 Additional timetable and performance modelling undertaken since the 2021 consultation confirmed that a four-track option would present a material performance risk to both EWR and Thameslink services. It would also hamper future expansion of Thameslink services, freight capability growth enabled by previous investments by Network Rail as part of the Corby enhancement project and curtail the ability for additional future freight growth. The modelling report is attached at Appendix 12.

8.2.36 By comparison, expanding the MML to six tracks would enable the segregation of EWR services, thereby significantly reducing these performance risks. Journey times would be more reliable because there would be a lower risk of disruption to services and delays as the railway layout would have more capacity and operational flexibility. Also, the potential for future growth of EWR and other train services would be maintained.

Delivering the Theory of Change and unlocking economic growth (Assessment Factors 1, 2, 15):

8.2.37 Both options have been assessed as providing similar levels of benefits and contribute equally to the realisation of the Theory of Change and unlocking economic growth. This is because the same level of EWR passenger service can be achieved under both options.

Summary

8.2.38 Following the application of the Assessment Factors and further operational modelling, EWR Co's preference remains the use of six tracks as this is the only viable option that enables EWR trains to serve Bedford town centre reliably and effectively whilst allowing for future growth, due to the level of congestion on the existing four tracks.

8.2.39 EWR Co recognises the impacts this six-track option would have on local residents and businesses in the Poets area and has sought to minimise these by optimising the design. The overall number of properties that are likely to be directly affected by the construction of two additional tracks has reduced from 98 (97 residential properties and one business property) identified at the 2021 consultation to 66 (65 residential properties and one business property) now.

8.2.40 EWR Co will continue to seek further opportunities to refine proposals to limit the amount of land needed.

Bedford St Johns

8.2.41 Two options to relocate Bedford St Johns station and provide an additional track were presented at the 2021 consultation:

- **Option 1: Relocating Bedford St Johns to the west, closer to Bedford hospital between Ampthill Road and Cauldwell Street**. Cauldwell Street Bridge would need to be rebuilt (as is the case with option 2 below), as it is not high enough for EWR trains to pass beneath. This new railway alignment would use the existing railway bridge over the River Great Ouse.

- **Option 2: Relocating Bedford St Johns to the south on the existing railway alignment close to Ampthill Road/ Elstow Road pedestrian link bridge**. This new railway alignment would require a new railway bridge over the River Great Ouse and the rebuilding of Cauldwell Street bridge.

8.2.42 Option 1, a relocation of the station to the west, was identified as EWR Co's emerging preferred option in the 2021 consultation because it performed better in respect of cost, environmental impact, and consistency with Local Plans. It would also provide easier access from the station to Bedford Hospital and good access to local schools.

8.2.43 Having identified that a northern alignment for EWR out of Bedford was to be preferred, the ACP then enabled the location of an upgraded Bedford St Johns station to be determined. The ACP confirmed that additional track capacity was required through Bedford St Johns to accommodate the EWR train service reliably and at an increased speed. Further, following the ACP assessment, the best performing option continued to be Option 1.

Options for Bedford – preferred approach

8.2.44 When considered against the differentiating Assessment Factors, southern options (HR3 and HR5) performed better than northern options (HR1 and HR2) in relation to capital cost. Northern options performed better than southern options in relation to environment, operational performance and unlocking economic growth. A -track northern option performed best from an environmental perspective and in terms of impacts on residential property, but performed less favourably from an operational perspective when compared to the six-track option.

8.2.45 Whilst the cost differential between the six-track northern alignment (estimated at £1.5-£1.8bn) and the Varsity alignment (estimated at £1.1-1.4bn) is estimated at approximately £400m (including risk), due to the environmental impacts (including effects upon receptors afforded higher planning policy protection, including loss of public open space and impacts on designated heritage and ecological sites) a northern option was preferred.

8.2.46 The operational constraints and performance risks associated with the four-tracking option mean that EWR Co's preferred option remains the six-track solution. It is recognised that this would require the acquisition of 66 properties and further work is needed at the next stage of design development to seek to reduce this impact.

8.2.47 Work undertaken in ACP, and the conclusion that six-tracking remains the preferred option, has not changed EWR Co's proposal to redevelop the station to the north of Ford End Road, which would align with Bedford Brough Council's proposals for the regeneration of the town centre.

8.3 Options for the Approach to Cambridge

8.3.1 After leaving Bedford, all remaining Option Families cross the East Coast Main Line, where options for siting a new station are under consideration. They then pass towards Cambourne and to its north, where a station would be sited. The Approach to Cambridge is the section of the route starting to the east of the proposed Cambourne station and finishing at Cambridge station.

8.3.2 Following the application of the updated Strategic Case to the Option Families (described in Chapter 7), two options for the approach to Cambridge remained. One option would approach from the north, known as the Northern Approach to Cambridge (NATC) and one from the south, known as the Southern Approach to Cambridge (SATC). A comparison of these options was undertaken, including having regard to EWR's Assessment Factors to enable a decision on the preferred route between Bedford and Cambridge.

8.3.3 A southern option was consulted upon as the emerging preferred option at the 2021 consultation and was endorsed by Network Rail, although it was not supported by all respondents. At the 2021 consultation, an option for a northern approach to Cambridge was described in an annex to the main report to provide supporting evidence for EWR Co's decision in favour of a southern route. The annex set out the reasons for the decision to discount a northern approach to Cambridge based upon the option described. The northern option involved adding two new lines along the West Anglia Mainline (WAML) north of Cambridge station to create a four-track railway from a new junction near Milton through to Cambridge station. The northern approach was considered to be less attractive than a southern approach. This was because of the higher cost of construction, impact on properties, operational constraints, and an inability to provide a clockface timetable in accordance with the PWOS even with a four-track alignment. A full explanation for that position is included in the 2021 consultation document Appendix F, pages 101 onwards.

8.3.4 Many responses to the 2021 consultation suggested the decision to approach Cambridge from the south should be reconsidered and that EWR Co should instead approach Cambridge from the north, stopping at Cambridge North station, before proceeding to Cambridge station. Following the 2021 consultation, the ACP provided an opportunity to review the options for approaching Cambridge, due to the Project Objectives being set aside and the requirement to consider how to improve the affordability of the new railway.

8.3.5 The setting aside of the Project Objectives, and the PWOS in particular – specifically, the requirement to operate an even-interval clockface timetable – enabled a review of potential design solutions. This led to the identification of a revised northern approach to Cambridge, capable of delivering up to four EWR trains per hour whilst requiring reduced infrastructure to that previously identified. The revised solution also avoided the impacts on adjacent

properties that had been anticipated to occur for the northern option. This option was developed through engagement with Network Rail and industry.

8.3.6 The design of the southern approach was also reviewed alongside capacity assessments and timetable analysis. This involved:

- Exploring new options, including a 2tph service via Cambridge South with a requirement for less new infrastructure and therefore a lower cost. Based on current capacity and infrastructure constraints, it was determined that it is not possible for EWR to be accommodated reliably on the current two track WAML railway into Cambridge from the south.

- Design development, including:

    - Refinement to reduce the height of embankments and viaducts.

    - Further development of the Cambridge-to-Shepreth Branch junction corridor to gain a more detailed understanding of the challenges of a four-track corridor and impacts on the Nine Wells area, green spaces, and a Scheduled Monument.

8.3.7 The following section describes the southern and northern approaches to Cambridge and then compares them. The two routes are shown in Figure 15 below.

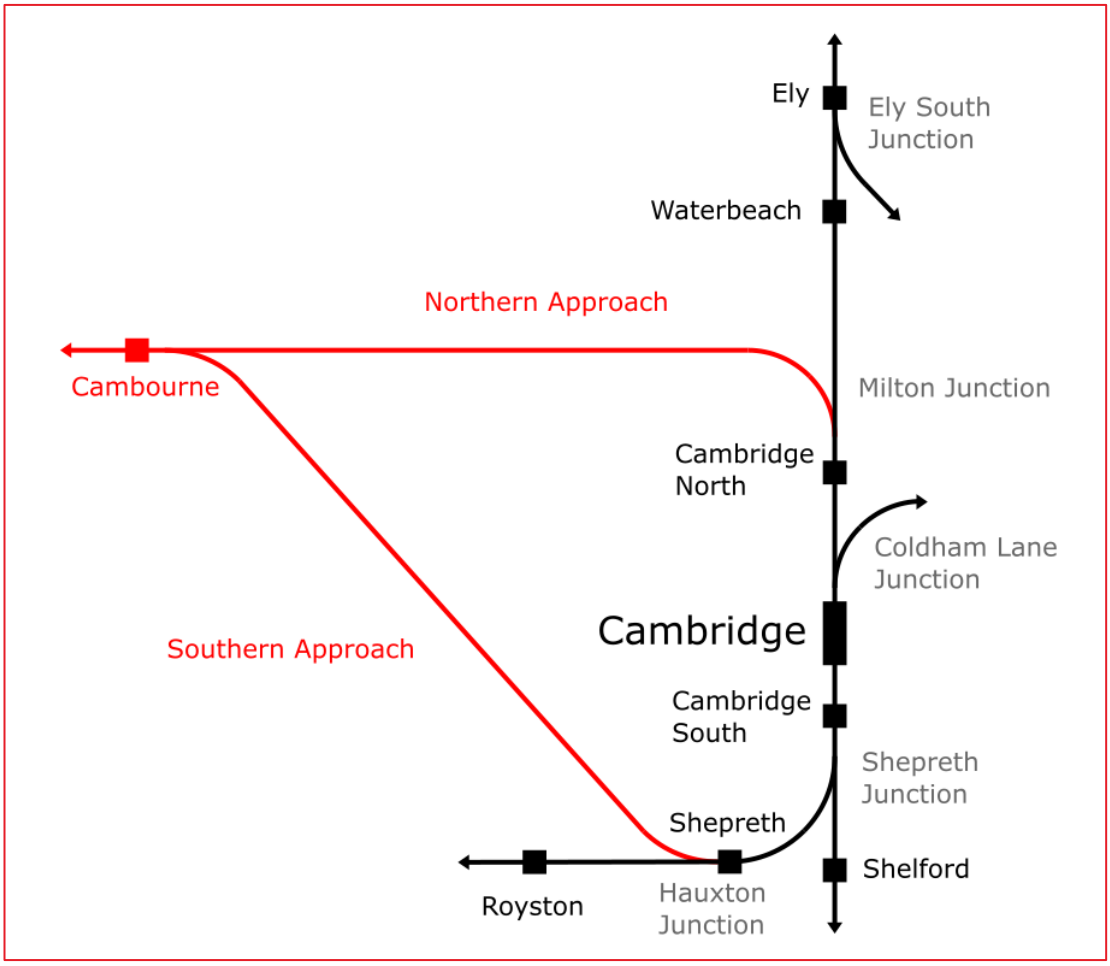


Figure 15 - Indicative diagram of the two approaches to Cambridge

Southern Approach

8.3.8 The proposed route of the southern approach to Cambridge would leave Cambourne using two new EWR tracks. It would head south-east passing under the A428, then north of Highfields Caldecote, west of Comberton Village and south of Haslingfield Village, passing through Chapel Hill, and crossing over the river Cam. It would then pass south of Harston Village where it would join the Royston Branch Line via a new grade-separated junction. The route would then meet the WAML at Shepreth Junction. Between Shepreth Junction and Cambridge South, the route would utilise two new additional tracks alongside the two existing WAML tracks, creating a four-track railway.

8.3.9 At Cambridge South station (currently under construction by Network Rail), EWR services would stop at the new station, providing access to the adjacent Biomedical campus.

8.3.10 Between Cambridge South station and the Cambridge station approach, the WAML would be widened from two to four tracks between Cambridge South and Long Road where it is not already widened by the Cambridge South station project, and from three to four tracks between Long Road and Cambridge station.

8.3.11 At Cambridge station, platforms 4, 7, 8 would be extended, with the creation of a new island platform for new platforms 9 and 10.

8.3.12 If it is decided that EWR services should be extended to Cambridge North station, there would be an opportunity to upgrade Cambridge North station and realise additional benefits. This could provide improved access to the station and provide increased operational flexibility, including the provision of south turnback capabilities. This opportunity would be further developed during the next stage of design and further information would be available at Statutory Consultation stage.

Northern Approach

8.3.13 The proposed route of the northern approach to Cambridge would leave Cambourne using two new EWR tracks and run south of Dry Drayton and Bar Hill before passing under the guided busway, which would need to be realigned. A new crossing would be required for the A14 and A1307 to the west of Girton, and the A10 near Milton would be rerouted. The two new tracks would join the WAML at a new grade-separated junction north of Milton and merge with the existing railway to access Cambridge North station. Milton Fen Level Crossing would need to close and be replaced with a bridge.

8.3.14 Cambridge North station would need to be upgraded to provide operational flexibility, including making the current bay platform a thorough platform with north and south turnback capabilities.

8.3.15 Between Cambridge North station and Coldham's Lane, EWR would make use of the two existing WAML tracks, and no new infrastructure is expected to be needed. Due to EWR increasing the number of trains on the WAML, extended barrier downtimes at Fen Road Level Crossing would mean closure of the crossing would be necessary, with alternative access provided.

8.3.16 The section between Coldham's Lane and Mill Road Bridge would comprise four tracks: two would be the existing WAML, one would be the extended and upgraded Down Goods Loop track to the west, and one additional track to the east would be needed which would replace several sidings to the east. At Cambridge station, EWR would use existing platforms, some of which would be extended in length. In addition, new platforms 9, 10 and 11 would need to be created.

Comparison of the Northern and Southern approaches to Cambridge

8.3.17 A comparative analysis of the two options was undertaken by applying the differentiating Assessment Factors, as summarised below.

Unlocking economic growth (Assessment Factors 1, 2, 6, 7, 8, 15)

Economic Growth

8.3.18 Cambridge hosts the largest and most successful life-sciences cluster in Europe, attracting investment into the UK from around the world. The life sciences industry has grown at an unprecedented rate over the last two decades. The Government recognises the importance of

increasing investment in life sciences research and development (R&D), which aligns with the government ambition to increase R&D spending to 2.4% of GDP by 2027 [93].

8.3.19 An assessment of the options demonstrates the key role that EWR would play to the continued success and growth of the life science industry – for the Cambridge Biomedical Campus cluster, Cambridge and the UK. The Cambridge Biomedical Campus is home to AstraZeneca, who contribute over £2bn to the economy every year and nearly £300m to the exchequer. Furthermore, Cambridge Biomedical Campus supports 15,000 jobs across regional supply chains[94]. In 2021, the Cambridge Biomedical Campus published a vision for major expansion aiming at creating new jobs and improving productivity locally and throughout the UK.

8.3.20 Seven of the world's top twenty pharmaceutical companies (by revenue) have a presence in South Cambridge[95]. The location of the Cambridge Biomedical Campus offers convenient public transport links to connect with other key R&D sites located south of Cambridge: Granta Park, Babraham Research Campus and the Wellcome Trust Genome Campus. Whilst the Cambridge Science Park in North Cambridge also hosts a variety of innovative businesses, including in the biomedical field, it is significantly more remote from these other critical hubs with less scope for it to contribute to wider clustering. Clustering is important in delivering agglomeration benefits such as shared labour pools, supply chains and innovation/collaboration opportunities. In this regard, clustering and agglomeration are inextricably linked because the agglomeration effects stem from clustering. Whereas some other areas (for example, 'Silicon Roundabout' in London) may provide an opportunity for businesses to co-locate, these areas would not provide these businesses with the scale of networks and facilities required for research-led industries to thrive in the same way they could around Cambridge. The innovation system effects of longer distance direct transport connectivity bring about scale benefits that can't be realised in places like Silicon roundabout.

8.3.21 However, the growth potential of Cambridge and the wider region is in danger of being eroded as businesses struggle to attract top talent and wages are driven up by high residential and commercial property prices. Despite the strong performance of the region and its high reputation globally, it still lags international competitors such as Silicon Valley for productivity. If these constraints are not resolved, there is a risk that high performing and high growth businesses could look to locate abroad instead of remaining in the UK. As a consequence, the economic powerhouse of the Cambridge cluster – and the Cambridge Biomedical Campus cluster in particular – would be undermined. In these circumstances, the strategic argument for EWR to serve Cambridge – and Cambridge South in particular – is strong.

8.3.22 EWR services on a northern approach would serve Cambridge North, which is the closest railway station to the Science Park on the north-eastern fringe of the city. Whilst this area has been identified for future growth in the emerging Greater Cambridge Local Plan, its delivery is already planned irrespective of EWR and on the assumption hitherto that EWR would access Cambridge from the south. In addition, the emerging North East Cambridge Area Action Plan

[93] Life Sciences Vision - GOV.UK (www.gov.uk)

[94] Cambridge Biomedical Campus celebrates 60 years with £2bn boost to UK economy | University of Cambridge

[95] Cambridge-Biomedical-Cluster-Report-2022.03.09.pdf (letscellit.com)

(NECAAP) – which sets out the vision for this part of the city in more detail – clearly establishes that the proposed development strategy focuses on the intensification of commercial and R&D uses on the existing Science Park site. The majority of the Science Park is located over 15 minutes' walk from the station, a factor which has a bearing on door-to-door journey times. The majority of the land within this radius of Cambridge North station is intended for housing-led development and, whilst some additional commercial floorspace is envisaged, delivery over the levels set out in the NECAAPP is not supported. A significant proportion of this will also entail re-provision of existing commercial floorspace which has to be re-located to facilitate the effective re-planning of the area, i.e. it is not all new floorspace.

8.3.23 By comparison, almost the entire Cambridge Biomedical Campus (including the potential expansion being considered as part of the emerging Greater Cambridge Local Plan process) would be within a 15-minute walk of Cambridge South station. This means that jobs at the Biomedical Campus – both existing and future – would be more accessible by active travel modes than jobs at the Science Park. Furthermore, it would be difficult to justify and secure consent for further development of the Cambridge Biomedical Campus without the expansion of sustainable transport modes serving the location, given the existing pressure on the roads in and around Cambridge.

8.3.24 Traffic congestion is a particular issue for Cambridge and has increased dramatically in the last decade. Both approaches into Cambridge offer an opportunity to reduce traffic congestion in Cambridge. However, there is heavier congestion in southern Cambridge compared to the north of the city, leading to slower, less reliable road journey times to the Cambridge Biomedical Campus for workers and patients. Most staff drive to the Cambridge Biomedical Campus due to poor connectivity, meaning that further expansion is being impacted by additional congestion and leading to large areas of the site being ineffectively used for parking instead of higher value research facilities.

8.3.25 There is currently no committed public transport solution in place or planned which would resolve this constraint and facilitate the intensification of the Cambridge Biomedical Campus site as sought in the emerging Greater Cambridge Local Plan. The Plan specifically recognises that the opportunities provided by the new Cambridge South station to enhance public transport access to the Cambridge Biomedical Campus must be maximised – both to reduce congestion and densify the Campus facilities.

8.3.26 By comparison, the Science Park has convenient access to the A14 dual carriageway and is already served directly by the guided busway and local bus routes, including from the Milton Park & Ride site.

Journey Times

8.3.27 Connectivity to Cambridge station under a northern or southern approach takes approximately the same amount of time. Therefore, journey times to the other stations in Cambridge were assessed for each option to test the journey times to Cambridge North vs Cambridge South. EWR Co mapped out two example journeys from Tempsford/ St Neots using both routes into Cambridge and taking account of first and last mile provision. These examples comprised a journey to Cambridge Consultants, an indicative business at the

Science Park (which hosts 11,000 jobs) in the north; and a journey to the AstraZeneca headquarters at the Biomedical Campus (which hosts 18,000 jobs) in the south.

8.3.28 From the south, AstraZeneca at the Biomedical Campus can be reached in 24 minutes and Cambridge Consultants at the Cambridge Science Park in 48 minutes. From the north, Cambridge Consultants can be reached in 38 minutes and AstraZeneca at the Biomedical Campus in 42 minutes. As noted in the previous section concerning economic growth, serving the Biomedical Campus with faster and more reliable public transport is a high priority.

8.3.29 Quicker journey times to the Biomedical Campus are achievable with a southern approach to Cambridge because it is located next to Cambridge South station. In comparison, the Science Park is a relatively lengthy walk from Cambridge North station.

Connectivity

8.3.30 A revised northern approach to Cambridge would facilitate quicker access to Cambridge Science Park, although most of the Park is beyond the 15-minute walk catchment area of Cambridge North station and another form of transport would be generally required by many to reach their destination (See Appendix 13 for further detailed analysis). Whilst there is better accessibility for journeys through Cambridge from the North to the Cambridge Biomedical Campus this is not likely to be an available option in infrastructure terms. This is because if a northern approach were to be selected, EWR services would not be able to serve Cambridge South directly, which is situated adjacent to the Biomedical Campus. The location that is heavily constrained, with the Biomedical Campus to the east side and Hobson's Park to the west side. To achieve direct connectivity for EWR trains from a NATC, infrastructure upgrades would be needed on the WAML south of Cambridge station to enable EWR trains to run through to Cambridge South station, or significant changes to existing services would be needed – this is described below.

8.3.31 This means that all EWR services would have to terminate at Cambridge station and would require passengers to change trains to complete their journeys, introducing an interchange penalty for passengers:

- It would significantly increase the journey time to Cambridge South compared to a southern approach. For example, from the new EWR station at Tempsford/St. Neots, the journey time would nearly double from an estimated 21 minutes via a southern approach to at least 39 minutes using a northern approach. The estimated journey time from Bedford would increase from 32 minutes to over 50 minutes.

- The inconvenience of an interchange would make the train less attractive overall as a mode of transport – for the types of journeys relevant to Cambridge South, research shows that passengers perceive the inconvenience of an interchange to be the equivalent of up to 25 minutes additional journey time.

8.3.32 To attempt to overcome these significant disadvantages of a northern approach, it would be possible (in theory) for existing Greater Anglia services from London Liverpool Street to Cambridge North (which it is envisaged will call at Cambridge South) to be extended onto EWR. However, this would still have several disadvantages:

- These extended services would be limited to only two trains per hour due to capacity constraints. In addition, the paths would be inflexible because of the need for the services to interact with other Greater Anglia services to London Liverpool Street further south on the WAML. This would raise operational and performance challenges due to the risk of service disruption further south on the WAML leading to consequential delays and potential cancellation of the extended services.

- At peak times, these services are extended from Cambridge North to Ely. If they were instead to extend onto EWR tracks, this would result in the reduction of capacity to Ely unless the trains divide into two portions at Cambridge North – one to Ely and one onto EWR. This would use up additional service capacity on the WAML north of Cambridge due to the time involved in splitting trains.

- The Greater Anglia services are served by electric trains. To extend them onto EWR tracks would require the section of EWR from Milton to Tempsford and/or Bedford to be electrified using conventional overhead line equipment, which has not yet been selected as an engineering solution for EWR. Platforms and stations on the EWR line would also need to be extended to accommodate the longer Greater Anglia trains. This would entail significant additional capital costs which are not included in the cost estimates for EWR.

- Journey times to Cambridge South would still be longer than for a southern approach. The Cambridge Biomedical Campus is reliant upon a pipeline of talent and is a hub for training of key health sector workers. The region between Oxford and Cambridge – especially the area between the MVL and Cambourne – is key because it has the potential to provide the affordable housing that is needed by these key workers in one of the most expensive areas of the country. Longer journey times, particularly with an interchange penalty, move key labour markets out of reasonable commuting distance and shrink the reach of the labour pool – which in turn hinders agglomeration. This means that – even if the interchange penalty of a northern approach is removed – the anticipated travel catchment would still not extend as far as it would with a southern approach and would exclude the MVL (and potentially Bedford as well) from a reasonable commuting distance. The lack of direct connectivity to Oxford and MVL stations would also impede the realisation of key agglomeration and innovation benefits.

- In addition to these issues, a northern approach would also require existing Great Northern services between Ely, Cambridge, and London King's Cross to be re-timetabled, significantly extending journey times by an extra ten minutes and increasing platform occupation times at Cambridge.

8.3.33 By comparison, a southern approach would enable all four EWR services to call at Cambridge South. This would bring the Cambridge Biomedical Campus within a realistic commutable distance of Cambourne, Tempsford and Bedford, and EWR stations on the MVL with estimated journey times from Stewartby and Ridgmont to Cambridge South of 45 and 51 minutes respectively. This would help to maintain the labour supply and extend the geographical reach of the Cambridge Biomedical Campus labour pool further.

8.3.34 In addition, with only relatively minor alterations at Cambridge North station, at least two of these services could be extended to serve Cambridge North without undertaking any other upgrades to the WAML between Cambridge and Cambridge North.

Service extension beyond Cambridge:

8.3.35 EWR Co has also considered the potential for rail services through Cambridge – both EWR and non-EWR – to be increased further in the future. Network Rail has indicated that there are aspirations for additional future services from Cambridge as follows:

- One extra train per hour to Ipswich.
- One extra train per hour to Norwich
- One extra train per hour to Peterborough

8.3.36 Each of these would supplement the existing hourly services from Cambridge to these destinations, although it should be noted that it is not possible for these extra services to run without additional upgrades being made to other parts of the rail network first.

8.3.37 Both the northern and southern approaches could potentially support one extra train per hour to Ipswich and at least one extra train per hour to Norwich or Peterborough, subject to further consideration of empty coaching stock movements at Cambridge station during the evening peak. In the case of a southern approach, this would be in addition to two EWR services extending to Cambridge North each hour.

8.3.38 However, if a northern approach is selected for EWR then the combination of the new EWR services as well as these additional services would increase the route utilisation of the WAML north of Cambridge to over 80% in some hours which would lead to a significant risk to railway performance.

8.3.39 In addition, if a southern approach is selected and EWR services are extended to Cambridge North, it would be possible for these to be extended further to Ely, Norwich and Peterborough instead of running additional services to these destinations commencing at Cambridge station. This would not only remove the need to find the additional train paths between Cambridge station and Ely, but also enable services to run from north and east of Cambridge directly onto EWR after calling at Cambridge and Cambridge South. This direct wider connectivity would not be possible with a northern approach.

Cost (Assessment Factors 3, 4 and 5)

Capital Cost and constructability:

8.3.40 High-level assessments indicate that a northern approach would be quicker to construct than a southern approach, as a northern approach would be less disruptive to the existing network, especially in the very constrained approach to the south of Cambridge station. Nevertheless, each option would be challenging and disruptive to construct. This is due to the existing railway in Cambridge being flanked by residential, commercial and designated common land on either side right up to the railway boundary. In addition, the majority of EWR works in the city would interface to some extent with a live and busy railway.

8.3.41 The northern approach is expected to be cheaper to construct than the southern approach. This is due to several factors, including the southern approach outside Cambridge having more undulating topography, which requires more earthworks. In addition, a greater level of work would be required in Cambridge to increase the number of tracks from two to four on the section from Shepreth Junction to Cambridge station. The estimated capital cost of each option (at Q2 2021 prices and assuming high growth freight capability), including risk, is as follows, noting the ranges provided reflect the relative design immaturity:

- Northern Approach £1.16-1.39bn
- Southern Approach £1.45-1.77bn

8.3.42 The northern approach is estimated to be in the order of £290-380m cheaper than the southern approach. However, given the early stage of design development, there is the potential for this range to narrow and it should be treated as indicative only.

Operating Cost:

8.3.43 Operating costs will be developed during the next stage of development work on the Project when designs will be refined in consideration of traction power, rolling stock and infrastructure, including the proposed maintenance regime. Therefore, there is no differential in the assessment of operating costs between northern and southern approaches at this stage.

Environmental Impacts and Opportunities (Assessment Factor 14):

Southern Approach:

8.3.44 The proposed alignment would cross beneath the A428, travelling southeast and crossing a number of water courses, including the Bourn Brook and River Cam/Rhee prior to joining the Shepreth Branch line south of Harston with a grade separated junction.

8.3.45 To the west of Cambridge, the alignment would pass within the core sustenance zone of a colony of barbastelle bats associated with Eversden and Wimpole Woods Special Area of Conservation (SAC). The provision of new infrastructure within this zone would need mitigation to maintain the integrity of the SAC and the design of the southern approach alignment has been developed to account for this. At this stage it is considered that impacts on the Wimpole and Eversden Woods SAC would be capable of mitigation and avoid an adverse effect on the integrity of the site, although avoiding the core sustenance zone altogether would be preferable.

8.3.46 To the north of the Shepreth Junction on the WAML there is a Scheduled Monument adjacent to the existing line. Currently, is it not anticipated that the works would result in a direct impact on the schedule area. Similarly, there are a number of Scheduled Monuments located in the area to south of Harston, and the design of alignment and potential construction working areas being adjacent to, but not directly impact on, the scheduled area of a number of Scheduled Monuments.

8.3.47 A southern approach would result in the new line being located closer to the Mullard Radio Astronomy Observatory (MRAO), which creates a risk of Electromagnetic interference which could impact the observatory's work. EWR Co is in ongoing discussions with MRAO to understand how any impact to the observatory could be avoided or reduced and mitigated.

Northern approach:

8.3.48 To the east and northeast of Cambourne, the proposed route would pass through predominantly agricultural and rural landscapes to the southeast of Bar Hill and Oakington. The route would continue east, joining the WAML between Waterbeach and Milton.

8.3.49 The primary environmental considerations for this section of the route are related to the impact on agricultural land, amenity impact to communities and the extent of route in flood plain. In addition, the northern approach generally follows a flatter topography with less, or no, requirement for embankments and tunnels which has the potential to result in lower embodied carbon emissions. However, the presence of new infrastructure within the large areas of floodplain crossed by a northern approach would require mitigation of the infrastructure itself to ensure resilience, as well as mitigation of potential up- and down-stream flood impacts. A minor increase in vertical alignment (0.5m), in addition to that currently proposed, is likely to provide sufficient freeboard for the rail line itself, but further work would be necessary to confirm this.

8.3.50 Both the NATC and the SATC would pass by various settlements in Cambridgeshire between the new Cambourne station and the point at which they join the existing rail network near Cambridge (near Milton and Hauxton respectively). Both would also involve works in the built-up area of Cambridge itself and the new EWR trains would also run through the built-up area, although the NATC would have a greater length in the built-up area than the SATC.

8.3.51 The number of properties within 500 metres of the NATC and SATC (between the Cambourne and Cambridge stations) would be broadly similar overall although, as set out in Appendix F of the 2021 Consultation Technical Report, there would be more properties within 200m of the NATC alignment compared to the SATC, i.e. more properties are located closer to the NATC.

8.3.52 The works needed to deliver the NATC would require the closure of, and replacement diversion for, Fen Road level crossing, which would have the potential for impacts on the established traveller community in this area. It would be possible to provide mitigation measures such as by constructing a replacement road access for the community.

Rail delivery and operations (Assessment Factors 9, 10, 11, 12 and 13):

8.3.53 In respect of rail delivery and operations, the extent to which each option for the approach to Cambridge would enable strategic rail growth or onwards connectivity to the east, was assessed. Table 33 below summarises the position.

Long distance passenger services	NATC	SATC
Enables/ provides the capacity in this section for an additional Norwich to Cambridge service (+1tph)	✓	✓*
Enables/ provides the capacity in this section for an additional Cambridge to Peterborough service (+1tph)	✓	✓* (cell merged to show that SATC allows one or the other of these services but not both)
Enables/ provides the capacity in this section for additional Ipswich service (+1tph on the track between Coldham's lane – Cambridge)	✓	

Table 33 - Extension of services to the East (Assessment Factor 9: long distance passenger services)

8.3.54 Both the northern and southern approaches could support one extra train per hour to Ipswich (beyond the core EWR service of four trains per hour).

8.3.55 In addition, the southern approach would afford one additional service to either Norwich or Peterborough, with the inclusion of additional infrastructure at Cambridge North station and timetabling optimisation between EWR and Greater Anglia services, and subject to other required network enhancements.

8.3.56 Further, the northern approach would also support a second and third additional train to run (to Norwich or Peterborough).

8.3.57 These potential additional services are out of EWR's current scope.

Expansion of EWR in the future (Assessment Factor 9):

8.3.58 The southern approach would enable extension of services further east. The northern approach would also afford extension of EWR services further east, but these would require reversing moves at Cambridge, interchange with other services, or services bypassing Cambridge station altogether. Therefore, the southern approach to Cambridge performs better than the northern approach in this regard.

Freight Operations (Assessment Factor 10):

8.3.59 The southern approach is expected to enable an estimated two freight trains a day from Felixstowe port, without further enhancements assumed to be required either on or off the EWR network, although further optimisation of the gradient of the route and available sidings in the Cambridge area may be required to facilitate the running of rail freight onto EWR. To

enable higher volumes of freight trains to run would require additional infrastructure both on and off the EWR network, with different interventions required depending on whether the services were to be routed via Newmarket or Ely.

8.3.60 The northern approach would require a north-west EWR connecting chord onto the WAML in the Milton area, and an avoiding line at Ely, to enable any freight trains to run from Felixstowe onto EW, bypassing the congested central Cambridge area. Once in place, no further interventions are expected be required in this section of the EWR route, however further enhancements would be necessary on the national network to facilitate higher volumes of freight trains per day, similarly to the southern approach.

Performance (Assessment Factor 11):

8.3.61 The level of train services that EWR interacts with for a southern approach is more intensive than for the northern approach, as the WAML is timetabled with more services to the south of Cambridge station. However, when recognising the varied routes and with inclusion of all the empty coaching stock moves and depots involved to the North, plus the additional segregated lines that the southern option proposes between Shepreth Junction and Cambridge station, the planned timetable should deliver a more robust service with a southern approach.

8.3.62 The current inclusion of 1:80 gradients on the southern approach requires further design refinement to mitigate performance impacts. In addition, there are more complex engineering solutions required at Chapel Hill for the southern approach, although these are included in the current design and cost estimate.

Alignment with wider railway strategy / infrastructure (Assessment Factor 12):

8.3.63 The southern approach aligns better with Network Rail's three main programmes of work in the area:

- Cambridge South station – opportunity to build upon the layout and four tracking in the corridor as provided by this Project.

- Cambridge re-signalling project (C3R), a project to update signalling in the area has progressed on the assumption that EWR will approach from the south. Ely Areas Capacity Enhancement (EACE) – although the Project is not fully committed, these proposals would temporarily disrupt the WAML to the north of Cambridge. A southern approach would avoid complications with, and compounding the impacts of, this Project.

8.3.64 In terms of the EWR train service specification and meeting the demand forecasts contained in the updated Strategic Case, both northern and southern approaches are able to deliver 4tph, between Cambridge and Bedford. The aim of the EWR timetable is to provide a service level that is spread across each hour and, as such delivers a 'turn-up and go' level of convenience. The modelling exercise (and comparison between the northern and southern

approaches) showed this was easier to achieve, and more robustly timetabled throughout the day for the southern approach.

8.3.65 Neither option precludes the benefits of Network Rail projects in the area.

Summary of Assessment Factors

8.3.66 The table below summarises the Assessment Factors for the southern and northern approaches into Cambridge.

AF	Southern Approach to Cambridge	Northern Approach to Cambridge
Economic Growth (AF1, 2, 15)	The southern approach provides better access to employment opportunities due to the quicker journey times to Cambridge South station, and its proximity to the Biomedical Campus. The northern approach requires a change of trains to get to Cambridge South station, or amending the route of an existing provider, which would afford only two trains per hour and would not cover the full EWR route. In addition, the southern approach provides better alignment with government life science priorities due to the direct connectivity to Cambridge South and the Biomedical Campus. Connecting to Cambridge South better satisfies EWR's Theory of Change in terms of unlocking constraints, particularly given the importance of for the Biomedical Campus and the ambition for its growth.	A northern approach provides quicker connectivity to Cambridge North station, which has more development potential than, for example the Biomedical Campus to the south, given the greater land availability in the area. However, the majority is some distance beyond a railway station and there is lower additionality and dependency. Aspirations for the area are focused on supporting the vision of a self-sustaining new city district that can reduce social inequality locally through the range of jobs and homes that are created[96].
Cost (AF3, 4, 5)	Capital cost is projected to be in the range of £1.45-1.77bn; circa £290-£380m more than a northern approach. Operating costs will be developed during the next stage of development.	Capital Cost is projected to be in the range of: £1.16-1.39bn; circa £290-380m less than a southern approach, noting the immaturity of the design. Operating costs will be developed during the next stage of development.
Environment (AF14)	The route passes through the core sustenance zone associated with the barbastelle population located in the Eversden and Wimpole Woods SAC and potential impacts would require	The northern route avoids potential impacts on the integrity of the Eversden and Wimpole Woods SAC requiring mitigation. The route has a lower presence of higher value habitats and

[96] The Proposed Submission for North East Cambridge Area, Action Plan Regulation 19 November 2021 by Greater Cambridge Shared Planning team

AF	Southern Approach to Cambridge	Northern Approach to Cambridge
	mitigation. In addition, there are higher presence of higher value habitats and higher embodied carbon than for a northern approach. The southern route would likely require a larger quantity of 'cut' material to be exported off-site.	lower embodied carbon than the southern approach. The northern approach-performed worse than the southern route in terms of impact on flood plains and climate resilience. Northern Approach has more properties within 200m of the railway corridor.
Rail delivery and / Operations (AF6, 7, 8, 9, 10, 11, 12)	The southern approach provides for 4 EWR trains per hour. This is the same as the northern approach. However, the southern approach provides a more robust timetable and more likely to achieve a 'turn up and go type service level'. The southern approach affords one additional service to Ipswich and one service to Peterborough or Norwich (in addition to the EWR 4 TPH). It also allows for the extension of EWR further east in the future. The option supports freight growth with inclusion of passing loops, Ely Avoiding Line and potential gradient alteration. The option aligns better with existing NR projects than the northern approach.	The northern approach provides for 4 EWR trains per hour. This is the same as the southern approach, although the timetable would be less robust than the southern approach. As per the southern approach, this option affords one additional service to Ipswich, Peterborough, and Norwich (in addition to the EWR 4 TPH). Unlike the southern approach, the northern approach would not be as easy to extend EWR further east in the future. The option supports freight growth with inclusion of loop, chord and Ely Avoiding Line. This option is less well aligned with existing NR projects.

Table 34 - Cambridge approach options – summary of Assessment Factors

Options for Cambridge – preferred approach

8.3.67 The analysis above shows that both approaches are technically viable, and each has its own merits. The northern approach costs less than the southern approach. However, the southern approach provides easier access for more people to more jobs, provides better support to the growth ambitions of Europe's largest life sciences cluster, and is more effective at unlocking the constraints identified that are holding back Cambridge's growth. This is due to the direct and quicker connectivity it would provide to Cambridge South station and the Cambridge Biomedical Cluster, which is of critical importance to the future success of the region.

8.3.68 Therefore, a southern approach into Cambridge remains EWR Co's preferred option.

8.4 Alignment Variation in the Tempsford/St. Neots Area

8.4.1 As part of the ACP process, it was identified above in this chapter that the preferred Option Family for the Bedford-Cambridge section of EWR, is proposed to be Option Family HR5. This exits Bedford via the North and enters Cambridge via the South. It has common elements between Tempsford/St Neots and a point east of Cambourne with the other heavy rail Option Families. Effectively, HR5 is an alignment very close to Alignment 1, which was an emerging preference in the 2021 consultation.

8.4.2 Alignments 1 and 9 were presented as the emerging preferred options for Section D between Clapham Green and The Eversdens in the 2021 consultation. Alignment 1 served a St Neots station location and Alignment 9 a Tempsford station location, where EWR intersected with the East Coast Main Line (ECML). Analysis indicated that Alignment 1 should be the preferred option for a new railway between Bedford and Cambridge due its lower environmental impact and cost. However, concern was raised in response to the consultation about the likely impact of Alignment 9 on the village of Roxton and associated conservation areas, Ravensden and Renhold. Also, the siting of an East Coast Main Line station was finely balanced in terms of the benefits of a Tempsford or St Neots location.

8.4.3 EWR Co decided that it should investigate whether its preferred route alignment (derived from Option Family HR5) would be able to serve a new station at Tempsford in case that location was considered to be preferential compared to St Neots for development.

8.4.4 A new variant to Alignment 1 between Bedford and Cambridge (which corresponds most closely with Option Family HR5), known as Alignment 1 (Tempsford variant), was developed in response to these issues. It includes a localised variation of Alignment 1, providing an alternative to Alignment 9, which would serve a Tempsford Station location. The variant would avoid Alignment 9's encirclement of Roxton village and Conservation Area by major transport infrastructure. It would also reduce potential impacts at villages between Bedford and Tempsford including Ravensden, Renhold and Roxton. Figure 16 below provides a visual comparison of Alignments 1 (Tempsford variant) and 9.

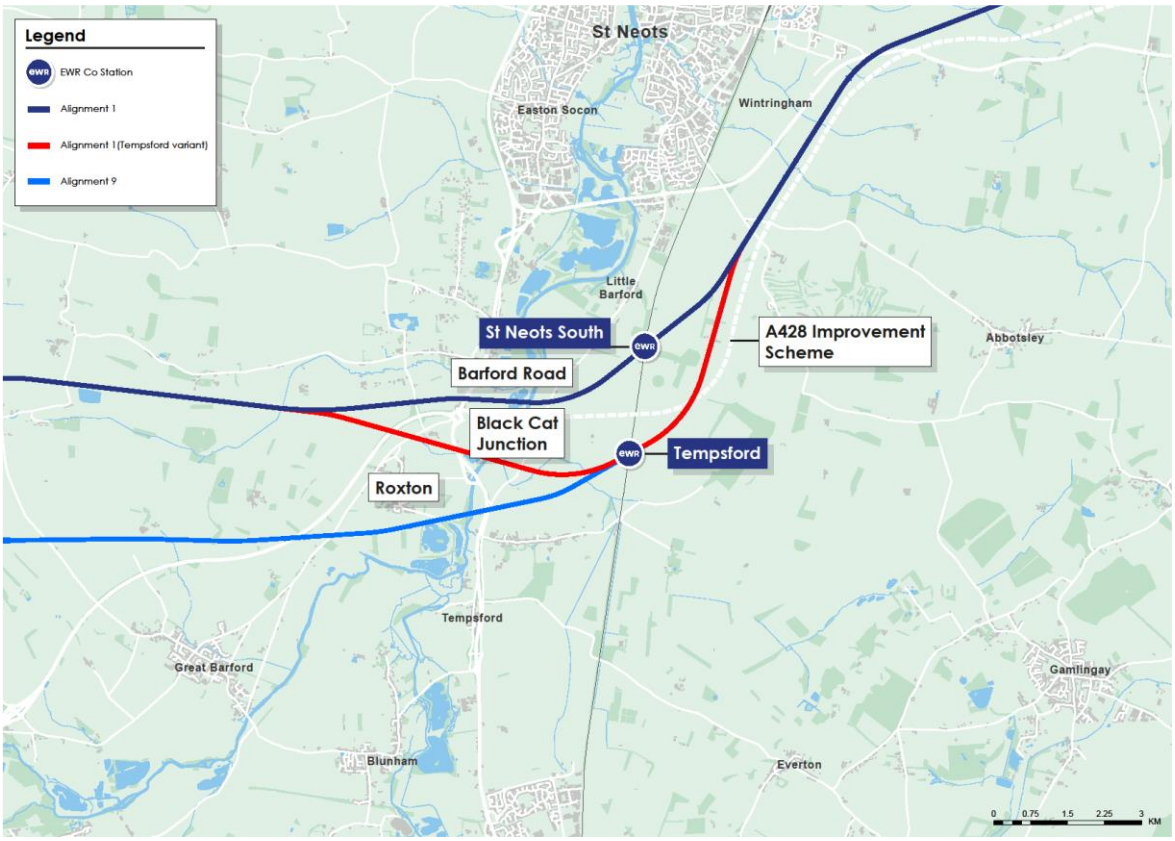


Figure 16 - Plan showing Alignment 1, Alignment 1 (Tempsford variant) and 9

8.4.5 Using EWR Co's Assessment Factors, the Alignment 1 (Tempsford variant) was compared to Alignments 1 and 9, with Alignment 1 set as the baseline to enable comparative assessment. The Alignments were compared over the full Section D route between Clapham Green and The Eversdens presented in the 2021 consultation.

8.4.6 The assessment concluded that Alignment 1 is preferred to Alignment 9 as Alignment 9 was judged as a slightly worse for environmental impacts and expected to have a higher estimated cost than Alignment 1. In addition to the encirclement of Roxton village and Conservation Area, Alignment 9 would also result in additional impacts on landscape character compared to Alignment 1, namely upon Brickhill Country Park, the River Great Ouse valley and indirect impacts upon the character of Roxton Park. The Alignment 1 (Tempsford variant) was then compared against the Assessment Factors to enable comparison with Alignment 1.

8.4.7 Alignment 1 is expected to be less expensive and was judged as a slightly better in comparison to Alignment 1 (Tempsford variant) in respect of safety due to its shorter length, although it is not expected to introduce any novel or unsafe construction practices. Creating a new station at a Tempsford location has a greater potential to support economic growth to come forward than a new station at St Neots, due to constraints at the St Neots location in relation to existing developments and infrastructure. Development at Tempsford would also enable the redevelopment of brownfield land at RAF Tempsford. The higher growth potential of Tempsford than St. Neots was validated by advice received from Homes England. For these

reasons, Alignment 1 (Tempsford variant) was judged as being better in terms of its contribution to enabling housing and economic growth.

8.4.8 It is noted that EWR Co had set out the purpose of the Project as part of the Project Objectives, which states 'The Railway shall be explicitly designed and delivered to stimulate economic growth, housing and employment.'

8.4.9 In conclusion, the localised Tempsford variant of Alignment 1 would better achieve the EWR Project Objectives in respect of offering the greater opportunity for development. Therefore, Alignment 1 (Tempsford variant) is EWR Co's preference, subject to future consultation, and will be taken forward for further design work. Residents, communities and other stakeholders will be able to provide feedback on the updated route design for Alignment 1 (Tempsford variant) as part of the statutory consultation.

8.5 Cambourne area

8.5.1 All shortlisted ACP route options incorporate a railway alignment close to the proposed A428 on the north side of the new road and include a station at Cambourne to the north of the town. ACP alignments which did not serve Cambourne station were not considered to provide the same level of benefits. This is in line with the two emerging alignment preferences at the 2021 consultation. A new station north of Cambourne remains EWR Co's preference as a station at Cambourne South would require a greater level of mitigation to protect environmental and heritage assets in the area. From a planning perspective, this would place greater constraints upon development at Cambourne South than at Cambourne North.

8.6 Conclusion on the Selection of a preferred Bedford – Cambridge Route Alignment

8.6.1 The assessment of the options for routes into and out of Bedford and Cambridge concluded that a northern six-track route from Bedford and a southern approach to Cambridge were required to serve Cambridge South and Bedford stations with the 4tph necessary to unlock the economic opportunity set out in Theory of Change. These options also provided the greatest operational flexibility and resilience, required to run a reliable and dependable service.

8.6.2 It was concluded therefore that HR5, which comprises the northern route out of Bedford and the southern route into Cambridge, with an assumed 4tph was the preferred solution for the new railway between Bedford and Cambridge. In addition, an emerging preference for the Tempsford Variant of the alignment between Bedford and Cambridge has been identified, and will be subject to further consideration and consultation at the statutory consultation on the Project.

9. East West Rail Service Pattern

9.1 Introduction

9.1.1 As explained in Chapters 7 and 8, the capacity requirements to accommodate the demand arising from the jobs and growth envisaged in the Theory of Change results in a 4tph heavy rail service between Bedford and Cambridge. In Chapter 3, an initial consideration of service options between Oxford and Bedford was undertaken. This chapter explains how this information was taken further and, by seeking to attain the objectives for jobs, housing and growth identified in the Theory of Change, how the appropriate service specifications for the Oxford to Bletchley and the Bletchley to Bedford sections were determined. Combining the service specification for these sections with that previously described for Bedford to Cambridge enabled an end-to-end route alignment and service specification for the entire Oxford to Cambridge route to be identified.

9.2 Service Specification

9.2.1 To enable the remaining options to be further developed and assessed, a preferred service pattern was identified. Work sought to determine the optimal rail service specification to deliver the required capacity outputs for EWR to 2050, in terms of:

- Train frequency between Oxford, Milton Keynes, Bletchley, Bedford and Cambridge, and
- Train length, including maximum likely to be required.

Methodology

9.2.2 Five different demand modelling scenarios were examined as part of the analysis to determine a preferred service pattern, comprising two conventional (base, high) and three Theory of Change scenarios (low, medium, high), while also considering the Covid-19 impact. These were assessed per section of the route: Western (Oxford to Bletchley), Marston Vale Line (Bletchley to Bedford) and Core (Bedford to Cambridge), to establish the required service level per section per scenario, before linking these together to produce coherent end-to-end service options.

9.2.3 An assessment of rail capacity and infrastructure capability was undertaken in parallel, to identify constraints which may prove prohibitive for certain train lengths or frequencies, to help inform the recommended service specification.

Outputs

9.2.4 The modelling outputs concluded the following service levels per scenario, shown in Table 35 (Theory of Change low is excluded as results were similar to conventional high growth).

Demand	Western Section (tph)	MVL (tph)	Eastern Section (tph)
Conventional Base Growth	3 or 4	3	3 or 4
Conventional High Growth	3 or 4	3	3 or 4
Theory of Change Medium Growth	4	3	4
Theory of Change High Growth	4	3	4

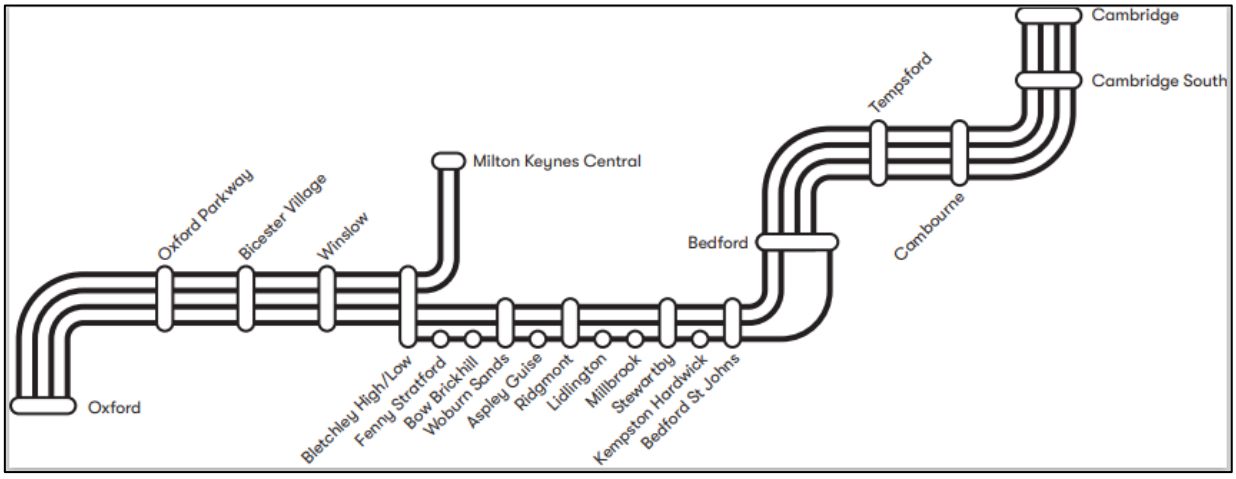
Table 35: Service Level Scenarios used for Modelling

9.2.5 The infrastructure capability assessment indicated that train lengths longer than six-car and a frequency higher than tph would trigger requirements for significant infrastructure interventions across the route and would contribute materially to the capital cost of the Project, harming its viability.

9.2.6 As previously explained, EWR is proposed as a catalyst for change, with the Theory of Change underlining the key role it would play to enable economic growth in the Oxford - Cambridge region. It is therefore considered that, of the modelling scenarios, planning should anticipate that EWR would need to serve conventional high growth and Theory of Change medium growth scenarios as a minimum, without precluding the ability to accommodate higher levels of growth as per the Theory of Change high growth scenario.

Service Specification

9.2.7 When considering the strategic case for EWR, as underlined by the Theory of Change, and respective modelling outputs, infrastructure assessment findings, and operational viability of train length/frequency combinations, it is determined that a 4-3-4tph train service is adopted (as depicted in Figure 17 below), at 3 or 4-car length (96m), with active[97] provision for 6-car strengthening of services.



[97] Active provision refers to the inclusion of all the necessary works for 6 tph services to operate on EWR in the future in the DCO and delivering them in one go as part of a single construction phase.

Figure 17 - Proposed EWR Service Pattern

9.2.8 This service specification has been used as the basis for the further assessment of the remaining infrastructure options. Where new or improved infrastructure is contemplated, the assessment considers whether the proposals can accommodate the services identified. The following sections summarise the findings of work undertaken to assess the remaining areas of optionality further and to identify a single route option.

9.3 Oxford to Bletchley

9.3.1 The Transport and Works Act Order (TWAO) (2020)[98] for the Gavray to Bletchley upgrade, that is facilitating the 2tph between Oxford and Milton Keynes (OXD to MKC), allowed for a total of three additional tph above today's service levels to pass over the level crossing (LX) at Bicester without additional works being required. It is likely that 3tph at Oxford is achievable with additional infrastructure works. Increasing service levels to 4tph would most likely necessitate a major upgrade at the Bicester Level crossing and more substantial infrastructure works at Oxford to provide a suitable solution. The 3tph could be achieved by either having 2tph OXD-CAM (Oxford to Cambridge) and 1tph OXD to MKC or 2tph OXD to MKC and 1tph CAM, albeit this second option would not meet the level of demand for the anticipated growth.

9.3.2 It would be challenging to remove one of the Oxford to Milton Keynes services and, as 2tph are required along the MVL to meet the Theory of Change and demand and capacity identified in the modelling. It was recognised that a choice would have to be made over service levels and cost as part of the ACP analysis.

Oxford to Bletchley infrastructure costs and associated service pattern

9.3.3 The cost of the infrastructure between Oxford and Bletchley could potentially be reduced if only 3tph are introduced at Oxford and over the level crossing at Bicester. At Bicester, work to upgrade the Level Crossing may no longer be required due to a reduced barrier down-time. This would be subject to further assessment but could result in a cheaper intervention. It is assumed that Oxford Phase 2 capacity enhancement is funded and delivered prior to CS2. However, to achieve this would require either reducing the Oxford-Milton Keynes or the Oxford-Cambridge service to only 1tph. Given 4tph is required to fulfil the potential for growth in the Ox-Cam region and accommodate the associated demand, it seems less likely that such savings will be realised, as discussed in chapter 10.

[98] The Network Rail (East West Rail) (Bicester to Bedford Improvements) Order 2020

Bletchley to Bedford

The Marston Vale Line

9.3.4 The service assumption along the MVL to date is a base service of two EWR services an hour plus an hourly stopping service which would unlock the economic opportunity identified by the Theory of Change approach.

9.3.5 EWR Co's analysis of the stations along the MVL identified that only two stations have a positive business case; Woburn Sands (driven by existing population), and Stewartby (driven by Kimberley College), based on highest value for money with today's population and travel patterns. There are significant development opportunities along the MVL; early indications suggest that adding a third stop at Ridgmont for EWR services would support this. There is also significant development proposed in local plans ats at Woburn Sands, Lidlington, which it may be beneficial for EWR to support. In the 2021 consultation, EWR Co explored two concepts on the MVL, the first keeping ten stations open and the second closing a number, relocating some and leaving others, so that five stations remained open that were more suitable to meet existing housing need and future growth of the line.

9.3.6 Adding an additional train on the MVL above 3tph triggers a significantly different level of infrastructure intervention, largely driven by level crossing closure requirements but also increased track interventions to support the increased usage.

9.3.7 These assumptions result in a series of service levels and stopping patterns for consideration based upon the Scheme Options that remain following the sifting process described in Chapter 4. These are based upon two, five and 10 stop services along the Marston Vale Line.

9.3.8 Figure 18 shows how the CS1 and CS2 services could look if there were 3tph along the MVL (orange and green lines) and also shows the potential stops for the EWR services. This would include 2 EWR services an hour between Oxford and Bedford (extended to Cambridge for CS3) and one stopping service calling at all stations. The train services between Oxford and Bletchley shown in the figure are dependent on the resolution of the matters set out in the section above.

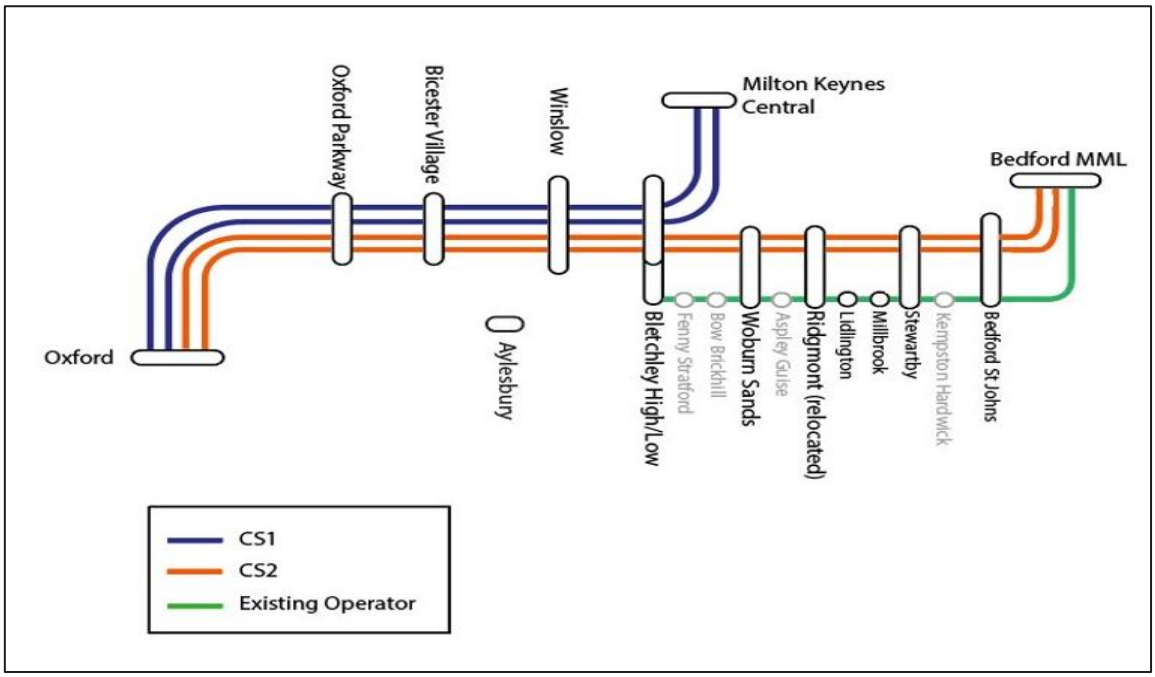


Figure 18 - How the CS1 and CS2 services could look if there were 3tph along the MVL

9.3.9 There is further work to be undertaken in respect of service patterns along the MVL. to consider how the service pattern could develop over time to deliver the real value of the investment in EWR, and identify which option is most appropriate. This analysis will need to consider the level of service, what stations will be served by which services, and the impact of the infrastructure changes along the MVL. There are trade-offs between wider regional connectivity, value for money, and community connectivity. These decisions will need to be made on a comprehensive basis.

Service options Marston Vale	Line speed mph	LX impacts	Stopping service	EWR service	Total no of stations
Do minimum – previous NR TWAO proposal 2019	60	11	1	1	10
NSC concept 1 EWR Non-Stat consultation 2021	100	31	1	4	10

NSC concept 2 EWR Non-Stat consultation 2021	100	31	2	4	5
1 stopping service 2 EWR or 3 EWR services reduced number of stations	75	19	1/0	2/3	TBC
1 stopping service 2 EWR or 3 EWR services 10 stations	75	19	1/0	2/3	10
1 stopping service 3 EWR or 4 EWR services	75	31	1/0	3/4	TBC
4 EWR services 5 stations	75	31	0	4	5

Table 36: Comparison of options for MVL

9.3.10 Table sets out some of the options that have been considered for the MVL including the assumed service level under the application for the 2020 Transport and Works Act Order and the two options proposed at the consultation in 2021. These have been supplemented by four options for how the service pattern along the MVL could be changed to support economic growth. The line speed of 75mph in the options outlined above is a working assumption to test options at a lower speed than 100mph. The final line speed is yet to be determined.

9.3.11 The service options along the MVL shown in Table 36 above could be further developed over time to deliver more services, although it can be noted that, as the number of trains increases, so does the requirement for additional infrastructure. Similarly, trains can be lengthened to increase capacity, although this would trigger other infrastructure requirements such as longer platforms at stations. Such additional infrastructure would trigger additional cost and is not a part of the current EWR Project estimate. The benefits of

such additional capacity would need to be considered against the costs and impacts (including station relocations or platform lengthening).

Bletchley to Bedford (MVL) infrastructure cost management and associated service pattern

9.3.12 As a result of the service pattern that is preferred on the MVL, the infrastructure interventions on the MVL can be reduced significantly from those which were proposed in the 2021 consultation. This includes reducing the line speed below 100mph, the upgrading of only three stations, relocation of only Bedford St Johns and reducing the number of level crossing closures and interventions from 31 to circa 19, as explained out in section 10.4 below.

9.3.13 Adding an additional train on the MVL above 3tph triggers a significantly different level of intervention and therefore increases cost.

9.3.14 The reduction in line speed also reduces the requirements for level crossing closures, requires fewer interventions at existing stations and allows more of the existing track to be retained. This reduction in capital cost is significant and the increase in journey time of around four minutes (depending on the service pattern) has only a small negative impact on passengers.

9.3.15 Therefore, the basis of EWR Co's service assumption along the MVL in the ACP is a base service of three trains per hour. The proposed services on the MVL would be two Oxford to Cambridge trains each hour, plus a service between Bletchley and Bedford. Further work is being carried out to consider how customer needs would best be met through these train services.

10. Infrastructure Decisions Between Oxford and Bedford

10.1 Introduction

10.1.1 Chapter 8 explains that the preferred route alignment between Bedford and Cambridge was identified as Option Family HR5. Chapters 2 and 3 explained that the sifting exercise for options under the ACP identified that the existing and "under construction" alignments between Oxford and Bedford should be adopted. Therefore, the preferred route alignment between Oxford and Cambridge was identified, along with the proposed service pattern, as described in Chapter 9.

10.1.2 Several outstanding issues between Oxford and Bedford remain from the matters that were subject to consultation in 2021 and in respect of the feedback to that consultation. These issues comprise the following and are dealt with in the remainder of this chapter.

- **Oxford station**, where interventions are required to create the capability and sufficient capacity to operate EWR services.
- **Bicester London Road Level Crossing**, where closure of the level crossing and provision of an alternative may be required due to the extended barrier down times necessary for an increase in the train service.
- **The Marston Vale Line**, where an increased number of trains and higher speeds will necessitate changes to be made to some existing stations and level crossings.

10.2 Oxford

10.2.1 The Theory of Change analysis demonstrated a need to operate 4tph in each direction at Oxford; a doubling of the services to be provided under CS1. Consequently, it was necessary to carry out an assessment to clarify the infrastructure enhancements that would need to be provided to enable the proposed EWR train service frequency. Two sets of potential interventions at locations in the Oxford area required consideration:

- **Increasing platform capacity at Oxford station** to account for high platform utilisation resulting from an increase in EWR services calling at the station.
- **Increasing capacity at Oxford North Junction**, where multiple operator services converge on the approach to Oxford station, to enable a greater frequency of trains to run.

10.2.2 To understand the current situation and way forward at Oxford, it is important to consider the interfaces and interdependencies in the context of increasing EWR services to 4tph in

each direction. Figure 19 below shows the different infrastructure interventions proposed at Oxford and the parties that are assumed will be responsible for delivering them. The following section describes interventions by other parties and the approach that EWR Co would need to take should these not be pursued.

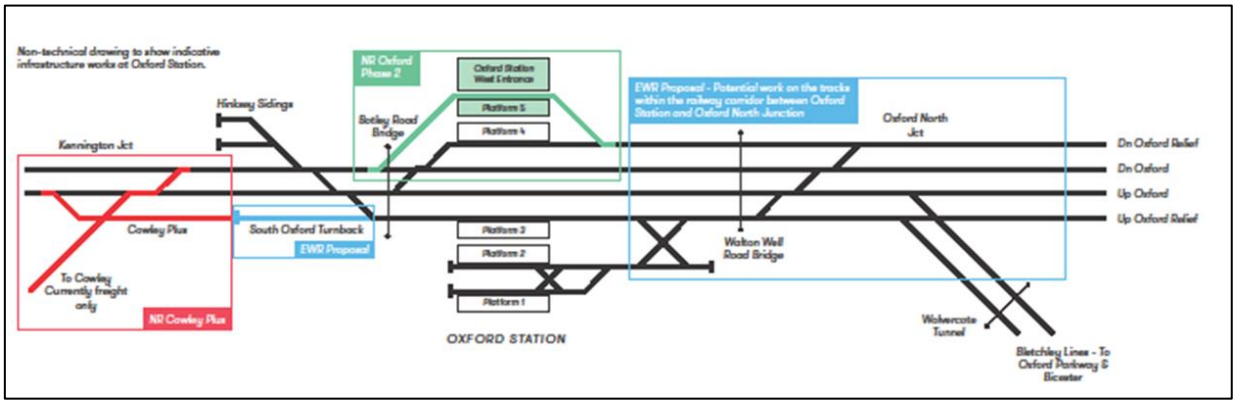


Figure 19 - Infrastructure interventions proposed at Oxford

10.2.3 There are two key interfacing projects being delivered by Network Rail that need to be considered as part of unlocking the capacity constraints:

- **Oxford Phase 2** – construction of platform five at Oxford station, a new western entrance and other infrastructure works. These works are being promoted by Network Rail to increase platform and station capacity at Oxford station. This allows for growth but does not enable EWR services beyond the 2tph introduced by CS1. Network Rail has secured the necessary consents and funding to proceed to construction and this is considered a committed Project. These works are expected to complete in December 2024. It is the base assumption that these works will be completed before the introduction of EWR services[99].

- **Cowley Plus** – introduction of passenger services to the Cowley Branch, providing platform capacity by facilitating turnback of services from the north, which would otherwise have terminated at Oxford station and occupied platforms. It results in the introduction of a new revenue raising route and the construction of new infrastructure, including two new stations, which would support the Oxford Business and Science Parks and future residential development. This project is promoted by Network Rail with capacity expected to come online between 2026-2030, which would be in line with the opening of EWR. Network Rail is currently working on the business case to secure funding

[99] https://www.networkrail.co.uk/running-the-railway/our-routes/western/oxfordshire/oxford-corridor-phase-2/

to develop this, meaning that this is not considered to be committed infrastructure[100].

Oxford – Current Proposal

10.2.4 Taking Network Rail's proposals into consideration, EWR Co has identified that additional turnback capacity is required south of Oxford to increase platform capacity to enable four EWR tph. Further timetable modelling and capacity analysis work is being undertaken in collaboration with Network Rail to validate which EWR infrastructure interventions are required. Some of the potential interventions are outlined below.

Increasing Platform Capacity at Oxford Station

10.2.5 If Cowley Plus goes ahead, it may be sufficient to enable the required platform capacity without an EWR intervention. However, as Cowley Plus is not yet a committed project a potential option to address this in the absence of a Cowley Plus project would be for EWR Co to develop an alternative proposal known as the South Oxford Turnback.

South Oxford Turnback

10.2.6 This is a turnback facility to the South (i.e. towards London) of the platforms that extends the Up Oxford Relief line. This would allow trains to be turned without using platform capacity.

10.2.7 This would be designed to be complimentary to Cowley Plus, should there be a need to proceed in advance of that project, which would allow Network Rail to build the Cowley Plus infrastructure from the end of the South Oxford Turnback.

Increasing Capacity at Oxford North Junction

10.2.8 Currently, Oxford North junction has insufficient capacity to accommodate four EWR tph. As traffic increases, there would not be sufficient infrastructure capacity to accommodate the additional trains. EWR Co is working collaboratively with Network Rail to identify if it is possible to achieve additional capacity through timetable harmonisation[101].

10.2.9 At Oxford North Junction, an infrastructure intervention may not be required for EWR, if timetable harmonisation is sufficient to enable four EWR tph.

10.2.10 However, in case the timetable harmonisation does not unlock sufficient capacity then two potential infrastructure interventions have been identified for Oxford North Junction:

[100] Cabinet approves £4.56m funding package to accelerate plans to reopen Cowley Branch Line to passengers | Oxford City Council

[101] Timetable harmonisation involves optimisation of the operation of train services through means other than infrastructure intervention, for example, by considering the times trains start and end their journeys and the timings that they will be in particular locations.

- **Four Track Option** – An EWR Co proposed enhanced running project, which optimises the use of all four existing tracks north of Oxford through installation of five mainline crossovers.

- **Partial Fifth Track** – An EWR Co proposed partial fifth track that re-joins the Up Oxford Relief north of Walton Well Road bridge to reduce the scope of works and the negative impacts of a full fifth track.

Next Steps

10.2.11 The next step is to undertake operational modelling and further development in collaboration with Network Rail and other stakeholders, to determine the EWR solution at Oxford, with further details to be presented at the statutory consultation.

10.3 Bicester London Road Level Crossing

10.3.1 The Theory of Change analysis demonstrated a need to operate four EWR tph in each direction between Oxford and Bletchley (see section 9.2), a doubling of services to be provided under CS1. This would increase the number of trains passing through the London Road level crossing in Bicester town centre and, consequently, increase the level crossing barrier down time. This has the potential to cause increased congestion and driver frustration.

10.3.2 However, mitigation for the effects of EWR on road users – in the form of a bridge or underpass – would be costly as well as challenging to construct given the relatively dense urban fabric surrounding the location of the crossing. Additional analysis has been undertaken to identify the preferred solution, including a review of previous work in support of the CS1 Transport and Works Act Order (TWAO)[102].

10.3.3 At the 2021 consultation, it was set out that the assumed introduction of a 4tph passenger service by EWR would likely require the level crossing to be closed. Six concepts to mitigate the closure were presented at the 2021 consultation.

- Concept 1: accessible bridge for non-motorised users

- Concept 2: road underpass at London Road

- Concept 3: road bridge at London Road

- Concept 4: road underpass alongside London Road

- Concept 5: road bridge alongside London Road

- Concept 6: alternative road crossing locations

[102] https://www.networkrail.co.uk/running-the-railway/railway-upgrade-plan/key-projects/east-west-rail/bicester-to-bletchley-milton-keynes/

10.3.4 All concepts presented design and construction challenges. Construction of either a bridge or an underpass within the town or near the level crossing would pose significant difficulties: access to nearby roads and properties would be affected and work would be disruptive. Also, the completed crossing would have the potential to be highly intrusive in terms of visual impact and amenity, especially if a vehicular bridge was provided. However, the feedback received during the 2021 consultation strongly expressed the local community's desire to maintain the link between the south east of Bicester and the rest of the town by keeping the level crossing open.

Estimated Level Crossing Down Time

10.3.5 The focus of the ACP assessment was on establishing if closure of the level crossing (with associated mitigation) was required and hence whether there was a better value alternative. This was dependent on a 4tph train service and whether the consequential impacts would be acceptable. An assessment of the impact of operating 3tph over the level crossing was also undertaken to determine the incremental impact of the fourth tph.

10.3.6 Although further technical analysis is required to determine a definitive down time for a 3-4 EWR tph service frequency in each direction, it is possible to provide an indicative range based on previous assessments[103]. This is summarised for an average hour as follows:

- EWR 3tph: 21.7 – 36.0 minutes; most likely: 25-30 minutes.
- EWR 4tph: 26.4 – 48.0 minutes; most likely: 30-40 minutes.

10.3.7 The CS1 Transport and Works Act Order (TWAO) is already consented, and the application considers a barrier downtime of 26.4 minutes per hour to be comparable to other busy level crossings around the UK. It is likely that running either three or four EWR tph will result in an average barrier down time each hour which exceeds the TWAO value of 26.4 minutes.

10.3.8 Given the above and noting that the jobs and growth envisaged in the Theory of Change determines a need for 4tph through the level crossing, an updated level crossing risk assessment is required including barrier down-time assessment and traffic modelling. This will enable a decision on whether the level crossing should be closed.

Mitigation Options for a 4tph EWR Service

10.3.9 The concepts presented at the 2021 consultation were further developed and assessed, resulting in the following options being considered in case it should be needed to address increased barrier downtime and/or the need to close the crossing. The final confirmation of a preference would be dependent on the outcome of an updated risk assessment and completion of an Equality Impact Assessment, enabling these considerations to be taken into account.

[103] Network Rail Downtime assessment in Aug 2015. A physical site census was done in Sept 2016 , after which the report was updated.

A. Keep the crossing open, implement improvements which reduce barrier down time and crossing risk

10.3.10 If the level crossing risk assessment permits, the crossing could be kept open for a four tph EWR train service. Potential improvements could be made to the current signalling arrangements to reduce barrier down time, possibly combined with a reduction in line speed. Additionally, the existing road layout could be enhanced to provide greater separation between stopping points and the barriers, reducing the risk of vehicles overrunning the stopping points and causing a barrier strike. Further, additional pedestrian signals could be installed to improve the warning system when approaching from Langford, as the existing footpath joins directly at the crossing. These enhancements would reduce the safety risk at the crossing by reducing the likelihood of vehicles and pedestrians encroaching onto the crossing.

10.3.11 Option A may still result in a barrier down-time that exceeds acceptable durations, particularly in peak periods. This would result in less time available to use the crossing and increase the risk of misuse. Additionally, the enhancements proposed above have not yet been assessed and may enable the crossing to be operated safely. Further modelling and investigation are required to determine the feasibility of keeping the crossing open, with mitigation measures in place. However, it is possible that, upon further investigation, this solution would be found not to be feasible or safe. In that case, this option could not be pursued.

B. Keep the crossing open, implement improvements which reduce barrier down time and crossing risk, install non-motorised user overbridge or underpass at or near London Road

10.3.12 The measures outlined above in Option A could be complemented with a new accessible Non-Motorised User (NMU) bridge or underpass provided at the crossing. This would allow pedestrians and cyclists to cross during barrier closure and so preserve the connection for NMUs. It would help to reduce the risk of pedestrian misuse which accounts for the greatest number of incidents at the crossing and would also make the extended down time less inconvenient for the public. Reconfiguration of station car parking would be required if it were to be located at the level crossing. This approach would be dependent on an acceptable barrier down time for vehicles, and other conditions, as outlined above in Option A, and a satisfactory level crossing risk assessment. Again, this may not be acceptable in practice as vehicle users would still have limited time available to use the crossing and this would increase the risk of vehicular misuse.

C. Keep the crossing open. Implement improvements which reduce barrier down-time and crossing risk. Provide a non-motorised user bridge or underpass at or near London Road and an offline road bridge to allow vehicles to cross the railway.

10.3.13 This option builds on Option B with the addition of a road bridge to allow vehicles to cross the railway when the barriers are down. At present, a preferred option for the location of a road bridge has not been identified and further feasibility work needs to be completed to refine

the preferred option. As with the other options this would be dependent on further level crossing risk assessment and traffic modelling.

D. Close the crossing, provide a diversion, and construct a non-motorised user bridge or underpass at or near London Road

10.3.14 This option would entail closure of the crossing, vehicle diversion and provision of an accessible NMU bridge or underpass at or near the current crossing location. Vehicles would be diverted across the railway via existing roads including the A41; a distance of up to 4km. There is significant public and stakeholder opposition to this approach, as many people believe road connectivity should be maintained in the London Road area to avoid excessive journey time, the division of the town and the risk of 'rat running'.

E. Close the crossing, provide a non-motorised user bridge or underpass at or near London Road and an offline road bridge to allow vehicles to cross the railway.

10.3.15 The final option – to be selected if a vehicular road diversion (as per Option D) is judged to be unacceptable – is to close the crossing and provide both a bridge for vehicles and a bridge or underpass for non-motorised users. A road tunnel or underpass was discounted due to the likely impact on a significant number of local properties to achieve the required inclines on the approaches and the high cost involved. Potential locations for a new vehicular overbridge are being investigated.

10.3.16 This option would provide the least inconvenience to those wishing to cross the railway whilst enabling an increase in train frequencies. However, in addition to the high cost of this solution, a large structure in this location would have an adverse environmental impact.

Bicester London Road Level Crossing – Current Proposal

10.3.17 A review of down time estimates at the level crossing suggests there is likely to be a requirement for its closure, as the maximum down time of 26.4 minutes presented for a 'Growth' scenario equivalent to 4 EWR tph through Bicester as part of the CS1 TWAO, is likely to be exceeded.

10.3.18 Option E (close the crossing**,** provide a non-motorised user bridge or underpass at or near London Road and an offline road bridge) is the most likely outcome and, therefore, EWR Co's working assumption. This is because it provides a means to cross the railway for both NMUs and vehicles whilst removing the risk of level crossing misuse. However, this is not yet a conclusive position and requires further feasibility work. Therefore, further investigation is proposed to understand the potential to maintain the existing crossing for local traffic. This will require an updated risk assessment, to evaluate whether a compliant risk level for or 4tph can be achieved with the crossing remaining open. In addition, the selection of the preferred option will be subject to an Equality Impact Assessment.

10.3.19 The preferred option will be presented in detail at the statutory consultation to enable stakeholders, including residents, business owners and current users of the crossing to provide feedback on the proposal.

10.4 Marston Vale Line

10.4.1 As discussed in section 9.3, the ACP assessment has sought to optimise the infrastructure works required between Bletchley and Bedford, to present the most affordable and viable proposition that would support the proposed train service required to unlock the economic opportunity identified by EWR.

10.4.2 Based on the findings of the Theory of Change, as summarised in section 9.3, the train frequency on the MVL was reduced from four tph (as set out at the 2021 consultation) to 3tph in each direction. A four-car service for EWR Co semi-fast services was assumed, on the basis of demand forecasting. From the position set out at the 2021 consultation, line speeds were reduced from 100mph.

10.4.3 The above would enable the following key changes to the proposed infrastructure presented in the 2021 consultation:

10.4.4 **Level crossings:** The most significant increase in risk through the introduction of EWR services would be at pedestrian, bridleway and user worked crossings – Non-Motorised User (NMU) crossings. By lowering line speeds, the level of risk increase at crossings would also reduce. The level of risk increase as a result of additional train services would be lower at the full barrier highway crossings and where level crossings provide access to platforms, as trains would typically be slowing to serve the station, albeit patronage could be higher. In summary, the following changes are proposed, with the rationale provided in Table 37 below:

- Closure of four user-worked crossings, 12 pedestrian crossings and one occupation-CCTV crossing, which are all lightly used. The current assumption is that no new crossings would be provided in their place.
- Upgrade of two automatic half-barrier highway crossings (Marston Road and Kempston Hardwick) to full barrier crossings with either CCTV or obstacle detection.
- Safety intervention measures at two pedestrian and bridleway crossings such as crossing warning systems (Pony level crossing and Forty Steps level crossing).

10.4.5 EWR Co's preferred proposals in relation to MVL level crossings following the ACP are summarised in Table 37 below.

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
Fenny Stratford	Highway – CCTV	Vehicles: Close crossing and provide one of the following; diversion	Retain as a CCTV crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
		routes, options for a new link road north of crossing. Pedestrians: options for diversion or a bridge.		compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing rather than create new link roads and diversions. This would reduce community severance within Fenny Stratford.
Bow Brickhill	Highway – CCTV	Close crossing and provide one of the following: new online bridge, with new link road between Caldecotte Lake Drive. and Bradbourne Drive, new offline bridge/ underpass (Three offline optio ns presented).	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and would potentially enable us to retain the crossing rather than install a new bridge. Traffic use is high, with the Red Bull campus and Caldecotte in close proximity, although alternative routes are available. Modelling will be needed to confirm this is acceptable.
Browns Wood	Footpath – FPW	Close crossing and provide new bridge or underpass. (Three options presented) .	Close & divert to Pony crossing.	The level of usage of the crossing is low, diversion to Pony bridleway (below) adds approximately 600m to a journey (or 6 minutes at an

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
				average walking pace).
Pony	Bridleway – FPGT	Close crossing and provide a new bridge or underpass. (Three options presented).	Upgrade to a MSL crossing (a miniature warning light/ miniature stop light crossing).	The level of usage of the crossing is low. Reducing the proposed increase in line speed and the train frequency of 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and would potentially enable us to retain the crossing rather than install a new bridleway bridge or underpass.
Woodleys Farm	Occupation – UWCT	Closed and diverted to new road crossing close by, or close and provide a new private bridge crossing.	Close & extinguish crossing rights.	The level of usage of the crossing is low. Further assessment will be undertaken regarding the private crossing requirements.
Fisher-man's Path	Footpath – FPW	Closed and diverted to new road crossing / private bridge crossing in proximity to Woodleys Farm.	Close with no re placement.	The level of usage of the crossing is low. An alternative would be to redirect users to Woburn Sands level crossing. Network Rail has already obtained authorisation for a temporary diversion through Woburn Sands level crossing. Further assessment will be undertaken regarding diversions of the crossing.

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
Woburn Sands	Highway – CCTV	Two options: Remain open; closure with an offline road bridge to the west of Woburn Sands connecting between Newport Road and Bow Bricknell Road, pedestrians diverted to new bridge at former School Crossing.	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the n proposals presented in the on-statutory consultation and potentially enable us to retain the crossing rather than create a new road crossing. This would avoid intrusive infrastructure in this urban location.
Mill Farm	Footpath – FPW	Two Options: Closed, diverted to new bridge at former School Crossing; or a new footbridge.	Close & divert footpath back to Woburn Sands level crossing	The level of usage of the crossing is low.
Sewage Farm	Footpath – FPW	Closed and close footpath.	Close & divert footpath.	The level of usage of the crossing is low.
Apsley Guise	Highway – CCTV	Two options: closed, offline road bridge to the east (near Old Manor Farm LX) of Aspley Guise; closed with no replacement and diversion routes.	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency of up to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. This would avoid intrusive infrastructure or potential community

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
				severance from closure.
Old Manor Farm	Footpath – FPW	Two options: Closed and new road bridge or new pedestrian bridge.	Close & divert footpath to Aspley Guise.	The level of usage of the crossing is low.
Berry Lane	Occupation – UWCT	Two options: Close and new access road from new road bridge; or diversion via access tracks.	Close and diversion via access tracks	Proposals are as one of the options presented at non-statutory consultation. Network Rail has already obtained authorisation for the closure of the crossing
Long Leys	Accomm-odation – UWC	Close and diversion via access tracks.	Close and diversion via access tracks	Proposals as presented at non-statutory consultation.
Husborne Crawley No6	Footpath – FPS	Close and two options: diversion via access tracks; new footbridge.	Close and diversion via access tracks	The level of usage of the crossing is low. Proposals are as one of the options presented at non-statutory consultation.
Matey Boys	Accomm-odation – UWC	Close and two options: diversion via access tracks; new footbridge at Husborne Crawley 06.	Close and diversion via access tracks	The level of usage of the crossing is low. Proposals are as one of the options presented at non-statutory consultation.

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
Husborne Crawley No10	Footpath – FPW	Close and new footbridge, new ramps connecting to A507, or divert to new footbridge at Ridgmont.	Close & extinguish footpath.	The level of usage of the crossing is low. Further assessment will be undertaken regarding a diversion via access tracks linking to Ridgmont level crossing.
Ridgmont	Highway – CCTV	Close and divert traffic, option of a pedestrian footbridge (connected to Husborne Crawley 10 options).	Retain as a CCTV crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing.
Broughton End	Footpath – FPS	Close & divert to Forty Steps crossing	Close & divert to Forty Steps.	Proposals as presented at non-statutory consultation.
Forty Steps	Footpath – FPS	Close, new online underpass.	Upgrade to a MSL crossing.	The level of usage of the crossing is low. Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. As an underpass raises

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
				potential issues due to a high-water table in this location.
Playing Field	Footpath – FPS	Close and divert to new road bridge or underpass east of crossing.	Close & divert to Forty Steps.	Non-statutory consultation proposals at this crossing were to close and divert east to new crossing point, the crossing would now divert to Forty Steps instead.
Lidlington	Highway – CCTV	Two options: remain open; close with offline bridge west of Lidlington and footbridge at crossing.	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk and potentially enable us to retain the crossing. This would retain connectivity within the village. Additionally, retention of the crossing would reduce the need for the railway to bypass the village.
Piling Farm South	Footpath – FPK	Close and divert footpath.	Close and divert footpath.	Proposals as presented at non-statutory consultation. Network Rail has already obtained authorisation for this work.
Marston Rd	Highway – AHB	Close crossing and provide new bridge.	Upgrade to a MCB-OD crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
				compared to the Non-Statutory Consultation and potentially enable us to retain the crossing. The level of usage of the crossing is low. Noting there are industry proposals to close this crossing, EWR Co will work closely with Network Rail to understand these and agree the way forward.
Millbrook	Highway – CCTV	Close and provide either a new bridge or underpass. (three options presented).	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. The level of usage of the crossing is low.
Green Lane	Highway – CCTV	Close and provide either a new bridge or underpass.	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. The level of usage of the crossing is low.

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
Stewartby Brick-works	Occupation – CCTV	Close with no replacement.	Close with no replace-ment.	Proposals are as presented at non-statutory consultation. Network Rail has already obtained authorisation for this work.
Wootton Broad-mead	Highway – CCTV	Close and provide new bridge. (Two options presented) .	Retain as a CCTV Crossing.	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. The level of usage crossing of the crossing is low.
Wootton Village	Footpath – FPS	Close and provide new footbridge.	Close and divert to Kempston Hardwick.	The level of usage of the crossing is low.
Kempston Hardwick	Highway – AHB	Close and provide new bridge. (Three options presented) .	Upgrade to a MCB-OD Crossing .	Reducing the proposed increase in line speed and the train frequency to 3tph would reduce risk compared to the proposals presented in the non-statutory consultation and potentially enable us to retain the crossing. The level of usage of the crossing is low. Noting there are industry proposals to close this crossing,

Name	Current Crossing Type	NSC 2021 Consultation Options	ACP Proposal	Reasoning
				EWR Co will work closely with Network Rail agree the way forward.
Woburn Road	Footpath – FPW	Close and provide new footbridge. (Two options presented).	Close with no replace-ment.	The level of usage of the crossing is low. Noting there are industry proposals to close this crossing, we will work closely with Network Rail agree the way forward

Table 37 – MVL Level Crossings Proposals

10.4.6 The preferred proposals for level crossing closures result in a substantial reduction in closures in comparison with the proposals at the 2021 consultation. A full risk assessment of these proposals will be undertaken at the next stage of development to confirm the proposals that will presented at the statutory consultation.

10.4.7 Stations: The assessment of station requirements is based on the train service of 3tph in total on the MVL required to meet the deliver the growth opportunities set out in the Theory of Change. Rolling stock assumed as part of ACP is a class 196 train which is 48m (2-car) or 96m (4-car), the latter length of train being part of the longer-term plan for EWR services. This would require platform lengths of 58m and 106m respectively, allowing for a 5m stopping tolerance at the front and rear of the train.

10.4.8 The majority of stations on the MVL have platforms between 37m and 68m in length. Stations that will be served by a semi-fast service, should this be confirmed at the next stage, require platform lengths of 106m. For stations only served by the stopping service (2-car) that have platforms shorter than the required 58m, it is expected that the existing derogations would remain in place so they would not need to be extended. Platform widths are below the minimum safety standard of 2.5m at some stations. With the proposed increase in line speed and train frequency, current platform width derogations may no longer be acceptable and work to increase the width of platforms may be required.

10.4.9 At the 2021 consultation, two service concepts were presented; a concept to retain and modify existing stations and a concept to focus services on a smaller number of better located stations. The stopping pattern was not considered further as part of ACP as this would not result in significant cost efficiencies. Further work will be undertaken at the next stage to consider stopping patterns on the MVL. ACP identified several potential different stopping patterns. However, the outcomes of ACP enable flexibility in respect of the calling pattern.

Therefore, it has not yet been determined which stations will remain open or close and which will service the trains which connect the whole route.

10.4.10 Where station closures or relocations are required, it is expected that authorisation would be sought for this in the application for a development consent order. So far as relevant and possible, this would be expected to address the case for closure/relocation in a comparable way to the statutory regime under the Railways Act 2005.

10.4.11 For the purposes of timetable and demand modelling, the assumptions made regarding station proposals served by EWR services are detailed in Table 38 below. Woburn Sands, Ridgmont and Stewartby are assumed to be served by the EWR semi-fast services and would therefore need to be upgraded to accommodate passenger demand. It is not possible to expand Woburn Sands and Stewartby stations in their current locations, which are constrained, so they would need to be relocated. Further work will be carried out at the next stage to determine station locations and stopping pattern. This will be presented for comment at a statutory consultation.

10.4.12 The preferred infrastructure solution for Woburn Sands would be to move the station to the west of its existing site as per the proposal for the station in the 2021 consultation. Stewartby's preferred relocation would be north of the existing station within the Stewartby Brickworks Site. Again, this location was proposed at the 2021 consultation. For stations served only by the stopping service, compliance with safety standards only is assumed.

MVL Scope Recommendations			
Station	New Station / Retain	Trains Stopping per Hour	Scope
Fenny Stratford	Close or retain	1	Close or rectify existing platform non-conformances
Bow Brickhill	Close or retain	1	Close or retain – rectify existing platform non-conformances including platform widening
Woburn Sands	New	3	New, re-located station constructed
Apsley Guise	Close or retain	1	Close or rectify existing – platform non-conformances including platform widening
Ridgmont	Retain and extend	3	Extension of existing platforms
Lidlington	New or retain	1	New, re-located station constructed or no further works required –

			platforms acceptable width
Millbrook	Retain	1	No further works required – platforms acceptable width
Stewartby	New	3	New, re-located station constructed
Kempston Hardwick	Close or retain	1	Close or rectify existing – platform non-conformances including platform widening

Table 38 - MVL Stations Scope Recommendations

10.4.13 For Bletchley station, a range of improvements were previously considered, for example, altering or replacing the current footbridge, enlarging the car park and creating a new eastern entrance. ACP identified that EWR Co needs to continue review opportunities for further improvement. While ACP does not identify that an eastern entrance is a requirement for EWR, further development of proposals may still be required at the next stage of the Project to determine whether to proceed with the eastern entrance to support the development of a vision and masterplan for the area.

10.4.14 **Track** Infrastructure**:** Two key infrastructure enhancements to the track between Bletchley and Bedford were presented at the 2021 consultation:

- To reinstate the second track alongside the section of single-track railway at Fenny Stratford, east of Bletchley, which would increase capacity and allow for the additional EWR services. This is considered to be a part of the preferred alignment for EWR.

- The need for a passing loop in the vicinity of Ridgmont Station or in the Stewartby area to allow faster trains to overtake slower stopping services safely. The passing loop would need to be approximately 1km long to enable freight trains to use it as well as passenger services. A passing loop is still required but further work is being undertaken to assess the precise location. This will be presented at the statutory consultation.

Marston Vale Line – Current Proposal

10.4.15 In summary, following further assessment of the MVL, the proposal is that the passenger speed on this section is increased from 60mph to a line speed that remains less than 100mph. This results in a different and more straightforward series of strategic infrastructure interventions in comparison with a full upgrade of the line and asset renewal as assumed and set out in the 2021 consultation.

10.4.16 Service concepts for the MVL have not been developed in detail; this will be done at the next stage of development and prior to a statutory consultation. This ACP assessment has confirmed the infrastructure needed for a 3tph service (2 EWR plus the existing stopper, if retained, or 3 EWR tph on the MVL) using 4-car trains for EWR semi-fast services; this is the emerging requirement following demand forecasting. It is expected that any station closures that are required would be considered and consulted upon as part of the statutory consultation.

11. Conclusion

11.1 The Case for East West Rail Restated

11.1.1 The Affordable Connections Project (ACP) has involved extensive work by EWR Co to review the strategic case for the Project and to investigate the potential for better value options to deliver improved connectivity for communities between Oxford and Cambridge.

11.1.2 This work has demonstrated that there is a strategic need for the Project, based on a forward-looking transformation scenario for the region which is driven by unblocking constraints to the growth of Cambridge, referred to as a Theory of Change. This demonstrates that the region has the potential to become an economic supercluster by bringing together complementary specialisations across the region, adding an estimated £4bn-5bn[104] GVA per annum based on Cambridge's growth alone. The area has also proven to provide economic resilience for the UK economy during successive downturns. The region contributed £120bn in GVA to the economy in 2021, with the potential to rise to between £191bn and £274bn a year if a programme of building new homes and linked-up towns by rail and strategic road was implemented[105].

11.1.3 The ACP has identified lower cost options than those presented in the 2021 consultation. This has been achieved by relaxing the Sponsor's Requirements and the Programme Wide Output Specification while making sure that the key benefits of EWR can still be achieved. This reduces EWR's costs. Heavy rail already exists or is in construction for EWR west of Bedford and there are options comprising different modes east of Bedford. However, only heavy rail produces a capacity that could be expanded towards meeting the transformational forecast requirement to deliver 4,000 passengers per hour east of Bedford.

11.2 A Preferred Single Route Option

11.2.1 Analysis of demand forecasts in future years has been undertaken to inform the service pattern for EWR.

11.2.2 On the basis of this assessment the recommended end-to-end transport solution for EWR between Oxford and Cambridge is summarised in Figure 20 below.

104 Estimated by EWR Co by multiplying the average GVA per worker for the Cambridge region by the projected number of additional jobs.

105 The life-sciences industry is a jewel in Britain's economy | The Economist

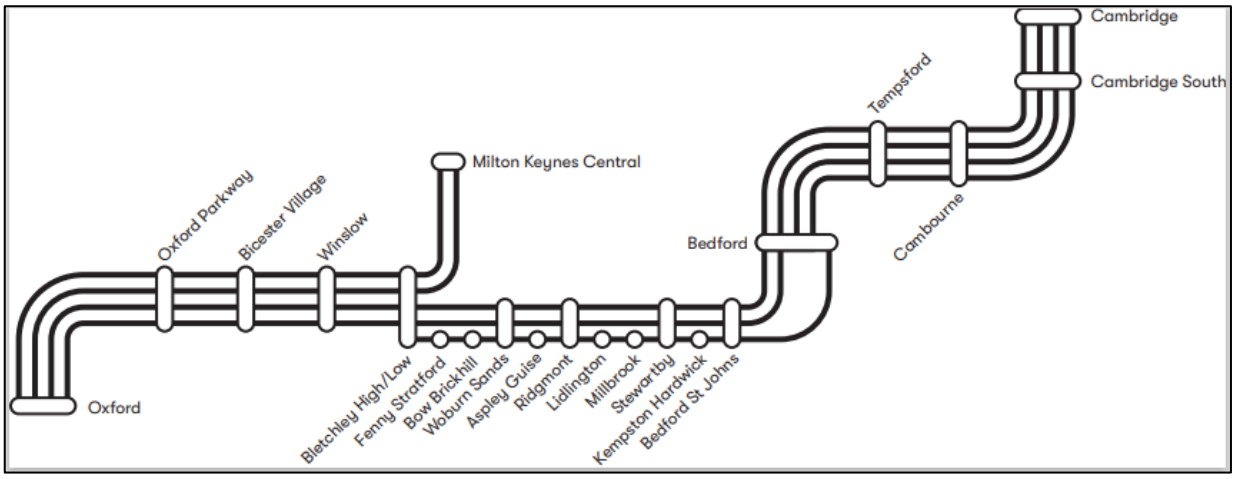


Figure 20 - Schematic of emerging preferred option

11.2.3 The cost of this preferred option has been estimated at £4.46 – £5.34bn (base cost plus risk, excluding electrification and inflation), noting that proposals are still in early development in relation to the Green Book and are subject to further work and consultation.

11.2.4 EWR Co continues to explore the optimum traction power solution given the technical, environmental, economic and customer experience objectives of the Project but the working assumption agreed with the DfT is that it will not be diesel powered. As noted previously, the costs of electrification are not included in the baseline estimates for the Project.

11.2.5 The conclusion of the ACP maintains the 2021 consultation position that EWR is predominately a passenger service but should enable low growth freight. The outcome of the ACP will allow EWR Co to revisit the number of paths created.

11.2.6 The infrastructure solution that supports the emerging preferred service pattern is set out below.

- **Oxford** – It is assumed that Network Rail's delivery of Oxford Phase Two and Cowley Plus would provide the necessary infrastructure to enable the operation of EWR at 4 tph. In addition, timetable harmonisation is assumed to address constraints to the North of Oxford. As a contingency, should the above projects not progress or not deliver as assumed, EWR Co will develop four-track and partial fifth-track options between Oxford station and North Oxford Junction, as well as the provision of a South Oxford turnback.

- **Bicester London Road Level Crossing** – The preference is that the level crossing would be closed, with provision of a new vehicular overbridge to be provided away from the current alignment of London Road and a separate NMU bridge in the vicinity of the current crossing location. However, more detailed analysis will be undertaken to confirm this proposal and determine whether the road crossing could be retained for local traffic.

- **Marston Vale Line** – Subject to the consideration of service patterns and the updating of risk assessments for level crossings at the next stage, the extent of work proposed for the MVL is as follows: the section of single track at Fenny Stratford would be twin tracked; the extent of work to level crossings would be minimised, with the closure of crossings where this can be achieved for an appropriate cost and without significant mitigation. Further work will be undertaken to determine where new stations should be built and where stations should be upgraded, to suit customer demand and to meet current Network Rail and other national standards and requirements.

- **Bedford Approaches** – A northern approach to Bedford from the Cambridge direction, making use of six-tracking as per the emerging preferred option at the 2021 consultation, remains the preferred option as it is the only viable way of accommodating the required number of EWR trains. Bedford St Johns station would be relocated as per the emerging preference set out in the 2021 consultation and the track through this section would be doubled; Bedford Station would be redeveloped, as proposed at the 2021 consultation.

- **Alignment between Clapham and The Eversdens** – Alignment 1 (with Tempsford variant as an emerging preference, subject to future consultation) is the preferred option for the route between Bedford and Cambourne as this secures the advantages of Alignment 1 over Alignment 9 whilst enabling a potential station at Tempsford, which is the location most expected to be most conducive to growth, as envisaged by EWR Co and in Homes England Research.

- **Cambridge Approaches** – Provision of good access to Cambridge South and the Cambridge Biomedical Cluster is central to the realisation of the economic opportunity identified in the Theory of Change. For this reason, as well as better operational flexibility, the preferred option is a southern approach.

- **Additional infrastructure –-** To enable the operation of the railway, the following infrastructure would also be provided, in locations yet to be confirmed: passing loops on the MVL and near Cambourne, a light maintenance depot, signalling control centre and management centre. At this stage provision has been made for these items within the cost plan only. Further work will be carried out at the next stage and proposals put forward for comment at the statutory consultation.

12. Appendices

12.1.1 Appendices are provided in separate files. A summary is provided below.

No	Document title
1	Long list of Scheme Options
2	Brief summary of demand modelling approaches
3	Theory of Change Transport Constraints
4	Theory of Change Trip End Modelling
5	Detailed appraisal tables
6	Heavy Rail route options: Councils impacted and potential issues, concerns and benefits
7	Light rail paper
8	Cost Estimates
9	EWR Co Assessment Factors
10	AVRT Paper
11	Case Studies
12	North of Bedford 4-track Operational Impact Assessment
13	Cambridge Operational Impact Assessment

Table 39 - Appendices