Regional Investment Programme
M25 Junction 28 Improvements

Stage 2 Scheme Assessment Report
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The Project Manager is responsible for production of this document, based on the contributions made by his/her team existing at each Stage.

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Contents

Executive Summary

The need for the scheme

In December 2014, the Department for Transport (DfT) published the Road Investment Strategy (RIS) for the first road plan period of 2015 to 2020. The RIS sets out the list of schemes that are to be delivered by Highways England over the period covered by the RIS1 period. In the Route Strategy for the London Orbital and M23 to Gatwick corridors (April 2014) Highways England identified Junction 28 as a key junction with capacity issues.

Based on the RIS Statement, a scheme to alleviate and manage current and future congestion through the junction is described in the Client Scheme Requirements for Junction 28 as, the introduction of a new free flow link for right turning traffic between the M25 motorway anti-clockwise and the A12 east.

Based on the evidence review undertaken during PCF Stage 0, four key problems were confirmed for Junction 28:

- **Problem 1** - Congestion and delay on the Junction 28 roundabout disrupts journeys on the strategic road network and local roads
- **Problem 2** - Actual and perceived safety concerns associated with driver movements on the Junction 28 roundabout
- **Problem 3** - Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times
- **Problem 4** - Air quality is an issue at the junction.

Without appropriate intervention to improve the performance of Junction 28, each of these problems would be expected to deteriorate further in the future as traffic levels increase. This would result in significant consequences for the efficiency of traffic flow, road safety, network resilience, and user satisfaction. Ultimately it will reduce the ability of the junction to perform its role in supporting local and regional aspirations for development and growth.

Specifically, without intervention:

- Junction 28 will be a constraint on the wider SRN caused by the inadequate capacity of the junction and the increasingly high traffic demands
- By 2037 average delays across all movements on Junction 28 will be at least five times that experienced at present (increasing to 5 minutes on average)
- Average speeds through the junction (excluding mainline M25 and A12 movements) consequently reduce by 25% by 2037
- The ability of the junction roundabout to remain open and available in the event of an accident or incident will diminish
- The ongoing local air quality issues will be exacerbated.

The scheme specific objectives have been identified in line with addressing the agreed problems:

- To cater for future traffic demands efficiently with minimal delay and to support future development and economic growth
- To improve the network resilience and enable smoother flow of traffic and reliable journey times
- Improve road safety on the approaches to and through Junction 28
- Minimise the impact of high traffic volumes and stopping traffic on local air quality and noise.

These align closely with the current business strategies for the South East Local Economic Partnership and for local and central government. They also align well with Highways England's performance specification area and outcomes set out in in their Strategic Business Plan.

Constraints

Several planning factors and related constraints have been identified and considered which impact on the development and choice of a preferred option.

A key constraint is concerned with several environmental issues identified around Junction 28. These relate to the proximity of several AQMAs, a number of Noise Important Areas, several small water courses in close proximity of the scheme, two designated Ancient Woodlands, a Site of Metropolitan Importance (SMI) for nature conservation, the several Local Wildlife Sites, a listed building, and designated Conservation Areas.

Option identification

During PCF Stages 0 and 1 it was confirmed that the identified problems would be best resolved through a highway intervention aimed at improving Junction 28 in line with the RIS Statement. A comprehensive review of a full range of options was completed in Stage 1 taking account the anticipated impacts of the options together with a detailed understanding of the key issues, risks and constraints. A key focus for the refinement and development of the options was to find an option that would achieve the identified objectives and outcomes while being affordable.

Following this initial review 3 options were short-listed to be taken forward to PCF Stage 2 for further consideration. These included:

- **Option 5B -** This option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28. It involves the widening of the existing M25 viaduct to support the proposed new M25 anticlockwise diverge and off-slip road for accessing the new link.
- **Option 5C -** This option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28. By moving further north compared to Option 5B, Option 5C avoids the need to widen the existing M25 structures. Following the diverge, the alignment of the new link turns into the adjacent land to the north-west of the existing junction.

- **Option 5F -** Option 5F is a variation of Option 5C but provides a two-lane loop road merging with the A12 eastbound carriageway underneath the existing Junction 28 roundabout structure.

The assessment against achieving the objectives

Each of the options assessed perform similarly against the scheme objectives, providing strong benefits with little difference shown in terms of forecast journey times, average delays and speed.

Traffic

Under a 2037 Do-minimum scenario a significant deterioration in traffic conditions is expected. Average delays could be up to 2 times that experienced in 2014 in the AM and PM peak hours increasing to around 3 to 4 minutes in the AM and PM peaks. As a result, journey times on key movements will also increase, and for example the A12 west to M25 (north and south) and Brook Street could see increases of 20% to 50% in the AM peak, and double in the PM.

With the introduction of the new link road each option provides additional capacity and can accommodate a greater throughput of traffic, thereby improving the junction's performance relative to the 2037 Do-minimum situation. Each option is expected to provide a reduction in average delay of around 5% in the AM peak and 20% in the PM, with average speeds increasing by 10%.

The additional capacity provided in each option also increases the resilience of the junction to incidents and reducing the delays associated with incidents and lane closures. In doing so the options will also improve journey time reliability for commuting, business traffic and other users through the increased capacity provided by the new free-flow link.

Safety

It has been established that safety is currently a key issue at Junction 28. However, the issue and consequences are concerned with the high occurrence of incidents and the implications on the disruption across the wider highway network as well as harm and injury. Many accidents are damage only, and of the total casualties resulting from the crashes 90% were slight injury. The level of killed and serious injuries (KSIs) is low with on average just under 1 KSI incident each year.

The impact of each option is to reduce traffic throughput using the existing roundabout, therefore reducing the number of accidents occurring on the roundabout. However, this benefit is offset by traffic using the new link and the expected number of accidents forecast to occur on the new link in each option. Hence there is a very slight negative impact on overall accidents predicted for each of the options due the slightly longer distance travelled for M25 anti-clockwise to A12 Essex traffic.

Due to the low level of killed and serious injuries recorded at Junction 28, this scheme is not expected to contribute significantly to Highways England’s KPI of reducing KSI collisions by 40% by 2020.

Non-motorised users

The study area is served by a number of footways, crossing and shared use paths, which would be traversed or impacted to some extent by all route options. These public rights of

way are important public amenity resources, and in all options the availability and continuity of these would be maintained.

Cost and value for money

Cost estimates for each of the options is set out below.

	Option 5B	Option 5C	Option 5F
Lanes on new link	1	1	2
Most likely cost estimate (£million) in current prices*	63.4	65.3	76.0

*Note: * 2014 undiscounted cost*

Against a set budget of £50 million to £100 million for the scheme, Options 5B, 5C and 5F are considered to be affordable options at this stage.

There is little difference between the benefits that can be realised for each option, reflecting that each option essentially does the same thing, and therefore achieve similar outcomes against the project objectives as discussed above.

Based on the findings of a value management workshop all options score well in terms of value against achieving the objectives. Option 5F did show the strongest weighted value score, largely reflecting its ability with 2 lanes to cater forecast traffic volumes beyond the design year.

Recommendation

Option 5F has been recommended as the preferred option as it best achieving the scheme objectives, balancing the needs of road users, the community, the environment and businesses. This recommendation is based on the following:

- Performs strongest in achieving the primary objective of improving journey times, particularly in the longer term beyond the 2037 design year
- Options 5B and 5C are 1 lane options and forecast traffic volumes are expected to approach and exceed capacity beyond the design year. It is noted that two lanes cannot be provided on the Option 5B alignment.
- Option 5F can be constructed without the significant disruption to traffic on the M25 motorway as expected under Option 5B (which requires widening of the M25 viaduct over the Junction 28 roundabout)
- Option 5B involves a departure from standard relating to the sub-standard distance between the successive diverges on the M25 anti-clockwise carriageway. This presents a significant concern over operational safety of the road user
- Option 5F provides greater network resilience through having a second lane on the new link
- Option 5F offers a two-lane link that is expected to be more advantageous in terms of maintenance and avoiding disruption to traffic
- Provides a strong BCR of 6.1 despite the additional cost associated with providing a second lane on the new link to cater longer term forecast demand flows.

It is noted that Option F (and Option C) is expected to have more adverse environmental impacts relative to the more compact Option B scheme. However, it is also considered that

these impacts can be managed and mitigated where necessary, and that with Option 5F offering more land this would give more opportunity for landscape planting and ecological enhancement.

1 Introduction

1.1 Background

In the Route Strategy for the London Orbital and M23 to Gatwick corridors (April 2014) Highways England identified Junction 28 as a key junction with capacity issues. The capacity issues at Junction 28 are attributed to:

- high volumes of traffic on movements between the M25 and the A12 towards Essex passing through the roundabout section
- the relatively high volumes of traffic to and from Brentwood via the A1023 Brook Street, accessed via an uncontrolled intersection on the roundabout
- limited capacity on the roundabout section due to the high traffic levels and the capacity of the signalised intersections.

The Client Scheme Requirements for M25 Junction 28 refer to the introduction of a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east.

In 2015 Atkins Ltd. were commissioned by Highways England to undertake the Project Control Framework (PCF) Stage 0 – Strategy, Shaping and Prioritisation. This work confirmed the need for an improvement at Junction 28, and considered initial options available for taking forward to the Option Identification Stage (PCF Stage 1).

The overall aim of PCF Stage 2, as set out in the Client Scheme Requirements and the PCF Handbook, is to identify and assess a full range of project options that give effect to the RIS statement, and deliver the identified project objectives.

The identified options have been considered alongside a multi-modal context, and seek to improve traffic conditions through the Junction 28 in terms of journey times, journey time reliability and safety.

1.2 Previous work

Several studies have been completed over recent years to improve Junction 28. These are summarised below.

Route Investment Strategy & Option Assessment Report (2015)

The Option Assessment Report (OAR) produced in January 2015 recommended the following options:

- ***Short Term*** – Upgrade junction technology to SCOOT to improve capacity; reconfigure junction markings to improve lane use and therefore junction capacity
- ***Medium Term*** – Widen some or all of the slip roads and circulatory area to increase junction capacity, queueing space and reduce the risk to mainline traffic; investigate free-flow slips bypassing signals for critical movements
- ***Longer Term*** – Construct bridges to create free flow for critical movements
- ***Maverick Solution*** – Close or divert A1023 Brook Street to reduce the pressure on the junction.

M25 Junction 28 / A1023 Brook Street Safety Improvements Study (2014/15)

In 2014/15 Connect Plus Services (CPS) on behalf of Highways England undertook an option study to examine ways to improve safety and reduce delays on the Brook Street approach. The study identified options to rectify the inconsistencies in the signing and lane markings, signalisation of the A1023 approach, and improve safety at several locations around the junction. The analysis also developed two longer term options:

- the addition of a free flow link between the M25 anticlockwise and the A12 eastbound,
- increasing the number of circulatory lanes increased from three to four to increase the circulatory capacity
- The option for an additional free flow link was considered for further investigation as an appropriate long term solution with significant benefits.

Signal upgrade scheme (2015)

The study looked at upgrading signal infrastructure on the main roundabout – replacing ducts, upgrading the method of signal control to SCOOT[1] / MOVA[2] , installing a new controller box, etc. The existing infrastructure was outdated, and was adversely impacting on the performance of the junction, and local congestion.

1.3 Timeframe

The scheme is to be funded regionally and is being developed under the RIS 1 road plan period (2015 to 2020), with construction planned to start by early 2020.

Table 1-1 sets out the timeframe over which the scheme will be developed from the current stage through to construction. This is consistent with the PCF Stage 1 Client Scheme Requirements.

Table 1-1 Scheme timeframe within RIS 1

Stage	Phase	Start date	End date
1	Option Phase	10/2015	10/2016
2		11/2016	07/2017
3	Development Phase	08/2017	07/2018
4		08/2018	11/2019
5		12/2019	03/2020
6	Construction Phase	04/2020	03/2022
7		04/2022	05/2023

[1] SCOOT – Split Cycle Offset Optimisation Technique.
[2] MOVA – Microprocessor Optimised Vehicle Actuation.

1.4 Scheme context

The Government's Road Investment Strategy (RIS) was published in December 2014 and sets out a long-term vision for the strategic road network, together with a multi-year investment plan and high-level objectives for the first road plan period of 2015 to 2020.

The RIS identifies five overarching long-term challenges for the strategic road network (SRN), of which the following are identified as being relevant to the M25 Junction 28:

- **Access around major cities** – addressing serious congestion at the periphery of the major cities which are anticipated to be the greatest drivers of growth (particularly London) through lasting solutions which make the best use of all modes
- **Connecting outlying areas** – providing better links to support growth within outlying regions, including for example London, Essex, and East Anglia
- **Building a smarter network** – unlocking the potential of smarter infrastructure and new technologies to enable the most to be made of the SRN.

1.5 Purpose of the Scheme Assessment Report (SAR)

The purpose of the Scheme Assessment Report (SAR) is to provide a summary of the more detailed technical reports produced for the scheme. The report summarises the expected environmental, economic, engineering and traffic impacts of the scheme interventions, allowing the public and statutory bodies to comment on the proposals. SAR describes the merits and demerits of each option considered, and identifies the key factors considered when recommending a preferred option to be taken forward. the improvement. This report is not intended to replace the technical reports.

1.6 Structure of this report

The SAR report is arranged in 10 chapters following this introduction, supported by a number of appendices.

- **Chapter 2** describes the existing traffic conditions, topography and land use, and the problems to be solved
- **Chapter 3** sets out the generic project objectives and specific phase objectives, and the strategic context for the scheme development
- **Chapter 4** describes the options taken forward to PCF Stage 2
- **Chapter 5** presents a detailed engineering assessment of the options, identifying key engineering considerations for developing the scheme further, covering the alignment and geometry, existing and new structures required, and the cost estimates
- **Chapter 6** provides an overview of the scheme operating regime and driver compliance requirements during construction and operational phase
- **Chapter 7** describes the technology requirements of the scheme, and summarises the maintenance regime of civil infrastructure and roadside technology
- **Chapter 8** presents the traffic analysis undertaken, and summarises the economic assessment
- **Chapter 9** summarises the environmental assessment

- **Chapter 10** provides a summary of the public consultation feedback and outlines how this has been considered in the design of the options
- **Chapter 11** presents a summary appraisal summary table, and
- **Chapter 12** concludes the report with a summary of the key findings and a recommendation on the preferred option.

2 Existing conditions and the need for improvement

2.1 Description of the scheme locality

Junction 28 of the M25 motorway is located to the west of Brentwood in Essex (Figure 2-1). The junction provides a critical intersection between the M25, the key trunk route of the A12, and the A1023 – which provides important local access to Brentwood. This junction plays a key role in connecting Chelmsford, Ipswich and Brentwood with London and other key destinations across the South East of England.

Figure 2-1 Scheme location

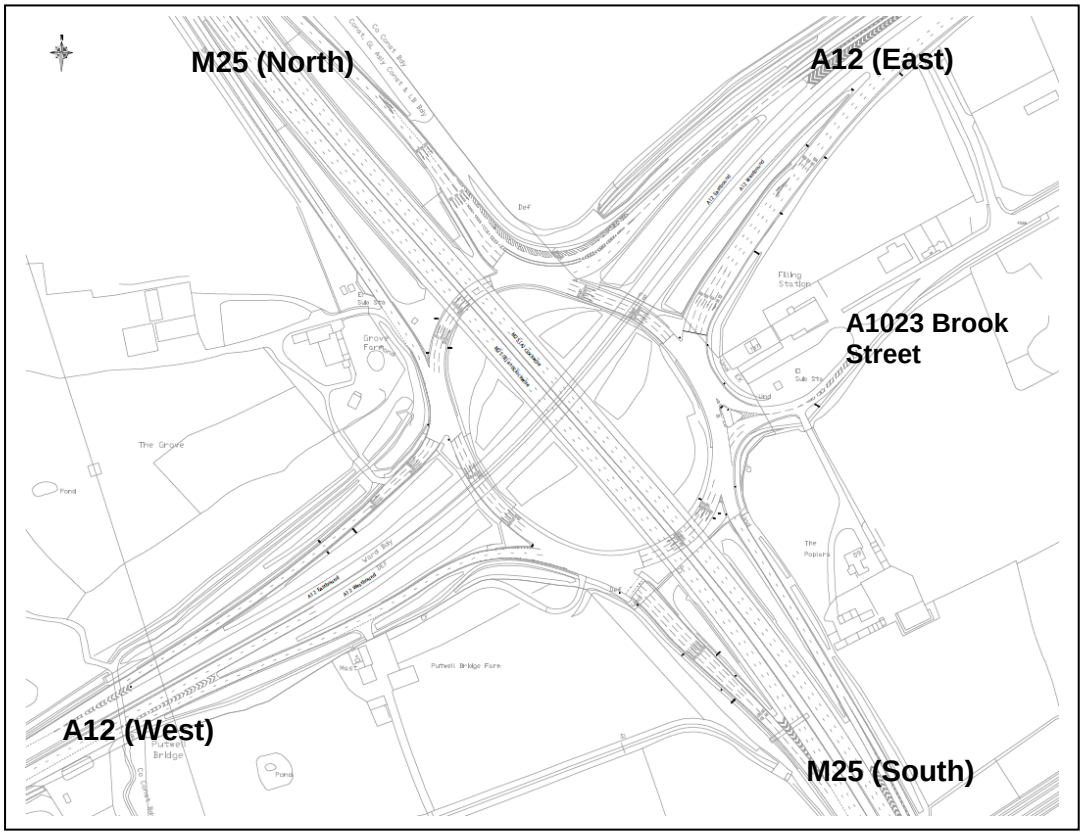
2.2 Existing highway network

M25 Junction 28

Junction 28 comprises a 3-tier grade separated junction with the roundabout operating at grade, the main A12 and M25 carriageways running below grade and above grade respectively.

The circulatory section itself comprises a five-arm signalised roundabout connecting the M25 and A12, as well as the A1023 Brook Street access to Brentwood. The junction between the roundabout and the A1023 Brook Street is currently uncontrolled, operating as a priority intersection. The layout of Junction 28 is shown in Figure 2-2.

Figure 2-2 M25 Junction 28 – Existing layout



M25 Junction 28 roundabout & slip roads

The current roundabout features three circulatory lanes providing for all turning movements. The flow of traffic on the roundabout is regulated by traffic signals that exist on the M25 and A12 approaches; that is all movements with the exception only of the free-flow M25 north (clockwise) to A12 east dedicated lane. The A1023 Brook Street approach is un-controlled with no traffic signals.

M25 motorway mainline

The M25 is a dual carriageway with 4 lanes in each direction (D4M) to the north and south of Junction 28. The section of the motorway through the junction is dual carriageway with 3 lanes in each direction (D3M) following lane drop arrangements at each of the motorway junction diverges.

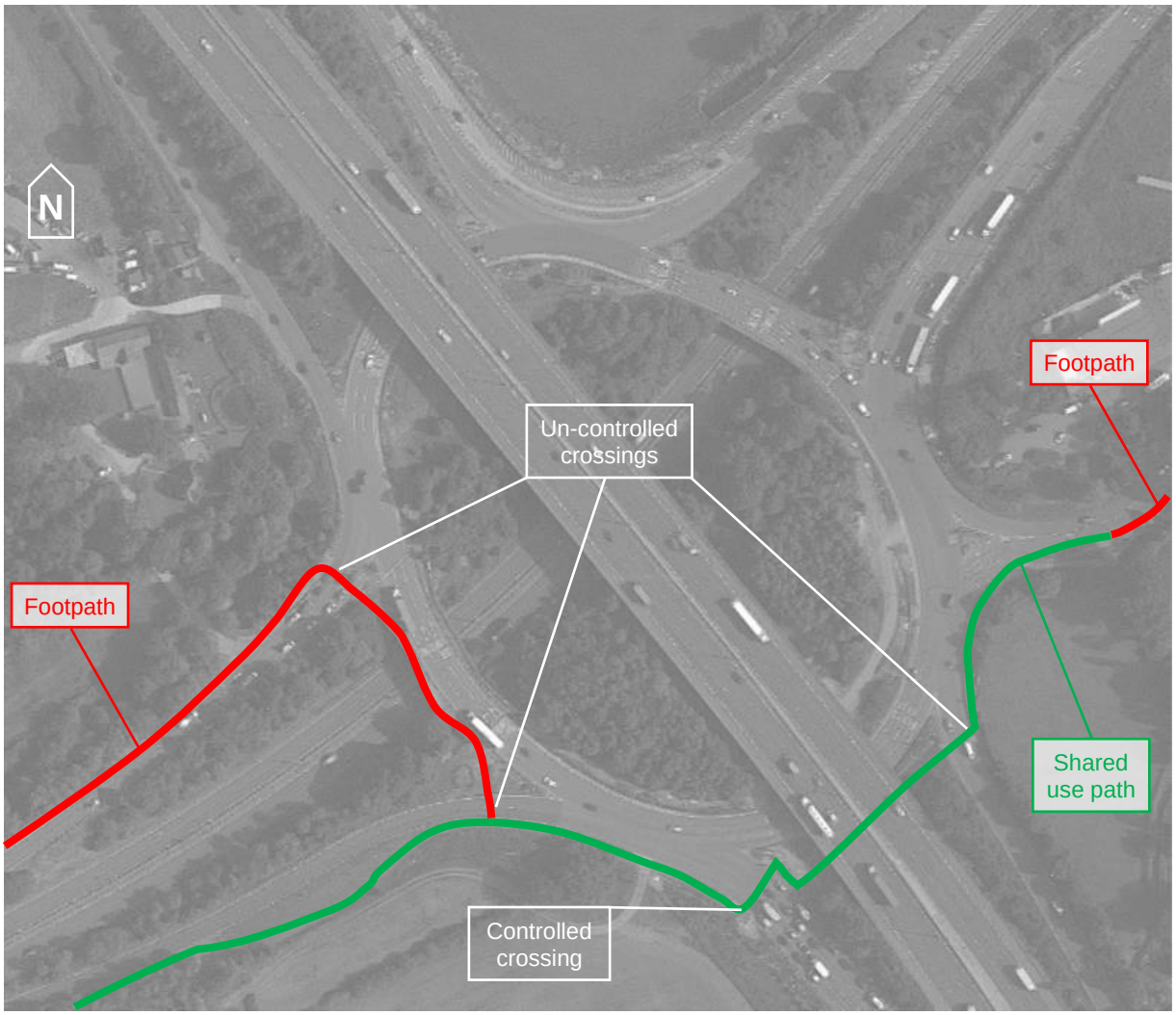
A12 mainline

The A12 is a major route connecting London with Essex and Anglia. In the vicinity of Junction 28 the A12 is of dual 2 lane carriageway standard. As the A12 approaches Junction 28 it operates with conventional diverges with no lane drop. In the westbound direction towards London the A12 continues 2 lanes through the junction. In the eastbound direction towards Essex the A12 initially continues with 2 lanes, but then reduces to 1 lane about half way through as it passes under the M25 carriageway.

Non-motorised users – current arrangements

On the northern side of the A12, west of Junction 28, a footway provides access to the vicinity of the roundabout and then to the southern side of the A12. This then connects with a shared use path (SUP) to the southern side of the A12 / A1023. SUPs exist on the A1023 immediately east of the junction, through to the southern side of the junction. This SUP then continues along the southern side of the A12, west of the roundabout towards Harold Wood, providing a connection to National Cycle Network Route 136. A further SUP exists on the northern side of the A12 near Harold Wood, but this is discontinuous and does not provide a direct route to the junction. A grade separated crossing exists near Harold Wood to facilitate movements across A12. These are shown graphically in Figure 2-3.

Figure 2-3 M25 Non-motorised users – current arrangements



2.3 Topography and land use

Junction 28 lies in a natural hollow to the west of Brentwood. To the north east the land rises steadily from approximately 35m above ordnance datum (AOD) to over 100m at Weald Country Park approximately 2km to the north of the junction. The M25 cuts into the western face of the hillside. To the north west the land falls towards Weald Brook, before rising towards Harold Hill on a slope which is parallel to the M25. South of the junction the land rises on a shallower gradient which is parallel to the A12.

Weald Brook (which is designated as a Main River) runs along a north south axis on the western side of the junction. This brook flows into the River Ingrebourne just to the north of the A12 and marks a low point in the local topography. A second brook runs along an east west axis adjacent to the southern boundary of the A12 before crossing to the northern side, approximately 500m to the east of Junction 28. It runs adjacent to the northern highway boundary of the A12, crossing under the interchange in a culvert emerging to the west of the junction before flowing into Weald Brook.

Agricultural land

Areas of agricultural land affected by the scheme are classified Grade 3 (good to moderate) in accordance with Defra's agricultural land classification[3]. To the south of the junction the current land use is predominately arable. To the north the junction is flanked by the Maylands Golf Course (north-west), buffered by areas of land which are currently fallow or woodland. To the east the land is primarily fallow with intermittent woodland, including an area of ancient woodland (Vicarage Wood) between A12 and Wigley Bush Lane.

Residential properties

The junction sits between the conurbations of Brentwood to the east and the London Borough of Havering to the west. Whilst the main built up areas are separated from the junction by green fields, there are businesses to the south east that abut Brook Street.

There is a small community of some 35 residential properties fronting Nags Head Lane, sited between Nags Head Lane and the mainline railway, on both sides of the M25 motorway.

To the north west of the junction there is a residential property associated with a small complex of businesses which occupy land immediately adjacent to the M25 north on-slip road.

Whilst there are few properties to the north east of the junction, Frenches Organic Farm is located approximately 300m north of the A12 adjacent to Wigley Bush Lane, and Weald Hall (equestrian) abuts the north side of Weald Park Way with an entrance joining Wigley Bush Lane. There are 4 residential properties adjacent to the east side of Weald Park Lane to the eastern extent of the study area.

[3] Natural England. 2010. Agricultural Land Classification map London and the South East.

2.4 Traffic conditions

The following sections provide a brief overview of the forecast traffic conditions at Junction 28. Greater detail is set out in the PCF Stage 2 Traffic Forecasting Report (March 2017).

Traffic demand and patterns

Junction 28 of the M25 is a heavily used junction with currently up to 7500 vehicles per hour travelling through the signalised roundabout during morning and evening peaks; this does not include M25 and A12 mainline through traffic flows. Similarly, during inter-peak hours, the roundabout caters up to 5000 vehicles per hour.

Current forecasts show that total traffic travelling through the roundabout is expected to increase to 8500 vehicles per hour during AM and PM peaks by 2037. During the inter-peak, flows are also expected to rise to around 6500 vehicles. The traffic growth will be constrained to the capacity of the Junction 28 circulatory. The capacity constraint is often influenced by the performance of the A1023 Brook Street un-signalised juncture, with queues from the Nags Head Lane traffic signals often blocking back on to the roundabout.

The turning flows through the junction are characterised by several key dominant movements, particularly between the M25 (north and south) and the A12 east towards Essex.

Journey times and congestion

In the AM and PM peak periods, motorists experience average delays of around 100 seconds across all movements. During the AM peak hour, the total delay time across all movements is currently around 580 hours/hour[4]. Without intervention to improve Junction 28, the roundabout would operate well above capacity during the peak times. As a result, during the AM peak hours the total delay time across all movements is predicted to increase to over 1000 hours/hour by 2037 (+80%). Similarly, average delays per trip in 2037 is forecast to increase by 40% to around 160 seconds in the AM peak hour. Similar the total delay across all movements is expected in the PM peak to increase from 600 hours/hour to 1338 hours/hour[5] (+150%) with average delays doubling from 111 seconds to 195 seconds.

Several of the circulatory lanes are predicted to develop queues considerably longer than the available queue storage. This will result in blocking back throughout the roundabout circulatory carriageway and along the approaches.

Accidents

Current records of accidents show that between 2010 and 2015 there have been 28 accidents reported (on the roundabout and the adjoining slip roads and M25 merge/diverge areas). This figure does not include damage only collisions. The 28 accidents have resulted in 34 casualties of which 30 were slight injuries (90%). The level of killed and serious injury (KSIs) incidents is low with less than 1 KSI each year.

Hence the safety problem is more related to the high occurrence of incidents (slight injury plus damage only), and the implications of these on the disruption across the wider highway

[4] See Table 8-2 of the M25 Junction 28 Traffic Forecasting Report
[5] See Table 8-8 of the M25 Junction 28 Traffic Forecasting Report

network, as well as harm and injury. A large proportion of these accidents have taken place at the point where the A1023 Brook Street approaches the roundabout.

Several issues identified in earlier Stage 1/2A safety audits are still outstanding. The safety review of the M25 Junction 28 has highlighted:

- inconsistencies in the signing and the lane destinations/designations on the roundabout, resulting in conflicting traffic movements, and
- that the un-signalised A1023 Brook Street approach is an accident hotspot, as drivers are opposed by four traffic lanes on the circulatory.

Journey time reliability

With the high demand of traffic using Junction 28 and the increasing levels predicted for the future, the ability of the junction to be resilient to unplanned events is poor. As traffic volumes increase closer to capacity in peak conditions, the greater the potential variation in travel times can be, and the more difficult it gets for users to predict delays and variability. In addition, the risk and rate of accidents and injuries also contributes to the resilience issues and the resulting variability in journey times.

Available incident data for Junction 28 suggests that a significant accident or incident (e.g. breakdown) occurs on the junction at least once a month. In such events traffic flows breakdown through the roundabout section, as well as along the exit ramps from the M25 and A12 carriageways, with queued vehicles often blocking back on to the main carriageways themselves. Delays of up to an hour can be expected with several miles of queued traffic along both the A12 and M25.

2.5 The problems to be solved

One of the key aims of the PCF Stage 0[6] work was to confirm the Strategic Case for improving the M25 Junction 28; that is to test and confirm the nature and scale of the problems affecting the performance of the junction.

This analysis had been achieved through a review of relevant evidence including information and data from previous and current projects looking at improvements to the junction. It also included engagement with Highways England and key stakeholders including Connect Plus Services (CPS), and the local highway and planning authorities. Based on this evidence review, four key problems were confirmed:

- **Problem 1** - Congestion and delay on Junction 28 roundabout disrupts journeys on the strategic road network and local roads
- **Problem 2** - Actual and perceived safety concerns associated with driver movements on Junction 28 roundabout

[6] Road Investment Strategy – M25 Junction 28 Improvements, PCF0 Final Report (September 2015), by Atkins on behalf of Highways England.

- **Problem 3** - Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times
- **Problem 4** - Air quality is an issue at the junction.

Without appropriate intervention to improve the performance of Junction 28, each of these problems would be expected to deteriorate further in the future as traffic levels increase. This would result in significant consequences for the efficiency of traffic flow, road safety, network resilience, and user satisfaction. Ultimately it will reduce the ability of the junction to perform its role in supporting local and regional aspirations for development and growth.

Specifically, without intervention the likely outcomes would include:

- Junction 28 being a constraint on the wider SRN caused by the inadequate capacity of the junction and the increasingly high traffic demands. Such a constraint would act as an inhibitor to economic growth and the attractiveness of the local areas, and the A12 corridor for new businesses and residents. Without intervention average delays across all movements on Junction 28 will be at least five times that experienced at present (and could be more); average delays could increase to around 4 or 5 minutes per movement in peak periods
- The ability of the junction roundabout to remain open and available in the event of an accident or incident will diminish. In such an event local commuters, residents and businesses will suffer with increasingly longer and unreliable journey times
- Without a reduction in traffic levels and the smoothing of traffic flows the ongoing local air quality issues will be exacerbated.

3 Planning brief

3.1 Phase objectives

The scheme is currently in PCF Stage 2 and the phase objectives are therefore to:

- take the shortlisted options to public consultation, analyse the comments received and undertake any relevant changes within the remit of the scheme
- update the traffic forecasts, environmental assessment, economic assessment and cost estimates
- recommend a preferred option to be taken forward to the project development phase.

3.2 Project objectives

The scheme objectives have been identified (Table 3-1) in line with addressing the agreed problems and the consequences (Chapter 2). The desired outcomes for each scheme objective have also been considered.

In terms of safety, the problems at Junction 28 are concerned with the high occurrence of incidents and the implications on the disruption across the wider highway network as well as harm and injury. The level of killed and serious injuries (KSIs) is relatively low with on average just under 1 KSI incident each year.

Table 3-1 M25 Junction 28 project objectives and desired outcomes

Scheme objectives	Desired outcomes
To cater for future traffic demands efficiently with minimal delay and to support future development and economic growth	• Improve journey time reliability • Improve journey times • Increase the vehicular throughput of the junction • Support employment and housing development planned for Brentwood, Essex and Havering
To improve the network resilience and enable smoother flow of traffic and reliable journey times	• Improve journey time reliability • Improve journey times
Improve road safety on the approaches to and through Junction 28	• Reduce the severity and rate of accidents and causalities • Improve journey time reliability
Minimise the impact of high traffic volumes and stopping traffic on local air quality and noise	• Reduce (or at least keep to neutral) carbon-dioxide emissions and noise levels • Reduce (or at least keep to neutral) noise levels

The scheme objectives align closely with the business strategies for Highways England, the Local Economic Partnership and for local and central government. The objectives are to cater for future demands, improve network resilience and road safety, and minimise the impact of high traffic volumes on local air quality and noise. Additionally, the Client Scheme Requirements sets out a number of other strategic objectives (Table 3-2). The measurement of relevant objectives and KPIs to inform the scheme development and assess the

performance of alternatives is undertaken with close alignment to Highways England's Operational Metrics Manual (OMM)[7].

As the Junction 28 improvements are primarily focussed on addressing issues concerned with congestion, safety and journey time reliability, there is a strong alignment of the key scheme objectives and outcomes which encourage economic growth and support the smooth flow of traffic (Table 3-3).

Table 3-2 M25 Junction 28 strategic objectives and indicators

Overall Objectives	• Make best use of existing infrastructure. • Suit the requirements of ongoing maintenance and minimising disruption from road works, by minimising whole life costs and the need to return to the location for a minimum of five years between schemes.
Transport Performance	• Improve junction performance, including performance assessment of A1023 and A12. • Eliminate queueing on the M25 mainline caused by the Junction 28 off-slips. • Reduce the average delay through the junction during peak and off-peak periods. • Improve journey time reliability through the junction during peak and off-peak periods. • Reduce the "after" accident numbers (per annum) below the "before" accident numbers, including the severity ratio. • Avoid the need for further capacity interventions for at least ten years after opening.
Environment	• Mitigate any Noise Important Areas on the SRN that fall within the junction. • Minimise any detrimental environmental effects of the scheme and offset by mitigation measures where technically feasible and economic to do so. • Incorporate improvements, such as biodiversity where, these can be identified.
Economy	• Provide maximum value for money against the whole of life costs in accordance with the Department's WebTAG guidance • Aim to improve on Appraisal Summary Table assessment results produced during the Options Phase and Development Phase, within the constraints of affordability.
Social and Distributional Impacts	• Support the growth planned (published statutory plans and emerging growth studies). • Minimise detrimental impacts on vulnerable people groups and provide appropriate mitigation where technically feasible and economic to do so.

[7] The OMM details definitions for the measures identified in the Performance Specification in a series of technical notes, and sets out the parameters for measuring and monitoring performance against the KPIs. It also defines and gives a performance framework for the supporting PIs both in terms of providing clarity on SRN performance as well as the improvement of existing and development of new measures for future Road Periods

Table 3-3 Alignment with performance specification objectives

Highways England performance specification - objectives	Junction 28 improvements - outcomes
Making the network safer	Enhanced capacity to cater for forecast traffic throughput, reduce queueing and congestion, thus reducing risk of conflicts and frequency of collisions.
Delivering better environmental outcomes	Improved air quality arising from improved performance of the junction, by reducing the levels and durations of stopping and stationary traffic.
Helping cyclists, walkers and other vulnerable users	Protected access for cyclists and pedestrians through the junction, particularly between Brentwood and Havering.
Encouraging economic growth	Improved junction capacity and performance to support future economic growth in the local areas, along the A12 corridor and across Essex.
Keeping the network in good condition	Renewed highway infrastructure possibly contributing to any planned maintenance works as part of the renewals programme.
Supporting the smooth flow of traffic	Additional capacity improving the junction's ability to remain open and operational during the event of an accident or incident, thereby improving journey time reliability.
Achieving real efficiency	Potential savings realised by carrying out planned maintenance during closures for traffic management.
Improving user satisfaction	Reduced journey time delays, particularly those related to the performance of the traffic signals on the Junction 28 roundabout.

3.3 Strategic context

A number of key policy drivers have been considered as part of the study. The M25 is recognised as having a widespread geographical function, therefore national, regional and local policies have been reviewed. A summary of what are the key implications of these documents for this scheme are shown below (Table 3-4).

Table 3-4 Policy overview

Scale	Policy Document	Key implications for Junction 28 Improvements
National	Road Investment Strategy (2014)	Promote safe and efficient movement, satisfy users of the network, can be delivered and operated within environmental constraints, support local access and well-being and be demonstrably cost-effective.
	Highways England Business Plan	Support short-term targets as well as long-term aspirations, and not significantly impact on network availability.
Regional	South East England Strategic Economic Plan	Enable local housing and employment growth in Essex and the wider South East by supporting efficient movement along the A12 and M25.
	London Plan	Enable targets for employment and housing growth in outer London by providing efficient access to the M25.
	Mayor's Transport Strategy	Support the smooth and efficient movement of traffic along the A12 to the west of the M25.
Local	Essex Local Transport Plan (2011)	Manage the impacts of traffic on the local community, support access to strategic locations in Essex along the A12 corridor, and support multimodal access for Brentwood.
	Brentwood Local Plan	Ensure improvements are consistent with land use and environmental constraints, and help to deliver local aspirations for housing and employment growth.
	LB Havering LDF	

4 Description of the Junction 28 options

4.1 Option constraints

During the option identification and development, consideration of the key issues, risks and constraints was critical. A summary of the key issues and constraints is provided below:

- **Design constraints**. The scheme development faces several design constraints such as introducing an additional merge for traffic travelling east on A12, challenging vertical alignment, and managing the proximity of Maylands Golf Club, the Weald Brook and Ingrebourne River, ancient woodland and the Great Eastern Mainline Railway.
- **Buildability constraints.** The development of the scheme considered options for extending existing structures adjacent to live running traffic lanes and diversions of existing nationally significant utilities.
- **Neighbouring development**. Neighbouring areas affected by the scheme include the skips hire and recycling business adjacent to the junction, residential properties and small businesses with frontages onto Nags Head Lane, Maylands Golf, as well as the Brentwood Garden Centre, the Poplars and the Holiday Inn which front onto Brook Street.
- **Environmentally sensitive areas.** Sensitive areas close to the junction include Noise Important Areas, Air Quality Management Areas, several small water courses, ancient woodland on north-east of junction, ecology risks and habitats, and listed buildings.
- **Operational.** Consideration has been given to minimising any implications on the Great Eastern Mainline Railway, maintaining the availability and minimising disruption to traffic on the M25 and A12 during construction, and minimising impacts on maintenance activities including winter maintenance.

4.2 PCF Stage 0 – Strategy, Shaping and Prioritisation

PCF Stage 0 culminated with the identification of a range of alternative options for improving Junction 28 to be considered further in PCF Stage 1.

To achieve this a range of strategic options were firstly identified, providing a high-level consideration to a range of alternatives including; doing nothing, alternative modes of transport (bus and rail), demand management, highway improvements, reclassification of the wider highway network. Based on this assessment, a strategic option focussing on localised highway improvements was confirmed as the preferred solution. The highway improvements proposal was seen to be most strongly aligned to addressing the local problem identified, and can be delivered within the RIS programme.

Based on this preferred Strategic Option, a range of highway improvements options were identified as concepts:

- A hamburger through-about
- A northern loop
- A compact northern loop
- A satellite roundabout
- A single cloverleaf

- A southern link
- A Do-maximum (for example a double cloverleaf).

These options were assessed based on the expected impacts of achieving the identified transport objectives, indicative cost ranges, and key issues and risks relating to scheme delivery. This assessment was aligned with the principles of the Department for Transport's (DfT's) Early Assessment Sifting Tool (EAST) approach, ensuring the five case business case model was included in the assessment at an early stage.

The single cloverleaf option was highlighted as the best performing option, presenting fewer delivery risks and issues. The alignment was considered technically feasible, minimising issues related to land-take, disruption to local communities, acceptance by the public and local authorities, network rail issues and processes, and environmental impacts.

The assessment indicated that the hamburger through-about option and satellite roundabout option would have very little effect on achieving the project objectives, and that any noticeable improvements would only be short term.

Based on the assessment, the following options were recommended to be taken forward for further consideration under PCF Stage 1:

- Option 2 - Northern hook
- Option 4 - Compact northern hook
- Option 5 - Single cloverleaf loop
- Option 6 - Southern link.

Full details of the Stage 0 findings are set out in the PCF Stage 0 Final Report (September 2015).

4.3 PCF Stage 1 – Option Identification

The RIS statement for the 2015 - 2020 road period sets out what Government expects in terms of improvements for Junction 28. This strategy also incorporates the following objectives:

- Improvements to Junction 28 to alleviate and manage current and future congestion through the junction, by the introduction of a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east
- Construction to start by end 2019/2020
- A set budget of £50 million to £100 million.

PCF Stage 1 commenced with a comprehensive review of the four options selected at Stage 0. This involved refining and developing the shortlisted options, and better the key issues, risks and constraints, as well as progressing the design. A key focus for the refinement and development of the options was to find an option that would achieve the identified benefits, can be implemented within the RIS1 timeframe, and is affordable. This process led to the identification of additional variants as the scheme options were further developed to avoid implications relating to key risks and constraints.

A number of options were identified to address the problems and achieve the project specific objectives. It was evident during PCF Stages 0 and 1 that the cloverleaf option offered the greatest potential to meet these objectives, as well as be refined and developed to best

manage the impacts against the identified risks and constraints. As such a range of cloverleaf and loop variants were developed for Option 5.

The options included:

- Option 2 – Northern hook
- Option 4 – Compact northern hook
- Option 5 – Cloverleaf loop (with 6 variants)
- Option 6 – Southern link.

A value management review was undertaken as part of PCF Stage 1, providing an initial assessment to assist in the short-listing of options to be taken forward to Stage 2 - Option Selection. Three of the cloverleaf variants (Options 5B, 5C and 5F) were identified as offering the most value against achieving the objectives.

Similarly, the traffic and economic assessments showed that the same three options yielded the strongest value for money BCR[8]s.

It is important to consider the affordability of each option alongside the other criteria included in the assessments. Based on the outcome of the Stage 1 assessments, it was therefore decided to take Option 5B, Option 5C and Option 5F to public consultation.

The assessments and the option short-listing is set out in detail in the PCF Stage 1 Technical Appraisal Report (November 2016).

The three options considered under PCF Stage 2 are described in the following section.

4.4 PCF Stage 2 – Option Selection

As discussed above, three options were short-listed in PCF Stage 1 for further consideration in Stage 2. There are all variants of the cloverleaf options and include Options 5B, 5C and 5F. These are described in turn below.

Option 5B – Cloverleaf loop variant 2

This option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28 (Figure 4-1). It involves the widening of the existing M25 structure to support the proposed new M25 anticlockwise diverge and off-slip road for accessing the new link.

The new diverge from M25 to the new link is proposed immediately after the existing diverge to the Junction 28 roundabout. The arrangement of the two diverges does not meet DMRB standards in terms of the required distance between successive diverges. The compact alignment of this option impacts directly on the buildings associated with the skip/recycling centre in this quadrant of the junction.

Accommodating the proposed link also involves the realignment of the existing A12 west diverge and off-slip road to enable the new link road a merge with the existing A12 eastbound carriageway before the existing structures that support the roundabout circulatory

[8] Benefit to cost ratio

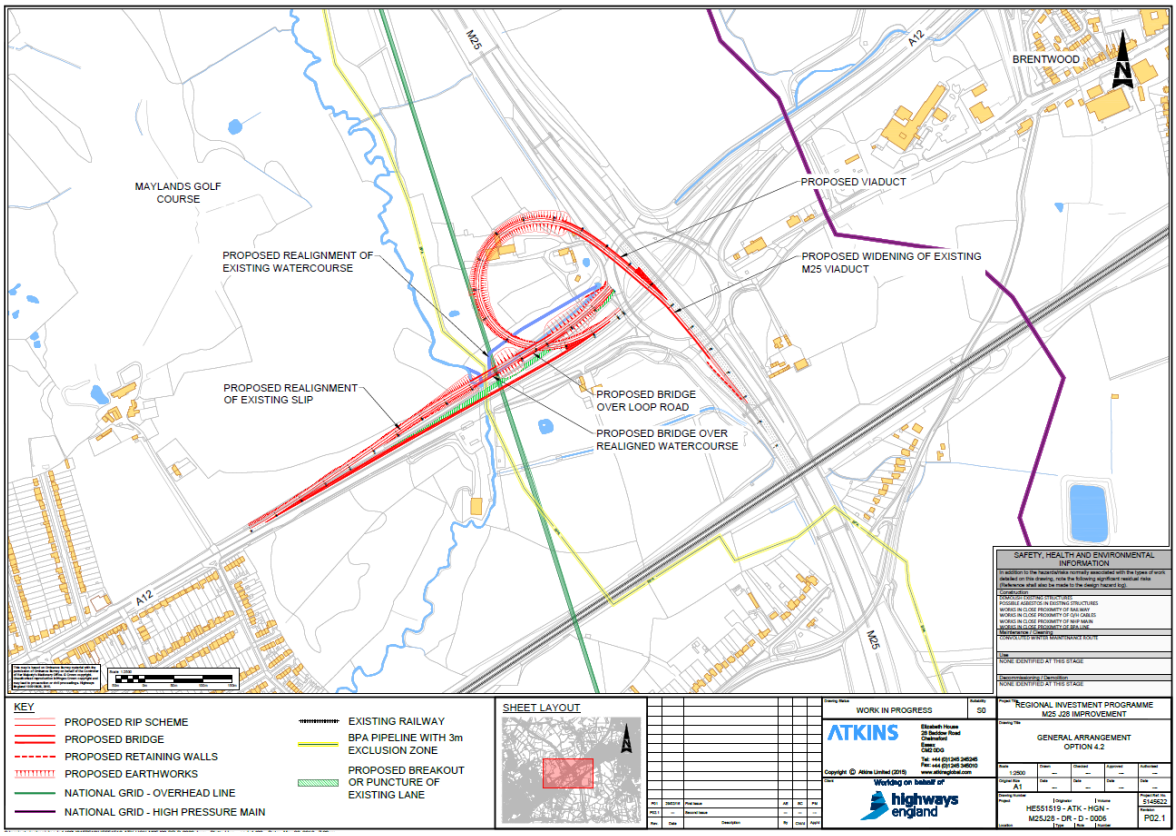
carriageway. The realignment of the A12 west off-slip road would involve a new structure that allows the proposed new link to run under the realigned A12 diverge/off-slip road.

In terms of arrangements for the A12 west merge and diverge, the option proposes to extend the existing single lane section of the A12 westwards in advance of the point where the new link will merge with the A12 to enable a lane drop arrangement. This would be followed by a lane gain as the new link merges with the A12. The A12 eastbound carriageway would then either reduce to a single lane as at present, or continue as two lanes through the junction.

Key interactions with existing infrastructure:

- Widening of existing M25 viaduct
- Existing hard shoulder utilised as auxiliary lane for proposed diverge
- Reconfiguration of A12 east diverge and off-slip road
- Realignment of existing watercourses
- Protection measures required for British Pipeline Agency infrastructure
- Possible diversion of National Grid overhead transmission cables
- Impact to G&R Skips and Recycling buildings.

Figure 4-1 Option 5B – Cloverleaf loop variant 2



Option 5C – Cloverleaf loop variant 3

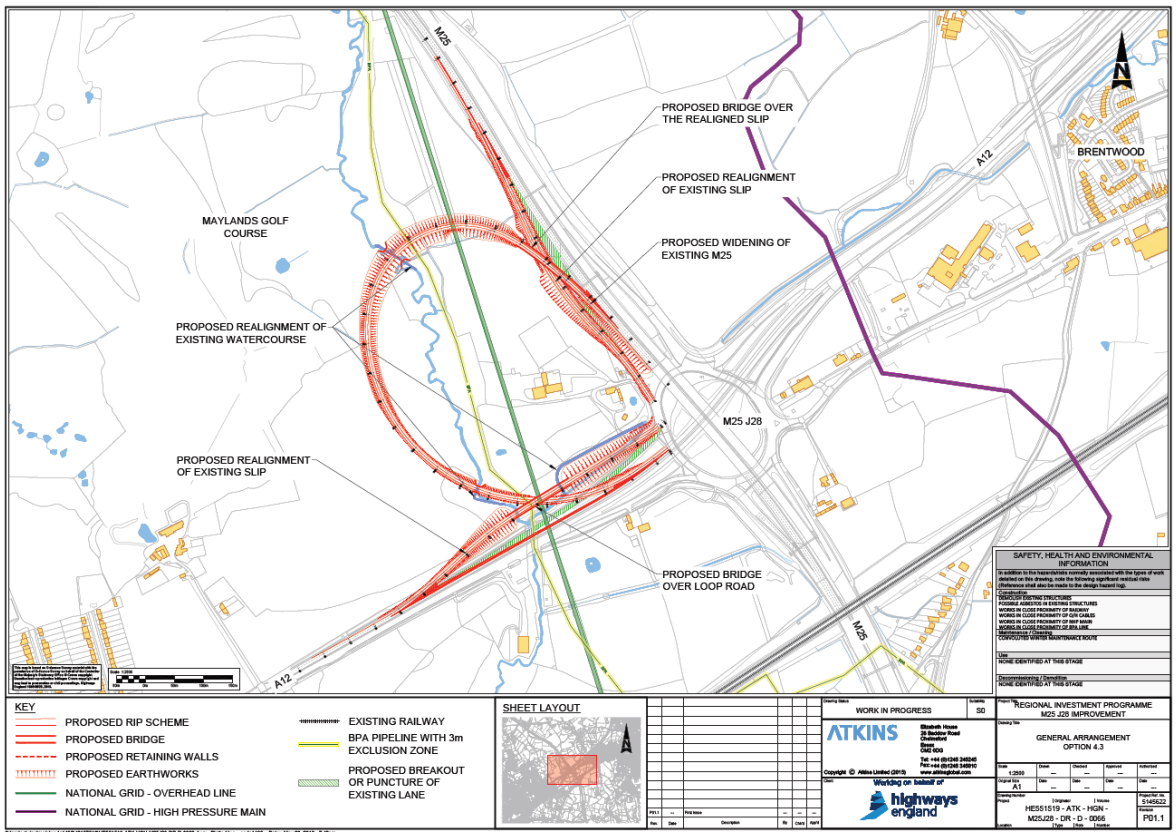
This option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28. By moving further north compared to Option 5B, Option 5C avoids the need to widen the existing M25

structures. Locating the diverge from the M25 for the new link to the north of Junction 28 requires realigning the existing M25 north on-slip road to pass under the new loop. Following the diverge, the alignment of the new link turns into the adjacent land to the north-west of the existing junction.

The evolvement of Option 5C was based on examining the potential to develop a less complex scheme compared to Option 5B by avoiding the need for widening the existing M25 viaduct, and address the issue concerned with successive diverges.

In terms A12 west merge and diverge, this option proposes to extend the existing single lane section of the A12 westwards in advance of the point where the new link will merge with the A12 to enable a lane drop arrangement. This would be followed by a lane gain as the new link merges with the A12. The A12 eastbound carriageway would then either reduce to a single lane as at present, or continue as two lanes through the junction.

Figure 4-2 Option 5C – Cloverleaf loop variant 3



Key interactions with existing infrastructure:

- Protection measures required for British Pipeline Agency infrastructure
- Realignment of existing watercourse
- Possible diversion of National Grid overhead transmission cables
- Reconfiguration of A12 east diverge and off-slip road
- Reconfiguration of M25 north anticlockwise on-slip road and merge.

Option 5F – Cloverleaf loop variant 4

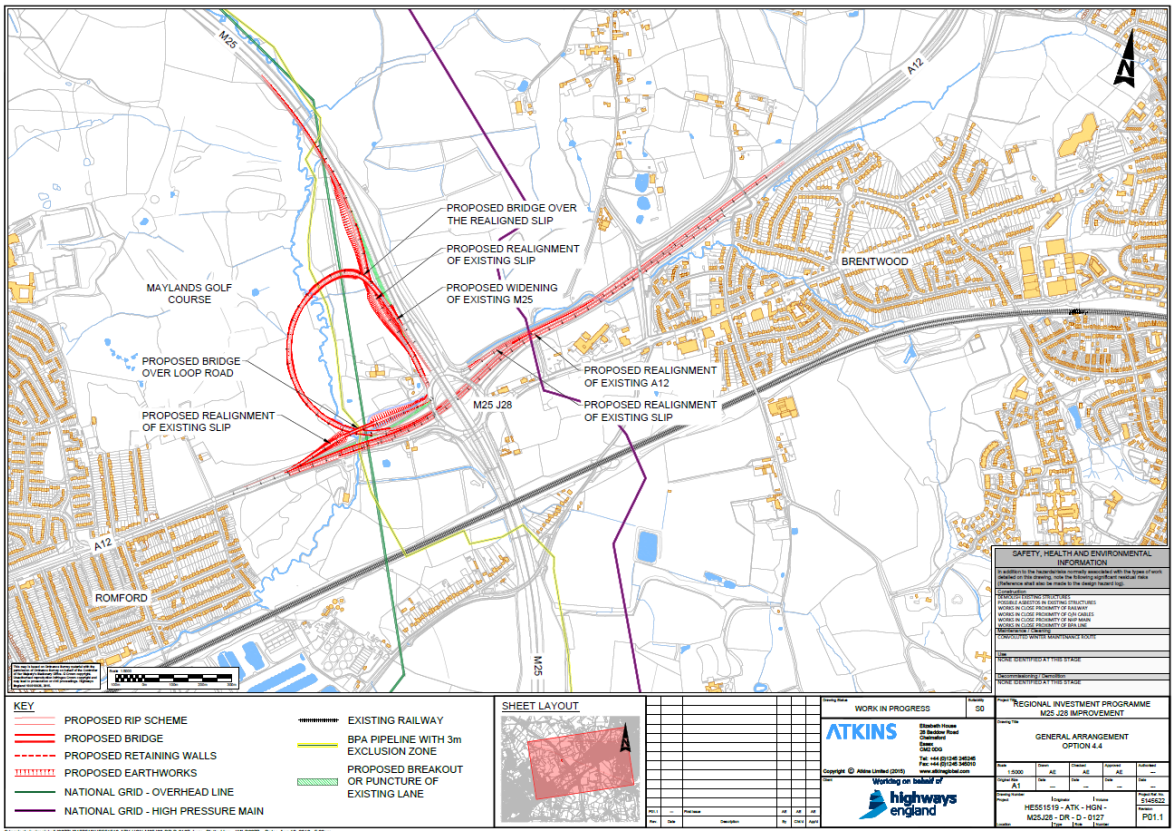
Option 5F is a variation of Option 5C and was developed to understand the implications and feasibility of providing a two-lane loop road merging with the A12 eastbound carriageway underneath the existing Junction 28 roundabout structure.

To accommodate a diverge to the two-lane link from the M25 anticlockwise carriageway, the diverge point is further north compared to Option 5C. Similarly, a reconfiguration and realignment of the cross section of the A12 is required to accommodate the merging of the two-lane loop road so that the proposed alignment doesn't impact the existing structures supporting the circulatory roundabout and the M25.

Key interactions with existing infrastructure:

- Protection measures required for British Pipeline Agency infrastructure
- Realignment of existing watercourse
- Possible diversion of National Grid overhead transmission cables
- Reconfiguration of A12 east diverge and off-slip road
- Reconfiguration of M25 north anticlockwise on-slip road and merge
- Reconfiguration of A12 mainline in vicinity of existing junction.

Figure 4-3 Option 5F – Cloverleaf loop variant 6



4.5 Interdependencies

The success of the Junction 28 scheme options is partially dependent on the successful implementation of complementary signal enhancements at adjacent traffic signals along the A1023 Brook Street, namely Nags Head Lane/Wigley Bush Lane and Spital Lane junctions. The proposed scheme seeks to divert the right turning traffic between the M25 anticlockwise and the A12 east away from the roundabout. This will in turn involve the optimisation of the traffic signals with different patterns of turning traffic using the Junction 28 roundabout, in terms of cycle times, green times and offsets. Whilst the traffic signalised junctions along the A1023 Brook Street operate independently from Junction 28, it is important that there is coordination in the operation of the two sets of signals.

Whilst not directly dependent, the Junction 28 scheme will also have an important interface with the proposed improvements of the A12 between the M25 and Chelmsford. A key interface will be the design of the merge arrangements for the new link on the A12 to the east.

4.6 Risk management

Details of the Projects Approach to Risk are set out in the Risk Management Plan. During PCF Stages 1 and 2, a risk register has been developed covering all options, and subsequently reviewed and updated through a series of workshops. The risks identified in each of the registers have been subject to qualitative assessment to identify the potential impacts of each risk, both pre-mitigation and post-mitigation. This confirmed the effectiveness of appropriate risk mitigation plans identified for each risk.

At this early stage a range of key potential risks have been identified. In terms of Junction 28 these typically relate to:

- Strategic issues such as changes in Government priorities and/or lack of support from local highway and planning authorities, statutory bodies as well as the public
- Traffic patterns and demands linking to any uncertainty over future growth and traffic patterns, as well as potential changes to the highway and transport network that may affect demands and routeing in unforeseen ways
- Technical challenges and complexities that may result in not achieving the project timescales, impacting on the operation and availability of the existing transport infrastructure and its users
- Statutory processes; the time and cost to acquire the land required
- Acceptance; potential opposition and challenges to the scheme.

4.7 Impact on property

Areas of development which may be affected include:

- G&R Skips and recycling and associated businesses to the north west of the junction which is directly affected by most options
- Residential properties and small businesses with frontages onto Nags Head Lane to the south of the junction
- The Poplars, Brentwood Garden Centre and the Holiday Inn which front onto Brook Street to the South East of the junction

- The Maylands Golf club to the north west.

4.8 Cost estimates

Option estimates have been produced by Highways England Commercial Planning team during PCF Stage 2 for Options 5B, 5C and 5F. A high-level summary of the cost estimates is shown in Table 4-1.

Table 4-1 PCF Stage 2 cost estimates for each option, 2010 undiscounted prices[9]

Option	Capacity	Preparation costs	Supervision costs	Capital works	Land costs	Total Cost
		(£ millions)				
Option 5B	1 lane	5.4	1.1	41.9	3.8	52.2
Option 5C	1 lane	5.5	1.1	42.1	4.7	53.4
Option 5F	2 lanes	5.6	1.2	51.1	4.8	62.7

4.9 Summary

As discussed previously, one of the key focusses of the option identification and selection process was to understand the key issues, risks and constraints surrounding the scheme, and develop the options to best manage and/or mitigate these. The previous sections discuss how the scheme options have evolved to best avoid the key project and planning constraints, and hence potentially reduce cost and time implications.

[9] See M25 Junction 28 Stage 2 Economic Assessment Report (Section 3.2 & Table 3-2)

5 Engineering assessment

This chapter provides a brief description of the engineering considerations relating to each of the options. This covers geometry, design standards, structures, as well as preliminary considerations for earthworks, drainage, signing and lining, gantries, lighting and statutory undertakers.

5.1 Option 5B – Cloverleaf Loop variant 2

Option 5B is a single lane and hard shoulder loop road configuration. To facilitate a compact layout it is proposed to introduce an exit from the M25 anticlockwise from the existing M25 Brook Street viaduct. Consequently, the existing structure is required to be widened.

Geometric alignment and specifications

Option 5B has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder, 3.7m wide lane 1 and a 0.7m wide offside hard strip in accordance with TD 27/05, Figure 4.1c. As the link passes through an angle greater than 180° it has been designed as a one-way loop (para 1.21 of TD 22/06) thus allowing a minimum loop radius of 75m. The realigned A12 slip road has been developed using a design speed of 70kph (TD 22/06 Para 4.2 and Table 4/1).

In Option 5B, the traffic on the M25 anticlockwise carriageway wishing to head towards the A12 east would be directed to, what was previously the hard shoulder of the motorway immediately after existing diverge for the Junction 28 roundabout. The hard shoulder is converted into an ancillary lane for approximately 220m which then forms a lane drop onto the single lane loop road. The distance between the successive diverge noses of the off-slip road to the Junction 28 roundabout and the loop road is 290m, which is a departure from the minimum permitted distance defined in TD22/06 (i.e. 3.75 times the design speed, which equates to 450m on the M25). Furthermore, there is no standard configuration in TD 22/06 comprising a mainline lane drop leading to a single lane connector road, and therefore this is a non-standard configuration and may represent a departure from standard.

In terms of the horizontal geometry there is a 1020m left hand radius which forms the near straight, transitions directly into a 107m radius left hand curve taking the loop through 270^0 and facilitating a tie in with the eastbound carriageway of the A12 to the west of the existing Junction 28. A stopping sight distance of 120m has been maintained on the loop road, which is the equivalent to a 70kph design speed and is consistent with the requirements of TD22/06 para 4.2 and stopping site distance as defined in TD9/93 Table 3.

As the loop road exits the M25 a vertical sag curve with a minimum K value of 85 carries the link over the M25 anticlockwise on-slip road from the Junction 28 roundabout. The increasing gradient is arrested by a 112K crest curve (one step below desirable for a short length immediately before the drop to the loop road design speed) which then changes to a 30K crest curve where the alignment transitions from the 120kph mainline speed to the 60kph loop road design speed.

The alignment then falls on a 5.90% downhill gradient towards the A12 before another sag cure with a K value of 25 brings it up to match the A12 vertical profile facilitating the tie-in. The loop road ties into the A12 eastbound carriageway utilising the nearside lane of the A12 as a lane gain. To facilitate this, the current nearside lane closure on the A12 is extended westwards such that A12 mainline traffic passes the merge point using the offside lane only. There is no standard configuration in TD 22/06 comprising a single lane connector road

merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard. This configuration avoids the need to widen the A12 carriageway under the existing interchange structures.

Interactions with existing highway infrastructure

The tie-in of the loop road to the A12 requires the A12 eastbound off-slip road to be realigned to traverse over the new loop road as it passes towards the A12 eastbound carriageway. Horizontally the slip road alignment leaves the A12 approximately 250m west of the existing diverge. The existing diverge is in the form of a basic Type A –Taper Diverge (TD 22/06, Figure 2/6.1), however the new configuration would be Type C – Lane Drop at Taper Diverge (TD 22/06, Figure 2/6.2). The A12 comprises two lanes at this location. There is no standard configuration in TD 22/06 comprising a two-lane carriageway where the nearside lane is dropped at a taper diverge with the mainline traffic proceeding in the offside lane only. Therefore, this is a non-standard configuration and may represent a departure from standard. The horizontal realignment of the A12 eastbound off-slip road is facilitated by a 510m left hand curve followed by a 720m right hand curve. This takes the off-slip road away from the mainline on a 2.0% downhill gradient followed by a vertical sag curve with a K value of 22 and a subsequent uphill gradient (of 3%) takes the vertical profile to a crest curve with a K value of 30, which brings the alignment over Weald Brook, the BPA pipeline and the proposed loop road. Beyond the loop road the vertical crest curve is followed by a sag curve with a K value of 20. The horizontal geometry transitions at the start of the crest curve to a straight which then aligns the slip road with the Junction 28 circulatory.

Departures from standards

Several departures and non-standard configurations are required for Option 5B which may constitute departures:

- The distance between the successive diverge noses of the slip road and the loop road on the M25 anti-clockwise carriageway is 290m which is a departure from the minimum permitted distance (450m) in TD 22/06
- The vertical curvature on the proposed diverge matches the existing profile of the M25, consequently the vertical curvature is one step below desirable minimum (112 K) over the distance of the diverge nose, which at 120kph is a departure to TD 9/93
- The proposed A12 eastbound diverge obstructs visibility of the complete loop from the diverge point of the M25. This constitutes a departure from TD22/06
- As the mainline M25 is three lanes at the point of the proposed single lane diverge it is considered a non-standard configuration in accordance with TD22/06 Table 2/5 and may therefore constitute a departure
- The two-lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure
- The single lane connector road merging with two lanes mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

Alterations to existing structures

- Widening of the existing M25 viaduct by 9.5m for 215m tapering to 20m over 90m to carry the new loop road over the existing circulatory carriageway and the A12.

Proposed new structures

- A 150m multi span, steel composite viaduct 11.5m wide to carry the new interchange link road over northern segment of the circulatory carriageway at Junction 28 and over the Junction 28 to M25 anti-clockwise slip road from IL chainage 390 to 540
- A 160m multi span composite steel viaduct 12.8m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 450 to 610
- An 85m retaining wall on the nearside of the loop road from the back of the nosing to the abutment of the viaduct to accommodate level differences between the link and the M25 anti-clockwise to Junction 28 slip road from IL chainage 100 to 185 (average height 1.5m)
- 1 major culvert to take the new loop road over the realigned watercourse. An extension of the existing culvert adjacent to the A12EB/circulatory diverge is also required.

5.2 Option 5C – Cloverleaf Loop variant 3

Option 5C diverges from the M25 mainline north of the existing M25 mainline viaduct that traverses over the Junction 28 roundabout, thus avoiding any structural alterations within the proximity of the Junction 28 circulatory carriageway.

Geometric alignment and specifications

As with Option 5B, Option 5C has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder to the nearside, a 3.7m wide lane 1 and a 0.7m wide offside hard strip (TD 27/05 Figure 4.1c). As the link curves more than 180^0 it has been designed as a one-way loop (TD 22/06, paragraph 1.21) thus allowing a minimum loop radius of 75m. The slip roads have been developed using a design speed of 85kph (TD 22/06, Para 4.2 and Table 4/1).

Traffic destined for the A12 east is directed to, what was previously the hard shoulder of the M25 anticlockwise beyond the existing diverge for the Junction 28 roundabout. The hard shoulder would be converted into an ancillary lane for approximately 470m which then forms a lane drop onto the single lane loop road. The conversion of the hard shoulder is a departure from the cross-sectional requirements outlined in TD 27/05 – Cross-Sections and Headrooms.

The distance between the successive diverge noses of the slip road and the loop road is 470m which is greater than the minimum permitted distance from TD 22/06. There is no standard configuration in TD 22/06 comprising a mainline lane drop leading to a single lane connector road, and therefore this is a non-standard configuration and may be subject to a departure from standard.

The horizontal geometry requires a compound horizontal loop radius. A 1020m left hand radius which forms the near straight, transitions directly into a 160m radius left hand curve which in turn transitions into a 295m left hand curve. Together these take the loop through 270^0, facilitating a tie in to the A12 eastbound carriageway to the west of Junction 28. A stopping sight distance of 160m has been ensured on the loop road.

The loop road diverges from the M25 further north than Option 5B, where the M25 mainline is starting to climb. A vertical crest curve with a K value of 173 is used to create a 1.0% downward gradient to minimise the embankment necessary to the west of the M25 carriageway. However, the loop road crosses the M25 anti-clockwise on-slip road 250m further north than Option 5B. The on-slip road is rising to join the M25 mainline carriageway

and consequently it is necessary to re-align and lower the existing on-slip road so that the loop road can pass over it. The vertical profile of the loop road reflects this so that a second crest curve with a K value of 100 and its apex adjacent to the slip road ensures that the elevation is maintained. This is then followed by a sag curve with a K value of 30 to providing a climbing gradient of 0.48%. A crest curve with a K value of 55 leads to a downhill gradient of 2.5%, followed by a sag curve with a K value of 20 before an inclined gradient of 0.49% and a crest curve with a value of 100 K reduces the height of the embankment and allowing the loop road to pass under the re-aligned A12 east off-slip road (similar to Option 5B). A gradient of 0.75% then aligns the carriageway to tie in.

As with Option 5B, the loop road ties into the A12 eastbound carriageway utilising the nearside lane of the A12 as a lane gain. To facilitate this, the current nearside lane closure on the A12 is extended westwards such that A12 mainline traffic passes the merge point using the offside lane only. There is no standard configuration in TD 22/06 comprising a single lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard. This configuration avoids the need to widen the A12 carriageway under the existing interchange structures.

Interactions with existing highway infrastructure

The loop road crossing of the M25 anti-clockwise on-slip road requires the realignment of the slip road to allow the loop road to pass over it. The realigned slip road leaves the roundabout with a straight which transitions to a 510m radius horizontal left hand curve to provide sufficient clearance from the existing infrastructure. This is followed by a 360m right hand curve to bring the alignment back towards the M25 carriageway followed by a left-hand curve (1020m) to facilitate the merge with the main carriageway.

Vertically the slip road follows the alignment of the existing slip before a vertical crest curve with a K value of 30 lowers the slip road to pass under the loop road. The slip road passes under the loop road on a vertical sag curve with a K value of 20 raising on a gradient of 3.0% to bring it back to the level of the M25 to facilitate the tie in with a crest curve with a value to 50 K.

The tie-in of the loop road to the A12 eastbound carriageway west of Junction 28 requires the A12 eastbound off-slip road to be realigned to climb over the loop road which then passes under it. However, the crossing point is further west than shown in Option 5B. Horizontally the slip road alignment is like Option 5B, leaving the A12 approximately 230m to the west of the existing diverge. The existing diverge is in the form of a basic Type A –Taper Diverge TD 22/06, Figure 2/6.1), however the new configuration is in the form of Type C – Lane Drop at Taper Diverge (TD 22/06, Figure 2/6.2). The A12 comprises two lanes at this location. There is no standard configuration in TD 22/06 comprising a two-lane carriageway where the nearside lane is dropped at a taper diverge with the mainline traffic proceeding in the offside lane only; therefore, this is a non-standard configuration and may represent a departure from standard.

The horizontal realignment of the A12 eastbound off-slip road slip is facilitated by a 510m left hand curve followed by a 720m right hand curve. These take the slip road away from the mainline on a 2.03% downhill gradient followed by a vertical sag curve with a K value of 20 and subsequent uphill 2.27% gradient, which is followed by a crest curve with a K value of 30 K which takes the alignment over Weald Brook, the BPA pipeline and the proposed loop road. Beyond the loop road the vertical crest curve is followed by a sag curve with a K value

of 20. The horizontal geometry transitions at the start of the crest curve to a straight which aligns the slip road with the Junction 28 roundabout.

Departures from standards

Several departures and non-standard configurations are required for Option 5C which may constitute as departures:

- Use of 470m of hard shoulder as an ancillary lane at the M25 anti-clockwise diverge to the loop road is a departure from the cross-sectional requirements outlined in TD 27/05
- The single lane diverge, including an auxiliary lane is not a configuration listed in TD22/06 and may therefore constitute a departure
- The proposed A12 eastbound diverge obstructs visibility of the complete loop from the diverge point of the M25. This constitutes a departure from TD22/06
- The two-lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure
- The single lane connector road merging with a single lane mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

Alterations to existing structures

- Demolition and replacement of 1 No sign gantry at the M25 anti-clockwise diverge to the new loop road at IL chainage 220 to facilitate construction of the diverge.

Proposed new structures

- A 145m multi span, steel composite viaduct 13.5m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 210 to 355
- A 125m multi span composite steel viaduct 17.0m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 440 to 565
- 2 No major culverts to carry the new loop road over Weald Brook at chainages 590 and 1075
- 1 No major culvert to carry the new loop road over the watercourse adjacent to the A12 at SR chainage 1220
- 1 No extension of the existing culvert adjacent to the A12EB/circulatory diverge
- 2 No extensions of existing culverts under the proposed M25 on slip, at changes SR chainage 870 and 995.

5.3 Option 5F – Cloverleaf Loop variant 4

Option 5F is very similar to Option 5C with the loop road diverging from the M25 mainline north of the existing viaduct. The key difference is that it has been designed to accommodate two lanes with hard shoulder which significantly changes the diverge and merge configurations, which in turn effects the geometry of the loop road.

Geometric alignment and specifications

Option 5F has been designed as a two-lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane 1, a 3.65m wide lane 2, and 1.0m wide offside hard strip (TD 27/05, Figure 4.1b). As the link traverses through an angle more than 180^0 it has been designed as a one-way loop (TD 22/06, paragraph 1.21), thus allowing a minimum loop radius of 75m. The layout of the slip roads have been developed using a design speed of 75kph (TD 22/06).

The loop road diverges from the M25 anti-clockwise carriageway using a Type A - Taper Diverge (TD 22/06, Figure 2/6.1). Local widening of the M25 at this location enables the continuity of the hard shoulder to be maintained. Leaving the M25 on a 1020m radius left hand curve, the alignment transitions into a 100m left hand loop for 85m beyond the near straight before slackening to a 285m left hand curve taking the loop, road through 270^0 to run parallel to the A12 eastbound carriageway. The loop road merges with the A12 eastbound carriageway using a Type F - Lane Gain with Ghost Island Merge (Option 2 Alternative). There is no standard configuration in TD 22/06 comprising a two-lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard.

At the point of the diverge the M25 mainline is on a 1.6% downhill gradient. As the loop road diverges from the M25 a vertical sag curve with a K value of 39 slackens the downhill gradient to 0.51% to carry it over the Junction 28 to M25 clockwise on-slip. Immediately beyond the slip road crossing, a vertical crest curve with a K value of 30 increases the downhill gradient to 4.92% with a sag curve with a K value of 20 taking the loop over its first crossing of Weald Brook before climbing on a 1.6% gradient up the hill side to the west of the brook. A further crest curve with a K value of 55 arrests the climb taking the alignment on a downhill gradient of 2.60% to take the loop under the realigned A12 west to Junction 28 slip road before tying into the A12 using a sag curve with a K value of 37 and a 0.21% followed by a crest with a K value of 55 and a downhill gradient of 0.76%.

Interactions with existing highway infrastructure

The loop road crossing of the M25 anti-clockwise to Junction 28 slip road requires the realignment of the slip road to allow the loop road to pass over it. The realigned slip road leaves the roundabout with a straight which transitions to a 510m radius horizontal left hand curve to provide sufficient clearance from the existing infrastructure to allow it to be lowered to pass under the loop road. This is followed by a 510m right hand curve to bring the alignment back towards the M25 followed by a compound left hand curve (1020m and 1440m) to facilitate the merge with the main carriageway.

Vertically the slip road follows the alignment of the existing slip before a vertical crest curve with a K value of 30 lowers the road on 4.0% downhill gradient to pass under the loop road. The slip road passes under the loop road on a vertical sag curve with a K value of 20 raising on a crest with a K value of 182 to bring it back to the level of the M25 to facilitate the tie-in.

The tie-in of the loop road to the A12 requires the A12 eastbound off-slip road to Junction 28 to be realigned to climb over the loop road as it passes underneath. This re-alignment is the same as that defined above for Option 5C.

The horizontal realignment of the A12 eastbound off-slip road is also the same as that detailed under Option 5B and Option 5C.

With a two-lane loop under Option 5F the merge of the new loop road with the A12 eastbound carriageway is different. This requires some minor realignment of the channel

lines of the existing A12 carriageway as it passes under the interchange. It does not require any alterations to the existing structures but may require reconfiguration of the safety barriers.

Departures from standards

A single departure and non-standard configurations are required in Option 5F, which may constitute departures:

- The proposed A12 eastbound diverge obstructs visibility of the complete loop from the diverge point of the M25. This constitutes a departure from TD22/06
- The two-lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure
- The two lane connector road merging with a single lane mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

Alterations to existing structures

- This option requires no known alterations to existing structures, however depending on a more detailed analysis of the geometric alignment of the A12 to accommodate the loop road merge, it may be necessary to undertake pier protection works to enable the road restraint system set-back to be maintained.

Proposed new structures

- A 110m multi span, steel composite viaduct 16.1m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 195 to 305
- A 115m multi span composite steel viaduct 12.8 m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 430 to 545
- A 100m retaining wall on the nearside of the Junction 28 to M25 anti-clockwise slip road near the M25 merge to accommodate level differences immediately before the back of nosing (average height 1m)
- 2 No major culverts to carry the new loop road over Weald Brook at chainages 495 and 1050
- 1No major culvert to carry the new loop road over the watercourse adjacent to the A12 at SR chainage 1120
- 1 No extension of the existing culvert adjacent to the A12EB/circulatory diverge
- 2 No extensions of existing culverts under the proposed M25 on slip, at changes SR chainage 870 and 995.

5.4 Earthworks

The underlying geology near Junction 28 is anticipated to comprise a bedrock of London Clay overlain with superficial deposits of gravel. For the purposes of the Stage 2, design allowance has been made for cutting slopes of 1:3 and embankment slopes of 1:2.5, which

is generally in keeping with the slopes of the existing earthworks at the junction on the A12 and the M25.

Generally, all options have an earthworks deficit of varying amounts requiring an overall import of suitable fill. Unsuitable material from cuttings may be used in amenity bunds/landscaping areas or taken to tip off site.

In the absence of detailed analysis, the amount of suitable fill to be sourced within the site is uncertain so a detailed analysis of the earthworks balance is inappropriate at this stage.

Steepened earthworks slopes may be appropriate at some locations, in the vicinity of pylons supporting the National Grid high voltage overhead power lines foundations for more conventional retaining walls may conflict with the foundations for the pylons. Short lengths of reinforced earth may be required in areas where the approach to interchange link diverge/merges have different vertical profiles to the mainline carriageways. However, it may be possible to eliminate these as the designs are refined and the earthwork interfaces are modelled in more detail.

5.5 Drainage

The highway geometry has been designed to avoid flat areas of carriageway with phased horizontal and vertical curvature wherever possible.

Outline drainage design has not been undertaken at this stage. The drainage design should be developed in accordance with the principals set out in DMRB HD33. It is envisaged that surface water channels will be used on link roads with associated fin drains to intercept seepage flows in the road construction. On loop roads with low horizontal radius, it has been assumed that a pipe and gully system will be used for ease of construction.

Linear drainage channels may be necessary in some interchange nosings. Drainage of bridge and viaduct surfaces will be by means of a combined kerb and drainage system.

Filter drains will be used at the bottom of cuttings to reduce ground water levels. Ditches or filter drains will be used at the top of cuttings and the toe of embankments to intercept run-off from existing land drainage systems.

Special provisions may be necessary in the area of historic landfill to the north west of the junction to prevent contamination of surface water and/or induced settlement due to water infiltration into the landfill depending on the nature of the materials deposited and any restoration works undertaken.

The underlying geology at Junction 28 is London Clay and therefore it is unlikely that infiltration methods of disposal will be effective. It has been assumed that balancing ponds or storage tanks will be required at locations to be determined, to limit runoff to current green field rates with appropriate pollution control measures before discharging into Ingrebourne River via upstream watercourses. The impact of some options on the existing balancing pond to the south west of the junction will also need to be considered at the next design stage if they are taken forwards.

5.6 Signing and lining

All road markings and signage will be designed in accordance with the Traffic Signs Regulations and General Directions (TSRGD). The existing signing and road marking arrangements are shown in The PCF Stage 1 Technical Appraisal Report (Appendix H). No strategic changes to signing are proposed.

M25 anti-clockwise

All options will require alterations to existing gantry signing on the M25 anti-clockwise carriageway with additional/amended directional signing for M25 anti-clockwise to A12 E (traffic which would have previously used Junction 28) now being directed onto the new link/loop road. Option 5B presents difficulties for directional signing due to the non-standard spacing between the successive diverges.

M25 clockwise

All options require no changes to the signing and lining on the M25 clockwise carriageway.

A12 eastbound west of Junction 28

Options 5A, 5B and 5C will require alterations to existing markings and signage on the approach to the A12 eastbound off-slip road. For these options the nearside lane of the A12 east becomes a dedicated lane to Junction 28 with the offside lane being for A12 through traffic only. This is a non-standard configuration and will require advanced “Get in Lane” signing on the approach and associated road markings. For all options the nearside lane remains closed to facilitate the M25 anti-clockwise to A12 east loop road merge.

A12 eastbound east of Junction 28

The current A12 eastbound lane configuration to the east of Junction 28 comprises 3 lanes separated by tiger tail style ghost island road markings (in line with Diagram 1042 of the TSRGD). The nearside lane is for traffic from the M25 clockwise to A12 east dedicated lane, the middle lane is for Junction 28 to A12 east traffic and the offside lane is for A12 eastbound through traffic only. The nearside lane is dropped approximately 1km from the junction.

For Options 5A, 5B and 5C the new link merges before the A12 eastbound on-slip road. In this arrangement the offside lane is used for A12 eastbound traffic, the middle lane is used for traffic arriving on the new link from the M25 anti-clockwise, with the exit lane from the Junction 28 roundabout merging with the middle lane. The nearside lane remains for the M25 clockwise to A12 east traffic.

Junction circulatory

A full review of the existing signage and road markings, including alterations to accommodate the re-aligned approaches will be undertaken during the preliminary design at PCF Stage 3.

5.7 Gantries

All options will require alterations to existing gantries on the M25 anti-clockwise and clockwise carriageways including;

- increasing the span of gantries to widen carriageways
- translocating gantries where the configuration changes make it necessary
- sign changes where existing gantries are unaffected but lane configurations are changed.

The need for additional gantries will need to be reviewed in accordance with the requirements of DMRB TD18/85, although none have been identified in PCF Stage 2.

5.8 Lighting

An appraisal in accordance with DMRB standard TA 49/07 Appraisal of New and Replacement Lighting on the Strategic Motorway and All Purpose Trunk Road Network has not been undertaken at PCF Stage 2. However, all approaches to Junction 28 (M25, A12 and the A1023) and the circulatory carriageway currently have street lighting. It has therefore been assumed that lighting will be required to avoid dark zones through the interchange and to provide route continuity. This will be examined and designed in accordance with DMRB standard TD 34/07 Design of Road Lighting for the Strategic Motorway and All Purpose Trunk Road Network.

5.9 Statutory undertakers

During PCF Stage 2 the Statutory Undertakers Estimate has been prepared, in which a full breakdown of affected utility infrastructure and the associated cost of diversionary works has been included. An outline summary of the impact the options have on existing utility infrastructure can be seen in Table-5-1.

For full details refer to the PCF2 product for Statutory Undertakers Estimate produced for Junction 28.

Table 5-1 Summary impact on statutory undertakers' utilities by option

Utility company	Options		
	5B	5C	5F
British Pipeline Agency		✓	✓
BT Openreach	✓	✓	✓
Essex & Suffolk Water	✓	✓	✓
National Grid – Local High Pressure Gas	✓	✓	✓
National Grid - Medium Pressure gas			✓
National Grid Overhead Transmission Cables	✓	✓	✓
Telent/KPN	✓	✓	✓
Thames Water	✓	✓	✓
UK Power Networks	✓	✓	✓
Zayo/Virgin Media	✓	✓	✓

6 Operational assessment

6.1 Road characteristics

All the links under consideration have similar operational characteristics in terms of the impact on the existing infrastructure and accommodate similar movements. The impact varies depending under the options under consideration. All options provide linkage to A12 east through the new direct connection utilising the proposed loop road, but also via the existing Junction 28 thus increasing network resilience overall.

6.2 Scheme operating regime

The M25 is a part of Highways England's controlled motorway network with variable speed limits and associated supporting technology.

Speed limits

It is envisaged that the management regime will include queue detection on the interchange links to enable the variable speed limit on the M25 to be lowered in the event of queues forming on the loop road.

Discontinuous hard shoulder

Option 5C utilises 470m of existing hard shoulder as an ancillary lane at the M25 anti-clockwise diverge to the proposed loop road.

Operational responsibilities

The M25 Junction 28 sits at the interface of 4 different asset management operations. The M25 is currently operated and managed on behalf of Highways England by Connect Plus Services in accordance with the 30 year DBFO contract which commenced in 2009. The A12 to the east of Junction 28 is part of the all-purpose trunk road network in Area 6, which falls under the Highways England asset management contract with Amey Highways Limited; this runs until March 2019. West of Junction 28 the A12 is part of the "Red Routes" network managed by Transport for London. The A1023 is part of the county road network managed by Essex County Council.

It is envisaged that regardless of option, the new link road will become part of the M25 network. This will have implications for operational management such as winter maintenance gritting routes and other routine maintenance operations with the nearest turn-around on the A12 eastbound is at exit 12 which is 7km east of Junction 28.

Other provisions

It is anticipated that emergency telephones will be provided on the loop road subject to future discussions with the overseeing organisation.

For the single lane loop road Options 5B and 5C consideration should be given to the installation of rotating prism warning signs on the M25 anti-clockwise approach to facilitate the diversion of traffic to Junction 28 in the event of an incident or for routine maintenance activities which necessitate the temporary closure of the loop road.

6.3 Driver compliance

Construction phase

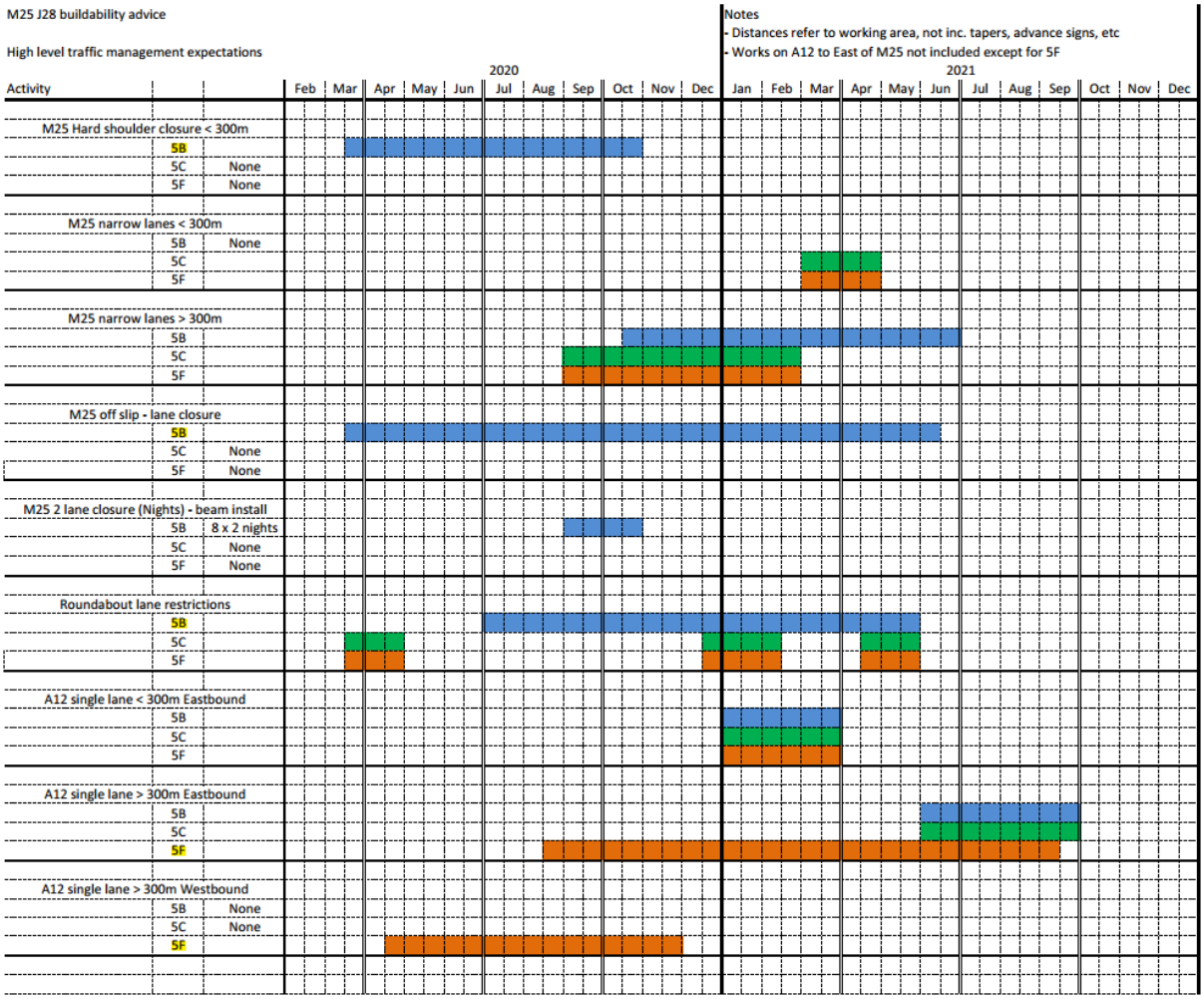
While total construction durations for the three options are likely to be similar, the associated traffic management regimes could vary significantly depending on the option under construction. At a high level, each option has the following construction variables:

- **Option 5B** – widening of the existing M25 Brook Street Viaduct;
- **Option 5C** – realignment of the existing circulatory/M25 anti-clockwise merge;
- **Option 5F** – realignment of the A12 mainline cross-section (in addition to the realignment of circulatory/M25ACE merge).

A traffic management strategy has been prepared to ensure that all works can be constructed using standard traffic management in accordance with Chapter 8 of the Traffic Signs Manual. This works package was peer reviewed and outline construction programmes have been prepared via Early Contractor Involvement (ECI) by representatives from Hochtief.

A preliminary traffic management strategy has been developed in conjunction with Hochieft contractors, as shown in Figure 6-1.

Figure 6-1 Outline traffic management schedule



Based on the preliminary schedule set out in Table 6-1, a number of key differences in the potential traffic management phases have been identified below.

Option 5B

- 12 month closure of the M25 anti-clockwise hard shoulder over the duration of the existing Brook Street Viaduct to facilitate the structural widening works
- 17 month of narrow lanes of the M25 anti-clockwise mainline carriageway to facilitate the structural widening works, the proposed M25 diverge
- Off-side lane closure of the M25 anti-clockwise/circulatory diverge approach for 30 month to facilitate the proposed diverge approach and the structural widening works
- 22 month closure of the lane adjacent to the inner ring of the roundabout circulatory, the closure facilitates the structural works to the existing Brook Street Viaduct.

Option 5C

- 12 month of narrow lanes of the M25 anti-clockwise mainline carriageway to facilitate the proposed M25 diverge.

Option 5F

- 12 month of narrow lanes of the M25 anti-clockwise mainline carriageway to facilitate the proposed M25 diverge
- 25 month closure single lane closure on the A12 eastbound carriageway to facilitate the reprofiling of the mainline cross-section
- 15 month closure single lane closure on the A12 westbound carriageway to facilitate the reprofiling of the mainline cross-section.

Operational phase

To encourage driver compliance all alignments have been designed to be fully compliant with standard road layouts and the design standards wherever possible, however consideration to the following will be required for specific options in future design stages if they are developed further:

- For Option 5B the distance between the successive diverges is below the minimum required in the design standards. Signs and road markings will need to be clear and consistent to ensure that there is no confusion as identified in the outline signage strategy drawings. Drivers that miss the slip road to Junction 28 will need to proceed to Junction 26 to turn around.
- Options 5B, 5C and 5F have been designed as loop roads. The layouts have been designed such that the loop radii do not decrease as drivers pass around the loop road with visibility available for the whole of the loop. Additional vehicle actuated signage on the loop road to encourage motorists to reduce speed in free flow conditions may be beneficial.
- Options 5B, 5C and 5F are currently designed with non-standard layouts on the A12 eastbound carriageway. These require A12 eastbound traffic to be segregated with a nearside lane drop taking traffic to Junction 28 and a single offside lane being used for through traffic onto the A12 east. Careful consideration will be required to the signing and lining on the A12 eastbound approach to prevent last minute swooping manoeuvres from traffic in the offside lane wishing to exit to Junction 28. If traffic in the nearside lane wish

to continue to the A12 they will still be able to do so via the Junction 28 roundabout. This will need to be reinforced with confirmation signing to avoid unexpected braking manoeuvres and confusion.

- Options 5B and 5C have non-standard layouts where they merge with the A12 eastbound carriageway where the single lane loop joins the single lane A12 with a lane gain. It is not envisaged that this will generate any issues with driver compliance however additional “Stay in Lane” signage may help to ensure that conflicts are reduced.
- For all options it is envisaged that the M25 variable speed limits will finish at the start of the link road.

7 Technology and maintenance assessment

7.1 Technology equipment

Where possible, the existing technology equipment will be retained. Instances where new infrastructure is required it shall be installed according to Highways England standards and specification and be CHARM (Common Highways Agency Rijkswaterstaat Model) compliant. This section summarises the impact to technology equipment of various options.

Any future design work, which could affect existing communication infrastructure should be undertaken in accordance with the following:

- Motorway Signalling – TD46/05
- NMCS TA 72/97 – System Design
- Infrastructure Design – TA77/97
- MIDAS – TD45/94
- Emergency Telephones – TA73/97
- CCTV – TD17/85 – Criteria for the provision of closed circuit television on motorways
- NRTS Technical Documents – Relevant standards and procedures
- Manual of Contract Documents for Highways Works.

Motorway incident detection and automatic signalling (MIDAS)

MIDAS is a distributed networks of traffic sensors, mainly loops which are designed to detect incidents or congestion and automatically set appropriate VMS messages to warn drivers of conditions of the road ahead, together with speed limits.

Various gantries are required to be relocated to accommodate carriageway widening. Where these gantries have associated MIDAS infrastructure it will also need to be relocated accordingly. Loops are typically installed in the road surface at nominal 500m intervals and are required to be a maximum distance from the associated gantries.

Additional MIDAS loops should be installed on the proposed link roads for all options to detect queuing. This will enable appropriate speed limit and warning to be set on the M25 mainline in advance of the link road.

Wherever alternations or additional infrastructure are made to the network the site data will need to be updated accordingly.

Variable message signs

The strategy for VMS installations and modifications will be agreed with the Overseeing Organisation during subsequent PCF stages.

Signals

Due to the options removing significant volume from the existing junction circulatory a review of the signal timings will be required during subsequent PCF stages.

Emergency roadside telephones

Emergency roadside telephones will be replaced/relocated wherever affected. It is envisaged that additional emergency roadside telephones will be installed at standard intervals on the proposed link roads.

CCTV

CCTV infrastructure will be replaced/relocated wherever affected to maintain existing levels of coverage. As the proposed link roads will become part of the M25 network it anticipated that additional CCTV infrastructure will be installed to increase the coverage accordingly.

National traffic information service (NTIS) assets

Existing NTIS assets will be replaced if affected by the proposals.

Distribution network operator supplies

It is foreseen that additional Distribution network operator supplies will be required which will be considered during subsequent PCF stages.

Fog detector

Fog detectors will be replaced/relocated and/or added to maintain existing levels of coverage.

RCC systems and sub systems

The Motorway Communications Systems are controlled from Highways England's Regional Control Centre East (RCC(E)), located at South Mimms (M25 Junction 23), which operates a Highways England National Motorway Communication System Mark 2 (NMCS2) Control Office Base System (COBS) with associated Sub Systems. These systems are required to be updated to accommodate changes to the communications infrastructure. This include additional installations as well as modifications to the data set because of changes to the MIDAS loops spacing.

Communications network

In line with the Overseeing Organisation requirements, all technology shall apply IP equipment and adopt NRTS IP services for the outstation to instation communications link. Existing infrastructure will be re-used where practicable.

7.2 Maintenance of civil infrastructure

Safe access for maintenance is essential to facilitate the safety of operational workers, motorists and NMUs. Access will be required along the entire length of all options to ensure maintenance works can be carried out while reducing or mitigating associated operational risks. Wherever possible it is highly desirable to synchronise any forecasted maintenance or renewal works planed in the vicinity of the proposals to take full advantage of the construction works and temporary traffic management.

Further detail regarding maintenance can be found in the Maintenance and Repair Strategy Statement, however as a principle designers are required by CDM regulations to improve the design in regards to the health and safety of others. As outlined in DMRB 69/15 this process can be demonstrated by following the hierarchy of control, known by the acronym ERIC (Eliminate, reduce, information, control), shown in Table 7-1.

Table 7-1 Overview of ERIC (Eliminate, reduce, information, control)

Action	Example
Eliminate the hazard	• Avoid maintenance activity through better or alternative design – choice another technique/approach
Reduce the hazard	• Change detail, proximity, material, use latest technology, design to reduce time of exposure etc. • Improve access, provide identification e.g. marker posts, ensure appropriate management systems are in place.
Information	• Inform others of residual hazards and assumptions after actions above. • Assumed diversion routes • Traffic management scheme • Access to works • Drainage access issues (confined space, traffic proximity) etc.
Control	• Having done the above, the responsibility for producing a 'safe method of work' to ensure it is safe, falls to those in charge of the work itself.

Key maintenance issues – Existing infrastructure

Key infrastructure that has associated maintenance activities at present include:

- routine drainage maintenance – outfalls, pollution control devices, gully and slot drain emptying
- surface course replacement
- road marking and studs replacement
- structure bearing and joint replacement
- routine structural inspections
- safety barrier inspection and replacement
- luminaire replacement
- Traffic signage, signals and technology
- Winter maintenance.

Key maintenance issues – Proposed infrastructure and safety considerations

While not currently detailed as part of the PCF Options Phase (including Stage 2) careful consideration will be given to the following elements of the proposed infrastructure to minimise maintenance intervention and associated operational risk. This will be considered further during the Development Phase of the preferred options.

The following are key consideration relating to potential maintenance activities associated with the options, covering road side features, structures, and drainage.

Road side features

- No vegetation plating in areas which provide visibility splays
- Harden verges close to signs and safety barrier to reduce grass cutting or utilise low growth species

- Locate all none road-user essential features (e.g. feeder pillars) as close to the highway boundary as practically possible
- Locate emergency refuge areas adjacent to features to be maintained
- Locate lighting columns to the nearside verge wherever practical
- Plant trees away from drainage pipes to reduce likelihood of damage caused by root systems.

Structures

- Continuities and integral bridge decks where possible – eliminating joints and bearings
- The possibility of using corrosion resistant rebar
- Removing joints from string courses to remove use of joint sealants over live running lanes
- Inspection galleries built into structures to remove the need for operatives accessing from carriageway.

Drainage

- Wherever possible limit the cross-carriageway drains, as these are difficult to maintain and repair, and they also contribute to pavement failure if damaged
- Avoid proposing manholes and gullies within the wheel track zone
- providing larger pipe diameters to offer additional capacity
- Minimise use of combined kerb/drainage units to reduce the likely hood of blockages and the requirement of intervention.

Inclusive of the above the introduction of any of the proposed options presents serval residual maintenance issues.

Winter maintenance operations are affected by all options. When selected, any of the potential options would be added to the existing winter maintenance route, however maintaining vehicles would have to utilise Junction 12 of the A12 to turn around and re-join the M25. This movement would add approximately 15km to the existing route and therefore a significant additional cost to the winter maintenance budget over the duration of the maintenance contract. Mitigating measures such as specific accesses/turnaround points for winter maintenance should be considered in detail once a preferred option has been selected.

Options 5B and 5C are single lane loop roads. Any significant maintenance activities to these options will require the closure of the loop road to ensure the safety of the operational workforce. The proposed diversion during the period of works would be to utilise the existing junction.

7.3 Maintenance of roadside technology

In the scheme area the Regional Technology Maintenance Contractor (RTMC) are working under the supervision of Connect Plus, who have been appointed as Service Manager for the contract. Through the engagements with Connect Plus, the maintenance requirements of equipment to be maintained by the RTMC shall be captured and agreed.

Where existing access provision for maintenance is in place, this should be preserved along the route. Where this is not possible a suitable alternative should be provided. Any new roadside infrastructure will need suitable access either from the M25 or the A12. Where practicable, positioning of roadside technology should consider access for routine maintenance, preferably away from the roadside. Access for vehicles and other equipment should be provided.

8 Traffic and economic assessment

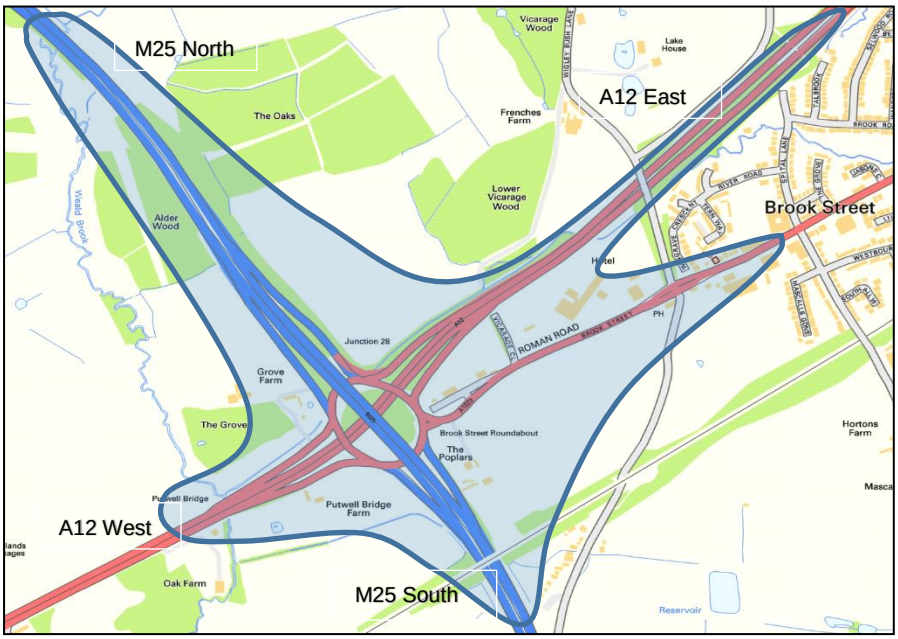
8.1 Modelling

Atkins submitted the M25 Junction 28 Appraisal Specification Report at the end of Stage 1 (September 2016). This report sets out the Stage 2 traffic modelling approach. In summary, the VISSIM model has been retained for the economic and environmental assessments during the Stage 2 work. Essentially the M25 Junction 28 improvement scheme is expected to provide relatively local benefits relating to the improved performance of the circulatory roundabout, reduced queuing on the ramps approaching the gyratory as well as along the A12 and M25.

Area of interest

In evaluating the proposed improvements (including a dedicated link between the M25 anti-clockwise and the A12 towards Essex) in terms of operational performance, safety, environmental effects and economics, the study needed to consider impacts beyond the immediate boundaries of the junction. On this basis the transport modelling has focused broadly on an area of interest as shown in Figure 8-1.

Figure 8-1 M25 Junction 28 area of interest



Base model

The VISSIM base model (2014) was developed using Highways England's guidelines for the 'Use of Microsimulation' software. The base model provided a robust representation of base year (2014) traffic conditions at the M25 Junction 28, hence it was used with a reasonable degree of confidence to forecast the likely traffic impact of the Junction 28 improvement options. The base model validation details including model development, calibration and demand matrices inputs are available in the Stage 2 Local Model Validation Report (February 2017).

8.2 Forecasting

The South East Regional Transport Model (SERTM) model has a base year of 2015 and covers all motorways, A-roads and most B-roads and other important local road networks in the South East as shown in Figure 8-2. The red line area shows the simulation area in SERTM whereas blue line represents the local authority area.

Figure 8-2 SERTM model area

It has been identified that SERTM could be used to provide an initial assessment of any strategic implications of the Junction 28 scheme. It will also be used to provide the basis for forecasting the future year demand matrices (under different scenarios) for the microsimulation model. This would replicate any changes in strategic routing or distribution of trips as a result of the improvements at Junction 28 and other major transport developments in the wider area, and hence the turning movements through Junction 28.

It is proposed that a SERTM based cordon model will be developed covering both M25 Junction 25 and Junction 28. This is being developed under the M25 Junction 25 RIS scheme as part of the PCF Stage 2 works[10]. This model will be based on a cordoned network and demand matrices extracted from the new SERTM model covering both Junction 25 and 28 and surrounding networks.

[10] See M25 Junction 25 Improvements Appraisal Specification Report, September 2016 for more details on SERTM developments

However, the programme to develop the SERTM based Junction 25/Junction 28 strategic model extends beyond the timescales to undertake the Junction 28 PCF Stage 2 option assessments. Therefore, the SERTM based Junction 25/Junction 28 model will not be used for the economics and environmental assessments during Stage 2. Instead the microsimulation VISSIM model has been refined and will be retained for these assessments. This approach was agreed with SES TAME.

Forecast scenarios

Forecasts have been developed for two purposes primarily. Firstly, the forecasts have been used to test the operation of the options under future conditions and guide the development of the proposed options. Secondly, the forecast models have been used to generate the key inputs for the environmental and economic assessment of the options. The M25 Junction 28 forecast models have been developed for the following years:

- 2022 (opening year)
- 2037 (design year)
- 2051 (horizon year).

The M25 Junction 28 VISSIM model has been developed for the DM and following three DS options. The detailed description of each option is presented in Chapters 4 and 5.

- DM - Includes signal timing optimisation at the Junction 28 gyratory
- DS 5B (Option 5B)
- DS 5C (Option 5C)
- DS 5F (Option 5F).

Methodology

The Junction 28 Appraisal Specification Report set out that under PCF Stages 1 and 2, the traffic forecasting and option testing would involve several key steps:

- Use of NTEM growth factors to forecast car demand based on LTC impact at the Junction 28
- As NTEM growth factors are only for cars, the NTM growth factors were employed for the goods vehicle
- Capacity constraint has been applied in the forecasting by controlling growth to the theoretical capacity of the local highway network
- Based on WebTAG Unit M4, the sensitivity test has been undertaken for treatment of uncertainty in model forecasting.

Development of growth factors

Average NTEM (TEMPRO) growth factors were considered for cars and for each time period. Furthermore, these factors were updated to take into account the influence of changes in fuel and income through time, in line with WebTAG Unit M4. The NTM growth factors were used for the goods vehicles. These growth factors are presented in Table 8-1.

Table 8-1 M25 Junction 28 growth factors

Peak Hours	NTEM Growth Factors (Cars)	NTM Growth Factor (LGV)*	NTM Growth Factor (HGV)*
2014-2022			
AM	1.128	1.221	1.091
IP	1.146	1.221	1.091
PM	1.128	1.221	1.091
2014-2037			
AM	1.323	1.608	1.268
IP	1.403	1.608	1.268
PM	1.331	1.608	1.268
2014-2051			
AM	1.498	1.953	1.449
IP	1.598	1.953	1.449
PM	1.503	1.953	1.449

*Note: * values from NTM March 2015*[11]

Uncertainty and sensitivity assessment

Sensitivity tests for the forecast demand matrices are undertaken to take account of any uncertainties in demand forecasting. The sensitivity tests follow the guidance set out in WebTAG Unit M4 (2014).

Uncertainty in traffic growth has been set out as ±2.5% for forecasts one year ahead, rising with the square root of the number of years multiplied by ±2.5%, to ±15% for forecasts 36 years ahead (i.e. 5% four years ahead, 7.5% nine years ahead etc.).

For the three forecast years of 2022, 2037 and 2051, the number of years ahead from the 2014 base year is 8, 23 and 37 years respectively. The uncertainties are then calculated as the square root of the years ahead multiplied by ±2.5%. The resultant growth factors' comparison between the core, low and high scenarios are shown in Table 8-2.

The 2014 base year matrices are multiplied by the percentages shown above to produce the uncertainty matrices in each forecast year.

The high and low growth factors presented in above table were considered for the sensitivity assessment.

[11] See M25 Junction 28 Stage 2 Traffic Forecast Report – Table 4-5

Table 8-2 Sensitivity growth factors comparison[12]

Forecast Year	Core Scenario			Low Growth Scenario			High Growth Scenario		
	Cars	LGVs	HGVs	Cars	LGVs	HGVs	Cars	LGVs	HGVs
AM Peak									
2022	1.13	1.22	1.09	1.05	1.15	1.02	1.20	1.29	1.16
2037	1.32	1.61	1.27	1.19	1.49	1.15	1.46	1.73	1.39
2051	1.50	1.95	1.45	1.31	1.80	1.30	1.69	2.10	1.60
Inter-Peak									
2022	1.15	1.22	1.09	1.07	1.15	1.02	1.22	1.29	1.16
2037	1.40	1.61	1.27	1.27	1.49	1.15	1.54	1.73	1.39
2051	1.60	1.95	1.45	1.42	1.80	1.30	1.78	2.10	1.60
PM Peak									
2022	1.13	1.22	1.09	1.05	1.15	1.02	1.20	1.29	1.16
2037	1.33	1.61	1.27	1.20	1.49	1.15	1.47	1.73	1.39
2051	1.50	1.95	1.45	1.33	1.80	1.30	1.68	2.10	1.60

Due to high traffic volumes on the A12 East and Brook Street zones, the high and low growth scenarios was found to generate traffic demands higher than the capacity. Consequently, all forecast vehicles were not able to enter the network, and often the Brook Street exit was noticed blocking the eastern gyratory of the Junction 28, which deteriorates the operation of the whole gyratory and slip roads. To overcome this, the sensitivity test growth factors were constrained to capacity, and the high and low growth demand matrices were furnessed, balancing refined origin and destination trips ends. This approach is consistent with the core growth demand constraint.

Total matrix vehicles (light and heavy vehicles combined) for each forecast year (2022, 2037 and 2051) and growth scenario (low, core and high) are summarised in Table 8-3 below.

Table 8-3 Growth scenario summary – total trip matrices[13]

Growth Scenario	2022			2037			2051		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Low	17,293 (-6%)	12,107 (-6%)	17,697 (-6%)	19,517 (-8%)	14,200 (-9%)	19,959 (-7%)	21,403 (-7%)	16,039 (-11%)	21,233 (-8%)
Core	18,273	12,855	18,711	21,015	15,511	21,300	22,830	17,736	22,936
High	19,221 (5%)	13,603 (5%)	19,638 (5%)	22,391 (6%)	16,822 (8%)	22,618 (6%)	23,014 (1%)	19,434 (9%)	23,071 (1%)

[12] See M25 Junction 28 Stage 2 Traffic Forecasting Report (Table 6-13)
[13] See M25 Junction 28 Stage 2 Traffic Forecast Report (Table 6-14)

8.3 Impact of the options against the project objectives

A comparison of the key network performance indicators across the M25 Junction 28 VISSIM network was undertaken between the Do Minimum scenario and each Do Something option. The Do Minimum scenario includes signal optimisation at the Junction 28 gyratory. The optimised signals have been obtained for each forecast year and each time period from the LinSig model. The Do Minimum and Do Something VISSIM network details including signal timings, demand matrices and network evaluation is presented in the M25 Junction 28 Stage 2 Traffic Forecast Report.

The 2022 assignment results for all three time periods are summarised as follows:

- Under 2022 DM conditions significant increases in queues, delays and journey times are expected compared to the 2014 base year. Average delay is expected to increase by 10% and 13% in the AM and PM peak hours respectively, with total delay increasing by 22% (+100 hours) and 25% (+150 hours)
- **The DS 5C and 5F** options perform well, with an overall good improvement in journey time and delays predicted
- **The DS 5B** option appears to perform the best in terms of reducing delays and improving journey times compared to the DM. The queue lengths are predicted to reduce at all approaches, except on the Brook Street approach which gets slightly worse in the AM peak.

The 2037 forecast assignment results for all three time periods highlighted a number of key observations:

- Under a 2037 DM scenario a significant deterioration in traffic conditions is expected. Average delays could be 2 or 3 times that experienced in 2014 in the AM and PM peak hours, with total delay times across all movements increasing by similar levels. As a result, journey times on key movements will also increase, for instance the M25 South to A12 East movement could see increases of 10% to 20%
- **The DS 5C and 5F** options perform well, with an overall improvement in journey time and delays predicted. The A12 West to M25 North (Route 4) journey time is predicted to improve significantly from 1300 seconds to 670 seconds
- **The DS 5B** option appears to perform like the other two options by reducing delays and improving journey times compared to the DM. The queue lengths are predicted to reduce at all approaches, except on the Brook Street approach. This is mainly due to priority controlled operation at this location for Brook Street traffic, combined with the freer movement of other traffic using the gyratory, resulting in vehicles struggling to find gaps in circulatory traffic to access the junction from Brook Street.

For the 2051 AM and inter peak hours assessment see the M25 Junction 28 Stage 2 Forecast Report. The 2051 PM peak assessment was seen as the worst-case situation and as such is summarised as follows.

- The journey times on all 12 routes are predicted to increase substantially in the 2051 PM peak hour, and more than doubling on some routes along the A12 West
- Average delay is expected to more than triple from around 110 seconds / vehicle to nearly 284 seconds / vehicle

- The queue length is predicted to increase significantly on all approaches to the junction. The maximum increase in queue is expected on M25 South, A1023 Brook Street and A12 West approaches
- All three options are predicted to perform better than the 2051 DM model with journey times improving on eight routes.

Sensitivity appraisal

All three DS options were assessed for the low and high growth scenarios. In summary, the sensitivity analysis confirms that:

- the DM and all three DS low growth scenarios for 2022, 2037 and 2051 perform better than the equivalent core scenarios
- the DM and DS high growth scenarios forecast worse network performance in both 2022 and 2037 relative to the core scenarios
- the 2051 high growth scenario yields unrealistic results due to significantly high demand.

8.4 Design life

In addition to the key network performance evaluation design life was assessed for each of the scheme option. The ratio of flow to capacity (RFC) was derived using practical capacity of new loop from the M25 anti-clockwise to A12 east. The practical capacity of single lane loop is assumed approximately 1600 to 1800 vph depending on the radius. The merge capacity will be lower and a capacity of approximately 1300 to 1400 vph has been assumed for this analysis. The forecast flows are forecast to be around 1500 vph in 2037 and 1800 in 2051, and are expected to be operating close to the capacity of a single lane loop beyond 2037 (Table 8-4). The two-lane loop on the other hand is expected to operate around 50% of capacity, and also with a tiger tail style merge would offer greater merging capacity or approximately 3000 vph. The capacity figures shown here are assumptions broadly based on DMRB (TD22/06) and will be considered in greater detail during the design processes in Stages 3 and 4.

Table 8-4 Design life (RFC summary)

Option		2022			2037			2051		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
5B	RFC	0.71	0.62	0.82	0.83	0.76	**0.87**	**0.90**	**0.88**	**0.89**
5C	RFC	0.71	0.62	0.82	0.83	0.76	**0.87**	**0.88**	**0.88**	**0.89**
5F	RFC	0.42	0.37	0.49	0.49	0.45	0.51	0.53	0.52	0.53

The above analysis shows that both the single lane loop options (5B and 5C) predicted to reach at capacity by 2037 (particularly in PM peak) whereas the option 5F predicted to operate well within capacity by the 2037 and beyond. Furthermore, the option 5F provides resilient during any incident and maintenance work.

8.5 Economic performance

The economic performance of each of the three options for the scheme was examined by comparing the costs and the benefits, to determine which option represented good value for money. This included the following elements:

- road user journey time impacts – due to changes in travel time and vehicle operating costs
- public transport (bus) journey time impacts – due to changes in travel time
- road user safety impacts – due to changes in the future number and/or severity of accidents
- incident delay impacts – due to changes in journey time related to incidents
- construction impacts – impacts on road user travel time and vehicle operating costs during construction
- indirect tax revenue – due to changes in the amount of fuel purchased and other direct vehicle operating costs, and changes in expenditure on transport offsetting changes in expenditure elsewhere in the economy
- greenhouse gas, noise and air quality impacts.

Economic appraisals of all three options were assessed in accordance with the latest guidance, using the following software packages:

- Transport User Benefit Appraisal (TUBA) Version 1.9.8
- Cost Benefit of Accidents – Light Touch (COBA-LT) Version 2013.2
- Queues and Delays at Roadworks (QUADRO) Version 4.R14.

All models were based on relevant traffic forecast information on flows, journey times and distances from the VISSIM traffic model. The traffic impacts of the construction period were assessed predominantly in QUADRO, while other benefits in TUBA and COBA-LT were assessed over a 60-year assessment period from the Opening Year.

Costs associated with the three options were supplied by Highways England Commercial Services team for use in the economic analysis. These costs included items such as the construction and land cost, preparation and supervision costs. Most the scheme costs would be incurred in the years leading up to the Opening Year.

Journey time impacts

Improvement of Junction 28 of the M25 with A12 is expected to greatly decrease queues and delays, resulting in significantly decreased journey times along the M25 and the A12 nearby. The TUBA analysis of the three options used traffic modelling results from the 12 hour AM/IP/PM periods, excluding any benefits arising in the off-peak night-time period and weekends. Travel time benefits for all options were roughly similar, reflecting on the fact that each of these options provide a dedicated right turn from the M25 anticlockwise to A12 eastbound, bypassing the Junction 28 roundabout. Option 5B provides the most direct dedicated route, resulting in largest overall benefits (£357m). Options 5C and 5F were slightly behind with £342m and £347m in benefits respectively.

Analysis of these benefits shows that business users gain the most. Most of the time saving benefits are derived from time savings greater than 5 minutes for all options and these benefits are realised during the peak periods with little benefit in the inter-peak. The 60 year profile of the benefits shows the PVB rising through the early years of the project lifetime in each case, with benefits increasing significantly between the first, second and third modelled years (2022, 2037 and 2051). Beyond 2051, it is assumed that there will be no further growth in demand or benefits.

Safety impacts

Safety modelling used accident rates for the circulatory carriageway, slip roads, merges and diverges around Junction 28 while the remainder of the modelled network was based on default national average rates by road type defined within COBA-LT. The results were a slight positive impact on accidents forecast for each option, ranging from £1.6m to £2.6m.

Vehicle operating cost impacts

There are Vehicle Operating Cost (VOC) disbenefits for consumers and business users in Options 5C and 5F. This is because of users experiencing large non-fuel VOC disbenefits due to slightly longer trips in these options.

User delay during construction

The construction of any of the options for Junction 28 would mean road users would experience increased delays during the construction period. All options would require traffic management, which would have a significant impact on Junction 28, including the mainline M25. This will most likely have substantial impact on road users at varying locations for much of the construction period in advance of scheme opening. Consequently, the estimated disbenefits are significant, ranging from -£34.7m (Option 5B) to -£21.3m (Option 5C)[14]. These disbenefits are however much reduced from the forecasts produced for the options at Stage 1. The large improvement for the three options at Stage 2 is due to the more detailed knowledge of the traffic management and sequencing required, especially on the M25 which saw the worst of the disbenefits and now has virtually no lane closures, the primary cause for the worst forecasts of construction period congestion.

Reliability

The economic assessment presented does not include a monetised estimate of reliability benefits. This is because the methodology for quantification has been under development and unfortunately the available baseline information on the occurrence and duration of events is not comprehensive and as such is not useable for this assessment. However, each of the Junction 28 improvement options are expected produce reliability improvements through a number of effects.

Firstly, each option would provide increased capacity and therefore improve the performance of the roundabout providing more flexibility to cope with fluctuations in capacity and demand, including the occurrence of any accidents or incidents. Additionally, through providing a new link, the proposed improvements would provide an additional route for a M25 to A12

[14] See M25 Junction 28 Stage 2 Economic Assessment Report – Table 5-12

eastbound traffic, helping to mitigate the impact of incidents by providing more options for diversion routes.

Finally, each of the improvement option is expected to reduce the occurrence of accidents on the roundabout and thereby improve journey time reliability.

Maintenance cost impacts

Maintenance costs for the scheme (Operating Costs) were not included at this stage as they will be minor in comparison to the main scheme implementation costs. They will be considered in subsequent PCF stages.

Indirect taxation revenue impacts were included as part of the benefits, in line with recent guidance.

Air quality, Greenhouse gases and noise

Assessment of environmental elements such as air quality, greenhouse gases and noise has been carried out following relevant TAG and discussed in details in the Chapter 9 – Environmental Assessment.

Commercial cost estimates

Outturn scheme costs are the expected costs in the actual years of expenditure. The expenditure profiles are based upon cost estimates for each financial year prepared in 2014 Q1 prices, and then inflated to outturn costs using Highways England projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the GDP- deflator series as published in the latest TAG data book. All the costs are in factor cost unit of account and exclude VAT, both recoverable and non-recoverable. All spend to date (historic cost) has been removed by Highways England Commercial Unit as these costs are considered as sunk costs and not included in the economic appraisal.

For cost-benefits analysis purposes, the costs were discounted to 2010 market price unit of account.

Table 8-5 summarises the value of the construction cost with expenditure profile. It also shows total discounted costs in 2010 market price unit of account (Present Value of Costs, 2010 prices, discounted to 2010) for each option.

Table 8-5 Discounted scheme costs – Investment, PV, £million[15]

	Option 5B	Option 5C	Option 5F
Preparation	£4.8	£4.8	£4.9
Supervision	£0.9	£0.9	£1.0
Works	£33.8	£33.9	£41.2
Land	£3.3	£4.0	£4.1
Total, PVC	**£42.8**	**£43.7**	**£51.2**

[15] See M25 Junction 28 Stage 2 Economic Assessment Report (Table 3-2)

Summary of scheme benefits

Based on the above assessment, all three options would deliver very high value for money (BCR greater than 4.0) in the core scenarios, using the criteria in the Department for Transport's guidance.

A summary of the total monetised costs and benefits for each option, expressed in Present Value, are summarised in out of all the options, Option 5B has the highest PVB of around £327m, with PVC of about £43m, giving a BCR of 7.6 which is the highest amongst all the options. Options 5C and 5F are both close to Option 5B in terms of benefits. These options have a PVB of about £315m and £314m respectively and PVC of about £44m (Option 5C) and £51m (Option 5F), therefore resulting in BCRs of 7.2 for Option 5B and 6.1 for Option 5F.

The assessment results detailed in Table 8-5 are based on the most likely growth scenario (Core) and weekdays only. In addition, sensitivity tests were undertaken for further scenarios and including weekends for all options. Inclusion of weekends increased the travel time and vehicle operating cost benefits by 6%-7% and hence the BCRs slightly. Traffic modelling based on the highest (High) and lowest (Low) levels of future traffic growth were used to forecast the associated benefits, BCR and value for money categorisation.

It should be noted that at this stage only TUBA sensitivity tests were run as the TUBA forecasts provide the greatest part of the benefits. The results from the sensitivity results showed that while the high growth produced a large increase in the scale of the benefits, low growth meant that the Do minimum scenario had less congestion, so the scheme's benefits were reduced, and the BCRs and value for money scores ranged from 1.0 for Option 5F (low value for money) to 1.5 for Option 5C (medium value for money).

The variation between scenarios reflects the fact that the performance of the junction is very sensitive to demand levels. However, the differences between scenarios are likely to be accentuated by the fact that it has not been possible to optimise the junction for the patterns of demand experienced in the low and high growth demand scenarios within the timescales available. Given the sensitivity of the junction to the balance between flows on different arms, this is potentially leading to overstated delay in the Do-minimum and/or Do-something scenarios in the growth sensitivity tests, with associated impacts on the level of benefits estimated.

Table 8-6 Traffic economics summary, excluding weekends – Core scenario, £million (PV)[16]

			Costs/Benefits		
			Option 5B	**Option 5C**	**Option 5F**
Benefits	Consumer Commuting User Benefits	Travel Time	£104.1	£101.1	£102.7
		VOC	£1.1	£0.1	£0.1
		Construction Delays	-£8.7	-£4.2	-£5.8
		Maintenance Delays	£0.0	£0.0	£0.0
		Net Consumer User Benefits	**£96.5**	**£97.0**	**£97.0**
	Consumer Other User Benefits	Travel Time	£91.1	£89.8	£90.0
		VOC	£0.5	-£1.4	-£1.4
		Construction Delays	-£10.1	-£6.4	-£9.2
		Maintenance Delays	£0.0	£0.0	£0.0
		Net Consumer User Benefits	**£81.6**	**£82.0**	**£79.4**
	Consumer Business User Benefits	Travel Time	£161.9	£151.3	£155.1
		VOC	£4.3	-£3.7	-£2.9
		Construction Delays	-£15.9	-£10.7	-£14.3
		Maintenance Delays	£0.0	£0.0	£0.0
		Net Business User Benefits	**£150.2**	**£137.0**	**£137.9**
	Accidents Benefits		£2.4	£1.6	£2.6
	Indirect Tax Revenues		-£0.6	£3.2	£2.8
	Noise		-£0.16	-£0.21	-£0.16
	Air Quality		-£0.04	-£0.07	-£0.07
	Greenhouse Gases (Carbon)		-£3.10	-£5.40	-£5.80
	Total PVB (£m)		**£326.8**	**£315.1**	**£313.7**
Costs	Operating Costs		£0.0	£0.0	£0.0
	Investment Costs		£42.8	£43.7	£51.2
	Revenue Change		£0.0	£0.0	£0.0
	Total PVC (£m)		**£42.8**	**£43.7**	**£51.2**
Net Present Value (NPV)			**£284.1**	**£271.4**	**£262.5**
Benefits to Cost Ratio (BCR)			**7.6**	**7.2**	**6.1**
Values are 2010 prices, in £millions, discounted to a 2010 present value year.					

[16] See M25 Junction 28 Stage 2 – Economic Assessment Report (Table 5-14)

9 Environmental assessment

9.1 Air quality

The air quality study area is within the boundaries of Brentwood Borough Council (BBC) and the London Borough of Havering (LBH). BBC have declared two AQMAs; for the eastern half of the junction and for the area near Nags Head Lane to the south. The LBH has declared a Borough wide AQMA which covers much of the area to the west. In total, there are three AQMAs within the air quality study area designated for exceeding NO_2 annual mean Air Quality Strategy objective. Defra Pollution Climate Mapping (PCM) and local air quality monitoring data indicates that there are currently exceedances of the annual mean NO_2 limit value and AQS objective within a number of key traffic corridors.

There are not expected to be any exceedances of the annual mean NO_2 AQS objective in the opening year with or without any of the proposed scheme options at any of the modelled receptors.

There is only expected to be one receptor (Grove Farm) with a small increase in annual mean NO_2 concentrations with option 5B only. Changes at all other receptors are expected to be imperceptible.

There are not expected to be any road links that exceed in 2020 in the air quality study area and changes in concentrations due to any of the proposed scheme options would not result in exceedances in 2020 or beyond. There is not expected to be a compliance risk due to any of the route options.

Given the magnitude of changes and number of receptors likely to be affected, it can be considered that none of the proposed scheme options would have a significant effect on local air quality emissions based on the expected changes in traffic.

In summary, the results from the local air quality assessment are broadly the same with all options as there is expected to be an imperceptible change in concentrations with the scheme at all receptors, with one exception for Option 5B, where there is expected to be a small increase in annual mean NO_2 concentrations at one receptor, so Option 5B is marginally worse.

9.2 Cultural heritage

There is a Grade II Listed Building, The Nags Head just to the east of the junction on Brook Street and two Registered Park and Gardens at Warley Place, to the south, and Weald Park to the north. The cultural heritage study area contains two Archaeological Priority Areas (APA), defined as areas of archaeological interest, due to their strong potential to contain archaeological remains of a particular type or period. Whilst the APAs are not defined as designated assets in the National Planning Policy Framework (NPPF), they are still a material consideration in the assessment process.

The construction and operation of the proposed scheme options will not give rise to any direct significant effects on known designated cultural heritage assets.

All proposed scheme options are likely to result in permanent moderate (significant) adverse effects in relation to two non-designated APAs associated with the former course of a Roman Road from London to Chelmsford and Colchester and palaeo-environmental deposits underlying the alluvium. This is due to potential removal of archaeological remains during construction.

In summary, although the same significant effects i.e. moderate adverse are recorded for each of the proposed scheme options, there is a preference for Option 5B due to the reduced land take which will reduce the likelihood and extent of disturbing buried archaeological remains.

9.3 Landscape

J28 lies within the Green Belt, adopted by the LBH and BBC. The landscape setting around the junction has a mixed character of rural fields bisected by road corridors including the M25 and A12. The junction is located within Weald Brook Valley between the eastern edge of Romford and western edge of Brentwood. Although the landscape of the study area is not protected by landscape designations it contains landscape elements like woodland areas, field patterns and landform. Valued elements of landscape character include strongly undulating wooded farmland, with extensive areas of woodland with some narrow rural lanes.

J28 itself, is set within blocks of Ancient and semi-natural Woodland, small-scale pastoral and arable fields bounded by hedgerows with intermittent trees, and by linear woodland belts. Semi-mature woodland belts are largely present along the entry and exit slip roads of the M25, as well as along the A12 east and west of the junction towards the fringes of the built-up areas of Brentwood and Romford.

The main receptors include some of the residential properties at the eastern edges of Romford (approximately 1.1 km from the centre of the junction) and receptors to the south of the junction along Brook Street/A1023.

During construction and operation of Option 5B, there will be minor loss / damage to the Grove woodland and to areas of vegetation local to the highway corridor. Damage to landscape character, including field patterns and landform would likely be unnoticeable. Options 5C and 5F would moderate loss / noticeable damage to field patterns, and partial loss/noticeable damage to the distinctive landscape elements of Alder Woodland and areas of vegetation local to the highway corridor resulting in moderate adverse effects during both construction and operation.

In terms of visual impact, several receptors have been identified. Significant effects are predicted for visual receptors including Grove Farm and users of Maylands Golf Course for all proposed scheme options.

In summary, during construction and operation, the landscape effects of Option 5B are the least adverse of the options assessed. In terms of visual impact, Option 5B is the least adverse of the options assessed. Option 5F would result in large scale loss of trees, which can only partially be mitigated through the proposed planting in operational stage.

9.4 Nature conservation

The Manor Local Nature Reserve, which is a statutory designation and includes Dagnam Park, Hatter's Wood and Duck Wood, is located within 400m of J28. There are a number of non-statutory sites namely Ingrebourne Valley Site of Metropolitan Importance (SMI) for nature conservation which is immediately adjacent to J28; Local Vicarage Wood and the Oaks Local Wildlife Sites located up to 400m to the east of J28; and Ducks Wood, located 400m to the west. Local Vicarage Wood, Vicarage Wood and Duck Wood are designated as Ancient Woodland.

The main habitats recorded within the survey area during the extended Phase 1 habitat survey were broadleaved semi-natural woodland; scrub (continuous and scattered); scattered trees; semi-improved grassland; improved grassland; tall ruderal and ponds and watercourses. The habitats recorded have the potential to support a range of legally protected species such as great crested newt, bats, badger and dormouse.

Temporary effects of moderate significance are anticipated on the Ingrebourne Valley SMI due to temporary loss of habitat for all proposed scheme options. Options 5C and 5F will have additional permanent effects of moderate significance due to shading of the Weald Brook in culverted sections and loss of riparian habitat.

Temporary effects of slight significance are anticipated on notable habitats and species due to construction impacts from all options. All the proposed scheme options may potentially impact on legally protected species during construction.

Appropriate compensatory measures and mitigation such as minimising of the loss of habitat, both from designated sites or notable habitats outside, through design; provision of compensation habitat which is appropriately managed to result in a net-gain for biodiversity; management of retained habitat to enhance biodiversity value and mitigation for disturbance of notable species through habitat retention and sensitive working practices, will reduce the level of significance of temporary effects to that which is not significant.

In summary, Option 5B will result in overall effects of the least significance on nature conservation features due to temporary effects only. Options 5C and 5F, both have temporary effects and permanent effects on the Ingrebourne Valley SMI. The permanent effects of Option 5C are greater (although significant at the same scale as Option 5F) due to the wider embankment and longer culvert at the northern river crossing of the loop road.

9.5 Geology and soils

The anticipated geology and soils present comprise Landfill Material, Made Ground, superficial Alluvium and Head Deposits and solid geology of London Clay Formation, including Claygate Member in the southern portion of the site. There is potential for impacts to the scheme associated with ground conditions that may be encountered and on human and/or controlled waters receptors associated with potential sources of contamination within or in proximity to the proposed routes, including localised deposits of Made Ground, the Brook Street Landfill and other potentially contaminative land uses such as the sewage treatment works to the south-west of Junction 28.

The agricultural land affected by all three options is Agricultural Land Classification (ALC) Grade 2b to 4, i.e. non Best and Most Versatile (BMV) land. The significance of effect of loss of agricultural soils is slight adverse as a result of being non-BMV land. Option 5B takes the least land and has the least adverse effect, with Options 5C and 5F equal in their effect.

In summary, slight beneficial effects are considered for all proposed scheme options relating to overall betterment of land contamination present in the study area.

9.6 Materials and waste

At this stage of the design process no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential

to produce more waste. A summary of the key effects associated with the Options 5B, 5C and 5F designs are summarised below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Increased waste arisings associated with the construction / widening of viaducts (Option 5B only)
- Increased construction waste arisings associated with the construction / extension of bridge(s)
- Increased construction waste arisings associated with the construction of watercourse realignments.

9.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is necessary to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time.

Regarding the operational phase, the Magnitude of Impact (DMRB) assessment predicts that none of the proposed scheme options are predicted to result in a ‘minor’, ‘moderate’ or ‘significant’ increase in noise at the noise sensitive receptors identified within the study area. Option 5F is predicted to result in a very small number of properties experiencing a “minor” decrease in noise upon scheme opening. By the future year all scheme options are predicted to result in a negligible change in noise.

The Significance of Effects assessment for both Options 5B and 5C predicts a very small increase in the number of properties experiencing noise levels above the threshold for adverse effects upon opening, however by the future year all scheme option assessments predict an increase in the number of properties experiencing noise levels below the threshold for adverse effect. No scheme option assessment predicts an increase in the number of properties experiencing noise levels above the threshold for significant effect.

In summary, the results from the noise impact assessment in accordance with DMRB are broadly the same with all options as there is expected to be a negligible change in noise with the scheme at all receptors by the design year, with a very small number of receptors predicted to experience a ‘minor’ decrease in noise upon scheme opening for Option 5F. The results from the noise impact assessment with regards to Summary of Effects are broadly the same with all options, with all options expected to result in an increase in the number of properties experiencing noise levels below the threshold for adverse impact by the design year, with a very increase in the number of properties expected to experience noise levels above the threshold for adverse effects upon scheme opening for Options 5B and 5C. Option 5F is therefore considered as marginally preferable to options 5B and 5C.

9.8 People and communities

There are no identified PRoW within the 500 m radius of J28 however, there are shared used paths and footways which provide pedestrian links between Brook Street, Brentwood and Harold Park, Romford and neighbouring areas.

Brentwood is approximately 2.1 miles east of the roundabout junction, along the A1023, incorporating all the local services and amenities expected of a town centre. Brook Street contains local services including a post office and public house (The Nags Head). A small roadside service area, containing a hotel and spa (Holiday Inn Brentwood), is located off Brook Street close to the east of J28 roundabout

The proposed scheme options are located within privately owned agricultural land and surrounded by a mixture of other privately owned uses including residential and commercial land including: Grove Farm, a residential property which also comprises G & R Skips and Recycling; Maylands Golf Course; Henderson Sports and Social Club; Maylands Cottages; Putwell Bridge Caravan Park; and residential properties. Putwell Caravan Park has recently been approved for change of use of land south of the A12 Colchester Road, west of Harold Park, to burial grounds. Land to the west of Maylands Golf Course is currently subject to a planning application for the creation of a burial ground with ancillary buildings, parking and landscaping.

The proposed scheme options are anticipated to have beneficial effects on driver stress, NMUs and community severance in the operational phase due to less congestion, less fear accidents, improved journey time and accessibility, through less congestion, to local community facilities.

Two significant adverse effects are anticipated from the proposed scheme options. The adverse effect on residential and private property in the form of permanent land take from Grove Farm and a moderate adverse effect on Development Land, anticipated only for Options 5C and 5F, relates to land take from a burial ground pending planning permission north of the A12.

In summary, the significance of effects of each of the proposed scheme options varies for views from the road, agricultural land and holdings, residential and private property and development land receptors. For all receptors, apart from views from the road, Option 5B will produce the least adverse effect. This option is therefore preferred from the people and communities' perspective.

9.9 Road drainage and water environment

One Water Framework Directive (WFD) (2000/60/EC) surface waterbody crosses the study area: the Ingrebourne River which runs to parallel and north of the A12, flowing south, where Weald Brook adjoins at Putwell Bridge.

Option 5B crosses two new watercourses including the River Ingrebourne and Weald Brook and their associated floodplains. Options 5C and 5F crosses five new watercourses and their associated floodplains, crossing Weald Brook in three locations.

All options could potentially, without appropriate mitigation, result in a deterioration of the water environment with potentially significant effects through construction and/or operation. All options will also require floodplain compensation.

The initial Water Framework Directive (WFD) assessment suggests that all three options would be compliant with the requirements of the WFD as they are not considered to cause

deterioration at the water body scale and should not prevent future attainment of good status.

All three options include design components (e.g. culverts) that generate minor or localised adverse effects. However, the options also include components with neutral or potentially beneficial effects on the water environment. In particular, the proposed realignments present an opportunity to restore sections of channel to more natural form and function.

Providing adherence to best practice mitigation and pollution prevention guidelines maintained during the construction period, adverse effects will be minimised and with good design, there may be beneficial effects on the water environment.

In summary, Option 5B is the smallest scale of the three options; it impacts the smallest area and has the fewest scheme components affecting the water environment. Option 5C is larger than Option 5B and smaller than Option 5F. Although the general arrangements show it to be of similar area to Option 5F, it includes fewer Scheme components that affect the water environment. However, it is the option with the largest number of crossings.

10 Summary of public consultation

10.1 Consultation approach

During PCF Stage 2 non-statutory public consultation was held to gather early views on the three options being considered under PCF Stage 2:

- Option 5B - single lane loop road, and widening of existing M25 bridge over Junction 28
- Option 5C - single lane loop road, and widening of short section of M25
- Option 5F - two-lane loop road, widening of short section of M25, and reconfiguration of A12.

Consultation arrangements

The non-statutory public consultation ran for 8 weeks between the 14th November 2016 to 6th January 2017.

Six public consultation exhibition events were held in areas around the M25 Junction 28 for the public and stakeholders, including local authorities, landowners and local businesses (Table 10-1).

Table 10-1 List of public exhibitions

Date and venue	Audience	Time
17 Nov 2016 Harold Hill Community Centre, RM3 9LB	Local media	11am – 12.30pm
	Invited stakeholders	1pm – 2.30pm
	General public	2.30pm – 6pm
18 Nov 2016 Harold Hill Community Centre, RM3 9LB	General public	10am – 4pm
9 Dec 2016 South Weald Parish Hall, CM14 4NP	General public	2pm – 8pm
15 Dec 2016 Harold Wood Neighbourhood Centre, RM3 0QA	General public	10am – 4pm
4 Jan 2017 Holiday Inn, Brook Street, Brentwood CM14 5NF	General public	6.30pm – 10pm
5 Jan 2017 Holiday Inn, Brook Street, Brentwood CM14 5NF	General public	11am – 9pm

Consultation material

The consultation material consisted of a consultation brochure and questionnaire, and exhibition boards and technical reports displayed at events. These were also available on the Highways England consultation webpage: www.highways.gov.uk/m25j28.

The consultation brochure included details on the scheme background, a summary of the options and their impacts and expected benefits.

The public consultation exhibition boards presented key information about the scheme including objectives, background, options, results of assessments, the consultation process, and next stages including the DCO process.

A 3D visual representation of each option was displayed at all the exhibitions and was available online on the scheme webpage[17].

Publicising the consultation

Around 28,000 letters of invitation to the exhibitions were sent to households nearby. Information was also available on Highways England website: www.highways.gov.uk/m25j28 and brochures and questionnaires were available from three libraries in the area.

- Central Romford Library, RM1 3AR
- Brentwood Library, CM14 4BP
- Shenfield Library, CM15 8NJ.

The scheme and consultation were announced in October 2016 in a Department for Transport press release which covered several South East RIS schemes.[18]

A full colour advertisement ran for one week in the Essex Enquirer from Thursday 3 November 2016, in print and online editions. Posters were also displayed at key information points.

Local media were invited to a specific press briefing session on the first day of the first public exhibition, the 17 November 2016, and specific key stakeholders (Tier 1 and 2, as identified in the Consultation Strategy – PCF Stage 1 product) were invited to a second briefing on the same day (refer to Table 10-1 above).

Facebook

Although Highways England did not post information about the consultation on Facebook, ten stories were posted by Essex County Council, Brentwood Chamber of Commerce and Hornchurch Life, among others.

Twitter

Highways England tweeted about the consultation via @highwaysSEAST, along with a small number of other organisations and individuals.

10.2 Consultation responses

Effectiveness of the public consultation

The public consultation exhibitions received 328 visitors across the six events, with 33% of attendees coming from CM14 postcode.

[17] The 3D visualisation can also be found at: https://www.youtube.com/watch?v=Pf-5QrUmeZ0.

[18] A copy of the press release is available at: https://www.gov.uk/government/news/multi-million-pound-road-improvements-for-south-east.

The Highways England M25 Junction 28 improvement scheme website recorded 4275 unique page views.

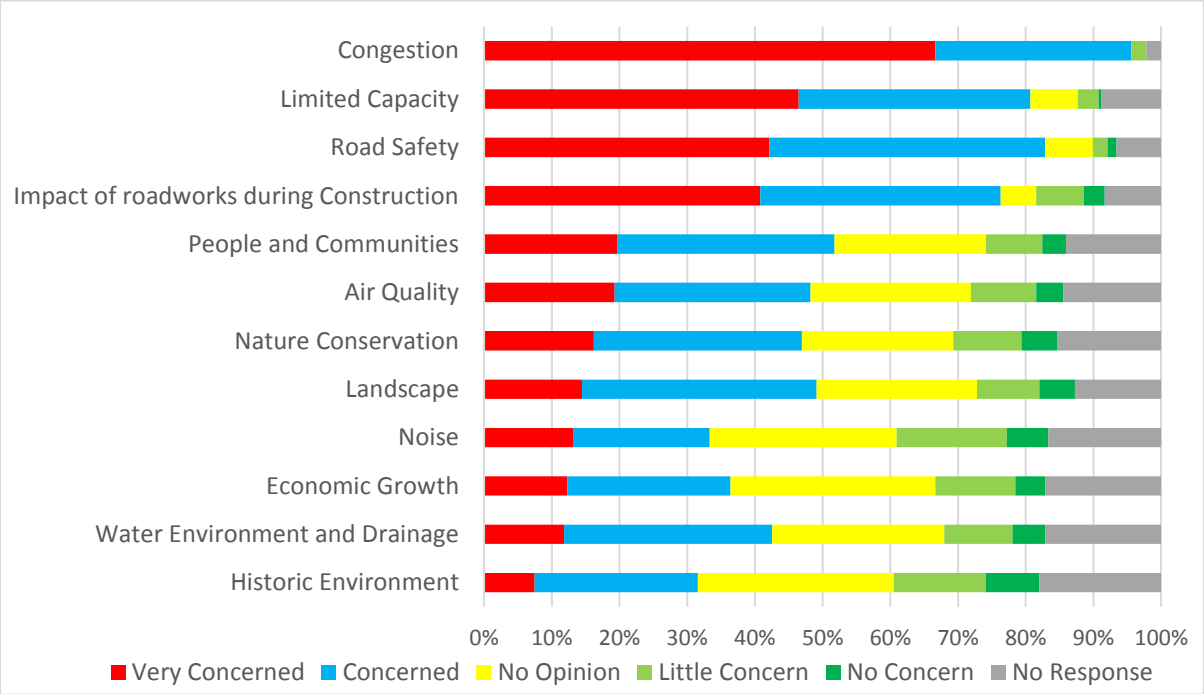
Questionnaire responses were received in hard copy (paper surveys and letters) and electronic form (online surveys and email). Hard copy responses were sent via a Freepost address or handed in at the exhibition events. Electronic responses were gathered via the website.

A total of 267 responses were received during the consultation period, comprising 145 online questionnaires, 83 hard copy questionnaires and 39 responses via Highways England customer contact centre.

Questionnaire response analysis

The questionnaire responses showed the issues that concerned the respondents the most included congestion, limited capacity and road safety (Figure 10-1). This is representative of scheme objectives and could be taken as a mandate to support the scheme.

Figure 10-1 Which issues around M25 junction 28 improvements are you most concerned about?



Option preferences

Nearly half of respondents (49%) said they prefer option 5F (Figure 10-2)

Option outcomes

Respondents were asked about the extent to which they think the options will encourage economic growth; reduce congestion and delays; improve journey time reliability and road safety; and reduce noise and air quality issues. The results are indicated in Figure 10-3 below. These results show that respondent anticipate Option 5F to deliver best against addressing the issued.

Figure 10-2 Which option do you prefer?

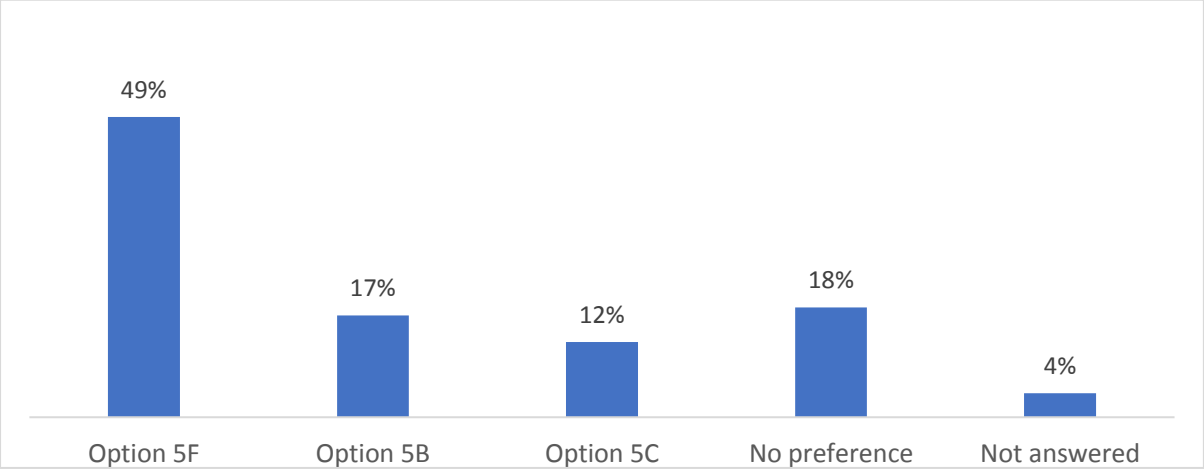


Figure 10-3 Comparing the responses for each option against the scheme objectives

Stakeholder responses

Although wide engagement was undertaken with all the key stakeholders, only three responses were received. These came from Essex County Council, London Borough of Havering and Will Quince, MP for Colchester, and all preferred Option 5F.

10.3 Changes since public consultation

Following a review of the public consultation feedback there were no comments that suggest any changes to the current designs of the three options need to be made.

However, several suggestions were received relating to additional improvements that could be considered in addition to the three option designs. These include:

- **Extending the taper for the existing dedicated left turn lane between the M25 north and A12 east** – Subject to affordability this could complement the scheme, and with a high flow making this movement (1900 vph) this could offer additional value. It is estimated that this will cost around £0.8 million.
- **A new dedicated left turn lane between the A12 west and M25 north** – Whilst this could be build, it would compromise access to and from Grove Farm via the existing slip roads, and will require works outside the highways boundary. This option would require an extension to an existing culvert and the diversion of an existing power sub-station. With a flow of around 500 vph it is not clear at this stage whether this would add more value over that gained by the core scheme. The approximate cost for this option is £1.2 million.
- **A new dedicated left turn lane between the M25 south and A12 west** – The flow making this turn is around 700 to 800 vph. It would compromise the existing footways/public right of way as well as access to the farm and maintenance track. At this stage it is not clear how much value this would add. This would cost in the region of £1.0 million.
- **A dedicated left turn lane between Brook Street and the M25 south** – If built this will further compromise the pedestrian rights of way on the south side of the junction roundabout. Secondly, integrating a link with Brook Street without widening it to two lanes, or at least providing a significant extension to the flare on the approach to the roundabout won't be feasible or add any benefit. Also, the proximity of the left turn taper and the petrol filling station would create a safety hazard for turning traffic. This has not been costed as it is not considered to be feasible at this stage as a RIS1 scheme.
- **A dedicated left turn from the A12 east to Brook Street.** Again, it is considered that to provide this left turn effectively would require widening of the A1023 Brook Street to offer any added value. Also, the proximity of the left turn lane/taper and the filling station would create potential safety hazards for turning traffic. This has not been costed as it is not considered to be feasible at this stage as a RIS1 scheme.
- **Improve Brook Street** – These proposed improvements fall within Essex County Council's remit. Highways England are liaising with Essex County Council to progress ideas/options.
- **A new facility to improve for traffic from Woodstock Ave wishing to do a U-turn to travel westbound** – This will require liaison with Transport for London as A12 falls under their remit.
- **Provide second link from the A12 E to the M25 N** – This is like the Do-maximum options considered in PCF Stage 0 in providing two dedicated links between the A12 in Essex and

the M25. This will require greater land take, and result in significant cost increase, hence would exceed the given budget and is not recommended as an addition to the current RIS1 scheme.

- I**mproved the pedestrian crossing facility from Brook Street to A12 west** – This can be implemented assuming an alternative route via the inside of the roundabout circulatory with crossings facilitated using the existing traffic signal phasing. The approximate cost is £2 million.

In terms of moving forward through the rest of PCF Stage 2, the three options remain unchanged. The above suggestions could be applicable to each of the three options and would not affect the selection of a preferred option.

It is advised that the additional suggestions received during the consultation are reviewed, and the viable ones considered for inclusion in the detailed design in PCF Stages 3 and 4. This would also be dependent on affordability and the ability to fund these within the existing budget of the current scheme.

11 Summary Appraisal Summary Table

The Value for Money (VfM) assessment is carried out as a staged process to ensure that a complete and robust analysis is undertaken. The Appraisal Summary Table (AST) helps to summarises all the monetised, qualitative and quantitative impacts of the scheme and present as a coherent package. The AST is prepared for each option and submitted as part of the PCF Stage 2 product – Appraisal Summary Table. A summary of key elements the AST is presented in Table 11-1.

Table 11-1 Summary Appraisal Summary Table

Impacts		Option 5B	Option 5C	Option 5F
		Qualitative	Qualitative	Qualitative
Economy	Regeneration	Not assessed	Not assessed	Not assessed
	Disruption during construction	Moderate adverse	Moderate adverse	Moderate adverse
	Noise	Slight adverse	Slight adverse	Slight adverse
	Air Quality	Slight adverse	Slight adverse	Slight adverse
	Greenhouse gases (CO2 emissions)	Slight adverse	Slight adverse	Slight adverse
	Landscape	Slight adverse	Moderate adverse	Moderate adverse
	Townscape	n/a	n/a	n/a
	Historic Environment	Moderate adverse	Moderate adverse	Moderate adverse
	Biodiversity	Moderate adverse	Moderate adverse	Moderate adverse
	Water Environment	Large adverse	Large adverse	Large adverse
Social	Physical activity	Slight beneficial	Slight beneficial	Slight beneficial
	Accidents	Neutral/slight beneficial	Neutral/slight beneficial	Neutral/slight beneficial
	Security	Neutral	Neutral	Neutral
	Access to services	n/a	n/a	n/a
	Affordability	Slight beneficial	Slight adverse	Slight adverse
	Severance	Slight beneficial	Slight beneficial	Slight beneficial
	Option and non-use values	Not assessed	Not assessed	Not assessed
	Disruption during construction	Moderate adverse	Moderate adverse	Moderate adverse
		Quantitative	Quantitative	Quantitative
Economy	Business users and transport providers, net benefits	£150.2m	£137.0m	£137.9m
	Reliability	Not assessed during Stage 2		
Social	Commuters and Others users	£178.1m	£179.0	£176.4m
	Reliability	Not assessed during Stage 2		
Public Accounts	Cost to Broad Transport Budget	£42.8m	£43.7	£51.2m
	Indirect Tax Revenues	-£0.6m	£3.2m	£2.8m
Initial BCR (Level 1)		**7.6**	**7.2**	**6.1**
Overall VfM Category		**Very High**	**Very High**	**Very High**

12 Conclusions and recommended option

12.1 Value in achieving project objectives

The findings of the Stage 2 value management workshop confirm that each of the three options are well aligned to giving effect to addressing the issues at Junction 28, and hence the project objectives. A summary of the findings of the value management workshop is provided in Table 12.1, with further detail set out in the PCF Stage 2 Value Management Workshop Report (May 2017).

A number of key findings can be drawn from the value management workshop:

- All options will deliver against the objectives relating to improving journey times and journey time reliability
- Options 5B and 5C feature a single lane link, and forecast traffic volumes on the link are expected to approach and exceed the capacity beyond the 2037 design year
- Option 5F on the other hand offers 2 lanes on the new dedicated link, and therefore is expected to deliver the strongest on these objectives in the longer term
- All options deliver against the safety objective
- All options achieve similar impacts an air quality and noise issues
- In terms of construction Option 5C was identified as having least impact in disrupting traffic across the network. Option 5F also achieved many elements of this objective with some disruption on the A12 eastbound and westbound carriageways during construction
- Option 5B will involve works on the M25, with the likely closure of the hard shoulder, narrow lanes on the M25 and speed restriction over a long period. This will result in some impedance of traffic flow affecting a high volume of traffic
- Overall Option F shows the highest weighted value score.

12.2 Recommended preferred option for Junction 28 improvements

The PCF Stage 2 Option Selection has identified Option 5F as best achieving the scheme objectives, and balancing the needs of road users, the community, the environment and businesses. As such Option 5F is recommended as the preferred option based on the following:

- Performs strongest in achieving the primary objective of improving journey times, particularly in the longer term beyond the 2037 design year
- Options 5B and 5C are 1 lane options and forecast traffic volumes are expected to approach and exceed capacity beyond the design year. It is noted that two lanes cannot be provided on the Option 5B alignment
- Option 5F can be constructed without the significant disruption to traffic on the M25 motorway as expected under Option 5B (which requires widening of the M25 viaduct over the Junction 28 roundabout)
- Option 5B involves a departure from standard relating to the sub-standard distance between the successive diverges on the M25 anti-clockwise carriageway. This presents a significant concern over operational safety of the road user

- Option 5F provides greater network resilience through having a second lane on the new link
- Option 5F offers a two-lane link that is expected to be more advantageous in terms of maintenance and avoiding disruption to traffic
- Provides a strong BCR of 6.1 despite the additional cost associated with providing a second lane on the new link to cater longer term forecast demand flows.
- In terms of environmental implications Option 5C would have the similar impacts as that shown for Option 5F. It is noted that Option 5C features only 1 lane (compared to 2 lanes in Option 5F). Therefore the higher environmental impact of Option 5C is not justified when the same 1 lane configuration could be achieved with Option 5B.
- Option 5F is selected over Option 5B based on the foregoing reasons, and that it also has the highest overall weighted Value Management score (Table 12-1) and was shown to be the preferred option noted as part of the public consultation.

At the time of preparing this Scheme Assessment Report it is noted that the alignment of the merge of the 2-lane link in Option 5F with the A12 is subject to review. This involves undertaking topographical surveys in the vicinity of the Junction 28 abutments to confirm clearance for the proposed cross-section. These surveys are programmed to be completed by August/September 2017.

Table 12-1 Summary of the value management assessment of Junction 28 options

Objectives	To cater for future traffic demands efficiently with minimal delay and to support future development and economic growth to 2037	To improve the network resilience of J28 and enable smoother flow of traffic and reliable journey times to 2037	Improve road safety on the approaches to and through J28 to 2037	Minimise the impact on local air quality high traffic volumes and stopping traffic	Can be delivered without significant disruption to the SRN and local traffic	Overall weighted score
Weighting	0.43	0.07	0.07	0.36	0.07	
Do minimum	0	0	0	0	6	0.43
Option 5B - Cloverleaf loop variant 2 (1 lane)	4	4	4	5	2	**4.21**
Option 5C - Cloverleaf loop variant 3 (1 lane)	4	4	4	5	5	**4.43**
Option 5F – Cloverleaf loop variant 4 (2 lanes)	*5*	*5*	*4*	*5*	4	**4.86**

Key to value management based assessment scoring:

6 = Fully delivers the objective
5 = Delivers almost all of the objective
4 = Delivers many elements of the objective
3 = Delivers half of the objective
2 = Delivers some elements of the objective
1 = Delivers few elements of the objective
0 = Does not deliver any of the objective