M25 Heathrow Tunnels Deliverability Report

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1 Introduction

Highways England (HE) has set up a contract for the provision of technical advice to produce an initial Deliverability Report to consider Heathrow Airport Limited's (HAL's) proposal for the new runway at Heathrow which crosses the M25.

The contract is managed by the National Infrastructure Programme (NIP) Division of Major Projects who represent HE's interests in dealing with the delivery and operational impacts of major infrastructure projects delivered by other public and private sector developers, including the Heathrow Airport runway and terminal expansion programme to which this scope relates.

NIP is working closely with Network Planning Division (NPD) of Strategy and Planning Directorate who are leading HE's statutory planning response to the proposed expansion of Heathrow Airport and its impacts on the wider Strategic Road Network. NPD is responsible for co-ordinating HE's response to the proposals across Directorates and for managing HE's relationship with the Department for Transport.

NIP has appointed TRL/Costain via the SPaTS framework to carry out this report to understand HAL's proposals and carry out an initial high level assessment of the information made available at this early stage in the design process.

2 Background

Heathrow Airport Limited is intending to construct a third runway which will be located to the north west of the existing airfield campus and will cross the route of the proposed realigned M25 motorway immediately to the south of M25 junction 15 (its junction with the M4 motorway).

The representative option is comprised of a northbound mainline carriageway and collector-distributor (CD) road, constructed in separate tunnel bores, together with a southbound mainline carriageway and collector-distributor road, again constructed as separate tunnel bores.

HAL's proposal is that the M25 will move laterally 130 metres to the west to enable construction to proceed whilst the existing M25 motorway remains in operation. The re-aligned M25 will also be significantly lower than the existing carriageway.

HE has agreed that an initial Deliverability Report will be produced to consider the potential impacts, constraints and risks associated with the construction and subsequent operation of the infrastructure needed to carry the new runway and associated taxiways across the motorway.

HAL's airline community has a specific interest in the early identification of these risks and issues to inform their comments on project cost estimates and risk allowances in HAL's budget for the delivery of the Heathrow Expansion Project (HEP).

HE liaison with HAL, including monthly Heathrow Highways Steering Groups, has been ongoing and managed by the Strategy and Planning Directorate within HE.

HAL has produced phasing plans and drawings which set out the proposed phasing arrangements and layouts for a representative option. This has formed the basis for the assessment by the Consultant.

3 Purpose of the Report

To produce a Deliverability Report that primarily intends to inform HE and HAL of the potential risks and logistical / operational issues associated with the construction, operation and maintenance of the proposed cut-and-cover tunnel arrangement needed to carry the proposed runway over the M25 motorway and the mitigation measures that may be appropriate.

The report will state HE's advice on how any delivery, operational and maintenance risks associated with HAL's current proposed alignment option for the diversion of the M25 under the proposed new runway may potentially be mitigated and managed, and sets out HE's recommendations and the minimum standards that must be adhered to regarding any works to the M25 and surrounding Strategic Road Network (SRN)

The Deliverability Report will be based upon the representative proposals presented by HAL, and will not consider the relative merits of other alternative options.

The report reflects the information available at the time, and will need to be amended and updated as more detail is issued by HAL.

4 Executive Summary

From the information provided, and the meetings and conversations with the design team, Highway's England's initial assessment is that the current proposal is deliverable in its current form. However, notwithstanding the fact that that the scheme is in a preliminary state Highways England have some concerns about several aspects of the design which will need to be resolved as the design progresses.

Firstly, the intent to have a fully integral structure with no expansion joints over such a long length and span is, as far as we are aware untested, and a specialist review team would need to be appointed by HE to ensure both its short term constructability and its likely long-term performance. This can only be done once HAL has substantially completed its calculations.

HAL needs to demonstrate that the cut-off wall that is intended to keep ground water out of the tunnel will retain its integrity over the long term, and also show an alternative proposal should this not be possible. The concern is that should the cut-off wall not perform as expected, water ingress into the tunnel may occur and the sump pumps have to work harder than designed for, leading to increased maintenance. The Environment Agency (EA) may also have concerns should discharge into watercourses be higher, especially if it is shown to have contaminants.

The proposed works may have an adverse effect on traffic flows, especially if these works progress at the same time as the M25 J10-16 Smart Motorway works, which would have to be amended to account for the proposed tunnel layout, and the M4 and M3 schemes are ongoing. HAL need to work with Highways England SMP to develop an agreed timeframe that the tunnel and tie-ins can be constructed. The HE Customer Services Team will also need to be consulted.

The tie-in's themselves will have an operational impact, and because the northeast portal sits over the existing carriageway means that traffic management becomes unduly complex. HAL should consider mitigations to this and develop proposals that allow the tunnel to be constructed as one. This will also allow the tunnel systems to

be commissioned in one go, instead of phases, and improve the chances of a successful handover into operation.

HAL need to engage with SES to discuss carriageway horizontal and vertical alignments, and ensure that where full design speed standards can't be met, any departures are minimised and where necessary agreed as early as possible.

The proposed ventilation system of transverse extraction on the face of it seems reasonable, but no proposals of how and where the ventilation flows to were shown. HE would like HAL to consider making the ventilation be bi-directional to allow the maximum level of flexibility in tunnel operation. Air quality needs to be considered during normal operating regimes, as well as during an incident. The proximity of the A4 to the tunnel means that should a major incident occur then as well as the tunnel being closed, the A4 may also have to be (as well as the runway operations).

Control of vehicle occupants in the event of an incident need to be made clearer, especially how it is intended to evacuate people from the main bores – the CD tunnels prevent people getting to a safe place of refuge.

The risk register accompanying this report lists some of the current observed risks that we feel exist, and need to be monitored and mitigated. This should be carried out on a bi monthly basis against the progress of the design and other activities and the register updated to reflect new risks.

[redacted]

Futureproofing of the tunnel and carriageway is essential, and HAL must demonstrate that it had taken all practical measures to anticipate future needs. Primarily this will be traffic modelling to show there is sufficient capacity in the road network for traffic growth, but also show that consideration has been given as to how the tunnel will be refurbished in future years.

5 Existing Operational Requirements of the M25

The M25 is the orbital motorway around London. It is operated and maintained on behalf of HE by Connect Plus, a consortium of companies under a 30 year Design Build Finance and Operate (DBFO) commission which ends in 2039. The section of motorway between junctions 14 and 15, where the proposed re-alignment of the motorway is to take place is a controlled motorway, with 6 lanes in each direction. The 6 lanes are currently split with 3 lanes for through traffic on the mainline M25 travelling through J15 and 3 lanes for traffic merging and diverging from the M25 to and from the M4. The M25 is part of the Trans European Network (TEN), and therefore subject to any regulations this imposes. It is not a high load route, or designated heavy load route albeit that there are specific heavy load vehicle requirements for M25 – 250t. The EU Road Tunnel Safety Directive enacted by UK SI Road Tunnel Safety Regulations also apply.

The controlled motorway regulates the flow of traffic by changing the speed limits, notifying drivers by means of Advanced Matrix Indicator's (AMI's) mounted on steel gantries above the lanes. In times of congestion, or if there is an incident, then traffic

can be managed to optimise through flows. Speed control due to congestion is automatically triggered by Motorway Incident Detection and Automatic Signalling (MIDAS) queue protection. Incident management is controlled from the regional control centre at South Mimms, the change to Godstone occurring at Junction 14. There is variable message signs (VMS) within this section of motorway that inform drivers of road conditions ahead.

This section of the M25 is the busiest link on the M25 and the entire UK motorway network, and it should be noted that peak flows vary in comparison to other sections of the M25 owing to the draw from Heathrow airport, particularly the early movements of workers and those catching flights reduces the working window for maintenance. This means that deployment of Traffic Management requires a different approach and significantly more planning.

Current tunnel management and operational procedures at Holmesdale and Bell Common Tunnel should not determine or dictate proposals for the new Heathrow Tunnel, however any synergies or lessons learnt should be considered, as well as from other EU tunnels on the TEN. Through discussion with HE and the DBFO, we understand that some of the equipment is now unobtainable for replacement purposes in the Tunnels.

The number of incidents on this section of the M25 is significant, one of the reasons being due to the amount of 'weaving' that takes place as a result of the close proximity of Junction's 14, 14a and 15, i.e. vehicles crossing multiple lanes to exit the M25 or making late manoeuvres to jump the regular queues of traffic heading north on the mainline M25. Incident management on this section is hampered predominantly by the volume of traffic, and the proximity of so many junctions. Works that are undertaken on the M3 and M4 corridor also have the potential to complicate incident management through additional traffic and tailbacks / queuing traffic at Junction 14 and 15.

6 Technical Overview

6.1 Highways

6.1.1 Geometry

Heathrow Airport Ltd have stated that there will be no additional traffic generated on the road network as a result of the proposed expansion, however they recognise it may increase in some locations e.g. the M25, and decrease in other locations. HE will require this to be sufficiently demonstrated via appropriate traffic modelling to show futureproofing of the network has been considered for the preferred option. The requirements of the draft National Policy Statement must be considered when modelling predicted future traffic flows. Notwithstanding this, HE would desire where possible maximum operational flexibility to manage network incidents within the tunnel without significantly affecting the capacity of the motorway, for example the ability to run a contraflow 3+3 in a single main bore.

The cross section for the carriageways should be in accordance with the principles of TD27/05 and BD78/99, or its successors, along with all appropriate Interim Advice Notes. It will not be possible to alter the tunnel once the runway is built and operational, and therefore future traffic growth must be accounted for. If it can be

demonstrated via appropriate traffic modelling that there is no additional traffic, then the carriageway provision within the tunnel section at opening should be D4M Controlled Motorway (CM) for the mainline and D3M CM for the collector distributors. Subject to traffic modelling, the long-term provision that should be allowed for within the design should be for D6M All Lane Running (ALR) for the mainline and D4M ALR for collector distributors. As such sufficient space within the earthworks outside of the tunnel should be provided for emergency refuge areas so that they can be added in the future, if required.

The preferred option for the realignment of the M25 and the provision of the collector distributor roads should be fully in accordance with TD9/93, or its successor, based on a minimum design speed of 120kph for the mainline and 120kph for the collector distributors. The current proposal doesn't appear to meet this standard for the northbound CD off-slip to the M4 West.

Longitudinal gradients should be a minimum of 0.5%. In addition, longitudinal gradients should be a minimum of 1% at the centre of super-elevation rollovers so that the channel edges do not fall below 0.5%.

Consideration should be given to limiting the super-elevation to 3.5% on the mainline to limit the length of the super-elevation rollover and associated transition length required. The pivot point of the carriageway will need to be carefully selected, to again limit the length of rollover, given the width of the carriageways involved.

All visibility splays should be designed based on 120A. Appropriate measures should be taken to prevent vehicles parking within any widening for visibility splays, whilst not impeding visibility. Any measures would need to be agreed as part of the tunnel operational risk assessment and be subject to road safety audits.

The existing weaving lengths from J14a to J15 and vice versa are approximately 1.0km each. Whilst the review of the proposals for J14A & J14 are outside of this remit, there is no weaving length shown at all within the current option proposals which connect into the location of J14A. Sufficient weaving lengths must be provided from J14/14A to J15 and vice versa in accordance with TD22/06 & TD 39/94 or their successors. The number of lanes through the tunnel and adjacent should remain constant over lengths in compliance with EU tunnel safety directive. The layout and capacity of the weaving section will need to be demonstrated to HE before any agreement can be reached on the proposed diversion and tunnel scheme.

The design philosophy of the preferred option should initially be to current standards, and Departures should be minimised. Any Departures that are identified through the design process should be discussed with HE as early as possible.

6.1.2 Signage outside of the tunnel

Currently there are no details for signage proposals outside of the tunnel. The proposed design will have to consider how the controlled motorway will operate, both in normal conditions and in congestion and incident conditions. Current M25 lane control is from a series of AMI's mounted on super span gantries across the

carriageway, and the proposed design would be expected to be the same. Gantries should be man access and where practicable span the whole carriageway. The adequate signage of junctions in this area is key to the safe operation of the tunnel.

Speed enforcement at present is by camera's mounted on the overhead gantries capturing vehicle registration numbers as they pass under at speeds above those shown on the AMI's.

Traffic management is currently assisted by the use of "blind" signs in the central reserve. These are unreliable and it is expected that Remotely Operated Temporary Traffic Management Signs (ROTTMS) may need to be installed both in the verge and central reserve, given the width of carriageway proposed.

6.1.3 Signage inside the tunnel

Due to constraints in headroom HAL believes there is limited opportunity to place signage within the tunnel. However, consideration should be given to some form of lane control so that signal settings outside of the tunnel can be mirrored over the lanes inside the tunnel. This would help to reduce red X infractions and reinforce lane discipline. Low profile LED signs similar to those in Hatfield Tunnel may be a possible solution.

How enforcement of speed limits is proposed to occur inside the tunnel is not clear at this stage, speed camera's placed at the portals would encourage vehicles to maintain the permitted speed limit.

6.1.4 Pavement

All carriageways should meet full motorway standards, have a design life of 40 years and be in accordance with all current standards. Given the poor ground conditions, the pavement should be of flexible construction with a suitable ground improvement to limit differential settlement. The phasing of the scheme must ensure that settlement of any embankments that could affect the carriageways will be substantially complete before the road pavement works are completed. Substantially complete shall mean that not more than 25 mm of settlement should affect the completed carriageway. Allowable differential settlement shall be 0.1% over a distance of 50m back from any structure and 0.5% elsewhere over a 5-year period after opening.
Where the carriageway emerges from the tunnel at the portals and starts to rise to tie back in to the existing carriageway, a clay cap will be required across the whole carriageway, and up the side slopes until such point that the underside of the road construction is above water table.

6.1.5 Drainage

The proposed scheme should include an integrated drainage design in accordance with HD 33/16 or its successor. Due to the gradients of the proposed alignment, it is assumed that the majority of run-off from the carriageway and side slopes will end up within the tunnel drainage system and the pumping arrangements for the tunnel should take account of this. Consideration should be given to how the drainage network within the tunnels can be maintained and replaced in the future. The Environment Agency (EA) should be consulted on an appropriate factor for climate change and return periods, and an allowance made within the design for this. In addition, the discharge rates should be agreed with the EA and suitable underground attenuation provided.

Due to the extra wide carriageways the drainage paths on the surface, especially within the super-elevation rollovers, should be carefully checked to ensure compliance with TA80/99 or its successor.

The sub-surface and ground water drainage systems should be kept separate from the surface water network where there is a possibility of leachate from the landfill. This separate contaminated system should be treated and discharged through the airport drainage system. Groundwater entering the tunnel should be minimised as far as practicable, and water flow paths from the sides and ends of the tunnels should be restricted accordingly.

Any run-off from the runway and wider airfield should not be permitted to enter the highway drainage network, including run-off into area inside the cut-off wall.

6.1.6 Central reserve barrier

Median barriers between carriageways should be rigid concrete barriers in accordance with TD 19/06, given the traffic volumes. An assessment should be made as to the need for gated emergency crossing points. If gantries are required over the carriageway, and full span are impractical, consideration should be given to providing half-span gantries and placing the leg in line with the barrier in the central reserve. This may require a piled foundation.

6.1.7 Crossovers

No crossovers are currently identified, however consideration should be given to providing them to facilitate maintenance, especially between the CD bores and adjacent mainline bore. Plant and signals within the mainline cells should be capable of operating in a contraflow situation.

6.1.8 Lighting

The current carriageway is lit from the central reserve, with columns mounted on a widened concrete barrier. There are currently no details on how the proposed carriageway will be lit, but consideration should be given to drivers entering and emerging from the tunnel, which will be lit. In addition, consideration should be given to lighting routes to a safe place of safety for people evacuated from the tunnel during an emergency situation. The lighting proposal needs to be developed with regard to the integration with the wider lighting asset base and associated strategy.

6.2 Structure

6.2.1 Overview

Two draft design tunnel structural forms have been presented: a buried ground bearing multi-cell concrete ‘box’ and a buried pile supported concrete multi-span portal frame ‘bridge’. For both cases it would appear that the designer is proposing the roof slab / bridge deck comprises a post-tensioned concrete slab with void formers to minimise the dead load of the concrete roof.

The excavation of the tunnel and its approaches may require the construction of temporary earthworks slopes. Where the required slopes are too steep, temporary

retaining walls may be required. Where these are to be formed close to the existing M25 consideration will need to be given in the design to the lateral restraint required for highways slopes and structures such as gantries and safety barriers.

During excavation for the tunnel base consideration will need to be given to the potential for heave and softening of the over consolidated London Clay. Furthermore, the ground water, particularly within the landfill material and the Terrace Gravel will need to be controlled. It is understood that the proposed cut off wall will control the ground water during the construction. This wall will need to be embedded sufficiently into the London Clay to effectively create a barrier to ground water and land fill leachate.

The construction of the A4 will require embankments up to 5m high. These embankments will need to be suitably designed and constructed to prevent bearing failure of the potentially weak landfill material below. Settlement of the fill, the landfill material and other compressible soils will also need to be controlled through the use of ground improvement, surcharging, or excavation of compressible soils.

It appears that granular backfill to the abutment walls are intended to be constructed adjacent to and over existing landfill material. The landfill material will have different modulus properties to the granular backfill wedge and will clearly experience some cyclic loading from the base/back face of the granular material. This contrasts with a 'conventional' integral bridge as the material behind the granular backfill wedge is engineered fill with modulus properties similar, or even better, than the granular backfill wedge. Furthermore, the made ground will be necessarily variable and potentially subject to differential settlement which, if occurring below the granular backfill wedge, could remove support from the wedge and hence the abutments. Consideration of suitable mitigation will need to be explored.

The backfill material to the abutments will in any case require a) careful design with regard to its angle of friction (also considering cyclic effects) and compressibility modulus, b) procurement to ensure that the designed material is actually available in the market in sufficient quantity/proximity to site to be viable and c) construction to ensure it satisfies the design requirements. The current proposal indicates the construction of the new clay cap to the landfill to close to the western wall tunnel / abutment; the clay cap and granular fill will need to be appropriately designed and specified to minimise different settlement and the formation of the 'hard spot' on the runway where it passes from the tunnel wall to the fill.

The piled 'bridge' solution consists of pairs of 1500mm diameter bored piles at 6.0m centres, throughout the length of the tunnel for all walls (approx. 1250 no.). The walls will be cast off the integral pile cap, with the cap protruding under the tunnel footways. This is a relatively straightforward solution, and allows the placing of services and supplies under the flexible carriageway both at the time, and in the future. Consideration will have to be given to the length of pile, and if the plant installing it infringes any airspace restrictions, operations may need to be carried out at night during non-fly times. Similarly, the eastern span and associated piers/abutments between chainage 4350 and 4600 require piling adjacent to live carriageway. Thorough planning should be undertaken to ensure the construction sequence envisaged by the designer allows sufficient working room for piling rigs of the size required to install the designed piles.

The ground bearing ‘box’ solution will require a layer of free draining material below the slab, and a means of collecting and discharging any water that this generates. The current construction proposal is to place a cut-off wall around the entire tunnel (discussed elsewhere) therefore controlling the ingress of water both during construction and subsequent permanent operation. While a slab can offer a thinner pavement, and over the long term less maintenance of the carriageway, it could preclude the placing of any services in the tunnel carriageway in the future. Due to the relatively high water tables, consideration should be given to any floatation issues. Currently this is proposed to be controlled via the cut off wall around the tunnel, however longer term this may not be a viable solution as development around the tunnel in the longer term could compromise its integrity. The cut off wall should be located sufficiently far from the proposed tunnel structure so that a) forces due to the differential water pressure on the cut off wall are not imposed onto the tunnel construction (assuming sufficient confidence in the water tightness of the cut off wall and drainage in the long term) and b) to lie outside the zone of cyclical strain which will be developed in the soil behind the tunnel wall by the movements of the integral bridge (to prevent any ‘fatigue cracking’ of the cut off wall).

6.2.2 Maintenance considerations

Both box and bridge options propose fully integral connections between deck/top slab (superstructure) and box walls / piers and abutments (substructure) negating the need for bearings which is a positive aspect to be retained. While this should reduce longer term maintenance, HE believe should any defect develop in the future, it will make it difficult to affect any repairs, regardless of any constraints on access due to the runway. The designer has also expressed a desire to have no expansion joints throughout the length of the tunnel regardless of which structural form is adopted. Whilst this aspiration meets HE’s expectations in providing a structure requiring minimal maintenance, there is a concern as to whether the technical viability of this proposal has been rigorously proven.

The pertinent issue is whether the tunnel should or should not be designed for uniform temperature change as this will inevitably determine whether expansion/contraction joints perpendicular to the carriageway are required. The differential temperature profile the structure is required to consider, will also have a bearing on need for such joints. Furthermore, should the structure be deemed to experience uniform temperature change the integral form of the bridge, coupled with the fact that it is circa 130m wide (long in terms of bridge span), will require affects associated with soil-strain ratcheting of the ground behind the abutments to be carefully considered. HAL must therefore demonstrate why they believe uniform temperature change is likely to occur, given that the different tunnel bores will carry differing amounts of traffic at different times and so will develop different temperature profiles, and such a large structure will no doubt also see different ambient weather induced conditions.

Owing to the proportions, size and critical importance of the structure care should be taken not to take out of context current codified requirements and guidance provided on these matters. As an integral structure PD6694-1 (Recommendations for the design of structures subject to traffic loading to BS EN 1997-1:2004) would normally be of relevance to the designer; specifically, if thought of as a buried concrete structure as seems to be inferred by the designer section 10 would apply, however HE believe the proposed tunnel is of a size which sits beyond the remit of

this part of the published document. It would therefore appear that guidance within this document (section 10.2.1) upon which the principle of omitting expansion/contraction joints appears to be based is not applicable.

If not idealised as a buried concrete box, instead an integral portal frame bridge with 1.2m overburden, uniform temperature change should be considered (albeit for modified minimum and maximum uniform temperatures as allowed by NA.2.2.2 of NA to BS EN 1991-1-5). In this instance it would appear ambitious for a 750m long roof slab integral with its supports to be able to accommodate even modest changes in temperature of the roof slab without joints. HE believe that this aspect is robustly challenged and proven viable to ensure a joint-less structure will be provided, hence achieving a structural solution which negates the need to close the carriageway for routine inspection/maintenance of joints and associated drainage guttering typically provided in such situations.

It is understood migration of landfill leachate and ground gas will be controlled in the long term by the proposed cut off wall and the clay cap. The cut off wall will need to maintain a low permeability in long term.

As part of the design of the clay cap it will be necessary to understand the composition of the underlying landfill material in order to determine the likely settlement of this material. Should significant settlement occur in the landfill material this may result in disturbance of the cap, potentially increasing in it permeability and reducing its effectiveness to impede the flow of leachate and ground gas towards the tunnel.

6.2.3 Durability and longevity considerations

Given the structure is to be constructed within an existing landfill area, appropriate investigation of the material surrounding the proposed tunnel, together with any potential leachate run- off, should be undertaken to establish what effect it may have on the structure, i.e. chlorides etc. to enable the concrete to be engineered and/or isolated from such deleterious material.

Both the London Clay and the underlying Lambeth Group are likely to have high sulphates which will create aggressive ground conditions for buried concrete. The chemical composition of the ground and ground water should be assessed in accordance with BRE SD1 and an appropriate Design Sulphate Class used for the design of buried concrete structures.

The majority of the structure will be designed to accommodate live loads associated with Code F aircraft (a circa 900 tonne vehicle). HAL have informed HE that the greatest loads applied to the runway (and therefore the structure) is at take-off and this is the loading that the tunnel will have to be designed for. In addition, between chainages 4100-4300 the proposed structure will be subject to dynamic effects associated with landing aircraft (published guidance suggests this may require the equivalent static load for design to be more than double the static load model e.g. upward of 1800 tonnes). Given the likelihood that this load case (e.g. aircraft landing) will be regular and cyclical, careful consideration is needed as to the magnitude and type of fatigue load model assumed by the design as well as shock loading from the planes landing. Owing to this relatively unique and onerous fatigue load case it is envisaged that the proportions of the structure may well be governed by such, particularly at the interface of roof slab and substructure where allowable fatigue stress range is severely restricted due to the likely incorporation of bent

reinforcement bars. Similarly, fatigue of the post-tensioned tendons at mid-span and hogging regions over intermediate supports should be of key concern. To ensure fatigue damage does not impinge on longevity of the structure this aspect should be robustly challenged and proven by the designer at concept stage.

Both bridge and box solutions appear to propose a post-tensioned roof slab / deck. Although post-tensioned tendons can be durably detailed within the confines of the deck, the terminals colloquially termed ‘cheese-boards’ used to anchor the PT tendons at the abutments will require significant protection to ensure durability of a principal structural element.

It is assumed that the roof slab / bridge deck will receive waterproofing to the top surface; whilst a conventional solution, consideration should be given to the more unique aspects of this situation e.g. a requirement to perform for the life of the structure without replacement, and be resistant to hydrocarbons associated with fuel spills and jet fuel residue etc. With this in mind, HAL should consider the provision of a cathodic protection management system. Likewise, consideration should be given to any finishes inside of the tunnel, including intumescent paint so that it doesn’t react with de-icing salts or detergents from wash-down.

Sufficient depth of fill should be provided over the tunnel to take the airfield services, such as drainage and fire main etc. These should be carried over the tunnel structure in an independent sealed ‘u’ trough, such that any leakage will not detrimentally affect the tunnel structure.

It is anticipated that an appropriate intumescent coating will be applied to the internal tunnel structure to protect it from the thermal shocks experienced during fire exposure and from explosive spalling.

Consideration should be given to a cross fall on the tunnel roof, and a roof sub-soil drainage system, where any water percolating down is captured and flows to the edge of the structure.

Some form of tunnel monitoring should be implemented with regard to the performance of the structure and surrounding ground conditions. This should be developed alongside the maintenance regime so that appropriate proactive interventions can initiated to prevent long term issues arising.

There are currently several products under development which can be added to concrete. These additives effectively allow the concrete to become “self-healing”, where any cracks that appear over time fill themselves with a carbonate solution, sealing the space. Investigations should be carried out to assess if this would help to mitigate long term maintenance concerns for the walls and roof slab.

6.3 Tunnel Equipment

The general approach should be to design a solution which requires minimum maintenance. This serves to deliver minimum interruption to normal service and reduce exposure of workers to potentially dangerous situations. The type of plant and equipment installed should be ‘plug and play’ wherever possible, and should have maximum asset life. Locations of such equipment is critical to ensure there are no unnecessary complications during routine maintenance. Where ever possible, maintenance should be able to be undertaken off-line. Where this is not possible,

smart technology and equipment should be considered to enable safe, fast and efficient replacement.

The sump for the drainage needs to be beyond the extents of the airport boundary, where it can vent in the event of hydrocarbon build-up from vehicle run-off. This vent should have a frangible covering so in the case of the hydrocarbons igniting, there is a means to vent gases under pressure.

Tunnel equipment will need to be selected so as to mitigate risks following an operational risk assessment. Requirements are given in BD78 and EU Tunnel safety directive.

6.3.1 Ventilation

At the moment there are no details of what the ventilation system is, other than a proposal to make it a high level transverse extraction system, where smoke and/or fire can be targeted and extracted via the space between bores to the portal. This system could be complex and costly to maintain in that it will need to have a series of controlled baffles that can open and close as required.

Any option that is considered should bi-directional ventilation, which would give the HE the maximum flexibility in how the tunnel can be operated.

6.3.2 Fire Suppression

At present it isn't clear if a full deluge system or emergency sprinkler system is intended to be installed. Whatever the choice, the location and maintenance of both storage tanks and pumping facilities is key, taking into account access to pump stations, efficient removal of pumps with minimal impact on normal operation and location of feeder supplies to storage tanks. It should be noted that the size of these tanks will be substantial, but need to be readily available for inspection of both the tank and the pumps. A risk assessment should be carried out to determine the most appropriate provision.

6.3.3 Lighting

Lighting should be low energy LED's to allow for longer asset life of replacement components. These should be plug and play to allow for a quick swap out and upgrading.

6.3.4 CCTV

Pan / Tilt / Zoom cameras to be fitted throughout the tunnel and its approaches. 100% coverage is required.

6.3.5 Incident Detection

Incident Detection to be installed as required. Locations and consideration of the transverse alignment are important.

6.3.6 Stopped Vehicle Detection

Smart Motorways Programme (SMP) are currently trialling a stopped vehicle detection system, and as the tunnel sits within the boundaries of an SMP scheme consideration should be given to its use within this scheme.

6.3.7 Power Supply

Dual independent incoming power supplies and UPS (Uninterrupted Power Supply) should be in accordance with BD78/99 or its successor.

6.3.8 Tunnel Control Centre

Location of Tunnel Control Centres (TCC) and plant rooms should have unrestricted access. This would mean in practise being outside of the airport boundary, so there is no need for permissions to be granted to enter the TCC from HAL. The intent should be for the tunnel to be operated remotely under 'normal operating conditions', via the RCC or Dartford Tunnel. The control buildings should be on land passed to Secretary of State along with the other highway land.

There should be means of maintenance personnel access to the tunnel bores from the TCC, other than accessing from the ends of the portal if possible.

Location and layout of portal controls is essential to allow Emergency Services to undertake incident management without complications. Consideration should be given to having a dedicated parking area at each portal for emergency services vehicles.

6.3.9 Plant Monitoring

Plant monitoring systems are not yet developed, or who is responsible for monitoring them. Where necessary they should be compatible with systems currently in use on HE networks. Currently all tunnels on the M25 are monitored from the Dartford Crossing and this may possibly be the case for the Heathrow Tunnels. Minimal intervention in the RCC is required, as is the need for additional equipment for monitoring purposes. Systems architecture needs to be developed early in the design process.

6.4 Deliverability of the Representative Option

6.4.1 Design

The design of the tunnel and highway is currently being developed by HAL, via a grouping of several consultants. These designers have formed various Technical Working Groups (TWG), led by specialist matter experts, with attendee's made up of stakeholders, designers and HE. These groups are:

- Road Design and Safety
- Structures
- Traffic Modelling
- Tunnel Ops
- Environment

The aim of the TWG is to develop the design philosophy, and have oversight of the detailed design; the intent being to have an agreed solution. The current proposals are preliminary, and not yet fixed. The project has not yet formally appointed a "Tunnel Manager" or "Tunnel Safety Officer" as per the definitions in the DIRECTIVE 2004/54/EC. The DIRECTIVE requires the appointments to be made by the Administrative Authority at the design stage. The project has been notified to the EU, and the Administrative Authority will be HE who will appoint the Tunnel Manager and Tunnel Safety Officer.

6.4.2 Procurement

Presently the procurement route for the scheme is not set, nor the form of contract it may be procured under. Similarly, who has ownership and responsibility for the tunnel once it is built and open to traffic is not yet agreed.

Currently the design of the tunnel is being progressed by HAL, and they could continue this, completing the design and procuring a suitable contractor to construct the tunnel and associated works, including the A4 and M25 motorway re-alignment. While this keeps the responsibility for programme with HAL, it does raise a risk of HE not accepting the motorway into operation until they are confident that there is no risk to the travelling public, and all the necessary documentation is complete to a level that the tunnel can be handed into maintenance.

Alternatively, the scheme could be procured by Highways England, but funded by HAL under a Section 278 agreement. This can apply to both the design and construction of the tunnel, or just the construction. This would enable Highways England to have control of the design of the structure, and allow them to dictate its form and the operational equipment it may become responsible for. HE would also have oversight of the construction and commissioning of the tunnel, and control over any traffic management placed on the network. This would make handover into operation easier. The risks associated with this is a design that may not fully take account of all the airport operations, and delays in hitting key milestones set by HAL that may impact on other airport expansion plans.

6.4.3 Construction of the structures

There are a number of constraints on the construction of the tunnel and bridge, primarily space, staff resource and the quantities of materials both generated and required. The amount of resource required to construct the tunnel is significant and this will be at a time when other nationally important projects are being undertaken.

It appears that the only reliable means of access into the site will be from the existing A4, which it is assumed will be subject to a stopping up order once the new A4 is built. The location for a compound is limited, and would appear that the most suitable place is adjacent to the tunnel, once demolition of the industrial area and rail head has taken place.

Approximately 750,000m^3 of material will be excavated from the site, with the majority being disposed of. It isn't clear yet if HAL intend to have a central recycling/re-processing area for materials where this material can go to. The material that is retained will be the excavated London Clay, which can go back into the works as part of the clay cap to the side slopes and carriageway.

The concrete required for the works is approximately 350,000m3, meaning a batching plant will be required for the site, with areas to store aggregate and cement silo's.

If a piled foundation solution is adopted the method of forming the bores will need to consider the potential for encountering water bearing strata in the London Clay or the Lambeth Group. If high water pressures are encountered drilling fluid (such as bentonite) support or casing may be required. This is introduced towards the base of the London Clay Formation, should be considered to prevent collapse of bored piles.

The method of forming piles will also need to be appropriate for the variable ground

conditions that may be encountered. Hard layers may be present within the Lambeth Group, and possibly the London Clay which may slow or prevent penetration of the piles unless appropriate cutting / drilling tool are used.

The desire to design an integrated structure means that there will be a higher proportion of steel for reinforcement in the structure, especially at corners, and experience has shown that in the past this can inhibit the free flow of concrete around the steel, leading to voids in the structural members. Consideration needs to be given to how the steel is detailed, and what the aggregate size is for the concrete.

The tunnel will be constructed adjacent to a live carriageway, and while it will be the responsibility of the contractor building the tunnel to ensure all works are carried out safely, HAL must consider what working space and temporary works are likely to be required and ensure that unrealistic constraints are not placed on the contractor.

The walls will need large shutters, and as a result a large crane to lift them into place. Care will have to be taken that this doesn't impact on airport operations. It would be expected that shutters will be 6.0m in width, and the walls poured in alternate hits, with a construction joint between pours. The sequence of pours, and ambient temperatures will have to be considered to minimise the potential for cracking. Consideration should be given to casting in a hydrophilic water bar at each construction joint to mitigate the chances of water ingress into the structure.

Similar constraints will exist for the roof, where it is proposed to cast the slab in-situ, with void formers and ducts for post tensioning. It is vital that the void formers are held securely in place, and not allowed to float, thinning the slab in the top section. Again careful sequencing of the pours will be required and the designer should demonstrate what conditions/sequencing is required. The slab will need large areas of falsework, with a firm foundation. This could be achieved by placing the carriageway sub grades with a sacrificial layer early, and allowing the falsework to be brought up from that level.

Temporary works for the tunnel will be complex. Firstly, there is a requirement for a cut-off wall to prevent the migration of water into the excavation in the short term, and in the long term to reduce as much as possible water around the tunnel walls. This cut-off wall can be either a bentonite slurry wall or a steel sheet pile wall. While the bentonite wall would generally perform better in the initial stages, evidence shows that where there is large water migration around the enclosed cell, over time it washes away and its integrity is compromised. Sheet pile walls would potentially last longer, but the clutches may leak slightly as it would be impossible to seal them. The sheet piles could be designed for a 120-year design life, to take account of any corrosion over time. The wall cannot be completed for the whole tunnel at once, as the north east portal currently encroaches into existing M25. Instead it will have to be incorporated into the permanent design of the tunnel, and then extended once traffic has switched to the new alignment.

Where the proposed M25 and existing M25 meet it is considered that there may be differences in levels that will require retaining walls and /or steep slopes. These may need to be formed through landfill material and the Terrace Gravels. The type of wall and the method of forming them will need to take into consideration ground water, landfill leachate, and obstructions within the landfill material. The construction these walls will need to be undertaken close to the 'live' lanes of the

existing M25 and therefore safety requirement and working space need to be assessed.

The roof slab, once cast in place will need to be waterproofed. This will need ideal weather conditions and several layers as revisiting in the future is precluded by the runway. Consideration has to be given as to how this is sequenced – either applied in sections following on from the roof slab being poured, or waiting until the whole roof is available and applying then.

The A4 structure is relatively straight forward in terms of construction, although care will have to be taken in its proximity to the existing M25 and any settlement issues on the embankment. The structure sits on top of the tunnel roof, and will use the walls of the tunnel to pass its loads down into the foundations.

6.4.4 Construction of the carriageway

The construction of the carriageway appears to be straightforward, except where it ties in to the existing M25. The high traffic volumes mean that any reduction in network availability will have a severe adverse effect on the Strategic Road Network. When an incident occurs in this part of the network at present there is a disproportionate effect on traffic on the M3, M4, M40, A30 and A3. HE have stipulated to HAL that no reduction in lane availability is permitted between 05:00 and 22:00. Outside of these times, no reduction in lane availability will be allowed at any time except when vehicle flows fall below 1600 v/h/l. Recovery vehicles should be stationed in appropriate places for the duration of the works to remove any stranded vehicles.

Consideration should be given to temporarily widening the M25 by about 35m to the east of its current alignment where the northeast portal encroaches into the northbound carriageway, and then tie back in about 200m south of the tunnel portal. This would allow the tunnel to be built in its entirety, and commissioned as one. It would also enable the tie in of the carriageway at the northern end to be constructed much more easily. This construction wouldn't necessarily have to be to full motorway standards, but be sufficient for the duration that it would be in place for.

Dewatering during drainage installation for the diverted M25 and A4 may be necessary, leading to potential leachate issues. Similarly, the box cut for the sub grade may also have water ingress issues. This needs to be managed and the water disposed of in an appropriate manner.

6.4.5 Installation of Tunnel Equipment

Particular attention should be given to the design of all tunnel equipment in relation to the way it will be installed and commissioned. The designer needs to work alongside experienced installers to identify common site issues.

Consideration should be given to the types of materials used to ensure maximum whole life benefits, and future refurbishment and renewal.

Building upon experiences of both Holmesdale and Bell Common Tunnels consideration should be given to placing the distribution panels inside the inter-bore access ways, instead of in the tunnel itself. Risk assessments should be undertaken to ensure that the design, location and material type does not compromise safety and tunnel management / operations.

7 Maintenance and Operation of the Representative Option

7.1 Maintenance

Maintenance regime should be developed early in the design process and should be intrinsically linked to a SMART set of MOR's (Minimum Operating Requirements). Tunnel washing and physical cleaning and maintenance of other fixed equipment may require closures, however, where possible this should be kept to a minimum – tunnel equipment should be placed where it is possible to maintain them with limited carriageway interventions. The agreed the level of carriageway availability for maintenance needs to be defined with OD as soon as practicable.

Types of coatings and materials should also be considered during design to ensure the minimum amount of maintenance is required, e.g. self-cleaning products, Teflon coated mountings, etc.

Due consideration to be given to the nature of any materials and / or chemicals used in the tunnel, in that they do not adversely affect the functionality.

Tunnel maintenance should ideally fall into two representative areas, these being the tunnel structure including:

- Structural lining, cladding and panels, walls, roofs, floors, doorways and portals
- Service buildings and plant rooms
- Ventilation shafts.

and Tunnel Mechanical and Electrical (M&E) Equipment including all equipment and systems associated with plant monitoring and control, traffic, communications and safety including:

- Ventilation
- Lighting
- Drainage and pumping
- Fire safety and emergency response systems and alarms
- Communication and traffic control systems, including remote controls and closures
- Tunnel operation and plant control systems
- Power supply and distribution
- Service buildings and plant rooms.

Access during maintenance with regards to transportation of equipment, replaceable items and personnel is also an integral part of creating an efficient regime, particularly if maintenance and /or works are to be carried out off-line.

As described earlier, owing to high traffic flows, the deployment of Traffic Management in a maintenance situation is certainly a more difficult task on this section of the M25. Currently TM is deployed on the four lane section prior to the six lane section at Junction 14. This will have the effect of shortening the available working window as it will take longer to deploy and remove, also traffic flows start to rise significantly around 5am in the morning due to the pull from the airport. The effect being a shortened working window available for maintenance. As such the development of a smart maintenance plan is essential and should be considered during design development.

The DBFO contract runs until September 2039 and it is assumed that the future asset management and maintenance of the structure and tie-ins to the existing M25 will be added to the M25 DBFO Contract for the remainder of its term. The DBFO should be consulted on both the design of the tunnel and equipment, and proposed maintenance and operation regimes.

It is felt that the current proposal for diversion routes are unacceptable, specifically the 14-mile diversion vehicles when the northbound CD is closed for maintenance. The M40 J1 is a complex signal controlled junction and this is likely to cause significant congestion and tailbacks onto the M25 and surrounding network.

7.2 Incident Management

Incident management will be derived from risk assessments PSCRG and TDSCRG stakeholders etc. along with objectives for carriageway availability. In terms of incident response there is also an issue that the tunnel is located on Berkshire but right on the border with Surrey. This will be a further challenge to effective incident response particularly as there are no other tunnels in either authority's areas so no tunnel management expertise to draw on.

The ability to stop traffic entering the tunnel if there is an incident is critical and needs to be developed. At present no clear method exists for achieving this on D5/D6 roads.

Listed below are examples of key factors that should be considered to allow a robust Incident Management Plan to be developed:

- Dedicated parking at tunnel portals for emergency and service vehicles.
- Consider modelling various scenarios to ascertain how the layout will cope and how people will actually evacuate.
- Are evacuation passages, cross passages and general access passages pressurised to control fire and allow safe egress.
- A detailed Fire Management procedure to be developed early in the design process and incorporated into the main Incident Management Plan. With specific consideration to multi-lane structure.
- Height restrictions, what is the lowest structure on the approaches to the Tunnel entrances.
- What scenarios may play out which means the tunnel or runway has to be closed, and who makes the decision to activate this
- [redacted]

8 Futureproofing Arrangements

8.1 Carriageway

The tunnels will place a permanent restriction on expanding the M25 and therefore need to be designed to facilitate long term growth in traffic volumes. The current proposed layout allows four lanes in each direction on the main carriageway, and 3

lanes on the collector/distributors, while allowing up to 6 lanes ALR in the future for the mainline and 4 lanes ALR on the collector/distributors (The tunnel would remain a D5M). While this would appear to give a significant amount of capacity, in needs to be fully assessed in conjunction with the proposed Smart Motorway schemes that are planned for this area of the SRN. Traffic modelling should be undertaken to demonstrate that this is sufficient for anticipated future needs. As stated previously, provision for future ERA's should be allowed for.

If a piled structure, with flexible carriageway is adopted, then there would be no hindrance in placing services and supplies in the carriageway in the future. Similarly, any in-road charging for electric cars could be installed without affecting the integrity of the structure.

8.2 Structure

The tunnel structure and overhead runway should be completely independent so that maintenance of either does not affect or interfere with the normal operation of either. The structure roof, once the runway is in operation above will become a "no-go" area to maintenance teams, and the ability to install new equipment to the outside of tunnel will be lost. Therefore, as much flexibility as possible needs to be built into the tunnel, including spare ducts in the roof and walls, cross tunnel ducts (with appropriate fire breaks) and a means of hanging new equipment from the soffit without having to drill into the concrete. This could be a "top hat" system of steel supports, or a series of cast in fittings such as that are available for future use.

8.3 Tunnel equipment

Equipment installed within the tunnel should not be dictated by what is currently in other tunnels, specifically Holmesdale and Bell common. The tunnel should use the latest systems and equipment available and these, including the Supervisory Control And Data Acquisition system (SCADA) shall be fully upgradeable via plug and play. Allowance should be made (space and installation) for new and emerging technology such as autonomous vehicles. As stated previously, all tunnel monitoring is conducted from the control centre at the Dartford crossing, and this could be the same for Heathrow tunnels.

9 Management Arrangements

9.1 Synergy with the rest of the network

There is already a variable tunnel estate within the M25 DBFO Network and – as far as equipment is concerned – it is more important to get robust, reliable and current equipment than to compromise the design in matching it with other tunnels. The philosophy of how the existing M25 tunnels operate, maintenance regimes and fire plans should be studied, and lessons and issues captured to ensure that they are fed into the new tunnel operating and maintenance plans. This also extends to equipment outside the tunnel such as gantries and associated technology for the operation of a controlled motorway. The tunnel design must consider the needs of the wider network, and how the M25 will operate in future years, not becoming a constraint on smooth vehicle flows.

This consideration should also be extended to the diverted A4, and look at future traffic needs, ensuring the proposed design doesn't become a choke point should the need for a widened A4 arise.

9.2 Smart Motorway Programme (SMP)

There is a commitment in SMP to commence the M25 J10-16 SMART motorway scheme in 2020/21, with a planned open to traffic for November 2022. This sits not only within the construction period of the tunnel re-alignment, but also the design phases (concept design for SMP M25 J10-13 has commenced). Similarly, the M4 J3-12 scheme is currently in detailed design, and will start on site early 2018, with a current planned completion of February 2022. The M3 J9-14, while not directly affecting the M25, will have an impact on the traffic as it goes to site in March 2020, with an open to traffic date in March 2022, and likewise the M25 J10/A3 junction improvement, due to commence 2020, and completing 2022/23. All these schemes will need to be accounted for in the traffic modelling, and the effect assessed on the M25 re-alignment. Currently there is no evidence that this is the case, although in some cases the SMP schemes may not be in a position to supply meaningful data.

Given the number of committed and considered schemes in the local and wider area, it is worth recommending the establishment of a Programme Board to manage the combined impact of the schemes on HE's customers.

9.3 Combined tunnel control centre

Within Highways England there is currently an ongoing discussion about creating a central control point for all tunnels on the M25 network, and other planned new tunnels within the South East, including the proposed Lower Thames Crossing. Heathrow tunnel should be capable of being operated from the tunnel location, the Dartford crossing control room and also remotely from any new control centre. The equipment will need to be compatible with the developing HE specifications. HE need to develop an operational and maintenance concept that covers this.

10 Safety and Security

Heathrow Airport Ltd has appointed Jacobs as part of the overall design team to review the safety aspects of the scheme. Currently this is being undertaken via the Safety TWG, but will have to develop into the Tunnel Design and Safety Consultation Group (TDSCG). This should follow the guidelines set out in BD78/99. As discussed above, a Tunnel Manager and Tunnel Safety Officer will also need to be appointed to comply with TEN regulations.

From current proposals, it isn't clear how the public will be evacuated from the tunnel in the case of an incident. There are passageways that are segregated from, but run parallel to the main bores, and it is indicated that the public will be able to walk along these to a safe place of refuge. Once the public reach the portals however there is a risk of them emerging into live traffic unless some form of safety zone is established, or a means of accessing a place of safety via stairs.

Human factors and behaviours will need to be assessed. There is some anecdotal evidence of the sight of planes currently coming into land at Heathrow distracting drivers (this also happens on the M1 for East Midlands) and due consideration will need to be given as to how the new layout will distract drivers, not only on the M25 but also on the re-aligned A4. Due consideration should also be given to those inside the tunnel from any noise that may be generated as a result of planes landing or taking off on top of the tunnel roof as vehicles pass below.

[redacted]

11 Delivery Schedule

There is a clear overlap in timescale from early 2022 when main works start on the re-alignment of the M25 and tunnel to Nov 22 when the new Smart Motorway becomes operational. This is a big risk to both schemes in terms of customer satisfaction, network access and traffic management availability. Also, both schemes need designing taking the other into account. It is unlikely the M25 SMP J10-J16 will be fully operational until the new M25 tunnels are finished.

Sequence & Constraint Commentary

Early works for the proposed tunnel could commence mid-2020. For the purpose of this report it is assumed that this means statutory undertakers diversions can take place from this point. The most efficient thing for the project is to have all the diversions complete prior to demolition & construction starting approximately Q4 2021 / Q1 2022.

From Development Consent Order (DCO) approval in mid-2021 a short mobilisation will commence as it is assumed the principal contractor will be in place to expedite procurement well before DCO approval followed by a twelve-week site compound set up. The compound needs to be strategically placed so that it maximises access to the works areas and has enough lay down area for reinforcement & formwork construction for the tunnel works. Ideally, there will be enough space for a concrete batching plant.

From DCO approval immediate access will be required to the industrial area and SSE pylons & Longford sub-station and the industrial area at Galleymead Road for demolition works. Local site welfare facilities can be set up for these works whilst the main compound is being built. This will require access from the old A4, Bath Road. This can easily be obtained from either J14 or J15 of the M25 and local roads. This will increase the traffic in the villages of Colnbrook & Poyle for the duration of the works. Alternative access could be gained via the A4 into green field land north of the industrial area where access will be required anyway as this area is one of the first earthworks realignment sections of work to commence.

The temporary diversion of the jet fuel pipeline needs to be complete at this point. We suggest that this diversion is completed earlier than the HAL Deliverability Report Presentation suggests so that it doesn't impact on the earthworks in this area.

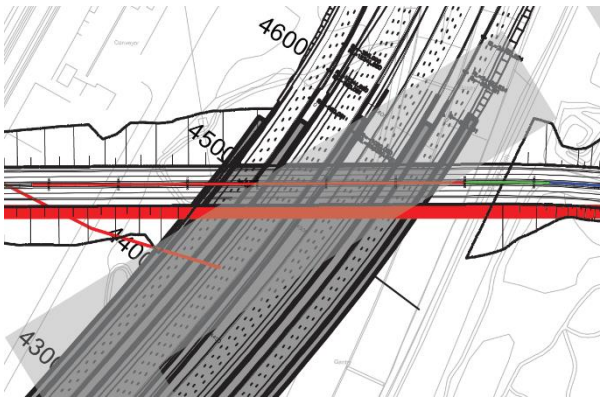
Access from the old A4, Bath Road through the villages of Colnbrook and Poyle will

be required regardless of access's mentioned above to construct the earthworks realignment to the south of the demolition works towards M25 J14. Alternatively access to this area of land can be gained from the existing M25 but would then require a crossing of the Wraysbury River.

This would have an interface with the M25 J10-J16 Smart Motorway and may not be possible depending on their traffic management arrangements. Access arrangements aside, the earthworks solution in this area needs to take into account the Wraysbury River. Ideally this needs to be diverted under the M25 outside the work area as one of the first tasks after accessing the work area in late 2021.

Access from the existing A4 will be required for the demolition of the distribution centre, the first section of tunnel to be constructed north of the distribution centre and the new M4 slip roads from early 2022. It would be prudent to allow the plant for the tunnel to be delivered to the northern area before demolition commences and then set up local traffic management to control and segregate earthworks realignment wagon movements and demolition activity.

This should be possible by constructing a haul road to the north from the existing local road network. The approval to close the railway to the distribution centre must be in place at this time. The tunnel construction at the northern end is constrained by the length of the tunnel due to the glide path over the M25 causing an interface issue with the new & existing M25. This means approximately the last 200m of tunnel will be constructed in phases. Briefly, the new north bound mainline and collector distributor bores can be constructed in full whereas the new south bound mainline and collector distributor bores can't be constructed in full as the last 200m overlays the current M25 alignment.



Once the river diversion & earthworks realignment is complete south of the old A4, Bath Road, then this road can be shut as access from it is no longer required. The earthworks realignment in this section can then progress and will marry up to the earthworks realignment in the previously demolished SSE pylons & Longford sub-station and the industrial area. At this point all earthworks realignment will be complete south of the new tunnel opening with the exception of the new tie in.

At this point all access to the works would be from the existing A4. The distribution centre is demolished and the tunnel works are progressing from the northern end towards the existing A4.

Running in parallel to the works described to date from DCO in mid-2021 is the new A4 construction. This has an interface with the northern tunnel opening in that it bridges over the top of it. Access to the new A4 construction would be from the existing A4 to the east and west which shouldn't impact on the M25 works. The new A4 needs to be built so that the existing A4 can be demolished at a suitable point in time so that no delay is suffered to the construction of the M25 tunnel. This means building up the new A4 embankment to the west of the north tunnel opening as

soon as possible and building the A4 bridge pier to the east of the M25 in a timely fashion. This will enable the new A4 bridge to be completed which, subject the remainder of the new A4 also being complete will enable the closure of the existing A4 and trigger the completion of the M25 southern tunnel opening which sits on the current A4 alignment.

Once the new north bound mainline and collector distributor bores are complete and the new tunnel bores fitted out and upon completion of the southern end earthworks realignment tie in the existing M25 north bound traffic can be diverted into the new north bound tunnels. This creates space by gaining the existing M25 north bound carriageway to complete the remaining new south bound mainline tunnel bore and the fit out and some of the remaining new south bound collector distributor tunnel bore. At this point the existing M25 south bound main line traffic would be diverted into the new tunnel by completing the tie in at the northern end. This creates space by gaining the existing M25 south bound carriageway to complete the remaining new south bound collector distributor tunnel bore and the fit out of the tunnel which will allow the existing M4 slip roads to be diverted into the new collector distributor tunnel.

Demolition of the old M25 would now commence. Access for this would be from the east via the old A4, Bath Road and the old A4, Colnbrook Bypass.

Summary of External Constraints

CONSTRAINT	REQUIRED RELEASE DATE
Early works approval for stats diversions	June 2020
Stats diversions complete	September 2021
DCO approval	June 2021
Temporary diversion of jet fuel pipeline complete	January 2022
Closure of railway at distribution centre	January 2022
Old A4 Bath Road, road closure in place	June 2022
M25 SMP J11-J16 complete	November 2022

Key Quantities, Outputs & Durations

NOTE: Outputs based on a 10hr day

ITEM	QUANTITY	OUTPUT	DURATION
Slurry wall	1,500m	6m panel per day per gang	250 gang days
Piling	1,250no.	1 per day per rig	1250no. rig days
Tunnel excavation	1,012,500m3	1200m3 per day per	844no. machine

		machine	days
Top slab falsework	918,000m3	60m3 per 2no. man gang per day	15,300no. gang days
Top slab reinforcement	73,440T	18 man hours / T Assumed avg bar dia 16mm	132,192 man days
Top slab formwork	5,992m2	1.29m2 / hour per 2no. joiners	4645 gang days
Top slab concrete	144,364m3	180m3 per day per gang	802 gang days

Appendix A –Risk Register

See attached sheet

Appendix B – Schedule

See attached Schedule

Appendix C – List of Drawings and Presentations Provided by Heathrow Airport Ltd.

List of Drawings Provided

Title	Number	Version
M25 RUNWAY BRIDGE AB7I G.A. LOCATION PLAN INCLUDING GLIDE PATH AND A4 SHEET 1	HEP46-S0-GA-XXX-100001	P01.2
M25 RUNWAY BRIDGE AB7I G.A. BRIDGE PLAN INCLUDING GLIDE PATH AND A4 SHEET 1	HEP46-S0-GA-XXX-100002	P01.1
M25 RUNWAY BRIDGE AB7I G.A. BRIDGE PLAN INCLUDING GLIDE PATH AND A4 SHEET 2	HEP46-S0-GA-XXX-100002	P01.2
M25 RUNWAY BRIDGE AB7I LONG SECTION INCLUDING GLIDE PATH AND A4 SHEET 3	HEP46-S0-GA-XXX-100003	P01.2
M25 RUNWAY BRIDGE AB7I PILED ARRANGEMENT SECTIONS INCLUDING GLIDE PATH AND A4 SHEET 4	HEP46-S0-GA-XXX-100004	P01.2
M25 RUNWAY BRIDGE AB7I ALIGNMENT GENERAL ARRANGEMENT SECTIONS SHEET 5	HEP46-S0-GA-XXX-100004	P01.1
KEY UTILITIES ASSETS AT RUNWAY TUNNEL	HEP46-XX-CS-XXX-100001	P01.1

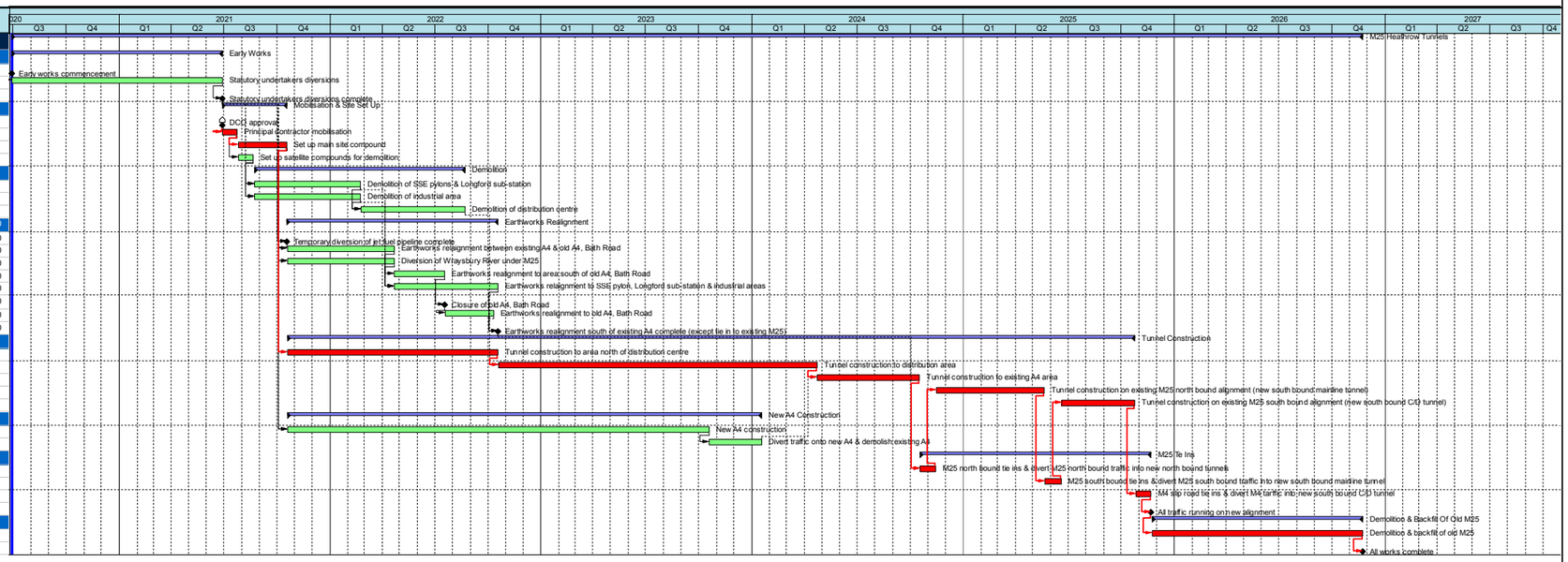
List of Documents and Presentations Provided

Title	Format	Date
Organogram	Paper	Q3 2017
Tunnel Operations	PDF	18 Oct. 2017
M25 Diversion – Deliverability Report	PowerPoint	23 Oct. 2017

M25 Heathrow Tunnels

High Level Indictive programme - For information purposes only, to be read in conjunction with Deliverability Report Decemebr 2017

Activity ID	Activity Name	Remaining Duration	Start	Finish	Total Float
M25 Heathrow Tunnels		1604.00	29-Jun-20	23-Nov-26	0.00
Early Works		250.00	29-Jun-20	28-Jun-21	79.00
A1000	Early works commencement	0.00	29-Jun-20		79.00
A1010	Statutory undertakers diversions	250.00	29-Jun-20	28-Jun-21	79.00
A1020	Statutory undertakers diversions complete	0.00		28-Jun-21	79.00
Mobilisation & Site Set Up		80.00	28-Jun-21	18-Oct-21	0.00
A1030	DCO approval	0.00	28-Jun-21*		0.00
A1040	Principal contractor mobilisation	20.00	28-Jun-21	23-Jul-21	0.00
A1050	Set up main site compound	60.00	26-Jul-21	18-Oct-21	0.00
A1060	Set up satellite compounds for demolition	20.00	26-Jul-21	20-Aug-21	40.00
Demolition		250.00	23-Aug-21	22-Aug-22	40.00
A1070	Demolition of SSE pylons & Longford sub-station	125.00	23-Aug-21	22-Feb-22	40.00
A1080	Demolition of industrial area	125.00	23-Aug-21	22-Feb-22	40.00
A1140	Demolition of distribution centre	125.00	23-Feb-22	22-Aug-22	40.00
Earthworks Realignment		250.00	18-Oct-21	18-Oct-22	500.00
A1090	Temporary diversion of jet fuel pipeline complete	0.00		18-Oct-21	500.00
A1100	Earthworks relaignment between existing A4 & old A4 , Bath Road	125.00	19-Oct-21	21-Apr-22	500.00
A1110	Diversion of Wraysbury River under M25	125.00	19-Oct-21	21-Apr-22	505.00
A1120	Earthworks realignment to area south of old A4, Bath Road	60.00	22-Apr-22	18-Jul-22	505.00
A1150	Earthworks relaignment to SSE pylon, Longford sub-station & industrial areas	125.00	22-Apr-22	18-Oct-22	500.00
A1160	Closure of old A4, Bath Road	0.00		18-Jul-22	505.00
A1170	Earthworks realignment to old A4, Bath Road	60.00	19-Jul-22	11-Oct-22	505.00
A1180	Earthworks realignment south of existing A4 complete (except tie in to existing M25)	0.00		18-Oct-22	500.00
Tunnel Construction		1025.00	19-Oct-21	24-Oct-25	0.00
A1130	Tunnel construction to area north of distribution centre	250.00	19-Oct-21	18-Oct-22	0.00
A1200	Tunnel construction to distribution area	375.00	19-Oct-22	22-Apr-24	0.00
A1210	Tunnel construction to existing A4 area	125.00	23-Apr-24	17-Oct-24	0.00
A1240	Tunnel construction on existing M25 north bound alignment (new south bound mainline tunnel)	125.00	15-Nov-24	21-May-25	0.00
A1260	Tunnel construction on existing M25 south bound alignment (new south bound C/D tunnel)	90.00	20-Jun-25	24-Oct-25	0.00
New A4 Construction		560.00	19-Oct-21	18-Jan-24	65.00
A1190	New A4 construction	500.00	19-Oct-21	18-Oct-23	65.00
A1220	Divert traffic onto new A4 & demolish existing A4	60.00	19-Oct-23	18-Jan-24	65.00
M25 Te Ins		275.00	18-Oct-24	21-Nov-25	0.00
A1230	M25 north bound tie ins & divert M25 north bound traffic into new north bound tunnels	20.00	18-Oct-24	14-Nov-24	0.00
A1250	M25 south bound tie ins & divert M25 south bound traffic into new south bound mainline tunnel	20.00	22-May-25	19-Jun-25	0.00
A1270	M4 slip road tie ins & divert M4 tarffic into new south bound C/D tunnel	20.00	27-Oct-25	21-Nov-25	0.00
A1280	All traffic running on new alignment	0.00		21-Nov-25	0.00
Demolition & Backfill Of Old M25		250.00	24-Nov-25	23-Nov-26	0.00
A1290	Demolition & backfill of old M25	250.00	24-Nov-25	23-Nov-26	0.00
A1300	All works complete	0.00		23-Nov-26	0.00



Appendix A

Highways England Deliverability Report for Heathrow Tunnels

Risk Register

Risk ID	Risk Description	Effect of Risk on Safety, Time, Cost or Reputation	Probability L/M/H	Impact L/M/H	Severity	Possible Mitigation	Residual Risk	Risk Owner
General								
Gen/01	Lack of Clarity over who is appointing contractor to build the tunnel and highway works	Possible delay to programme as parties try to agree who appoints the contractor, and agree a Section 278.	L	M	L	Agree in principle now who is going to appoint the contractor.	L	HAL/HE
Gen/02	Section 61 needed for noise and vibration	May restrict or delay the works	M	M	M	Engage with the relevant Local Authority to understand what issues may arise.	L	HAL
Gen/03	Environmental constraints	EA may place restrictions on the scheme such as discharge rates or water quality, or nesting birds and reptiles have an impact	M	M	M	Engage with EA early, undertake environmental studies as soon as practicable and engages with a contractor to understand construction impacts	L	HAL
Gen/04	Lack of engagement from a competent contractor to advise on buildability	The scheme may not be designed in the most efficient way it could be to facilitate the building of the tunnel.	M	M	M	Appoint a contractor to advise on buildability, so ensuring the design is completed in the most efficient way to build and commission.	L	HE/HAL
Gen/05								
Gen/06								
Gen/07								
Schedule								
Sch/01	Impact to the project from other schemes on the Strategic Road Network	The RIS 2 identifies works to be carried out on the M25 between J11 and 16 over the coming years, which may be built at the same time that HAL wish to build the tunnel.	M	M	M	Work with HE teams to ensure that disruption to the customer is kept to a minimum and traffic management doesn't clash	L	HE
Sch/02	Failure to gain access to land	The scheme needs to acquire land and properties before the scheme is built. Failure to achieve this could delay the project.	M	H	H	Start negotiations with land owners and businesses as soon as possible	M	HAL
Sch/03	Road closures not available when needed	There will need to be a number of road closures to facilitate the tie-ins to the existing carriageway. These have to be coordinated with other network activities, and planned well in advance.	M	M	M	Ensure that closures are kept to a minimum, are well publicised and are coordinated with the Airport operations team	L	HE/HAL
Sch/04	Tunnel bores not independent	If the northbound and southbound tunnel bores are not independent of each other, and cannot be fully commissioned separately, the structure cannot be completed.	M	H	H	Design the tunnel bores so that the northbound tunnels and the southbound tunnels are independent of each other and don't rely on each others systems for commissioning.	L	HE/HAL
Sch/05	Statutory Undertakers diversion works	The diversions of services and supplies may take longer than anticipated, impacting the schedule	H	H	H	Have detailed early engagement with the relevant Statutory Undertakers and where possible carry out diversion of the equipment ahead of current programme	M	HAL
Sch/06	Network Rail approvals	Approvals not in place to close the railway to the distribution centre, impacting on the demolition schedule	L	M	L	Have detailed early engagement with Network Rail	L	HAL
Sch/07								
Sch/08								
Sch/09								
Design								

Des/01	Scheme fails to achieve all of HE standards	The scheme may require a number of departures from standard, and therefore need HE specialist sign off. If the specialists are not content that the departure is acceptable, then there may be a delay in completing the design.	L	H	M	The dialogue that has commenced with the HE specialists should continue, and the design presented to them at regular intervals.	L	HAL
Des/02	No expansion joints may lead to high stresses on structure	With the desire to have no expansion joints, there will need to be careful and complex planning of how the structure is constructed, to avoid any cracking through shrinkage during the pouring of the concrete. Likewise, there will be a risk longer term of cracking due to differential thermal expansion, leading to cracking and possible water ingress.	H	M	H	Specify bespoke low shrinkage concrete mixes, limit pours to cooler days and consider expansion joints to allow a degree of thermal expansion. Hydrophilic water bars may help with this.	M	HE/HAL
Des/03	Clash between runway drainage and equipment and the tunnel roof	With only 1.2m of cover to the tunnel roof, there may be a clash between services and supplies the runway needs to operate, and the top of the tunnel roof - there is a chance that the waterproofing needed for the roof structure is compromised from future works to the runway.	M	M	M	Consider placing a protection slab on top of the tunnel waterproofing to protect it from the risk of damage from future airport activities	L	HE
Des/04	Tunnel has to comply with Trans European Network standards	The tunnel will sit on the Trans European Network, and as such has to comply with the relevant standards - Directive 2004/54/EC on minimum safety requirements for tunnels in the Trans-European Road Network	L	M	L	The Tunnel manager shall advise the design teams of the necessary requirements and ensure the standards are met	L	HAL
Des/05	Tunnel fails to meet future network capacity needs	The proposed tunnel may have insufficient capacity for future traffic growth. Widening the tunnel will not be possible.	M	H	H	Traffic modelling needs to be carried out to satisfy HE that there will be sufficient capacity for future growth	M	HE
Des/06	Cannot achieve independent power supplies	Risk of having to bring new supplies from a long distance, or have enhanced UPS and generators	M	L	L	Assess supplies now to ensure they are both close enough and have the capacity - plan for upgrades at the same time the SU works are undertaken	L	HAL
Des/07	Alignment does not support cross-overs at portals, as required by BD 78/99 and Directive 2004/54/EC	Long diversions will be needed if the alignment of the carriageway entering and exiting the tunnels does not support crossovers to be used during maintenance.	M	M	M	Cross overs shall be installed where it is practical and safe to do so.	M	HE
Des/08	Design work shows initial proposal to provide a fully integral structure becomes unfeasible meaning bearings and movement joints are required.	Bearings/movement joints pose an operational risk to the motorway as such will require inspection and maintenance which will more than likely effect traffic flow and customer experience.	H	M	H	Early design work to focus on and prove viability of proposed integral structure. If such work shows a integral structure is unfeasible other structural forms and arrangements to be considered and proposed.	M	HAL
Des/09	Fatigue damage of structure under cyclical dynamic 'aircraft landing' load case leading to reduced service life.	Fatigue damaged structure could require significant intervention and repair affecting both operation of airport and M25.	H	H	H	Early design work to focus on and prove proposed structure proportions permit sufficient reinforcement at critical junction of roof slab/substructure and at mid-span to accommodate fatigue.	M	HAL
Des/10	Weaving lengths too short between J14/14A and J15.	Increased number of accidents as motorists unable to safely access/egress from collector distributors. Increase the weaving length will not be possible at a later date.	H	M	H	Traffic modelling needs to be carried out to satisfy HE that there will be sufficient capacity for weaving, both now and for future forecasts.	M	HAL
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Des/12	Insufficient information on the ground conditions, groundwater regime, geotechnical and chemical properties.	Unquantified geotechnical hazards managed through a conservative design approach. Potential to increase costs and extend construction programme.	H	M	M	Additional targeted and good quality ground investigation	M	HAL
Des/13	Composition of landfill not clearly understood.	Potential for excessive settlement and possible localised collapse of the ground on the approach embankments as waste decomposes.	H	H	H	Detailed review of EA records for landfill. Targeted GI to allow characterisation of the landfill. Mitigate settlement risks through ground improvement or dig out and replace.	L	HAL
Des/14	Composition of landfill not clearly understood - Significant amounts of putrescible waste.	Landfill gas migration (Methane, CO_2) into tunnel	M	H	H	Suitable cut off wall / landfill barrier to prevent gas migrating to tunnel. Dig out and replace putrescible waste	M	HAL
Des/15	Surcharging of compressible ground (mainly landfill) from proposed 5m of embankment	Potential for significant settlement and long term creep	M	H	H	Ground treatment to reduce settlement or increase rate of settlement. Excavate compressible soils	L	HAL
Des/16	Surcharging of landfill from proposed 5m of embankment	Higher groundwater and landfill gas pressures and flows	M	M	H	Slurry cut of wall to be designed for higher groundwater and gas pressures	L	HAL
Des/17	Aggressive ground conditions for buried concrete	Deterioration of buried concrete and consequential reduction in design life of tunnel and foundations	H	H	H	Assessment of aggressively of ground and design of suitable sulphate resistant concrete.	L	HAL
Des/18	Adverse impacts on air quality	Air Quality issues not fully addressed, leading to adverse impact on residents and ecology	M	M	M	Robust assessment and where appropriate mitigation measures put in place to counteract any adverse impact on air quality	L	HAL
Des/19								
Des/20								
Des/21								
Construction								
Con/01	Cut off wall fails to halt ingress of water during construction.	With the proximity of the high water table, and the fact that there is a band of gravels across the site, there is a risk that groundwater will continue to migrate into the excavation areas, despite having a cut off wall - it may also be difficult to complete the wall as the tunnel intersects the existing M25.	M	H	H	The cut off wall will have to be designed such that it can be incorporated into the permanent works, and extended as required.	M	HE/HAL
Con/02	Contaminated Land more than anticipated.	There could be a significant increase in the amount of contaminated material required to be removed from site. Depending on the effectiveness of the cut off wall, this could be exacerbated by leachates from beyond the construction area.	M	M	M	Carry out comprehensive testing of materials and develop a schedule of hotspot areas that need to be removed, that which can be treated/processed and what can be reused. Because of the relatively poor road links, and the need for fill for the future runway scheme, keeping material on site will help keep costs down.	L	HE/HAL
Con/03	Slow materials delivery.	Due to the restrictive nature of the site, materials delivered to site may be slow, impacting on both time and cost. The A4 diversion bisects the local rail head, removing the ability to bring materials in via this route.	M	M	M	Look to use precast and prefabricated construction techniques to minimise vehicular deliveries. Use the proposed logistics hubs to store materials and fabricate off-site	L	HAL/HE
Con/04	Constraints in DCO limit the working methods and time allowed for activities	DCO constraints could lengthen the time to build the tunnel to an unacceptable date.	M	M	M	Engage a construction partner to advise on buildability so case can be put to DCO that reduces risk of construction constraints.	L	HAL/HE

Con/05	Consolidation of A4 embankment takes longer than anticipated	The re-aligned A4 requires significant height approach embankments to be constructed. This sits on made ground and as such could be subject to significant consolidation. Long term there could be a level difference in the carriageway as the approaches settle, compared to the structure.	M	M	M	Look to minimise settlement by either stone columns, digging out compressive material, or placing the embankment fill very early in the programme and surcharging.	L	HAL/HE
Con/06	Craneage and piling rigs for construction may impinge on airspace restrictions	The current design will require significant cranage to build the structure - This may encroach into restricted airspace and therefore may dictate the method of construction	L	H	M	Try to minimise depth of piling, and weight of any prefabricated units therefore reducing the size of cranage required	L	HAL
Con/07	Statutory Undertakers equipment	Despite measures been taken to divert all necessary statutory undertakers plant and equipment, some services may remain that clash with the tunnel or carriageway works	M	M	M	Pre construction site investigation to locate and remove any remaining live services	L	HAL/HE
Con/08	Lack of resource to construct the works	With Highways England continuing its Roads Investment Programme, and HS2 proceeding, construction resources for tier 2 and tier 3 may be restricted.	H	H	H	Contract incentives, early engagement and collaborative working can all aid this, but not guarantee of success	H	HAL/HE
Con/09	Construction of embankments for runway causes settlement of live carriageways.	High settlements, especially differential, could lead to the closure of the affected lanes and significant remedial works to make them safe.	M	M	H	Construct any embankment that could affect the carriageway and allow time for settlement before road pavement is constructed.	L	HAL
Con/10	Ground water encountered in the Terrace Gravel, London Clay and Lambeth Group during piling	Deeper / more casing of piles required. Increased time and cost	H	M	M	Better characterisation of the ground conditions in the footprint of the foundations.	M	HAL
Con/11	Obstructions and difficult ground conditions encountered in landfill material during construction of slurry wall	Method of excavation and plant used may need to be changed affecting time and cost.	H	H	M	Better characterisation of the ground conditions along the line of the slurry wall to allow selection of the appropriate excavation plant.	M	HAL
Con/12	Temporary works required during excavation of the tunnel - obstructions and difficult ground conditions encountered in landfill material preventing sheet piles reaching the required toe depth	Different plant required for driving of sheet piles. Different temporary works solution required.	H	M	M	Good information on the ground conditions.	M	HAL
Con/13	Excavation of the proposed tunnel close to existing M25 - loss of lateral restraint	Possible instability that could undermine the live carriageways of the M25. Loss of restraint for safety barriers	H	M	M	installation of suitable temporary works. Lane closures and TM to keep traffic out of zone of influence.	M	HAL
Con/14	Hard layers encountered during boring of piles	Increased time to form piles.	H	M	M	Assessment of ground conditions at locations of proposed piles. Selection of correct pile boring tools	M	HAL
Con/15	Settlement of backfill and/or proposed new clay cap adjacent to the tunnel walls	Differential settlement of the runway pavement	H	M	M	Good compaction of clay cap of landfill and granular backfill. Incorporate geogrid at base of pavement construction.	M	HAL
Con/16	Impact on the SRN during construction, both in terms of air quality and disruption to traffic flows	Unacceptable delays and AQ levels above permitted acceptable	H	M	H	Use Programme Board to plan and coordinate schemes. Design TM to give maximum thru flow of traffic.	M	HE
Con/17	Commissioning of the Tunnel	The design of the tunnel, choice of equipment and standard of construction are all critical to the commissioning of the tunnel and bringing it into operation.	M	H	H	HE must be involved at all stages of the design and construction of the tunnel to ensure that a successful commissioning is more probable.	M	HAL/HE
Con/18								
Con/19								
Con/20								
Operation and Maintenance								

*

OM/01	Poor surface drainage, as a result of superelevation rollovers becoming too large when trying to pivot very wide carriageways and drainage paths becoming excessive.	Water not removed quickly from the carriageway could lead to aquaplaning of vehicles	M	L	H	Alignments of separate carriageways to be divorced or supplementary pivot points used to reduce rollover lengths and keep drainage paths to a minimum.	L	HAL
OM/02	Parking within visibility splays within the tunnel.	Blocking of visibility may lead to traffic incidents.	M	L	H	Suitable measures to be taken to prevent parking whilst maintaining visibility.	L	HAL
OM/03	Deterioration of a permanent slurry cut-off wall over time	Increased permeability of cut-off wall. Contaminated ground water and ground gas migrate through wall towards the tunnel	M	H	H	Incorporate impermeable membrane core into cut-off wall.		
OM/04	Working window available for maintenance is shorter due to traffic flows and time to deploy and remove TM	Greater amount of TM required, greater exposure to road worker safety, less time available to complete maintenance, potentially more closures required to complete required level of maintenance.	H	M	H	Well planned maintenance, right choice of tunnel equipment and tunnel design - all leading to minimum level of operation & maintenance required in order to satisfy the agreed MOR's. This also applies to the carriageway.	M	HE / HAL
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	M	HE / HAL
OM/06	Unable to provide big enough reservoirs for fire suppression system.	Reduced capability of fire suppression system, direct impact on incident management and ability to protect tunnel structure and equipment.	L	H	M	Early consideration to type of fire suppression system required, what is needed to maintain and operate it, built into design - large areas / volumes will be required for the amount of water required.	M	HE / HAL
OM/07	Installing incorrect or poorly specified tunnel equipment.	Increase in number of failed components, or additional / unnecessary maintenance.	M	H	H	Understanding equipment specifications, matching risk with cost, understanding implications of additional maintenance or unnecessary closures in tunnels.	M	HE / HAL
OM/08	Failure of Pavement / fretting / cracking / potholes.	Tunnel closures / unplanned maintenance / significant impact on traffic flows - safety / time cost / reputation.	L	H	M	Robust carriageway design, utilise planned closures to undertake pro-active maintenance on carriageway.	M	HE / HAL
OM/09	Traffic tailbacks and congestion as a result of implementing planned / tactical diversion routes	Safety, reputation - Constraints on accessing Heathrow Airport.	M	H	M	Review of proposed diversion routes, appropriate JTR's undertaken - GD04 undertaken to understand impacts - alternatives explored and evaluated.	M	HE / HAL
OM/10	Speed of vehicles not controlled effectively within tunnel.	Safety, Cost, Reputation - damage to life, tunnel structure and / or equipment, delays, closures.	M	H	H	Consider average speed cameras (no ability with current camera set up on managed motorways), appropriate in tunnel and portal signage.	M	HE / HAL

OM/11	Emergency vehicles unable to respond effectively to tunnel incident.	Risk to life (multiple), tunnel structure and reputation.	M	H	H	Consider providing permanent Hard Shoulder, dedicated parking at tunnel portals, dedicated response units located at an appropriate location.	M	HE / HAL
OM/12								
OM/13								
OM/14								

Highways England's response to Heathrow Airport Consultation 28/03/2018

Runway location
Our Emerging Plans - Page 39
Statement 1 – Please tell us what you think about the options for the new runway.
Question 1 – What factors do you think should be important in fixing precise location and length of the runway?

- Highways England does not have a preference over the options which are proposed to be taken forward (A2, A3, A4). However, the length / location of the runway has a bearing on the driver's eye view of aircraft from the M25 and M4. The safety impact of potential driver distraction needs to be considered, and included in option evaluation.
- Consideration must be given to measures to reduce driver distraction as a result of the runway crossing the M25 and associated aircraft movements both on taxiways and take-off and landings. Measures which reduce decision making for motorists in this location should be considered, such as collector-distributor roads. A driver's eye simulation from all approaches on the strategic road network will be required to understand the visual impact.
- Consideration must be given to the fact that the M25 in the location of the proposed runway crossing between Junction 14a and Junction 15 is the busiest section of the UK motorway network with approximately 220,000 vehicles per day (source WebTRIS 2017). Constructing a runway in this location is challenging and disruption to motorists during construction must be minimised.
- Consideration must also be given to ensuring the M25 can operate efficiently once the runway is operational and that an unacceptable permanent restriction on the future capacity and development of the M25 is not imposed as a result.
- The height of the proposed runway above the M25 must allow sufficient headroom for vehicles, signage and operations and maintenance equipment.
- The runway must be raised sufficiently above the existing ground level to prevent the M25 having to be lowered to a level which will result in a gradient on the M25 carriageway in excess of 3% in any location. This would result in unacceptable capacity and safety implications as a result of slow moving HGVs.
- Consideration should be given to the landing zone of aircraft and the impact this will have on the proposed tunnel structure and on driver distraction.
- Consideration of emergency procedures in the event of incidents on the M25 under the runway or on the runway over the M25 must be developed to minimise closures on either asset as a result of incidents.
- [redacted].
- The maintenance of the proposed runway and the M25 must be able to take place independently without any impact on each other.
- A decision on whether the proposed runway crossing of the M25 will include one long tunnel including the two proposed parallel taxiways and potential rapid exit taxiways or a separate runway crossing and taxiway crossings should be made in collaboration with Highways England to ensure the option chosen does not have any negative impacts on the operation and maintenance of the M25.

Taxiway Locations
Page 42
Question 1 – What factors do you think should be important in deciding the location of the new taxiways?

- When determining taxiway locations west and north of Terminal 5 Highways England require that they are located as far east as possible to ensure they are as far as possible from the M25. Taxiways could otherwise impose complexities and additional cost in providing road access to Terminal 5 and any new terminal facilities in this area

and would constrain land available for rivers and other infrastructure between the M25 and the taxiways.

- The location and design of the proposed new taxiways should take into consideration the need for surface access to cross under, over or around them in order to serve the existing and proposed new terminal and satellite locations. The elevation and alignment of the proposed taxiways to the west of Terminal 5 (highlighted yellow in Figure 60 on page 85 of the Scheme Development Report) must consider the need for road access routes from M25 Junction 14 and 14a and the A3113.
- Proposed taxiways must not prevent or lead to excessive costs and complexity in providing access to and operating and maintaining access to M25 Junction 14, M25 Junction 14A or the A3113.
- Taxiways west of what will become the central runway (highlighted red in Figure 60 on page 85 of the Scheme Development Report) will constrain land available for rivers and other infrastructure between the M25 and the taxiways. It is therefore important that these taxiways are located as close as possible to the central runway to maximise the land available in this constrained area. Given the central runway is 3,900 metres long consideration should be given to shortening this runway at its western end (without impacting its operational capacity) to maximise space between the taxiways and the M25.
- As with the runway location, the impact of driver distraction caused by taxiways to the western end of the existing runways and those proposed to cross the M25 must be considered. A driver's eye simulation from all approaches on the strategic road network will be required to understand the visual impact.
- As with the runway, taxiways crossing the M25 or any other part of the SRN should be designed so that they are at a sufficient height above the carriageway to allow sufficient headroom for vehicles, signage and operations and maintenance equipment.
- As with the runway the taxiways over the M25 must be raised sufficiently above the existing ground level to prevent the M25 having to be lowered to a level which will result in a gradient on the carriageway in excess of 3% in any location. This would result in unacceptable capacity and safety implications as a result of slow moving HGVs.
- Rapid exit taxiways must not be constructed on an alignment where an accidental overrun would lead to an aircraft entering or overhanging the M25.
- Taxiways and associated verges crossing the M25 should be designed to be wide enough for aircraft wing tips not to overhang the M25.

M25 Alignment and Junctions
Page 53
Statement 1 – Please tell us what you think about the re-positioning of the M25.
Statement 2 – Please tell us which family of options you prefer for the alterations to Junctions 14 and 14A and reasons why.
M25 Alignment

- Consideration should be given to the fact that the M25 in the location of the proposed realignment between Junction 14A and Junction 15 is the busiest section of the UK motorway network with approximately 220,000 vehicles per day (source WebTRIS 2017). Construction in this location is challenging and disruption to motorists during construction must be minimised.
- Highways England prefer solutions that create a new alignment away from the existing M25 as this will reduce disruption to motorists during construction.
- The new alignment should not be so far from the existing one as to significantly lengthen the distance traffic has to travel.
- Hard shoulders must be provided in the tunnels for safety and operational purposes.

- For safety purposes weaving traffic within the tunnels and their approaches and exits must be reduced or eliminated through measures such as collector-distributor roads parallel to the mainline M25.
- In the Scheme Development Report, the option with collector-distributors scores highest, however some of the wording around collector-distributors indicates Highways England may allow weaving in the tunnel which is not the case. Highways England has been clear in our design requirements that the proposals must reduce or eliminate weaving in the tunnel. Many of the options do not seem to adequately address the issue of weaving. Highways England will not accept a design which does not address this issue and would make representations at the DCO hearings if this is not addressed.
- Robust traffic modelling must be used to determine and agree the number of lanes to be provided on the M25.
- The proposed tunnel structure, which is required purely to enable the construction of HAL's third runway, will impose a permanent capacity restriction on the M25. HAL must therefore ensure the new tunnelled solution and any other new structures or infrastructure allow for future expansion of the M25, without the need for significant future alterations. Highways England in under a statutory direction from the Secretary of State for Transport which is specified in Highways England's licence to provide sufficient flexibility and future-proofing in planning the long-term development and improvement of the SRN.
- The consultation documents appear to assume that if J14a is removed, then the weaving issue no longer applies. Previous work Highways England carried out when reviewing the Airports Commission submissions against DMRB standards identified that this is not the case and weaving remains a significant concern. Highways England are therefore clear that weaving in the proposed tunnels will still need to addressed in a one junction scenario without J14a**.**
- Network resilience must be fully considered in the scheme design and HAL must demonstrate how this will be provided in the tunnel structure. From Highways England's analysis of Heathrow's proposals, this may be best achieved by four separate monolithic tunnel structures carrying each carriageway of the main and joining flows.
- Highways England request that HAL clarify how discontinuation rules have been established and applied, particularly discontinuation rule 1 relating to no costly or disruptive effects on M25 J15, which rules out 'AD' options, and rule 5 which discounts options that impose constraints on HALs masterplan such as AB3. In Highways England's view, re-design of M25 J15 doesn't necessarily cause more deterioration in level of service than other options considered.
- It is not clearly demonstrated that all options carried forward for evaluation meet the requirements of discontinuation rule 2 "any option which requires the closure of the M25 for construction should be discontinued"
- HAL's decision making needs to demonstrate that whole life costs have been taken into account in the design of the scheme, not just capital construction costs. The scheme must be designed to minimise maintenance interventions to keep disruption to the SRN to a minimum when carrying out maintenance activities. The commuted sum to be paid to Highways England by HAL will be for a minimum of 60 years additional operational and maintenance costs post completion in line with Government policy.
- Close engagement will be required with the M25 Design Build Finance Operate (DBFO) contractor Connect Plus / Connect Plus Services (CP/CPS) during the scheme design. CP/CPS will be able to provide their expertise in the design to ensure Operations and Maintenance deliverability, to optimise the whole life cost of the scheme, safety during operation and to minimise customer disruption during operation and maintenance. Highways England will facilitate this engagement.

- Measures to manage traffic following tunnel incidents and during planned or unplanned maintenance must be fully considered to ensure the M25 can continue to operate effectively. Introducing cross-overs to allow traffic to use alternative tunnels during periods of disruption, including in a contraflow arrangement must be considered. Tunnels must therefore be designed to accommodate traffic in a contraflow arrangement.
- HAL will be required to demonstrate compliance with air quality regulations and to fully consider noise receptors and potential mitigation required as a result of HAL's proposed changes to the SRN.
- It is not clear in the option evaluation that the requirement to keep the M25 operational during construction works has been applied consistently. HAL must ensure that the M25 is kept operational and existing capacity must be maintained during construction except where agreed otherwise with HE.
- The height of the M&E equipment zone in the tunnels appears very limited. Clarification is required of the assessment that has been made of the required space. Allowance also needs to be made for future technologies to be installed with requirements to be agreed through engagement with Highways England specialists.
- A signing strategy is required to reduce or eliminate weaving and to aid driver decision making. It is not clear that allowance has been made for signage in the designed headroom of the tunnel. This needs to be reconsidered in conjunction with a clear signing strategy to be agreed with Highways England.

M25 Junctions

- Robust traffic modelling and microsimulation of the proposed junction arrangements must be undertaken before a preferred option is chosen to ensure sufficient capacity and safety is provided.
- In order to reduce or eliminate weaving in the tunnels the location of north facing slips at Junction 14/14a should be considered carefully in relation to their proximity to the tunnels.
- Junction layouts should be capable of allowing traffic to leave the M25 freely, in order to prevent the danger of traffic queuing back on to the motorway.
- The road layout should be as simple as possible so that drivers can easily understand it.
- Network resilience must be taken into consideration when deciding between providing a one or two junction solution. Highways England will be able to provide advice to HAL on this issue through technical working groups.
- The impacts of HALs expansion proposals on M25 J13 and J15 must also be carefully considered and modelled to determine if mitigation is required.
- The operations and service criteria in evaluating options is critical and the long term operation and maintenance of the proposals must be fully considered when evaluating options. It is noted that Option JB1 scores highest for operations and service but is not proposed to be taken forward in the scheme development process. Highways England request that Option JB1 is reconsidered and further explanation is given of the findings of the other criteria for this option. Further detail is also requested on the road related operations and service criteria used and how they were agreed.
- There appears to be a disconnect between the M25 alignment options to be taken forward and the junction options. Junction options compatible with collector distributor roads do not appear to have been taken forward. These options need to be reconsidered given the concerns expressed above around weaving.
- The consultation documents refer to trade-off between cost, deliverability and land take with regard to proposed junction layouts and tie ins. Whilst Highways England accept that these are important considerations for HAL, safety is Highways England's priority. As such HAL must be able to demonstrate that all interfaces and new routes can meet Highways England's standards, or be reasonably certain that a departure from

standards is achievable. As explained in Annex 4, HAL must minimise departures from standards. HAL must demonstrate they can't comply with standards before applying for a departure. This means that detailed traffic modelling will be required and significant early engagement with standard owners/decision makers must take place (this to be informed by evidence and detailed design documentation).

- Highways England requires that developers meet the safety requirements that Highways England would seek to achieve if the infrastructure changes proposed were promoted by Highways England. Developer commercial considerations do not form part of this process or influence our decision making.

A4 Alignment
Page 58
Statement 1 – Please tell us which option you prefer for the diversion of the A4 and reasons why.

- The interface and delivery phasing of both the existing and new A4 with the proposed diverted M25 alignment is critical. The completion of the new A4 and A3044 is also critical to the demolition of the existing roads and subsequent completion of earthworks. Highways England requests that HAL establish a technical working group on construction planning / phasing / sequencing / logistics.

A3044 Alignment
Page 60
Statement 1 – Please tell us which option you prefer for the diversion of the A3044 and the reasons why.

- The proximity of family 2 to M25 Junction 14 may create operational difficulties, depending on what option is adopted for M25 Junction 14. This will need to be carefully considered.
- Option 2bi appears only to work if there is no M25J14a in the future. If this is correct this option may not be viable.

Rivers
Page 68
Statement 1 – Please tell us what you think about the options for the diversion of rivers and the approaches to replacement flood storage.

- The conflicts between river locations, taxiway locations and M25 alignment options need to be carefully considered and shared with Highways England in more detail.
- The lowering of the M25 next to flood zones may increase flood risk to the M25 compared to the current alignment of the M25. This must be carefully considered and proposals must be designed to ensure no increased flood risk to the M25 or wider SRN.
- Options C1a, C1b C1c include rivers in tunnels under the runway next to the proposed M25 Tunnels which will be at a lower level – again there is potential increased flooding risk compared with existing M25 levels and designs must prevent any increase in flood risk. Also options C2a C2b have similar arrangements.
- Other options have river crossings of the M25 not far from the portal areas which is a potential flood risk.
- Highways England's requirement is that there is no increase in flood risk to people or property, accounting for reasonably foreseeable effects of climate change.
- More information is required on the construction programme of river diversions proposed in relation to the re-alignment of the M25. More detail on the proposed programme would help assess temporary risks of flooding during construction.
- It is not clear whether flood risk during various phases of construction has been considered, rather than only being considered at completion of the masterplan.

- Variants of M25 alignment option AB1 were examined by looking at local shifts to the east and west of the current alignment. A shift to the east (option AB3) was seen as triggering a discontinuation rule on the basis of the impact upon airport land and was not taken forward for further evaluation. Clarification is required on whether this was also as a result of the impact on rivers and watercourses.

Highways England's response to Heathrow Expansion Masterplan Options- 29th June 2018

It is noted that all four masterplan options include the M25 being realigned approximately 130 metres to the west between Junction 14 and 15. Highways England will require further detail of the proposed M25 alignment; please see Highways England's 28 March consultation response for further details on our views on the M25 Alignment. At the masterplan session we re-iterated our concern over the driver distraction risk of aircraft movements surrounding the SRN. We need to see a risk assessment that demonstrates what is acceptable here prior to the preferred masterplan being selected. It is also noted that the masterplan options shown have variations in the taxiway arrangements immediately to the east of the M25.

……..

2. HAL initially presented options with and without collector distributor roads and with two and four bore tunnel options. However, on 8 June HAL confirmed verbally that all options now include collector distributor roads in four tunnel bores which is HE's strong preference as stated in our consultation response. We request that HAL confirm this in writing.

3. It is noted that Masterplan assembly 2 & 3 did not include future proofing as part of the M25 alignment.

Highways England's response to Heathrow Expansion Masterplan Options- 30th October 2018

M25 Alignment

1. As with the AOAs presented in June, it is noted that all four masterplan options include the M25 being realigned approximately 130 metres to the west between Junction 14 and 15. Highways England urgently requires further detail (including general arrangement drawings) of the proposed M25 alignment in the preferred masterplan to confirm its acceptability to Highways England. Please see Highways England's 28 March consultation response for further details on our views on the M25 alignment.

M25 Junctions

2. At Consultation One Highways England expressed a preference for junction options which provide network resilience when deciding between providing a one or two junction solution. It is noted that three of the four AOBs include two junctions on the M25, which is welcomed. However, there are two variants of the two junction option (JB13 and JB17). Each of these junction options has significantly different impacts on the SRN, both from construction and operational perspectives. We therefore require a clear understanding of the pros and cons of each option and how this has informed decision making on a preferred option.

3. The one junction option in AO2B appears to be challenging and more disruptive to construct, overly complex to navigate and would not provide resilience. The complexity of all proposed junction solutions could be reduced if local road connections were rationalised. However, the impacts of this on traffic flows both on the SRN and local roads would need to be modelled and appropriate mitigation provided if required.

4. JB13 in AO3B appears to have significant construction challenges and offers limited resilience to Junction 14 as Junction 14a cannot be utilised by northbound M25 traffic. JB13 also appears to have limited capacity compared to JB17. JB13 removes the current free flow J14a northbound link into Terminal 5 and versions of JB13 with and without a free flow

northbound flyover link at J14 have been shown to Highways England, although AO3B appears to include that link at J14. Conformation is required whether this flyover is included in JB13. The proposed roundabouts in JB13 would also need to be assessed through robust modelling and microsimulation to ensure they provide sufficient capacity and do not lead to queueing back onto the mainline M25 or collector distributor roads

5. JB17 in AO1B and AO4B appears to offer significant benefits in terms of constructability over JB13, by largely retaining the existing J14 and J14a. JB17 also appears to provide resilience and higher capacity through retaining the free flow northbound M25 access at J14a. However, JB17 needs to be reviewed to improve merges and to reduce weaving on the approach to the northbound M25 tunnels. The proposed roundabout at Junction 14a also needs to be reviewed through robust modelling and microsimulation to ensure it provides sufficient capacity and does not lead to queuing back onto the mainline M25 or collector distributors. Consideration should be given to providing a grade separated or segregated link through the roundabout for M25 mainline southbound traffic to avoid that issue.

6. For both options JB13 and JB17 there are a number of operational, capacity and safety concerns which cannot be assessed until detailed modelling outputs including microsimulation are available. Highways England will therefore require robust modelling outputs, including microsimulation, before the masterplan is finalised ahead of Statutory Consultation to understand the impacts on the SRN of the different junction options.

7. The free flow northbound flyover at M25 J14 shown in the one junction option in AO2B and two junction AO3B may be required to provide sufficient capacity and resilience even in a two junction AO1B or AO4B scenario (JB17). Consideration should be given to incorporating that flyover into the two junction JB17 options shown in AO1B and AO4B to test the benefits and feasibility of doing so.

8. The impacts of HALs expansion proposals on M25 J13 and J15, and M4 Junctions 3 and 5 must also be carefully considered and modelled to determine if mitigation is required.

9. The number of decision points for motorists is a concern with all options. A suitable signing strategy, which is able to protect the safe and effective operation of the SRN, will be required to be demonstrated to Highways England.

10.Highways England will require detailed discussions through technical working groups to resolve the issues outlined above.

……

Collector Distributor Roads

14.Highways England welcomes the fact that collector distributor roads on the M25 are included in all AOBs as this will reduce weaving in the proposed M25 tunnels and provide a much safer arrangement.

18th July 2017 Heathrow Expansion Programme Highways England Workshop Minutes
Summary of Actions/Further Work Requirements:

• HAL to look at an offline diversion that moves the anticlockwise carriageway east and the clockwise carriageway west
• HAL to look at a partial online diversion

7.0 M25 Principles

[redacted] explained the big questions surrounding the M25 diversion – capacity/lanes required, alignment, profile, collector/distributors, junction strategy

HAL default position will be to design a tunnel that allows the smart motorway to work.

HE expressed strong desire for the final option to have collector/distributors and that any option not showing a collector/distributor would cause concern. [redacted] asked if HAL had looked at diverting the anticlockwise carriageway east and the clockwise carriageway west.
[redacted] explained that a 3% vertical gradient will be what the design will aim for but a 4% gradient may be required.

There was concern from HE that whilst a 4% gradient was a relaxation the other sub-par issues related to weaving in the tunnel and junction capacity would be concerns for HE moving forward and may affect the overall experience and operability of the section of motorway. Therefore, a 3% gradient was preferred.

……

October 2017- Deliverability report. Report to set out the complexity and risks associated with the delivery and operation of a tunnel, and two taxiway bridges on an off-set M25 alignment with collector distributors, as per Airports commission layout, including J14A. Report to give judgement on what the likely mitigations/management practises are needed to overcome these risks.

9TH January 2018 - Pre-CON1 material presentation to HE minutes

Proximity of Infra. to M25. [redacted] commented that the taxiways get close to the M25 when further west which feeds on the tightness of space. Also, 6.1.2 wording correct regarding airport expanding into path of M25?

Heathrow noted that there are space constraints and issues in accommodating all of the infrastructure, but considers there are workable solutions. 6.1.2 is intended to note that the airport (runway) is necessitated to be in the path of M25.

Junctions/Alignment code compliance. [redacted] requested to see a detailed analysis of geometry and grade separation issues J14/J14a/roundabout, and design/code-compliance generally and how that fits in with M25 alignment.

Heathrow will cover this in one of the greater detail meetings. Action: 15/01/2018 to schedule session (s).

Alignment. [redacted] noted that preference noted in BRAG analysis aligns with HE thinking.
Noted.

HE preference for C/D's noted in text. [redacted] confirmed this.
Noted.

27th February 2018 Technical Working Group – Environment minutes

3.1.3. [redacted] outlined the options for M25 alignment (shown on slides). Some options (west of the runway) were discontinued because of the scale of their likely impacts, particularly with regards to those on communities west of the M25.

3.1.4. With regards to the Options Identification process, [redacted] asked whether HAL were confident that all reasonable options had been covered/considered? [redacted] responded that he, was given the constrained nature of the M25 corridor west of Heathrow. SDR sets out the constraints that informed which options were considered and why some were not taken forward – e.g. proximity to built-up or industrial areas. [redacted] added that if there are additional options that come to light, then this underlines the importance of the consultation process.

……

3.1.6. [redacted] outlined M25 junction's options. Proposal for an enhanced J14 raised reservations about impact on communities, preferred options seek to maximise separation of infrastructure from the Stanwell Moor area. Benefit of maintaining 2 junctions is works in this locality are likely to be of a smaller scale.

7th March 2018 Road Design & Safety Technical Working Group Minutes
3.0 M25 Design Assumptions

3.1 Cross Section

3.1 [redacted] presented the cross section information (see slides) and the AB7i section believed to meet HE requirements/red lines: capability for 6-lane ALR M25 and 4 lane ALR CD elements. See 3.6 below: HE team noted that this cross section excludes visibility splay in the collector-distributor tunnel sections and this is not consistent with the red line requirements.

3.2 Noting aspiration for contraflow in each M25 box element for planned maintenance activities (not in red lines document).

3.3 The documentation on design proposals will set out the geometric restrictions and their effect on contraflow arrangements

All design parameters interact with each other, for example horizontal and vertical alignment geometry decisions can result in higher super-elevation, impacting crossover and tie-in impacts see slides 10-12. The design team is seeking a solution balancing all of these aspects and fully compliant with red lines/requirements in terms of permanent-works geometry and works-phase impact.

3.3 Design Speeds including Horizontal / Vertical Alignment
……..
3.6 Allowance for visibility splay in tunnel for M25, but not CD elements which assume lower design speed. Uncertainty about whether segregated connecting elements are 'slip road' or 'link road' and 'urban' or 'rural' which impact design requirements (slide 13 inc TD9 4.5: design speed of link roads one design speed step below mainline design speed)

3.7 Noted that it is necessary to show what 120kph design speed means for CD elements and all other aspects, i.e. demonstrate the red-linecompliant solution to capture what's possible in practice. [redacted] noted that some newish sites (M60 6-8?/M1 J7-9?) had 120kph design speeds.

4.0 M25 Junctions
4.1 [redacted] presented the junction options in current masterplans (4No at present, will narrow to single option by the end of August, with an improved definition by end May) Slides including two-junction J14 scenario with remodelling of J14 and J14a realignment. HE requirements/standards must be met unless insurmountable constraints could be demonstrated to the satisfaction of Steering Group

4.2 Complexity very high, multi-level interchange; vertical alignment based on current preferred tunnel runway heights is constraint on achieving 120kph on slips/links.

4.3 As above, include this in next meeting presentation of what is possible on CD/link/slip design speed. If cannot achieve 120kph this would be agreed at TWG before being escalated to steering group (HHSG)

4.4 Noted that objective is to provide self-explaining layout, design consistent with driver expectation/perception.

4.5 No weaving into Heathrow: separate link

4.6 M25 southbound cannot access J14a due to constraints
4.7 [redacted] noted not all masterplan arrangements were seen to date; [redacted] agreed that these could be shared shortly (couple of week)

4.8 [redacted] noted that southbound weaving issue with mainline traffic weaving to offside and minor flow to nearside for airport exit. Junction merge type depends on flow – to be confirmed.

4.9 It was noted that any design options taken forward need to be capable of being signed – this is a significant concern of HE given the physical constraints at either end of the tunnel, and the associated mandatory signage. [redacted] noted that signage strategy is early delivery product, and this will address the recorded risk. This will be recorded in the TWG risk register for review at future meetings Signage strategy will be brought to TWG when it is completed.

4.10 The three river diversions place severe constraints on junction arrangement options

16th April 2018 Road Design & Safety Technical Working Group Minutes
4.0 M25 Actions from last meeting
4.1 Design Speed of links/CDs/slips
4.1 [redacted] presented the slides (pages 4-10) noting [redacted] comments clarifying red line definition regarding these roads.

4.2 Link Road is the correct term (collector-distributor was used in previous standard and no longer current).

4.3 Vertical alignment is a major challenge.

4.4 The existing T5 spur infrastructure would be re-used to minimise impact on J14, and existing 40mph speed limit remain (Page 8).

4.5 With 3 successive diverges, (Airport/J14; Airport; direct J14), the impact of higher design speed is to push the first diverge south towards J13 by 200m to 300m, with adverse potential impacts on that junction.

4.6 Page 10: with information received from airports team, the tunnel portal has moved south a little.

4.7 Concerns remain about safely managing a transition from 120kph design speed on link road parallel to M25 to the 255m radius of the slip road.

4.8 Page 11 (J14 :The multiple slip road levels including southbound diverge to J14 and southbound merge from J14a to M25) The multiple tiers of this area make design particularly challenging, pushing roundabout level up by 5-6m, impacting southbound merge slip which cannot be accommodated without reconstruction of the northern bridge of J14, with consequences for traffic management during the works, and cost.

4.9 Page 12: other constraints:
- airport land use is affected by highway footprint;
- lower vertical alignment impacts river diversion
- larger radii on link roads increase retaining structures with capital and maintenance revenue impact.

4.10 [redacted] noted that it would be useful to get a feel for the J13 impacts and asked that these be submitted for review (including what Departures would be required to mitigate these effects)

4.11 It was noted that design speed also increased tunnel spans to accommodate the higher visibility splay.
4.12 It was agreed that the design team would supply a list of specific questions to HE team for review and response, setting out impacts of compliant-design and how Departures could address identified problems.

4.13 This should be based on compliance where possible and identifying those areas where compliance is not achievable without extreme adverse effect.

4.13 Signing including Gantries

……

4.20 [redacted] noted that southbound diverge to J14 was likely to be non-preferred parallel diverge rather than ghost island due to constraints.

4.21 [redacted] will distribute JB6 design

4.22 [redacted] requested that tunnel is shown as super-elevation (not balanced cross fall). It was confirmed that the radius is all 2040m except the final section. Various options being evaluated.

……

5.2 J14a 'roundabouts are not true roundabouts with full circulatory, but used to create direction change safely in constrained locations. Note that some entry flows eg southbound M25 diverge have no circulatory flow to give way to so in practice are free-flow.

……

5.5 Visibility splays not yet determined.

……..

5.12 A dedicated slip would be provided for A3044 traffic to turn left to join M25 north or south.

5.13 [redacted] will share drawings for this arrangement too.

17th April 2018 Constructability Technical Working Group Minutes
Buildability Challenges:

i. ***New M25 encroachment on existing M25:*** [redacted] explained that widening of the tunnel structure and runway design issues had, over the duration of the design, resulted in the new M25 tunnel encroaching onto the existing M25 alignment. This would require a staged construction and commissioning of the tunnel, diverting north-bound traffic into the new tunnel to allow construction to be completed for the south-bound tunnel. There have been improvements in the alignment recently and the project is hopeful of achieving a completely off-line design, allowing single-phase commissioning.

ii. ***Tie-ins.*** [redacted] detailed the current issue with tie-ins to the existing motorway as these may require extensive overlay (typically several hundreds of mm) onto the existing motorway. This would need to be laid overnight across all lanes, and opened to traffic at line speed in the morning. Connect Plus discussed its experience in this work and thought that appropriate methods of achieving this existed; having previously laid up to 150mm maximum thickness by maintaining running lanes off to the side. The increase in overlay would require the motorway Vehicle Restraint System (VRS) to be altered to maintain design requirements – several methods were discussed, including removal and reinstatement and constructing a new barrier that would accommodate all layers of overlay. It was noted that some of the design scenarios involved an element of having to cut into the existing motorway – this should be avoided at all costs if possible as it will cause significant additional technical challenges, delays and disruption.

18th June 2018 Road Design and Safety TWG minutes

5.0 M25 Junctions

5.1 [redacted] presented the slides, updating the options shown in April which were JB6 single junction 14. JB13 by contrast retained J14a. Both had problems including the design speed on link roads; the two options presented to this meeting address those problems.

5.2 JB13(Mod1) presentation slide 2 retains J14a, pushes airfield boundary west and M25 offline further south, but J14 unchanged. Straighter alignment on link roads and 120kph design speed achieved (or close to it).

5.3 The eastern roundabout is over M25 with Constructability issues. Tunnel design would be unchanged.

5.4 JB17 option J14, 14a unchanged aiding buildability. Northbound link road bypasses the whole junction to the west. Southbound link has roundabout at same level as existing link. M25 southbound link and m4 link both connect to roundabout.

5.5 New bridge at J14 not needed.

5.6 [redacted] noted concern about southbound queues approaching roundabout because traffic must give way to northbound diverging traffic turning right.

5.7 [redacted] asked if roundabout needed – it is to achieve connections and direction changes on slips.

5.8 Weaving section 750m for northbound merge M25 – lane gain: 5 lanes through tunnel and lane drop before j15.

5.9 [redacted] concerned about HGVs offside moving to nearside – could we put an extra lane through tunnel link road? [redacted] will review[redacted]

5.10 [redacted] noted that northbound M25 diverge to heathrow is nice to have, but lose resilience c/w free flow. He asked if hybrid is possible with access from J14? [redacted] advised not at present based on modelling.

5.11 [redacted] noted JB13 Mod 1 helps constructability, while JB17 is a dominimum, lose flyover, re-use existing infrastructure with minimum intervention.

5.12 [redacted] interested in modelling outcome – how it operates?

5.13 [redacted] advised a network diagram with flow links could be shared [redacted]

5.14 [redacted] concerned if better solution might not be carried forward – SRN needs not sufficiently reflected?

5.15 [redacted] noted that disruption of construction needed to be set against capacity; all options require some compromise.

5.16 [redacted] noted at at DCO an inspector would test DfS – weaving etc – have departures been minimised.

5.17 [redacted] noted J14 bridge not needed for 2040 existing but in 2040 do something. Might adding free flow link flyover later be possible? If modelling suggests it is, JB13 would be preferred.

17th July 2018 Constructability Technical Working Group Minutes

4. BRIDGING STUDY FOR THE M25 ALIGNMENT

[redacted] presented the construction assessment that the constructability team prepared for the bridging study. Three options for the M25 alignment have been assessed;

- Single long tunnel
- Three bridges
- Two bridges and a short tunnel

The options have been scored against 14 influencing factors and evaluated of being feasible, buildable and affordable. The first option required provision of full length internal ventilation tunnels with associated M&E ventilation plan. The section does not require M&E ventilation plant, whereas the third requires M&E equipment including ventilation plant only for the tunnel section. [redacted] mentioned that the second option provides significant cost savings along with constructability benefits. [redacted] agreed with [redacted] on that matters, but was concerned that future long term maintenance may be an issue. The following actions were raised;

1. Road Design & Safety TWG to ensure that the second option has been checked and reviewed from a CDM perspective (already an outstanding action).
2. [redacted] to up-rev the document to include CDM and maintenance considerations together with associated risks.

5th December 2018 Heathrow Highways Steering group minutes

[redacted] expressed concern on outstanding areas of work relating to M4 J4/M4 Spur and M25 alignment. [redacted] noted that HE generally agrees with the current M25 proposals but need to understand geometric specifics of J14a and merge/diverge arrangements to collector/distributor roads. [redacted] confirmed HAL aware of these challenges and are working to arrange a deep dive on these specific areas to address concerns. [redacted] requested that HHSG are kept up to date on progress given critical nature of SRN to HALs proposals.

Email 11th August 2017 from Highways England to Heathrow

Hi [redacted],

I will add in the HE requirements to the minutes. Just to provide some context to what was written In the minutes, whilst it is possible to build that many lanes in a tunnel under a runway, the reason why we need to look at it in more detail is because the wider the spans are, the thicker the soffIt will be. This may result In HAL having to sink the tunnel structure lower, to ensure the runway is at the requisite level. Doing this has major knock on effects to not only the final vertical profile of the M25 but also our whole earthworks strategy. Hence, its inclusion in the minutes.

On the 31st July we discussed the fact that as junctions 14 and 15 were being left as is, the hard shoulder would have to be curtailed some way before both of these junctions. It was mentioned that "100·200m" either side of the tunnel portal would be sufficient but this would obviously need to be looked at to ensure a suitable and safe design Is provided. However, and more Importantly, we also discussed the safety Issues of having a hard shoulder in the tunnel only, specifically the fact that with the hard shoulder being available only in the tunnel, It may encourage drivers to stop there, rather than find a better refuge further up the road. So there are clearly major safety issues that we need to be aware of in providing a hard shoulder just in the tunnel and in my view, it is this conversation that will actually inform the conversation above re: number of lanes.

Email 29th August 2017 from Heathrow to Highways England

Hi [redacted],

Thanks for this. I have updated the big questions document to reflect your responses. We are currently putting a Technical Note together explaining why the carriageways cannot be split either side of the existing alignment. It has more to do with space constraints as opposed to a better airfield design. We are diverting 3 rivers and due to the levels of the existing ground in

the area, we are being told a l00m wide culvert will be installed alongside the existing M25 to ensure flow can still occur. As such, as an organisation, we know that splitting the carriageways is not an option and so would not want to leave it up there and give the impression we were still looking at it. I understand the requirements of HE to see the detail, which will be forthcoming.

Email 29th August 2017 from Highways England to Heathrow

M25 Big Questions

Re Horizontal Alignment, [redacted] (at workshop on 31" July) specifically requested that Heathrow provide clarity on his suggested option that would build new carriageways either side of the existing alignment - the attached drawing provides some background. This particularly notes the fact that this has a better horizontal alignment particularly for tie-ins to the collector/distributor roads.

My suspicion is that [redacted] will continue to ask for confirmation that this has been ruled out, and reasoning why, particularly if this Is only to provide for a 'better' airfield design.

Some additional points:

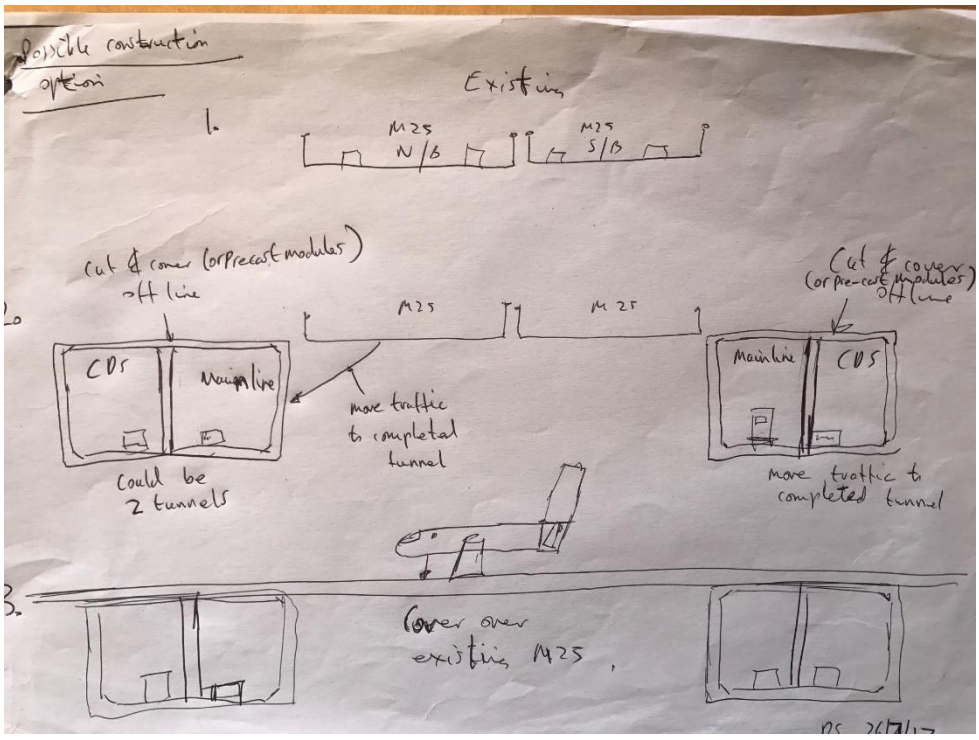
• 0617/SM is confusing - I think this is saying that should have 6, 7 or 8 lanes of traffic, but confusing given collector/distributors. I think the latest position is to provide DSM and D3M .. ?

• SMP schema doesn't include collector/distributors

• J14 to remain untouched - I recall a conversation about replacing the structures to allow the collector/distributor to flow underneath?

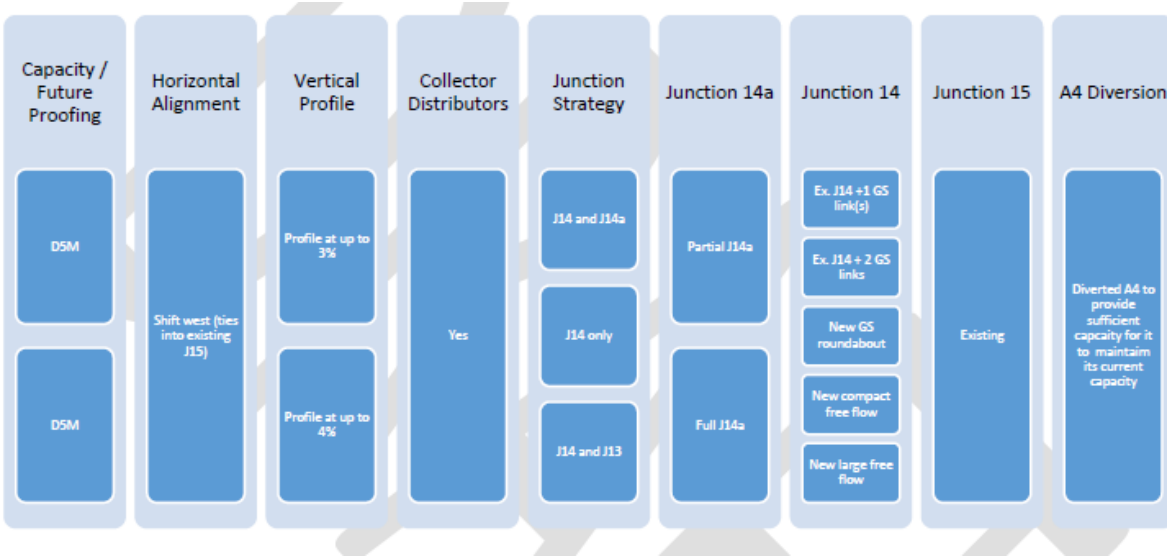
• A4 is not part of the SAN

Attachment to above 29th August 2017 email – Rough sketch drawn in meeting with Heathrow of potential option for M25 Alignment (now superseded and not taken forward in HAL's 2018 consultation).



Email 29th August from Heathrow to Highways England
M25 Big questions
Context
Further to the two successful workshops between Highways England and Heathrow, elements of the M25 design were discussed, with tacit agreements being made on certain parts of the design and other elements still to be agreed upon. This document outlines the stages of agreement for each element of the M25 design. The document will be presented at the Heathrow Highways Steering Group (HHSG), where final agreement will be sought. Any elements of the design not yet complete will be agreed at future HHSGs.

M25 Design Elements



Capacity/Future proofing
As discussed and agreed at previous workshops, on day one of opening, the new M25 will be able to run the Highways England proposed Smart motorway scheme along the mainline carriages. Future proofing within the tunnel will be required, however, the actual width of the tunnel/lanes provided is still to be determined. Final decision on number of lanes to come through the Steering Group.

Horizontal alignment
The horizontal alignment will be shifted west and will tie into the unmodified, existing J15.

Vertical profile
The desirable maximum gradient for a motorway is 3%. Heathrow will be aiming to achieve this. Should the profile require a 4% gradient, there is understanding from Heathrow that due to other constraints the proposed scheme is putting on the network, Highways England may not be able to give approval for it. Final decision to be worked through the Technical Working Groups.

Collector/distributors
Collector/distributors will be provided. As minute and agreed at the two previous workshops.

Junction Strategy and J14a
Junction strategy is still to be determined internally within Heathrow. Upon internal approval, strategy will be shared with the Technical Working Groups (TWG) and Steering Group.

Junction J14
Existing Junction 14 to remain untouched with new grade separated link(s) to be provided. Final detail to be shared with the TWGs.

Junction J15
Existing and untouched.

A4 diversion
The A4 diversion will be equivalent in size and lane width to what currently exists. This ensures it can still fulfil its function as part of the Strategic Road Network, as required by Highways England.

Success criteria
Ensure Highways England, as a statutory consultee, do not object to the M25 motorway design, transport assessment and changes to the SRN that will be presented as part of HAL's DCO.

Email- 13th November 2018 from Highways England to Heathrow Airport
[redacted],
Please can you send out slides in advance of the session on Friday so we can ask informed questions on the day to make best use of the session.

Also, we have asked previously and in our AOB response for the general arrangement drawings of HALs preferred M25 alignment. Please can these be shared ahead of Friday's session and discussed in the meeting. I know this will need to be discussed in more detail in the TWGs, however if you share it with us now we can suggest key areas that will need further detailed discussion at the TWGs. Given the timescales HAL have to get to a con 2 we need to be having those discussions now.

Email 10th December 2018 from Heathrow to Highways England
The purpose of the meeting is to discuss the M25 alignment / junctions, how it is intended to work and raise any initial concerns that HE might have with this, thus facilitating work on addressing these concerns to be picked up, by the successful consultant, next year. There are no papers for this meeting only the GA circulated with the original Invite.

This is one of the several workshops that will be undertaken during next year. During this workshop, the JB18 M25 option will be reviewed, and some of HE concerns will be discussed, as follows. We understand there will be more issues that will be raised during the workshop.
1. Capacity at J14a - potential to cause queuing back onto the M25 Southbound from Jl4a
2. M25 mainline Cross Section
3. Collector Distributor Southbound offside merge
4. Any other concerns/Issues to be raised during the meeting

The General Arrangement for the option has been attached FYI and to help the discussion during the TWG.