Department for Transport

Review of the Technical Specification for High Speed Rail in the UK

A report to Government by HS2 Ltd

January 2012

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List of acronyms

ATO	Automatic Train Operation
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
GSM-R	Global System for Mobile Communications – Railway
IMechE	Institution of Mechanical Engineers
LTE	Long Term Evolution
TfL	Transport for London
tph	trains per hour
TSI	Technical Specification for Interoperability
WCML	West Coast Main Line

Executive summary

1. This is HS2 Ltd's report to Government which presents the outcomes of the review of responses to the consultation regarding the technical specification for HS2. The *High Speed Rail: Investing in Britain's Future* consultation was launched on 28th February 2011 with a closing date for responses of 29th July 2011. That consultation covered both the Government's strategy for high speed rail, and the line of route for phase one from London to the West Midlands. Consultation responses expressed concern around a number of areas which this report specifically considers;

   - specifying proven technology;
   - capacity of HS2: 18 trains per hour;
   - a design speed of 250mph (400kph);
   - hours of operation;
   - gauge of HS2 trains;
   - the specification of the classic compatible trains;
   - reliability;
   - impact on other existing rail services;
   - freight on HS2;
   - interconnectivity with other transport networks; and
   - operational safety.

2. To address these we established a programme to review existing work and, where appropriate, undertake new analysis. This work has highlighted a number of areas that would require careful consideration during the subsequent design stages of HS2 and its interface with the classic network and, if a decision is taken to proceed with HS2, we would seek to address these in our future work programme. We have also identified a small programme of adjustments to infrastructure on the West Coast Main Line (WCML) that would be needed to mitigate impacts on journey times for classic compatible services north of Lichfield. These have been included in revised cost estimates for HS2.

3. Overall, we conclude that the specification developed for HS2 is robust and appropriate for the stage of development of the project.

4. Issues covering potential changes to the consultation route, the Appraisal of Sustainability and Economic Case are covered in other reports produced by HS2 Ltd.[1]

1 See *Review of possible refinements to the proposed HS2 London to West Midlands Route*, *Review of HS2 London to West Midlands Route Selection and Speed*, *Review of HS2 London to West Midlands Appraisal of Sustainability* and *Economic Case for HS2: updated appraisal of transport user benefits and wider economic benefits*

1. Introduction

1.1.1 This is HS2 Ltd's report to Government which presents the outcomes of the review of responses to the consultation regarding the technical specification for HS2.

1.1.2 The *High Speed Rail: Investing in Britain's Future* consultation was launched on 28th February 2011 with a closing date for responses of 29th July 2011. That consultation covered both the Government's strategy for high speed rail, and the line of route for phase one from London to the West Midlands.

1.1.3 The consultation asked seven questions:

- Do you agree that there is a strong case for enhancing the capacity and performance of Britain's inter-city rail network to support economic growth over the coming decades?
- Do you agree that a national high speed rail network from London to Birmingham, Leeds and Manchester (the Y network) would provide the best value for money solution (best balance of costs and benefits) for enhancing rail capacity and performance?
- Do you agree with the Government's proposals for a phased roll-out of a national high speed rail network, and for links to Heathrow Airport and to the High Speed 1 line to the Channel Tunnel?
- Do you agree with the principles and specification used by HS2 Ltd to underpin its proposals for new high speed rail lines and the route selection process that HS2 Ltd undertook?
- Do you agree that the Government's proposed route, including the approach proposed for mitigating its impacts, is the best option for a new high speed line between London and the West Midlands?
- Do you wish to comment on the Appraisal of Sustainability of the Government's proposed route between London and the West Midlands that has been published to inform this consultation?
- Do you agree with the options set out to assist those whose properties lose a significant amount of value as a result of any new high speed line?

1.1.4 Almost 55,000 consultation responses were submitted. These were analysed by an independent response analysis company.[2] This report considers the responses made to part of the fourth question regarding the principles and specification used by HS2 Ltd. The second part of the question relating to the route selection process is covered in the *Review of HS2 London to West Midlands Route Selection and Speed* report.

2 See *High Speed Rail: Investing in Britain's Future Consultation Summary Report*

1.1.5 Issues covering potential changes to the consultation route, the Appraisal of Sustainability and an update to the Economic Case are covered in HS2 Ltd's other reports.[3]

3 See *Review of possible refinements to the proposed HS2 London to West Midlands Route, Review of HS2 London to West Midlands Appraisal of Sustainability* and *Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits*

2. Specifying proven technology

2.1.1 Our technical specification was based on internationally accepted practice, established European specifications and developments that would be implemented over the next few years. Consultation responses expressed the view that some of the technology specified was unproven.

2.1.2 Given the timescale over which HS2 would be operated, our operational and technical specifications anticipated, to some extent, likely technological development in the coming decade based on advice from leading suppliers and academics. The specifications were tested with an independent panel of experts of international standing. However, none of the technologies identified are unproven and the core systems underpinning our specification are available now:

- train braking capability – based on the Alstom AGV very high speed train due to come into service in the coming months. This train has a top speed of 225mph (360kph) and is our reference train. We have used a reference train to establish performance characteristics to model the HS2 service. The train has the technical characteristics of the Alstom AGV currently being manufactured and introduced on the European high speed network, and is used for example to calculate journey times;
- train control (signalling system) – we have specified the European Standard cab based system European Train Control System (ETCS), which is part of the European Rail Traffic Management System (ERTMS). We have specified European Train Control System (ETCS level two), which is in use in a number of European countries including Italy, the Netherlands, Germany, France and Belgium and is being fitted system-wide in Switzerland;
- Automatic Train Operation (ATO) – to deliver 18 trains per hour (tph) reliably, we expect to use ATO. This is in common use on metro systems and also on some mainline railways in Spain and Japan. The current Thameslink scheme integrates ATO with the ETCS. There would be at least a decade of experience with this before HS2 came into operation;
- power supply – the 25kV Alternating Current autotransformer power supply specified is in use on the WCML; and
- telecommunications – we have specified the system mandated in the relevant Technical Specification for Interoperability (TSI) which is the Global System for Mobile Communications – Railway (GSM-R). Currently this is a second generation digital technology.

It is expected that by 2025 telecommunication technology will have advanced to fourth generation technology known as Long Term Evolution (LTE). We anticipate that the TSI will be progressively updated to reflect this, however we have not assumed all the benefits such technology advances would bring.

2.1.3 We would seek to improve the capabilities of these existing technologies, bringing them and other systems together and applying them on HS2.

Figure 1 – An AGV Train (Italy) © Alstom Transport

3. Capacity of HS2: 18 trains per hour (tph)

3.1.1 A number of consultation responses expressed the view that achieving an ultimate capacity of 18 train paths per hour on the Y network, was not feasible, citing international experience where no high speed rail lines currently achieve this. In addition, the Transport Select Committee raised concerns about the feasibility of operating 18 train paths per hour, and recommended that full details of the technical basis for this assertion should be published.

3.1.2 Recognising these concerns and the high levels of capacity proposed for HS2, we developed a programme of work to explore the issues of capacity on HS2 in more detail. This comprised:

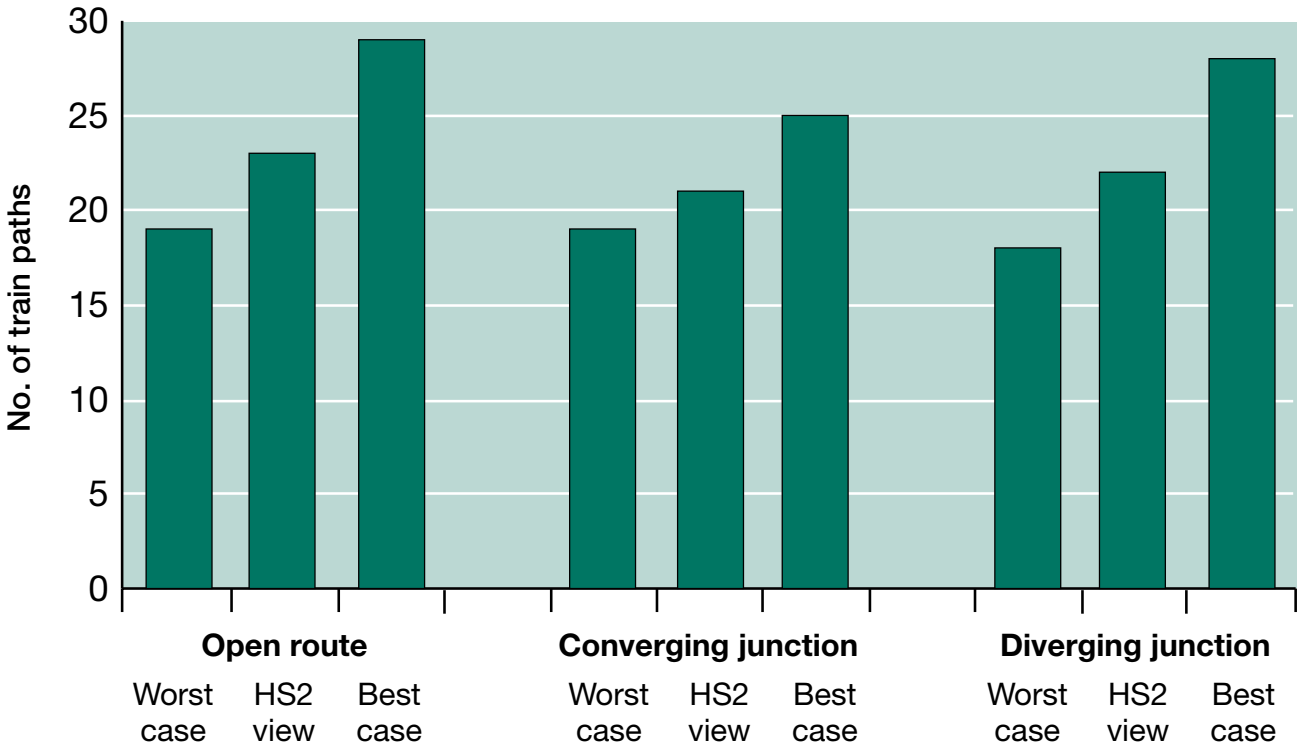
- internal work on signalling headways and maximum operational capacity, which was peer reviewed by two industry experts: Andrew Simmons (Director of Future Train Operations and Control Systems for Network Rail) and Prof. Roderick Smith (FREng, President of IMechE and Professor of Future Rail Research at Imperial College London);
- work by Systra SA on capacity and reliability. Systra has extensive experience in the operation of existing high speed rail networks, particularly the TGV network in France. We commissioned them to develop the overall operational requirements of the high speed network;
- capacity evaluation by Bombardier Transportation considering the reference train in respect of its technical characteristics and proposed signalling system capabilities; and
- a report by Arup on the design trade offs between signalling system and station design.

3.1.3 These reports identify the key factors affecting capacity. We assessed the resultant best and worst case scenarios for capacity. Sensitivities were considered for three operational scenarios; normal open route running, as well as operations at converging and diverging junctions (see Figure 2). The conclusions of all pieces of work are set out in a summary report which has been published.[4]

3.1.4 The HS2 assumptions sit centrally in the ranges derived, with the worst combination of assumptions still delivering 18tph. Additional potential capacity benefits from the use of ATO were not assumed. The summary report concludes therefore that it is appropriate to continue to develop HS2 proposals on the basis of 18tph running on the core trunk of HS2 between London and the West Midlands.

4 HS2 Ltd, 2011, *Summary report on the capacity and capability for the high speed network*, http://hs2.org.uk/publications/Summary-report-on-the-capacity-and-capability-for-the-High-Speed-Network-77735

Figure 2 – **Line capacity sensitivity results for the three operational scenarios (HS2 Ltd)**



3.1.5 The reports do however identify the significant technical, operational and planning requirements underpinning the achievement of 18tph. Should the project progress into the next stages, we would use these to form the basis of future design work to confirm the ongoing achievement of this assumed capacity level.

3.1.6 Aside from the work summarised above, we have undertaken a sensitivity test on the HS2 business case for the Y network using a lower train service level of 16tph. This test showed that the business case was unchanged i.e. it is not highly sensitive to 18tph assumptions.

4. A design speed for the route alignment of 250mph (400kph)

4.1.1 The consultation proposals assumed that the route should be designed to accommodate future speeds of up to 250mph, where possible, although it was assumed that trains would, in phase one, have a maximum operating speed of 225mph. Designing with a 250mph maximum speed allows a margin for potential future advances in train design.

4.1.2 Consultation responses expressed the view that a maximum design speed of 250mph was excessive, and that a lower-speed high speed line would allow more flexibility with the route and therefore reduce impacts, while still delivering the benefits of high speed rail.

4.1.3 In response to this we undertook a study to enable us to understand the environmental, engineering and economic implications of a high speed line with a lower maximum design speed. This considered the potential effect of adopting a maximum design speed of 186mph (300kph) on the consultation alignment and on alignments more closely following existing motorways. We also looked at a 225mph (360kph) version of the consultation alignment.

4.1.4 The outcomes of the study are outlined in the report *Review of HS2 London to West Midlands Route Selection and Speed*. The conclusion was that there were some potential environmental benefits that could be achieved through a lower maximum design speed, either through reduced operational noise or through the ability to move the route further away from sensitive sites. However, overall the environmental benefits of any alignment changes were marginal over and above those that could have been achieved by mitigating the consultation route. Also, the lower speed routes were found to cause significantly longer journey times, generating lower benefits and revenues. Routes which followed existing motorway corridors resulted in significant additional cost due to their increased length and tunnelling to mitigate other environmental impacts. Using our established methodology, we conclude these disadvantages outweigh the marginal environmental gain.

4.1.5 Other respondents challenged why a higher design speed was not being specified. As reported in our *Review of London to West Midlands Route Selection and Speed* report, we therefore considered the ability to achieve speeds in excess of 250mph between stations and other permanent restrictions of speed such as junctions and tunnels. It found that given the distance taken to accelerate a train, speeds in excess of 250mph would only be possible for relatively short amounts of time, and therefore the potential for further journey time reductions would be small. Accelerating to and running at these speeds would

require more energy consumption, meaning higher carbon emissions and operating costs for low commercial benefit.

4.1.6 We do specify design speeds lower than the maximum where we consider that gives a better balance for example in built up areas of London and Birmingham. However, as a result of the work described we propose to continue designing the HS2 route where appropriate to a maximum speed of up to 250mph. We believe this provides a realistic margin for the on-going evolution in train performance capabilities along with an appropriate balance between journey time, costs and environmental effects.

5. Hours of operation

5.1.1 A number of consultation responses expressed the view that the proposed operating hours for HS2 would be too long.

5.1.2 Unlike some of the existing UK main lines, we did not propose to operate trains throughout the night. We proposed to operate services on HS2 between the hours of 05.00 to 23.59 hours Monday to Saturday and 08.00 to 23.59 hours on Sundays. These would be the times between the first train of the day setting off from its origin to the last train completing its journey.

5.1.3 We have considered whether the opening hours could be curtailed. Overall demand is recognised to be at a lower level than at peak times, however a service offer of early and late trains to extend working and social opportunities is typically expected for services such as HS2. On that basis, we recommend retaining the proposed operating hours recognising that the level of service operations would ramp up over the first two or three hours at the start of the day and ramp down similarly at the end in line with required demand.

5.1.4 In accordance with normal high speed rail practice, the railway would be available for maintenance only between midnight to 05.00 hours. General maintenance work would typically take place, on average, over two or three nights per year in any particular location. More frequent inspection and maintenance could be expected at junctions. Should the project proceed, we would develop our Infrastructure Maintenance Plan, which would include provisions for mitigating potential impacts such as noise and lighting, during night time maintenance at specific locations along the corridor.

6. Gauge of HS2 trains

6.1.1 A range of responses were made on the proposal to have two different HS2 train gauges and the additional costs and complexities which may be involved, expressing the view that the classic network should be upgraded to accommodate GC gauge trains.

6.1.2 Trains running only along HS2 infrastructure, known as "captive", could be "off-the-shelf" European standard high speed trains with known costs and performance. If required for capacity reasons, this includes the potential use of double deck trains. However, our principle of allowing some HS2 trains to run through on to the classic rail network to provide journey time benefits to a wider range of destinations requires that HS2 trains for these services must be compatible with the UK classic rail network gauge (height and width). This is smaller than the HS2 high speed European standard gauge. So classic compatible sets would be a high speed train design modified for the smaller gauge. Eurostar currently uses a UK compatible gauge high speed train.

6.1.3 An alternative to providing classic compatible gauge sets would be to enhance the gauge of the existing classic rail lines involved to accommodate European standard gauge trains. We have undertaken studies to consider the feasibility and potential cost of such enhancements, particularly to Liverpool and Newcastle. We concluded that such enhancements would not be viable, on the basis that the potential scale and cost of physical alteration to the existing network plus the service disruptions whilst undertaking such works would not be economical, for example, alterations would be needed to overbridges, tunnels and stations.

6.1.4 The cost of upgrading the existing York to Newcastle railway to accommodate European GC gauge trains has been estimated at between £3.5 billion and £4 billion, exclusive of disruption costs. The work would take over eight years to complete and would involve significant route closures every weekend. In contrast an entirely new high speed line from York to Newcastle would cost in the region of £3.5 billion, and could be built largely away from the operational railway to minimize disruption to existing users.

6.1.5 The most cost-effective solution to the operation of through services to locations such as Liverpool and Newcastle is use of a classic compatible train. As the benefits of through running far outweigh the disbenefits associated with the introduction of classic compatible trains, we recommend continuing to specify a mixture of captive and classic compatible sets for the HS2 network.

6.1.6 In our continuing work on the wider Y network, we will develop the fleet strategy further. We also recognise the additional complexities of introducing more than one train type as highlighted at consultation. We have allowed suitable time between train delivery and start of phase one operations to undertake testing and shadow running of both types of fleet.

7. The specification of the classic compatible trains

7.1.1 Concerns were expressed that classic compatible trains would reduce seating capacity into Manchester in phase one, and be slower than Pendolinos on the WCML impacting on journey times between stations north of Lichfield.

7.1.2 The assumption we developed for consultation was for 200m long classic compatible train sets, specified for use on the classic network and HS2 without a tilting mechanism. This would make them shorter than the planned lengthened 11-car Pendolino trains which are 265m long, resulting in a loss of seating capacity on each train. They are also slower than Pendolino trains on some sections of the WCML where tilt enables trains to negotiate certain curves at higher speeds than conventional trains.

7.1.3 The possible loss of seating capacity only applies to classic-compatible services, as services operating captive to the HS2 infrastructure could be strengthened to two 200m sets coupled together as demand requires. The maximum length of passenger train feasible on the classic network's WCML would be 265m. In response to concerns regarding possible loss of seating capacity per train, we held discussions with train manufacturers, which confirmed that high speed classic compatible trains up to around 260m in length could be provided. Modern high speed train design enables flexibility in the number of carriages. Should seating capacity equivalent to or greater than the seating capacity of an 11-car Pendolino be required for particular service groups such as Manchester day one services, this would be viable. At this stage, we have only assumed the use of 260m sets for phase two operations to Newcastle services.

7.1.4 The performance of the specified classic compatible train design on the WCML against that of the tilting Pendolino is, however, more challenging to address. Pendolino trains would be able to travel on the more curved northern sections of the WCML faster than classic compatible trains where tilting is not currently considered reasonably practical by train manufacturers in weight, complexity and cost terms.

7.1.5 Recognising the classic compatible train performance characteristics, we estimate that the time differential on the longest journey, to Glasgow, would be 11 minutes on the route today. We have therefore worked with Network Rail to identify a number of limited adjustments to the WCML infrastructure which with appropriate speed signage would reduce that differential to four minutes. This is less than the seven minute penalty originally estimated to develop the business case and journey times of the consulted route. In respect of

Manchester, the phase one service is not calculated to have any penalty north of Lichfield compared to the two minutes originally assumed for the business case. These infrastructure modification costs have now been included in our cost estimates.

7.1.6 On this basis we propose to continue with the current train specification rather than seek to specify a tilting train design, using minor modifications to the WCML to minimise impacts on journey times north of Lichfield.

8. Reliability

8.1.1 High speed rail networks that are segregated, such as in Japan, can maintain very high levels of reliability. A number of consultation responses expressed concern that services originating from the classic network and coming onto HS2 could import poor reliability from the classic network onto HS2.

8.1.2 The maximum service frequency currently specified for phase one services when London to West Midlands infrastructure is brought into use is 11tph in the peak and 10tph off-peak. A technical limit for phase one maximum line capacity has also been set at 14tph. This lower level of capacity utilisation provides a reliability buffer recognising that most of the services operating at this stage would be ones running on from the classic network. The spare time not allocated to running trains throughout a typical hour provides recovery margins for trains should they be presented late from the classic network. On the most critical core element of the route, only high speed services would operate; this segregation continues into our London Euston terminus, unlike most European practice, and provides additional reliability.

8.1.3 We have timed trains to run along the line of route at less than maximum line speed, for example, line speed at 225mph with train timings calculated at 205mph (330kph). This approach, which is in line with proven continental practice, provides a performance recovery margin as it permits a late running train to regain time by running up to the line speed without exceeding normal operational parameters.

8.1.4 We have also considered reliability for the full Y network. At this stage, the majority of services operating on the core HS2 infrastructure would be captive to the network with the maximum line capacity specified on the core section rising to 18tph. We would use network management tools to manage real-time and near term train running.

8.1.5 To mitigate against unreliability being imported from the classic network, all our interfaces with the classic network would be away from the busiest HS2 core section, providing an element of less-trafficked “buffer” space where trains can be regulated without impeding either network. Our network management tools would interface with the equivalent Network Rail systems enabling fine control of train routing and speeds, to deliver optimal performance through the interface between the classic and high speed railway.

8.1.6 Some responses identified the risk that greater network segregation reduces the potential to use diversionary routes in the event of an incident. In normal operations, greater segregation brings performance benefits to high speed

operations, so this would remain our priority. Our emphasis is to avoid failures by specifying reliability and resilience within the HS2 system so eliminating operational failure risks. In addition, we would enable operational flexibility within the HS2 system through the specification and provision of features such as bi-directional signalling, which can be used safely to operate trains in either direction over a section of track.

8.1.7 The work undertaken by Systra on capacity and reliability for the full Y network[5] also identified a range of future measures to be undertaken to deliver high reliability. These include the careful detailed design of junction and station configurations, actions to minimise station dwell times such as staff training, use of software tools to optimise real-time traffic management (in increasing use worldwide) as well as ongoing analysis and mitigation of potential external causes of delay from the existing network. All of these are achievable and we would develop them further during the next phases of design. Taking all of these considerations together, we conclude that delivering high reliability as well as capacity, as set out in our Technical Specification, would be achievable.

5 Systra, 2011, *Operational concept study, Technical note: capacity and reliability* (redacted), http://www.hs2.org.uk/publications/SYSTRA-Technical-note-capacity-and-reliability-redacted-77741

9. Impact on other existing rail services

9.1.1 Diversion of most long-distance services onto the new HS2 line would free up significant amounts of capacity on the WCML. This capacity could be used in a number of ways, including provision of better commuter services to and from London and Birmingham; provision of better links between the towns and cities at the southern end of the WCML and the major centres of the North West and Scotland; and enabling more freight traffic to pass by rail, thus providing carbon benefits by saving lorry miles.

9.1.2 However, concerns were raised through consultation about potential impacts of HS2 on existing services, both in terms of the ability of the classic network to accommodate classic compatible HS2 services, and with our assumptions for released capacity on the WCML (including changes to service levels at some locations such as Coventry). The Transport Select Committee also echoed the concern over capacity north of Lichfield, and suggested that further thought be given to this, particularly for the period between phases one and two of HS2.

9.1.3 To arrive at the service specification that we used to estimate costs and benefits, we considered what level of demand would exist at each location assuming the HS2 service was in operation, and then sought to tailor the service levels to meet that foreseen demand, rather than trying to match any historical levels of service provision. This also took into account potential suppressed demand, where people have been unable to travel either due to overcrowding or due to the stopping pattern of the trains. We produced an assumed level of services on the national network which we considered met the likely level of demand, and used this for our business case. We assumed that some locations which currently experience over-provision could see a reduction in future service levels.

9.1.4 It is important to make clear, however, that this specification was developed for the purposes of calculating the economic case for HS2. The actual level of service provision would be determined at a much later date in accordance with established rail industry processes and franchise arrangements.

9.1.5 Mindful of concerns about the ability of the classic network to accommodate classic compatible HS2 services, we have considered the effect of the assumed phase one service on the capacity of each route section of the WCML north of Lichfield in turn, including both routes towards Manchester (via Crewe and via Stoke). Our baseline was the existing capability of the routes concerned including any relevant Network Rail committed schemes.

9.1.6 From our high-level analysis of route capacity, we concluded that sufficient capacity would exist to operate the proposed pattern of HS2 services without detriment to other Train Operating Companies and Freight Operating Companies. However we do acknowledge that detailed timetabling work for a potential 2026 timetable would be necessary and would expect to work closely with Network Rail should the project continue to be developed.

9.1.7 In the case of Manchester Piccadilly, we recognise that the implementation of the Northern Hub, notably the recent decisions to take forward the Ordsall Curve and also the North Trans-Pennine Electrification scheme would enable extra services to run into Manchester. Services would include both the three through-running HS2 trains per hour running from London into Manchester Piccadilly, as well as operation of conventional trains servicing locations along the WCML between Euston and Manchester.

9.1.8 Some impact on existing rail services would be inevitable at Euston during the enlargement and rebuilding of that station. Our initial assessment is that the current timetable can operate on 14 platforms instead of the 18 currently available, and that by further timetable alteration it would be possible to release additional platforms to enable construction work to take place. We would work closely with Network Rail to develop a more-detailed proposal should the project be developed further. It is likely there would be closures but these would be limited to several days over Christmas and New Year periods in association with major track or signalling change-over stages.

9.1.9 Some concerns were raised about the capacity of the North London Line in the Camden Road area to support the international services on the link between HS1 and HS2. We have provided additional detail of the proposed infrastructure configuration in that area on the updated plan and profile diagrams. This shows more clearly the additional tracks proposed there. We are also working with Network Rail to consider further options for train pathing, freight handling and some limited infrastructure should it be required. In light of this, we are confident that the required capacity level can be achieved within the current cost envelope.

10. Freight on HS2

10.1.1 Our proposition is to restrict HS2 to high speed passenger services with the potential for increased freight capacity on the existing network. This provides significant safety benefits to HS2 through the avoidance of the risks of operation of mixed traffic (i.e. passenger and freight).

10.1.2 The proposal led to some consultation comments, principally from a leading rail freight operator. The operator accepted that in the daytime the HS2 route would be fully used by passenger services but proposed the opportunity to operate some freight traffic in late evening or overnight periods.

10.1.3 We have considered the implications of this proposal and whilst the specification we have used to design the HS2 route alignment (e.g. gradients) does not technically preclude freight, we do not recommend freight operation in the late evening or overnight. Such operation would impinge on the time set aside for essential inspection, maintenance and renewal of the infrastructure. This maintenance window is based on very clear international experience where intensive high speed operation is undertaken safely and reliably during the day with all maintenance activity in the short time frame reserved through the night.

10.1.4 The cost of a more constrained infrastructure management regime, should it be possible to develop it, would need to be factored into the freight access charges. Additionally, the consultation route included the costs of provision of noise mitigation and safe operation in tunnels arising from high speed passenger trains only during the proposed operational hours. There would be additional cost and mitigation needed for running freight at night which we have not included in our proposals.

10.1.5 We propose that the HS2 technical and environmental specification should continue to be developed for passenger operation only, making no additional provision for freight operations. The focus for freight should continue to be on beneficial use of the significant released capacity on the classic rail network. Should commercial opportunity warrant it, however, the entirely different proposition of operating high speed trains carrying freight such as postal traffic during normal operational hours could be practicable.

11. Interconnectivity

11.1.1 Views were expressed that the benefits of a new high speed line would be eroded by poor onward transport links from interchanges, and that providing only for city centre to city centre journeys missed out significant markets which would not benefit from high speed rail.

11.1.2 We recognise the vital importance of high speed rail being considered as part of a door-to-door passenger journey. Our selection of station locations, in conjunction with our delivery partners including TfL, Centro, local authorities and the then Regional Development Agencies, reflected this through positioning stations where high quality links exist to and from destinations and origins in the city regions served. For example:

- Birmingham Curzon Street was designed with a common concourse to Moor Street Station, which is currently being expanded. We continue to support Birmingham City Council in its development of proposals for the city centre which integrate these twin stations with the other services operating from the nearby New Street Station;
- Birmingham Interchange was specifically chosen to maximise access from the wider West Midlands area to high speed rail. In addition, the HS2 proposal and costs include a high quality rapid transit connection to Birmingham International Airport and the existing rail system at Birmingham International Station;
- London Old Oak Common was developed to provide very easy interchange with Crossrail. This would provide for rapid access to and from West London, the West End, the City of London, Docklands and East London/South Essex. There is also connectivity with the Great Western Main Line serving destinations to Bristol, the South West and South Wales, as well as rail interconnectivity to Heathrow Airport; and
- London Euston was selected as the practical location which offers effective connectivity with North London, Westminster and South London, then to the wider area south of London.

11.1.3 The case for alternative and additional stations is considered in our *Review of HS2 London to West Midlands Route Selection and Speed* report.

11.1.4 We have considered views expressed during consultation and believe that the level of detail of our studies to date is appropriate to understand the implications of our proposed stations and the demand they would generate. If a decision is taken to proceed with HS2 we would continue to work closely with key stakeholders to ensure that concerns raised during consultation are addressed and that proposals for HS2 are well integrated with local transport networks.

12. Operational safety

12.1.1 A number of respondents raised issues regarding concern over the risk of high speed accidents or terrorism. Rail is one of the safest modes of transport, far safer than road transport. There has been no loss of life in a train accident on a dedicated high speed line built to European or Japanese standards in over four decades of international experience of high speed rail. The HS2 route would build upon this international experience by including numerous safety systems and features to ensure safe and reliable journeys for HS2 passengers.

12.1.2 These features would include:

- provision of a dedicated two-track railway exclusively for the use of high speed passenger trains;
- continuous monitoring and safety control of all train movements, preventing any possibility of collisions between trains;
- continuous train-to-signaller communication;
- continuous monitoring of infrastructure to detect trespass and vandalism;
- provision of security fencing to exclude animals and deter trespassers, including at maintenance depots;
- design of road bridges to avoid any possible vehicular incursion onto the railway lines; and
- regular inspection of both the trains and the tracks.

12.1.3 By running homogenous fleets of trains with the same acceleration and braking characteristics, the route would become easier to operate – even when running as many as 18tph in each direction. This would also lead to greater levels of performance and reliability compared with a mixed-traffic railway with trains of many different speeds and differing technical characteristics. By taking measures such as these it is possible to design out a high proportion of the risks of high speed rail operation, ensuring that high speed rail remains a safe long distance travel option.

13. Conclusion

13.1.1 Consultation responses highlighted a number of areas of concern around the technical specification for HS2. Our view, in light of the future considerations described here, is that the technical specification used is justified and provides a robust basis on which the Secretary of State can make a decision. However, it has highlighted a number of areas that will require careful consideration as part of later design stages of HS2 and its interface with the classic network, and we would seek to address these in our future work programmes should a decision be made to proceed with HS2.

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