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Manchester City Council

Development of Piccadilly Station

Technical Report
Confidential

12 December 2019

Development of Piccadilly Station

Final Report

For: Manchester City Council

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Executive Summary

On 2 July 2019 Bechtel was commissioned by Manchester City Council, co-sponsored by Transport for Greater Manchester (TfGM), to conduct a three-month study of proposals developed by HS2 Limited for the expansion of Piccadilly station to accommodate HS2 and Northern Powerhouse Rail (NPR) train services. A Bechtel review team examined a body of documentation available to the Council and TfGM, along with other publicly available documents. The team commissioned a short train movements simulation exercise to support its work.

Examining the proposals and the sequence of their development, the review team considered termination of HS2 services in a four-platform elevated station alongside the northern flank of the existing Piccadilly station logical enough in the context of the challenge of constructing a new main line railway and station within a mature urban environment, notwithstanding the inherent disadvantages of the construction of additional tunnel length to reorientate an alignment heading due north from the airport to a portal east of the city centre and subsequently to head in a westerly direction over a surface section to arrive parallel to Piccadilly station.

However, when examining HS2 Limited's proposals to make additional provisions for NPR services, the review team considered that there was insufficient reappraisal of the original scheme, with additional track and platforms seemingly just an "add on" to the original scheme. It was far from clear to the team that HS2 Limited's preference for two additional platforms in its surface station would provide a satisfactory solution for NPR, with through services required to reverse and loss of additional development land, both in the immediate vicinity of the station and along its approaches.

HS2 Limited's alternative proposal for the accommodation of NPR, the addition of two underground platforms below the original surface extension, suffers from the same issue of poor orientation for east-west NPR services, though it does eliminate reversal of through NPR services in the station, and does remove the requirement to take additional land from the development area to the north of the station.

Cost information available in the documentation supplied to the review team lacked supporting detail and was limited to estimated incremental costs of the two options examined, with little apparent consideration of costs and benefits of the options beyond the immediate confines of the station and its approaches.

The train movements simulation work conducted for the review team confirmed that both of HS2 Limited's options would allow the timetabling of currently envisaged train services, though neither has any spare capacity. Recovery margins are tighter in the case of the underground scheme, but HS2 Limited's preferred surface option, with its turnback layout, is inherently less able to accommodate future evolution of train services, a significant disadvantage given existing and predicted growth trends for rail passenger volumes.

The review team also found that determination of an optimum solution for Piccadilly station may have been impeded by design parameters developed by HS2 Limited for its high-speed line. The review team found in HS2 Limited's proposals a potential missed strategic opportunity to deliver best value in terms of more effective regeneration of central Manchester, reduced land-take, flexibility to develop train services beyond those initially envisaged, and even possibly in terms of more direct, and therefore less expensive, approaches to the new station.

In summary:

- Both of the options for expansion of Piccadilly station examined by HS2 Limited could support operation of the train services initially foreseen, but neither offers additional capacity for subsequent service intensification;
- Of HS2 Limited's two options, only the underground option could offer capacity for train service intensification, and this only by doubling the number of underground platforms;
- That neither of HS2 Limited's options is efficiently orientated for east-west services, and that the most direct route into the city centre from Manchester airport is in tunnel from the south;
- That HS2 Limited's options may have been unnecessarily constrained by application of technical standards developed for different situations;
- That a wholly underground, reorientated station for both HS2 and NPR services could address all of the main weaknesses of the existing options, offering much more flexibility for future train service evolution, reduced distances and associated tunnelling costs, much reduced permanent land-take and reduced environmental impact.

In short, a more imaginative solution might deliver significantly better value and a more fitting gateway to the city. The review team's report concludes with some suggestions of what a wholly underground solution might look like, and suggests that they merit a suitable appraisal of their feasibility.

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1 Introduction

1.1 Brief

Bechtel Limited ("Bechtel") was appointed on 2 July 2019 by Manchester City Council to review planning and design work conducted in connection with the intended expansion of Manchester Piccadilly station. Bechtel's contract is with Manchester City Council, but the study is co-sponsored by Transport for Greater Manchester (TfGM). It is understood that both the Council and TfGM strongly support the construction of both HS2 and Northern Powerhouse Rail (NPR), and wish to secure their successful integration into the heart of Manchester and its transport system.

Extension of Piccadilly station is required to accommodate new train services planned to operate over the HS2 and NPR networks, once completed. Expansion to the northern side of the existing station has been proposed by HS2 Limited, the Government's planning and delivery organisation for the new line, to provide platform capacity for the two new service groups. There has been intense discussion over the configuration and location of these platforms and their approaches, the level of interoperability of HS2, NPR and classic services, and the integration of the station design with plans for redevelopment of the area as a whole. The objective of the assignment is to help the authorities involved to seek a solution that optimises outputs in terms of improved train services and their potential for further development, station design, and regeneration of the south eastern part of central Manchester.

Bechtel's assignment has taken the form of a review of documentation supplied by the Council, along with other material available in the public domain. The work is wholly separate from that being conducted by and for HS2 Limited, and no information other than that provided by the Council or publicly available has been sought or used. The objective is to assess the accuracy and quality of the documentation the Council has and what it means for delivery of the required outcomes in Manchester. Findings cover the configuration and principal design features of the proposed station itself, its relationship with its immediate environs (including interchange with local transport), its railway approaches and its relationship with the regional railway network as a whole, along with its implications for train services and their future development. Areas examined have included the configuration of platforms, including the issue of whether underground through platforms should be provided for NPR services, along with consideration of other possible means of achieving required outputs. In summary, the brief was to examine capacity, reliability, resilience and future-proofing of the station options proposed.

An interim report was submitted on 22 July 2019, in the form of a PowerPoint document discussing initial findings. This is the Final Report of the study team.

Thanks are due to the City Centre Regeneration Team at Manchester City Council, and in particular to Pat Bartoli, Hilary Sayers, Mike d'Ambra and Stephanie Dick, for their support throughout the period of the study. Thanks are due also to Liz Goldsby, Martin Lax, Mick Butler and Andy Park for the support and advice given by TfGM.

1.2 Team

The core team assigned to the study was as follows:

Project Manager:	Redacted*
Railway Systems Engineer:	Redacted*
Railway Civil Engineer:	Redacted*
Planning Engineer:	Redacted*
Specialist subconsultant:	Redacted*

Additional specialist work was undertaken in support of the study, with necessary adjustments agreed with the Client:

Railway works:	Redacted*
Station architecture:	Redacted*
Train movements simulation:	Redacted*

The core team conducted the bulk of its work at Manchester Town Hall, examining documentation and conducting discussions with Council and TfGM personnel. The additional specialist work was conducted in north America and in Germany.

1.3 Context

Plans were initially made for the extension of Piccadilly station by HS2 Limited solely to meet the requirements of terminating HS2 services. Largely unused land along the northern flank of Piccadilly station offered a suitable site, approached by an alignment from the south east, and a station meeting HS2's operational requirements was conceived. Later, following adoption of the Northern Powerhouse as a concept for the harnessing of agglomeration benefits to secure economic transformation in the North, a means of further extending the station to accommodate Liverpool-Leeds NPR services was sought, and HS2 strongly favoured an apparently straightforward widening of its previous extension to accommodate two additional platform faces, avoiding radical change to the original extension concept, and minimising programme and cost implications for HS2.

Review of the development of the plans for Piccadilly station prepared by HS2 Limited suggests more work could be done to reappraise the original extension concept in the light of the very different requirements introduced by NPR. Such reappraisal may offer a strategic opportunity to create a station that fully meets the requirements of both HS2 and NPR, that derives the full transport benefit of their integration, and that delivers the greatest possible regeneration benefit to Manchester. The absence of any such reappraisal, and the multiplication of benefits that it might offer, underlies the controversy surrounding the current concept.

2 Summary of review work undertaken

The Bechtel study team has worked systematically to check the accuracy of plans for the proposed expansion of Piccadilly station, and the capacity of the resulting facility. This work led first to the findings presented in the Interim Deliverable, submitted to Manchester City Council (MCC) on Monday 22 July 2019, and is completed by the submission of this final report.

2.1 Review of documentation supplied by Client

At the start of the contract Manchester City Council provided a tracker listing 150 documents for review and shared available copies. As the review works progressed the Council determined that 18 documents were not required. It emerged also that 5 documents were duplicated, whilst 2 documents remain unavailable. Subsequent to providing the initial tracker, from 15 July 2019 onwards, the Council supplied 19 additional documents to support the study works. The document tracker is shown in Appendix A, with the status of each document indicated by a colour coding.

Bechtel assigned an identification code to each document; this formed a double-check of what had been received from the Council. A member of the project team was assigned as a lead reviewer for each document and tasked with summarising the findings in a Document Review Record (DRR), a template of which is shown in Appendix B. Each DRR was labelled in accordance with the standard naming system detailed in Figure 1.

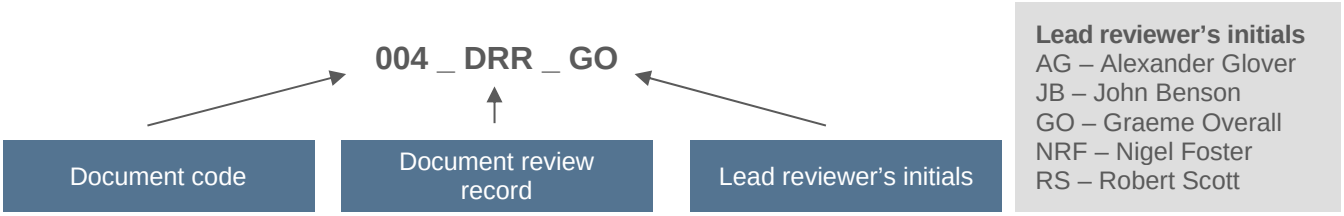


Figure 1 - Document Review Record naming system

Bechtel has reviewed a total of 144 documents supplied by the Council and this forms the principal basis of the findings presented in the remaining sections of the report. DRRs prepared during the study were filed in the project shared folder.

2.2 Other sources of information

The review of documents provided by MCC has been supported by consideration of other publicly available information. The use of other sources of information has been referenced throughout the report and where possible source documents are stored in the project shared folder. Documentation review was supplemented by informal visits to Piccadilly station and the areas immediately surrounding it.

2.3 Engagement

To supplement the review works Bechtel has engaged in dialogue with the Council and its partners. This has helped to improve the understanding of information presented in the reviewed documents and to develop an understanding of wider concerns and issues. Throughout the review period Bechtel has held regular progress meetings and other meetings with Manchester City Council (including one with the Leader of the Council), with TfGM and with its consultant, Mott MacDonald.

2.4 Engagement with Technical Specialists

Bechtel has engaged technical specialists to advise on specific subject areas to deepen understanding of the subject of the development study. During the study period and beyond the members of the core team, Bechtel has engaged internal specialist personnel and an external sub-consultant, all of them listed below with a short summary of their investigative work. Their advice and outputs have been incorporated into the relevant sections of the report:

1. A railway works specialist (internal) – critique of the operational layout of HS2's surface and underground concept, advice on the practicalities of constructing an underground station and recommendations on an optimal railway layout for a combined station.
2. Architectural specialists (internal) – critique of the architectural layout and functionality of HS2's surface and underground concept, advice on integration with immediate environs and delivery of an options assessment as detailed in Section 6.0.
3. Train movements specialists (external sub-consultant) – critique of HS2's track layouts for surface and underground concepts and the capacity of the Manchester Spur, and advice on an optimal railway layout for a combined station.

3 General Findings

3.1 Quality, depth and organisation of documentation

The 144 documents provided by Manchester City Council and reviewed during the course of this study are diverse in both character and origin and cover a wide range of planning and design matters. The documents in many cases relate directly to Piccadilly station, but in many others more generally to the plans for HS2 and NPR. Nearly 50 of the documents were identified as HS2 Limited documents, and most of these were prepared in the context of the company's work for TfN on the development of NPR. Some 30 of the documents were TfN documents, with smaller numbers originating with Network Rail (12) and TfGM (7). The documents range widely in both source and level of detail.

It was noted that relatively few of the documents supplied appeared to be formal, controlled documents. Fewer than 20 of those supplied carried formal document control information, whilst a much larger number (more than 30) took the form of PowerPoint slide presentations, many of them doubling as meeting agendas. The Council and TfGM stated that they would welcome the opportunity to review any more detailed documentation that may lie behind the more conceptual material shared hitherto. The review team found little in the way of detailed information on technical designs, standards, cost estimates or movements simulation data, suggesting either that such information had not been prepared, or more likely that it simply had not been shared. Indeed, one of the more detailed HS2 documents supplied (Document 126 ***Manchester Piccadilly Underground Station Technical Note***), was clearly identified in its file name as "accepted with redactions".

Whilst, therefore, the team was able to develop a broad understanding of HS2's plans for Piccadilly station, and some of the factors influencing those plans, the assessment of the appropriateness of the plans for the HS2 / NPR and classic services required a measure of interpretation to understand the basis of the scheme for expansion of the station, and the reasons for rejection of concepts for which the Council has expressed a clear preference.

3.2 Missing elements

Central to the conclusions of HS2 Limited relating to the plans for Piccadilly station is its stated position that the proposed six platform extended surface option is the only affordable solution. Within the documentation reviewed it is clearly stated by HS2 Limited that construction of two additional platforms underground for NPR services would add £2.2bn to the cost of expansion of the station, a sum nearly four times the estimated £586m cost of widening the previously developed proposal from four platform faces to six.

Nowhere in the documentation examined by the review team was any breakdown of this cost increase offered, though Arup in their ***Review of HS2 Ltd Proposals for Manchester Piccadilly Station*** (Document 16) state that they had access to more detailed estimates. Nowhere did the team find any estimates for any cost relating to the station other than those for the two extension schemes assessed. The team was told that TfN and TfGM had on one occasion been shown some high-level cost information, though no documents had been supplied. In the absence of any evident challenge or review, it seems perhaps a little surprising that HS2's estimates have been taken as the basis for benefits calculation and determination of the preferred station option, when the original scheme that provides the foundation has, as far as the available information suggests, been subjected to no such examination. It would perhaps be helpful, given the importance of getting the best solution for Piccadilly station, to hold a formal cost review with partners to understand in more detail what the cost estimates include, what allowance for risk and contingency has been made, and how they compare with the costs of similar infrastructure.

Similarly, in the available documentation there is little in the way of technical evidence to support HS2's preferred proposal. Statements are made about necessary changes to alignments to adapt the track layout, but standards relating to trackwork geometry, speeds and other constraints remain unexplained. The same applies to decisions that have been made about headways and platform reoccupation times, but no supporting data is offered. HS2 Limited's endeavours to communicate clearly and succinctly with its stakeholders may be appropriate, but stakeholders may nevertheless reasonably expect that supporting detail should be made available where contentious issues arise.

The review team noted a general imbalance in the level of development of the two options considered for Piccadilly. More detailed development of the surface option was reflected in, for example, Documents 6, 7 and 11, presentations to meetings which contain architectural renditions of the planned surface station, and Document 47, a ***Technical Note*** which considers approach layouts in some detail. By contrast, documents discussing the underground option seemed primarily concerned with identifying its disadvantages: Document 43 ***4x400m Platforms Indicative Impact Assessment*** aims to show the significant potential surface impact of construction of a large underground station and its approaches (orientated in the same way as the existing station) entirely by cut and cover means, whilst Document 44 ***Station Options Vertical***

Transition Times focusses on lengthy vertical travel times from a deep underground station. Drawings of the underground option appeared to be limited to a small number of simple plans and a cross section.

By comparison, the assessment process described within TfN's NPR Strategic Outline Business Case documents seemed clear, transparent and thorough. The problem remains, however, that some of the most important inputs, in particular those relating to capital costs, appear to have been accepted at face value, with no evidence of any in depth formal review to understand the rationale behind the decisions taken. This is particularly important for Piccadilly station given that it is a key part of the City Council's development plans for central Manchester, and that the design will impact on this part of Manchester for a long time. This apparent failing has affected both the selection of options for appraisal and the appraisal process itself. Given the high costs of the infrastructure and the scale of impact on the city, it would not be unreasonable to have expected a more detailed, specific review. Application of the HS2 sifting process was not evident to the Council or TfGM at the time of initial review of available documentation.

3.3 Chronology and sequence of the development process

The process by which a concept for NPR has been developed and integrated with planning for HS2 is well documented in Arup's ***Review of HS2 Ltd Proposals for Manchester Piccadilly Station*** (Document 16). Starting in 2015, work conducted in three "sequences" has involved identification of synergies between NPR and HS2, high level feasibility design during 2016, a focus on HS2 "touch points" during 2017, and in recent months (under Sequence 3, Phase 2) development of the Strategic Outline Business Case for NPR, using the concept and associated costs for favoured options developed and selected in earlier phases.

The original proposal for extension of Piccadilly station to accommodate HS2 by means of additional platforms along its northern flank was developed for the accommodation of HS2 services only. With the development and broad acceptance of the case for NPR as an essential component in the economic transformation of the North from 2013, Transport for the North was established to become the first sub-national transport body, and to develop infrastructure schemes including NPR in partnership with other regional stakeholders and with the assistance of HS2 Limited and Network Rail. There are potentially significant benefits and efficiencies to be achieved by integrating HS2 and NPR, but to get this right requires a comprehensive design solution. The different timelines and individual cost plans for HS2 and NPR understandably make this challenging.

Documentation relating to Piccadilly station seen by the review team is in many cases undated, but for the most part it has been developed since 2017. There are clearly expressed pressures to build upon the work conducted earlier by HS2 Limited, and thus to avoid disruption to the timetable for promotion of a Hybrid Bill to obtain the necessary parliamentary powers for construction in Manchester and elsewhere. There is, very obviously, a need to balance the necessary search for optimum alignments and a station in Manchester that meet the combined objectives of HS2 and NPR with the parliamentary timetable, whilst recognising that the assets being built may have a very long life indeed and that it is important not to allow short-term programme constraints to drive the various authorities into error.

3.4 Principal issues considered

The detailed observations of the review team relating to the documents it has reviewed are recorded on the review record forms described in Section 2 above. This section necessarily seeks only to summarise key observations relating to issues identified in the study scope and during the review.

3.4.1. Standards Applied

The design standards developed by HS2 Limited and their application have had a considerable impact on solutions that have been proposed for Manchester Piccadilly station. This issue is discussed in detail in Section 5 of the report. The review team found very little direct description of technical standards and parameters in the documentation. This may reflect a perception that planning of land-use and transport services were of more interest to the local authorities in Manchester, but technical parameters, some of them untypical, in many cases seem to underlie disagreement over the layout and general arrangement of the station.

3.4.2. Orientation of the station

It is a strategic weakness of both of the design options examined by HS2 Limited that the new part of the station will be poorly orientated for NPR. This arises from the original logic of the extension of the station for HS2, a logic which has not apparently been challenged as NPR has been developed. HS2's ***Options Development History*** (Document 121) shows how differently orientated station sites were identified at several locations, including Piccadilly, but does not offer detail on any sifting process or how otherwise the two final options, surface and underground, were selected for further development and examination. Section 6 of this report considers what better options might still exist.

3.4.3. Rail traffic volumes and future development

Office of Rail and Road (ORR) data shows that rail passenger journeys in the North West grew by 237% between 1995/96 and 2017/18, indicating profound changes in the regional economy, land-use and behaviour. As ever, the fact of a trend in the past is no guarantee that the same trend will continue into the future, but forecasting work relating to demographic, land-use and economic factors suggests that it will, and in any case such dramatic change as has occurred clearly illustrates the need to invest in capacity enhancement in ways that allow flexibility. Public policy relating to the environment and land-use is also likely to encourage growing use of rail. Traffic forecasts featured amongst the documents reviewed during the study. Document 25, the ***Manchester Piccadilly Station Demand Report*** is a key document. The team noted that its findings were based on now outdated data from the National Rail Travel Survey, and that inputs such as Metrolink access to the station and elements of the analysis such as car parking should be included and form part of the assessment.

3.4.4. Pedestrian traffic in and around the station

Several of the documents provided to the review team considered pedestrian traffic issues, including platform capacity, vertical travel times and boarding and alighting times, a positive finding in itself. However, results did not in all cases appear to be consistent with the arguments made by HS2 Limited for its preferred designs. The finding contained in Document 48 ***NPR Platform Modelling,*** for example, that it would take, in either layout studied, 2.21 minutes to unload and load a full NPR train, does not match the assumptions of a maximum two minutes dwell time made elsewhere by HS2. Recent acceptance by HS2 Limited and TfN of longer dwell times was reported to the review team; at this stage it is probably appropriate simply to note that dwell times are sensitive to both rolling stock and platform design, with wide doorways equally spaced along the train's flank, wide vestibules offering unrestricted access to saloons, wide, uncluttered platforms and simple, quick berthing and despatch processes offering the shortest dwell times. Two minutes is quite a lengthy stop period, typical for long-distance trains at intermediate stations, and very long for any mass transit system (the longest dwell planned for Crossrail, for example, is one minute at Liverpool Street); there will certainly be opportunities to address necessary concomitant design characteristics as the development of NPR proceeds.

More generally, Document 56, HS2 Limited's ***Manchester Piccadilly Station Demand Overview and Intermodal Report*** does not sufficiently consider the footfall and passenger flows associated with the upgraded station and the urban realm development around Piccadilly, so it is not clear how this has been assessed by HS2 Limited. Evidence of such consideration is an important indication of attention to the urban development context.

It was reported to the review team that additional pedestrian modelling results for the surface station had arrived too late for review but were currently being examined.

3.4.5. Capacity, resilience and reliability

Rapid growth in demand in recent decades is discussed briefly above. Section 4 of this report discusses the requirement for "future-proofing" in the context of the station track layout. HS2 has quite fairly, in documents such as its ***Non-Technical Operations Summary*** (Document 143) pointed to the capacity of the 6-platform surface layout to handle the planned train service, and with some margin. This is not quite the same as selection of a layout that offers a maximum of flexibility to adapt to unforeseen changes in travel patterns, however. In this respect options providing through platforms have an inherent advantage, and those providing a through layout on the same level offer a maximum of adjustability, with reduction of reversing moves always available as a means of increasing the train movement capacity of the layout.

3.4.6. Land-take and station environment

For Manchester City Council this is one of the most critical areas. The Council's ***Strategic Regeneration Framework*** and ***Greater Manchester Growth Strategy*** provide the basis for several of the documents reviewed. Documents 113-117 are formal HS2 Limited drawings showing the alignment and station extension as plans on maps of the city. Elsewhere in the documentation, and in particular within the series of Growth Strategy documents prepared for TfGM and the City Council, there is consideration of the role of the extended station as a gateway to the city, and of the enhancement of that function by means of removal of existing buildings on the station approach road and the relocation of the existing Metrolink stop and bus station currently at low level within and to the south side of the station. There was less evidence of integration of the regeneration role of the station in the HS2 Limited documents reviewed, reflecting some divergence of interest between HS2 Limited's need to add to the functions of the station by means of adjustment and extension of its originally proposed development along the northern flank, and the requirements of the Council and TfGM for minimised land-take alongside maximised transport and development function.

3.4.7. Interchange with local transport

Piccadilly's role as the principal transport hub in Manchester, combining long-distance, local and regional train services, connections to Manchester airport, Metrolink, bus and pedestrian access to other parts of the city is already a vital one, and will be intensified by the arrival of HS2 and NPR. The Growth Strategy documents referred to above provide evidence of work accomplished in this respect, including the proposal (a Greater Manchester requirement accepted by DfT) to relocate Metrolink to an area below the proposed new surface level platforms, which is reflected in cross sections of the surface layout (but not the equivalent underground option cross section) included within HS2 Limited's ***Vertical Travel Times*** document (Document 44). Clearly further development will be required to ensure convenient interchange with Metrolink and other public transport services as the station takes its final shape.

There was also evidence within the Growth Strategy documentation of consideration of how to handle interchange and other pedestrian movements within and through the extended station complex, with the role and capacity of the existing interchange bridge linking Platforms 13 and 14 to the remainder of the station being properly highlighted as a key issue. Opening the undercroft beneath the existing train shed seems a practical approach to the provision of capacity for interchange demand.

3.4.8. Configuration and location of platforms

This basic issue of the manner in which platforms and their approaches are provided for HS2 and NPR services is clearly at the core of definition of the development of the station and is fully reflected in the emphasis of HS2 documentation provided for review, along with those of other stakeholders including those prepared by Network Rail's system operator function. Almost all of the documentation reviewed examined the question of layout in terms of the choice between the options of the extended 6-platform "surface" extension, and the addition of the two 200m NPR platforms to form the "underground" option. There was very little evidence of consideration of other options, beyond illustration of the scale of construction required for a four platform, longer underground extension.

HS2's contributions, as noted above, sought to explain the issues to a broad audience. This is a laudable objective, but it was not matched within the documentation available with hard evidence of simulation of the operational performance of the various options, and the review team therefore commissioned preliminary work of this nature, limited in its extent to the station and its approaches, and described in Section 4 below. Similarly, the impact of HS2's technical standards on the proposals received little attention in the documents examined, and this is considered further in Section 5 below.

There are several documents discussing capacity constraints. Document 50, ***Manchester Piccadilly Operations with HS2 & NPR Technical Note***, concludes that given pathing constraints for HS2 services on the Manchester spur, HS2 services will be heavily constrained by the timetable structure required to operate Euston station. The logic here is that there is no opportunity to adjust the pathing of HS2 services calling at Manchester without having wider impacts on the operation of the HS2 network, and therefore NPR services must fit around HS2 services on the Manchester spur.

3.4.9. Architectural Development

The documentation reviewed contained a small number of architectural renditions, cross sections and plans of the extended station prepared for HS2 Limited, and these were the focus of consideration by specialist members of the team. Mott MacDonald reports (Documents 99 and 163) providing an options assessment for Piccadilly NPR Station were amongst those considered and were used as the basis for comparison with a fully underground station. The three station arrangements were assessed against typical design criteria and given comparative scores to indicate the relative benefit. The full assessment is contained in Appendix C.

This part of the review concludes that there is overall benefit in part, or all, of the station being underground. This is most obvious in the reduction of land-take, enabling greater opportunity for commercial development above the station and more flexibility in the location of a new entrance for the station, offering both interconnectivity between transport modes and flexibility in the integration of the station extension within the wider development. It is also noted that by moving away from the expansion of the existing Piccadilly Station at an elevated level, an opportunity arises to reduce the horizontal mass and visual impact of the transport development, with improved accessibility at a more human scale as a result. Further discussion of the different options is provided in Section 6 of this report.

4 Train services and layout concepts

This section examines the various proposed layout options to achieve the Interim Train Service Specification (ITSS) and to handle traffic equal to the potential capacity of the HS2 Manchester spur (assumed for now to be 18tph). This includes modelling work conducted in relation to the proposed layout options to validate their suitability to achieve the ITSS specified capacity and future aspirations.

The current HS2 proposals assume that HS2 and NPR services share HS2 infrastructure between Manchester Airport and Manchester Piccadilly station. The connection between Manchester Airport and Manchester Piccadilly station, known as the Manchester spur, is in tunnel and then transitions to a viaduct to enter a new surface station adjacent to the existing Piccadilly station.

The conception of NPR came after development of the original plan to run HS2 to an extended Piccadilly station. HS2 Limited has developed two options to accommodate Liverpool-Leeds NPR trains: the first an expansion of the new station from four to six platforms, with NPR trains reversing in the station; the second construction of two new underground through platforms for NPR services below the new surface station extension, allowing NPR trains to continue to Leeds via new tunnels curving below the city.

4.1 Current service plans and expectations

The current ITSS timetable incorporates a number of HS2 empty coaching stock (ECS) paths which take up valuable line capacity on the Manchester spur. No information has been provided to the review team enabling it to fully understand the requirement for these ECS movements and the necessity to split trains off-peak, raising a question as to whether commercial policies intended to fill off-peak seats at lower yields have been examined as an alternative. Shortening of trains in service off-peak offers some reduction in energy consumption and in mileage and tonnage related maintenance costs, but it also generates labour costs and consumes train paths.

If there really is a requirement to shorten trains off-peak, it would seem more logical to remove complete 400m trains from service, and to split remaining trains in half, rather than to split a larger number of trains as HS2 seems to propose, in each case with one half returning to Crewe depot and the other half remaining in service. If the revised option of splitting a 400m train into two operational services and removing a complete 400m train was adopted, then an additional path could be created. Beyond this, the inherent reliability risk of coupling and uncoupling should be fully understood, factoring in additional time within the timetable.

Within the documentation provided for review, a number of restrictions relating to system changeovers for signalling and traction power at Infrastructure Manager boundaries were forecast, and specifically issues as to where these changeovers could take place. Due to various TSI and ETCS requirements there are several parameters that have to be respected. However, rather than restricting any solution, it would seem better that the preferred track layout option should be agreed first and then the system changeover requirements assessed. The system changeover boundaries would obviously need to be considered alongside operational and maintenance boundaries.

4.2 Development of layout to match service plans

As defined by the ITSS, the level of HS2 and NPR services assumed on the Manchester spur are as follows:

- 4tph London to Manchester (including growth path);
- 2tph Birmingham to Leeds via Manchester;
- 4tph Liverpool to Leeds via Manchester;
- 4tph empty coaching stock movements for stepping down/up the London to Manchester 400m trains outside the peak.

Therefore, the basic level of service is defined as 14tph. However, the limiting factor for the level of service was found to be the Manchester spur.

4.3 Terminus layouts and through services

In general, either a terminus or through station track layout option could allow delivery of the train service initially foreseen, as expressed in the ITSS. With a terminus station the layout will generally offer more flexibility in track usage but typically a through layout is easier to operate; through layouts avoid blocking of platforms by terminating services, avoid the reliability risks associated with train turnaround operations, and of course avoid conflicts between departing and arriving trains in the station approaches.

4.4 Layout options

4.4.1. HS2 Manchester Piccadilly surface station option

The basic design philosophy for the surface station assumed for modelling purposes includes:

- Grade separated junctions;
- Six 13m wide, 400m long platforms;
- NPR dwell time of 5 minutes (the review team noted concern that this time might prove insufficient and a source of reliability risk; clearly design and operational measures may be adopted to minimise such risk, but self-evidently there are reliability risks associated with shutting down and opening of cabs, and changing of ends by drivers, that are eliminated by any layout that avoids the need for reversal of trains mid-trip);
- Required platform reoccupation time of 4 minutes;
- Turnouts positioned such that NPR services cannot conflict with HS2 services travelling in the opposite direction;
- Provision for parallel movements for HS2 or NPR services either entering or leaving the station to be permitted;
- Sufficient space to hold short of the platform an NPR service (travelling away from Liverpool) once it has left the HS2 Down Line so it neither interferes with a following HS2 service approaching the HS2 platforms, nor with an NPR service leaving the southern NPR platform and heading towards Leeds;
- Arrangement of the NPR chord heading into Piccadilly from the Leeds direction such that it can hold an NPR service in a manner which neither blocks the Guide Bridge route, nor prevents a Liverpool-bound NPR service from leaving Piccadilly;
- Basic turnout speeds set at 80km/h.

4.4.2. HS2 Manchester Piccadilly underground station option

The basic design philosophy for the underground station assumed for modelling purposes includes:

- Grade separated junctions;
- Two 12m wide, 200m long platforms;
- Two banks of escalators, each with two exit escalators;
- Dwell time of 2 minutes (see also 3.4.4 above: 2 minutes is the value generally used in the documentation reviewed, and is typically achievable given rolling stock and platform designs reflecting a requirement for rapid boarding and alighting; it is used here as a reasonable assumption for the purpose of simulation);
- Required platform reoccupation time of 4 minutes;
- NPR station junction at surface level;
- Basic turnout speeds set at 80km/h.

4.5 Simulation of services over different layouts

To compare and analyse the proposed different layouts using modelling and simulation software, track layouts and block sections are required. As these are not defined within the documents available to the review team these had to be specially developed along with some basic assumptions for the characterisation of the ETCS signalling system.

The basic technical assumptions include:

Track Layout

- General layout, gradients and line speeds, including switches and crossings speeds, taken from the relevant supplied HS2 Plan & Profile drawing and documentation;
- NPR flying junction gradient assumed to be 1.2%.

ETCS Level 2 (ATO over ETCS)

- Software Baseline 3;
- System Requirements Specification 3.6.0;
- ETCS National Values according to UNISIG standard;
- Start of Mission: V_NVSTFF = 20 km/h until first signal, at signal upgrade to mode FS;
- No Q_NVSBTSMPERM, i.e. no service braking in target-speed monitoring;
- Approaching time starts at indication curve;
- Train brakes along permitted curve;
- Constant odometry error of 25 metres;
- Automatic Train Operation overlay.

Rolling Stock characteristics as provided by various HS2 documents

- Speed Limit;
- Train lengths;
- Train Weight;
- Braking percentage.

The detailed modelling analysis focused, first, on a Manchester Piccadilly combined HS2 and NPR surface station, and then on a HS2 surface station with NPR platforms underground as defined in Section 4.4. However, the modelling also considered other options including:

a. Revised HS2 and NPR surface track layout;
b. NPR underground station with 2x400m platforms;
c. NPR underground station with 4x400m platforms.

As a concept a combined HS2 and NPR underground station with 6x400m platforms was also considered, but further analysis would be required to develop this option to the same level as those above.

The figures below are the basic track layouts for each of the station options being considered. It should be noted the Manchester spur was similarly modelled. These drawings are reproduced at larger scale as Appendix D.

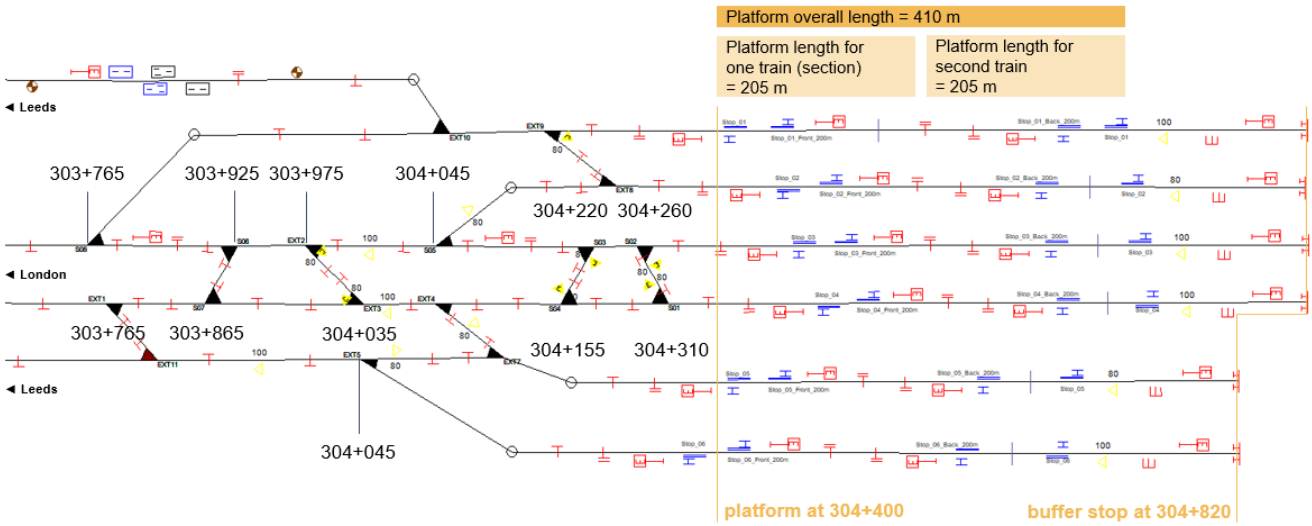


Figure 2 – HS2 Limited Surface Station Track Layout showing signalling scheme assumed for simulation (2 island and 2 side platforms variant)

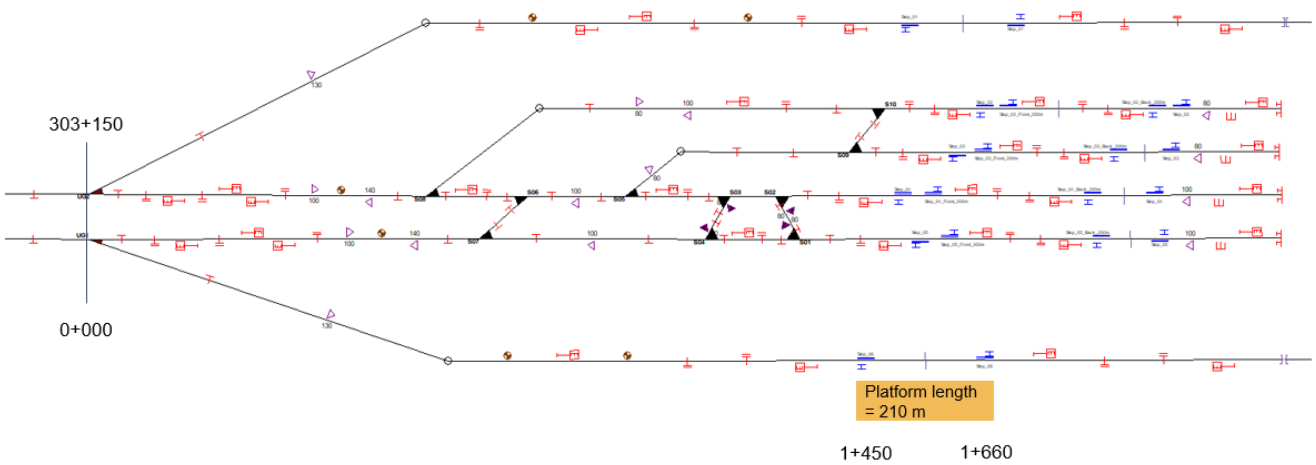


Figure 3 – HS2 Limited NPR Underground Station Track Layout showing signalling scheme assumed for simulation (2x200m underground platforms)

4.6 Simulation results

For each of the main station options, modelling was undertaken to assess whether a conflict free timetable with a basic platform allocation/reoccupation could be achieved, along with a capacity assessment.

4.6.1. Timetable assessment

A basic timetable was produced in conformity with the ITSS as outlined in Section 4.2 to achieve the 14 tph. The timetable effectively provided arrival/departure times which thus enabled the various Manchester Piccadilly station options to be modelled and analysed.

The results show that for both the surface and underground station options a conflict free timetable could be compiled. However, a number of observations and conditions to achieve the conflict free timetable were identified as follows:

- A robust timetable with suitable margins requires a shorter headway on the entire Manchester Spur of 2 ½ minutes, instead of 3 minutes; deviation from more even headways is required in order to optimise movements in the station approaches;
- It is necessary to reverse the running sequence of two trains (an HS2 and an ECS train) identified within the HS2 equivalent timetable, addressing issues arising from variation in dwell procedures;
- Dwell and preparation times for turnaround for trains to/from Crewe North Rolling Stock Depot are insufficient;
- Timetable symmetry (mirroring in both directions) and clock-face timetabling are not possible due to restrictions on HS2 as a whole, including working at Euston;
- Some ECS trains will need to call at Manchester Airport station to avoid conflicts arising from trip time variations.

4.6.2. Capacity analysis

The capacity analysis provides an assessment of the remaining capacity for a future timetable. The analysis was conducted in accordance with guidance contained within the International Union of Railways (UIC) Leaflet 406 and industry best practice.

For the figures below, ρ equates to the occupation ratio, which should be lower than 75 % in peak periods according to UIC Leaflet 406 and ***r*** is the remaining capacity after deduction of the occupation margin.

Figure 4 shows that the surface station option is at capacity and Figure 5 that the underground station is slightly over capacity. Both options are compliant for the occupation rationale: that is, they both offer an ability to accommodate the required timetable, which in the absence of delays would in both cases work. In essence this means that whilst a conflict free timetable can be produced for both options, the underground option will be relatively more vulnerable to disruption arising from movement perturbations.

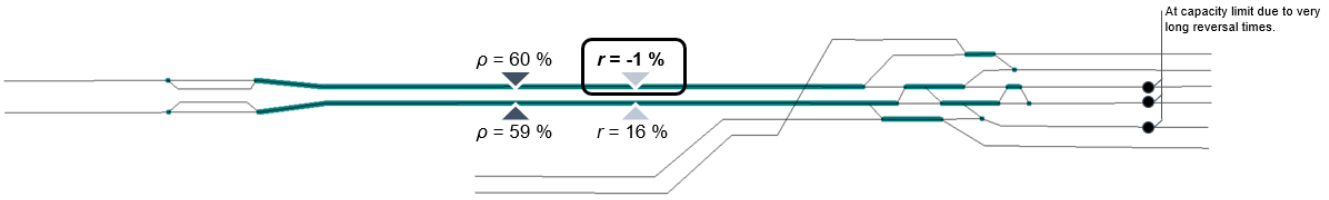


Figure 4 - Surface Station Capacity Assessment

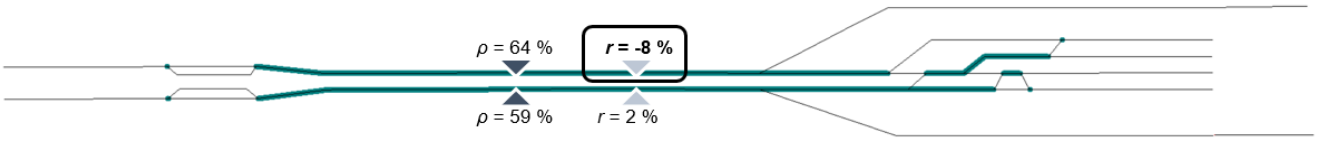


Figure 5 - NPR Underground Station Capacity Assessment

4.6.3. Modelling conclusions

The modelling exercise allows conclusions to be drawn relating to the capacity of the two specific station layouts examined by HS2 to handle the movements required by the ITSS. These conclusions, naturally, form only a part of the evidence required to decide upon the adoption of one, or neither, of the two options. The key conclusions are:

- For both options, a conflict free timetable can be compiled, at least theoretically deliverable; this does not necessarily mean that margins for reliability are adequate;
- The tracks on the Manchester Spur are the most limiting elements for both options and thus the headway needs to be reduced to 2 ½ minutes;
- Timetable/Reversal structure of HS2 ITSS causes high capacity demand for the platform inner tracks, especially for the surface station option;
- The surface station offers some additional capacity by comparison with the underground option, if the mix of trains/routings stays constant;
- The surface option offers more flexibility in track usage (it allows for some variations in platform working in response to events);
- A reduction in journey times arises from the underground options due to less dwell time and higher entry speeds;
- HS2 Limited's surface station option is at capacity (i.e. margins are just adequate for reliability, but offer no scope for service intensification);
- HS2 Limited's underground station option (2x200m NPR platforms) is at the capacity limit (i.e. a theoretically operable timetable can be compiled but margins for reliability are inadequate). Roughly every second NPR service is followed by another NPR service; thus the potential dwell time in tunnel for approaching trains awaiting the platform severely impacts the overall capacity.

4.6.4. Alternative solutions

The full capacity on the Manchester Spur cannot be utilised due the combination of conflicting movements, timetabled arrivals in bundles, block length and duration of reversals/dwell times.

Within the surface station option certain headways are restricted by long reversals and crossing movements, as highlighted by the figure below.

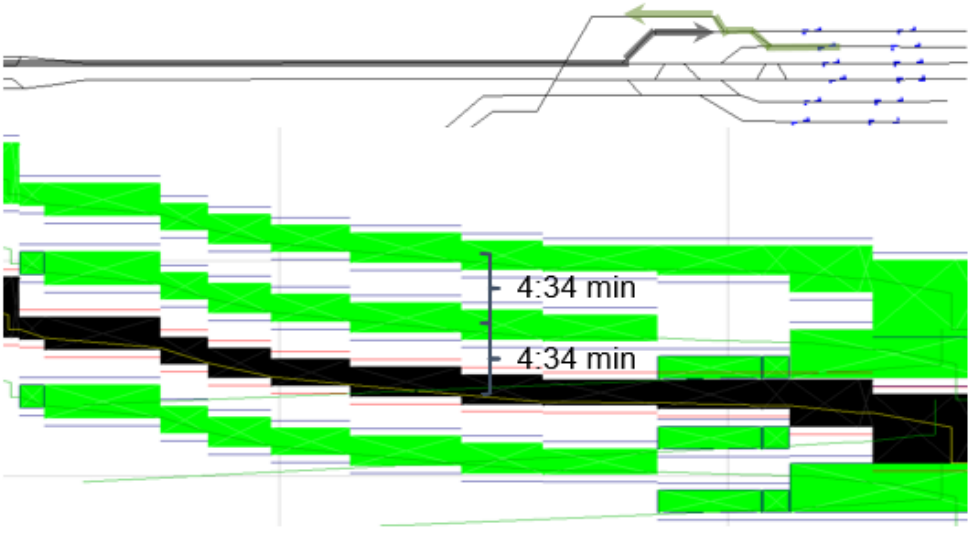


Figure 6 - Surface Station Restricted Headways

It can be seen that for a train arriving at Manchester Piccadilly, followed by a departure to Leeds, the subsequent arrival from Manchester Airport has a potential headway of 4:34 minutes.

Similarly, for the surface station option, headway is restricted by one platform per direction.

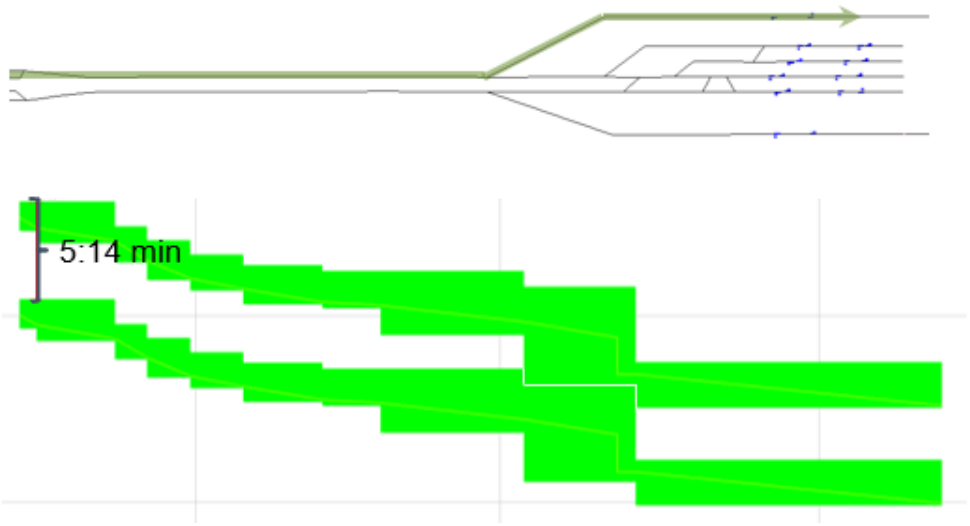


Figure 7 - Underground Station Restricted Headways

As can be seen from the above figure the time interval between consecutive trains is 5:14 minutes, thus restricting the theoretical headway for the Manchester Spur.

To overcome some of the above restrictions, alternative track layout arrangements for both surface and underground options were analysed, as defined in Section 4.5.

4.6.4.1. Revised HS2 and NPR surface track layout

To create additional capacity and improve the track layout, a revised connection Leeds NPR connection was modelled, as shown in the figure below.

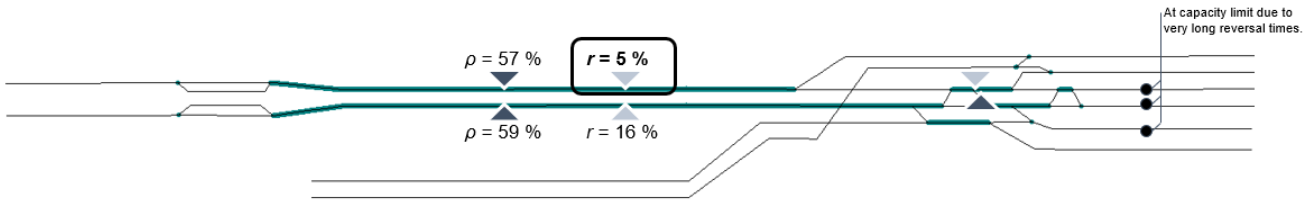


Figure 8 - Revised Surface Station Option

Whilst the practicability and constructability of this revised track layout has not been assessed, from the modelling analysis an improvement in capacity (-1% to 5%) has been achieved and is worth considering for further assessment.

4.6.4.2. NPR Underground station with 2x400m platforms

Increasing the length of the two underground station platforms to 400m delivers improved journey times compared to the base surface option and provides additional resilience to the capacity (-8% to -1%) with the option of two trains occupying the same platform; this option is still at full capacity.

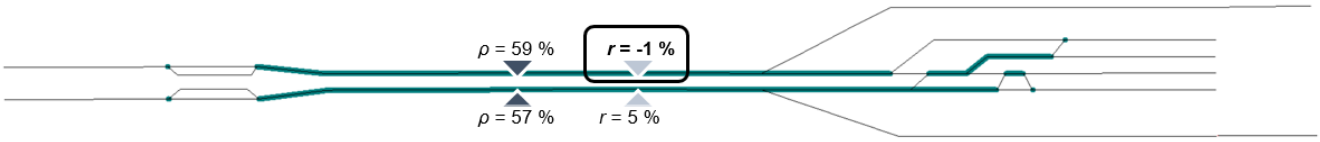
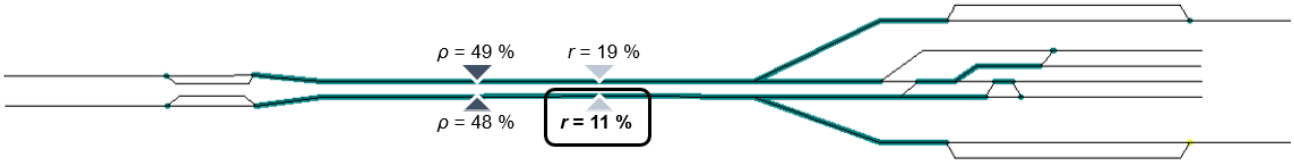


Figure 9 - Underground Station with 2x400m Platforms

4.6.4.3. NPR Underground station with 4x400m platforms

With the provision of 400m additional platforms for both directions in an underground option, the flexibility for operations, especially following perturbations, is increased, with associated enhancement in capacity (-8% to 11%). This improvement arises from the ability of the layout to accept successive NPR services on alternate platforms. The possibility of a 4x200m platform underground station was also examined; here simulation showed performance similar to 4x400m for the currently planned service, with capacity to accept two trains in one platform of little value in the case of 4x400m, at least for the timetables examined. The disadvantage – failure to future proof for eventual lengthening of NPR trains



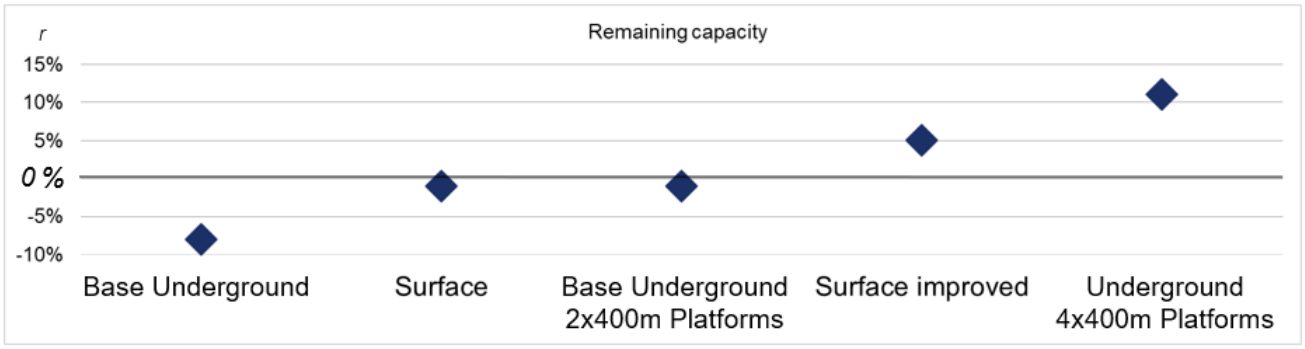
or projection of HS2 trains – remains.

Figure 10 - Underground Station with 4x400m Platforms

4.7 Preferred concept

As can been seen from the modelled options above, the solution identified within Section 4.6.4.3, an underground station with 4x400m NPR platforms, is the best option for overall capacity and flexibility. The available capacity has the option of providing additional services, assuming that the connected infrastructure and the application of standards will also support the increase in the service pattern.

Figure 11 below is a pictorial representation of the direct comparison for the various solutions modelled and the associated capacity for each option.



- High occupation on NPR due to long approaching time and stop
- Low flexibility for new timetables or in case of disturbances (only 1 track per direction)

- More flexibility
- Conflicting movements limit capacity

- Occupation of Spur by a 2nd NPR train is reduced
- Double occupation of platform leads to operational risks, which are not analysed
- Low flexibility similar to *Base Underground*

- Conflicting movements are reduced, parallel entry/leaving improved

- Occupation of Spur by a 2nd NPR train is further reduced and approaching time is reduced
- Operational risks of double occupation are eliminated

Figure 11 - Comparison of Station Capacity Options

When assessing the overall benefits of capacity, flexibility of the track layout to recover from perturbations with scope for future proofing then, of HS2 Limited's two options or improved layouts directly derived from them, the underground option with 4x400m platforms would be the most advantageous solution.

Figure 12 below is a comparison of the various items modelled with the advantages and disadvantages for each option considered. This supports the overall assessment that an NPR underground station with 4x400m platforms is the most advantageous option amongst HS2 Limited's two options and improved layouts directly derived from them. It should be noted that the 1% capacity deficit identified for the surface option is shown in green as it is within calculation tolerances; this does not apply to the 8% deficit for the Base Underground (i.e. 2x200m underground platforms) option, which is therefore shown in red. Both options are able to handle movements for the ITSS, though margins for disruption are less in the case of the Base Underground option.

Subject	Surface	Surface improved track layout	Base Underground	Base Underground 2x400 Platforms	Base Underground 4x400m Platforms
Train specifications	As per HS2 train				
Remaining capacity *r* of station and adjacent lines	-1 %	5 % additional margins	-8 %	-1 %	11 % additional train(s) possible
NPR Journey times	Basis	± 0	- 4 min to Leeds and - 3 min to Airport due to less dwell time and higher entry speed		
Dwell times	5 min		2 min NPR; 5 min HS2 London		
Platform Reoccupation	3 ½ – 4 ½ min depending on track		Underground tracks: 3 ½ min		
Assessment of Resilience	Medium delay propagation in case of delays		High delay propagation for NPR trains	Less delay propagation	Flexibility underground
Future Proven	Other timetable concepts not possible		Capacity to Leeds restricted	More Capacity and flexibility in timetabling	Different timetable concepts possible (but no more HS2)

Figure 12 - Comparison of the Various Station Options

It should be noted that as part of the modelling results the ETCS speed supervision towards dead-end track assumes the use of the standard national brake rate. However, some countries permit a more aggressive brake rate and thus a less restrictive braking curve could be used.

If HS2 implement a similar practice, then this would lead to reduced approaching times and as a consequence reduced headway time. Albeit without additional confirmatory modelling, it was felt the biggest improvement would be seen with any underground station option where two NPR trains follow each other.

4.8 Future proofing

4.8.1. Additional trains

As previously noted within Section 4.7 the surface option is at capacity and offers no potential for train service intensification, whilst a development of the underground station option with four underground platforms provides enhanced capability that could be used by additional train services. An indicative assessment of an enhanced service pattern has been undertaken to see whether 18tph could be supported by each of the various options.

From the initial assessment a conflict free timetable potentially could be produced for an 18tph service pattern, but only in the case of the underground option with four platforms, and additional capacity would be available for through services only. Further detailed modelling could be carried out to verify the suitability of the layout for reliable delivery of 18tph (initial assessment indicates tight margins).

4.8.2. Fully underground station

Section 6 of this report considers the possibility of adopting a wholly new approach to the creation of capacity for new services at Piccadilly. If a fully underground station with both HS2 and NPR platforms were considered, then below is an indicative track layout for the option. It should be noted that, intuitively, the capacity would be predicted to be less than the development of HS2 Limited's underground scheme incorporating an underground NPR 4x400m platform station because of the terminating HS2 services, but further analysis could be undertaken for a comparison against the other options.

However, a clear advantage of a solution of this nature is that it would allow maximum flexibility for the evolution of services in different ways. Projection of a proportion of terminating HS2 services

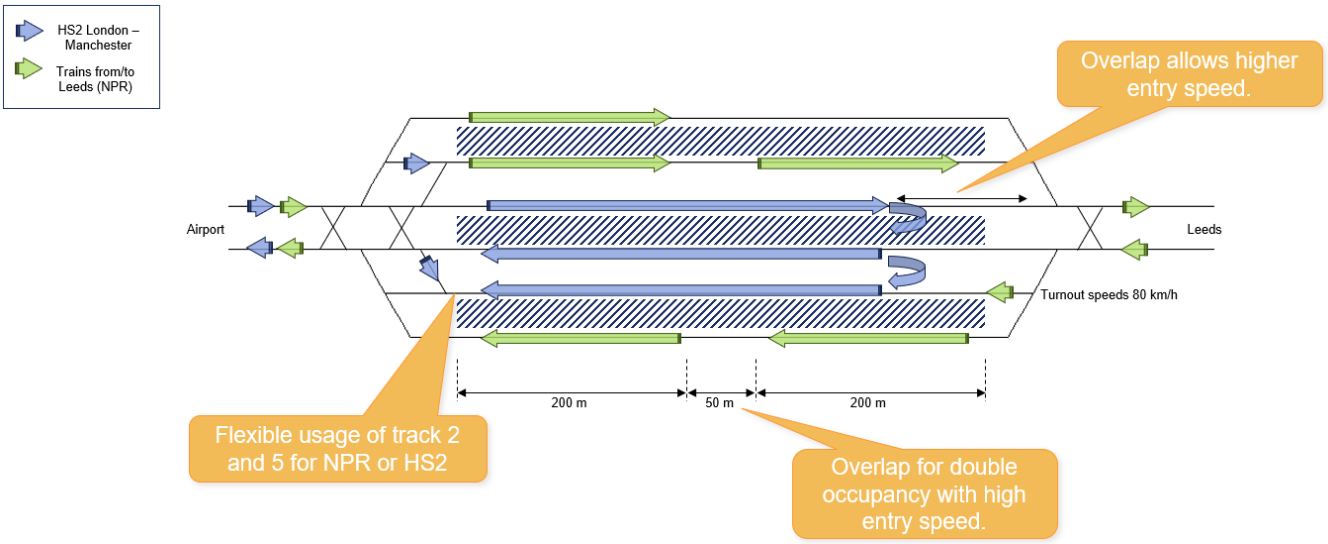


Figure 13 - Possible Combined HS2 and NPR Underground Station Option

towards Leeds is entirely possible and would enable additional capacity to be provided. Reversal of services arriving from Leeds would also be possible. Further analysis would be required to determine more exactly the potential capacity of a layout of this nature, but it is clear that it offers considerable flexibility to adjust services in response to long-term changes in demand, in ways that the layouts developed by HS2 Limited, even with the possible additional features discussed in this report, never could.

4.9 Possible further analysis

For possible future analysis we recommend the following issues be considered and addressed:

- Dwell time regime at Manchester Airport and headway time at junctions at the western end of the spur, as they may significantly impact performance of the Piccadilly layout;
- Differentiation of operating programme by transition to peak, peak and transition from peak, as the pattern of coupling/uncoupling (and empty movements) significantly affects outcomes;
- Optimisation of speed profiles to decrease capacity consumption; slightly longer running times may allow significantly shorter headway times;
- ETCS speed supervision towards dead-end tracks;
- 18tph enhanced timetable service pattern modelling;
- Combined HS2 and NPR Underground Station modelling with 6x400m platforms.

5 The development and application of HS2 design parameters

5.1 Development of HS2 design parameters

Detailed information concerning HS2's design and technical standards was not available to the review team, though public release of the Train Technical Specification has provided specific details of some technical parameters. It has, however, been understood for some time that HS2 Limited is pursuing the development of a railway incorporating a number of technical standards specific to its network, and incompatible with those of High Speed 1 and other high-speed railways in neighbouring European countries. HS2 has offered little in the way of public explanation for this approach, but it appears to have arisen partly as a consequence of the pursuit of higher than usually specified maximum speeds, along possibly with a desire to limit access to the network as this might in some way constrain the planned operation of the system.

It is perhaps worth making the point that this aspect of HS2 development runs counter to the objective of open access built into the privatisation of the British main line railway network under the 1993 Railways Act, and to EU regulations intended to facilitate open access, international interoperability, and supply market competition promoted and supported by successive UK Governments. Where HS2 deviates from the European Technical Standards for Interoperability (TSIs), it will be required under current law, as implemented through the Railways (Interoperability) Regulations 2011, to seek and justify formal derogation, introducing a measure of additional project risk.

In practical terms, certain characteristics of HS2's currently intended design will render the future operation of through train services between Manchester and the European mainland via HS2 much more difficult and expensive than it would have been had HS2 adopted the same standards and practice as HS1 and other European high-speed lines.

Specific areas in which HS2 is believed to be deviating from established European standards and practice appear to include maximum speed, platform heights, location of junctionwork in tunnels, tunnel ventilation and train evacuation. In each case the application of these different design standards has implications for the development and costs of a station to serve the new HS2 and NPR services at Manchester Piccadilly. In so far as HS2 is likely to be setting precedents for the design of NPR, the risk that HS2's decisions may affect not only the function and performance, but also the economic viability, of NPR, is worthy of consideration.

5.2 Available information

Only limited information is available on the standards and practice to be adopted in the design of HS2. Much of what the review team has concluded concerning HS2 standards has been inferred from the available documents. There have been no discussions with HS2 Limited or its design teams.

Recent publication of the Train Technical Specification (HS2 Document HS2-HS2-RR-SPE-000-000007 Rev P11) has, however, provided formal confirmation of certain intended standards, including those relating to platform heights, maximum speed and emergency egress. However, an Appendix "O" referred to in the document as providing a list of non-compliances affecting the intended train is not attached to the version available via the HS2 website.

In other cases, references to standards are in the documentation supplied to the review team. A constraint upon the development of efficient track layouts at Manchester Piccadilly appears to have been HS2 Limited's insistence that switches and crossings (track components forming junctions) should not be placed in tunnels. Only one clear reference to this as deliberate policy was found, in a 2017 HS2 Limited note (document 101, "***NPR Cost Estimate and Indicative Design Diagram"***) concerning strategies and costs for providing for NPR station facilities, in which it is stated in paragraph 21 that "Providing these [switches and crossings] in tunnels would be non-compliant with HS2 design standards".

5.3 HS2 standards potentially influencing Piccadilly station

5.3.1. Switches and Crossings in tunnels

Whilst it seems that HS2 Limited's designers have been prevented by the company's design standards from placing junctionwork in confined spaces, the review team has not seen any stated reason for this constraint. There may be a desire to avoid some of the difficulties of handling large components, such as switchblades, when they require replacement, or there may have been a desire to avoid the additional potential consequences of derailment at high speed in tunnels. To the extent of the review team's knowledge other modern railways have no such restrictions. There are two sets of scissors crossovers (an arrangement allowing trains to pass from one track to the other in either direction)

deep under the English Channel, for example, a key underground junction at Stepney Green on the new Crossrail central section, and junctions in tunnels at either end of the box forming the lower level of the new Berlin Hauptbahnhof.

At Manchester Piccadilly, HS2's adherence to this design standard constrains the development of a layout efficient in terms of both capital cost and operational performance. Because junctionwork associated with the station has to be placed between the portal of the Manchester spur tunnel and the station itself, any extension of the length of that approach layout has required movement of the portal and adjustment of the entire gently curved approach to it from Manchester Airport, over a distance of several kilometres. For the same reason, additional crossovers between adjacent lines that might be desirable in certain abnormal or degraded operating conditions have been ruled out. In short, subordination of a an operationally optimum layout to insistence upon the positioning of switches and crossings outside tunnels almost inevitably reduces speed, capacity and service reliability, and is all the more likely to do so as the pattern of services, and therefore the track layout, becomes more complex.

Similarly, adherence to this HS2 design standard makes the adoption of a fully underground station for both of the new services problematical, as extension of any station box to include the necessary length for junctionwork at either end of the platforms would make it much more difficult to find a suitable site for a box in the Piccadilly area. The potential costs of this constraint, in terms of operational inefficiency, surface construction in built-up areas, and reduced opportunities for an optimal station location, are likely to be significant, and need to be set against benefits, in this case in a lower speed area, which have not been explained and may be of relatively little value.

5.3.2. Platform heights

The Train Technical Specification is clear that the "Classic Compatible" HS2 fleet (the initial fleet, designed to run over both HS2 and existing lines) will be required to serve platforms at two heights above rail level: 1115mm (the intended height for new HS2 stations), and 915mm, the nominal height of platforms at stations on the British main line network formalised as a TSI "specific case" derogation. The specification is clear that no other capability is required. The origin of the new higher value appears to be a desire to obtain level boarding, benefiting passengers with disabilities and generally facilitating ease and rapidity of boarding and alighting, whilst also allowing a level floor inside the train clear of wheels and other running gear and underfloor equipment, taking into account HS2 Limited's demanding speed requirement. An "Opinion" prepared by the European Rail Agency for the European Commission (ERA/OPI/2015-10) in 2017 confirms this. The review team is not aware of the current status of any application for a derogation.

HS2 Limited's ease of access objectives are of course entirely laudable, but it should be understood that high platforms are not the only available means of securing level boarding, and that there is a clear non-compliance with the platform heights laid down in the Technical Standards for Interoperability (550mm or 760mm). This in turn renders use of trains of standard unmodified European designs problematical, a significant obstacle to any party wishing to exercise open access rights, and also to the projection of services beyond HS2 and the conventional British network. Platform heights for international services on HS1 are set to the TSI compliant 760mm value, and the newer (Class 374) trains using them are designed only to match the two TSI values. Adoption of standard designs offers the lowest rolling stock cost, both in terms of the initial price and residual value.

In the case of Piccadilly station, this is not perhaps the most serious issue posed by HS2's standards, but it does introduce a possibility of a measure of restriction on the flexible use of platforms, should a future "captive" HS2 fleet (used only on HS2 lines) be designed only for the higher 1115mm platforms, and the NPR fleet only to the lower "specific case" 915mm value. It seems more likely, however, that the NPR fleet would be specified in the same way as the HS2 "classic compatible" fleet, allowing all platforms at the new shared stations to be built to the 1115mm height, albeit at some additional rolling stock cost.

In the longer term any requirement to provide for international trains compatible only with TSI platform heights (assuming provision of the connection to HS1 deleted earlier in the project, or a substitute for it), might require modification of parts of the station, and dedication of one or more platforms to such services. This is an example of the compromised future flexibility of deployment of HS2 assets implicit in HS2 Limited's decisions to adopt non-standard design parameters.

5.3.3. Tunnel Ventilation and Evacuation

HS2 Limited has adopted an elaborate tunnel ventilation concept for all its tunnels in response to the need to demonstrate preparedness to handle a train fire in a tunnel. HS2, like others, plans to use powerful fans to manage tunnel airflows in the event of a fire, with the objective of providing smoke-free evacuation routes and safe areas. HS2 Limited's concept appears to surpass the provisions made by previous new railways of its scale and requires construction of shafts and associated buildings at frequent intervals. Moreover, it also builds capacity restrictions into the system.

The design of HS2 incorporates lengthy tunnel sections as a means of penetrating built-up areas and reducing impact on the semi-rural and suburban terrain it traverses. Tunnels are in several cases lengthy, but always at relatively shallow depth, introducing the physical possibility of frequent connections to the surface not available, for example, to the builders of the Channel Tunnel or the new Alpine base tunnels.

The risk of train fires underground has existed throughout railway history. However, serious events of this nature have been rare on both metros and main line networks. Historically, design provision for such events has been limited, and main line services continue to operate around the world through tunnels lacking even basic provision of lighting, communications, fire mains, mechanical ventilation or dedicated evacuation routes. The expense of retro-fitting such facilities has not been justified given the very low frequency of serious incidents, a frequency in any case diminishing given the design of modern trains, with their electric traction, fire resistant construction materials, fire detection systems, and redundancy of traction equipment distributed along the train to reduce the risk of stalling (amongst other benefits).

Existing standards reflect the diversity of railway assets and terrain. For main lines, the Safety in Railway Tunnels TSI is not heavily prescriptive. It applies to new or upgraded infrastructure, and covers areas including application of the Common Safety Method (CSM-RA) relating to risk management, the fire integrity of tunnel linings, evacuation and rescue points, operating rules, emergency plans and co-operation with local emergency services. It requires the provision of an emergency exit giving access to a safe area at least every 1,000m, ***or*** cross passages between adjacent tunnel bores at least every 500m. Modern Metros often adopt the more stringent North American Fire Protection Association standard NFPA130, but this is aimed specifically at metros. Modern tunnels such as the Channel Tunnel and Gotthard base tunnel incorporate access to (respectively) a service tunnel and underground refuges as places of relative safety, but not to the open air, whilst shorter modern tunnels such as the HS1 London tunnels incorporate frequent cross passages to the opposite running tunnel in a twin single-bore arrangement.

Safety justification of designs for new railway tunnels necessarily requires, however, demonstration that all reasonable provisions have been made to contain the risk of fatalities in the event that a serious train fire should occur, albeit within the context of near elimination of the probability that a train should both burn and stop. Crossrail, in its early design phase, considered the costs of generous provision of tunnel ventilation and access shafts, but eventually limited their construction largely to those at each end of each station. Within the “ventilation sections” thus formed by consecutive ventilation shafts, it was found that a limit, enforced through the signalling system, of two trains, could be achieved with little impact on operations, obviating the risk that a third train might be trapped in the smoke of a burning train ahead by the presence of a train behind. There are cases of railways that have chosen to implement limits of one train per tunnel ventilation section (the Docklands Light Railway and the Heathrow airport branch provide examples), but these typically involve short tunnels not requiring more than one train per tunnel section to operate timetabled services anyway.

Examination of the documents made available to the review team, and discussions with Council and TfGM personnel, indicate that HS2 Limited has gone further than Crossrail’s principle and developed a strategy allowing only one train per ventilation section, bringing a significant impact to both costs and potential line capacity. The asset cost of HS2’s strategy, surpassing standards and previous provision on similar railways, is expressed in terms of frequent ventilation shafts, each requiring planning consent, construction and permanent access, along with the installation and continuous maintenance of a quantity of electrical, mechanical and electronic equipment.

The ventilation sections between each shaft act as block sections superimposed on those of the signalling system, which permanently constrains the capacity of the line. In the case of Manchester, the impact is potentially significant, given the proposed intensive utilisation of the spur by the combined HS2 and NPR service pattern. Shafts have been planned every two or three kilometres. In the assessment of an underground option for NPR platforms at Piccadilly, HS2 Limited has pointed to the limiting factor of the capacity of the Manchester spur, but has not offered detail on the factors determining this capacity. HS2 Limited’s own unusual ventilation strategy is likely to be a significant limiting factor.

The Train Technical Specification contains a requirement, believed to be unique to HS2, that each 200m unit incorporates two side doors for evacuation such that, whatever their orientation, a pair of 200 metre units coupled can stop with two evacuation doors directly opposite tunnel evacuation cross passages provided every 350 metres. The idea here is to use the “bubble effect” of clear air at a cross-passage to provide a smoke free evacuation route. This principle features in the fire evacuation provisions for the Channel Tunnel, though in the case of the Channel Tunnel cross passages are provided every 375 metres, and there are variations in door spacing and locations between the several different types of passenger carrying trains using the system. There is clearly some risk that the requirement for the new HS2 fleet might in some way be extended to other rolling stock where application is made to use it in the future, creating a barrier to the operation of new services.

Here again, therefore, it is possible to discern an absence of consideration of the need to "future-proof" HS2 and NPR assets, and a tendency to build-in hard operational constraints from the outset around the expediencies of answering perceived design problems. Review of the one train per ventilation section principle, taking account of the increased density of traffic arising from NPR over some sections and therefore fuller utilisation of the HS2 route, and considering other potential strategies and factors relevant to the (diminishing) risk of a serious train fire incident, should be a priority for HS2 Limited. It would be helpful for HS2 Limited to confirm its tunnel ventilation and evacuation strategy and the basis for it, including reference made to existing practice in comparable modern railway tunnels.

5.3.4. Maximum speed

HS2 Limited has specified its initial "Classic Compatible" fleet for a maximum speed of 360km/h and has specified its infrastructure with yet higher maximum speeds in mind. These maximum speeds exceed those practiced elsewhere. 300km/h is the maximum on most European high-speed lines, including HS1, though the newest lines are designed for higher (up to 350km/h) top speed. There is a business case for higher speeds: the utilisation of staff and rolling stock is enhanced because more trips can be accomplished in a given time, and at the same time revenue is increased because passengers will pay to save time and will travel more often. HS2 Limited's business case for higher speeds is largely driven by value of time savings calculated in accordance with DfT appraisal guidance. However, pursuit of higher speeds generates higher construction costs. Once operational, negative factors relate to energy costs, which grow exponentially as speed increases because of aerodynamic drag, and the existing railway network, which may, in the short-term at least, be rendered uneconomic in places as business gravitates to a new network offering a dramatically different product.

Speed is also related to line capacity. In Manchester the apparent pursuit by HS2 Limited of speed as a primary objective affects, again, the capacity of the spur. Minimisation of trip times requires achievement of maximum possible speeds, even over the 13km between the airport (where it will make sense for all trains to stop) and the city. In this case the achievable maximum speed is much less than 360km/h, but maximum throughput may be best achieved at a lower speed still, albeit with only a minor effect on the trip time over such a short distance. It is not the purpose of this document to consider the overall question of optimum speed and trip times for HS2, but for Piccadilly station and the Manchester spur, carrying as it will a relatively frequent combined HS2 and NPR service over a short distance, and bearing in mind the potential need to increase that frequency over the long-term, it seems clear that train run profiles need to be optimised for line capacity.

5.4 Trade-offs between segregation and inter-operation of new and existing lines

There is a case to be made for total segregation of HS2 from the existing main line railway network. A simple, segregated, line dedicated to one type of traffic offers the highest reliability of train operation, and through this not only the highest quality of service but the highest capacity too. Such an approach offers simple relief of the existing network between key nodes at the lowest cost, avoiding all the technical complexities of system boundaries and interoperability. Indeed, a wholly segregated line need not necessarily be a conventional railway at all.

However, a fully segregated line also misses many opportunities to enhance the overall utility of the existing railway network, which it cannot exploit for penetration of urban areas or provision of direct connections to towns and cities beyond its route, or for purposes of phased development. Because of the narrow 1067mm national network gauge, the original high-speed network, the Japanese Shinkansen that first operated in 1964, was fully segregated, but all subsequent networks have been integrated with existing networks. Even in its original conception HS2 was to be integrated for purposes of serving towns and cities beyond its route, and the subsequent development of Northern Powerhouse Rail builds upon this, seeking to exploit underutilised capacity on sections of HS2 to create a transformational northern network, and requiring further integration between HS2 and the existing network.

NPR illustrates the benefits of a high-speed line concept intended for both speed and interoperability: any railway has much greater potential for future development, for adaptation to long-term changes in land-use and economic activity, if it forms a part of a network. A line conceived and developed as a part of the existing network is more likely to foster development of that network, adding capacity and improving journey times, but avoiding undesirable abstraction of existing network traffic on parallel or feeder routes through private transport "railheading". The worst outcome of all is one in which a new line undermines the economic performance of the lines it supplements to the extent that those lines are lost, leading in a generation or so to repetition of precisely the capacity problem that the new line was intended to address in the first place.

In short, NPR offers certain challenges to HS2 in terms of complexity of operation and possible import of delays, but the cost and development efficiencies that can be achieved by harnessing HS2 assets to support a new regional network

offer major benefits to the region, to the railway network, and to HS2 itself. It is hugely important that the characteristics of the new combined railway reflect its joint function in the North of England.

5.5 Optimisation of characteristics to meet regional objectives

NPR has shorter inter-station sections than HS2. Its trains (along with some of HS2's), will for the foreseeable future also be shorter, and will need to be designed to facilitate easy boarding and alighting. They are likely to perform best over the NPR route through high acceleration, rather than high top speed. They may be seen in these respects as analogous to the Southeastern high-speed services that share HS1 with Eurostar, using Class 395 units which run at a maximum speed of 225km/h on a line that allows 300km/h.

The deployment, therefore, of rolling stock that is as far as possible compliant with the standards applied to other rolling stock is a key factor. This allows a maximum of flexibility over the long-term for successive generations of trains, it protects the residual values of fleets by facilitating their redeployment elsewhere, and it allows for procurement of rolling stock by train operators and leasing companies as well as the Government. Capital and operating costs will be lowest where interoperability is achieved.

NPR customers will be making generally shorter journeys than HS2 customers, and this will be reflected in the time they spend at stations. They will require convenient entry and egress at stations, and the most efficient possible interchange with local public transport.

To better accommodate NPR's goals, HS2 Limited could reappraise its tunnel ventilation and evacuation strategy to facilitate more flexible operation. Should its one train per ventilation section principle become standard and required practice, construction and operation of new NPR routes, particularly under the Pennines, may be expected to be significantly more expensive, and may face constraints on capacity and resilience that would not otherwise apply. HS2 is likely to serve as a benchmark for future projects and to that extent bears some responsibility for their cost, utility and viability..

Beyond the impact of HS2's design parameters on the capability and cost of the railway itself, they may have also a crucial impact on the magnitude of its impact on the cities it serves. Given the role that regeneration plays in the economic justification for HS2, it would seem strange if its impact were diluted by a self-inflicted limitation on its ability to regenerate areas such as the one around Piccadilly. Successful regeneration requires the efficient integration of the new station into the regeneration area and its existing infrastructure. Elsewhere in this report the negative impact of HS2's design standards relating to the positioning of junctionwork is discussed at length. It is of very great importance that the impact of this, and possibly other technical standards, on the ability of HS2 to do its economic job is understood and the necessary thought and flexibility is applied. It does not seem logical for a single and unusual technical standard to be the source of obstacles to underground options for a vital transport terminal in the middle of a major city, options moreover that have been successfully executed elsewhere.

5.6 Recommendations concerning design characteristics

Key recommendations relating to Manchester Piccadilly station are summarised at the end of this report. Optimisation of the development of Piccadilly station, including the potential for NPR services, could benefit from reappraisal of a number of features of HS2's current design, at least for the common sections. Several such areas could be considered, including:

- Relaxation of the prohibition of switches and crossings in tunnels, in particular where speeds are not high such as on the approach to Manchester Piccadilly;
- Reappraisal of the one train per ventilation section principle, with other evacuation strategies deployed to avoid the capacity limitations the current strategy threatens, or failing this appraisal of the option of increasing frequency of ventilation shafts;
- Optimisation of speeds, layouts and line capacity to reflect traffic density and business functions of the railway as a whole, and to manage costs;
- Avoidance of special rolling stock features that might constrain future deployment of HS2 assets, both rolling stock and infrastructure, and potentially increase costs.

These issues are combined within the recommendation relating to design characteristics made in Section 8 of this report.

6 Optimising the Development of Piccadilly Station

This section of the report sets out some of the key factors that have influenced the proposals for developing Piccadilly Station and provides a review of those proposals in meeting the expressed objectives of HS2, NPR and the Council. The review considers the approach taken by HS2 and then takes a fresh look at the objectives to establish an alternative concept that seeks to address some of the operational concerns and to improve upon the benefits of major investment in and around Piccadilly Station.

The development of a design solution begins with outlining at high-level what each organisation seeks to achieve. The document review has identified the following:

- HS2 – to build a fairer, more balanced country by connecting more than 25 stations and 30 million people with a reliable high-speed train service. For purposes of this study, this means a new high-speed rail connection between Manchester Piccadilly, Manchester airport and southern England.
- NPR - deliver a transformed rail network in the North of England and bring new opportunities to millions of people and businesses. For purposes of this study, this means a new rail connection between Liverpool, Manchester airport, Manchester Piccadilly and Leeds.
- Manchester City Council and TfGM - to create a 'One Station Solution' where all elements and stakeholders drive towards a common goal of integration, mutual benefit and excellent townscape whilst at the same time maximising economic growth and regional connectivity for the area.

6.1 Considerations for developing a solution

From the document review undertaken in Section 2.0, Bechtel has identified the following considerations used by others in the assessment of solutions for the development of Piccadilly Station. It may be useful to list these considerations in advance of providing the review as it has helped provide focus on the benefits, impacts or opportunities that may arise from the station development. The team has elaborated on these considerations by expressing the questions to be answered when seeking to optimise a solution for Piccadilly station. Reference to these considerations is to be found in the review of the HS2 proposals and they are used in a more structured way when assessing alternative solutions.

Consideration	Questions to be addressed
Benefits	What are the benefits of the solution in near and long-term?
Costs	What are the costs / impacts of the solution in near and long-term?
Cost / Benefit Ratio	What is the relationship between cost and benefit?
Alignment - plan	Does the horizontal alignment support optimal rail operations for both NPR and HS2 services and make best use of the available space?
Alignment - profile	Does the vertical alignment support optimal rail operations for both NPR and HS2 services and make best use of the available space?
Future-proofing – rail operations	Does the rail system offer flexibility to adapt to future demand changes?
Future-proofing – station	Does the station offer flexibility to accommodate future changes?
Passenger connectivity	Are the concourses and platforms well connected with simple passenger movements?
Platform capacity	Does the platform capacity support peak demand and offer the flexibility to accommodate future demand changes?
Rail connection to existing train shed	Is there an option for a rail connection into the existing rail shed?
Connectivity for local transportation	Are there direct connections to Metrolink, bus and taxi services?
Station approach / throat	Is the station approach well integrated for improved interoperability?

Impacts to HS2's preferred route and station	Does the station impact HS2's preferred route and surface station concept?
Impacts to key infrastructure	Are there any impacts to existing key infrastructure during construction and on completion (i.e. Mancunian way / River Medlock)?
Impacts on regeneration area	Does the solution enable or impede future regeneration of adjacent areas?
Integration into the regeneration area and wider city centre	Does the solution offer flexibility for future integration into the regeneration area and the wider city centre?
Creating a destination	Does the solution create the opportunity to transform Manchester City Centre into an urban centre with exceptionally inter-city connectivity?
Construction sequencing	What is the likely construction sequencing for HS2 and NPR elements?
Environmental impact	Is historical heritage and surrounding environment protected and enhanced by the solution?
Sustainability	Does the solution balance present needs without compromising the ability of future generations to meet their own needs?

6.2 An overview of HS2's original intent

The design of the HS2 network has progressively developed over the past decade with an aim of providing a new high-speed rail connection between the North and South of England. In the Greater Manchester area, the new railway runs northwards from Birmingham / London before splitting at Hoo Green. One branch of HS2 heads north from here, connecting into the existing West Coast Main Line towards Wigan for services towards Scotland. The other branch, known as the Manchester spur, connects solely to the city and runs via Manchester airport before terminating at Piccadilly station. The decision by HS2 Limited to provide Manchester with a terminating line has been a key factor in the determination of the location and approach of a terminus, and the proposals for the layout of the station facilities. This is explored further below.

In the current proposals, the Manchester spur will run at grade level to the airport and shortly after departing the airport will enter twin running tunnels. The tracks remain in tunnels heading north easterly to the south eastern fringes of the city and return to the surface through a cut and cover portal in the Ardwick area. The route transitions to an elevated viaduct on the approach to Piccadilly station and in so doing, avoids the River Medlock and Mancunian Way. The railway is proposed to terminate in a new 440m long four-platform elevated station on the northern flank of the existing Grade 2 listed Piccadilly train shed. An approximate HS2 alignment can be seen in Figure 14.

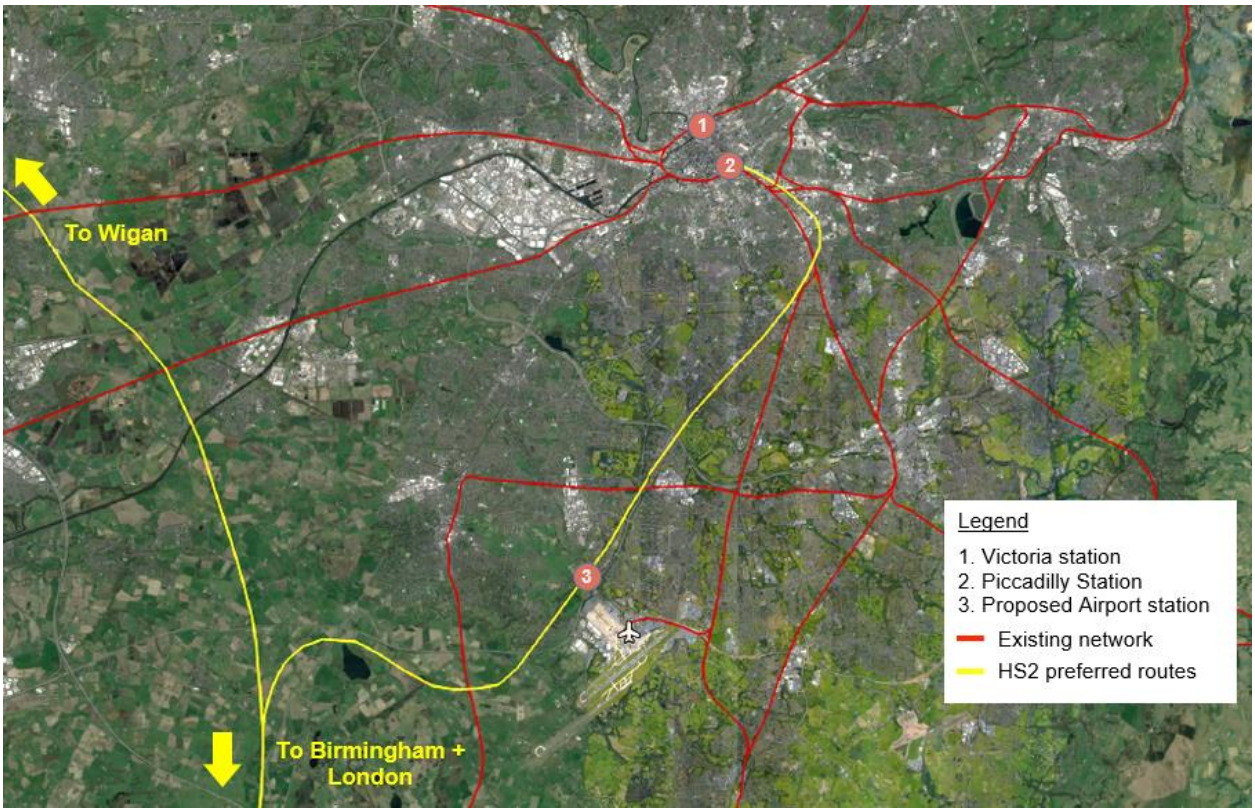


Figure 14 - Aerial view of HS2's routing in Greater Manchester area

The northern side of the existing Piccadilly train shed would appear to be a logical location for a new terminus station as there is little significant existing infrastructure in this area, reducing the extent of relocation, demolition and enabling works required prior to station construction. A station in this area would offer connectivity benefits into the existing train shed, Metrolink, bus and taxi services and is ideally located for easy pedestrian access into the centre of Manchester. Figure 15 shows HS2's preferred route and terminus station plan.

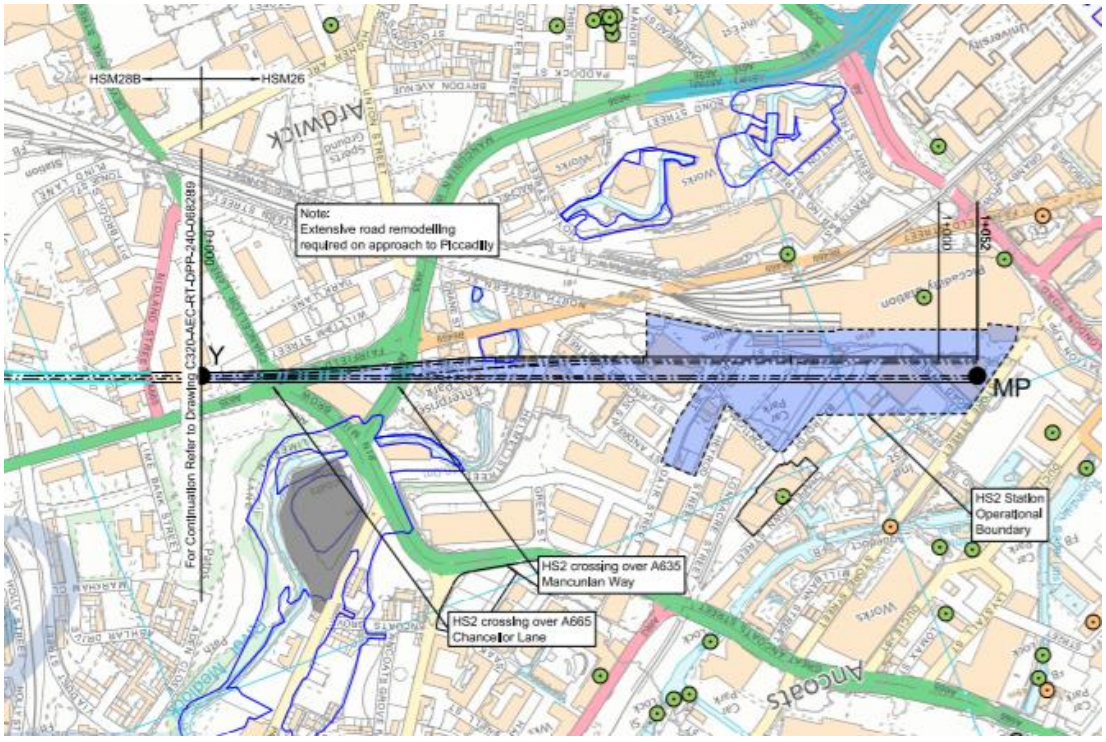


Figure 15 – Snip image from HS2's 2017 preferred route, plan and profile drawing (with north to the bottom of the image)

Considering the objective of HS2 in isolation the alignment provides a new connection between Manchester, Manchester airport and the South of England that is suited to terminating services. The station is located near to the city centre with connectivity to regional and local transportation modes and the proposed location can be seen to offer benefits to construction scheduling and cost through reduced constraints on access and lower impact on existing infrastructure. However, it should be noted that an elevated station option consumes land that might otherwise be used for commercial or leisure development in the future.

6.3 The introduction of NPR and changes in the development of Piccadilly Station proposed by HS2 Limited

In 2014, the One North report introduced the idea of connecting urban hubs in the North of England by a new railway which came to be called Northern Powerhouse Rail (NPR). This new, faster and more frequent rail connection between major cities in the region is central to the rationale of the Northern Powerhouse and more recently, NPR became a fundamental part of TfN's Strategic Transport Plan.

In 2016, the NPR Sequence Two report explored the integration of new rail infrastructure to connect Liverpool, Manchester and Leeds with HS2's preferred routing. The report suggested that a new rail connection between Liverpool and Manchester should utilise the spare capacity of the Manchester Spur to reduce NPR costs and incorporate the stop at Manchester airport to add to the value of NPR. NPR trains arriving at Manchester from Liverpool were proposed to continue onwards to Leeds via turnback or through services depending on the station layout at Piccadilly.

Figure 16 shows possible alignments for a Liverpool-Manchester airport-Piccadilly link via the Manchester spur and a turnback service between Piccadilly and Leeds. This option has considerable drawbacks in terms of train operation as detailed in Section 4.0.

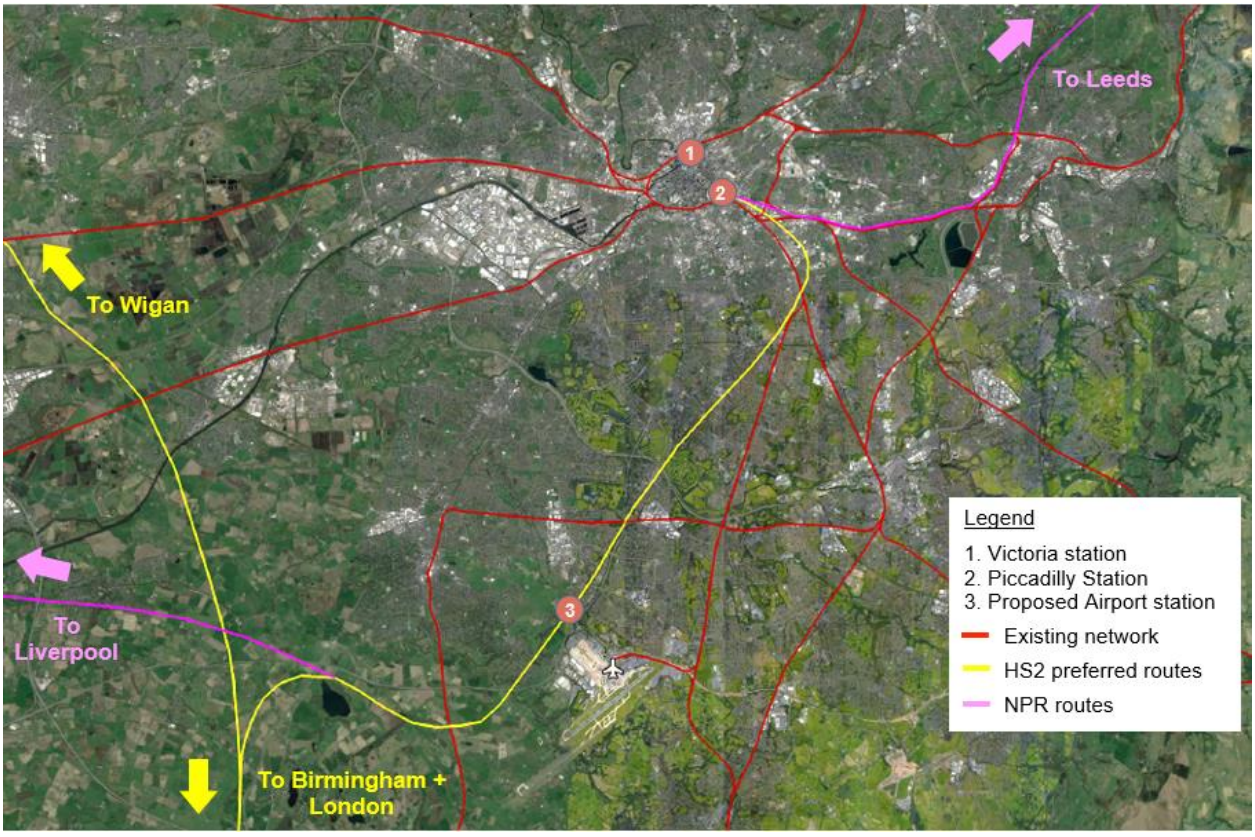


Figure 16 - Aerial view of HS2 + NPR turnback routing in Greater Manchester area

Figure 17 shows possible alignments for Liverpool-Manchester airport-Piccadilly link via the Manchester spur and a through service between Piccadilly and Leeds. This option offers improved rail operations, though suffers from considerable drawbacks in terms of capacity. The route is also circuitous, adding significant additional infrastructure and cost to the solution.

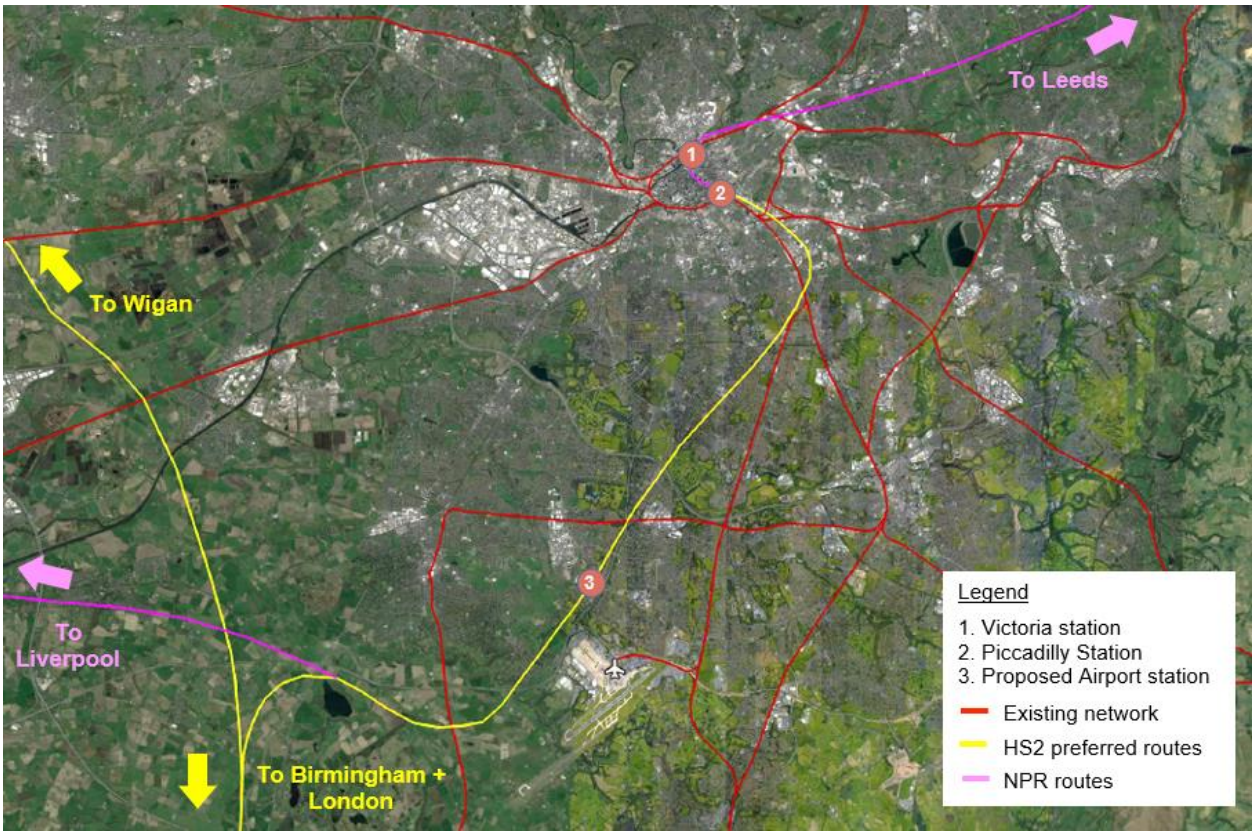


Figure 17 - Aerial view of HS2 + NPR through routing in Greater Manchester area

In early 2018, HS2 published two technical notes that explored options for NPR as an underground through station and as a surface turnback station. A defining assumption made in both reports was that HS2's Piccadilly station would be elevated with four platforms, 400 metres long for terminating services from the South of England. The decision to retain the original HS2 solution and provide additional facilities for NPR introduces constraints for the combined station and does not consider the potential benefits that may be gained by a more complete reappraisal of the considerations listed in Section 6.1.

For the surface concept, HS2 Limited has included two additional 440 metre platforms for NPR turnback services at the same elevation as the HS2 station. This increases the width of the station to 71 metres and land-take on the northern flank by approximately 9,680 square metres, without consideration of the required wider station approach. The platform length does allow for occupation by two shorter 200m trains, which offers a measure of flexibility for future demand changes.

The surface concept benefits from a concourse that is shared between HS2 and NPR and is linked at the same elevation as the existing train shed. The shared main station entrance could offer an attractive city gateway, especially with the removal of Gateway House, which Greater Manchester believes to be required to deliver the current HS2 Limited proposal by providing an appropriate entrance sequence. However, a station on one level suffers from poor inter-connectivity as there is a minimum of two vertical transitions (one up and one down) for pedestrians to cross between platforms. Figure 18 shows a plan and a cross-section of the surface concept and Figure 19 highlights the additional land-take which results in encroachment on the regeneration area and which could also impact on the industrial heritage buildings in the area.

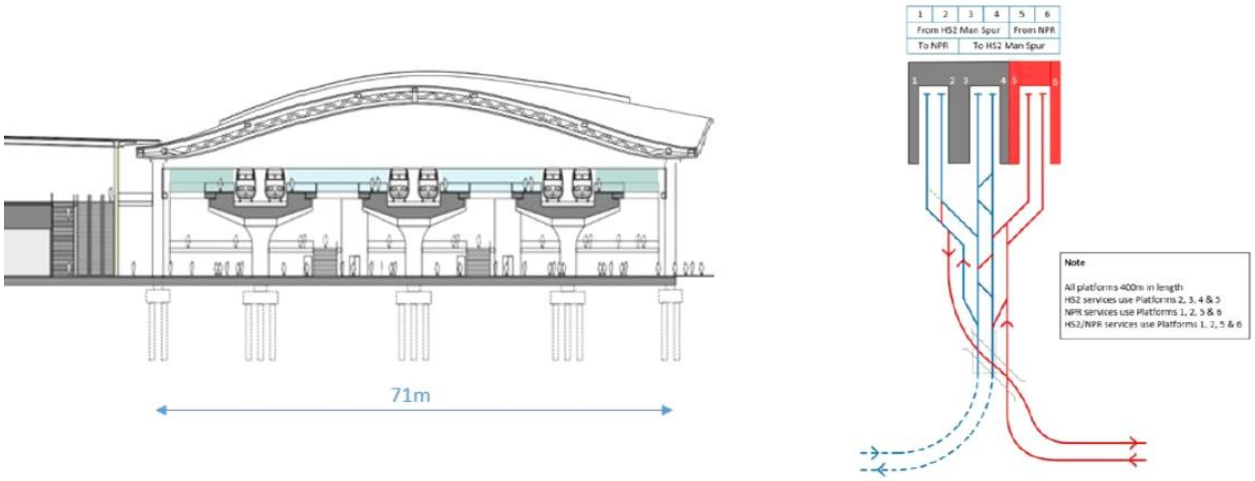


Figure 18 - 2D schematic and indicative layout of HS2's surface concept.

Figure 19 - 3D visualisation of HS2's surface concept.

For the underground concept, HS2 Limited has included two additional 200 metre platforms for NPR through services directly below the HS2 surface station. This maintains the HS2 surface station width and therefore does not impact the regeneration area on the northern side. The ***Strategic Regeneration Framework*** and ***Greater Manchester Growth Strategy*** are predicated on an underground NPR station at Piccadilly***.*** The underground platforms provide a through service towards Leeds with obvious operational benefits. However, 200 metre long platforms do not provide the same future proofing benefits as 400 metre platforms.

The underground concept could benefit from a shared HS2 and NPR concourse at the surface level, also with links to the existing station. Vertical circulation would be required to transition between surface level and the below ground NPR platforms. Underground cross connections between NPR platforms would be required to ease pedestrian inter-change movements.

As with the surface concept, the issues around interconnectivity between platforms at one level would still exist. The reduction in land-take when compared with the surface concept enables the boulevard to be situated further towards the existing train shed and gives more space for regeneration at surface. Figure 20 shows a plan and a cross-section of the underground concept and Figure 21 highlights the land-take of HS2's surface station and underground through NPR services.

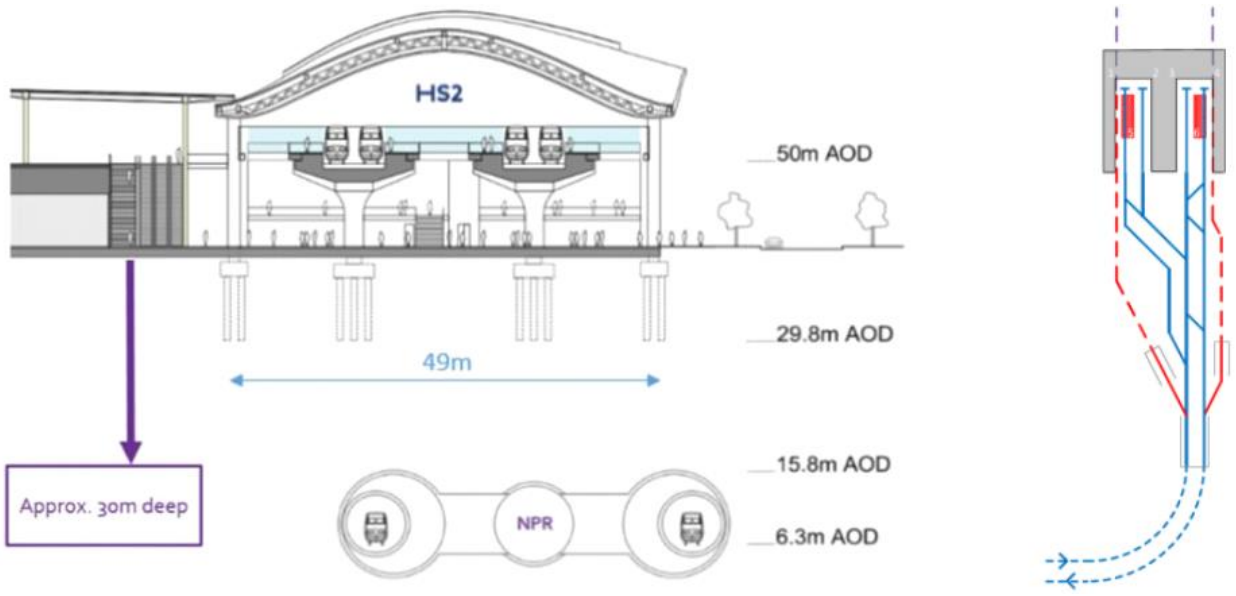


Figure 20 - 2D schematic and indicative layout of HS2's underground concept

Figure 21 - 3D visualisation of HS2's underground concept

In both of HS2's options, the wholly surface option shown in Figure 18 and Figure 19, and the partially underground option, there is an opportunity to refine the station and canopy structure to improve its interaction with the planned boulevard and regeneration area. This might be achieved by cantilevering the outer edge of the station deck and providing a barrier-free incorporation of a partially covered boulevard running alongside and beneath. Further enhancement may be possible with coordinated design solutions for the station roof and adjacent boulevard buildings which would help avoid further set-back of the buildings and reduce the impact on the development land.

The proposals developed by HS2 begin with the assumption that HS2's Piccadilly terminus is elevated and adjacent to the existing train shed; that being the case, the options for incorporating NPR are restricted. The concepts proposed meet HS2's objectives of connecting the North and South of England, but do not necessarily optimise NPR's connection between Liverpool, Manchester and Leeds, and do not consider the potential transformation of land-use under the plans of Manchester City Council.

6.4 An alternative solution for Manchester Piccadilly station

A design solution that balances the objectives of HS2, NPR and MCC should be based on balanced design principles. Suggested design principles that build upon the considerations noted in Section 6.1 are as follows:

Category	Description
Alignment	▪ Orientated to best fit terminating north-south services and through east-west services
Rail Operations	▪ Seamless inter-operability between new Manchester Spur, terminating and through services ▪ Reliable, resilient services with capacity to easily cope with peak demand ▪ Optimal headway, dwell and platform reoccupation times
Connectivity	▪ Continuous connectivity to Manchester city centre ▪ Seamless inter-connection to existing local and regional transportation medians ▪ Enhance accessibility to transport service and spaces around ▪ Spread growth potential across Greater Manchester
Destination	▪ Maximise the opportunity for regeneration around Manchester Piccadilly ▪ Creating places and spaces that provide positive improvements to communities ▪ Provide freedom for progressive surface development
Environmental	▪ Protect and enhance historical heritage and surrounding natural environment
Sustainability	▪ Satisfy present needs without compromising the ability of future generations to meet their own
Construction	▪ Minimise impacts of construction to local community and transport routes ▪ Minimise the period of construction on the local community and transport routes, reducing blight and facilitating development
Future	▪ Builds-in maximum flexibility for long-term evolution ▪ Enables economic development and regeneration

A solution to meet these design principles approaches the problem with an aim of achieving a complete, well integrated unit, as opposed to fragmented elements that are later connected. First, considering an alignment that is orientated on a north-east / south-west axis with the southern end pointing towards Manchester airport would greatly improve operations. NPR services are better aligned for east-west services and HS2 benefits from a more direct route towards the South of England. Figure 22 shows two combined alignments that allow both terminating and through services at Manchester Piccadilly and link into the current HS2 preferred route north of Manchester airport. No change to the strategically important location of the airport station or its southern approach is suggested, but there is clearly an opportunity to develop a shorter route from the airport to a reoriented extension of Piccadilly station, offering potential cost and journey time savings. The blue and green alignment would significantly reduce the length of track between the airport and Piccadilly by comparison to HS2's preferred alignment (yellow).

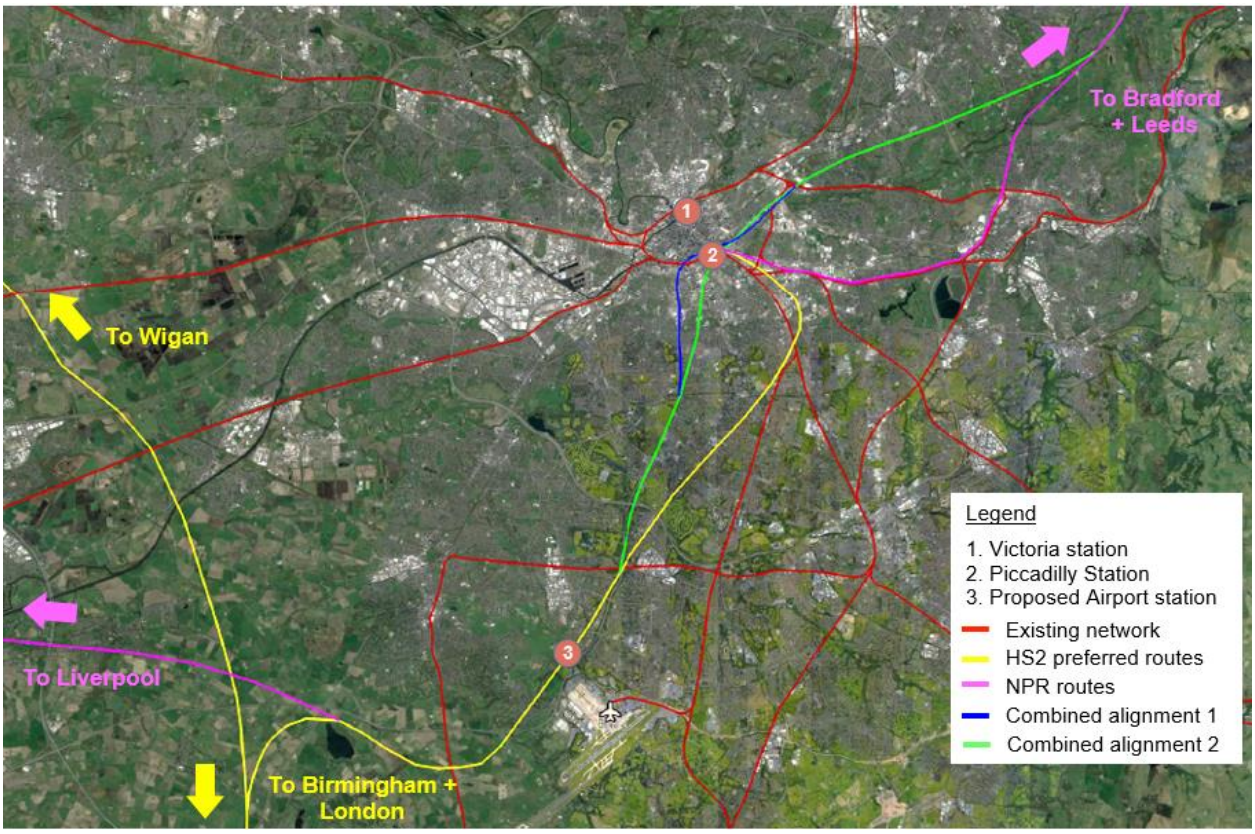


Figure 22 - Aerial view of combined HS2 + NPR alignment in Greater Manchester area

An underground station consisting of three 450 metre island platforms would offer six platform faces for terminating and through operations (the additional 50 metres allows for stopping accuracy and occupation by two 200m trains). To build-in flexibility for future demand changes it would be appropriate to provide switches and crossings that allow all six platforms to be operated as through services, as proposed in Section 4.8. Figure 23 shows what an underground station layout could look like.

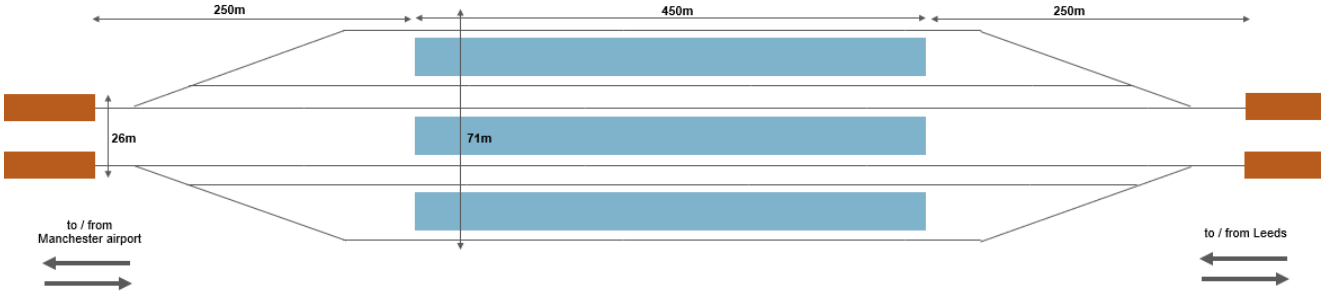


Figure 23 - Indicative layout for alternative concept

Studying the environs of Manchester Piccadilly, it appears that the area on the northern flank is covered with considerably less infrastructure than that on the south; this would ease the construction of the new station by reducing the need to relocate local businesses and residents and divert fewer transport routes. There are, however listed buildings around Piccadilly station that constrain the available space, as shown Figure 24.

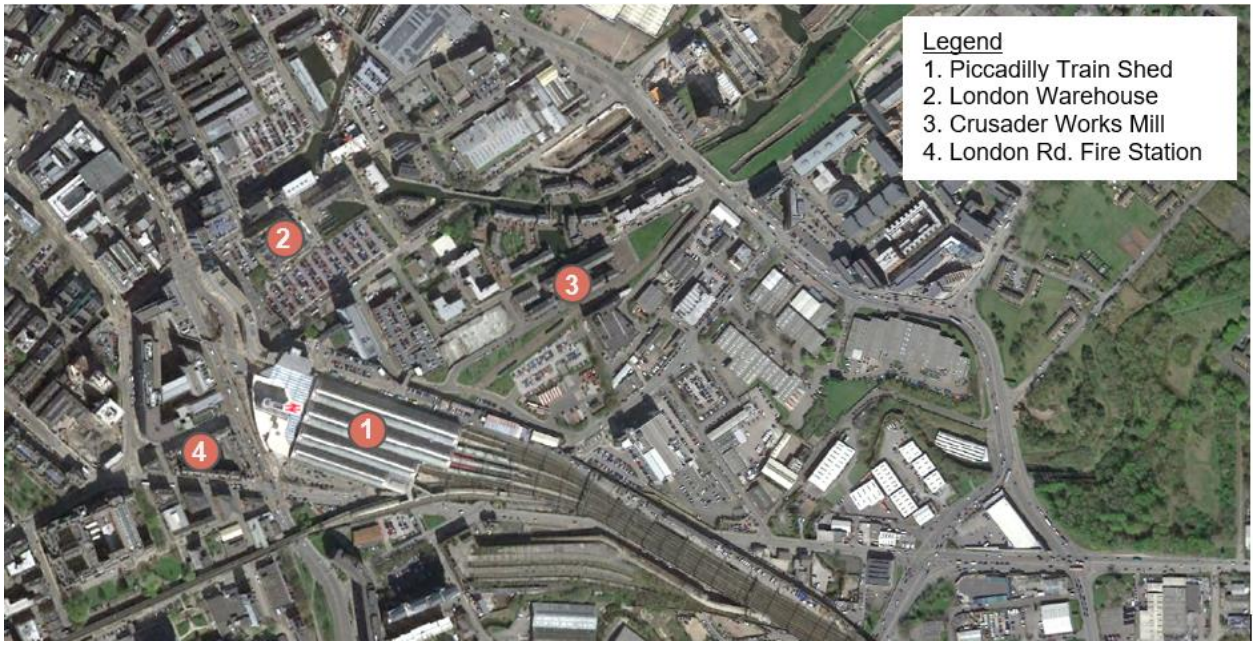


Figure 24 - Aerial view of physical constraints in Piccadilly area

The space shown to the north of the station in Figure 24 is assumed to be available for positioning a new station and its junction work. It must be emphasised that this is simply an assumption for now, made on the basis of an initial informal visit by the project team. Further work would be required to confirm the availability and exact location of space to construct, largely as an open "box", an underground station within this redevelopment area. Positioning the indicative station box layout and its junction work (Figure 23) along the alignments orientated for improved operations could lead to the locations shown in Figure 25 and Figure 26.

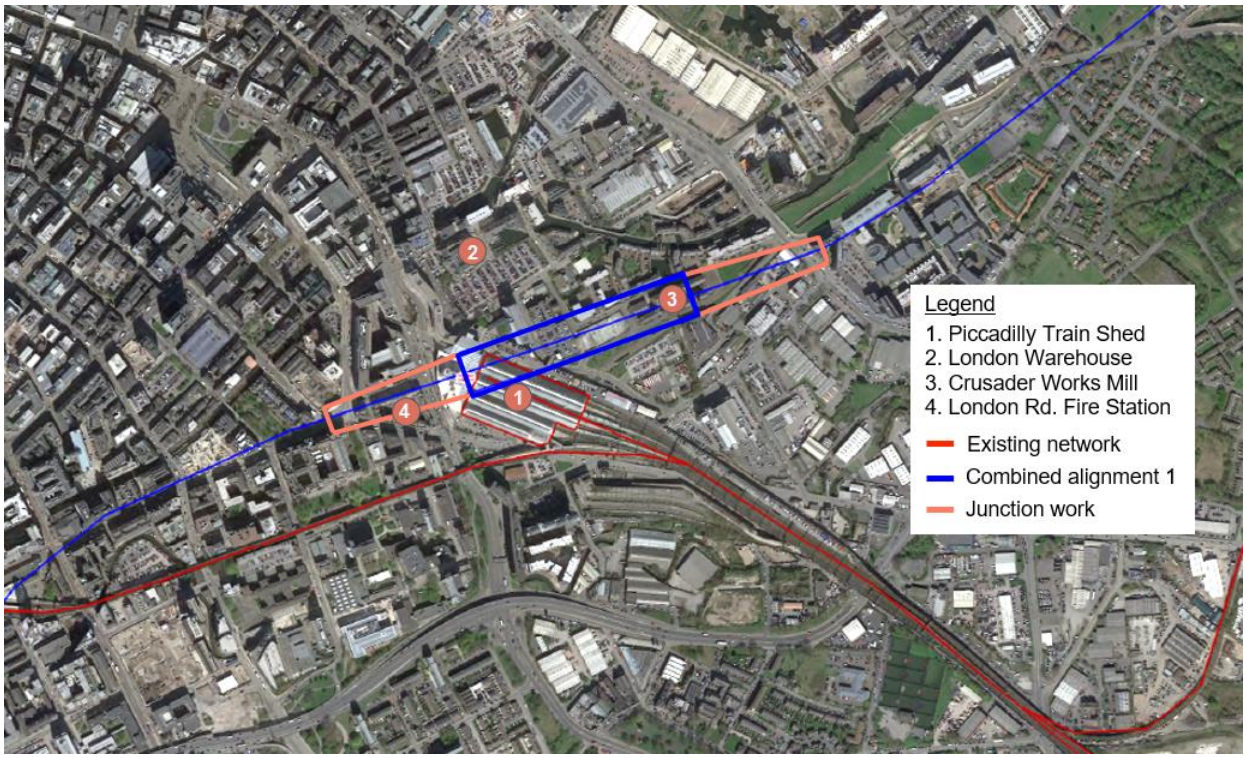


Figure 25 - Aerial view of alternative concept along combined alignment 1

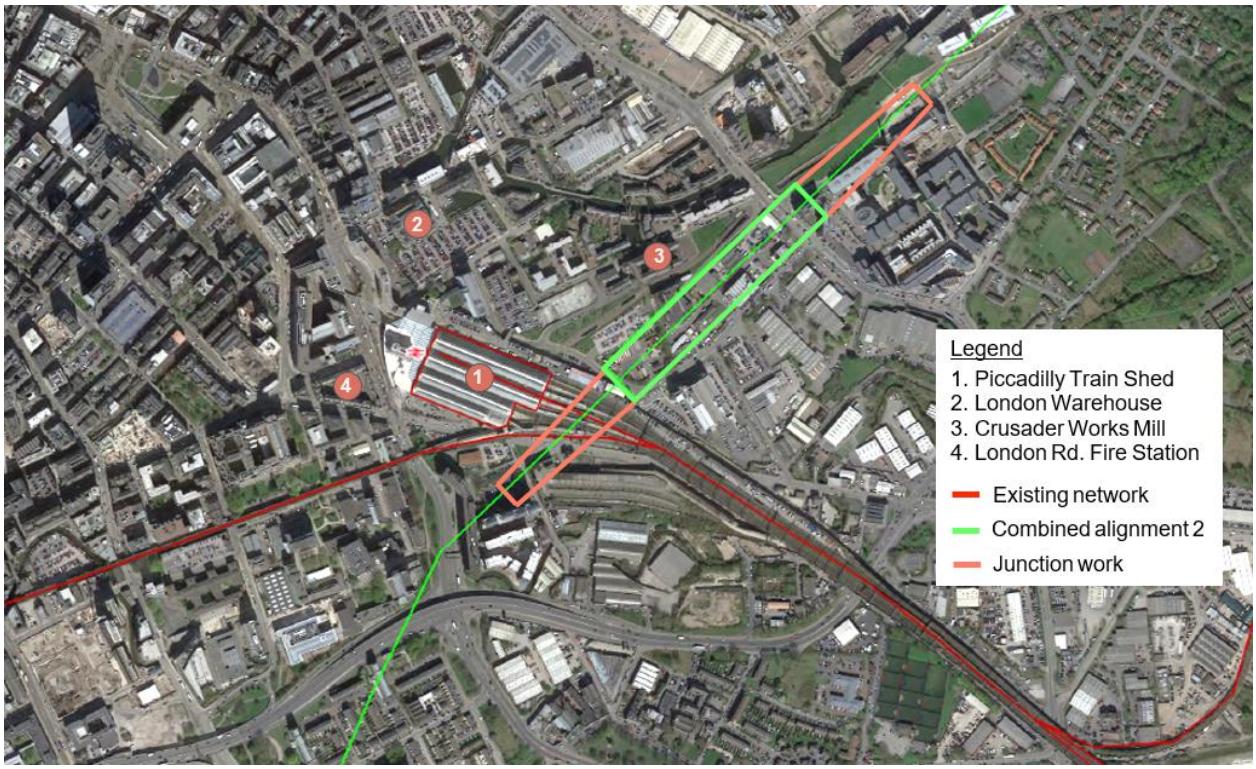


Figure 26 - Aerial view of alternative concept along combined alignment 2

Both combined alignment 1 and 2 benefit from enabling the bored tunnel to continue in to an open deep box that will form the underground station. This removes an above-ground station approach and portal structure, subsequently reducing land-take around Piccadilly and Ardwick and reducing demolition of existing infrastructure. Furthermore, a tunnel allows a temporary access for transporting bulk materials in and out of Manchester, minimising impacts to the city above. Launching the tunnel boring machines from outside the city and travelling through enables all spoil and segments to be transported without using the city centre road network.

Combined alignment 1 would offer optimal connectivity between the existing Piccadilly train shed and the City Centre as the stations are effectively stacked on top of one another. At this stage, a central open box could be constructed and then extended by mining as necessary to the east and west. There are however concerns around mining beneath listed buildings, although this is not an unusual activity, with ease of execution determined by local geology.

The main station box and eastern junction work for combined alignment 2 could be constructed in an open box with western junction work being mined beneath Piccadilly station approach. This simplifies the construction in comparison to combined alignment 1 but the station box is situated further east which may reduce connectivity to other transport modes.

A significant benefit of placing the station within a sub-surface box is the facilitation of oversite development. There is minimal restriction on the proposed development area resulting from this solution and building foundations can be incorporated into the box structure with only basic coordination during initial design.

It should be noted that these are only conceptual ideas for improving the overall solution at Piccadilly. Further, more detailed studies are required to check for feasibility, in particular ground investigation works and identifying any constraints along the new tunnel alignments.

6.5 Modified HS2 proposals

The options explored in Section 6.4 are driven by improving the orientation of the alignment to better suit HS2 and NPR services. Other solutions are available for a new combined HS2 and NPR station if improving the alignment is not a key consideration. Simply burying the current HS2 surface concept (6 platform faces) and the currently proposed alignment would greatly reduce valuable land-take. The station could be designed to allow future development directly above the underground station and tunnelling could continue in a loop under Manchester city centre to provide through services to Leeds. It should be noted that any tunnelling under city centre buildings with piled foundations will result in deeper tunnels and hence a deeper HS2 and NPR station. Obviously, greater depth introduces disbenefits of greater distances of vertical travel when accessing the platforms and longer construction schedules that are inevitably costlier.

There are further adjustments that could be made to optimise this solution as follows:

1) Moving the underground box westwards would improve integration to the City Centre and reduce travel distances for pedestrians. This could be combined with the removal of Gateway House on the station approach to further improve connectivity and support the Council's ambition to create an attractive city gateway;
2) Skewing the box slightly north-south to run parallel with the existing Piccadilly station approach could reduce the length of the Manchester spur and running tunnels to Leeds, and
3) Moving the main station box and its junctionwork eastwards could enable an easier, cheaper construction method with all underground works in an open deep box. This would however, decrease connectivity to the existing Piccadilly station and City Centre.

Figure 27 illustrates a combination of adjustment 1 and 2 listed above. Shifting the underground station westward could make a pedestrian entrance and connection to Piccadilly Gardens feasible (subject to further work).

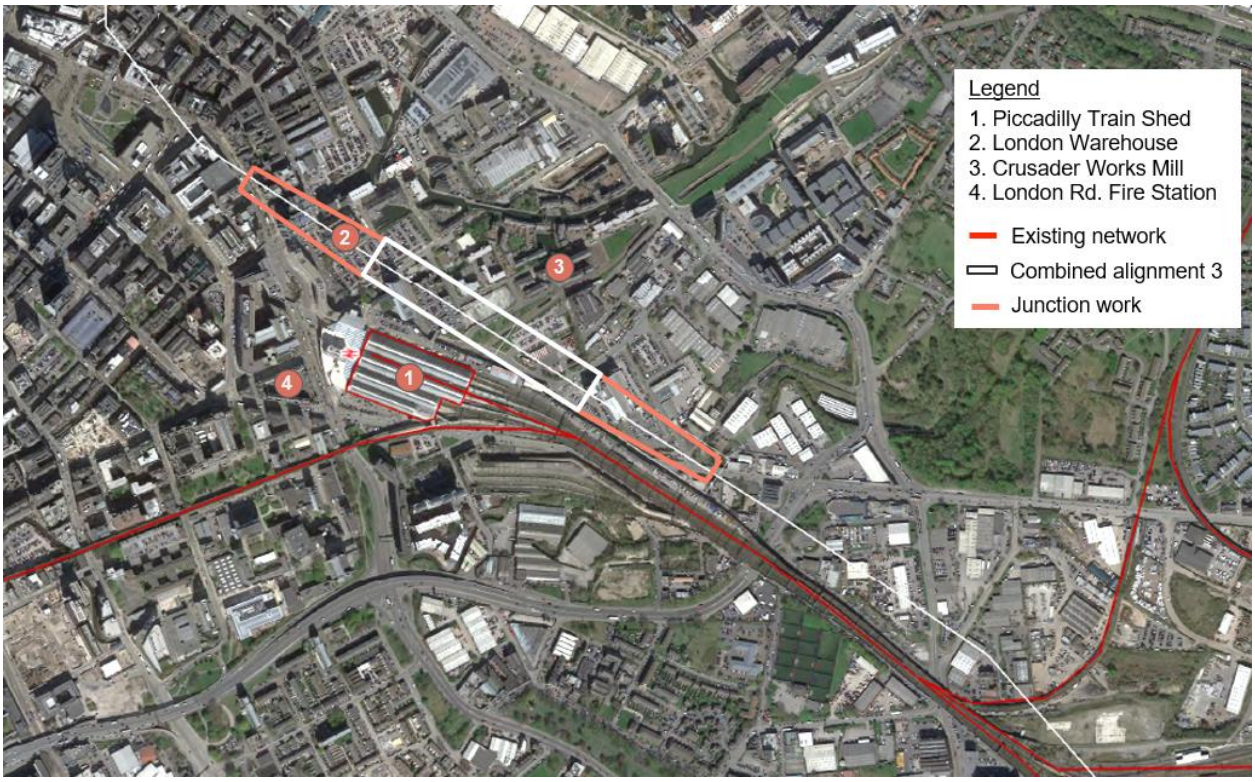


Figure 27 - Aerial view of alternative concept along combined alignment 3

6.6 Construction considerations for an underground station

The construction of an alternative underground station option is determined mainly by the geology of the area and its characteristics, ground water and underground constraints located along the alignment. Ideally, an underground station would be as shallow as practically possible to simplify construction and reduce installation costs. As indicated in Figure 24, there are known above-ground constraints in terms of listed buildings; however, the information available does not highlight any underground constraints or investigate geology. Further works are required to identify any underground constraints along the alignment, such as buildings with piled foundations, which could in turn drive the depth of the box further below ground. In addition, the depth of competent rock strata will be a determining factor for the depth of tunnelling and the underground station itself.

HS2 has specified a maximum permissible vertical gradient for the alignment of 2.5% which enables the alignment to rise or fall 10m vertically over 400m horizontally. This allowable gradient can be used to provide deeper station approaches to avoid any underground constraints along the alignment with the platforms of the underground station at a lesser depth. It is common in the design of stations for trains to brake on a rising gradient approaching a station and accelerate as the tunnel falls away from the platform on departure to lessen energy consumption and brake wear and to improve performance

Locating the alignment wholly in bored tunnels has several benefits as listed below:

- Eliminates those demolition works of existing above-ground structures which would be necessary to enable the construction of the portal and viaduct into HS2's elevated station;
- Minimises land-take on the station approach from the Manchester spur, giving more freedom for future development and removes undesirable severance within the proposed park along the River Medlock,
- Launching the tunnel boring machine(s) (TBM) outside the city and boring towards Piccadilly will reduce above-ground disruption during construction as spoil and tunnel lining rings would be transported within the completed tunnel to and from the outskirts of the city.

The construction of the underground station itself obviously also requires work to break ground to provide access from the surface to platforms. The most economical solution for the station can therefore be an open box excavated from the surface with a slab constructed to fully or partially cover the station. The track switches and crossings required on the approaches to the station may also be more easily installed in an open cut because of the size of the track-work units which need to be positioned.

The open box construction would require either interlocking reinforced concrete secant piles, or continuous diaphragm walls to form the vertical sides of the box. External anchors or internal props are required to support the walls as excavation proceeds and the chosen approach to construction will often depend on geology and an assessment of the likely impact on surrounding infrastructure. The chosen form of construction can also be dependent on other key factors such as land availability, an ability to mobilise works on site at the earliest opportunity, the required station configuration and the proximity of adjacent buildings to excavation.:

Further construction techniques, such as grouting can be utilised and can help to reduce ground water ingress, stabilise rock strata and help mitigate base heave.

The above methods of construction are feasible if the underground station and its junctionwork boxes are in a vertically accessible location. If, however, elements are to be located beneath or partially beneath infrastructure to be retained, mining would be required to widen tunnel boring to the desired dimensions.

During the design stages consideration would be given to any future above-ground developments (i.e. Strategic Regeneration Framework) and allowances included, giving flexibility for future requirements. Allowances may include but not be limited to: thickening or increasing the strength of external walls, increasing column size and/or reducing spaces and/or additional piling below the base slab.

It should also be noted that a wholly underground alignment and station would have to consider the impacts and, potential, additions to the tunnel ventilation strategy as discussed in Section 5.3.

6.7 Benefits appraisal of solutions for Piccadilly station

HS2 Limited has reported the costs for its NPR solutions as a differential incremental from HS2 CP1 design. For the surface concept the differential costing is £586.25m and for the underground concept it is £2,205.91m. This estimate begins with an assumption that HS2's preferred option is fixed, an approach that does not lend itself to optimising or realising the potential cost benefits of a combined solution.

Bechtel has undertaken a qualitative comparison with publicly available information. HS2 Phase 1 Old Oak Common Station in West London has been considered for comparison as it is a new underground station that will house six 450m platforms with twin running tunnels for HS2 through services between London-Euston and Birmingham. HS2 platforms will be in an underground box measuring approximately 1,000 metres in length and 20 metres below grade level, with the box and running tunnels in close proximity to the Great Union Canal. At the surface there will be a new conventional station providing interchange to the Elizabeth Line (Crossrail). The sub-surface HS2 station has allowed the local Councils to plan for a future mixed-use development to be provided partly over the railway facilities. Figure 28 shows an aerial view of the proposed Old Oak Common Station.

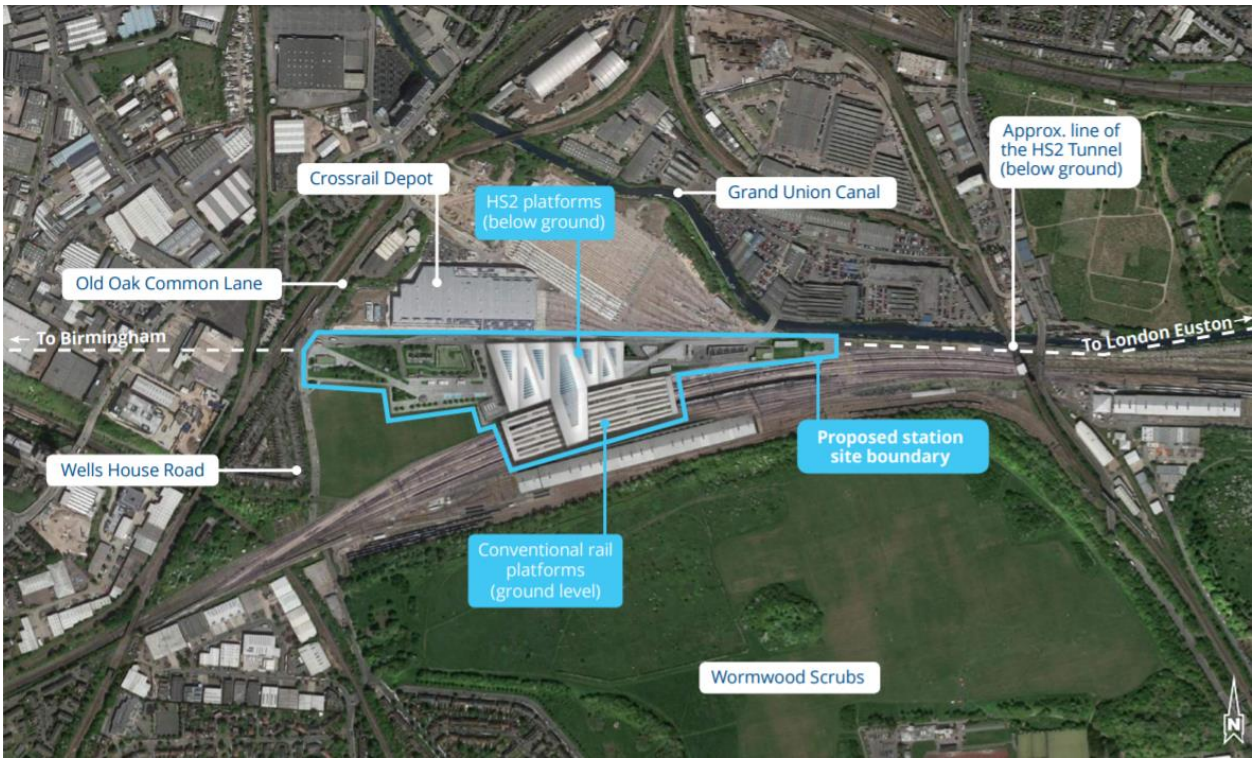


Figure 28 - Aerial view of proposed Old Oak Common

HS2's estimated cost for Old Oak Common Station has been stated as £1bn - £1.3bn, and the design can be considered as broadly comparable to a combined HS2 and NPR solution that could be provided at Manchester Piccadilly. With the limited information available for review, it is not possible to determine how an additional £2,205.91m, as reported by HS2, is required for a 2x200 metre platform underground NPR station. Without a fuller cost breakdown, it is also not possible to assess the additional £586.25m for two 400m elevated NPR turnback platforms. However, a comparison of the known infrastructure quantities is included in the table below and from this, it can be simply deduced that there are potentially significant savings to be made from reevaluating the overall approach to providing the infrastructure for a combined HS2 and NPR underground station at Manchester Piccadilly.

Table 1 - Comparison of known infrastructure quantities

Criteria	HS2's Surface Concept	HS2's Underground Concept	Modified HS2 Proposal	Alternative Concepts
Configuration	Two additional 440m long platforms for NPR included in HS2's elevated station	Two additional 200m long underground platforms for NPR directly below HS2's elevated station	Six 450m long underground platforms	Six 450m long underground platforms
Layout of HS2	Terminating	Terminating	Terminating ***(with flexibility for through services)***	Terminating ***(with flexibility for through services)***
Layout of NPR	Turnback	Through	Through	Through
South bound station approach	Two 13km bored tunnels, 0.6km portal + ramp, 0.6km elevated section	Two 14km bored tunnels, 0.6km portal + ramp, 0.9km elevated section, 1.5km NPR transitions	Two 13km bored tunnels	Two 12-12.3km bored tunnels
North bound station approach	Nil	Two 10km bored tunnels	Two 9.4km bored tunnels	Two 7.5-7.8km bored tunnels

Construction of platform(s)	Elevated on series of three viaduct piers	HS2 - elevated on series of two viaduct piers NPR – tunnelled and mined excavation	c.450m long, 20m deep open box excavation	c.450m long, 20m deep open box excavation
Construction of junctionwork boxes	Nil	South: open cut North: mined	South: open cut North: open cut or mined depending on final location	Open cut or mined depending on final location

The above does not factor in the benefit of freeing up land for commercial development nor does it identify the potential in the value of that development by removing the barrier created by an above ground station. A detailed study of the infrastructure design in conjunction with proposals for regeneration and wider city centre development is recommended to provide a holistic assessment of the costs and benefits.

6.8 References

Referencing logic: Author (date published) ***document title***; link (if available)

HS2 Ltd. (2019) ***HS2 Our story and key facts***;
https://assets.hs2.org.uk/wp-content/uploads/2019/08/14094931/our-story-and-key-facts.pdf

TfN (2019) ***At a glance... Northern Powerhouse Rail***
https://transportforthenorth.com/wp-content/uploads/TFTN_-_NPR_At_a_Glance.pdf

Mott MacDonald (2017) ***HS2 and NPR Options Analysis for TFN***

MWJV (2019) ***Manchester Airport Station, Tunnels, Portals, Approach Viaducts & Piccadilly Station***
HS2 Ltd. (2017) ***Preferred Route Plan + Profile***
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/629153/C320-AEC-RT-DPP-240-068261_HSM26_Sheet_1_of_1.pdf

TfN (2019) ***Northern Powerhouse Rail SOBC Strategic Case***

Network Rail (2016) ***Sequence Two Report Northern Powerhouse Rail***

HS2 Ltd. (2018) ***Manchester Piccadilly Turnback Station – Sift Level 3 Report***

ARUP (2019) ***Review of HS2 Ltd Proposals for Manchester Piccadilly Station***

HS2 Ltd. (2018) ***Manchester Piccadilly Underground Station Technical Note***

HS2 Ltd. (2019) ***Old Oak Common Station Design Leaflet***
https://s3-eu-west-1.amazonaws.com/commonplace-customer-files/hs2inoldoak/HS2+OOC+Leaflet+v12+FINAL-compressed.PDF

NCE (2019) ***Balfour Beatty JV signs HS2 £1bn Old Oak Common contract***
https://www.newcivilengineer.com/latest/balfour-beatty-jv-signs-hs2-1bn-old-oak-common-contract-17-09-2019/

7 Conclusion

It is far from straightforward to insert successfully a new main line railway into a mature urban centre, and especially so a high-speed line like HS2. For the promotor and engineer, having designed a scheme, to have to accommodate a new route and service with necessarily different characteristics and requirements, is a challenge indeed. HS2's original scheme for a four-platform extension along the north flank of the existing Piccadilly station, intended only for its own terminating services, and approaching from the south west in much the same way as the original 1842 route from Stockport, made considerable sense.

With the launch of the Northern Powerhouse concept, the inauguration of Transport for the North, and the direction of HS2 Limited to develop revisions to its Manchester spur and stations scheme to accommodate NPR, whilst at the same time maintaining cost and programme discipline for its original objective, the designer has been required to reconcile complex and, arguably, conflicting objectives. Its programme is a national one requiring a strategy for its route as a whole, yet each of its nodes will inevitably bring such profound local change that it has also to work as a local developer, interacting with local stakeholders to ensure the greatest possible net benefits and, as far as possible, an absence of opposition. None of this is easy.

The outcome of HS2 Limited's deliberations is a station that can be constructed at the least risk to the HS2 programme and that could deliver the train services initially foreseen. Future changes to service patterns or enhancements to frequency would however be problematical. There appears to be some potential to make layout adjustments that would improve reliability margins, but none that would offer potential to permit the reliable operation of a train service any more intensive than that offered in the initial years of operation.

It appears, therefore, on the basis of the work conducted by the review team, that the current design is less than optimal. A focus on initially foreseen train services, and on the time and cost demands of the HS2 programme, may lead to the missing of significant opportunities. It is of course important to assume an initial train service for the purpose of business and asset definition, but it should be remembered that railway assets last for many generations beyond their initial deployment. In the long-term, land-use, behaviour and economic activity change, and infrastructure must evolve too if it is to retain its value. It is the "future-proofing" characteristics of the planned surface station that perhaps represent the greatest potential missed opportunity, whilst the allocation of considerable areas of regeneration land to the station and its approaches similarly may be a source of regret in the future.

The review team is not close enough to HS2's programme to be able to assess what programme impacts might arise if time is taken to deliver a more exciting, more operationally flexible and resilient station for Manchester, and to meet better the aspirations of the city. However, whilst it may be difficult to make a strong case for the small and poorly orientated NPR underground station selected by HS2 for comparison with its surface option, the same cannot be said for more ambitious underground station schemes, which offer potential for better use of the regeneration area and better through NPR services, with additional capacity and reliability and more flexibility for the future evolution of train services. It is not entirely clear that all such schemes would be more expensive than the current one, indeed there may be potential for significant savings to be made, either in cost/benefit or indeed in absolute terms.

In order to reappraise the station extension concept at Manchester Piccadilly the review team recommends review of some of the technical standards adopted by HS2, which in the context of a facility in Manchester serving multiple train services may now have a cost exceeding their originally intended value. The review team has had only limited information concerning these standards, but those relating to tunnel ventilation, the location of switches and crossings, and train speeds seem likely to be of particular pertinence to any reappraisal of the station plans.

8 Recommendations

On the basis of analysis, it has been able to make, and noting its limited access to technical and cost information, the review team recommends the following:

- ***Recommendation 1:*** That a further formal request be made to HS2 Limited and DfT to provide detailed technical and costing information where it is needed to inform choices to be made concerning the expansion of Piccadilly station.

- ***Recommendation 2:*** That a short study is commissioned to reconsider the engineering feasibility and indicative/conceptual costs of one or more underground options at Piccadilly, taking account of all relevant factors including the relative costs of different approach routes. This study should include both detailed simulation of train movements with a view to optimization of track layouts and line speeds, and, in so far as available information on geotechnical factors allows, the technical feasibility of a combined wholly underground station.

- ***Recommendation 3:*** That HS2 Limited be strongly encouraged to review those of its technical standards that may be influencing adversely the feasibility of a solution at Piccadilly that would better meet the requirements of local stakeholders, and the long-term potential evolution of train services. Specific areas for re-examination should include standards relating to the location of switches and crossings, tunnel ventilation principles, speed and capacity optimisation, and special features of rolling stock.

- ***Recommendation 4:*** That a brief architectural appraisal is commissioned to consider the potential townscape opportunities that a wholly underground station option would offer for the Strategic Regeneration Framework and The Piccadilly Package (The Gateway Scheme, Metrolink relocation and bus/coach interchange).

- ***Recommendation 5:*** That structured engagement of the regional stakeholders with DfT and HS2 Limited be arranged to examine the content of this report in order to support the implementation of an optimum solution at Manchester Piccadilly.

Appendix A: Document Review Tracker

Last Updated: 27-Sept-19

Development of Manchester Piccadilly station
Document Review Tracker

Summary Table

	Category	Count
	Available on One Drive	144
	Not Available on One Drive	2
	Not required / not available	18
	Duplicated	5
	Total	169

Code	Document Title
~~001~~	~~HS2 Ph2b C1000_231: Piccadilly Station Options~~
~~002~~	~~HS2 Ph2b C1000_231: Piccadilly Station Options~~
~~003~~	~~Manchester Airport Station - Stakeholder Scheme Development~~
004	20180215 HS2 Airport Station workshop 15 Feb 18
005	180227_Airport station_Stakeholder workshop V3
006	20180215 HS2 Piccadilly Station workshop 15 Feb 18
007	20180227 HS2 Manchester Piccadilly Station Workshop - FINAL
008	HS2 Stakeholder Meeting Actions - Consolidated Action Tracker
~~009~~	~~180705 MCR Transport Workshop_a2 for HE_PDF - Airport Proposals~~
~~010~~	~~180705 MCR Transport Workshop_a2 for HE_PDF - Piccadilly Proposals~~
011	Manchester Stations NPR Meeting
012	Working Draft Environmental Statement Consultation
013	Working Draft Environmental Statement and Equalities Impact Assessment
~~014~~	~~Manchester Sheffied NAC~~
~~015~~	~~Liverpool to Manchester NAC~~
016	Arup "Review of HS2 Ltd Proposals for Manchester Piccadilly Station" Report
017	SOBC Strategic Case
~~018~~	~~Sheffield Leeds NAC~~
019	SOBC Management Case
020	SOBC Commercial Case
021	SOBC Financial Case
022	SOBC Economic Case
~~023~~	~~Manchester Hub NAC~~
~~024~~	~~Arup Piccadilly Independent Review of NPR Proposals - Initial report~~
025	HS2 Demand Technical Note - Piccadilly

Code	Document Title
026	HS2 Demand Technical Note - Airport
027	Highways Record of Review
028	~~DfT Summary of actions from 21st January~~
029	DfT Piccadilly Action Tracker (following feedback on actions from 21st January
030	HS2 Construction Presentation
031	Metrolink Economic Case Update
032	Metrolink Relocation Scheme Options Assessment Report (OAR)
033	The Piccadilly Package - Gateway Scheme OAR
034	The Piccadilly Package - Strategic Case
035	The Piccadilly Package - Gateway Scheme Economic Case
036	The Piccadilly Package - Financial Case
~~037~~	~~Economic Case Sensitivity Tests~~
038	Economic Summary Presentation (presented to DfT & MHCLG on 01/05/2019)
039	NPR draft Sequence 4 remit for Network Rail
~~040~~	~~HS2 Pin Mill Brow Presentation 21/03/2019~~
041	Arup Piccadilly Independent Review of NPR Proposals - Final report
042	NPR manchester Piccadilly spur and stations capacity V1.0
043	HS2 NPR Manchester Piccadilly 4x400m Underground Impact Assessment v2
044	HS2 NPR Manchester Piccadilly NPR station options Vertical transition times v1
045	HS2 NPR Routes to Leeds interface with Piccadilly station options v1
046	HS2 Route Development Procedure P08 - FOR INFORMATION ONLY
047	Manchester Piccadilly Turnback Station - November 2017 - FOR INFORMATION ONLY
048	Manchester Piccadilly HS2 NPR Platform Modelling - DRAFT P01
049	Piccadilly HS2 NPR Dwell Time V03
050	Phase 2b 2RS02 Manchester Piccadilly Operations Technical Note P01
~~051~~	~~STEM Framework Presentation~~
052	Metrolink Piccadilly Construction Presentation (Presented to Metrolink/Strategy on 09/04 at Mott MacDonald)
053	~~Pin Mill Brow ELG Paper~~
054	~~Pin Mill Brow Scoring Assessment Matrix~~
055	HS Stations - Updated TA Demands and Intermodal Report - Airport
056	HS Stations - Updated TA Demands and Intermodal Report - Piccadilly
057	ISP2 Sift Process Paper
058	~~WYG WDES Lessons Learned Report and Issues Tracker~~
059	DfT action tracker
060	HM Government TfN - The Northern Powerhouse: One Agenda, One Economy, One North
061	NPR Sequence 2 Summary Report - October 2016 (HS2) Final
062	NPR Sequence 2 Report (Network Rail)

Code	Document Title
063	~~HS2 Phase 2B Data - MW Email 161122~~
064	NPR Sequence 2.5 Manchester Piccadilly Station Summary Report
065	Manchester Piccadilly HS2 Sequence 2.5 Comments Log with Responses - MW Email
066	NPR: Manchester Piccadilly Station - HS2 Passive Provisions for NPR
067	NPR: Manchester Piccadilly Station - HS2 to Network Rail Connections
068	Seq3 Manchester Piccadilly Station: Provision of workable 400m Platform 0
069	NPR Sequence 3 Phase 1: Manchester Piccadilly (HS2 Station) - Underground Station Options: Technical Note
070	NPR Sequence 3 Phase 1: Manchester Piccadilly (HS2 Station) - Turnback Station Options: Technical Note
071	NPR Sequence 3 Phase 1: Manchester Piccadilly (HS2 Station) - Better Access to Platforms 9-12
072	~~Manchester Piccadilly NPR Sequence 3 Draft Technical Notes - MW Email 170614~~
073	Sequence 3 Phase 1 – Strategic Alternative Engineering Interventions to Support ITSS NPR11AB on the Chat Moss / CLC (HS2) Routes
074	Piccadilly Next Steps Matrix - MW Email
075	~~NPR Piccadilly Station Boundaries - MW Email. Attachments: Passive Provisions TN, HS2 to NR Connections TN and Plan and Profile Map~~
076	~~Seq3 Fiddlers Ferry 125mph Concept Technical Note~~
077	Seq3 Fiddlers Ferry 125mph Concept Technical Note
078	Sequence 3 Phase 1 - Fiddlers Ferry Route Initial Assessment
079	Sequence 3 Phase 1 – Strategic Alternative Engineering Interventions to Support the Initial Assessment on the Fiddlers Ferry Route
080	~~NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoints A, B1, B2, N, Summary, Partner Workshop Notes)~~
081	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoint A)
082	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoint B1)
083	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoint B2)
084	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoint N)
085	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Touchpoint Summary) - Touchpoints required to support each concept
086	NPR Sifting Narrative Liverpool to Manchester Touch Points
087	NPR Liverpool to Manchester Sequence 3 Sifting Spreadsheets (Partner Workshop Notes 18/07/2017)
088	Manchester Piccadilly Station HS2-NPR Pedestrian Flow Review
089	NPR Sequence 3 Phase 1 - Manchester Piccadilly NR Station
090	NPR Sequence 3 Phase 1: Manchester Piccadilly (HS2 Station) - HS2 Concept Technical Note
091	Response to Crewe Hub Consultation 2017
092	NPR Bill Provisions Instruction Scope of Work
093	Manchester Piccadilly Option U Instruction Scope of Work
094	HS2 NPR Touch Points Briefing to Partners
095	TfN Manchester to Leeds ESIM Workshop Presentation
096	Manchester Piccadilly 6 Platform Turnback Station Footprint

Code	Document Title
097	NPR Sequence 3 - Phase 1 Client Scope - final version
098	Scoping Document - Sequence 3 Phase 2 Client Scope / Remit - draft
099	HS2 and NPR Options Analysis Report for TfN
100	Piccadilly Station Boundaries
101	NPR Costs
102	Piccadilly - Further Reports from Sequence 3 Phase 1 - MW email and attachments: Pedestrian Flow Review, NR Station Report, HS2 Concepts Report
103	20180503 - HS2 NPR Piccadilly Technical Workshop to Partners - DRAFT - A
104	20180503 - HS2 NPR Piccadilly Technical Workshop - Updated in response to GM Comments v1
105	TfN Strategic Transport Plan Draft
106	HS2 NPR Piccadilly Presentation to SRL
107	Arup Manchester Piccadilly Review - Final Scope - MW Email
108	201808 - NPR Manchester Capacity - V2.0 (Presentation August 2018)
109	201808 - NPR Manchester Perturbation Scenarios V1.0 (Presentation August 2018)
110	20180831 - NPR Manchester + animation models V5.0 - presentation to the leader of MCC (Presentation 31st August 2018)
111	20181001 - NPR Manchester Piccadilly Station Concepts Review (Presentation 1st October 2018)
112	20181001 NPR Partner workshop Arup Review (Presentation 1st October 2018)
113	Manchester Piccadilly Option Key Plan (2DE01-MWJ-RT-DPL-M005-100411)
114	Manchester Piccadilly Turnback Station Sift 3 Plan and Profile Sheet 1 of 2 (2DE01-MWJ-RT-DPP-M005-100421)
115	Manchester Piccadilly Turnback Station Sift 3 Plan and Profile Sheet 2 of 2 (2DE01-MWJ-RT-DPP-M005-100422)
116	Manchester Piccadilly Underground Station Plan and Profile Sheet 1 of 1 (2DE01-MWJ-RT-DPP-M005-100511)
117	Manchester Piccadilly Underground Station Plan and Profile Sheet 1 of 2 (2DE01-MWJ-RT-DPP-M005-100521)
118	Manchester Piccadilly Underground Station Plan and Profile Sheet 2 of 2 (2DE01-MWJ-RT-DPP-M005-100522)
119	NPR Sequence 3 Phase 2 C&CA Assumptions Techincal Note
120	Journey Times
121	Manchester Piccadilly NPR Options Development History V1.0
122	NPR Development (Piccadilly)
123	Underground Station 24-08-18 V1.0 (Media)
124	Surface Station 24-08-18 V1.0 (Media)
125	HS2 P2B - NPR - Manchester Piccadilly Turnback Station TP4 Sift Report - Code 1 Accepted with redactions
126	HS2 P2B - NPR - Manchester Piccadilly Underground Technical Note - Code 1 Accepted with redactions
127	HS2 P2B - NPR and Midlands Connect - Rail Systems Technical Note - Code 1 Accepted with redactions

Code	Document Title
128	All Corridor OAR
129	Liverpool - Manchester NAC
130	Manchester - Leeds NAC
131	Manchester - Sheffield NAC
132	Manchester Hub NAC
133	Sheffield - Leeds NAC
134	Leeds - Newcastle NAC
135	Leeds Hub NAC
136	Sheffield - Leeds - Hull NAC
137	NPR Economic Impacts Report v1.1
138	Manchester - Leeds ISP-1 Spreadsheet
139	Manchester - Sheffield ISP-1 Spreadsheet
140	Manchester - Liverpool ISP-1 Spreadsheet
141	GIS Data Collection Summary Letter
142	Phase 2b 2RS02 Headway and Technical Cpability Modelling - Information only
143	HS2 NPR Manchester Piccadilly Options - Non-Technical Operational Summary
144	Technical Explanation of the 4 minute headway in NPR 2x200m Underground Station Option
145	Manchester-Leeds JT's (Supporting information in response to queries from 21st January 2019)
146	NPR Sequence 4 Manchester Platform Widths Note (Supporting information in response to queries from 21st January 2019)
147	NPR Sequence 4 Manchester Station Examples (Supporting information in response to queries from 21st January 2019)
148	Arup Report - Review of HS2 Ltd Proposals for Manchester Piccadilly Station
149	GM combined comments log on: 104_20180503 - HS2 NPR Piccadilly Technical Workshop
~~150~~	~~Piccadilly Partner Briefing RoR - GM Comments Log~~
Added after 15-July-19	
151	Delivery Group report from 9 May
152	Partnership Board report from 16 May (this is an amended version of the above which is slightly more positive about our KPMG/Savill's analysis)
153	Our response letter to the report.
154	Explanation and re-cap of headways for Manchester Piccadilly Underground option
155	ARUP Report 2011 - Design Trade-Offs for Stations and Headways (Section 6)
156	IRSE News 255 - ETCS Article (May 2019)
157	P01 CP2.1 NPR TP Partner Brief Final - TfN Issue
158	190306 NPR ITSS version 0.9
159	Proposed changes to the ITSS - issue to partners
160	190322 NPR ITSS for PS4 version 1.18.xlsx
161	Outputs from HS2 NPR TPs Eastern Leg Partner CP 2.1 Update Rev P03

Code	Document Title
162	260719 Partner session northern segments and new hubs
163	Piccadilly NPR Station - Options Assessment (Mott MacDonald Report)
164	NPR-S4-ITSS-Baselined_for_S4-v1.23
165	Liverpool Hub Options Technical Note
166	NPR - Hope Valley Tunnels Quantitative Risk Assessment
167	TfN Leeds Manchester placemats with GM comments for issue
168	Man-Leeds August 2019 Partner Session
169	Man-Leeds ISP1 SIFT Workshop Presentation

Appendix B: Document Review Record Template

Document Review Record		Document Number:	
Reviewed by:		Date reviewed:	
Document title:			
Referred to:			
Notes:			

Appendix C: HS2 and NPR Architectural Assessment of Options

	HS2 + NPR Architectural Assessment of Options							
	Design Element	**HS2 Surface Concept HS2 terminating + NPR turnback services**		**HS2 Underground Concept HS2 surface terminating + NPR underground**		**Alternative HS2 + NPR concept North-south orientation, underground station**	
		Score out of 5	**Remarks**	**Score out of 5**	**Remarks**	**Score out of 5**	**Remarks**
	Location: The station is proposed to be located on the northern side of the Piccadilly train shed, providing connectivity to existing local and regional networks, bus, Metrolink and taxi services and is an easy walk to the City Centre.						
1	Land-take and impacts to future developments	2	The over-ground station and its elevated approaches use space than could otherwise be developed in the future.	3	Placing NPR underground reduces the over-ground land take in comparison to HS2's surface concept. Less impacts to future development than HS2's surface concept.	5	Underground station minimises land-take and enables the potentials for future over-ground developments
2	Public Realm: Public park along river Medlock	2	The proposed public park will be subdivided into multiple small parks due to the elevated station approach, making it a less desirable public realm.	3	The proposed public park will be subdivided into two smaller parks though the station approach is reduced in width with NPR approaches in tunnels.	5	Enables full potential to develop a large public parks in Manchester, especially along River Medlock as station approaches are within bored tunnels.
3	Is the location conducive to meeting the future vision for the community?	3	Over-ground station constrains future development opportunity and obstructs connectivity between the development area and city centre. Connection to the city centre is not direct, separated by Gateway House and level changes, and elevated above the proposed boulevard.	4	Reduces impact of HS2's surface concept as two platforms located below-ground, however still obstructs connectivity.	5	Enables easy connection between development area, existing train and city centre whilst preserving industrial heritage.
	Station Entrances : Station entrances are reviewed for their relationship to locality. Entrances facing the surrounding community work well when adjacent to, or facing public spaces. The main station entrance to the west fronting the planned city centre/civic plaza will form a preferable gateway to the city for arriving passengers connecting them both visually and physically to the city. The internal street provides connection to the eastern side.						
4	Combined Main Entrance (S - shaped Gateway building not removed)	3	HS2, NPR and existing station entrance can be provided at same elevation. Gateway House reduces visual impact of arriving into Manchester city. Poor accessibility between station concourse and station approach road and between entrance an development area.	3	HS2, NPR and existing station entrance can be provided at same elevation. Gateway House reduces visual impact of arriving into Manchester city. Poor accessibility between station concourse and station approach road and between entrance an development area.	3	Shared HS2 + NPR main entrance would be provided but at a different elevation to existing train shed, reducing connectivity. Poor accessibility between station concourse and station approach Rd. Better connection between entrance and development area.
5	Combined Main Entrance (S - shaped Gateway building removed)	5	Removal of Gateway house would improve connectivity to the City and visual impact of a Gateway at the station entrance.	5	Removal of Gateway house would improve connectivity to the City and visual impact of a Gateway at the station entrance.	0	Removal of Gateway house would improve connectivity to the City and visual impact of a Gateway at the station entrance. Level differences would pose a challenge.
6	Secondary Entrances	5	Secondary entrances can be provided as required.	5	Secondary entrances can be provided as required.	5	Secondary entrances can be provided as required.
	Connectivity with other transportation modes						
7	Connectivity between existing rail network, HS2 and NPR	4	A shared main concourse can be provided between existing train shed, HS2 and NPR. Inter-change between platforms can be provided via link bridge or opening up undercroft and enhanced with the introduction of an 'internal street' between the existing train shed and HS2/NPR station.	5	A shared main concourse can be provided between existing train shed, HS2 and NPR. Vertical circulation would be provide to NPR platforms. Inter-change between platforms can be provided via link bridge or opening up undercroft and enhanced with the introduction of an 'internal street' between the existing train shed and HS2 station. Underground cross connection between NPR platforms would be required.	4	Shared main concourse between HS2 and NPR but separate to existing train shed. Inter-change between platforms can be provided via link bridge or opening up undercroft.

	HS2 + NPR Architectural Assessment of Options							
	Design Element	HS2 Surface Concept HS2 terminating + NPR turnback services		HS2 Underground Concept HS2 surface terminating + NPR underground		Alternative HS2 + NPR concept North-south orientation, underground station	
		Score out of 5	Remarks	Score out of 5	Remarks	Score out of 5	Remarks
8	Connectivity to Metrolink	4	Connectivity to existing MetroLink station could be via existing station concourse or Fairfield St. There are potential impacts to the MetroLink and routing in its current location during and after construction. There is an opportunity to relocate and expand the MetroLink at Piccadilly station beneath the surface concept, this would support opening up of the undercroft.	5	Connectivity to existing MetroLink station could be via existing station concourse or Fairfield St. There are potential impacts to the MetroLink and routing in its current location during and after construction. There is an opportunity to relocate and expand the MetroLink at Piccadilly station beneath the HS2 elevated station, this would support opening up of the undercroft.	4	Connectivity to existing MetroLink station could be via existing station concourse or Fairfield St. There are potential impacts to the MetroLink and routing in its current location during and after construction. There is an opportunity to relocate and expand the MetroLink at Piccadilly station above the underground station, this would support opening up of the undercroft.
9	Vehicular circulation (connectivity to taxis, passenger drop off areas, local buses and road network)	3	Master planning for vehicular circulation is constrained by the increased land-take of the surface concept. Taxis and Passenger drop off areas could be located along the north boulevard. Connections to local bus routes are available. Connections to intersecting street are difficult due to level differences. Bike path networks connecting to the station could be designed and bike storage could be included. Park & ride facilities could be provided.	4	Master planning for vehicular circulation is constrained by the increased land-take of the underground concept, though less than surface concept. Taxis and Passenger drop off areas could be located along the north boulevard. Connections to local bus routes are available. Connections to intersecting street are difficult due to level differences. Bike path networks connecting to the station could be designed and bike storage could be included. Park & ride facilities could be provided.	4	There is an opportunity to create logical and efficient master planning of vehicular circulation around the station and development area. Taxis and Passenger drop off areas could be located along the north boulevard. Connections to local bus routes are available. Connections to intersecting street are difficult due to level differences. Bike path networks connecting to the station could be designed and bike storage could be included. Park & ride facilities could be provided.
	Accessibility (Universal Design)						
10	Accessibility with the Gateway Building not removed	3	A shared main entrance for existing, HS2 + NPR can be provided from the existing station approach road. There is however poor accessibility to the area of the northern flank due to level differences. Inter-change would benefit from opening of the undercroft.	3	A shared main entrance for existing, HS2 + NPR can be provided from the existing station approach road. There is however poor accessibility to the area of the northern flank due to level differences. Inter-change would benefit from opening of the undercroft.	3	Existing train shed can be still be accessed by the existing station approach and a separate entrance for the new station complex at a different level. Inter-change would benefit from opening of the undercroft.
11	Accessibility with the Gateway Building removed	4	Removal of Gateway House will enable greater connectivity and easier pedestrian access to the main station entrance and surface concept.	4	Removal of Gateway House will enable greater connectivity and easier pedestrian access to the main station entrance and HS2 elevated station.	0	Removal of Gateway House will enable greater connectivity and easier pedestrian access to the main station entrance and efficient planning of these spaces could provide easy accessibility to the HS2 + NPR underground station entrance.
12	Accessibility of secondary entrances	5	All new secondary entrances can be designed to be accessible.	5	All new secondary entrances can be designed to be accessible.	5	All new secondary entrances can be designed to be accessible.
	Pedestrian Access						
13	Walkable distances	5	Walkable routes from the surrounding developments can be designed to provide good pedestrian access into the combined station concourse and internal street.	5	Walkable routes from the surrounding developments can be designed to provide good pedestrian access into the combined station concourse and internal street.	5	Long walkable distances from the new concourse to classic station are inherent to the design due to the location of the new station and length of platforms. However, walkable routes from the station and surrounding developments can be designed to provide good pedestrian access into the classic station via the internal street.
14	Pedestrian safety-minimize crossings	3	Public spaces and amenities on the opposite side of the boulevard force pedestrians to use street crossings. Overhead or underground walkways could be considered.	3	Public spaces and amenities on the opposite side of the boulevard force pedestrians to use street crossings. Overhead or underground walkways could be considered.	5	Public spaces and amenities are on the same side of the boulevard as the new station. Underground concourse connecting to the classic station via internal street will eliminate street crossings for station related activities.

	HS2 + NPR Architectural Assessment of Options						
	Design Element	HS2 Surface Concept HS2 terminating + NPR turnback services		HS2 Underground Concept HS2 surface terminating + NPR underground		Alternative HS2 + NPR concept North-south orientation, underground station	
		Score out of 5	Remarks	Score out of 5	Remarks	Score out of 5	Remarks
15	Human scale	3	The combined old and new station is a very large imposing structure.	3	The combined old and new station is a very large imposing structure, though less so than surface concept.	5	The underground station and walkways can be designed with respect to the human scale for pedestrian routes because the two stations are separate.
16	Minimize elevation changes	3	Access to the HS2-NPR platforms from the internal street and main concourse involves multiple elevation changes	3	Access to the HS2-NPR platforms from the internal street and main concourse involves multiple elevation changes	3	Access to the HS2-NPR platforms from the internal street and main concourse involves multiple elevation changes
17	Near local bus stops	5	Primary and secondary entrances can be located to provide access to multiple bus routes.	5	Primary and secondary entrances can be located to provide access to multiple bus routes.	5	Primary and secondary entrances can be located to provide access to multiple bus routes.
18	Inter-platform walkways	3	Pedestrian link bridge in existing train shed is reportedly too narrow to handle future demand changes and there is limited available space to increase. Opening of undercroft underneath the existing station as a pedestrian area is likely to meet future demands and would effectively allow inter-change between platforms.	3	Pedestrian link bridge in existing train shed is reportedly too narrow to handle future demand changes and there is limited available space to increase. Opening of undercroft underneath the existing station as a pedestrian area is likely to meet future demands and would effectively allow inter-change between platforms.	4	Pedestrian link bridge in existing train shed is reportedly too narrow to handle future demand changes and there is limited available space to increase. Opening of undercroft underneath the existing station as a pedestrian area is likely to meet future demands and would effectively allow inter-change between platforms.
	Pedestrian circulation						
19	Inside the station	4	Long walkable distances from the end of NPR-HS2 platforms (400m) to the main entrance are inherent to the design due to the length of the platforms. Internal street would enhance the experience of being in this space.	4	Long walkable distances from the end of HS2 platforms (400m) to the main entrance are inherent to the design due to the length of the platforms. Internal street would enhance the experience of being in this space. A pedestrian undercroft would greatly benefit the experiences of NPR underground platforms.	4	Long walkable distances along new NPR-HS2 platforms (400m) are inherent to the design due to the location of this station. A new underground concourse connecting the classic station via the internal street to the new platforms will provide safe pedestrian circulation and a good traveller experience (modern to classic) and larger retail spaces are possible.
20	Outside the station	4	Sidewalks along the boulevard and city centre will provide good pedestrian access outside the station. Street crossings are required to access Piccadilly Central and East side developments. Walkways at strategic locations could eliminate street crossings.	4	Sidewalks along the boulevard and city centre will provide good pedestrian access outside the station. Street crossings are required to access Piccadilly Central and East side developments. Walkways at strategic locations could eliminate street crossings.	5	Sidewalks along the boulevard and vehicular routes leading to new station entrances will provide good pedestrian access outside the stations. Street crossings are not required to access Piccadilly Central and East side developments.
	Platforms						
21	Width of Platforms/Capacity	5	Preliminary calculations show that the platform width provided (13m) far exceeds the width required to meet the acceptable Fruin level factor of 0.93m2 per passenger. Pedestrian modelling during the detailed design stage will reinforce this statement.	5	Preliminary calculations show that the platform width provided (13m) far exceeds the width required to meet the acceptable Fruin level factor of 0.93m2 per passenger. Pedestrian modelling inclusive of the circulation elements during the detailed design stage will reinforce this statement. Platform widths in the underground NPR station could be designed for the expected ridership forecast to optimize their width.	5	Platform widths in the underground station could be designed for the expected ridership forecast and acceptable Fruin level factor to optimize the station box width. Pedestrian modelling inclusive of the circulation elements on the platform will be required to demonstrate adequate capacity.
22	Length	4	At least 420m long platforms are required for 400 m long HS2 trains. NPR trains are assumed as 200m long. All platforms are expected to be at least 420m long to avoid station design issues that may arise from having different platform lengths.	5	At least 420m long platforms are required for 400m long HS2 trains. NPR trains are assumed as 200m long. HS2 platforms can be designed for 400m long trains and NPR platforms can be designed for 200 m long trains (no future proofing in platform)	5	At least 420m long platforms are required for 400 m long HS2 trains. NPR trains are assumed as 200m long. All platforms are expected to be at least 420m long to build-in flexibility for future demand changes.

	HS2 + NPR Architectural Assessment of Options							
	Design Element	HS2 Surface Concept HS2 terminating + NPR turnback services		HS2 Underground Concept HS2 surface terminating + NPR underground		Alternative HS2 + NPR concept North-south orientation, underground station	
		Score out of 5	Remarks	Score out of 5	Remarks	Score out of 5	Remarks
23	Travel distance to exits	5	All options are required to be designed to comply with the code.	5	All options are required to be designed to comply with the code.	5	All options are required to be designed to comply with the code.
24	Exit capacity	5	All options are required to be designed to comply with the code.	5	All options are required to be designed to comply with the code.	5	All options are required to be designed to comply with the code.
25	Weather protection	4	Platforms are not conditioned, but provide weather protection	4	HS2 platforms are not conditioned, but provide weather protection. NPR platforms are underground and can be air conditioned.	5	Platforms provide full weather protection and can be air conditioned
	Concourses						
26	Unpaid Concourse	4	Space under the new viaduct is used to create a large retail concourse, pedestrian routes and the loading bays. Space would benefit from relocating MetroLink to shallow underground station. Calculations are needed to verify adequacy of size for the anticipated travellers passing through the station.	4	Space under the new viaduct is used to create a large retail concourse, pedestrian routes and the loading bays. Space would benefit from relocating MetroLink to shallow underground station. Calculations are needed to verify adequacy of size for the anticipated travellers passing through the station.	5	A large concourse can accommodate passengers between the old and new stations, other patrons and can be adequately sized for the projected ridership. Space would benefit from relocating MetroLink to shallow underground station.
27	Paid Concourse	4	The new paid concourse can be shared but needs to be sized for the projected demand. There is sufficient space available. Metrolink and pedestrian routes need to be considered.	4	The new paid concourse can be shared but needs to be sized for the projected demand. There is sufficient space available. Metrolink and pedestrian routes need to be considered.	5	Existing concourse is not affected. New paid concourse can be sized as required for the projected demand but will be separate to existing due to level difference.
28	Gate line	3	Multiple gate lines are required in the concourse and on the internal street to control access to the platforms.	3	Multiple gate lines are required in the concourse and on the internal street to control access to the platforms.	5	Due to new construction, Gate lines can be optimally located due to a completely segregated location for new platforms.
29	Waiting area size	4	Metrolink and pedestrian routes interruptions need to be considered in location waiting areas in the concourse. The internal street can be designed for inviting waiting areas incorporating landscape zones.	4	Metrolink and pedestrian routes interruptions need to be considered in location waiting areas in the concourse. The internal street can be designed for inviting waiting areas incorporating landscape zones.	5	Waiting areas can be designed as required.
30	Ticketing Area	4	Multiple ticketing areas will be required at multiple entrances. Existing ticketing area needs to be modified.	4	Multiple ticketing areas will be required at multiple entrances. Existing ticketing area needs to be modified.	5	Existing station ticketing areas may not need to be affected because new ticketing areas will be part of the new construction.
31	Passenger Amenities (Restrooms, concessions)	4	Due to split level concourses and long routes, passenger amenities need to be distributed through out. However, some locations may see greater demand than others. Design must consider existing station and new station users.	4	Due to split level concourses and long routes, passenger amenities need to be distributed through out. However, some locations may see greater demand than others. Design must consider existing station and new station users.	5	Passenger amenities can be located and sized for the new station users and projected ridership.
	Other Considerations						
32	Vertical circulation (stairs/ramps/elevators/escalators)	5	All vertical circulation elements need to be sized to comply with the code for egress and platform clearance times.	5	All vertical circulation elements need to be sized to comply with the code for egress and platform clearance times.	5	All vertical circulation elements need to be sized to comply with the code for egress and platform clearance times.

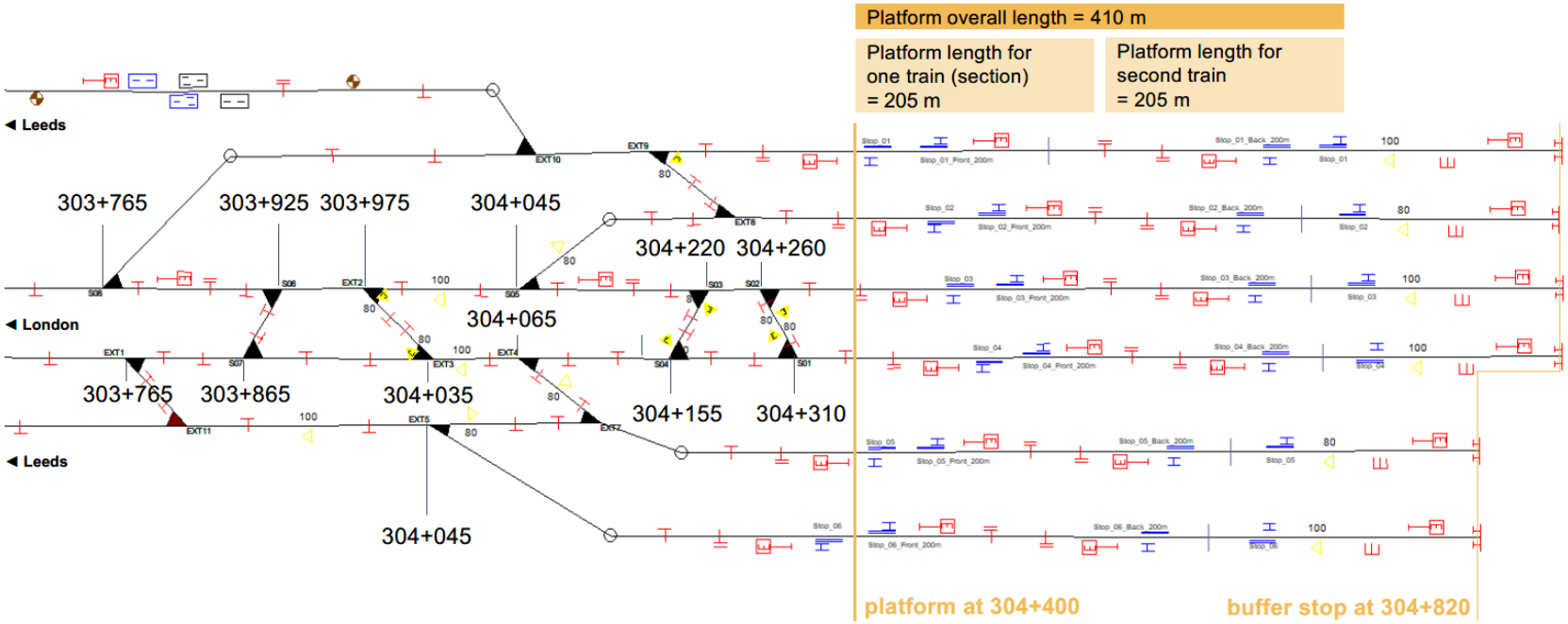
	HS2 + NPR Architectural Assessment of Options							
	Design Element	**HS2 Surface Concept HS2 terminating + NPR turnback services**		**HS2 Underground Concept HS2 surface terminating + NPR underground**		**Alternative HS2 + NPR concept North-south orientation, underground station**	
		Score out of 5	**Remarks**	**Score out of 5**	**Remarks**	**Score out of 5**	**Remarks**
33	Emergency egress and exit discharge.	4	Emergency egress and exit discharge must comply with code. Exits from the new platforms discharge into the concourse which must entirely conform to "point of safety" requirements or exit discharge is near the loading area which will require additional safety measures. Area of refuge may need to be created on the platform level for all platforms.	4	Emergency egress and exit discharge must comply with code. Majority of the exits from the new platforms above and below discharge into the concourse which must entirely conform to "point of safety" requirements. Area of refuge may need to be created on the platform level for both HS2 and NPR platforms.	5	Emergency egress and exit discharge must comply with code. Exits from the new platforms could discharge into the concourse or could discharge directly to the public way. Only part of the concourse needs to be treated as a "point of safety" . Area of refuge may need to be created on the platform level for all platforms.
34	Ventilation shafts	5	Ventilation shafts are unlikely to be required in the station footprint as elevated station and approach.	3	Ventilation shafts are likely to be required and would need to be considered during design stage.	3	Ventilation shafts are likely to be required and would need to be considered during design stage.
35	Back of house spaces for station functions	4	Complex functions for each rail line need to be managed from one location	3	Complex functions for each rail line need to be managed from one location. Reduced footprint for back of house areas.	5	Existing station operation areas can be maintained if required. New back of house functions for the new lines are fully segregated from the existing or can be incorporated together as required.
36	Station staff areas	4	To be included in detailed design. Staff areas for multiple rail networks will be required and segregated staff amenities may need to be provided.	4	To be included in detailed design. Staff areas for multiple rail networks will be required and segregated staff amenities may need to be provided.	5	To be included in detailed design. Staff areas for multiple rail networks will be required and segregated staff amenities may need to be provided.
37	Access/usability of the dark spaces under viaducts	3	Space below existing station and beneath new elevated station and approach could become dark and unusable if not considered in design stage.	4	Space below existing station and beneath new elevated station and approach could become dark and unusable if not considered in design stage.	5	Space under the existing station is not affected with the new station which has no viaducts. Space under the existing viaducts could be developed into above ground retail areas which can also be accessed from outside the station.
38	Decision Points	3	Multiple decision points are created in the main concourse and signage is required at each decision point. Concourse is interrupted by Metrolink and pedestrian routes.	3	Multiple decision points are created in the main concourse and signage is required at each decision point. Concourse is interrupted by Metrolink and pedestrian routes.	5	Decision points are simplified as the two stations are fully separated.
39	Preservation of community character in the design of the station.	3	A large new HS2-NPR station adjacent to the existing grade listed Piccadilly train shed and other listed buildings in the area detracts from industrial heritage and character. Surrounding residential communities are adversely impacted due to major reconfiguring of plots.	4	A large new HS2-NPR station adjacent to the existing grade listed Piccadilly train shed and other listed buildings in the area detracts from industrial heritage and character. Lesser than surface concept. Surrounding residential communities are adversely impacted due to major reconfiguring of plots.	5	An underground station will cause the least impact on the above ground community character. More land is available for development. It is possible to restore back the land disturbed due to construction.
40	Loading dock and waste pick up area	4	Loading bays and vehicular circulation are located in the space under the viaducts on the ends that could have been included as retail space instead.	3	Loading bays and vehicular circulation are located in the space under the viaducts that could have been included as retail space instead.	5	There is an opportunity to create an efficient layout of the loading area serving both stations and also leaving ample space for retail areas.
41	Signage locations	5	To be included in detailed design	5	To be included in detailed design	5	To be included in detailed design
	Total score	**159**		**164**		**182**	

Appendix D: Track and signalling layouts assumed for simulation

Modelling assumptions

Track layout (surface station)

Schematic drawing, not to scale.



Modelling assumptions

Track layout (semi-underground station)

Schematic drawing,
not to scale.