Appendix 4

HS2 Route Capacity and Reliability

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Introduction

4.1 This appendix considers the planned utilisation of HS2, its technical capacity and its potential reliability.

Planned Utilisation

4.2 The business case for HS2 is based on a very high level of utilisation of the route, at 18 trains per hour in peak periods and 14 trains per hour off-peak on the Birmingham – London section. The proposed service pattern is set out in the "Economic case for HS2"[1]. This is shown in Figure 4.1.

4.3 Of the eighteen trains per hour in peak periods, six operate to and from destinations on the existing network[2], with inevitably a serious risk of importing any delays incurred on the existing network on to HS2. There are no intermediate stations between Old Oak Common and Birmingham Interchange, so capacity can be optimised on this section of the route.

4.4 North of Birmingham there are between six and nine trains on the Manchester branch, depending on whether Liverpool and Glasgow services leave the route at Lichfield or at a junction south of Manchester; no information is available on this at present. The Leeds branch has nine trains per hour, of which five are shown to stop at the East Midlands and South Yorkshire stations. This operating pattern represents a major constraint on timetable planning, and may in practice be difficult to achieve, given the need to ensure that southbound trains join the core section south of Birmingham at precise intervals.

[1] http://highspeedrail.dft.gov.uk/sites/highspeedrail.dft.gov.uk/files/hs2-economic-case.pdf Page 61

[2] Assuming that dedicated high speed infrastructure is provided throughout to Manchester and Leeds

FIGURE 4.1 PROPOSED SERVICE PATTERN FOR HS1

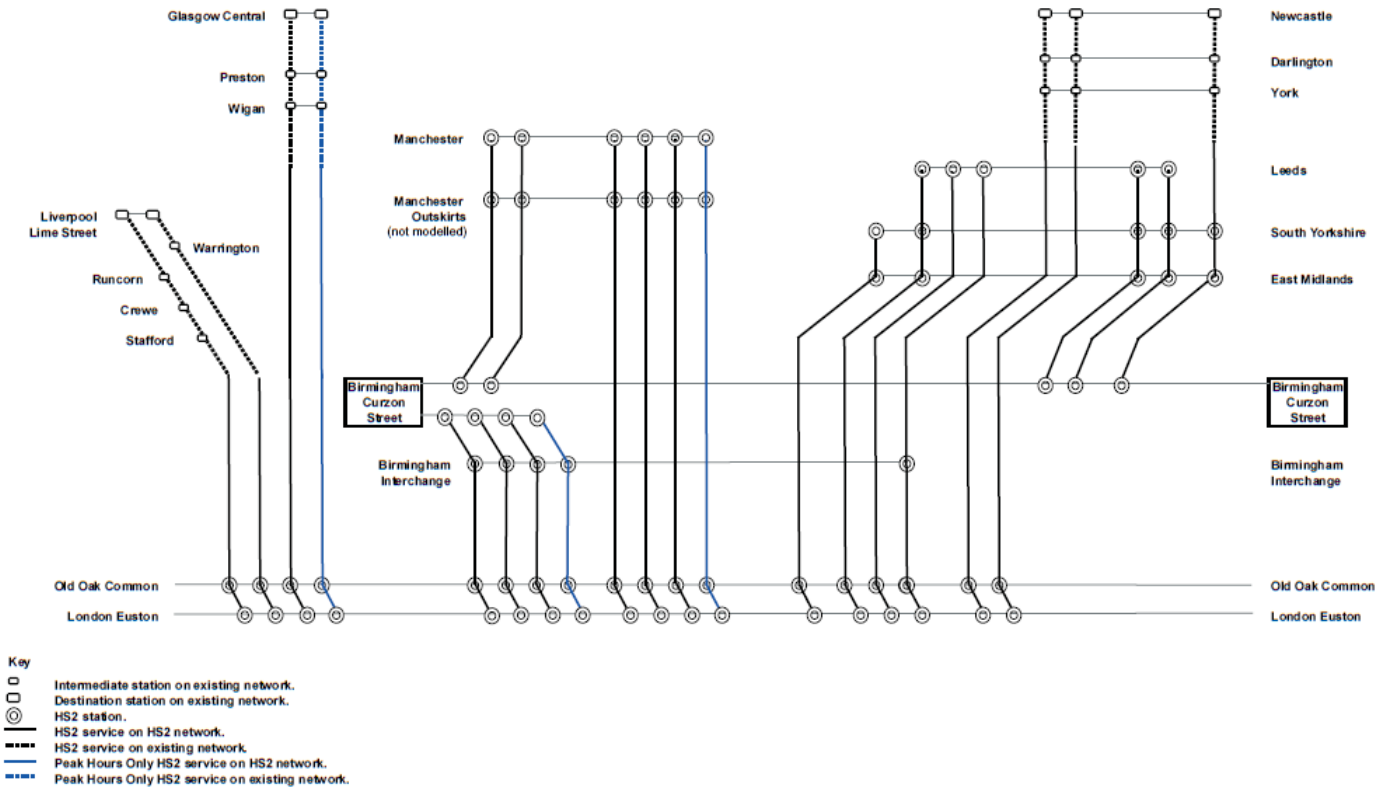

Figure A2 – **Service specification assumptions for the Y network**

N.B. Further work is being done to determine which of the above services might serve Heathrow and which might serve Heathrow, and which might run on to mainland Europe.

4.5 The specification does not include any trains to Heathrow or mainland Europe via the HS1 connection. The document states:

"further work is being done to determine which of the above services might serve Heathrow….and which might run to mainland Europe"

4.6 No information is available on the proposed frequency of Heathrow and HS1 services, other than it is stated that Heathrow trains may join and split on-route, presumably at Birmingham Interchange. Again, this operating pattern represents a major constraint on timetable planning, and may in practice not be possible.

Experience on other High Speed Lines

4.7 The planned utilisation of the route is higher than that achieved on any other high speed line in the world.

4.8 The Tokaido Shinkansen operates at the highest capacity, with up to fourteen trains per hour at peak periods, despite the constraints of varied stopping patterns – slow trains are overtaken several times on-route. However, the Japanese high speed network is self contained, and does not connect with or import delays from the "classic" network, which is built to a different track gauge.

4.9 French high speed lines operate at up to 12 trains per hour at peak times at present. German, and Spanish routes operate at lower levels of capacity, in the case of Spain typically at no more than four or five trains per hour.

4.10 In a "Why we need HS2" supplement (April 2011, page 56), Modern Railways reports that Jacques Robouël of Systra stated at a recent HS2 conference that

"the present signalling on high speed lines allows a dozen trains an hour in each direction – the European Rail Traffic Management System is probably not going to increase this number."

4.11 Systra is SNCF's consultancy arm, so the company has an enormous knowledge of high speed rail and a clear interest in promoting it. Yet its staff believes that twelve trains per hour, not eighteen, is the practical maximum for a high speed line.

Technical Capacity

4.12 Greengauge21, the pro-HS2 lobby group, published a useful and comprehensive technical note on its website, as Appendix B to its report "*Fast Forward: a high-speed rail strategy for Britain*" [3]. This gives considerable detail on the technical capacity of high speed lines, as shown by the following extract.

FIGURE 4.2 HEADWAY BETWEEN TWO 300 KM/HOUR TRAINS[4]

2.4.2 Speed and headways

Maximum commercial speed and braking sequences will define the minimum headway distance and time between two trains. Figure 1 shows the 7 block sections that are required to meet the braking sequence and consequently to follow the previous train.

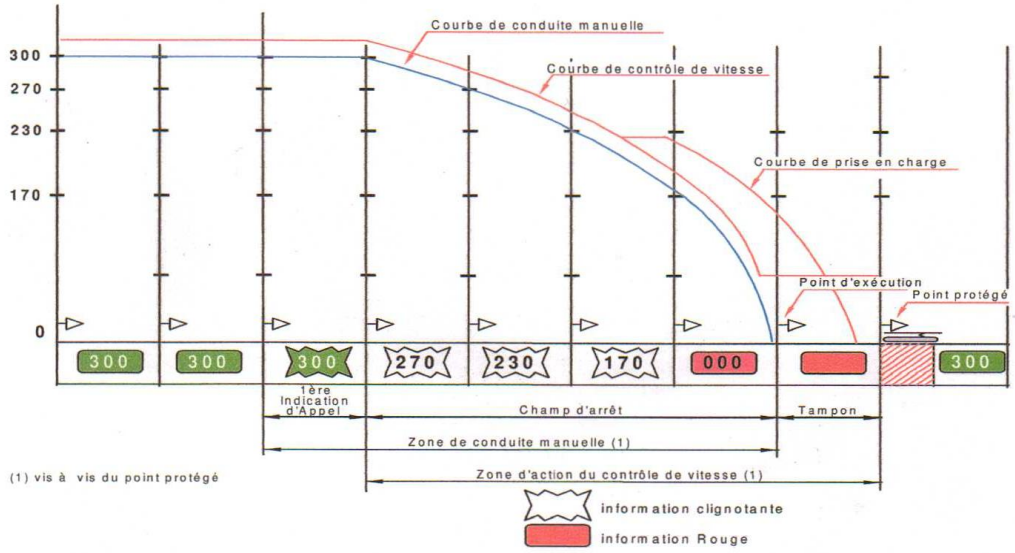

Figure 1 : Headway between two 300 km/h trains

A major threshold shall be considered as seven blocks are needed when running at 300 km/h (sequence is 300, (300), (270), (230), (170), (000), 000) including the buffer block) but eight blocks are required when running at 320 km/h.

4.13 The report also includes a table setting out the "technical headway", the absolute minimum time between two trains at various maximum speeds. This is shown in the following figure.

[3] Greengauge 21 (2009). . www.greengauge21.net/publications/fast-forward-a-high-speed-rail-strategy-for-britain, Appendix B, §2.4-2.6.

[4] Based on the signalling system used on HS1. Use of ETCS level 2 will not significantly change the constraints.

FIGURE 4.3 TECHNICAL HEADWAY

Maximum speed limit (km/h)	Speed with 5% punctuality margin (km/h)	Number of blocks	Block lengths (m)	Headway (m)	Speed (m/minute)	Technical headway (min)	Trains/hr, design capacity	Trains/hr 75% of design capacity
300	285	7	1600	11600	4750	2.78	21.6	16.2
300	285	7	2000	14400	4750	3.36	17.8	13.4
320	304	8	1600	13200	5067	2.94	20.4	15.3
320	304	8	2000	16400	5067	3.57	16.8	12.6
350	332.5	8	1600	13200	5542	2.72	22.1	16.6
350	332.5	8	2000	16400	5542	3.29	18.2	13.7

4.14 The best technical headway quoted in the Greengauge21 report is 2.27 minutes, at 350 km/hr, close to the 360 km/hr claimed by HS2 Ltd for their operation. However, no European high speed line in fact operates at this speed at present (320 km/hr is the current maximum), and the only country to have done so is China, which has recently reduced speeds to 300 km/h, to reduce unsustainable maintenance and energy costs.

4.15 The table indicates that the design capacity varies between 16.8 trains per hour and 22.1 trains per hour. However, this is a purely theoretical capacity, as it makes no allowance for any delay whatsoever, even of a few seconds. The more realistic figure is the "trains per hour at 75% of design capacity" column, which represents the maximum realistic level of operation, ranging from 12.6 to 16.6 trains per hour. This itself significantly exceeds European Rail Agency/International Union of Railways recommendations for timetable planning.

4.16 Network Rail's assessment is similar. Its "Strategic Business Case for New Lines"[5] states:

"In options that have through running to the classic line network a maximum capability of 14 tph in each direction is assumed. This reduced capability is to reflect the significant additional performance risk and the difficulty of integrating the respective route timetables."

4.17 In addition, Greengauge21 held three workshops in May and June 2010, which concluded that 18 trains per hour was not realistic, and acknowledged that there were major capacity problems on the West Coast Main Line north of Lichfield in Phase 1. The options identified for the longer term were (a) to plan for four tracks over the trunk route between London and Birmingham, (b) to plan for lower service frequencies, or (c) to plan a second north-south high speed line.

5 http://www.networkrail.co.uk/documents/About%20us/New%20Lines%20Programme/5883_Strategic%20Business%20Case.pdf page 17 para 3.20

4.18 It is therefore clear that the claimed 18 trains per hour for HS2 is not achievable. The key constraint is not signalling technology but the braking distance for trains from full speed to a stop, which increases in relation to the square of the speed – if a train comes to a sudden halt for any reason, it is essential that the following train can stop safely without running into the train in front.

4.19 HS2 Ltd have recently responded to an FOI request from HS2AA, quoting the March 2010 HS2 Technical Appendix (Para 2.3.2):

"The project shall assume an ultimate capacity of 18 tph based on a longer term high speed network with services largely segregated from the classic network and anticipated improvements in train control systems and train braking technology"

but have offered no evidence of the deliverability of the claimed technical improvements. Nor does the proposed service pattern meet the requirement that services should be "largely segregated form the classic network", since six out of eighteen trains an hour operate to and from the classic network, in most cases over substantial distances.

4.20 Moreover, informal discussion with major European train manufacturers indicate that a quantum increase in braking capability beyond present performance is not achievable.

HS2 Route Constraints

4.21 As with any high speed line, there are constraints caused by the specific characteristics of HS2:

- The approaches to Euston, with conflicting moves in and out of the terminal platforms. This is mitigated, but not eliminated, by grade separation.
- The approach to Old Oak Common station. All trains will stop there, and there are parallel platforms in each direction, but with trains running at the minimum technical headway, deceleration of the first train causes progressively greater delay to subsequent trains – equivalent to the effect of delays propagating on a congested motorway.
- The approaches to other intermediate stations (Birmingham Interchange, East Midlands and South Yorkshire). Stopping trains can be "looped", and overtaken by non-stop trains, but this consumes capacity on the route, as the train which stops takes up twp paths, one in advance and one behind the fast train.

- The section of route between the connection from Birmingham to the North and the junction for the "Y". The planned service pattern envisages 19 trains per hour over this section, with trains to and from Birmingham and Euston in the south and Manchester and Leeds in the north. Even with grade separated junctions at either end of the section, this level of utilisation is unrealistic, given the complexity of the service pattern.
- Integration of service from Heathrow with trains from Euston.
- Integration of services from HS1 at Old Oak Common, and trains from the existing network south of Leeds, south of Manchester and at Lichfield.

4.22 It is clear that no detailed timetabling exercise has been carried out to demonstrate that capacity for the claimed service pattern is available, even on a theoretical basis.

HS2 Reliability

4.23 There are a number of factors which will impact on HS2's reliability

- The requirement for absolute precision in all aspects of operation. Operation at the claimed level of eighteen trains per hour requires trains to operate at an average interval of 200 seconds, little more than the absolute technical minimum.
- Presentation of trains from the existing network. Southbound, six out of the proposed eighteen trains per hour will have started their journeys on the existing network, in most cases having travelled significant distances over busy two track main lines, with a mix of fast and semi-fast passenger trains and significant freight flows. These routes present greater operating challenges than the south end of the West Coast Main Line, on which one pair of tracks is effectively only used by InterCity trains, all operating at the same speed. It is therefore not realistic to expect that these trains will always be precisely on time – but if they miss their "path", there will inevitably be significant consequential delays, as there is no resilience or spare capacity with eighteen trains per hour operation.
- The intensity of the planned operation of the section of route between the connection from Birmingham to the North and the junction for the "Y". The degree of precision required to achieve reliable operation of this section is clearly unrealistic.

- Presentation of through services from mainland Europe. These trains will inevitably be subject to risk of delay, having travelled on TGV Nord, through the Channel Tunnel, HS1, the busy North London Line and the single track tunnel between Camden and Old Oak Common – again, if they miss their "path" from Old Oak Common, there is a real risk of consequential delays to other HS2 services
- The pattern of operation proposed for Heathrow trains, with joining and splitting on-route, adds significant complexity and risk to the planned operation. Joining trains will require slower approach speeds approaching Birmingham Interchange, further reducing route capacity. Without a detailed timetabling exercise, which it is clear has not yet been carried out, the ability even to plan the proposed Heathrow services is unproven and indeed may well be impracticable.

4.24 As with timetable planning, it is clear that no work has been done to simulate the reliability of the planned use of HS2.

Reliability of Alternatives

4.25 As discussed earlier, the relationship between maximum speed and headway is crucial. The technical headway on the existing West Coast route, with a maximum speed of 200 km/h, is only about 1.67 minutes, giving an equivalent design capacity of over 30 trains per hour. However, as with HS2, the actual capacity of the route is dictated by constraints at stations and junctions, and the varied characteristics of the trains using it.

4.26 The alternatives evaluated by DfT in 2010 involved investment in specific pinchpoints, increasing overall route capacity, but still well below the design capacity of most sections of the route. DfT have claimed that this approach would reduce reliability, but this directly contradicts their consultant's conclusions in the "High Speed 2 Strategic Alternatives Study, which states:

"Even with higher levels of train frequency, the packages may enhance train performance at a network level…..these locations may more than compensate for other area where there will be an enhanced train frequency but no infrastructure enhancements" [6]

6

http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/rail/pi/highspeedrail/alternativestudy/pdf/railintervention.pdf Appendix B Section 1.1.1 page 16

Conclusions

- Operation of the planned 18 trains per hour is almost certainly impractical. Based on experience in other countries, the maximum realistic capacity is 12 – 15 trains per hour.
- A reduction in planned use to 12 – 15 trains per hour, together with the use of some paths for Heathrow and HS1 trains, will significantly reduce the available range and frequency of HS2 services to London, with a major adverse impact on the business case for the project.
- Government's claims that HS2 will operate more reliably than the existing West Coast Main Line are neither substantiated nor justified.