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TECHNICAL R E P O R T

Comparison of the Long-Distance Model and PLANET Long-Distance

Phase 2, Demand Model

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Prepared for High Speed Two Limited

The research described in this report was prepared for High Speed Two Limited.

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Published 2012 by the RAND Corporation
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Summary

High Speed Two Limited (HS2) was established in January 2009 to investigate the feasibility and credibility of building new high-speed rail (HSR) lines between London and Scotland. During 2009, HS2 developed a modelling framework for the assessment of high-speed rail options and, given the time available, the framework had to be based on an existing set of models. The PLANET suite was selected as a suitable set of models to assess different high-speed rail options.

The core of this model is PLANET Long-Distance (PLD), which is an updated version of the PLANET strategic model developed for the Strategic Rail Authority (SRA) in 2001–03. PLD is a multi-modal model of all-day travel across Great Britain that focuses on long-distance-travel demand, considering rail, car and air travel for trips selected to cover the market for the current HSR proposals. It is a trip-based incremental model, forecasting changes in travel demand as a result of an intervention relative to an exogenously-defined future do minimum matrix.

The Long-Distance Model (LDM) was developed on behalf of the Department for Transport (DfT). It is a multi-modal all-day model of long-distance travel demand that covers all of Great Britain. Long-distance demand is defined as trips more than 50 miles in length. The LDM is designed to be able to assess the impact of policies on all four existing modes used for long-distance travel (rail, car, air and coach) and is able to predict demand for HSR drawing on information from stated preference surveys collected during December 2009 and January 2010. The LDM is a tour-based model that is applied absolutely to base and future scenarios to pivot off base matrices.

HS2 commissioned two phases of work to compare the growth rate and demand model predictions from the PLD and LDM models, and to recommend how these should be handled in future HS2 analysis. Phase 1 is a comparison of the levels of growth predicted by the two models between 2008 and 2021, and is reported separately. Phase 2 is a detailed comparison of the demand model predictions in a scenario in which HSR is assumed to be available in the 2008 base year with a base-year comparison, so there is no impact of differential growth in trips over time. These phases were preceded by work undertaken in Phase 0, which delivered inputs necessary to the Phase 1 and 2 work. The Phase 2 work is reported in this document.

Below we summarise the structure of the incremental applications of LDM and PLD before going on to discuss the comparison between their predictions, additional PLD analysis and detailed analysis to compare the models at the production/attraction (P/A) level.

Incremental application of LDM

The reduced-segmentation versions of the LDM frequency, mode and destination choice models have been implemented in incremental form as an Excel spreadsheet that uses Visual Basic macros to implement the incremental model code. The incremental model, termed XLDM, predicts demand for HSR from P/A trip matrices split by mode, purpose and segment that are output from a base-year run of the LDM. Changes in generalised cost resulting from the introduction of HSR are calculated from level of service (LOS) supplied from 2008 base-year runs of the LDM. The 2008 base (without HSR) run is used to output classic rail LOS, and the 2008 with HSR Y-network run is used to output HSR LOS. All calculations are undertaken using the 406-district zoning system used in the LDM.

Two versions of XLDM have been implemented. The first predicts HSR versus classic rail choice as a probabilistic choice, consistent with how the original LDM model was estimated and implemented. The second predicts the HSR versus classic rail choice on the basis of minimum generalised cost. The second implementation does not correct the parameters to take account of the different calculations that are made in the minimum generalised cost version and consequently the generation and mode switch effects are always lower than in the choice-model version. If such a structure were to be used for forecasting, correction to the parameters would be required.

The total demand for HSR in 2008 predicted by the probabilistic version of XLDM has been compared with the HSR demand predicted by URS Scott Wilson when it applies the reduced-segmentation versions of the LDM models in absolute form. Total HSR trips match very closely for commute and visiting friends or relatives (VFR) /other, and closely for business.

Incremental application of PLD

The PLD mode-choice models have also been implemented as an Excel spreadsheet containing Visual Basic macros to implement the incremental model code. The incremental application, termed XPLD, uses the PLD model parameters (in 2008 values), and applies these parameters to LOS changes output from the reduced-segmentation version of the LDM to calculate changes in generalised cost, and then applies the changes in generalised cost to calculate changes in trips relative to the long-distance P/A trip matrices output from the LDM.

Important implications of this approach are that changes are forecast relative to LDM, rather than PLD base-matrix totals and on the basis of changes in LOS taken from LDM rather than from PLD. The LDM base matrices use the simpler LDM definition of a long-distance trip as all trips greater than 50 miles in length, rather than the more complex definition used in PLD.

When XPLD is used to predict demand for HSR, total demand for HSR is around half the level Atkins predicts when it forecasts 2008 HSR demand for the Y-network in real PLD, with the largest difference in trips between the two approaches observed for the VFR/other purpose. Tests demonstrated that the PLD predicted demand for HSR was highly sensitive to the values of HSR generalised access/egress time, and so differences in the definition of LOS between LDM and PLD are judged to be a significant factor in the substantial difference in total HSR trips.

Comparison of XLDM and XPLD predictions

During detailed validation of the XLDM model, it was discovered that some of the assumptions regarding HSR generalised access/egress could be improved: specifically the interchange penalty was high and the access legs to the first station were not weighted in a consistent way compared to classic rail as a main mode.

Enhanced HSR generalised access/egress LOS was generated with improved assumptions. This had only a minor impact on predicted demand for HSR in both XLDM and XPLD, with the effects of the two changes cancelling one another out, but nonetheless the enhanced LOS is taken to be a better definition and so was used for all subsequent comparisons.

The total demand predicted for HSR in a hypothetical 2008 situation is 96,700 trips per day in the XLDM probabilistic model, 86,100 in the XLDM minimum generalised cost model and 61,600 in XPLD. Checks for individual production zones suggest XLDM and XPLD demands are reasonably consistent in production zones with good access to HSR, but that XPLD demand for VFR/other travel may be lower for production zones where access to HSR is more difficult.

In terms of the composition of HSR demand, the probabilistic version of LDM predicts significantly higher levels of generation than PLD, in particular for business.

For all purposes, the LDM frequency response is more sensitive than PLD. It is noted that the LDM frequency parameters are estimated from observations of long-distance travel and include switching from shorter distances, whereas in PLD the frequency response is assumed to be one-third as sensitive as the next-level choice in the structure, based on professional experience; it is not clear that the PLD parameters are specifically based on long-distance travel or are drawn from contexts in which destination-switching is excluded.

The sensitivity of the LDM business model to frequency changes is relatively high, so that the generation response comprises 45 percent of total demand. A recommendation from this study is that the model structure for the LDM business model is reviewed if further model development work is undertaken; this review should look for evidence from other HSR schemes on the proportion of HSR demand for business that comes from generation.

If the LDM model is applied using the minimum generalised cost approach for HSR/classic rail choice, the proportion of HSR demand from generation is significantly reduced, whereas the proportion of classic rail capture is significantly increased. Therefore **the choice of modelling approach for the classic rail versus HSR choice has a significant impact on the composition of the predicted demand for HSR.** It is noted that proportions of generation and classic capture in the minimum generalised cost version of LDM are in line with those predicted by PLD. The significant changes in the composition of demand observed for the LDM model indicate that the model should be recalibrated if the approach for modelling HSR/classic rail choice is revised to minimum generalised cost.

Analysis has been made to examine the role of redistribution in the LDM predictions, which is done by distinguishing HSR demand from generation, redistribution from other zones summed across all modes, and pure-mode capture from the same destination. **The**

analysis runs demonstrate that redistribution makes a significant contribution in the LDM model, accounting for 20 to 40 percent of total HSR demand.

HSR fare elasticities have been run for all three sets of models, applying a 10 percent increase in HSR fare. **The elasticities in LDM are relatively high, with a total fare elasticity of -1.3. However, significantly higher elasticities are obtained if the LDM model is run with the minimum generalised cost approach, and the elasticities are higher still in PLD, with a total fare elasticity of -4.6.** This analysis demonstrates a significant reassignment effect to classic rail. Nonetheless the mode-choice fare elasticity is above two, demonstrating the predicted demand for HSR to be highly sensitive to the no-premium-fare assumption.

On the basis of the HSR access/egress time sensitivity tests and the HSR fare elasticity runs, **it is recommended that sensitivity tests should be run for the full PLD HS2 model to assess the sensitivity of predicted HSR demand to changes in modelled HSR costs and times.**

Additional PLD analysis

Following discussion at a technical meeting held on 10 January 2012 at HS2's offices, a series of additional analyses were run with the objective of understanding why the spreadsheet implementation of PLD (XPLD) predicts much lower levels of HSR demand than real PLD.

Comparison of the PLD and LDM rail cost skims in the base case without HSR demonstrated consistency in rail in-vehicle times. However, other components showed significant differences. In particular mean access/egress times are substantially higher in real PLD (given that the weighting of four was not applied we are not clear why this is the case); the PLD network skims have less frequent services; and the number of interchanges is substantially lower.

When the *difference* in cost skims that results from the introduction of HSR was calculated, the key difference was in access/egress times. In the with-HSR case, in PLD access to HSR services by classic rail forms part of rail in-vehicle time whereas, in the LDM-derived LOS access by classic rail forms part of access/egress time. Access/egress time is weighted by four in the generalised journey time calculation that determines the choice between classic rail and HSR, and as a result in XPLD, which uses PLD-derived LOS, HSR is predicted for a lower proportion of P/A pairs, specifically P/A pairs where the access legs to HSR are short.

The impact of mode-choice iteration on the levels of demand predicted for HSR in PLD was investigated.¹ The results suggest slightly higher HSR demand would be obtained if results from the first, rather the final, mode-choice iteration were used. However, this effect appears to be small.

The operation of XPLD was revised following the technical meeting. The key change was to change the choice between classic rail and HSR to use generalised journey time to

¹ When PLD is run, there is iteration between the mode-choice model, and the assignment models. Changes in the skims from the assignment models impact on the predicted mode choices, and so an iterative process is required in order to reach a point where demand and supply levels are in equilibrium.

mimic the calculation applied in the real-PLD rail assignment. This change has resulted in the total level of HSR demand predicted by XPLD falling further, from around half the real-PLD value to under 30 percent of the real-PLD value. This reduction follows from the high weight of four applied to access/egress time in the generalised journey time calculation.

Analysis of six test P/A pairs demonstrated significantly higher levels of base rail demand in PLD than in the LDM synthetic base matrices used for this work. The PLD base matrices are likely to be of higher quality than the synthetic LDM base matrices used in XPLD. These differences in base-matrix totals contribute to higher total rail demand in PLD for P/A pairs where both XPLD and PLD predict demand for HSR.

Multi-routing, whereby a proportion of rail demand between a P/A pair uses HSR at some point in the journey and a proportion uses classic rail for the entire journey, plays an important role in the real-PLD rail assignment. XPLD predicts demand for HSR as an all-or-nothing choice and so cannot emulate real-PLD behaviour for P/A pairs where multi-routing occurs. However, because the split in the multi-routing is balanced between cases with more and less than 50 percent of demand assigned to HSR, it is likely that the net effect of multi-routing is small.

It is our view that the different treatments of HSR between PLD and LDM, with HSR choice determined as an assignment choice within a single rail network in the former, and on the basis of completely separate HSR network with classic rail as an access mode in the latter, mean that it is not possible for XPLD to emulate the real-PLD results using the LDM-based LOS. If the LDM-based LOS were to be revised to achieve greater consistency in the treatment of access time between classic rail and HSR, then a better correspondence between XPLD and real-PLD predictions for HSR would be expected.

Finally, it should be emphasised that the issue of low predicted HSR demand relates to the application of LDM-based LOS in XPLD. The levels of demand predicted for HSR in the real version of LDM are much more consistent with those predicted in PLD.

Additional P/A pair analysis

Following discussion at the project steering group meeting on 20 February 2012 at HS2's offices, additional analysis was undertaken to compare the XLDM and XPLD models for individual P/A pairs. To facilitate comparison between the two models, these tests were made assuming HSR was introduced for individual P/A pairs offering 0, 15 and 30 minute time savings relative to classic rail.

Comparison of the continuous HSR/classic choice version of XLDM (XLDMC) and the assignment version of XLDM (XLDMA) demonstrated that XLDMC gives much larger mode shift and generation effects. Detailed investigations to understand these differences showed the main cause of the increased mode shift and generation effects to be the 'diversity benefit' that results from the addition of a new alternative when HSR is introduced into the LDM system.

The diversity benefit is large in minutes because of the small lambda values in the LDM, a consequence of the long tour lengths for long-distance travel. In XLDMA and XPLD there is no diversity benefit resulting from the introduction of HSR, despite the fact there would be a frequency benefit and in many cases a benefit arising from diversity of access points.

The XLDMA and XPLD models gave broadly similar results, with demand for HSR dominated by capture from classic rail. XPLD is more sensitive for generation and capture from modes other than rail, but XLDMA gives higher rail capture due to some capture from other destinations.