TEG TRANSPORT ECONOMISTS' GROUP

The Transport Economist

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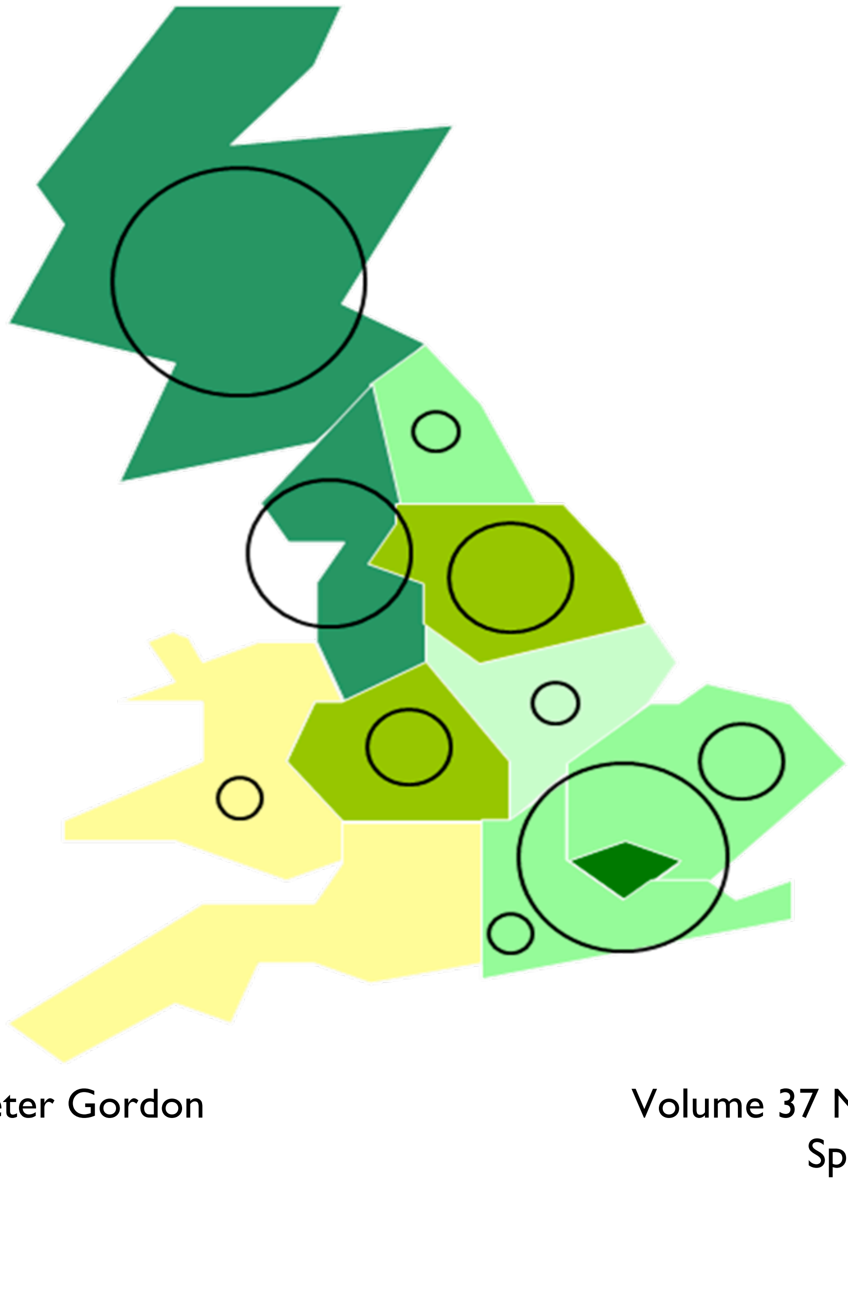

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A strategy for a high speed rail network in Britain – why do we want one?

John Segal, Director, Rail, MVA Consultancy

Arup

28 October 2009

INTRODUCTION

John Segal began by explaining that the objectives of a High Speed Rail network were not always obvious. His paper was as much about what we should be seeking to achieve as about defining what a network would look like. The paper was based on a study by MVA and SYSTRA (a sister company of MVA, partly owned by SNCF and engaged in studies of High Speed Rail worldwide) for Greengauge 21, but John emphasised that the presentation represented his own views and not those of Greengauge 21.

Greengauge 21 is a Limited Company that has formed a Public Interest Group of stakeholders, including many UK Regional Development Agencies, city councils, and rail and other transport operators, such as BAA. Central government is an observer.

The study, focused on developing a High Speed Rail strategy for the whole of Great Britain, was undertaken at the same time as two other studies:

- By Network Rail, which considered the need to build new lines, essentially to enhance rail capacity on specific routes
- By central government's High Speed 2 Ltd (HS2), on the route for a possible High Speed Line linking London with the West Midlands and beyond

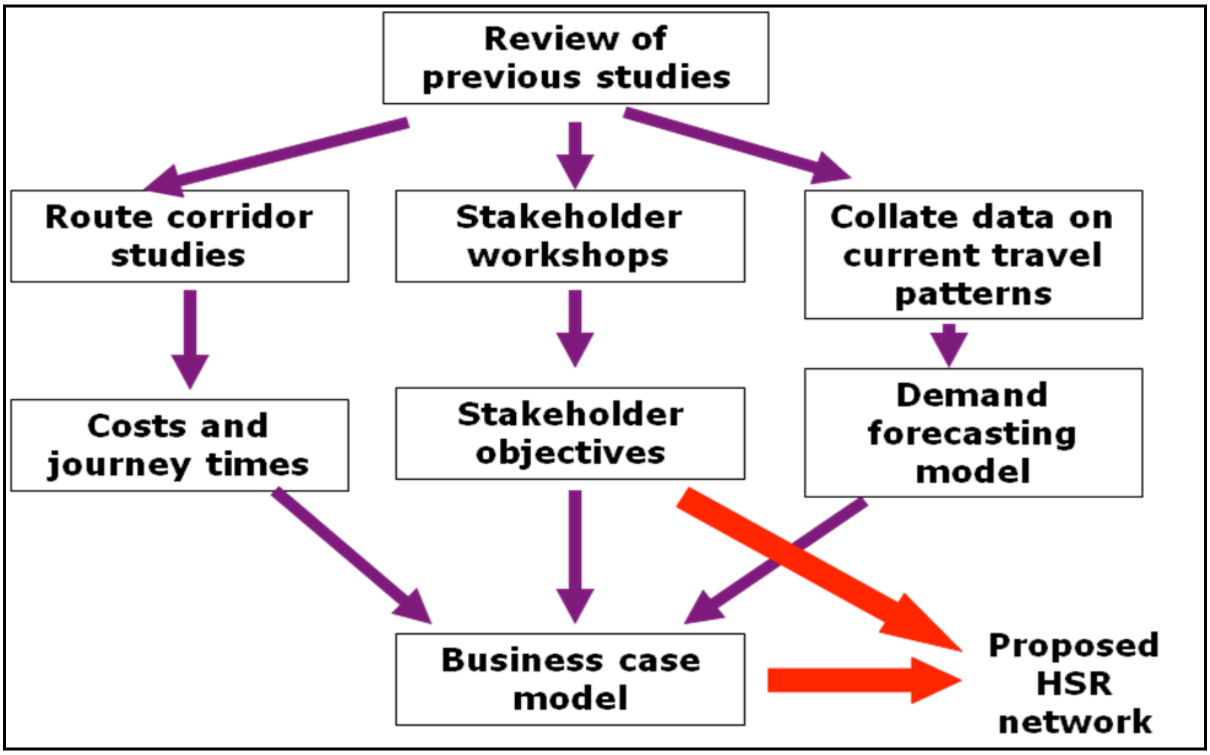
As John commented, High Speed Rail studies could be a bit like London buses: a long wait, then three come along together.

His study addressed the strategy for a High Speed Rail network; parallel studies covered funding arrangements, market research and public consultation exercises.

OVERVIEW OF THE MVA/SYSTRA STUDY PROJECT

The following diagram summarises the study process.

Figure 1: summary of study process



PREVIOUS STUDIES AND LESSONS LEARNT

The SYSTRA/MVA study was able to draw on various lessons learnt, by reviewing previous studies relating to both the UK and mainland Europe. First, it was apparent that increasing rail capacity was a principal catalyst for governments and other agencies to consider High Speed Rail and a primary objective in building High Speed Lines. John reminded his audience that the driver for the original Ligne à Grande Vitesse between Paris and Lyon had been capacity constraints on the classic line via Dijon.

Another lesson was that economic regeneration of regions and cities, while increasingly seen as important, is not an automatic consequence of High Speed Rail. To be realised it needs stations in city centres or other locations where economic activity can be generated, and complementary planning of economic activity. The evidence for this can be seen in France, where stations in city centres such as Lille or Lyon had been very successful but there has been little or no economic generation around those outside urban centres.

Japan had successfully developed commercial activities around new stations outside cities, but greenfield development around stations in the UK would be difficult because of planning constraints. There is also the risk of abstracting economic activity from smaller localities to main centres through increases in longer distance commuting.

If High Speed Rail is to achieve its objectives, good access to stations, especially by public transport, is very important, as is integration with the existing rail network, including operating through services.

Technical standards on gauge, train length, gradients, curvature, and other matters need to be established early, so that a homogenous network can be developed. These are mainly now prescribed by the European Commission (EC) through the European Railway Agency (ERA). The maximum potential line capacity is seen as 15 trains per hour (tph), assuming adoption of the European Rail Traffic Management System (ERTMS) of signalling. However, the overall capacity could be significantly reduced by junctions and/or intermediate stations, each of which also adds around 10 minutes to the journey time of a 300 km/h train. Timetables on the French TGV network are currently planned at a maximum of 12 tph.

STAKEHOLDER REQUIREMENTS

The study team defined a set of what it termed "Guiding Principles" based on the responses from stakeholders. Essentially these represented the objectives which stakeholders wished to see achieved through development of a high speed network. While the various stakeholders accorded different priorities for each of the objectives, all agreed on the list as a whole.

The Guiding Principles agreed for the study were to consider developing a High Speed Rail network in order to:

- Provide additional transport capacity, both on long distance routes and for access to cities
- Stimulate local economies in a sustainable manner
- Address the whole journey, and provide an attractive lower carbon alternative to car use
- Achieve modal switch from air to reduce the carbon impacts of longer distance travel

- Form an integrated part of the whole transport network with phased delivery to maximise overall value and the spread of benefits across the nation, both geographically and socially.

In the context of these Guiding Principles, the Association of Train Operating companies (ATOC) provided its own well-founded study of the carbon impacts of different modes of transport, taking into account load factors. Short-haul air travel is seen as particularly carbon inefficient.

ROUTE SELECTION

Designing specific alignments or choosing particular station sites was not part of the study. The work was conducted at a higher level, but did need to look at general routes in order to establish their feasibility, estimate journey times and provide indicative costs. The route work was at a level sufficient to provide indicative lengths for tunnels and other major structural works. It also considered access to city centres and potential broad localities for stations. Defining specific station sites was avoided in order to obviate any potential for planning blight.

Infrastructure costs were based on experience with High Speed 1 (HS1) in the UK and high speed lines elsewhere in Europe. Similarly, UK and other European experience was used to provide operating costs for infrastructure, train services, retailing and other inputs to the study.

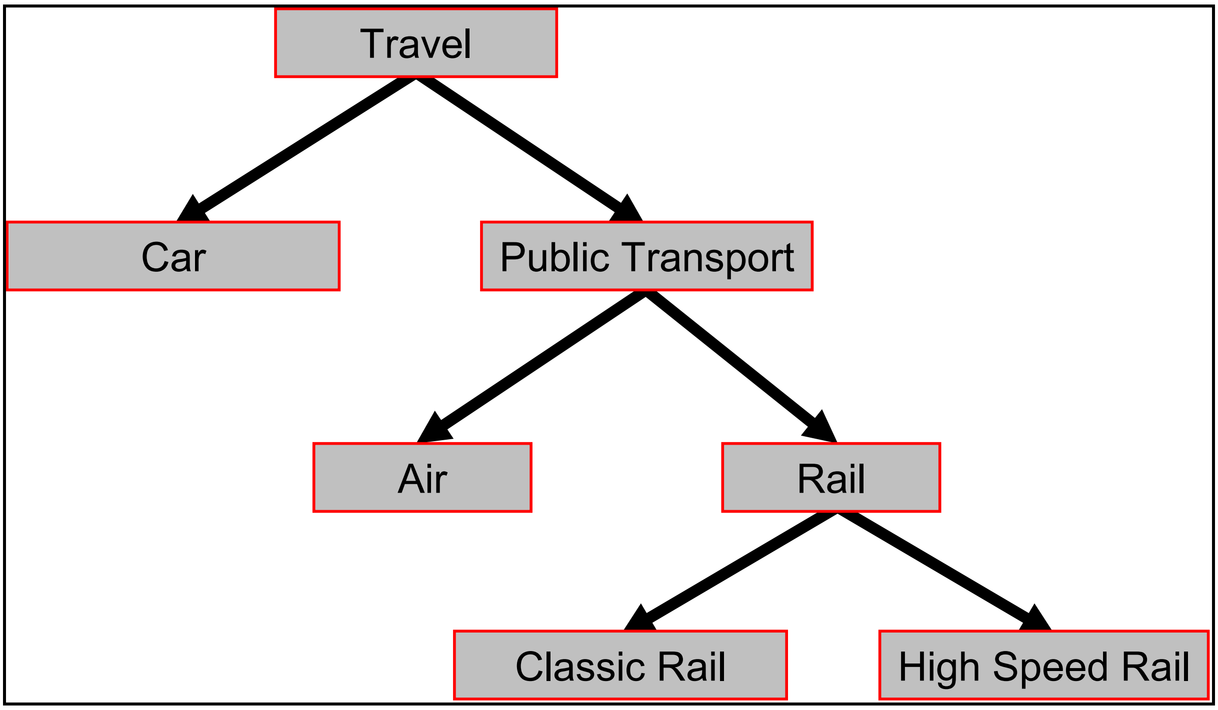
Consideration of the institutional arrangements for financing and/or operating high speed lines and services was not part of the study.

DEMAND FORECASTING AND MODELLING

A hierarchical logit model was used to forecast demand for High Speed Rail. Three primary modes were included in the model: air, rail and car. High Speed Rail was included as a secondary modal choice alongside classic rail, as shown in Figure 2 below.

Coach travel was only included as a mode in the context of travel to London Heathrow airport, since the existing substantial differences in journey time from rail on other routes suggest that coach users have a low value of time. Similarly, some elements of demand were considered captive to specific modes: for example, it was assumed that large families travelling on holiday would continue to use their cars. It was also assumed that the additional demand generated by High Speed Rail would not occur in its absence.

Figure 2: logit model hierarchy



For forecasting purposes the country was divided into some 38 zones around on city centres and other attractors of demand. The choice of zones sought to reflect the much higher rail modal shares for travel between city centres (especially to and from London) and the different competitive situations of the various modes.

The data used to calibrate and validate the forecasting model were:

- Rail: LENNON is a good data set based on ticket sales, but only provides station to station flows and not details of passengers' origins and destinations. The National Rail Travel Survey (NRTS) provides journey purpose and actual origin/destination details, which could be aggregated to the zoning system adopted for the study.

- Air: CAA has a large and established survey, providing point-to-point and interlining details by airport as well as origin and destination information for air travellers. The CAA is also able to provide good information on coach travel to and from Heathrow.

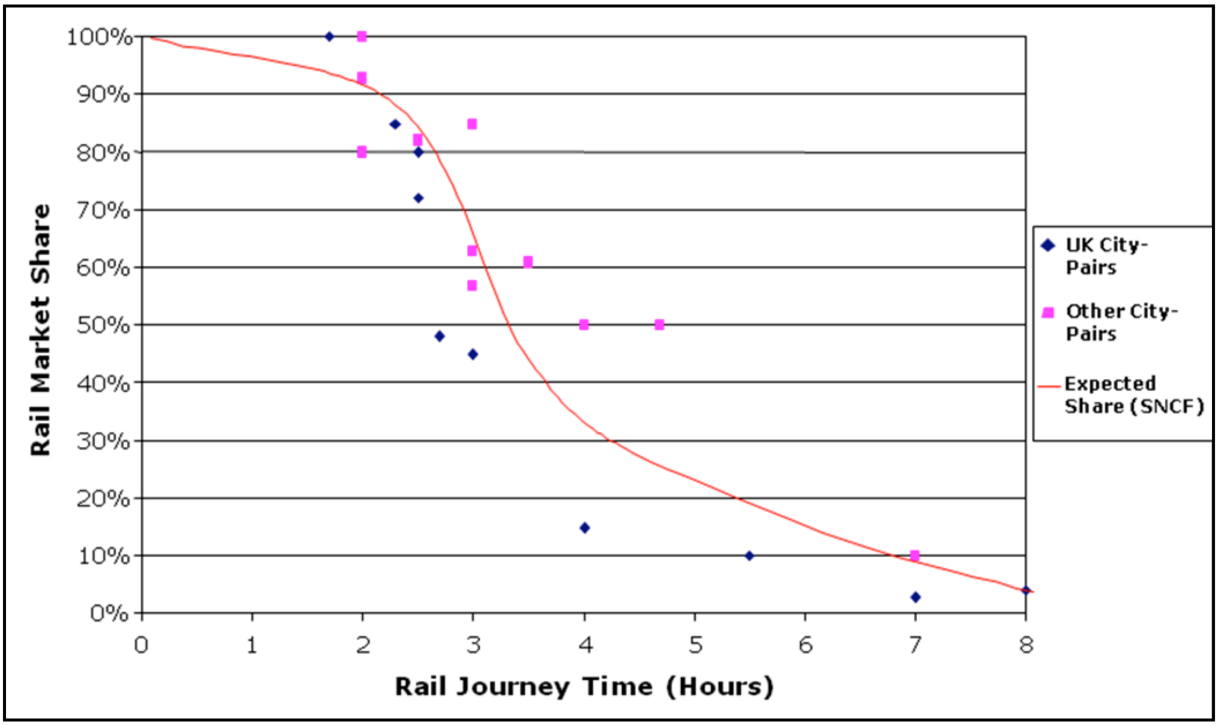
- Car: obtaining good data on car travel is always a problem for all models. Information from the National Transport Model was used with some smoothing of demand to remove anomalies.

The hierarchical logit modal choice model was calibrated using this data to ensure both that current mode shares were accurately reproduced on a zone-to-zone basis and that the model's sensitivities to changes in cost and time of rail and other modes were as expected. The model had to satisfy both of these conditions to provide confidence in the forecasts.

The model applied generalised costs in terms of units of minutes. The inverse of the value of time was used as the coefficient of fare/cost. Different scale parameters were adopted at different levels in the model, driving the model's sensitivity. Adoption of mode constants ensured a good match with the base mode shares.

The elasticities and sensitivities used came from the railway Passenger Demand Forecasting Handbook (PDFH) and from the following well-established graph of air versus rail mode shares (Figure 3). This mode share depends principally on the rail journey time, since there is little difference in overall air journey times within the range of distances considered.

Figure 3: rail mode share as a function of journey time



The differences between the data points for the UK and for other city pairs (mainly French) can be accounted for by higher rail fares and the more dispersed nature of urban housing in the UK, with people living further from city centres and closer to airports.

APPRAISING THE NETWORKS

The appraisal of the various network options was carried out against the multiple objectives set out in the “Guiding Principles”, including:

- Demand and revenue
- Capital and operating costs
- User and non-user benefits, such as reduced highway congestion
- Carbon impacts
- Wider impacts such as on land use and regional economic activity

The methodology employed was compliant with NATA and WebTAG, except that demand was allowed to grow beyond 2029. Some 15 scenarios were tested as part of the study. The base forecast assumed continued growth in air travel.

The appraisal looked, in particular, at how the various benefits accrued to different cities and regions. These were assessed by allocating most of the user benefits equally to the regions between which they occurred, with no distinction between production and attraction regions. Only a few of the benefits, such as road decongestion, could not be specifically allocated to regions.

The wider economic benefits (WEBs), such as the effects of agglomeration and improved competition, were also identified to regions. These were assessed in a number of ways. The change in average accessibility from each of a number of small zones was based on the weighted average generalised cost from the zone to all destinations. The effects on employment were estimated using a land use interaction model based on DELTA (a model developed by the David Simmonds Consultancy). The wider impacts were calculated in accordance with the established (rather than the current draft) DfT guidelines by inputting the changes in employment and average accessibility into the appraisal.

The study found that the wider economic benefits typically ranged between 15% and 25% of journey time benefits, which intuitively appeared to be of the right order of magnitude. Annex 1 shows the total 60-year present value of regional economic benefits (journey time and WEBs) and the wider impacts (WEBs) alone for a number of broad regions. The very high benefits for Scotland result from the very substantial changes in journey times which High Speed Rail would bring.

KEY CONCLUSIONS

High speed trains should operate beyond a core network onto the classic network in many cases. It would be seriously unwise to restrict services just to the high speed lines. However, the largest benefits accrue from being able to operate very high capacity trains on the core network. The core network should be engineered to EC requirements for new high speed lines, based on UIC (International Union of Railways), for 400m long, double deck trains capable of providing over 1000 seats.

Stations need to be in city centres in order to provide good (public transport) access and to reinforce economic planning policy. This enhances the agglomeration benefits. There may, however, be a role for specific “Parkway” stations, provided they have good public transport access as well. Airports may prove to be suitable locations for such “out-of-town” stations, as they are often well-connected. On TGV calls at Roissy/Charles de Gaulle airport, around 25% of passengers alight and are replaced by boarders.

High Speed Rail can release capacity used by existing intercity trains on the classic network, and this can be used to run additional local trains for commuters and more inter-regional services. Freight can also benefit from using part of the released capacity, particularly on the West Coast Main Line route. Wider impacts accrue from some transfer of freight from road to rail.

The total demand for High Speed Rail north of London is likely to exceed the capacity of a single two-track route by about 2040. A four-track route was estimated to cost 1.8 times as much as a two-track route, and a second two-track route would give significantly higher benefit-cost ratios (BCRs) than one four-track route. According to RFF, the French rail infrastructure provider, TGV Sud-Est is nearing capacity. RFF and SNCF are currently considering whether to quadruple or to build a second route on a different alignment to serve different locations.

The strongest case for the initial route is from London to Birmingham and Manchester:

- Birmingham alone is not seen as viable
- Manchester with a branch to Birmingham is more attractive than Manchester via Birmingham
- Extension to Scotland would have a strong case, given the ability of High Speed Rail to abstract traffic from air

An East Coast high speed route to Leeds and Newcastle is needed later for capacity and journey time reasons. However, while journey times from London to Glasgow and Edinburgh via a West Coast alignment are approximately equal, times to Glasgow are much longer via an East Coast route. The case for extending this East Coast route to Scotland therefore rests on issues of capacity on the West Coast route and on providing connections between Scotland and eastern England.

Heathrow is worth serving both as an airport in its own right and as a transport hub for west London and the Thames Valley, but should not be on the direct route between London and Birmingham because of the impact on journey time and capacity. Rather, it should be served by a branch from the West Coast route, which would also offer an opportunity for through services to destinations south of London. The study noted that a large element of domestic air travel, including around 70% of air traffic from Manchester to London, is transfer traffic via Heathrow. High Speed Rail could capture a large part of this traffic given suitable journey times and an attractive service frequency and providing that the rail leg formed part of an integrated transport offer.

South West and Wales can probably best be served by a partial upgrade to the existing route rather than building a new high speed route on an entirely new alignment.

A link to the Channel Tunnel via HS1 is worthwhile if it can be provided at reasonable cost.

Annex 2 shows the economic impacts of a possible High Speed Rail network. The study forecast that a network would make an operating profit, but that this would be insufficient to pay for the entirety of the capital costs.

Annex 3 shows a possible High Speed Rail network. It is assumed that 400m long, double-deck high capacity trains would operate only on the core new network, with British gauge trains running over the upgraded lines and to reach destinations off the new network.

DISCUSSION

Peter Gordon (Editor, The Transport Economist) noted that the analysis suggested there would be five time more passenger journeys diverted from air than from car. However, car travel represented a much larger market. Might this indicate the need for a more extensive High Speed Rail network than the one suggested in the presentation?

John pointed out that High Speed Rail needed at least 100 miles between stops to achieve the desired improvements in long distance journey times. However, the major proportion of car journeys were well under 100 miles, so only a relatively small number of them were relevant to any analysis of modal shift. Trains on a High Speed Network would not stop as frequently as on current intercity routes. However, intermediate destinations would benefit from the capacity released on the classic network for more frequent services running at the existing maximum of 200 km/h.

Michael Schabas (Independent Consultant) was concerned that defining High Speed Rail as a separate mode in the logit model introduced the "Red Bus / Blue Bus" problem, which could lead to an overestimation of demand.

John doubted that this was the case, since a hierarchical logit model had been used. Also, the static and dynamic calibration of the model should have eliminated any potential for significant error.

A visitor from the South West Regional Development Agency (South West RDA) felt that the South West could suffer massive disbenefits from the High Speed Network suggested by the study, since only electric trains capable of running at 300 km/h would be able to access it. In his view this could mean a loss of through trains to the South West, with consequential loss of economic activity.

John rejected this view. He pointed out that the study had assumed implementation of current electrification plans and aspirations for the classic network. Experience in other countries was that High Speed Trains operated well beyond the limits of the dedicated network in order to provide through services.

Dick Dunmore (Steer Davies Gleave) recalled that when modelling High Speed 1, Eurostar had been positioned first as a "rail" competitor to existing rail-ferry-rail services, but later as a "fast" competitor to air, which had proved to be more realistic. Had indicative assumptions on fare structure, reservations policy and sales channels for high speed rail been set out, and would they have any influence on where it should be in the model hierarchy?

John responded that the question was really outside the scope of the study. The sales channels for air and longer distance rail tickets were becoming more similar, with many more purchases via the internet. His personal belief was that as load factors continued to increase the traditional “walk-on” basis for rail travel would have to be addressed in some manner. Compulsory seat reservations on classic intercity rail services might become a necessity before too long, although this need not preclude the ability to “walk-on” given sufficiently sophisticated real-time computer systems.

Stephen Glaister (RAC Federation) noted that, according to the study, development of High Speed Rail led to massive growth in demand for long distance rail services, thus requiring a second High Speed route to be proposed for later in the period under review. This suggested that the pricing levels assumed in the study were too low. What did the economics look like if the average ticket prices were pitched higher?

John explained the social and geographical accessibility to High Speed Rail had been driven by the “Guiding Principles” of the study. Hence, a detailed analysis of the effects of pricing-off demand had not been part of the study remit, but sensitivity tests had been undertaken. Indications were that higher ticket prices would reduce the BCR.

Tim Leunig (LSE) pointed out that the analysis of previous studies had shown that increasing rail capacity was a primary objective. In that case, might not a large proportion of the benefits be realised by running longer trains with higher density seating on the existing network, rather than providing additional expensive infrastructure? In comparison to companies like Ryanair, he did not perceive SNCF as one of the most financially successful travel providers in Europe.

John reminded the audience of the structure gauge and length limitations imposed by the existing infrastructure, and the difficulties experienced on the West Coast Main Line in modifying an operational railway. The French TGV network operated at around 70%-80% load factors, compared with nearer 50% for intercity services in the UK. Double deck TGVs could carry around 1,000 people, improving the utilisation of infrastructure capacity compared with the classic network.

David Simmonds (David Simmonds Consultancy) wished to record that his organisation had not carried out a full scale land use modelling exercise as part of their input to the study. Only a much simplified DELTA model had been used. He was also concerned that the study had not taken into account the requirements for additional facilities to cope with the large numbers of passengers shown as arriving at a London station and requiring onwards travel. The costs of providing for this local distribution could be high.

John acknowledged that the costs of providing additional local distribution facilities had not been included in the appraisal. However, discussions with the relevant bodies had suggested that, within the timescales envisaged, the capacity improvements required were feasible and many of them were already envisaged.

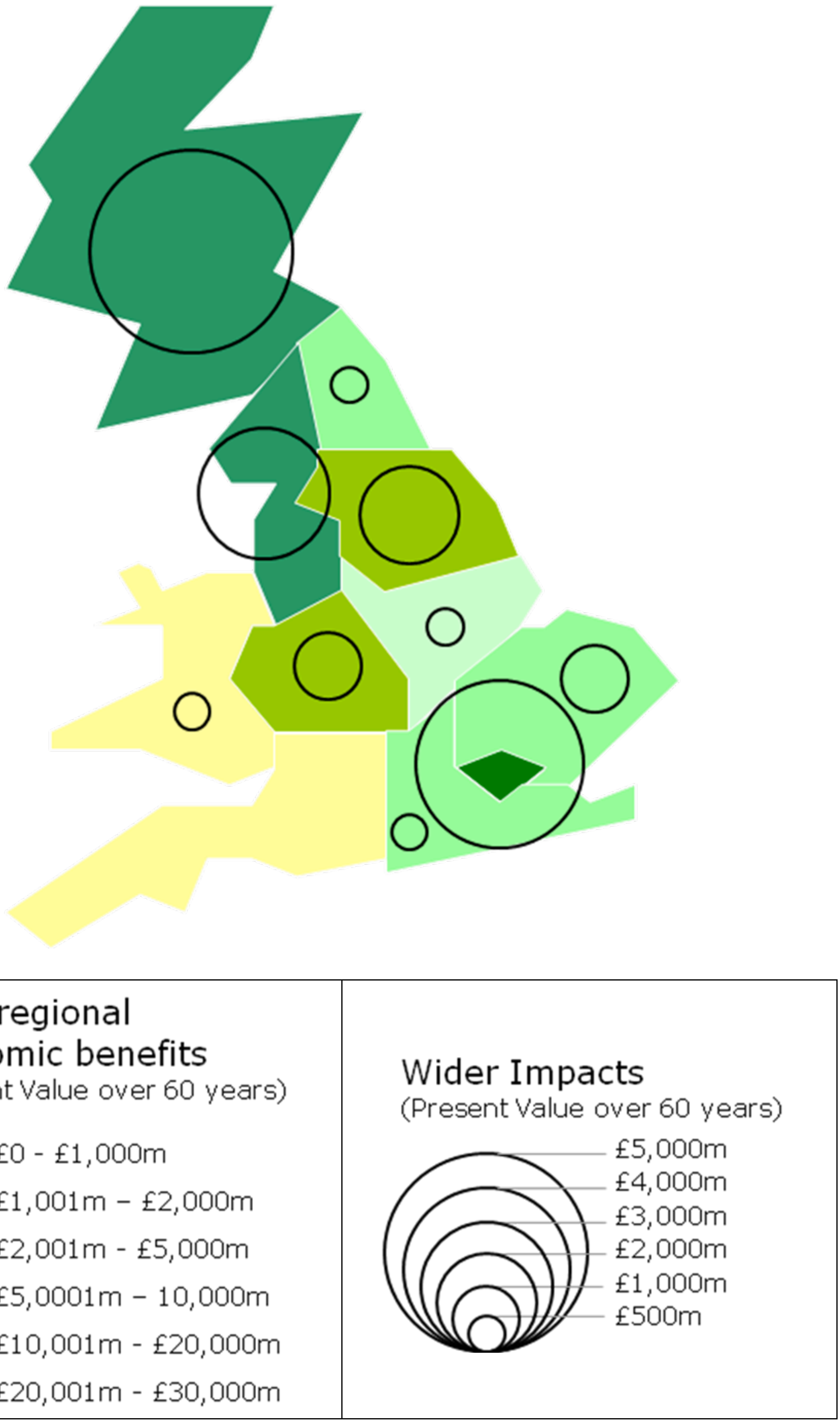
Tim Elliot (Mouchel Limited) felt that the demand for internal flights to Heathrow would tend to decline as regional airports became busier and could justify through flights to a greater range of destinations. Also, any rail links would need to be as seamless as possible, including provision for baggage handling, if transfer passengers were to be attracted from using internal flights.

John explained that BAA had been one of the stakeholders consulted as part of the study. Baggage had not been seen as a significant issue for attracting transfer passengers to High Speed Rail, but through ticketing had.

Julie Mills then thanked John Segal for his paper and closed the meeting.

Report by Gregory Marchant

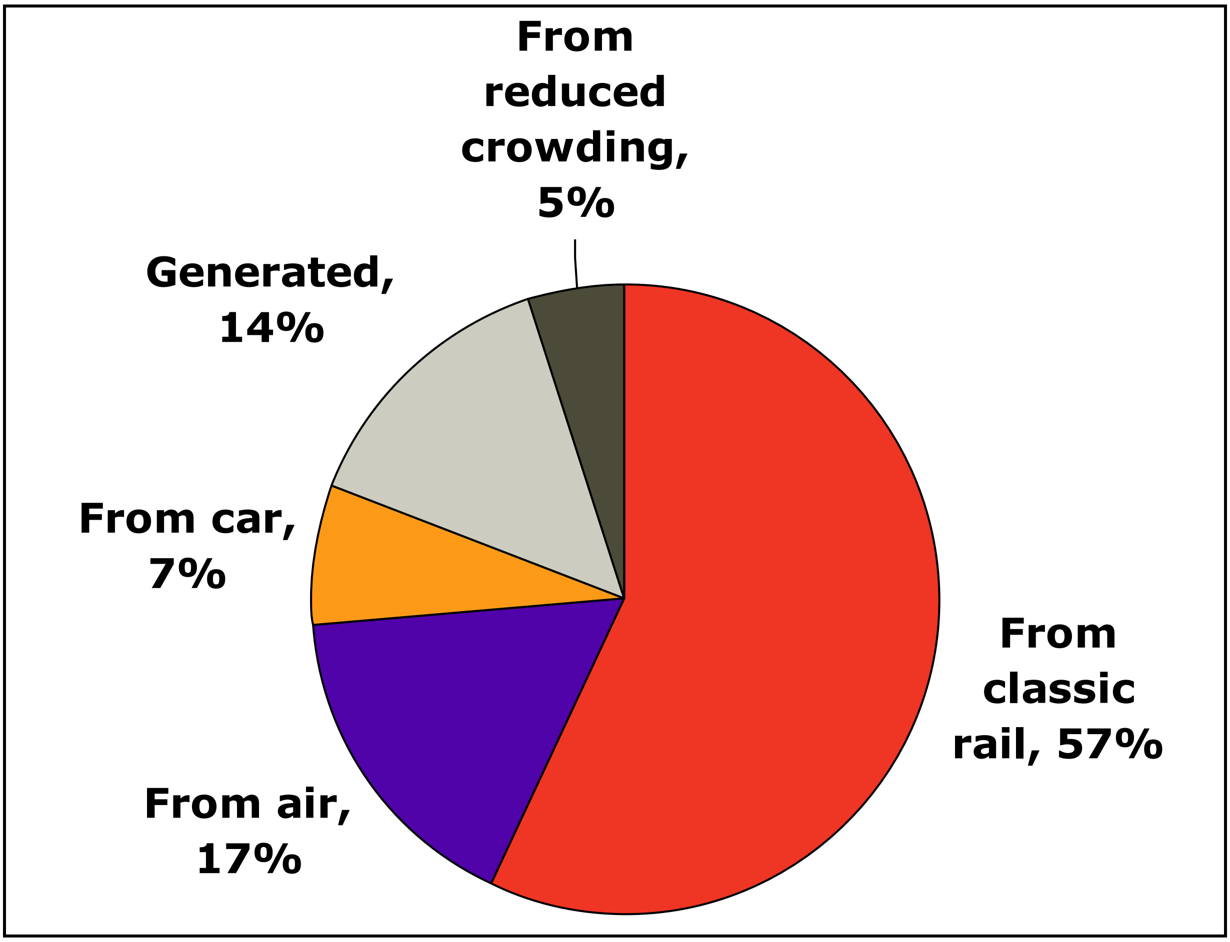
ANNEX 1 - REGIONAL ECONOMIC BENEFITS



ANNEX 2 - IMPACT OF A HIGH SPEED RAIL NETWORK

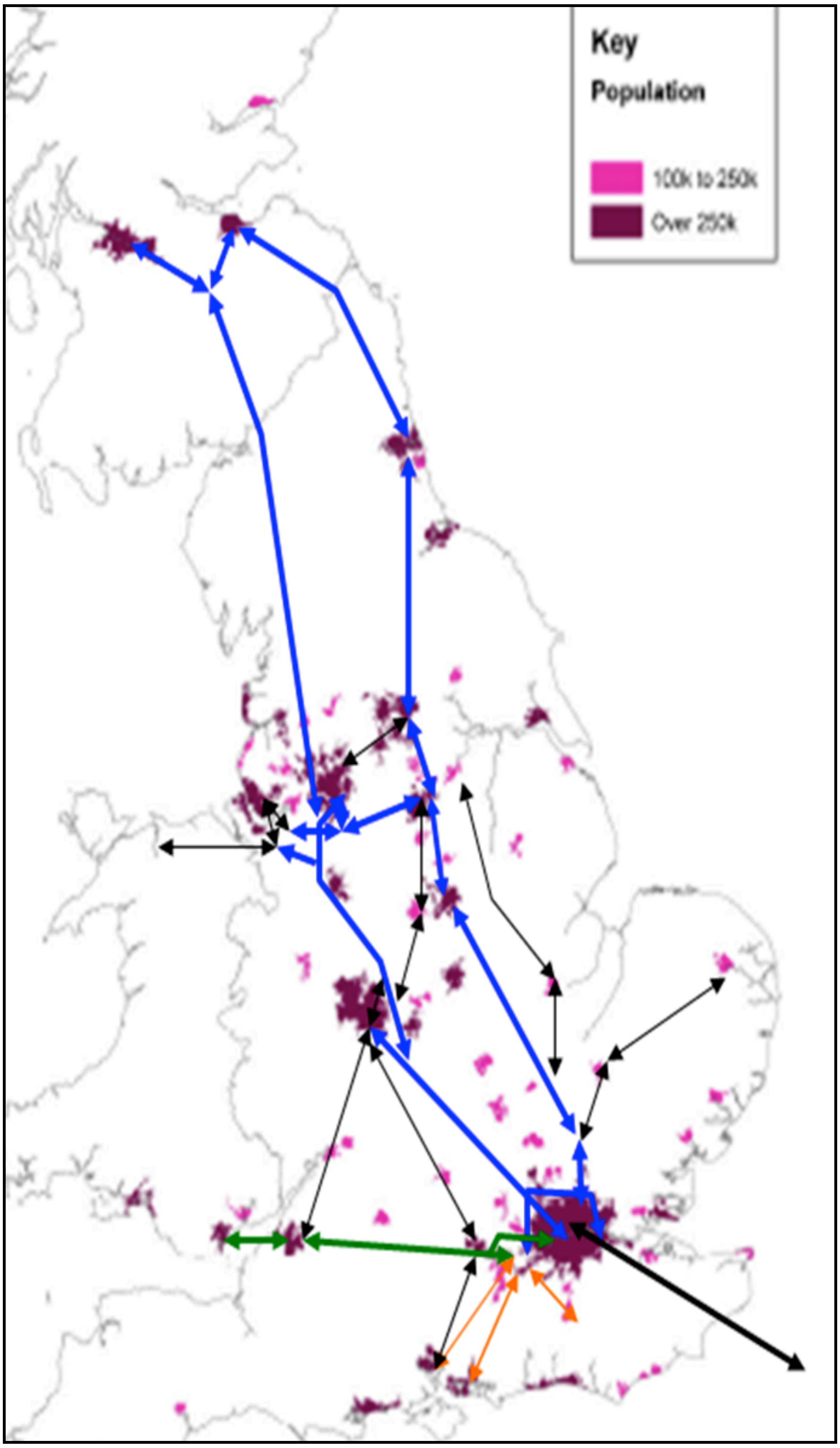
Infrastructure cost	£69 billion
Increase in rail OPEX	£2.6 billion
Increase in rail revenue	£4.6 billion
NPV of user & non-user benefits	£89 billion
NPV of wider economic benefits	£11 billion
BCR for public sector funding	3.5:1
Car-km removed	2.7 billion per annum
HGV-km removed	0.4 billion per annum
Air passenger km removed	18 billion per annum
Tonnes of CO_2 saved	1 million per annum

178 million trips by High Speed Rail forecast by 2055, including diversion from an expanded number of air travellers, was as below.



ANNEX 3 - POSSIBLE HIGH SPEED RAIL NETWORK

(blue line)	Core High Speed Routes
(green line)	South Wales & South West
(thick black line)	HS1 to Channel Tunnel
(orange line)	Links via London Heathrow to Southern England
(thin black line)	High Speed services on classic routes



Valuing transport's impact on the natural landscape

Allan Provins, Economics for the Environment Consultancy

Arup

25 November

BACKGROUND

Allan Provins began by explaining that he would be outlining the emerging findings from an ongoing project for the Department for Transport (DfT) being undertaken by *eftec* with support from Accent, ADAS and TRL. The overall aim of the project is to provide the information required by DfT for appraisal of the impact of transport projects on the natural environment. This requires empirical research that provides representative and transferable monetary values for the landscape "good", covering the visual amenity, tranquillity, recreation and cultural heritage elements within DfT's appraisal framework.

There are two approaches to estimating transferable values. The unit value transfer approach (as commonly used in transport appraisal such as through values of time) works well where there is a good correspondence between goods and sites. The value function transfer approach is more appropriate where goods are similar but sites are heterogeneous.

APPROACH

The basis for the research is a Stated Preference (SP) study to estimate changes in consumer surplus. The study applies the contingent valuation method to estimate the willingness to pay (WTP) to prevent the landscape impacts of transport schemes. This was considered to be the appropriate basis in this study as landscape is a bundled good and its attributes are not independent. The first phase, scoping and typologies, and second phase, design and testing, including the pilot survey, have been completed. Phase three, if the go-ahead is given, will be implementation of the full survey and analysis of the results.

The economic value of individual (*i*)'s WTP to prevent the landscape impact of a transport scheme is estimated by the general form function:

$$WTP_i = f(P,\ Y_i,\ L^0 - L^1,\ X_i)$$

where:

- P = prices of other goods and services
- Y = household income
- $L^0 - L^1$ = landscape impact; change in landscape quality where L^0 (pre-scheme) > L^1 (post-scheme)
- X = substitutes and other explanatory factors

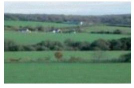
Phase 1 of the study developed a typology of seven transport scheme types and five landscape types, giving 35 potential “valuation scenarios”.

Site-specific factors will also have an influence. Expectations before the pilot survey were that:

- WTP will vary with scheme and landscape type
- WTP will be influenced by site-specific factors such as environmental designation (as a proxy for high quality natural landscape), unique features (such as cultural elements), level of development, and mitigation features
- WTP will be positively related to household income
- WTP will be negatively related to abundance of substitutes
- Familiarity/use of the site will influence WTP, with a distance decay effect as more substitutes become available
- Other socio-economic/demographic factors will influence WTP but need to be identified empirically

The landscape typology from Phase 1 covers the range of landscapes found in England. Similarly, the seven types of transport scheme were based on those expected to be appraised now or in the future. Given that sampling requirements made a set of 35 scenarios impractical for the Phase 2 study, the range was narrowed by focusing on all types of schemes against one landscape type and by ruling out “Mountains & Valleys” and “Coastal” lands as affected by few schemes in practice.

Figure 1: Valuation scenarios

Transport Scheme	***Landscape Type***				
	 Mountains & valleys	 Moors, hills & dales	 Rolling lowlands	 Lowlands	 Coastal lands
Single carriageway (offline)			✓		
Dual carriageway (offline)		✓	✓	✓	
Widening single to dual (online)			✓		
Widening dual 3 to dual 4 (online)			✓		
Active traffic management (online)			✓		
High speed rail (offline)			✓		
Park & ride			✓		

SP SURVEY DESIGN

The SP questionnaire was tested and retested with focus groups, cognitive interviews and a pilot survey in various locations across England. In developing the valuation scenarios, actual transport schemes were reviewed, and landscape impacts specified through descriptions and the gathering of visual material.

The scenarios presented were:

- A dual carriageway road (offline), such as a bypass, on rolling lowlands with a cultural heritage impact
- A non-local single carriageway road in either moors or rolling lowlands, to assess non-use values
- A high-speed railway line in rolling lowlands
- Three types of motorway scheme, including widening and Active Traffic Management (ATM), in rolling lowlands
- A park-and-ride scheme in rolling lowlands, inside a designated Area of Outstanding Natural Beauty (AONB)

In the pilot, 158 respondents were surveyed and presented with two scenarios (either a local scheme and a non-local scheme or two local schemes) giving a sample total of 316. Scenarios were presented by means of a verbal explanation, text on showcards, CAPI (computer assisted personal interviewing) showscreens and other visual material. It was found that a using variety of formats gave best results.

The material showing the before and after views of the landscape were presented from a variety of different perspectives and had some element of subjectivity as they required photo-manipulation. The results were tested in focus groups and seemed to give a good balance between resources and results.

Figure 2: Example of summary card

	Current Situation	New Dual-carriageway
Landscape *Short distance*		
Mid distance		
Tranquillity	• No major sources of noise	• Additional road noise will be audible over a wide area
Recreation	• Footpaths in area used for recreation	• The road will affect views of the White Horse hill figure and be visible and audible from footpaths
Other impacts	*Please do not consider*	

Original images: ADAS UK Ltd. Manipulated images: iSev Ltd.

WTP was elicited by presenting respondents with choices between the situation with the scheme with a zero payment or the current situation, with a payment ladder, to understand how much they would pay to retain the current situation. A series of entreaties were developed to probe motivations for responses provided and to focus respondents on the landscape impacts only of transport schemes. The payment vehicle was not specified (a “magic wand” approach) in order to exclude protest responses to alternatives such as council tax payments.

PILOT SURVEY AND RESULTS

The results from the pilot survey are promising, with several statistically significant variables and emerging values for a function transfer model. The overall R2 statistic was relatively low, unsurprisingly given that the pilot only had 227 observations, although the F statistic was significant.

Overall, 22% of respondents state they would be willing to pay to avoid landscape impacts. The mean WTP is £16 per household: there are some quirks between scheme type, but the results presented in Figure 3 opposite have not been corrected for outliers and protest responses (where the contingent market is rejected). When outliers and protests are excluded there is a much narrower range of responses, with a mean WTP of £2.27 per household.

An overall theme from the study so far is that the effects of a transport scheme are a “bundled good”, comprising positive and negative elements, with landscape effects forming only one element. Once the questionnaire design has successfully screened out the other attributes, it is clear that landscape effects are not a major determinant of well-being relative to other impacts. In particular, for many schemes landscape is seen as non-unique and to have a large number of substitutes. There will of course be cases where schemes impact on high quality landscapes and expectations here would be for larger WTP values to prevent landscape impacts.

The determinants of WTP confirmed prior expectations. The key predictors are income (as modelled by socio-economic group), perceived impact, and habituation/adaptation to impacts. There was some variation in WTP by type of scheme, but results were limited because of the small sample. Unique landscapes do have non-use values. Proximity/frequency/familiarity does seem to have an effect on WTP, probably because this limits the substitutes seen to be available: a distance decay function is therefore something to pursue in Phase 3.

Figure 3: Indicative WTP results

Scheme	Prob. WTP	WTP	n
	Mean	Mean WTP (£/hh)	
Dual carriageway (offline)	0.33	16.19	48
Single carriageway (offline) (NU)	0.20	22.70	110
High speed rail (offline)	0.30	14.32	50
Widening single to dual (online)	0.10	21.67	50
Widening dual 3 to dual 4 (online)	0.15	0.63	27
Active traffic management	0.33	15.76	21
Park and ride	0.13	2.07	30
Total	**0.22**	**15.98**	**316**

NEXT STEPS

The SP questionnaire for Phase 3 has been prepared and is ready to be used with a larger sample size to estimate transferable monetary values. The Phase 2 testing has demonstrated that the questionnaire is effective in collating WTP evidence, consistent with theory and qualitative research. It has demonstrated the importance of scheme type, population characteristics and spatial factors in determining WTP and hence in controlling for these in scheme appraisal. The work so far has also shown that the model would be enhanced by a distance decay function.

DISCUSSION

Peter Gordon (Editor, The Transport Economist) queried how reliable are people in assessing impacts when air quality and noise impacts tend to be less in the countryside.

Allan agreed this was an important issue and was part of the reason for carrying out so many cognitive interviews. The strategy was to be concise in descriptions, so as not to put too much burden on respondents.

Andrew Spencer (WA Fairhurst) asked about the element of proximity to respondents' homes and how this affects valuations.

With a bigger sample size, allowing a stratified sampling strategy, this issue would be explored to determine the distance decay function. Ideally, a distinction would be made between respondents who live in the immediate area of the scheme, locals, visitors to the area and the non-use population.

Gradimir Stefanovic (GS Transport Consultancy) commented that the work appeared to be a good tool for transport planners, but asked for whom the views are being protected: local residents or passers-by in cars, who might enjoy the views as they travel.

Allan explained that the work was looking only at one feature in the appraisal guidance and does not address journey ambience.

Tom Worsley (Department for Transport) asked whether the project was looking at the impacts of roads or roads plus traffic.

There was a textual prompt giving summary information on how busy a road would be, so the survey examines tranquillity and lighting effects, for example, but not noise.

John Dodgson (independent) asked whether the average value of £2.27 WTP per household was an annual figure.

For the purpose of the pilot survey, respondents were asked for a one-off amount, but a payment period could be specified. Values elicited in the pilot ranged up to hundreds of pounds for some respondent households, with maximum observations being £500 (the highest amount on the payment card). While the average value looks low, it excludes the highest outliers and the total valuation of the landscape effects would depend on the size of the affected population and how this was quantified. This is why the distance decay function is needed. It also reflects the fact that many landscapes are not unique and have substitutes.

Dick Dunmore (Steer Davies Gleave) referred back to historic analysis of the effect of new roads on house prices and suggested that a similar revealed preference analysis be carried out on WTP for hotel rooms.

Allan said the study had considered hedonic models but they would not generate non-use values. Transport noise is an example where a good study using hedonic methods has been undertaken.

John Cartledge (London TravelWatch) suggested that some people considered man-made structures to be adornments to the landscape.

This is the case for bridges, for example, which is one of the reasons why bridges were not included in the survey.

Tom Worsley (Department for Transport) thought it surprising that the payment mechanism was not specified.

Allan explained that the survey excluded it to attempt to minimise protest responses. For example, some people have no confidence in local government (as project sponsors) and there is also a credibility issue since local authorities may be the proposers of a scheme.

Gregory Marchant (TEG) asked whether the approach might be transferable to urban areas as there might be expected to be large impacts, particularly at historical sites.

The remit for the project was the natural/rural landscape and from the value transfer perspective, in urban areas the context would be very different.

Dick Dunmore (Steer Davies Gleave) questioned whether the approach could work in reverse to establish the value of reverting to a natural landscape where there might be opportunities to remove infrastructure.

Allan outlined that the approach used in this study was based on asking what will happen if a transport scheme is not built. If there was a credible location scenario, then the alternative question could work well, although further issues would be likely to be generated.

Gregory Marchant (TEG) queried what would be effect of removing the White Horse from the Westbury scenario.

Allan explained the value of that scenario, which tested the impact of cultural heritage, which will be different from effects such as those of AONBs and National Parks.

Report by Julie Mills

Methods for valuing the reliability of travel across different modes

Dr. Richard Batley

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Arup

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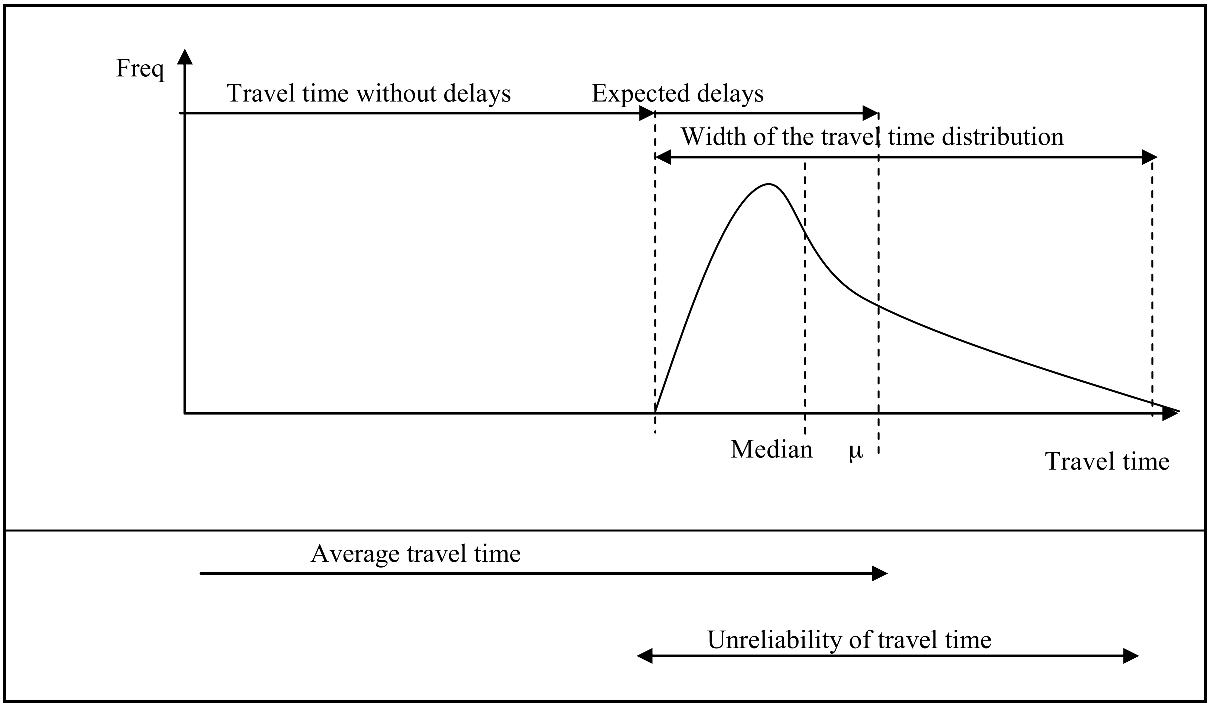
INTRODUCTION

Dr. Batley began his presentation by posing the question of "What do we mean by reliability?" He would focus on the reliability of travel time, or travel time variability. Other forms of reliability, such as seat availability or the likelihood of the buffet being open, could also affect travellers' decisions but did not form the essence of this paper.

The following diagram illustrates how travel time for a car commute might vary.

Figure 1: how car travel time might vary



Suppose the driver regularly sets off at 08:00 on a journey with an uncongested time of 1 hour. As seen from the diagram, the driver experiences various degrees of delay with varying degrees of frequency. The mean delay is 20 minutes, giving an average (and thus predictable) journey time of 80 minutes. For transport economists, interest is focused on the behaviour of travellers in response to the variation in the average journey time.

The Eddington Study of 2006 identified the potentially highly beneficial impact of reliability as a key element missing from transport appraisal, and highlighted the need to move away from mode-specific approaches to valuing reliability in transport planning. This provokes the challenge of adapting existing planning models in a way that could be, in some sense, consistent across modes. In approaching the work, Dr. Batley argued that it is important to be clear about the relevant modelling concepts, since the potential for confusion in this area is considerable!

The next five sections summarise the work undertaken to meet this challenge.

1: FRAMEWORK FOR MODELLING RANDOMNESS IN OUTCOMES

The construction of a modelling framework began by defining a discrete choice set, with options such as bus, train or car, each of which has attributes with various qualities. Dr Batley sought to distinguish between three potential sources of randomness. These were identified as:

- Randomness in **preferences** – the notion of *random utility*
- Randomness in **tastes** – the notion of *random parameters*
- Randomness in **outcomes** – the notion of *expected utility*

Preferences means that an individual repeatedly undertaking a discrete task may not always make the same choices[1] and/or that individuals within a population may make different choices[2]. The random utility model relating to such variations in preferences can be depicted as:

$$P(n|C) = Pr\{U_n > U_m\} \text{ for all } m \in C, m \neq n$$

where *U* is a random vector unique up to an increasing monotone transformation. Randomness in preferences manifests itself as random error.

Tastes (representing the marginal utility of attributes) can vary within and across individuals, thus creating randomness. It is possible to specify the deterministic utility of alternative *n* for repetition *r* as follows:

$$V_{nr} = V\left(\mathbf{x}_n ; \boldsymbol{\alpha}_r\right)$$

Here x_n are attributes of alternatives *n*; and α_r are parameters to be estimated for repetition *r* by an individual or across individuals. That is, the randomness in tastes manifests itself as randomness in a deterministic utility within/across individuals.

Outcomes vary because some attributes of journeys and/or modes may be subject to variability or risk, and this source of randomness is especially pertinent to our interest in reliability. Hence, by implication, any deterministic utility may be subject to variability or risk. Thus it is possible to introduce the notion that utility may vary by event, and to re-define the choice set as consisting of prospect vectors, rather than attribute vectors. For any given prospect vector, one can denote the attribute vectors by event and the probability that these events will arise.

From here one can build a Random Expected Utility Model, which follows the conventional approach for expected utility maximisation. The probability of choosing prospect *n* is given by the probability that the expected utility is greater than that of prospect *m* for all *m*.

$$P\left(\mathbf{w}_n \middle| \widetilde{C}\right) = Pr\left\{Z\left(\mathbf{w}_n\right) > Z\left(\mathbf{w}_m\right)\right\} \text{ for all } m \in \widetilde{C}, m \neq n$$

where $Z\left(\mathbf{w}_n\right) = Y\left(\mathbf{w}_n\right) + \varepsilon_n$ and $Y\left(\mathbf{w}_n\right) = \sum_{k=1}^{K} p_{nk} V\left(\mathbf{x}_{nk}\right)$

2: APPLYING THE FRAMEWORK TO MONEY RISK

Table 1 shows an example of a discrete choice under money risk.

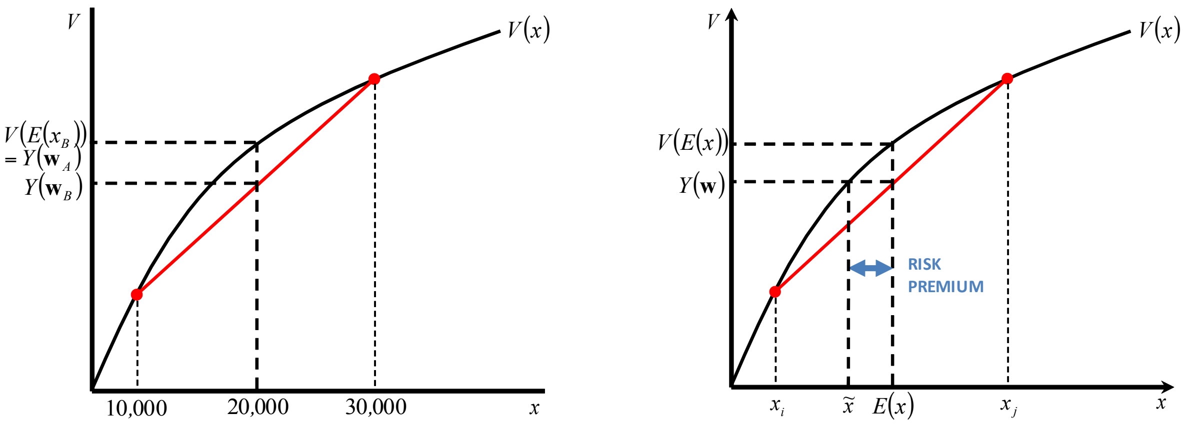
Table 1: example of a discrete choice

Alternative A	£20,000 payoff with certainty
Alternative B	50% probability of £10,000 payoff 50% probability of £30,000 payoff

Although the certain payoff under A is the same as the expected payoff under B, in experiments individuals tend to select alternative A.

There must be some reason why people make this sort of choice. They are, to a certain extent, “risk averse”, which can be represented as the following diagram, where the utility *V* is measured on the vertical axis against events *x* on the horizontal axis. The red line represents the Expected Utility and the black curve shows people’s actual behaviour, or their personal utility function. The degree of risk aversion is measured by the difference between $Y(w_A)$ and $Y(w_B)$ in the left-hand diagram.

Figure 2: risk aversion



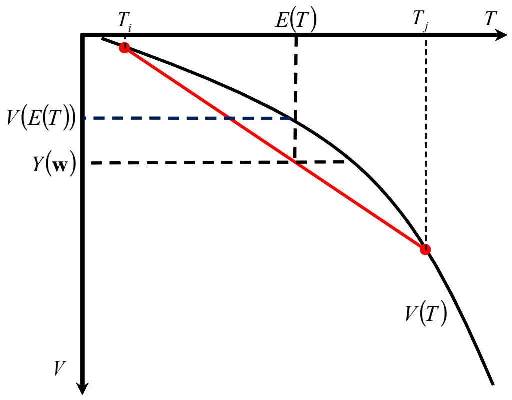
The utility function would be a straight line for those who are risk neutral and a concave curve for those with a risk prone attitude.

For risk-averse individuals, risk carries a cost, which explains why people buy insurance and the basic rationale why reliability should be valued. A measure of the risk premium that people attach to money risk can be seen from the right-hand diagram above.

3: APPLYING THE FRAMEWORK TO JOURNEY TIME RELIABILITY

The next stage in the development of the model was to try to turn the concept of risk aversion from a monetary approach into terms of journey time. On the basis that time is bad, but money is good, one might postulate that this amounts to a reorientation of the above diagram. This produces a negative concave value function with respect to journey time.

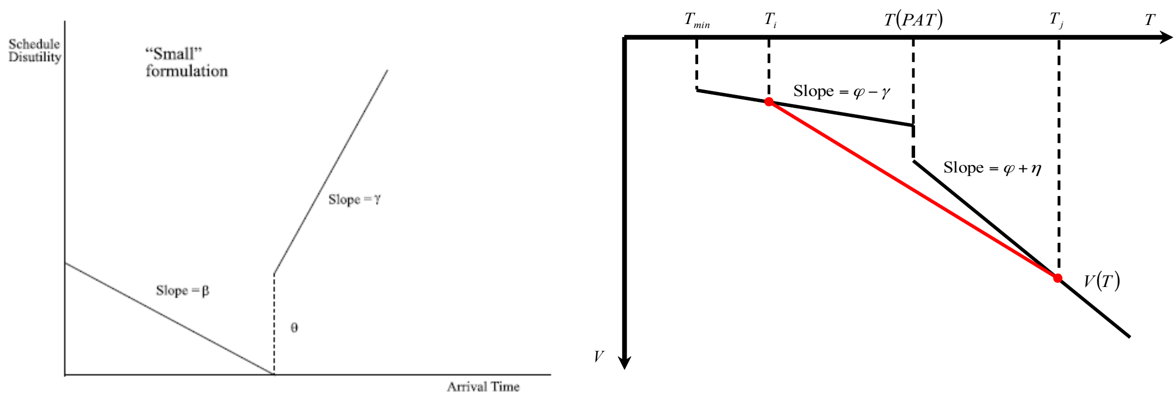
Figure 3: risk aversion applied to journey time reliability



When considering how to assess people's risk aversion to variability in journey time, there are three different approaches to defining the Expected Utility functions used in standard transport models, as discussed below. It is interesting to consider the correspondence of each approach with the negative concave function postulated above.

The **Scheduling Approach** was first proposed by Vickrey in 1969 and embellished by Small in 1982. This forms part of the standard methods for valuing reliability in some countries, such as the Netherlands. It assumes that, for a given variability in journey time, the traveller's choice of departure time is conditioned by his/her preferred arrival time. According to the Scheduling Approach, early arrival will incur undesired waiting time, while late arrival will incur both a fixed penalty and an increasing disutility according to the degree of lateness. This is illustrated in the left-hand diagram below. The slope of the lines is posited on the basis that the perceived penalty for each minute of lateness is greater than the penalty for being early. Redrawn in terms of journey time units we derive a linear approximation to the negative concave function shown previously, as in the right-hand diagram.

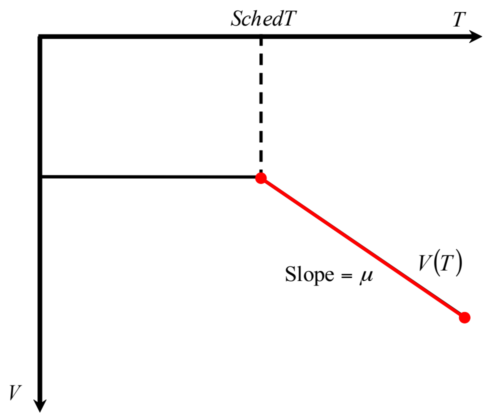
Figure 4: the Scheduling Approach



The **Mean Variance Approach** represents a well-established approximation to Expected Utility maximisation. This is the basis of the **Reliability Ratio** and is the standard approach for valuing reliability in regard to the UK road network. It is a conventional approximation to Expected Utility derived from portfolio analysis. In practice, despite the name, this approach is typically implemented using standard deviations. The key Reliability Ratio metric is zero for risk neutral people, positive for the risk averse, and negative for those who are risk prone.

The **Mean Lateness Approach** forms the basis of the **Lateness Multiplier** (the key metric) adopted in the Passenger Demand Forecasting Handbook (PDFH) for valuing reliability in respect of UK rail schemes.

Figure 5: the Mean Lateness Approach



It is less conventional, but again purports to be an approximation to the Expected Utility, as shown. On the face of it, this diagram could be rationalised as another linear approximation to the negative concave utility function. However, this approach discounts the relevance of early arrivals and only considers the effects of on-time or late arrivals. In effect it assumes that the traveller is risk neutral.

Scheduling Approach v Mean Variance v Mean Lateness

Adopting different approaches to assessing the value of reliability implicitly assumes that road users are risk averse and rail passengers are risk neutral. It can even be questioned whether the Mean Lateness Approach adopted for rail reliability assessment really models risk at all!

4: EMPIRICAL ILLUSTRATION: THE VALUE OF RAIL RELIABILITY

Data were taken from a DfT study (DFTRG/0027/2006) which investigated the impact of reliability on passenger rail demand, led by ITS (Richard Batley, Mark Wardman, Joyce Dargay, Nicolás Ibáñez, Jeremy Shires and Gerard Whelan), with The Railway Consultancy and Accent Marketing & Research. Note that the analysis and interpretation that follow are based on the personal thoughts of Dr Batley, and do not necessarily reflect the focus of the study or DfT policy.

A freepost self-return questionnaire was used to assess people's attitudes to reliability. Questionnaires were distributed on station platforms and combined elements of revealed preference, retrospective questioning and stated preference. The target sample for this field study was principally commuters but included some business and leisure travellers. There was a particular focus on journeys where passengers had experience of changing levels of reliability and had a choice between different services with different levels of reliability.

The revealed preference and retrospective questioning covered elements such as:

- Journey purpose and frequency
- Ticket type, cost, who paid and how purchased
- Preferred departure time when planning the journey
- The degree of flexibility in the planned arrival time
- Whether the train departed on time
- Prior experiences of and behavioural responses to punctuality and reliability
- Changes in regular departure times in response to past experiences
- Details of age, gender and income

The twelve origin-destination pairs used for the study are shown below.

Table 2: study origin-destination pairs

Edinburgh - Glasgow	Peterborough - London	Bristol TM - London
Leeds - London	Stevenage - London	Swindon - London
Leeds - Sheffield	Woking - London	Reading - London
Leeds - Birmingham	Portsmouth - London	Brighton - London

Response rates for each of the three waves of survey are shown below.

Table 3: study response rates

	Wave 1 (RP#1/SP)	**Wave 2 (RP#1/SP)**	**Wave 3 (RP#2)**	**Total**
Questionnaires distributed	6,800	7,900	5,300	20,000
Questionnaires returned	1,576	1,314	1,029	3,919
Response rate	23%	16%	19%	19%

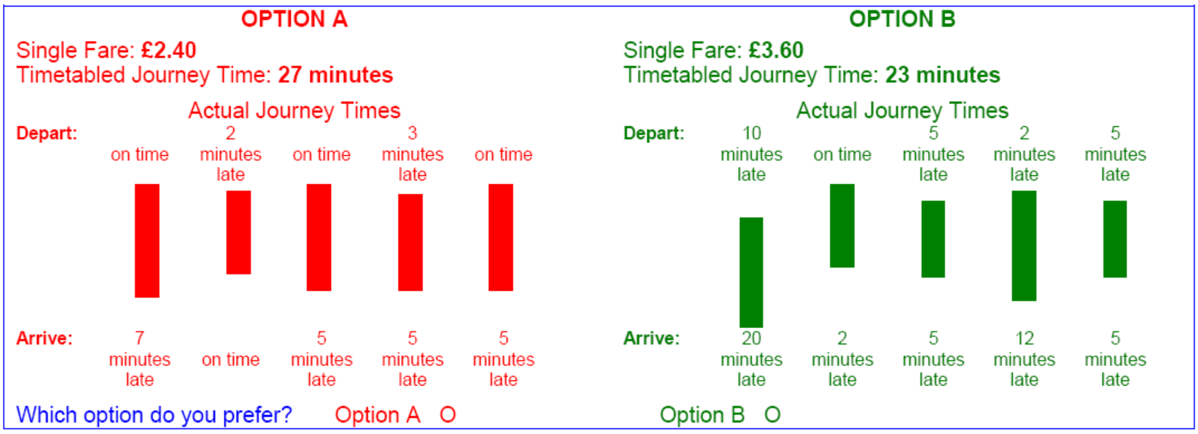
The breakdown by ticket type and journey purpose for all three waves is shown below.

Table 4: survey ticket types and journey purposes

Ticket type	**Business**	**Commute**	**Leisure**	**Total**
Single	3.7%	2.2%	2.0%	7.8%
Return	24.6%	11.2%	12.6%	48.4%
Season	3.7%	38.9%	1.2%	43.8%
Total	31.9%	52.2%	15.8%	100.0%

In stated preference analysis of reliability, a particular challenge is to communicate the concept of a distribution of travel times to rail passengers. In this study, a derivative of Hollander's presentation was used whereby respondents were presented with a choice between two options for a given rail journey. Each option represented 5 experiences for a journey (that is, 5 risk events) in terms of journey length, and departure and arrival times relative to the timetable. A typical pair of options are shown below.

Figure 6: options for rail journey



The final stage of the study was to express the three sources of randomness – in **preferences**, **tastes** and **outcomes** – as a series of models. Mathematically, these models can be expressed in terms of the three models set out below.

Model 1: Randomness in preferences

$$Y_n = \lambda SchedT_n + \nu C_n + \pi \overline{B}_n + \mu \overline{L^{+}}_n \quad \text{for } n = a,b$$

where *SchedT* is the scheduled journey time, *C* is the cost for a single leg of a return journey, *B* is the lateness at boarding, *L+* is the (positive) lateness at destination and *λ*, *ν*, *π*, and *μ* are parameters to be estimated.

Model 2: Randomness in preferences and outcomes

$$Y_n = \lambda SchedT_n + \theta \sigma_n + \nu C_n + \pi \overline{B}_n + \mu \overline{L^{+}}_n \quad \text{for } n = a,b$$

where *σ* is the standard deviation of in-vehicle journey time across events k = 1, ..., 5; and *θ* is a parameter to be estimated.

Model 3: Randomness in preferences, outcomes and tastes

$$Y_{nj} = \lambda SchedT_{nj} + \rho_j SchedT_{nj} + \theta \sigma_{nj} + \tau_j \sigma_{nj} + \nu C_{nj} + \upsilon_j C_{nj}$$
$$+ \pi \overline{B}_{nj} + \omega_j \overline{B}_{nj} + \mu \overline{L^{+}}_{nj} + \xi_j \overline{L^{+}}_{nj}$$

for $n = a,b$

where estimates of (λ, ρ) are distributed across R individuals, etc...

Results from the models for the key metrics are shown below.

Table 5: key metrics emerging from models

Metric		Model 1	Model 2	Model 3 (Mean)	Model 3 (Median)
Value of time	*λ/v*	35.32p/min	41.38p/min	25.62p/min	18.55p/min
Reliability Ratio	*θ/λ*	--	1.55	2.07	0.85
Lateness Multiplier at destination	*μ/λ*	3.96	2.80	3.64	1.62
Lateness Multiplier at Boarding	*π/λ*	2.41	1.72	1.25	0.50

Model 1 estimated a **Lateness Multiplier** at destination of 3.96, which is slightly higher than the industry standard of 3. The **Lateness Multiplier** at boarding is also significant but less that that at destination, as might be expected.

Model 2 produced a **Reliability Ratio** which was significant and positive, corresponding to the known risk aversion to journey time unreliability. The values, however, are different from those currently used in WebTAG, 0.8 for road and 1.4 for rail (based on lateness).

The key metric results for Model 3 indicate how the **Reliability Ratio** is distributed. The distributions of the **Value of Time** and **Reliability Ratio** illuminate how attitudes to randomness in outcomes are distributed across the population, with the expected skew towards risk aversion.

5: ISSUES IN TRANSFERRING THE VALUATIONS ACROSS MODES

As discussed earlier, the methods used for assessing travellers' attitudes to unreliability vary between road and rail:

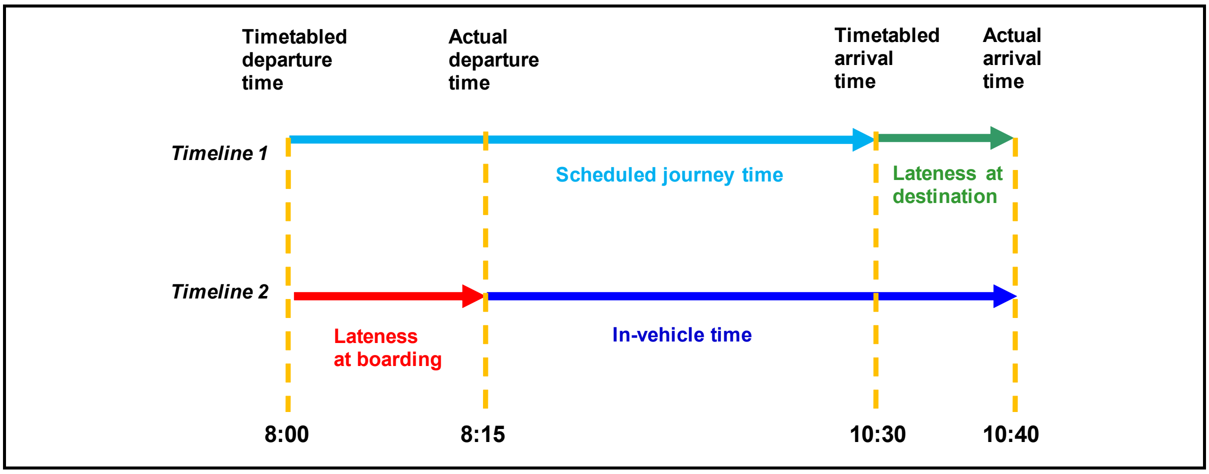
- For **road** schemes, WebTAG 3.5.7 uses the **Reliability Ratio**, the ratio between the marginal utilities of the standard deviation and the mean of in-vehicle time

- For **rail** schemes, PDFH uses the **Lateness Multiplier**, the ratio between the marginal utilities of mean lateness at destination and scheduled journey time

In effect the study was an attempt to reconcile the mean-variance and mean-lateness approaches.

This transformation can be illustrated through a simple example for a common rail journey, with two alternative timelines constructed in terms of different definitions of journey time. Timeline 1 is focused on variability around scheduled journey time and Timeline 2 is focused on variability around in-vehicle time. For simplicity the journey involves no interchange or service interval penalties.

Figure 7: timelines for rail journey



Using this transformation it was possible to respecify Model 2 to include early arrival at destination. This produced a model different to that recommended by PDFH, and achieved a coherence between the approaches for road and rail. The key distinction with PDFH is that the new model recognises lateness in boarding and earliness at destination.

Model 4: Synthesis of mean variance and mean lateness approaches

$$Y_n = \lambda SchedT_n + \theta\sigma_n + \nu C_n + \pi\overline{B_n} + \mu\overline{L^+{}_n} + \psi\overline{L^-{}_n} \quad \text{for } n = a,b$$

where $\overline{L^-}$ is mean earliness at the destination station, and ψ is a parameter to be estimated, so that substituting for *SchedT* gives:

$$Y_n = \lambda T_n + \theta\sigma_n + \nu C_n + (\lambda + \pi)\overline{B_n} + (\mu - \lambda)\overline{L^+{}_n} + (\lambda + \psi)\overline{L^-{}_n}$$

for $n = a,b$

The model produces the following results.

Table 6: key metrics emerging from models

Segment	**Lateness Multiplier at destination**	**Reliability Ratio**	**Lateness Multiplier at destination**
Based on	Scheduled journey time *μ/λ*	In-vehicle time *θ/λ*	In-vehicle time *[μ-λ]/λ*
Short distance business	2.68	1.25	1.68
Short distance commute	3.12	1.31	2.12
Short distance other	5.19	2.69	4.19
Long distance business	1.78	1.49	0.78
Long distance commute	2.00	2.19	1.00
Long distance other	1.77	2.18	0.77

Although the usual practice is to derive the Reliability Ratio and the Lateness Multiplier from separate models, the work has shown in a simple way how both metrics can be derived from a single general model. In doing so the study clarified the distinction between the two metrics, which is not always apparent in official guidance.

This raises the question about how transferable the PDFH analysis is to road assessments. Should road and rail travellers display different attitudes to risk, as is implied by current methodologies? Is it adequate to adopt the pragmatic approach of PDFH, which applies an uplift to the lateness multiplier in order to proxy for the absence of variability?

SUMMARY

The model developed achieves transferability of the evaluation approaches between rail and road in a simple way. However, some significant challenges remain. One practical difference is that road journeys are not conditioned by an external timetable; service intervals and interchanges are not immediately relevant to road. Also, consideration needs to be given to where each journey begins and ends.

There are always access issues for rail. Furthermore, where does the responsibility for reliability perceived rest – is it with the traveller or with the service operator – and how do the attitudes to risk differ between these parties?

The work has demonstrated that it is possible to derive estimates of the **Reliability Ratio** and **Lateness Multiplier** from a common model. The model distinguishes between on the one hand lateness at boarding, and on the other hand earliness or lateness at destination.

The outcome of the study has implications for standard transport modelling methods. It has to be recognised that the PDFH mean lateness approach imposes risk neutrality on rail travellers, while the WebTAG mean-variance approach admits travellers may be risk averse or risk prone. Hence, the question remains of whether PDFH adequately captures the value of reliability.

While attitudes to journey time risk are distributed across the population, it is clear that the predominant behaviour is risk aversion. Thus, there is a value to reducing journey time risk and improving reliability. However, the analysis is partial and raises the question of how travel time variability might contribute to a multi-dimensional perspective on risk.

DISCUSSION

John Segal (MVA Consultancy and editor of PDFH) noted that the study had distinguished between standard deviation in journey time and lateness in arrivals. In practice, in railway operations, there was a strong correlation between these measures.

Richard recognised this as a good point. When designing stated preference questionnaires it was easy to draw such a distinction. However, when looking at the results of revealed preference it might be much more difficult to do so.

Emily Bulman (NERA) considered that there were good reasons for the differences in approach between road and rail. Rail passengers base their assessments of journey times on the published timetable, whereas road travellers rely far more on personal experience.

Richard felt there was some merit in this argument and that one might be measuring reactions to different things. The pressure had come from policy makers to seek a common approach to assessing reliability, but this may not always be productive.

Robert Cochrane (Independent Consultant and Visiting Professor at Imperial College) supported Emily Bulman's point. Road users are able to choose when they depart, whereas rail travellers are constrained by the timetable. He found it difficult to understand why starting late held any significance for rail passengers: what mattered was lateness in arrival. Also, there was strong evidence that the likely degree of lateness was related to the square root of journey time: had the study found evidence of this?

Richard recognised that, while the scheduling model presupposes that people are able to choose their start times, the stated preference work reported was an experiment in abstract choice, and did not specifically analyse departure time choice. The study team spent a lot of time trying to understand the correlations between the variables and identifying independent variables. In relation to lateness and journey time, the study did find that the coefficients were less for longer distances.

John Cartledge (London TravelWatch) commented that, despite the previous comments about how unreliability varied with distance, the compensation regime for rail travellers was based on a fixed amount of lateness, irrespective of journey length. Research by Passenger Focus had shown a stronger dissatisfaction with unreliability than with scheduled journey time. He was not surprised that people perceived unreliability on road and rail differently: this corresponded to their attitudes to safety, and related to the supposed degree of individual versus external control.

Richard acknowledged that a valid issue for rail travellers was "Who is the agent?". Is it the traveller or the operator?

David Metz (Visiting Professor, UCL) picked up on the previous point about attitudes to reliability and journey time. He wanted to know whether the methodology could be developed to address the issue of comparing the economic effects of journey time savings with improvements in reliability. These were practical issues relevant to investment appraisal.

Richard agreed that journey time was an important factor in appraisal. The key objectives, he felt, were to try to quantify the risk premium which ought to be adopted and to determine whether current approaches represented a common stance across modes in relation to reliability. Possibly the biggest challenge for using the techniques in appraisal relates to forecasting the anticipated degree of unreliability, rather than travellers' reactions to lateness.

Peter Jones (UCL) noted that rail operators typically treated a 5-10 minute late arrival as “on time”. He asked whether there was any evidence that this degree of lateness was relevant to travellers and whether this was allowed for in the model?

Richard explained how the study had found that there was a change in values after about 10 minutes of lateness. This suggested that the current convention about what constitutes “on time” was fair.

Peter White (University of Westminster) drew attention to Quality Contracts for urban bus services, which typically penalised operators for unreliability. The consequence was that operators tended to extend layovers at termini to compensate, which required more buses and crews, thus increasing costs. This was a practical example of how risk premia worked.

Richard felt that a comparable situation existed on rail, where operators extended their published journey times to increase the likelihood of “on time” arrivals, although this might appear to make the offered product less attractive.

With no time for further questions, the convener closed the meeting.

Report by Gregory Marchant

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The Transport Economists' Group, formed in 1973, provides a forum for people involved in transport economics to meet regularly and discuss matters of mutual interest. Membership is open to economists working in transport and others whose work is connected with transport economics.

The aim of the Group is to improve the quality of transport management, planning and decision making by promoting lectures, discussions and publications related to the economics of transport and of the environment within which the industry functions.

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The Group's Journal, "The Transport Economist", is published three times a year reporting on meetings and other activities of the Group. It reviews recent publications of interest and contains papers or short articles from members. The Editor welcomes contributions for inclusion in the journal, and can be contacted at peter.gordon@deltarail.com

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