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The Transport Economist

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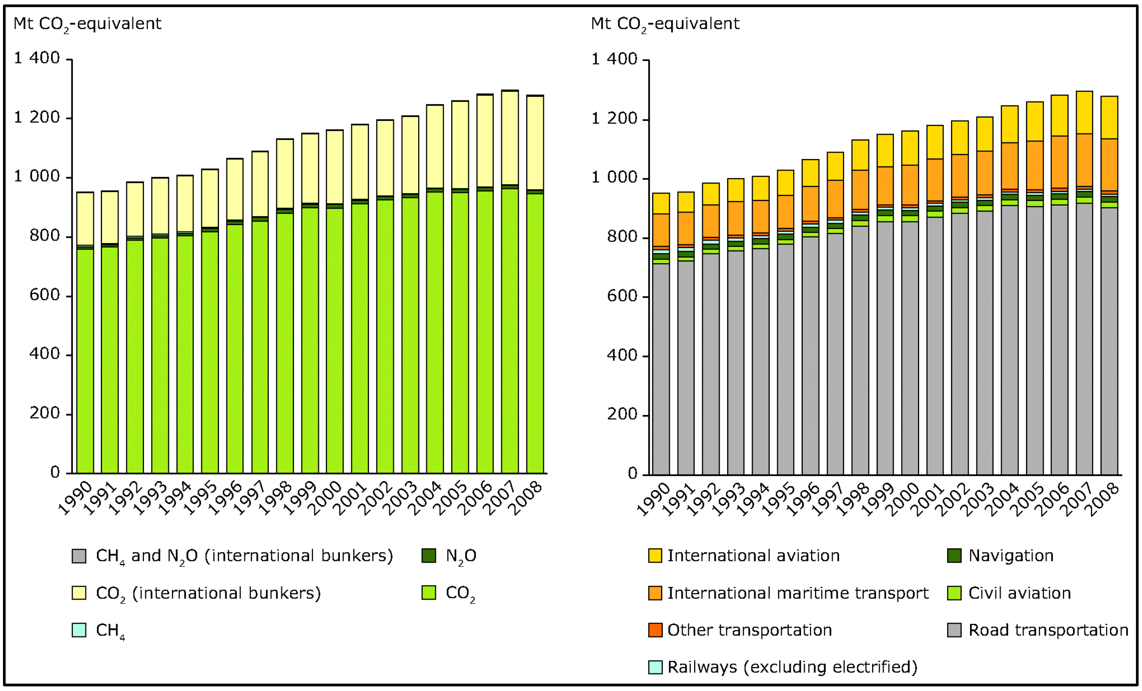

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Competition Commission investigation into the supply of local bus services in the UK

Tom Farrell and Robin Finer, Competition Commission

Arup

2 February 2012

INTRODUCTION

The presentation covered four topics:

- The reasons for the investigation and the remit
- The main findings on competition
- The main strands of economic analysis: demand model, survey, cost modelling and performance-concentration analysis
- Remedies

THE REASONS FOR THE INVESTIGATION AND THE REMIT

The Office of Fair Trading (OFT) had reviewed the local bus market in 2009, making use of price concentration analysis, and had concluded that fares were higher where there were fewer operators in the local market. On 7 January 2010 a reference from the OFT to the Competition Commission (CC) was made, to consider the supply of local bus services in the United Kingdom outside London and Northern Ireland. The CC is required to decide whether:

"Any feature, or combination of features, of each relevant market prevents, restricts or distorts competition in connection with the supply or acquisition of any goods or services in the United Kingdom or a part of the United Kingdom."

In the event of a decision that there is such a feature or combination of features, there is said to be an adverse effect on competition (AEC). The finding of an AEC requires the CC to decide whether to take action, or recommend the taking of action by others, to remedy, mitigate or prevent the AEC, or any detrimental effect on customers and, if so, what action to take.

THE MAIN FINDINGS ON COMPETITION

Market definition

Competition from other transport modes was not a sufficiently significant influence to broaden the market beyond the supply of local bus services, since the evidence showed that relatively few passengers would switch modes in the event of small changes to bus fares or service quality. Local markets are best defined in respect of specific flows, on certain routes, or across wider networks. Profits in a large section of the industry were persistently some level above the cost of capital, indicating that competition may not be fully effective across the reference area.

There was a finding of an AEC arising from a combination of:

- High concentration, because of limited overlap of competing services and hence no choice of operator for most passengers, and limited competition across wider geographical areas.
- Barriers to entry, in terms of sunk costs, risks of post-entry competition on the route and strategic retaliation elsewhere, access to bus stations, “cheap retaliation” and ticketing barriers.
- Customer behaviour, in terms of purchase of single operator multi-journey tickets, or propensity to board the first bus that arrives at the bus stop, regardless of other characteristics of the service (including price).
- Operator conduct in terms of avoiding competing for core territories.

THE ECONOMIC ANALYSIS

Three strands of analysis were described:

- Demand analysis to understand passenger behaviour, comprising:
    - A discrete choice demand model
    - A passenger survey (quantitative and focus groups)
- The operator supply function
    - Modelling operator costs

- Outcomes
    - Performance concentration modelling
    - Profitability analysis

In addition, the analysis included assessment of more general evidence including a literature review, case studies and hearings, questionnaires and hearings with the industry and passenger groups.

THE DEMAND ANALYIS

The discrete choice demand model

The many existing studies were reviewed but found to be quite dated and not to cover precisely the CC's area of interest. A new model was commissioned, based on DfT's National Travel Survey data, a household survey covering a typical week's travel made by some 14,500 individuals. The nested logit model covered three sets of choices:

- Of season ticket type: bus only, rail only, rail and bus, no season
- Of travel and purpose, conditional on holding a ticket: no travel, commute/education, shopping/personal business, entertainment/ other, return home
- Of choice of mode, conditional on the decision to travel: bus, walk, cycle, car/van driver, car/van passenger, rail, taxi

The choice set was segmented into days in the week and time periods, with 13 hourly periods (7am to 8pm) and two single periods before and after those times. Travel choice in each time period was independent of the choices made in other periods, except for amendments to the choice set on direction/purpose to allow for a return home trip and to ensure that car driver and cycle return trips were constrained to car driver and cycle outward trips. Discrete choice models require information on alternative modes and choices in order to calibrate the model. The NTS does not provide information on the options that were not used, and so a set of alternatives that could have been used, and the likely prices for these options, were imputed from NTS data.

The demand model provided an estimate of an industry fares elasticity of -0.36, close to the estimates derived in earlier studies. While individuals with access to a car were significantly less likely to use bus, both those with and without cars displayed a low elasticity of demand. Thus the prospect of substitution between bus and private car did not appear to constrain significantly the fare setting behaviour of bus operators.

Passenger surveys

The purpose of the passenger surveys was to supplement the demand model by providing evidence on the elasticity of demand for the individual operator at the firm level. The first stage of the analysis was to establish what aspects of a local bus service were of most importance to bus users and so had the biggest effect on choice between operators. A representative sample of some 1,100 passengers was chosen and conjoint analysis was used, through giving passengers a series of options, to estimate elasticities with respect to fares and to frequency. The analysis showed industry-wide elasticity values from -0.2 to -0.73, consistent with the findings from the discrete choice model, and firm level elasticities of around -1.7 on competitive corridors.

OPERATOR COST MODEL

Cost modelling was undertaken to establish the extent of any economies of scale that might inhibit competition. A translog cost estimation technique was used to assess the effect of various output changes on operators' total costs. Firm outputs were defined in terms of passenger boardings, miles driven and routes served. Six large operators provided data covering around 250 depots outside London over the period 2007-9, including the costs of labour and materials and capital costs, as estimated using fleet composition data by the CC and complementary data on demographics in the areas surrounding the depots in the dataset. The cost equation was specified as:

Total cost = [indicators for year, firm, region]

+ $\beta0$Boardings + $\beta1$Miles + $\beta2$Routes + $\beta3$Kprice + $\beta4$Lprice + $\beta5$Mprice

+ βx [Demographics of area]

+ βy [measures of local bus network and local road network density]

+ [all interactions and square terms involving Boardings, Miles, Routes]

+ ε

where ε is a random error.

Total cost, Boardings, Miles and Routes are entered in logarithms, so the coefficients on $\beta 0$, $\beta 1$ and $\beta 2$ can be interpreted as elasticities.

Instruments are used to control for potential endogeneity in Boardings and Miles.

The results showed no evidence of economies of scale for the average depot and little evidence of economies of density, although there was evidence of modest economies of scale for the 33% of smaller depots.

PERFORMANCE CONCENTRATION ANALYSIS

The performance concentration approach was used by the OFT in establishing a case for the reference and has been used widely in other examples of competition enquiries. Typical of the models estimated was one which examined the effect of competition on frequency in urban areas, using an equation of the form

$\log(\text{FREQ}) = \beta 0 + \beta 1\ \text{CONCENTRATION.MEASURE}$

$+ \beta w +$ (firm and region dummies)

$+ \varepsilon$

where w is a vector of explanatory variables which contains input prices and characteristics of the urban area.

The analysis was carried out both at a route level and using urban networks, taking as dependent variables either revenue per boarding or service frequency. There were insufficient data to use other quality-related dependent variables. A number of control variables were included to take account of other factors, such as those that might account for locally-specific demand or cost differences. Instrumental variables were used as a technique for taking account of unobserved factors that might affect both the level of competition and the outcomes in the market and that would otherwise confound the expected relationship between competition levels and outcomes.

The performance concentration analysis showed that frequency was higher where there was greater competition. At the route level, an additional operator results in an increase in frequency of between 12% and 15%, while the increase on an urban network is of between 24% and 32%. While the finding on frequency was robust to a number of checks, evidence of an effect of competition on fares from this analysis was generally inconclusive.

OVERVIEW OF REMEDIES

Multi-operator ticketing should be facilitated

- CC to establish the principles of effective schemes (such as governance, prices, zones, ticket type).
- Local Transport Authorities (LTAs) to be given (and use) additional powers to enable them to introduce schemes that satisfy these principles and reform existing schemes.
- Department for Transport (DfT) to develop guidance and oversee voluntary reform pending new laws.
- OFT to review the Ticketing Block Exemption, in relation to two specific issues.

Operator behaviour

- Changes to registration process to make it difficult for an incumbent to react aggressively to new entrants.
- Code of conduct to be overseen by Traffic Commissioners.
- Restrictions on undermining municipal operators during sales process.

Access to bus stations

- Obligation to provide access to bus stations on Fair, Reasonable and Non-Discriminatory (FRND) terms.

Effective competition enforcement – recommendations to OFT

- Continue to apply a high priority to identifying bus mergers between competing operators, making full use of bus-market-specific sources and routinely following up bus mergers.
- Take a cautious approach in exercising discretion not to refer mergers to the CC on de minimis grounds.
- Revise and update the Frequently Asked Questions (FAQs) about the application of competition law to the bus industry.

Supportive policy environment

- Recommendation to OFT and LTAs to establish a regular forum to discuss issues raised by the competition assessment of partnership proposals.

- Recommendations to DfT on how reforms to Bus Service Operator Grant (BSOG) could support our remedies.

Among the remedies considered and rejected were ones for:

- Franchising, which was seen as no more effective than the recommended remedies, and significantly more onerous.

- Divestiture where, given the wide geographic scope of the reference, the CC preferred to focus on more broadly-based measures.

- Direct controls on outcomes, a remedy generally not preferred when the CC considers that it has other means of promoting competition.

DISCUSSION

David Metz (University College London) asked how the value of the detriment had been estimated, and whether it had been measured against the counterfactual of services provided through franchising. He was of the view that franchising provided higher welfare benefits than did competition in the market. Tom Farrell replied that the detriment was calculated by identifying those routes on which more competition might be expected without the features that comprised the AEC, and calculating the value to consumers of a 12% reduction in frequency on those routes. The CC based its counterfactual on the statutory question set out in the Enterprise Act, the current market without the features which gave rise to the AEC.

Peter White (University of Westminster) asked how frequency had been measured, since the value of frequency was higher when demand was higher or when continuity of service, such as in the evenings or at weekends, was desirable. There was little to be gained from increased frequency if it led to bunching. Tom Farrell replied that the CC had adopted a measure of average frequency in terms of the number of buses on a route during the week. There was little evidence of bunching when competing operators operated on a route.

John Cartledge (London TravelWatch) asked how a route had been defined and what attributes had been covered. He also asked whether passengers had been asked about the remedies that they would prefer to see where there were adverse effects on competition. Robin Finer explained that the CC collected information about passengers' direct experiences and used this information as part of a range of evidence to inform an appropriate choice of remedies for the particular problems that it had identified. The CC amassed a lot of detailed information on routes and the extent of any overlap between operators on a route to show where passengers were most likely to have a choice. It also examined timetables, to provide a good indication of those routes where passengers had a choice, and so to show the places and routes where competition could be assumed to be working most effectively.

John Carr (Public Transport Consultant) suggested that the industry could perform better and that the CC had omitted to address ways in which operators could increase the overall market. He also asked whether the speakers thought that there should be a specific bus regulator. Robin Finer reminded the questioner that the CC's analysis had shown an inelastic market-level demand and hence a market which the operators themselves had little power to grow significantly with minor changes in their offering. However, there was potentially scope to grow the market through partnership with local authorities and the development of bus-prioritisation measures. The CC had not identified the need for an independent bus regulator within its remedy package.

Martin Higginson (Independent Consultant) asked whether the fact that the demand model covered only a single year's NTS returns resulted in some important effects, such as the growth in car ownership, being omitted from the analysis. He also suggested that the impact of car ownership on bus use, which he felt had been very significant over the past 60 years, might have been underestimated in the CC's work. Tom Farrell explained that the model exploited cross sectional variation in the data and was based on an equilibrium approach. The model therefore measured long run responses to the decisions modelled (ticket choice, journey purpose and mode choice). He agreed that there were some unexplained effects in the CC's demand model, because it did not model consumer choices such as choice of home or work location and so would not capture instances where customers move house or change jobs in response to high bus fares. The CC looked very carefully at the evidence on long run substitution patterns and based on the evidence as a whole did not think that substitution of this type would be enough to change the results significantly.

Martin Kerridge (Independent Consultant) asked about the analysis of economies of scale, which showed no evidence of economies between larger and smaller operations, and referred to an example in Brighton of an operator with 3 buses whose attempts to compete were met with a fares reduction from the incumbent. Robin Finer replied that the analysis of economies of scale had been conducted on the data of larger operators. The findings of this analysis were therefore limited the implications of different sizes of operation within these larger operators – the data simply were not available for smaller operators of the kind mentioned. With regard to the particular example, there was evidence of multi-operator ticketing schemes being introduced at very low cost and therefore it was possible that the CC's remedies could help address problems of the kind identified in the question.

Peter White (University of Westminster) asked whether there was any evidence of profits being reinvested. Robin Finer replied that the CC's accountants had conducted the profitability analysis and the economists present were unfortunately unable to answer the question posed.

Gerard Whelan (KPMG) asked about the process whereby the OFT had found that prices were higher in areas where there were fewer operators, while the CC had reached the rather different conclusion that the main adverse effect was on frequency rather than on price. Robin Finer suggested that this finding showed the two-stage system working well. The initial OFT findings were open to challenge, having been based on less detailed data, but demonstrated the case for further analysis. Further, more detailed analysis was then carried out by the CC and provided a more developed assessment of the market and the effect on competition, exactly as one would expect from a two-stage system.

David Metz (University College London) suggested that the CC's findings provided some evidence of a lack of enthusiasm for on-road competition and that a more integrated solution, as was common elsewhere in Europe, might provide a better solution. Tom Farrell said that the CC's focus was on identifying the factors that restricted competition and their effects.

Report by Tom Worsley

The full Competition Commission report can be found at:
http://www.competition-commission.org.uk/our-work/local-bus-services

Delivering Greenhouse Gas Reductions in European Transport by 2050

Ian Skinner, Transport and Environmental Policy Research

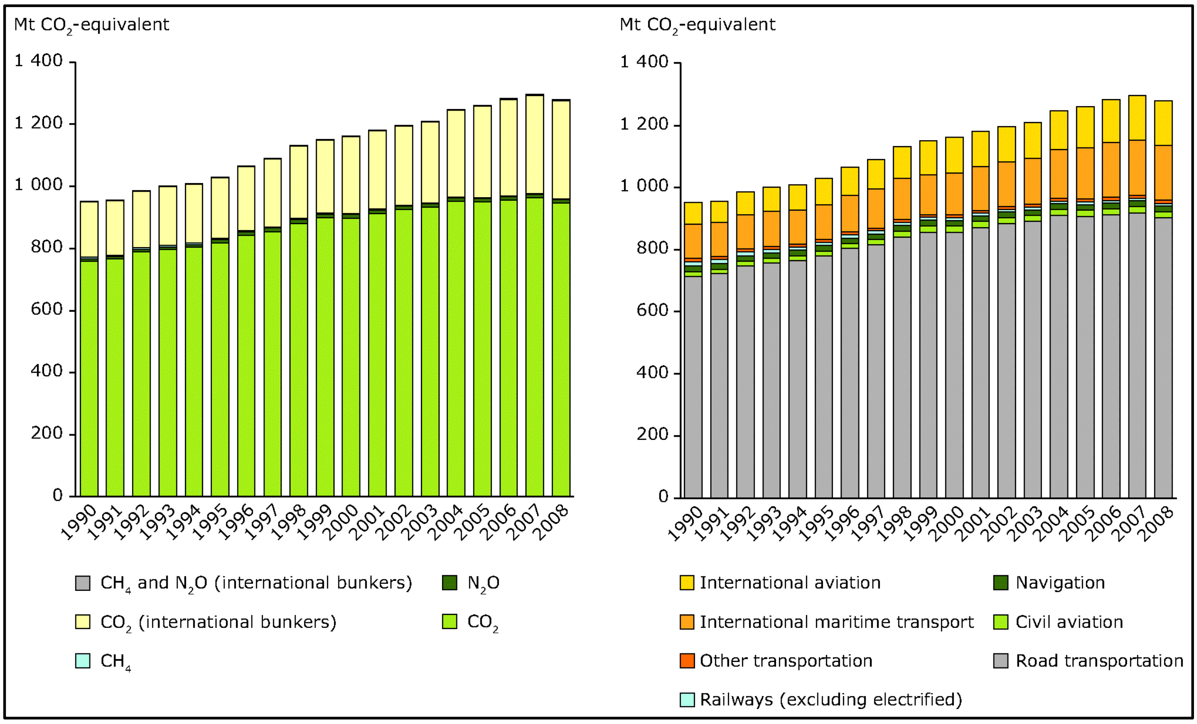
Arup

28 March 2012

BACKGROUND

Ian Skinner introduced his talk by explaining that it covered two projects and three years of work for the European Commission: "EU Transport GHG: Routes to 2050". He explained that the terms greenhouse gases (GHGs), carbon dioxide (CO_2) and carbon are more or less interchangeable for transport as 98.7% of transport's greenhouse gas emissions are CO_2 (see Figure 1).

Figure 1: Transport GHGs: gases and sources



Source: European Environment Agency (www.eea.europe.eu)

Across the EU, 19.6% of economy-wide GHG emissions come from transport, with another 6% from international aviation and shipping.

Since 1990, transport-related emissions have continued to increase, while emissions from all other sources have declined. As Figure 1 shows, the majority of transport's GHGs are produced by road transport.

In February 2011, the European Council reconfirmed the EU objective of reducing greenhouse gas emissions by 80-95% from 1990 levels by 2050. For transport, the EU White Paper "Roadmap to a Single European Transport Area" contained a target to deliver a minimum 60% reduction in GHG emissions from transport by 2050. The challenge for the transport GHG projects was to identify how to suppress the trend of increasing transport emissions in a way consistent with meeting these targets.

OVERALL APPROACH

The objective of the first project was to understand how far transport emissions could be reduced by 2050, accepting that there will be greater uncertainty further into the future. Key elements of the work were the development of a quantitative tool (called SULTAN) and engagement with EU-level stakeholders. The second project aimed to fill some of the gaps of the first. Ian concentrated in his talk on the aspects of risks and uncertainties and on scenario testing.

A distinction was made between "options" to deliver GHG emission reductions, such as the introduction of new technologies and travelling less, and "policy instruments", such as regulations to improve vehicle efficiency or pricing mechanisms, which may be implemented to promote the application of these options. The SULTAN quantitative tool is a high-level calculator but provides estimates of GHG emissions of well-to-wheel, not just "in-use", GHG emissions. It covers all major transport modes for the EU as a whole, but not the individual 27 EU countries.

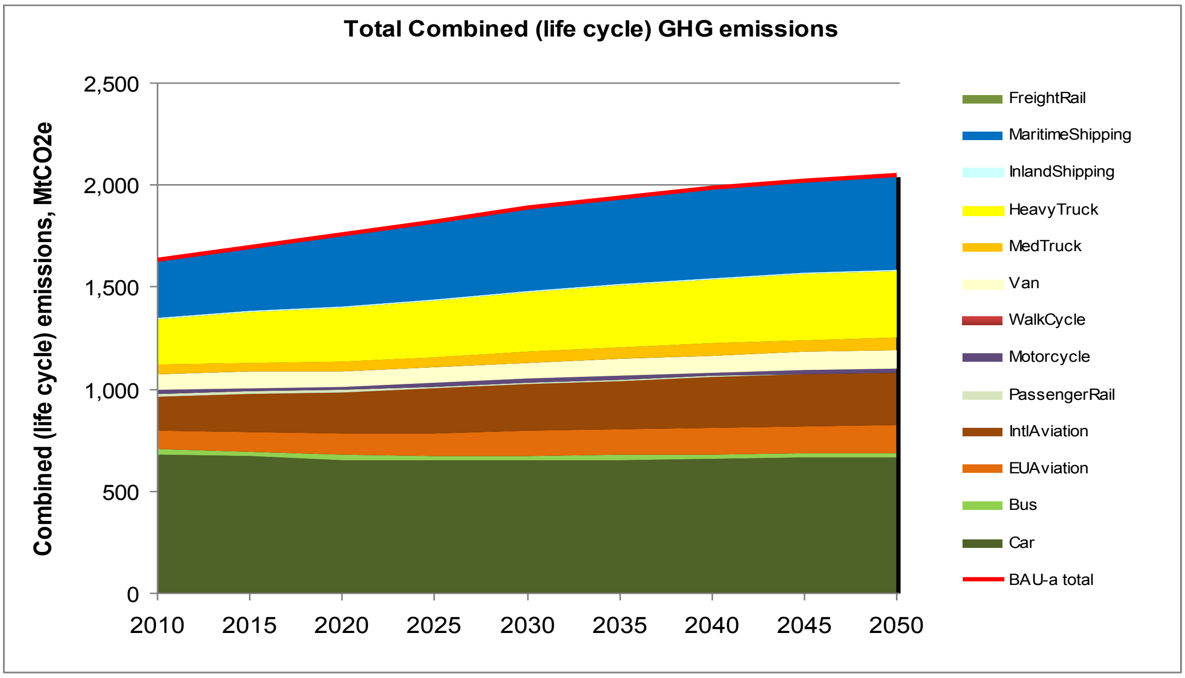
Three broad categories of options were considered, addressing:

- Options to reduce the carbon/GHG intensity of transport fuels or energy sources
- Options to improve vehicle efficiency
- Options to improve system efficiency (sometimes referred to as demand management)

HIGHLIGHTS OF RESULTS

For the first project, a baseline was prepared establishing transport's GHG emissions without further interventions – as summarised in Figure 2 – showing a continued increase through to 2050. Then potential GHG reductions from the application of different options were assessed (Figure 3), which were able to deliver a GHG reduction from the EU transport sector of 89% compared to 1990.

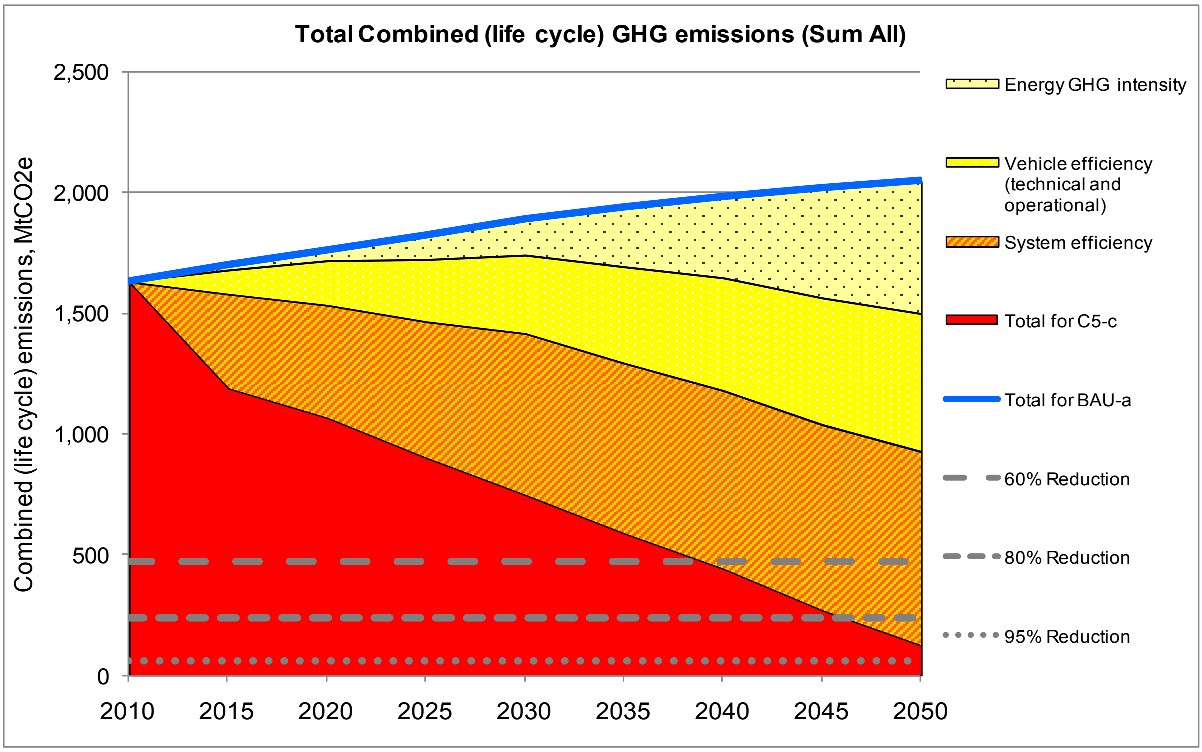
Figure 2: Baseline



Source: Skinner et al (2010) *Towards the decarbonisation of EU's transport sector by 2050* Final project report; see www.eutransportghg2050.eu

As can be seen from Figure 3, the reductions are achieved with more or less equal contributions from reducing the GHG intensity of fuels and energy sources, from increasing use of low carbon biofuels, electricity and hydrogen, and improvements to vehicle efficiency, with a larger contribution from system efficiency. The amount of biofuels used was capped because of considerable issues concerning the sustainability of biofuels. Hence, while technical options can deliver significant GHG emissions reduction, it is only with the application of non-technical options, that involve travelling less, that the reductions of around 90% can be achieved.

Figure 3: Combined results from all options

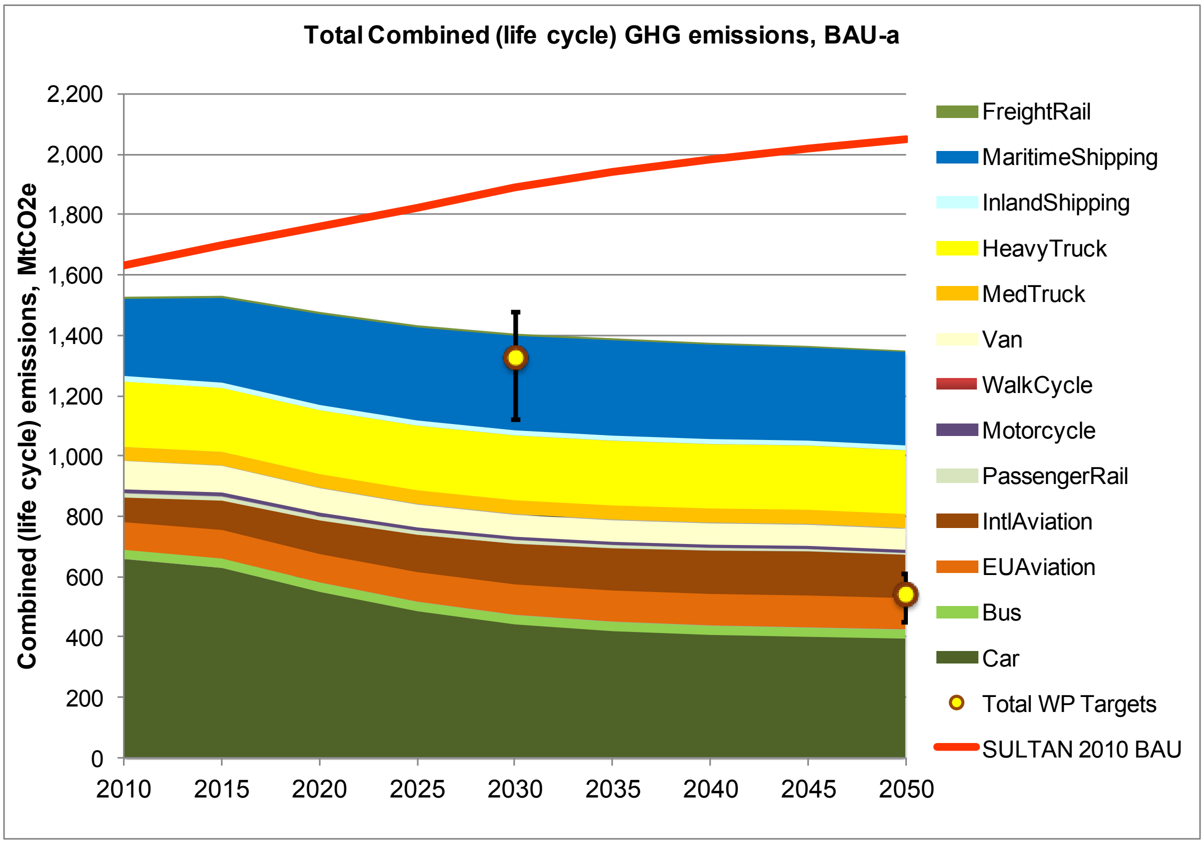


Source: Skinner et al (2010) *Towards the decarbonisation of EU's transport sector by 2050* Final project report; see www.eutransportghg2050.eu

The second project prepared an amended baseline, taking account of the effect of economic recession and recent policy developments such as international efficiency standards for ships and the 2020 targets under the passenger car and light van CO_2 regulations, which had not been included in the baseline of the first project. These changes brought the baseline down significantly, as shown in Figure 4.

The focus of the second project was on testing sensitivities around the EU's White Paper target of a 60% reduction in transport emissions. Where the 60% target was not achieved, then the additional options that needed to be put in place to make up for the shortfall were identified. The system efficiency options were not required to meet the 60% target, but were applied to make up for any shortfall. It was decided to exclude these in the first instance, rather than other options, as action to stimulate the application of the technical options is already underway at the EU level and options to improve system efficiency (that could involve increased prices) are likely to be politically more difficult. Additionally, once technical improvements in, for example, vehicle efficiency are achieved, these are locked in to the system, whereas behavioural or policy instruments need to be maintained.

Figure 4: Revised baseline



Source: Hill and Morris (2012) *Further development of the SULTAN tool and scenarios for EU transport sector GHG reduction pathways to 2050.* Task 6 paper; see www.eutransportghg2050.eu

The sensitivity tests were based on an assessment of the risks and uncertainties associated with the technical options that were identified, as summarised in Table 1.

Table 1: Risks and uncertainties

Biofuels	Electricity/hydrogen	Improvements in vehicle efficiency
GHG performance: biofuels do not always deliver GHG emissions reductions	Will the electricity supply sector decarbonise sufficiently?	Political uncertainties surrounding future development of passenger car/van CO_2 regulations
Sustainability: implications for biodiversity; land and water use; socio-economic concerns	How will the costs of alternative technologies evolve?	Level of reduction potential from conventional powertrains
Technical compatibility: use of biofuels in existing vehicles/engines	Will there be a sufficient supply of rare earth metals?	Need to develop regulation for other modes, including those used for international transport
Public support: concern about potential risks of using biofuels	Will the energy and transport systems develop in same direction?	Consumer acceptance of alternatively fuelled vehicles
Availability: demands for biomass from other sectors		

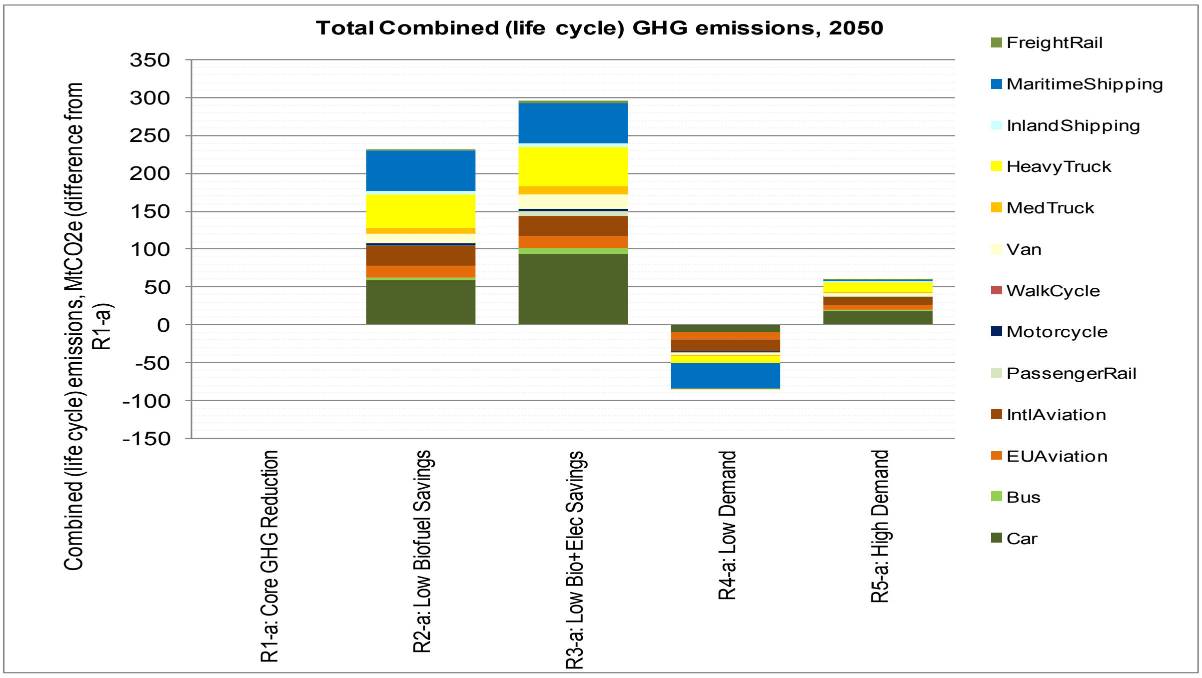
Scenario testing was carried out using the SULTAN tool, to understand how the risks and uncertainties identified might affect the achievement of the White Paper target and what additional options or policy instruments from the list in Table 2 might then be needed to ensure the target was achieved.

Table 2: Additional options/policies

1. Driver training (road/rail)
2. Speed enforcement for road vehicles
3. Tighter speed limits for road vehicles
4. Further improvements in spatial planning
5. Tighter new light duty vehicle (LDV) new GHG standards (intermediate)
6. Tighter new heavy duty vehicle (HDV) GHG standards (intermediate)
7. Further modal shift (passenger and freight) (intermediate)
8. Further maritime efficiency measures
9. Further increase in harmonisation of fuel taxes (intermediate)
10. Tighter LDV+HDV new vehicle GHG standards (high)
11. Further improvements of new ship efficiency
12. Further improvements in new aircraft efficiency
13. High levels of modal shift (passenger and freight)
14. Further increase in harmonisation of fuel taxes (high)

Figure 5 shows the results of sensitivity assessments if biofuels, and then biofuels and electricity, delivered less GHG savings than assumed in the baseline, plus the effects of different demand levels.

Figure 5: Selected results



Source: Hill and Morris (2012) *Further development of the SULTAN tool and scenarios for EU transport sector GHG reduction pathways to 2050.* Task 6 paper; see www.eutransportghg2050.eu

It was assessed that, if biofuels fail to deliver the anticipated GHG reductions, then options 1-10 of Table 2 would be needed to meet the shortfall against target. If biofuels and electricity decarbonisation both fail to deliver, then all the options above would be needed. This would be politically difficult to deliver, given the nature of some of the options.

Another set of scenario tests on the application of LDV and HDV standards demonstrated that under certain conditions reductions greater than 60% could be achieved, although this would have cost implications.

The scenario testing revealed that:

- If the anticipated GHG reductions from biofuels and electricity are not realised, then the core reduction scenario level of 545 $MtCO_2$ by 2050 could be missed significantly (by up to 300 $MtCO_2$) leaving a gap to target of 54%.
- Weaker/stronger vehicle GHG standards could mean under/over achieving by over 100 $MtCO_2$ (a gap/over achievement of >16%).

- In the case of under-achievement, this would need the adoption of (in some cases many) other options/policies.

The costs of reducing GHG emissions were considered in the project, at a high-level in the SULTAN tool and also in two specific working papers. However, cost-effectiveness was not included as a tool output because of the uncertainties in looking so far ahead. As an illustration, over recent years independent assessments of the costs to the motor industry of meeting the targets in the EU car and van regulations have suggested declining costs. This shows how quickly our understanding of costs change, and this is in an area for which costs have been studied in relative detail.

CONCLUSIONS

A broad range of ambitious options (technical and non-technical) is required to meet EU GHG targets, as:

- The risks and uncertainties associated with GHG reductions from biofuels and electricity could lead to 2050 target levels being missed significantly.
- If less is achieved from energy/fuels or vehicle efficiency, many (or all) of the other options would be needed.
- Broad action decreases the risks associated with putting confidence in too few options.
- Modes with the largest projected GHG growth have fewer technical GHG reduction options and slower fleet turnovers.
- Options are linked: action on vehicle efficiency means less GHG reductions is needed from energy/fuels, thus reducing risks.

A range of policy instrument is needed to stimulate uptake of these options as:

- Instruments can work together in a complementary fashion to enhance potential benefits or to mitigate potential adverse impacts.
- Different instruments better stimulate different options and target different actors or address problems such as split incentives or first mover.

- When dealing with reducing GHG emissions and delivering co-benefits, different instruments are useful:
    - To reduce GHG and to relieve congestion: speed policy and user charging.
    - To reduce GHG and air pollutants: eco-driving, speed limits, economic instruments and spatial policies.

Action is needed earlier rather than later as:

- There are long lead times of, for example, the technical options.
- Significant risks and uncertainties mean that options and policy instruments need testing. In the event of an option not delivering, early action will leave time to take alternative (or more stringent) action.
- Different policy instruments will mean different political considerations and barriers to be overcome.
- A wide range of stakeholders need to be engaged and involved.

Ian concluded by pointing out that the study had looked at the options and technologies available now, as it is impossible to quantify possible solutions that don't yet exist.

DISCUSSION

Dr Mayer Hillman (Policy Studies Institute) said that the European Commission should know that this is a global problem and that seeking to understand how to accommodate growth in demand is the wrong approach. The starting point should be understanding what is the capacity of the planet to accommodate fossil fuel burning and the finite nature of the atmosphere. An 80% reduction in transport emissions is inadequate. Ian agreed that this is a global problem but, given that we don't have a global government system to address it, it is important that the EU is taking action. This is far better than anything else happening globally even if it is only part of the solution. While addressing demand levels is important, the focus of the research programme was on improving fuel efficiency and vehicles, which is important.

Tim Leunig (London School of Economics) said he had hoped to see costs of measures to allow for comparison with costs of, for example, insulation. He would expect it to be more effective to address “stationary” sources of emissions rather than transport, which necessarily involves moving things around with high energy fuels. Ian explained that the assessment tool was too high level to examine costs, even though some stakeholders would have welcomed that kind of focus. Part of the aim of the project was to get climate change and transport on the EU’s agenda, and it was probably successful in achieving that.

Dr Robert Barrass (Independent) queried whether it was assumed that variables such as transport intensity and land use all remained the same over the next 40 years. Ian replied that the study team did consider decoupling transport intensity and the economy, but it wasn’t clear how the relationship would change, so it was assumed that it didn’t.

Jeremy Drew (Independent) explained that he was also involved in the first project as a stakeholder and it looked as if the 80% reduction was going to be unachievable, so the findings look extraordinary. While this is only one step, he is glad that Europe is setting the tone. Did any of the options consider international air and international maritime, which presumably could easily wipe out any reductions from other modes? Ian confirmed that international air and international maritime were both included in the assessment. The multiplier effect for aviation was recognised by the project team, but not included in the assessment, partly as the study was assessing greenhouse gas emissions not their effects. Actions to bring down the emissions from international air and maritime transport, such as biofuels for aviation, were included in the assessment.

Scott Clyne (Arup) asked whether, given the link between demand for travel and economic growth, there was any feedback on the burden on businesses, in terms of job creation and other factors, in the calculation of baseline demand. Or was it assumed that transport demand and GDP were decoupled? Ian explained that there was no feedback into the economic implications – the baseline to 2030 was taken from existing European models – although stakeholders did raise this as an issue.

Robin Cathcart (Independent/retired) queried the assumptions on biofuels. It was assumed that biofuels were capped at 174 $MtCO_2e$ by 2050, based on what could be produced sustainably in the EU.

Aileen Hammond (Independent) queried whether CO_2 emissions from manufacturing vehicles were assessed, as there might be a downside from replacing cars frequently in order to achieve fuel savings. Ian replied that the team did look at embedded emissions in vehicles and infrastructure, but only the former was put into the tool. Including all embedded GHG emissions was too complex, so this is a gap in the study, but there is a paper that includes comparisons of embedded GHG emissions for different infrastructure.

Peter Gordon (TEG Journal Editor) asked if there was any consideration of social factors such as in Japan, where the tsunami has turned people away from nuclear power. Without technical solutions, there will be social implications from restricting travel. As noted, the baseline was taken from existing models used at the EU level, so would have taken account of the latest projections. Decarbonisation of the electricity supply sector was considered. The EU electricity supply trade body has looked at scenarios and these were used in the assessment. It was noted that there are risks associated with assuming greater take-up of nuclear power (Germany has recently had a complete change in policy, for example). There was no explicit feedback on social issues but there are acknowledged to be risks.

Professor Peter White (University of Westminster) said that as outputs are expressed in person-km rather than vehicle-km, then load factors should be considered? Ian agreed and explained that this is addressed in system efficiency options and especially for freight.

Simon Lister (Independent) asked about stakeholders: were they providing a consensus view or taking a lobbying position? Ian explained that they were involved more to ensure that all options were identified, and to identify what could be delivered in terms of potential reductions in GHG emissions. Papers on technical options were discussed with stakeholders at small meetings but the study team decided how to integrate the resulting findings in the model.

Robin Cathcart shared a concern that the study makes GHG reduction look too easy: surely it needs to be heavily caveated? Ian explained that the risks and uncertainties were fully documented in the study reports. It is clear from the way they are presented – and indeed it was clear to all of those who attended any meetings as part of the project – that there are no straightforward or easy solutions.

Report by Julie Mills

MOIRA2

Ben Condry, Imperial College

Arup

25 April 2012

INTRODUCTION

Ben Condry is now a Senior Research Associate at the Rail and Transport Strategy Centre at Imperial College London but up until six weeks before the talk worked for ATOC and managed the Passenger Demand Forecasting Scheme which developed and managed MOIRA2 with funding from Train Operating Companies, the Department for Transport (DfT) and Network Rail.

MOIRA2 is a timetable-based rail demand and revenue forecasting model which covers the entire National Rail network. It includes a representation of the full timetable which includes all stations and the stopping pattern of each train. It estimates demand and revenue impacts of incremental changes to the train service including journey times, frequency, through services, fares crowding and punctuality.

Applications range from the detailed to the more strategic, including detailed service and timetable planning, bids for franchises, industry-wide strategic option evaluation and replication of ORCATS, the operational research system used to allocate revenue from inter-available fares between train operators.

Users include most of the rail industry including the DfT, Transport Scotland, the Office of Rail Regulation (ORR), Network Rail, Train Operating Companies (TOCs), both franchised and open access (such as Hull Trains), and consultants.

The original version of MOIRA, developed under British Rail, was a DOS-based timetable-based demand and revenue forecasting model. MOIRA was not an acronym. A poster for InterCity, shown in Figure 1, featured a young lady called Monica, and thereafter that all BR Operational Research models were named after women with names starting with M.

Figure 1: Monica, a predecessor of MOIRA

MOIRA was developed to run on Windows, into geographic versions covering parts of the country, and into operator-specific versions. It is still widely used in the industry, but becoming dated, and lacks areas of functionality that users are increasingly wanting. The industry therefore agreed the development of a replacement with increased functionality.

MOIRA2 is an entirely new model, not just an update of old MOIRA, developed by DeltaRail (formerly AEA Technology), with Steer Davies Gleave involved in methodological developments. MOIRA2 was first released in Summer 2011, and is now being adopted across the industry with a major programme of training.

KEY BENEFITS OF MOIRA AND WHAT IT DOESN'T DO

MOIRA2 has a number of areas of increased functionality compared with its predecessor including:

- Crowding
- Fares, including ticket restrictions
- Flexibility on zone aggregation, the grouping of stations to create a manageable number
- An integrated WebTAG-compatible economic benefits module
- Changes to infrastructure, such as the ability to define new stations and stretches of line
- Punctuality (average delay minutes)

It used a probabilistic rather than a deterministic assignment. Passengers are allocated to trains using a logit model, whereas MOIRA used the "roof top" model.

It uses better, more up-to-date data from LENNON (Latest Earnings Networked Nationally Over Night, the central rail industry ticket sales database) and revised demand profiles (those in MOIRA dated from the early 1990s). It uses a more modern, open, software platform, which makes it easier to develop and maintain.

It is elasticity-based, so primarily designed for changes to existing services, and will calculate demand and revenue growth from the current base level.

However, very large magnitude changes may be beyond the applicability of the underlying elasticities, and it cannot be used to estimate demand for new lines, as there is no existing base to which to apply changes.

Fares are included, but it is not primarily a “fares model” and other systems need to be used for detailed fares modelling.

It calculates the time from origin station to destination station, including waiting time, interchange time and penalties but not access or egress from the starting point to first station or last station to the final destination. Elasticities are from the Passenger Demand Forecast Handbook (PDFH), calibrated for station-to-station segments.

WHAT DOES MOIRA2 INCLUDE?

MOIRA2 requires five sets of data, described below.

The timetable

It includes the full national timetable with all trains and all station stops including both public and working timetables and portion working, the splitting and joining of services en route.

Stock types and train formations are defined for all services. These include capacity (seats and standing space) for use in crowding calculations. The system contains all current stock types, but users can also create new ones for future builds.

New timetables can be created, or existing ones can be edited to test future scenarios. These can imported and exported, including to and from other industry systems such as TrainPlan and VoyagerPlan.

The demand and revenue matrix

This contains annual journeys and revenue between all stations pairs, disaggregated by route code, ticket type, class and season (summer/winter). It is in producer-attractor format, in which each journey is a two-way (return) journey.

The primary data source is LENNON, with some enhancement such as a “PTE infill”, demand profiles to reflect journeys not in LENNON. LENNON records virtually every rail ticket sold, and includes all information on the ticket including origin, destination, route restrictions, class, ticket type, discounts and date (but not always date of travel).

Figure 2: Information on a rail ticket

The latest data is for the year to September 2011, but MOIRA2 will be updated twice a year to coincide with timetable changes.

However, it does not provide a full demand matrix: it does not indicate time of travel (other than factors such as peak restrictions) and has limited details of return journey, such as the day the return journey is made for an Anytime return. It is a station-to-station model and, other than for London and other large cities, has no information about the ultimate origin and destination of the trips of which the rail journey is a stage. Multimodal tickets in urban areas are not included, but a PTE infill has been developed for MOIRA2.

Demand profiles: time of travel

Demand profiles are used to allocate daily demand to 15-min time bands. Total demand is disaggregated by journey purpose, geography and day of week.

The new demand profiles are based on the National Rail Travel Survey (NRTS). This is more up-to-date than the ORCATS demand profiles in old MOIRA, which date back to around 1991. They generally have an earlier AM peak and more demand late at night, reflecting changes in working patterns and more activities after work.

Demand profiles were developed by Steer Davies Gleave using market research. They are "ideal" – when people would like to travel – rather than "observed" – when services have run – which prevents bias towards existing timings. Leisure demand profiles have been adjusted to remove ticket restriction effects, while commuter demand profiles adjusted to eliminate crowding impacts.

Fares in MOIRA2: ticket types and classes

There are four ticket types: Full, Reduced, Seasons, and Advance. There are two classes: Standard and First Class, optional in model runs.

For modelling purposes, Full and Reduced are combined as “walk-up” fares, allowing demand to switch between them in the model. It is assumed that there is no switching to or from Seasons, Advance or First, but scaling with elasticities.

Up to four fare levels can be modelled within walk-up, based on percentage reductions from full fare, such as Anytime, Off Peak, Super Off Peak and an optional extra.

Route and time restrictions can added for individual ticket types by origin and destination. These can be:

- Time restrictions, such as arrival in London after 09:30
- Route restrictions, such as not via London
- Operator restrictions, such as an operator-specific ticket

Zone structures

More than 2,500 stations in Great Britain are aggregated into zones, enabling model runs to focus on areas of interest while minimising run time. Zone aggregation can also protect confidentiality of results. The model is supplied with a user specific (TOC) zone structure, but most users are also supplied with an editable zone structure.

Each zone includes a “primary location” to which all relevant demand can be aggregated. City zones are included for major cities with several stations. Spatial (postcode-based) areas of larger cities are used to reflect accessibility of stations and model station choice. For London, demand is allocated to zones based on the London Area Travel Survey.

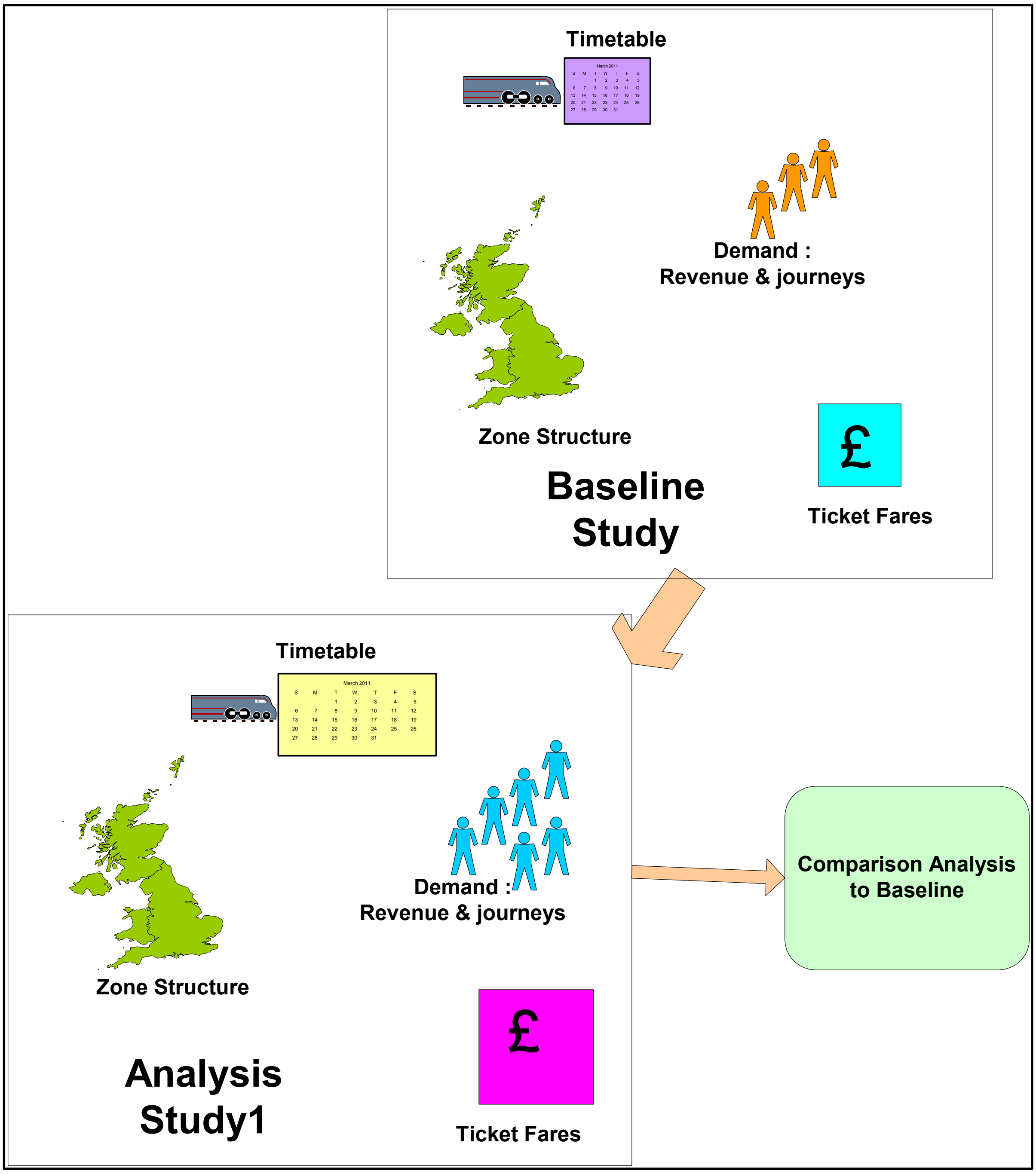
HOW DOES MOIRA2 WORK?

MOIRA2 uses research summarised in the Passenger Demand Forecasting Handbook (PDFH), originally developed under British Rail in 1980s and the primary source of demand forecasting guidance in the rail industry in Great Britain. The current Version 5 contains over 800 pages. The PDFH is produced by the Passenger Demand Forecasting Scheme Council (PDFC) managed by ATOC on behalf of the industry including

TOCs, DfT, Network Rail and ORR. There is an annual research programme to update and enhance the PDFH.

Guidance is primarily focused on demand elasticities. Fare elasticities and generalised time elasticities are predicted by market segment. Guidance is also included on impacts of crowding, reliability, quality and other factors such as weightings on generalised time. This includes adjustments for factors such as waiting time (which is valued at more than time spent travelling) and overcrowding.

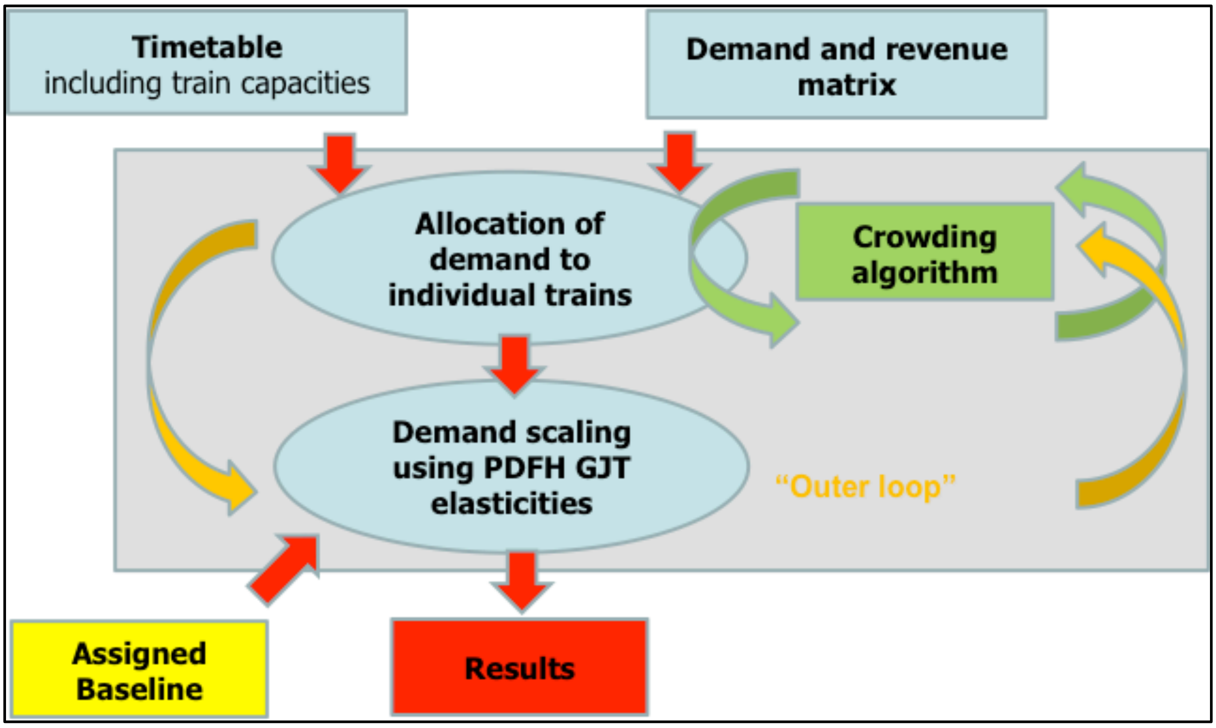
Figure 3: Outline of MOIRA2 usage



The base component of Generalised Journey Time (GJT) is the actual station-to-station time, based on Opportunities to Travel (OTTs).

In Vehicle Time (IVT), interchange time and cross-city walks are weighed by one. Additional GJT weightings and components in MOIRA2 include interchange penalties from the PDFH, crowding penalties, as described elsewhere, displacement time weightings for deviation from ideal departure time and optional rolling stock quality weightings. Demand is then allocated to trains.

Figure 4: The outer and inner modelling loops



The demand matrix is divided into 15 minute time slots based on new demand profiles. OTTs are generated for all relevant flows, based on the timetable for flows in the zone structure that have demand in the matrix.

Demand on each flow is allocated to the OTTs on the flow, depending on the attractiveness of the individual OTTs, using the logit model. The OTT allocations are used to create loads for each train in the timetable between each pair of stops.

A crowding algorithm reduces demand for heavily loaded trains using the crowding methodology based on PDFH Version 5. The weighting factors are applied to the in-vehicle time component of GJT. The factors relate to the number of standing passengers per square metre of standing space. For example, 5 people per square metre in London commuting is a factor of 2.2 on IVT.

Once train loads have been assigned, crowding penalties are calculated for each journey segment. The allocation of seats is probabilistic to allow for daily variations in loading.

The attractiveness of crowded OTTs will change due to IVT weighting, and the demand is then reallocated to OTTs reflecting this. The process is an iterative process (inner loop) repeats until the loads have converged. The crowding functionality is optional and can be turned off.

Demand is scaled by the application of PDFH elasticities. Once the crowding algorithm has run, “composite” generalised time and generalised fare are calculated for each flow.

Composite GJTs and fares are compared to the baseline study and the demand on each flow is scaled by application of the elasticities. However, demand scaling affects crowding, so the crowding algorithm is repeated with the scaled demand. Demand scaling and crowding processes iterate until convergence criteria have been met.

The OTT allocation and demand scaling for Advance (book in advance) fares is different from other ticket types and the demand on “Advance” tickets is separate within the matrix. Passengers with Advance tickets are allocated only to trains with spare seats after allocation of other ticket types: this reflects Advance tickets generally being restricted to less busy trains. The crowding level below which Advance demand is allocated can be adjusted. Advance demand is allocated iteratively in “chunks”.

Demand scaling for Advance takes place once all Advance demand has been allocate to trains.

Like Advance, demand for First Class is assigned separately. However, the methodology is the same as for Standard Class. Where appropriate, train capacities for First Class are held separately for each stock type. Standard passengers are assumed not to stand in First Class areas. Where no First Class accommodation is available, demand is allocated to Standard.

OUTPUTS AND REPORTING

MOIRA2 can produce a wide range of default and customisable reports in Excel format.

Reports can be filtered by geography and various types of reports can be produced including flow-, arc- or station-based reports, train-based reports such as detailed train loadings, and top flows reports. TOCs only see revenue aggregation for their own services. The model can be run to output either “real world” - what passengers will actually do – or ORCATS replication – what ORCATS assumes they will do, and the reports produced reflect this.

The economic benefits module provides WebTAG compatible outputs. Model can be run with or without this option. Results include standard components required for appraisal including time savings, carbon emissions and indirect tax.

The default assumptions, such as the price base year (2002), values of time, and diversion factors to car and other modes, are based on WebTAG. However, users can edit parameters for scheme-specific circumstances, diversion factors at local or regional level and potential changes to DfT guidance such as a change of base year.

The requirements for the model included criteria for three levels of calibration and validation, which have been met:

- Rail industry or TOC level
- Station level
- Train level

The calibration and validation at train level was undertaken for selected routes into London and in the North of England. Train level validation is dependent on accuracy of train formations, both timetabled and actual. These can be adjusted if detailed loading results are required.

HOW IS MOIRA2 BEING USED?

MOIRA2 was first released to PDFC members in April 2011 with historic sample data. The first full version (with the Summer 2011 timetable) was released in June 2011. The timetable and demand data are updated twice yearly in June and December.

Development to enhance the model continues, reflecting the scale of the model and level of functionality. There will be parallel running with (old) MOIRA to continue through 2012.

The initial use and primary purpose is as a replacement for old MOIRA. However the increased functionality and flexibility suggests potential for wider application such as crowding and fares. As users and potential users become more familiar with the model, additional applications are likely. Open architecture and accessibility of data to users greatly extends potential uses.

The process for access to MOIRA2 is the same as for the old MOIRA. The demand and (especially) revenue data are confidential and so TOC versions show revenue totals for their own TOC only.

MOIRA2 is provided to all TOCs, the DfT, Transport Scotland, Network Rail, Transport for London (TfL), and ORR. Organisations with access to the model can authorise access of their version to others, such as consultants working for them. Third parties such as local authorities can request access via ATOC, which requires agreement from the TOCs concerned to release data. Training courses are provided by DeltaRail.

DISCUSSION

Tim Gent (WSP) said that he had been the Project Manager for PLATO which was a system for forecasting passenger loadings in 2005 when he worked for AEA Technology. He suggested that MOIRA2 was not the first model that could analyse train loadings. **Tom Worsley** said that his former employer, DfT, had developed the Network Modelling Framework (NMF) for analysing options to reduce crowding for the 2007 HLOS.

David Starkie (Independent consultant) asked whether MOIRA2 took overcrowding into account, as this was a big issue. Had there been any studies to measure the effect of this? **John Segal** (MVA Consultancy) said that MVA had undertaken a study on which the PDFH Version 5 GJT values for crowding were based. This was both stated preference, examining how overcrowding equated to increased journey time, and also observed results, for example looking at the extent to which passengers preferred to take slower but less crowded trains and would be willing to wait for a later, less crowded, train.

Jeremy Drew (Independent consultant) asked if First Class was modelled separately, and in particular how tickets such a weekend upgrades were handled. Ben said that first class traffic was available as a separate layer so could be separately identified, but that it would only be produced if information was available in LENNON. **Jonathan Pugh** of ATOC said that only some First Class upgrades went through LENNON, so the data would be partial.

Martin Higginson (Newcastle University) asked if generic factors such as rolling stock quality, regular interval services and simpler fares could be modelled? Ben replied that the user could apply weightings to reflect the quality of rolling stock. It was not possible to model things such as simpler fares. Passenger Focus was not a member of the Passenger Demand Forecasting Scheme and so did not have automatic direct access to MOIRA2.

Dick Dunmore (Steer Davies Gleave) commented that MOIRA2 was used for the modelling of complex projects such as the Intercity Express Project (IEP), which had a large number of different impacts on GJT including OTTs, journey time, crowding and fare.

Scott Levine (Imperial College) asked if MOIRA2 could model parking at stations and heavy overcrowding. Ben said that no account was taken of parking in MOIRA2. It would adjust for demand. Car competition can be taken into account through the PDFH exogenous demand elasticities.

Larry Falkner asked if it could calculate the revenue impact of engineering work and be used to calculate the best strategy? Ben said that it could, but that TOCs would also use other models. There was a facility to apply the dates during which trains run to reflect the pattern of engineering work of a timetable season. **Peter Gordon** (formerly of DeltaRail) said that he has used for a TOC to model the effect of line closures on revenue and the allocation between competing TOCs.

Dick Dunmore asked if continental railways have similar systems? Ben said that they did have their own demand based systems but that he was not aware of the details.

David van Rest (Retired) asked about the accuracy of predictions that MOIRA2 made. Ben did not have figures to hand, but said that reflecting the validation criteria, accuracy at a more aggregate route level would be within a few per cent, but that on individual trains he believed would be in the order of 10%.

Hugh Jaeger asked if MOIRA2 covered Northern Ireland? Ben said that it did not, as for historical reasons railways in Northern Ireland are managed separately and are not part of the national rail network.

John Cartledge (Passenger Focus) asked if the train loadings predicted by MOIRA2 had been cross-checked with real data such as train counts, noting the difficulties associated with obtaining this data? Ben said that the validation stage had included comparison with train count data supplied by TOCs, although the agreed that there was no universal source of such data.

Alan Peakall (Retired) asked if the level of overcrowding was an average level and did it vary between trains? **Peter Gordon** said that he had undertaken the Green Book overcrowding calculations for a large London TOC which used PLD (Passenger Load Device) counts backed up with manual counts. He said that it was necessary to obtain a number of counts in order to get degree of certainty, and that there would be both systematic variations owing to factors such as seasonality and "random" day-to-day variations. DfT required real data, which was increasingly coming from sources such as Planet Long Distance (PLD), RIMS and ticket gate data as well as manual counts.

Peter Gordon asked if MOIRA2 was calibrated to take account of missing data such as ticket revenue that does not go through LENNON. This could be very significant on a route such as the Hounslow loop, where many Travelcards were bought at LUL booking offices and newsagents. Ben said that it was.

Report by Peter Gordon

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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.

Meetings are held every month from September to June (except December) at Arup's Central London HQ at 13 Fitzroy Street. The meetings consist of short papers presented by speakers, drawn from both within the Group's membership and elsewhere, followed by discussion.

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 petersgordon@blueyonder.co.uk.

The current membership of over 150 covers a wide range of transport modes and types of organisation. Members are drawn from transport operators, consultants, universities, local and central government and manufacturing industry. All members are provided with a full membership list, updated annually, which serves as a useful source of contacts within the profession. Applications from people in all sectors are welcome.

Applications for membership should be made on a form obtainable from the Membership Secretary at gregorymarchant.teg@btinternet.com.

Alternatively, an application form can be downloaded from the Group's website: www.transecongroup.org.

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Details of meetings are provided on our website at

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