FINAL REPORT

Assessment of Applications for Track Access on the East Coast Main Line: Phase 2 Final Report

Prepared for

Office of Rail and Road

15th January 2016

CH2M HILL
43 Brook Green
London
W6 7EF

Contents

Authors: Chris Judge, Oliver Haycock
Reviewers: Richard Sanderson, Jon Clyne

1. Introduction

1.1 Background

1.1.1 Disclaimer

In preparing this report, CH2M relied, in whole or in part, on data and information provided by the Client and third parties, which information has not been independently verified by CH2M and which CH2M has assumed to be accurate, complete, reliable, and current. Therefore, while CH2M has utilised reasonable skill and care in preparing this Report, CH2M does not warrant or guarantee the conclusions set forth in this Report which are dependent or based upon data, information, or statements supplied by third parties or the client.

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1.1.2 Context

ORR has received several applications for rights to use capacity on the East Coast Main Line (ECML). These applications have been submitted by:

- open access operator GNER, owned by Alliance Rail Holdings (Alliance);
- Virgin Trains East Coast (VTEC), owned by Stagecoach Transport Holdings and Virgin Holdings, which commenced operation of the East Coast Franchise in March 2015; and
- open access operator East Coast Trains Limited owned by First Group (First).

CH2M has been commissioned by ORR to provide two key pieces of evidence to support its forthcoming decisions on these applications. These pieces of evidence are:

- Revenue projections for the new services contained within the track access applications, produced in a way that enables ORR to conduct its Not Primarily Abstractive (NPA) test and assess the impact of each application on the funds available to the Secretary of State for Transport; and
- An economic appraisal of a number of the incremental benefits and costs of the new services.

We understand that ORR will use these pieces of evidence in conjunction with other key information to decide the applications, including assessing impacts that we have been asked to exclude from our analysis.

CH2M conducted the first phase of this study between October 2014 and June 2015, culminating in a rail industry hearing chaired by ORR on 12th June 2015. Following this hearing and a review of previous and subsequent written submissions, ORR commissioned CH2M to undertake a second, more detailed, phase of work.

Throughout both phases of this study we have engaged in regular dialogue with stakeholders to take account of their views, and make effective use of the information they have provided. Where appropriate we have reflected their feedback and expert local knowledge in our analysis.

The number, variety, and complexity of options for new track access rights received by ORR in this process are, in our opinion, well beyond the scale of the applications considered in previous track access decision processes.

As a consequence, the production of demand and revenue forecasts, in particular, has been an extremely challenging exercise, stretching both the frontiers of current passenger demand forecasting research, and the limits of the data available to us. Nevertheless, we have endeavoured to produce calculations to a high degree of demonstrable robustness, commensurate with the terms of reference for phase two of this study, and, in our view, beyond which is required in many other rail industry processes.

We have tried to report our methodology, assumptions, and results in a transparent manner. This has been, at times, difficult given requirements to treat commercially sensitive information in confidence. We have also not been granted access to all of the information that we have requested, which has placed some limitations on our preferred approach, and the implementation of our forecasts.

We are pleased that ORR has commissioned an independent audit of our work, and have worked collaboratively with independent auditor Systra, to take account of its recommendations in our models and forecasts, where appropriate. Whilst this wasn't the approach set out in ORR's terms of reference to us, we believe that it is to the benefit of our work, and thank the Systra team for their professional approach. We received an early draft of Systra's audit report shortly before the completion of our final report. In general Systra's draft report appears to present a fair and balanced review of our work, although we have not seen the final version.

Finally, given the complexity described above, we have found the study timescales to be challenging; however we are confident in the robustness of our forecasts and appraisals.

1.1.3 Purpose of this report

The purpose of this report is to:

- Explain how and why the proposed services in the track applications received by ORR have been packaged into options for this assessment;
- Summarise and explain in detail our revenue forecasting methodology;
- Summarise and explain in detail our economic appraisal methodology; and
- Present our revenue projections and economic appraisals for the proposed new services.

Our phase two interim report was issued by ORR in October to enable ORR, the applicants for ECML track access rights, and other interested parties to understand and comment on the full approach taken, prior to completion of the revenue projections and economic appraisals.

This final report retains the same structure as the interim report, with a new section added containing the revenue projections and economic appraisal results.

1.1.4 Managing potential conflicts of interest

CH2M is Technical Advisor to the Department for Transport (DfT) for the Northern and TransPennine Express re-franchising competitions. As part of this work, DfT commissioned us to assess the implications of GNWR's WCML aspirations on future TransPennine and future Northern franchise revenue.

DfT also advised that it intended to ask us to assess the implications of GNER's proposed ECML services on future TransPennine Franchise revenue and future Northern Franchise revenue. DfT did not subsequently commission us to undertake this work.

The work for ORR was untaken prior to the announcement of the preferred bidders for these franchises and the service patterns they propose to operate. We had no knowledge of these service patterns, or the potential implications of them on ECML capacity.

CH2M and its subcontractors are also Technical Advisors to DfT for the West Midlands Franchise Direct Award and West Midlands re-franchising.

CH2M and its subcontractors currently undertake work for Arriva's UK rail division including its subsidiaries. This work is not on behalf of, or in conjunction with Alliance Rail Holdings, and has no obvious relevance to the ECML.

CH2M and its subcontractors are not undertaking any current work for the UK rail divisions of Stagecoach, Virgin, or First Group.

One of CH2M's subcontractors assessed East Coast Franchise Bidders' train service delivery plans on behalf of DfT. This work concluded some time ago.

The following procedures are in place to avoid potential conflicts of interest:

- Use of a ring-fenced project team with no involvement, for the duration of this study, in work for other clients relating to open access or the ECML, and with no involvement in the work to advise DfT on the implications of GNWR's access applications on franchise revenue;
- All project files are stored on password-protected computer servers, with access only granted to members of the project team;
- All paper files are stored in locked drawers;
- All project meetings and telephone conferences are held in meeting rooms separate from open plan offices; and
- Project team members will not discuss the project with other colleagues.

1.2 Report structure

The remainder of this report is structured as follows:

- **Section 2** summarises the applications received by ORR;
- **Section 3** explains how the applications have been packaged into options for assessment, and the key assumptions that support this process;
- **Section 4** summarises our revenue forecasting approach;
- **Section 5** summarises our economic appraisal approach;
- **Section 6** presents our revenue projections and economic appraisals;
- **Section 7** presents our conclusions and our advice to ORR;

- **Appendix A** shows the options from section 3 in diagrammatical form;
- **Appendices B-F** explain individual stages of our revenue forecasting processes; and
- **Appendix G** explains our economic appraisal process.

2. Track access applications received by ORR

This section of the report summarises the track access applications received by ORR. Section 3 provides a more detailed description of the services contained within these applications, explaining how and why these services have been packaged into options for assessment.

Most applications include early morning/late evening short workings to balance stock moves. For brevity these trains are not listed until section 3. The descriptions in this section relate to weekday services. Some proposed weekend services differ slightly from the weekday proposal. Again for brevity, these differences are only described in section 3.

2.1 Track access applications from Alliance

2.1.1 King's Cross – Yorkshire/Lincolnshire services

Alliance has proposed:

- Four return services per day from London King's Cross to Cleethorpes, from December 2017; and
- Six return services per day from King's Cross to Bradford and one per day from King's Cross to Ilkley, from 2018.

2.1.2 King's Cross – Edinburgh services

Alliance has separately proposed:

- An hourly fast return service between King's Cross and Edinburgh, calling only at Newcastle and occasionally Stevenage, from May 2017 or soon thereafter.

2.2 Track access applications from VTEC

VTEC has submitted both a long term track access application, intended to operate following deployment of the Intercity Express Programme (IEP) fleet and the completion of planned ECML upgrade works, and a series of interim applications for operation prior to this. Phase 2 of our work only considers the long term application.

2.2.1 Long term track access application

VTEC has proposed operating an enhanced frequency of trains, serving a wider range of stations than currently (from May 2019 unless stated):

- Introduction of a half hourly King's Cross – Edinburgh service, replacing a two hourly service pattern comprising approximately three return King's Cross – Edinburgh services and one return King's Cross - Newcastle train (every 2 hours);
- Extension of one weekday return King's Cross - Edinburgh service to/from Stirling;
- Introduction of an additional hourly King's Cross – Newcastle stopping service;
- Extension of one weekday King's Cross - Newcastle service in each direction to/from Sunderland;

- Replacement of the existing hourly King's Cross – Newark/York stopping service with an hourly stopping service between King's Cross and Newark/Leeds on alternate hours. The Leeds services would extend to/from Harrogate and the Newark services would extend to/from Lincoln;
- Extension of some existing King's Cross – Leeds services to form a two-hourly King's Cross – Bradford Forster Square service. (One train per day in each direction is currently extended to/from Bradford Forster Square);
- Extension of one existing King's Cross – Leeds service to Huddersfield; and
- From May 2020, introduction of a new two-hourly service between King's Cross, York, Northallerton and Middlesbrough.

2.3 Track access application from First

2.3.1 King's Cross – Edinburgh services

First has proposed:

- Five return King's Cross – Edinburgh services per day, calling at Newcastle, Morpeth and occasionally Stevenage, from 2019.

3. Option development and key assumptions

3.1 Approach

ORR has received applications for a large number of proposed services on the ECML, and it is not practical for us to test all possible permutations. Instead, ORR has asked us to focus on testing applications or subsets of applications consistently (against a consistent do-minimum scenario), testing services together that may interact strongly, and a number of sensitivity tests. ORR considers that these options combined, together with any relevant supplementary information from within and outside this study, will be sufficient to consider the merits of permutations of services proposed in the applications.

ORR has instructed us to test the following options. We have discussed how these options are structured, and in some cases packaged, with each of the applicants, and also with DfT. We have endeavoured to agree the logic of this structure and packaging with these stakeholders.

For ease of presentation, we have assigned the options to three categories, as follows:

- Main options. These are groups of proposed additional train services which ORR has requested are assessed separately. Each option is tested against the same base timetable ("IEP base", described below), with the exception of some of the VTEC options which are increments to, and hence tested against a base including VTEC's additional Edinburgh, Newcastle and Leeds services.

- Additional options. These are packages of more than one option and/or individual options tested against a base of one of the other options.

- Sensitivity tests. ORR has requested that some tests are undertaken to understand the impact of some key assumptions relating to various options, and also the impact on other ECML operators.

Table 1 below provides a list of all options and Appendix A shows the core options and additional options in diagrammatical form. The remainder of this section of the report describes the base timetable, and the options grouped by applicant.

We have endeavoured to use the timetable files and other assumptions supplied by the applicants. We have only replaced these files or assumptions where we viewed them as potentially inappropriate for ORR's requirements. See appendix B for a description of the timetable development work.

Table 1: List of train service options for assessment

Main Options

Option ID	Title	Option summary	Do- minimum base timetable
1	Alliance Yorkshire /Cleethorpes	4 per day, London King's Cross - Cleethorpes 6 per day, King's Cross – Bradford 1 per day from King's Cross – Ilkley	May 2014, IEP journey times ("IEP base")
2	Alliance Edinburgh	Hourly King's Cross – Edinburgh	IEP base
3	VTEC Core	Half hourly King's Cross – Edinburgh, plus hourly King's Cross - Newcastle. 1 x weekday King's Cross - Edinburgh extended to/from Stirling. 1 x weekday King's Cross - Newcastle extended to/from Sunderland. Hourly stopping service between King's Cross and Newark/Leeds on alternate hours, Replacing hourly King's Cross – Newark/York stopping service	IEP base
4	VTEC Lincoln/Harrogate	Extension of the hourly stopping King's Cross – Newark/Leeds service to Lincoln/Harrogate, respectively	VTEC core (option 3)
5	VTEC Bradford Forster Square	1 King's Cross – Leeds service every 2 hours extended to/from Bradford FS	VTEC core (option 3)
6	VTEC Middlesbrough	2 hourly King's Cross – Middlesbrough service	VTEC core (option 3)
7	First Edinburgh	King's Cross – Edinburgh 5 trains per day	IEP base

Additional options

Option ID	Title	Option summary	Base timetable
8	VTEC Full	Combination of options 3-6 inclusive	IEP base
9	First Edinburgh as submitted	King's Cross – Edinburgh 5 trains per day (journey times differ to option 7)	VTEC full (option 8)
10	VTEC Core & Alliance Yorks. / Cleethorpes	Combination of options 1 and 3	IEP base

Sensitivity tests

Option ID	Title	Option summary	Base timetable
11	Alliance Edinburgh non-tilt	Option 2 with slower journey times	IEP base
12	VTEC Middlesbrough offset	Option 6 with Grand Central services offset one hour	VTEC full (option 8)
13	VTEC Middlesbrough switch	Option 6 with Grand Central and VTEC arrival at King's Cross switched	VTEC full (option 8)
14	VTEC Full no overtake	Option 8 without VTEC overtaking Hull Trains	VTEC full (option 8)
15	First Edinburgh no overtake	Option 9 with overtaking manoeuver on First services removed	VTEC Full (option 8)

3.2 IEP base timetable

3.2.1 Timetable assumptions

A single base timetable, "IEP base", was developed to enable a consistent assessment of options.

Given that the purpose of our assessment is to provide evidence to inform ORR's decisions, the base timetable is intended to represent the likely future (2020) timetable in the absence of any of the proposed incremental services beyond the current quantum and pattern of services currently operated.

In constructing the base timetable we therefore assumed that all Long Distance High Speed (LDHS) services are as per the May 2014 timetable, however with journey times reduced for services where IEP rolling stock is planned to replace current stock. Table 2 below shows indicative May 2014 and base journey times between selected locations.

Options are tested against this base timetable (IEP base), except where they form increments to other options (e.g. option 4 is incremental to option 3, hence tested against a base of option 3).

Table 2. Indicative journey times, May 2014 vs IEP base – weekday departures 13:00-13:59

King's Cross - Edinburgh		**King's Cross – Newcastle**		**King's Cross - Leeds**	
May 2014	**IEP Base**	**May 2014**	**IEP Base**	**May 2014**	**IEP Base**
4 hrs 22	**4 hrs 15**	**3 hrs 01**	**2 hrs 54**	**2 hrs 12**	**2 hrs 07**

3.2.2 Fleet assumptions

The fleet plan for VTEC's proposed 2020 timetable, including all services in its long term access rights application, is to operate mainly IEP rolling stock, with a small number of Intercity 225 trains in 7-car formation. VTEC has suggested that this sub-fleet of 225s is required to meet future capacity requirements – with operation of 225 trains on some London – Scotland services enabling a cascade of IEP rolling stock onto other services.

The IEP base would require a significantly reduced fleet size versus the proposed 2020 timetable, meaning that a sub-fleet of 225 stock would not be needed. We therefore assume that:

- Services shown as being operated by IEP stock in VTEC's 2020 timetable are operated by the same stock type and formation in the IEP base.
- Services shown as being operated by 225 stock in the 2020 timetable base are operated by IEP stock in 9 car formation in the IEP base.

3.2.3 Fares assumptions

A number of stakeholders have written to ORR with conflicting views on VTEC's likely fares in the IEP base scenario.

We understand that the level of available on-train capacity plays a large part in determining the number of (discounted) operator-specific fares made available by VTEC, hence determining VTEC's average yield.

We have estimated, for VTEC's train service groups, the ratio of passengers to seats on weekdays at the busiest point on the train's journey (the critical load point). These factors are broadly equivalent to May

2014 levels. We assume, therefore, that VTEC's fares in the IEP base timetable would be equivalent to 2014/15 fares in real terms.

We have requested that VTEC shares its estimated future fares (yields) that underpin its future fares strategy. We understand that this should be readily available from VTEC's franchise-bid revenue model, which is held in escrow. VTEC has not responded to this request, and we have therefore conducted our analysis in the absence of this data

3.3 Main Options – Alliance services

3.3.1 Alliance Yorkshire/Cleethorpes (Option 1)

3.3.1.1 Base timetable

This option is tested against the IEP base. See section 3.2.

3.3.1.2 Option timetable

Alliance has proposed:

- Seven return services per day (broadly two hourly) between London King's Cross and West Yorkshire. All services would call at Doncaster, East Leeds Parkway, Leeds and Kirkstall Forge, with six out of the seven extending to/from Shipley and Bradford Forster Square, and one out of the seven extending to/from Guiseley and Ilkley. East Leeds Parkway and Kirkstall Forge are planned new stations;
- Four return services per day between London King's Cross and Cleethorpes, calling at Doncaster, Scunthorpe, Habrough, Grimsby Town, and Cleethorpes;
- One early morning non-stop service between Doncaster and London King's Cross; and
- One late evening non-stop service between London King's Cross and Doncaster.

The above pattern would provide nine return services per day (rather than 11) between Doncaster and London King's Cross, as two of the above services would be operated via splitting/joining at Doncaster with one half extending to/from Bradford Forster Square and Ilkley (one each), and the other half extending to/from Cleethorpes.

- Alliance's application also includes the following services which are proposed as a means of balancing train diagrams stabled in the Doncaster area:One morning peak service between Doncaster and Bradford Forster Square (arriving Leeds at 08:22); and
- One late evening service between Cleethorpes and Doncaster.

On a Saturday, Alliance intends to operate similar (but retimed) services as outlined above, with the following changes:

- One less morning London – Bradford service;
- An additional morning service from Doncaster to Bradford Forster Square (assumed for diagram balancing);
- Additional morning Cleethorpes service joining a Doncaster – London service at Doncaster;
- One less afternoon Bradford – London service; and

- Additional afternoon service from Bradford Forster Square to Doncaster (assumed for diagram balancing purposes).

On a Sunday, Alliance intends to operate the following service provision:

- Five services in each direction between London and Bradford Forster Square;
- Two services in each direction between London and Ilkley;
- Four services from London – Cleethorpes and 3 services from Cleethorpes – London;
- Two services in each direction between London and Doncaster;
- One service in each direction between Doncaster and Cleethorpes;
- One service from Bradford – Doncaster; and
- One service from Doncaster – Ilkley.

Three of the above services would be operated via joining at Doncaster with one half extending from Bradford Forster Square and the other half extending from Cleethorpes. Two of the above services would be operated via splitting at Doncaster with one half extending to Bradford Forster Square and the other half extending to Cleethorpes.

Table 3 below shows indicative weekday journey times for journeys made by Alliance services, versus average journey times in the IEP base.

Table 3. Indicative journey times, Option 1 vs IEP base – weekday departures 13:00-13:59

Leeds – King's Cross		**Bradford FS – King's Cross**		**King's Cross – Scunthorpe**	
Alliance	**IEP Base**	**Alliance**	**IEP Base***	**Alliance**	**IEP Base***
2 hrs 3	**2 hrs 10**	**2 hrs 27**	**2 hrs 56**	**1 hr 57**	**2 hrs 24**

*Including interchange time

3.3.1.3 Rolling stock and other service characteristics

Alliance proposes to use new Hitachi Super Express Trains, fitted with bi-mode traction power. We understand that trains would operate in 5-car formation generally, with formations of 2 x 5 car on the portions of the journeys that are operated via splitting/joining at Doncaster.

3.3.1.4 Fares

Alliance proposes to operate a similar fares structure to Grand Central's current offer. Based on analysis of LENNON data for London to/from York, Doncaster, Bradford and Sunderland we estimate that, for flows with direct Alliance services, Alliance's revenue per journey (yield) in current prices will be approximately 25 percent lower than VTEC's current yield for the same journeys. This is a larger difference than the 11 percent estimate quoted in our interim report. This is because the previous estimate included flows which Grand Central does not serve directly, and hence does not offer advanced tickets for these flows. We understand that Grand Central's yield for these flows therefore comprises only inter-available fares, which are generally more expensive than advanced fares.

We believe that Alliance would achieve this lower yield through offering more (discounted) operator-specific fares as a proportion of all fares, than VTEC does currently.

Given these lower fares, we assume that VTEC would seek to respond to this by increasing the availability of operator-specific tickets sold at the same price offered by Alliance. We assume that the number of these tickets made available is equivalent to the number of spare seats on departure/arrival at King's Cross on VTEC's trains which arrive/depart at King's Cross immediately before or after an Alliance service. As a simplification we only consider VTEC's London – Leeds services, as these services are likely to cover the most significant flows in terms of revenue.

We have used estimated future train loads on VTEC's London – Leeds services (see section 4) to understand the number of spare seats, and therefore to estimate the number of additional operator-specific tickets on these services. On this basis we estimate that VTEC's average weekday London – Leeds fare would reduce by around five percent in real terms.

3.3.1.5 Other assumptions

Planning work for East Leeds Parkway station is at an early stage, with funding yet to be committed. We understand that, subject to an award of track access rights, Alliance intends to fund or part-fund work to construct the station.

3.3.2 Alliance Edinburgh (Option 2)

3.3.2.1 Base timetable

This option is tested against the IEP base. See section 3.2.

3.3.2.2 Option timetable

Alliance's proposed pattern of new services on the ECML is as follows:

- Hourly services between London King's Cross and Edinburgh (15 services per day southbound and 14 services per day northbound); and
- All services would call at Newcastle, with two early morning northbound services and three evening southbound services calling at Stevenage to pick up and set down passengers respectively.

In addition, Alliance's proposal includes the following early morning/late evening short workings:

- One early morning service between Newcastle and London King's Cross;
- Two late evening services between London King's Cross and Newcastle;
- Three early morning services between Newcastle and Edinburgh; and
- Two late evening services between Edinburgh and Newcastle.

On Saturdays, Alliance intends to operate a similar service provision as outlined above, with the following changes:

- One fewer service from London – Edinburgh;
- Two fewer services from Edinburgh – London;
- One additional service from Newcastle – Edinburgh (assumed for diagram balancing); and
- One fewer southbound call at Stevenage.

On Sundays, Alliance intends to operate the following service provision:

- 12 services in each direction between London – Edinburgh;
- Two services in each direction between London – Newcastle;
- Three services from Newcastle – Edinburgh;
- Two services from Edinburgh to Newcastle; and
- Stevenage calls as per Saturdays.

Table 4 below shows indicative weekday journey times for journeys made by Alliance services, versus average journey times in the IEP base.

Table 4. Indicative journey times, Option 2 vs IEP base – weekday departures 13:00-13:59

King's Cross - Edinburgh		**King's Cross – Newcastle**	
Alliance	**IEP Base**	**Alliance**	**IEP Base**
3 hrs 43	**4 hrs 15**	**2 hrs 28**	**2 hrs 54**

3.3.2.3 Rolling stock and other service characteristics

Alliance proposes to operate new Class 390 Pendolino rolling stock in a 9-car formation, with tilt capability enabled.

3.3.2.4 Fares

Alliance's fares proposal in 2014/15 prices is very similar to VTEC's existing offer, with a similar average yield.

We therefore have made an assumption that Alliance will offer the same average fares as VTEC for the relevant flows.

3.3.2.5 Other assumptions

We have modelled the journey times provided in Alliance's MOIRA files with small adjustments to comply with time allowances shown in the current Train Planning Rules (TPR). We understand that these timings are TPR compliant, but ORR's terms of reference to us does not include the validation of timetables. Modelled journey times are broadly 3 hrs 43 London – Edinburgh and 2 hrs 28 mins London – Newcastle in the northbound direction assuming no call at Stevenage, and 1-2 minutes slower in the southbound direction.

These journey times are not possible under the current and committed future capability of the infrastructure, particularly as the infrastructure does not currently allow the full benefit of the Pendolino's tilt capability to be realised.

The journey times are therefore dependent on an infrastructure upgrade, which we understand that Alliance would fund. These infrastructure upgrade costs are costs that are integral to service journey times, and hence integral to the assessment of option 2. As the total cost of this upgrade is not currently well understood, however, ORR will assess these costs separately and, as explained in section 5.2.6, they are excluded from this report.

ORR has requested that we undertake a sensitivity test to assess the application in the case where the infrastructure upgrade does not occur. The purpose of this test is to better understand the impact of the reduced journey times enabled by tilt, on the revenue assessment and economic appraisal. Under this sensitivity test (**option 11**) we assume that journey times are the same as IEP rolling stock would achieve when calling at the same number of stations. All other characteristics are as above.

3.4 Main Options – VTEC services

ORR requested that VTEC's long term access application was split into its constituent elements, to enable ORR to better understand where the benefits of the application arise.

3.4.1 VTEC core (Option 3)

3.4.1.1 Base timetable

This option is tested against the IEP base. See section 3.2.

3.4.1.2 Option timetable

We understand that the core proposition in VTEC's long term application is the operation of additional services between King's Cross, Newcastle and Edinburgh, and between King's Cross and Leeds, allowing the intermediate station calls in existing services to be switched to these new services. This enables significant journey time savings between the most populous locations and an overall increase in train frequency.

We assume the following weekday pattern of services:

- A half hourly King's Cross – Edinburgh service, (one per hour calling typically at York and Newcastle only, with the other calling at more locations);
- Extension of one weekday King's Cross – Edinburgh service in each direction to/from Stirling;
- An hourly King's Cross – Newcastle service calling at multiple locations;
- Extension of one weekday King's Cross – Newcastle service in each direction to/from Sunderland; and
- An hourly service between King's Cross and Newark/Leeds on alternate hours, calling at multiple locations.

On Saturdays the same pattern would operate except:

- The hourly King's Cross – Newcastle stopping service would operate 2-hourly north of Newark North Gate; and
- The hourly King's Cross – Newark/Leeds stopping service would not operate.

On Sundays the same pattern as weekdays would operate except:

- The hourly King's Cross – Newcastle stopping service would extend occasionally to/from Edinburgh; and
- The hourly King's Cross – Newark/Leeds stopping service would become a King's Cross – Newark/York service, with occasional extensions to/from Newcastle.

Table 5 below shows indicative weekday journey times for journeys made by VTEC Core services, versus average journey times in the IEP base.

Table 5. Indicative journey times, VTEC Core (option 3) vs IEP base – weekday departures 13:00-13:59

King's Cross - Edinburgh		King's Cross – Newcastle		King's Cross – Leeds	
VTEC Core	**IEP Base**	**VTEC Core**	**IEP Base**	**VTEC Core**	**IEP Base**
4 hrs 2*	**4 hrs 15**	**2 hrs 47****	**2 hrs 54**	**2 hrs 01**	**2 hrs 08**

* Fast hourly service only (excludes all stopping trains), ** fastest two services (excludes stopping train)

3.4.1.3 Rolling stock and other service characteristics

As discussed in section 3.2, VTEC intends to operate its proposed 2020 timetable with predominantly IEP trains as well as a small sub-fleet of Intercity 225 rolling stock. The VTEC core option consists of significantly fewer services than the 2020 timetable, and we therefore believe that sufficient capacity exists in the IEP fleet to operate the VTEC core. On this basis we assume:

- Services shown as being operated by IEP stock in VTEC's 2020 timetable are operated by the same stock type and formation in this option; and
- Services shown as being operated by 225 stock in the 2020 timetable base are operated by IEP stock in 9 car formation in this option.

3.4.1.4 Fares

We understand that current high passenger loadings constrain the availability of (discounted) operator-specific tickets on the King's Cross – Newcastle – Edinburgh route, whereas we understand that this is not the case on the King's Cross – Leeds route.

VTEC has suggested that, given sufficient future capacity, it would look to increase the availability of operator-specific tickets as a proportion of all tickets on King's Cross - Newcastle – Edinburgh services to the current level available on King's Cross – Leeds services. As discussed above, we do not have access to VTEC's estimated future fares.

We have estimated future train loads for services on the London – Newcastle – Edinburgh routes upon departure and arrival at King's Cross (see section 4), and have calculated the ratio of passengers to seats at this point. As a sense-check we repeated the analysis at the busiest point on each train's journey. We estimate that under this option, across the day, load factors will be around the same as in both the IEP base and in May 2014. We therefore do not believe that VTEC would increase the number of operator-specific tickets, and assume that fares remain at the 2014/15 level in real terms. We are unable to present in this report estimated figures for the ratio of passengers to seats as we understand that this is commercially sensitive information.

3.4.1.5 Other assumptions

None.

3.4.2 VTEC Lincoln / Harrogate (Option 4)

3.4.2.1 Base timetable

This option is an increment to the VTEC Core option, so the base timetable is the VTEC Core (option 3).

3.4.2.2 Option timetable

This option consists of the extension of the weekday hourly stopping service between King's Cross and Newark/Leeds to/from Lincoln and Harrogate, respectively.

At weekends the same Harrogate extensions would be via an existing fast Leeds service, and the Lincoln extensions would be via a King's Cross – Newark stopping service.

3.4.2.3 Rolling stock and other service characteristics

We estimate that the extension of services to/from Lincoln and Harrogate would require around two additional units. Based on both discussions with VTEC and our own assessment we do not believe that VTEC would have sufficient spare IEP rolling stock to provide these services, and understand that procurement of a sub-fleet of two units would be infeasible. These service extensions would therefore have to be operated through a redeployment of rolling stock from other services. We assume that this would be done by operating some off-peak King's Cross – Leeds services in 5-car formation, which would otherwise operate as 9 or 10-car trains.

3.4.2.4 Fares

We assume that fares in 2014/15 prices are as per VTEC's current offer, with a similar average yield.

3.4.2.5 Other assumptions

None.

3.4.3 VTEC Bradford Forster Square (Option 5)

3.4.3.1 Base timetable

This option is an increment to the VTEC Core option, so the base timetable is the VTEC Core (option 3).

3.4.3.2 Option timetable

This option involves the extension of one weekday King's Cross – Leeds service every second hour, to form a two-hourly King's Cross – Bradford Forster Square service. (One train per day in each direction is currently extended to/from Bradford Forster Square).

3.4.3.3 Rolling stock and other service characteristics

We estimate that the extension of services to/from Bradford Forster Square would require one additional unit. Based on both discussions with VTEC and our own assessment we do not believe that VTEC would have sufficient spare IEP rolling stock to provide these services, and understand that procurement of a sub-fleet of two units would be infeasible. The service extension would therefore have to be operated through a redeployment of rolling stock from other services. We assume that this would be done by operating some off-peak King's Cross – Leeds services in 5-car formation, which would otherwise operate as 9 or 10-car trains.

3.4.3.4 Fares

We assume that fares in 2014/15 prices are as per VTEC's current offer, with a similar average yield.

3.4.3.5 Other assumptions

None.

3.4.4 VTEC Middlesbrough (Option 6)

3.4.4.1 Base timetable

This option is an increment to the VTEC Core option, so the base timetable is the VTEC Core (option 3).

3.4.4.2 Option timetable

This service proposition involves introduction of a new weekday two-hourly service between King's Cross, Peterborough, York, Northallerton and Middlesbrough.

The York stop would be switched from the corresponding fast Edinburgh service, enabling faster journey times between Edinburgh and London.

The Peterborough and Northallerton stops would be switched from the corresponding stopping Newcastle service, enabling faster journey times between a number of locations.

Table 7 below compares journey times between selected locations with and without the Middlesbrough service.

Table 7. Indicative journey times, VTEC core vs VTEC core + Middlesbrough (option 6) – weekday departures 13:00-13:59

Edinburgh – King's Cross		Newcastle – King's Cross		Middlesbrough – King's Cross*	
VTEC core	**VTEC core + M'boro**	**VTEC core**	**VTEC core + M'boro**	**VTEC core**	**VTEC core + M'boro**
4 hrs 3**	**4 hrs****	**2 hrs 47*****	**2 hrs 45*****	**3 hrs 15**	**2 hrs 47**

* Including interchange time (there is no northbound Middlesbrough service from King's Cross between 13:00-13:59).

** Fast hourly service only (excludes all stopping trains).

*** Fastest two services (excludes stopping train)

3.4.4.3 Rolling stock and other service characteristics

As discussed in section 3.2, VTEC intends to operate predominantly IEP trains as well as a small sub-fleet of Intercity 225 rolling stock. We believe that the King's Cross – Middlesbrough service would require a sufficient number of additional units to enable the leasing of a sub-fleet of rolling stock to augment the IEP fleet.

We therefore assume that rolling stock types and formations are as shown in VTEC's proposed 2020 timetable.

3.4.4.4 Fares

We assume that VTEC's fares in 2014/15 prices maintain current average yields.

3.4.4.5 Other assumptions

A small amount of infrastructure work would be required at Middlesbrough station to enable the King's Cross – Middlesbrough service. We understand that VTEC would fund this work.

3.5 Main Options – First Group services

3.5.1 First Edinburgh (Option 7)

3.5.1.1 Base timetable

This option is tested against the IEP base. See section 3.2.

3.5.1.2 Option timetable

First's service proposition is to operate five King's Cross – Edinburgh services per day in each direction, calling at Newcastle, Morpeth and occasionally Stevenage. The service would operate seven days per week, with some omitted station calls on Saturdays and particularly Sundays.

The timetable submitted in support of First's access rights application was designed to fit with VTEC's proposed 2020 timetable. In this submission First's northbound services are flighted behind the regular hourly VTEC service, except for First's earliest departure from King's Cross, which commences operation before VTEC's first service. Southbound services set off prior to VTEC's regular hourly trains, and are shown as being overtaken on the way to London. First's services are typically 9 minutes and 10 minutes slower between King's Cross and Edinburgh in the northbound and southbound directions respectively.

First's submission to ORR indicates that the key characteristics of the service are low fares, an early morning departure from King's Cross addressing a perceived gap in the market, and improved connectivity to/from Morpeth. Fast end to end journey times appear to be a secondary consideration against these stated aims, particularly given First's proposed journey times.

As mentioned above, this option is tested against the IEP base in our assessment. This is so all options, other than increments to the VTEC core timetable, are assessed against a consistent base. In retiming these services we assume the same characteristics as above, with First's services flighted behind the northbound regular VTEC hourly service in the IEP base instead of the service in VTEC's indicative 2020 timetable in their long term access application and overtaken by the southbound regular VTEC hourly service in the IEP base. Journey time differentials are as above.

Table 8 below compares journey times for First's services with journey times in the IEP base.

Table 8. Indicative journey times, First Edinburgh vs IEP base – weekday departures 13:00-13:59

King's Cross - Edinburgh		King's Cross – Newcastle	
First Edin.	**IEP Base**	**First Edin.**	**IEP Base**
4 hrs 23	**4 hrs 15**	**2 hrs 49**	**2 hrs 54***

*Average of semi fast and stopping service

3.5.1.3 Rolling stock and other service characteristics

First proposes to use new Hitachi Super Express Trains operating in high density, single class, 5-car formations.

3.5.1.4 Fares

First proposes to offer a high proportion of heavily discounted operator-specific fares, with the stated aim of competing with low cost airlines and coach operators. First proposes to offer a significantly cheaper advanced fare than currently offered by VTEC, and to make available a large number of these tickets in proportion to the total ticket sales. We estimate that First's overall average yield would be around 50% - 60% of VTEC's.

We estimate that First's ratio of passengers to seats across the weekday in 2020 would be around 80%. Whilst this is undoubtedly high compared to current long distance operators, our revenue assessment indicates that most of First's journeys would be made using advanced fares, which would provide a significant opportunity to manage train loads via the number of advance fares made available for each train. We therefore do not believe that First would, under normal circumstances, need to increase fares to manage train loads. Clearly load management may be required at exceptionally busy times of the year, but this is no different to other long distance operators.

Given these lower fares, we assume that VTEC would seek to respond by increasing the availability of operator-specific tickets, and reducing the fares for these tickets on the adjacent train services, providing that spare capacity is available on these services. We would not expect VTEC to reduce fares on trains that are already full. We have estimated the number of seats available at the critical load point on VTEC services immediately before and after First's trains, and have assumed that VTEC would offer an equivalent number of fares at the same price offered by First. On this basis we estimate the average reduction in VTEC's London – Newcastle and London – Edinburgh fares would be around seven percent in real terms.

This method is one reasonable means of calculating a competitive response, based on yield management principles articulated previously by several stakeholders. We are confident that this is an appropriate method, but there may also be other legitimate approaches.

Section 6.9 presents our forecasting and appraisal results for option 7.

3.5.1.5 Other assumptions

The assumption that First's southbound service is overtaken by VTEC's regular (fast) hourly service may have a material impact on our revenue assessment and economic appraisal. ORR has therefore requested that the impact of the overtaking manoeuver is tested in our assessments. With ORR's agreement, this was undertaken as a sensitivity to First's Edinburgh service as submitted (option 9) rather than this option. (See 6.3.2)

It is possible that a future timetable planning process may result in First's service being timetabled to run in front of VTEC's regular hourly service, as the former stops at 2-3 few stations and could in theory operate with significantly faster journey times. ORR has not instructed us to test the impact of this outcome in our assessment.

First intends to fund the expansion of Morpeth station car park as part of its proposal.

3.6 Additional Options

As discussed in section 3.1, ORR has requested that some packages of options are assessed to identify the impact of some potential mixed uses of additional capacity.

3.6.1 VTEC Full (Option 8)

3.6.1.1 Base timetable

This option is tested against the IEP base. See section 3.2.

3.6.1.2 Option timetable

The timetable for this option is the same as VTEC's 2020 timetable, so a combination of all services from options 3, 4, 5 and 6. ORR has requested that VTEC's proposed service extension to/from Huddersfield is not considered in the assessments presented in this paper.

3.6.1.3 Rolling stock and other service characteristics

We assume that rolling stock types and formations are as shown in VTEC's proposed 2020 timetable, namely IEP stock in a mixture of 5, 9 and 10 car formations, and a small sub-fleet of Intercity 225 trains.

3.6.1.4 Fares

Fares are as per options 3-6, i.e. the same as 2014/15 in real terms.

3.6.1.5 Other assumptions

In developing the 2020 timetable VTEC has made a number of assumptions about how its services would fit with other operators' services and vice versa. ORR has requested that the revenue impact of some of these assumptions is tested:

- VTEC Middlesbrough offset (option 12). In VTEC's 2020 timetable VTEC's King's Cross - Middlesbrough services operate in the same hour as Grand Central's King's Cross – Sunderland services in the southbound direction. This sensitivity test moves Grand Central's services forward by between 60 and 75 minutes, so that Grand Central's services depart from York and arrive at King's Cross before VTEC's. This is to show the impact on Grand Central's revenue, and to allow a comparison with option 8 (and option 6 by implication).
- VTEC Middlesbrough switch (option 13). This sensitivity test builds on option 12 by also switching the order in which Grand Central's services and VTEC's services arrive and depart King's Cross, by bringing forward Grand Central's services by between 60 and 80 minutes. This is to show the impact on Grand Central's revenue, and to allow a comparison with option 8 (and option 6 by implication).
- VTEC Full, no overtake (option 14). In VTEC's 2020 timetable VTEC's services overtake services operated by Hull Trains, between King's Cross and Doncaster in the southbound direction. In our timetable files we only adjust services operated by the relevant applicant, and in our VTEC full timetable (option 8) only the 09:18 Hull Trains weekday arrival at King's Cross is overtaken (at Retford). In this sensitivity test this overtaking manoeuver is removed. This is to show the impact on Hull Train's revenue, and to allow a comparison with option 8.

3.6.2 First Edinburgh as submitted (Option 9)

3.6.2.1 Base timetable

This option is tested against the VTEC Full timetable (Option 8).

3.6.2.2 Option timetable

The timetable submitted by First in support of its access rights applications is used for this option. This involves the same quantum of services and calling pattern as described for option 7. Table 9 below compares selected journey times for the VTEC full option and First's proposed services as submitted to ORR.

Table 9. Indicative journey times, First Edinburgh as submitted (option 9) vs IEP base – weekday departures 13:00-13:59

King's Cross - Edinburgh		King's Cross – Newcastle	
First Edin.	**VTEC Full**	**First Edin.**	**VTEC Full**
4 hrs 10	**4 hrs 2***	**2 hrs 42**	**2 hrs 47****

* Fast hourly service only (excludes all stopping train), ** fastest two services (excludes stopping train)

3.6.2.3 Rolling stock and other service characteristics

As per option 7.

3.6.2.4 Fares

Our estimated ratio of passengers to seats is similar to in option 7, and our fares assumptions are therefore the same.

Section 6.9 presents our forecasting and appraisal results for option 9.

3.6.2.5 Other assumptions

The following sensitivity test has been undertaken:

- First Edinburgh, no overtake (option 15). (See section 6.10.4). As discussed above, all except the earliest of First's southbound services are overtaken by the VTEC fast hourly southbound service. In this sensitivity test, this manoeuver is removed, with First's services retimed to operate approximately 16 minutes faster between Edinburgh and King's Cross.

  As for options 7 and 9 we have estimated First's fares, and VTEC's fares response based on estimated train loads.

  We estimate that First's ratio of passengers to seats across the weekday in 2020 would be very high, with most trains fully loaded. We therefore supplement the assumptions from options 7 and 9 with a simple sensitivity test showing the impact of higher fares.

3.6.3 VTEC Core and Alliance/Yorkshire Cleethorpes (Option 10)

3.6.3.1 Base and option timetables

We test the VTEC Core option against the IEP base, and then both the Alliance and VTEC service against the VTEC core option. We then sum the revenue and benefit of both options.

3.6.3.2 Rolling stock and other service characteristics

As per options 1 and 3.

3.6.3.3 Fares

As per options 1 and 3.

3.6.3.4 Other assumptions

None.

4. Summary of revenue forecasting approach

4.1 Introduction

Our revenue forecasting approach consists of a number of individual steps. In the first step we use the industry standard MOIRA software to compare the timetable for an option with the timetable for the relevant base. This produces an estimate of journeys and revenue before and after the introduction of the option timetable, split by pairs of stations (flows) and by TOC.

We then apply a series of modelled overlays to scale the flow-level journeys and revenue figures produced using MOIRA. This is to adjust for the factors which influence journeys and revenue, but which are not estimated well, or at all, within MOIRA.

The rest of this section of the report summarises each step of the forecasting process, with appendices B-F explaining the process in more detail. Figure 1 at the end of this section provides a flow map of the full forecasting process.

4.1.1 Quality Assurance

We have undertaken a full internal review of our analysis, models and results, including review by senior staff outside of the immediate project team.

We have worked collaboratively with ORR and with stakeholders so that our assumptions and methodology are clear, and to allow for rigorous challenge of our work.

ORR has procured independent external review by consultants Systra of our methodology and resultant forecasts and appraisal. We have provided Systra's team with all models and data used in this work. We have also worked collaboratively and transparently with Systra, so that its team understands our work thoroughly.

To date we have not seen the assurance report produced by Systra.

4.2 MOIRA

4.2.1 Timetable development process

MOIRA timetable files were produced by CH2M for the IEP base and all options (1-15) listed in table 1. Separate timetable files were produced for weekday, Saturday and Sunday.

Timetable files for the options were based on the MOIRA (SPG) files supplied by each applicant in support of their access rights applications, with adjustments made where we felt this was appropriate (see Appendix B).

All base and option timetable files were supplied to all applicants for review, and all applicants submitted a response to ORR. We considered the comments and made a small number of adjustments. All revised (final) timetable files were shared with all applicants.

The same draft and final set of timetable files were shared with ORR, and with DfT upon request.

4.2.2 Estimated impacts of improvements to journey times and travel opportunities

The MOIRA analysis estimates the impact on journeys and revenue of two main changes caused by the options:

- Reallocation of revenue between TOCs, as a result of the new opportunities to travel and (generalised) journey time (GJT) improvements provided by the new services. GJT is the sum of all elements of journey time, such as time on the train, time waiting for a train and interchange time. This reallocation is undertaken using the same algorithm as the ORCATS system used to allocate ticket sales revenue between operators; and
- Estimation of the growth in total journeys and revenue as a result of the GJT improvements caused by the introduction of the new services. This is done through the application of GJT elasticities taken from the Passenger Demand Forecasting Handbook (PDFH5.1).

4.2.3 Output

The assessment described above produces tables of journeys and revenue split by flow and by TOC.

Appendix B provides a more detailed description of the approach taken.

4.3 Fares overlay

The demand and revenue projections from the MOIRA analysis are scaled to estimate the impact of operators' fares strategies. An overlay is necessary as MOIRA does not have the functionality to assess the impact of fares on demand and revenue.

The scaling of journeys and revenue undertaken in this overlay includes both the impact of the applicant offering a reduction in fares versus the current offer, and any reduction in fares from the incumbent operator, in response.

This analysis is undertaken in two stages.

4.3.1 Revenue reallocation

The first part of the process reallocates estimated journeys and revenue from the MOIRA analysis between the various TOCs.

This estimate is produced using the LOGIT function specified in PDFH5.1[1].

4.3.2 Market growth estimate

The second stage of the process estimates growth in journeys and revenue as a result of a reduction in average fares. PDFH5.1. fares elasticities are used to produce these estimates.

4.3.3 Output

The output of this analysis is revised estimates of journeys and revenue by flow and by TOC.

Appendix C provides a more detailed description of the approach taken.

[1] PDFH 5.1, Section B11.4.

4.4 Air competition overlay

The forecasting process described above uses elasticities published in PDFH5.1 to estimate the impact of changes in GJT and fares on rail demand and revenue.

However, as most flows in Great Britain do not have any air competition we are concerned that use of PDFH elasticities may understate the potential impact of a reduction in GJT or fares on flows that compete with air.

We therefore re-estimate journeys and revenue for flows where air competition is present, assuming that the difference between these new estimates and the estimates using MOIRA and the Fares overlay is a result of passengers transferring from airline travel.

Two air competition overlays are applied, as described below.

4.4.1 Competition on journey time

This stage of the assessment re-estimates rail journeys and revenue, following a reduction in air-competitive rail journey times when new services are introduced.

The PDFH[2] relationship between the journey time by rail and rail's share of the total rail and air market is used to forecast total rail journeys following a reduction in journey times on routes where air/rail competition occurs. These forecasts are scaled to reflect rail's current mode share. We then estimate growth in the total air and rail market, using a method consistent with PDFH.

Two main domestic air routes compete with ECML rail services, namely London - Edinburgh and London - Newcastle. Separate estimates of the total number of journeys between London and Edinburgh and between London and Newcastle are therefore produced.

Estimates are capped so that the forecast number of journeys cannot exceed the combined rail and air market, (excluding air passengers who travel to connect with other flights), although we estimate the growth in the total combined air and rail market as a result of improved rail journey times. This is an improvement to a limitation in our previous methodology acknowledged in the phase 2 interim report.

We prefer the above approach to development of a multi-modal model, as the former draws on potential analogies from elsewhere in Europe when forecasting the potential modal share, whereas the latter requires calibration to current mode shares, which would be likely to change significantly following the introduction of several of the options.

4.4.2 Competition on fares

This stage of the assessment re-estimates rail journeys and revenue, following a reduction in air-competitive rail fares when new services are introduced.

We are unable to implement a similar approach to the previous overlay, as insufficient evidence exists on the relationship between rail fares and rail's share of the total market.

A logit model is therefore used to estimate rail demand, hence revenue, following a reduction in rail fares. This model, which is consistent with both PDFH guidance and WebTAG, allocates demand to either rail or air using the estimated Generalised Journey Cost (GJC) for each mode, split into the constituent elements (e.g. journey time, waiting time, rail fares and access/egress costs).

[2] PDFH5.1, section 2.8.

Mode shares, hence total journeys and revenue, are estimated by adjusting only the rail fares component of generalised cost, with values for all other elements of GJC the same in the base as the forecast. This means that there is no overlap with the previous air market overlay.

4.4.3 Output

The output of this analysis is revised estimates of journeys and revenue by relevant flow and by TOC.

Appendix D provides a more detailed description of the approach taken.

We have not used the above methodology for London – Leeds flows, as we understand that rail already has a dominant share of the combined London – Leeds (West Yorkshire) air and rail market. We therefore believe there to be an extremely limited potential for the options to capture significant demand from air.

4.5 Direct demand overlay – new direct services

As described above, MOIRA uses elasticities published in PDFH5.1 to estimate the impact of changes in GJT on rail demand and revenue.

We are concerned that use of these elasticities may not adequately capture the impact of some of the factors which PDFH attributes as a source of variation in passengers' sensitivity to GJT, and that recent PDFH studies have not addressed adequately some of the characteristics of the options for consideration in this study.

Of particular concern is that travel to/from locations with infrequent or no direct rail services may be suppressed as a result. Therefore, the elasticities used may not capture the uplift in journeys from the provision of new direct long distance services to/from locations of this nature. PDFH suggests that a number of factors could dissuade people from travelling by rail:

- Where GJT or journey time is above a threshold level, e.g. where day return trips are infeasible; and
- Where opportunities to travel do not exist at or close to the desired time of day, or where the quality of service, e.g. rolling stock, falls below a minimum threshold level.

The options to be considered in this study include the provision of new direct links between London and a number of locations with few or no direct services such as Middlesbrough, Scunthorpe and Harrogate, as well as two proposed new stations.

We have therefore produced a demand overlay to re-estimate journeys and revenue on flows which have a current frequency of less than hourly, and where the options considered increase this service frequency.

4.5.1 Gravity model

Journeys and revenue for the flows described above are re-estimated using a gravity model of the type described in PDFH[3].

The model estimates, for existing ECML flows, the relationship between rail journeys and a number of the characteristics identified in PDFH as factors which influence travel demand, specifically:

- Station catchment population;

[3] PDFH5.1 section 10.

- Average wage of the catchment population (as a proxy for propensity to travel); and
- Rail GJT.

This relationship is used to estimate the impact on journeys and revenue of a change in any of these characteristics following introduction of a new service, particularly a change in GJT.

Catchment areas for the stations in question are examined to enable an estimate of the split of new journeys and revenue that would be a result of passengers transferring from other stations.

We assume that the difference between these new estimates (net of passengers transferring from other stations), and the estimates using MOIRA and the Fares overlay is newly generated demand and revenue. Our estimate of passengers transferring from other stations uses ticket sales data and population data.

This overlay is only applied to flows between the London Travel Card Area (TCA) and ECML stations, as the previous phase of this study showed that application of a similar model to non-London flows had minimal effect on the overall revenue projections. This is therefore a simplification proportionate to ORR's requirements.

4.5.2 Output

The output of this analysis is revised estimates of journeys and revenue by relevant flow and by TOC.

Appendix E provides a more detailed description of the approach taken.

4.6 TOC marketing overlay – no longer used

Our planned approach was to rescale the demand and revenue estimates from above to account for the impact of TOC marketing, through application of an assumed ratio of revenue gain to marketing spend of 2:1.

This approach has been criticised by stakeholders, with applicants in particular suggesting that:

- Their own marketing activities would target predominantly revenue generation, rather than abstraction; and
- The marketing activities of other applicants would target revenue abstraction rather than generation.

Having considered the issues further and reflected on stakeholder comments, we have decided to remove the marketing assessment from our demand and revenue forecasting approach. This is for three reasons:

- There is little, if any, published rail industry evidence to substantiate our assumed ratio of revenue gain to marketing spend;
- We are unable to validate with confidence applicant's stated future marketing budget; and
- The industry revenue data used in this analysis already includes the impact of TOC marketing. We therefore assume that applicants' future marketing expenditure are as per the baseline.

4.7 Crowding model scaling

The estimated number of journeys produced using the above approach, and the estimated number of journeys in the IEP base are re-scaled using a Crowding model.

This model, which uses the principles outlined in PDFH, either supresses or increases the number of journeys based on the availability of train capacity to accommodate forecast demand.

4.7.1 Model approach

The main inputs to the model are current train loads, taken from passenger count data, current and future train capacity figures, future timetables, and estimated journeys for the IEP base and options, using the approach described above.

The model works by undertaking a number of calculations:

- Allocation of passengers using any-operator tickets to individual trains, based on the known profile of journeys across the day;
- Allocation of passengers using advanced (operator-specific) tickets to individual trains, based on the cost of operator-specific fares. The number of passengers is capped based on the availability of both capacity and fares at a certain level, within pre-defined time bands; and
- Generation of further journeys if the model calculates that the base timetable has suppressed demand, and the option timetable has available capacity.

4.7.2 Output

The main output of this analysis is a set of scaling factors which are used to re-estimate journeys, hence revenue by flow and by TOC.

The model also allows us to re-estimate operator-specific, and hence overall fares on the basis of the availability of on train capacity.

Appendix F provides a more detailed description of the approach taken.

4.8 Issues not modelled

Some factors which could potentially influence demand and revenue are not modelled explicitly in the forecasting methodology. These are described below.

4.8.1 Train punctuality

The impact of the option timetables on train punctuality, hence demand and revenue, is not assessed. This is because the performance analysis provided to us does not allow us to quantify the different performance impacts of the various options.

ORR would therefore need to consider separately the extent to which our assessment may overstate the revenue impacts and benefits to passengers of the options assessed.

4.8.2 Coach market capture

We have not modelled directly, as suggested by at least one applicant, the potential for options to abstract coach market demand and revenue. This is because coach competition has existed on most long distance routes for many years, and PDFH elasticities are therefore likely to include the impact of competition with travel by coach. Our forecast revenue generation therefore includes an element of transfer from coach to rail. We also do not have access to an independently produced set of data on the number of coach services and journeys made by coach. One applicant has supplied data of this nature to us, but we are unable to verify it.

We note that PDFH states that there is greater uncertainty over larger changes in fares, with ± 10% cited as the threshold for a large change. We have discussed this with ORR, and understand that ORR intends to conduct its own supplementary analysis.

4.8.3 Service quality and passenger satisfaction

At least one applicant has contended that the characteristics of its proposed service offer are more attractive to passengers than the typical current service offer. We have not attempted to model this, as the evidence relating to most future service quality attributes is, in our view, largely conjecture.

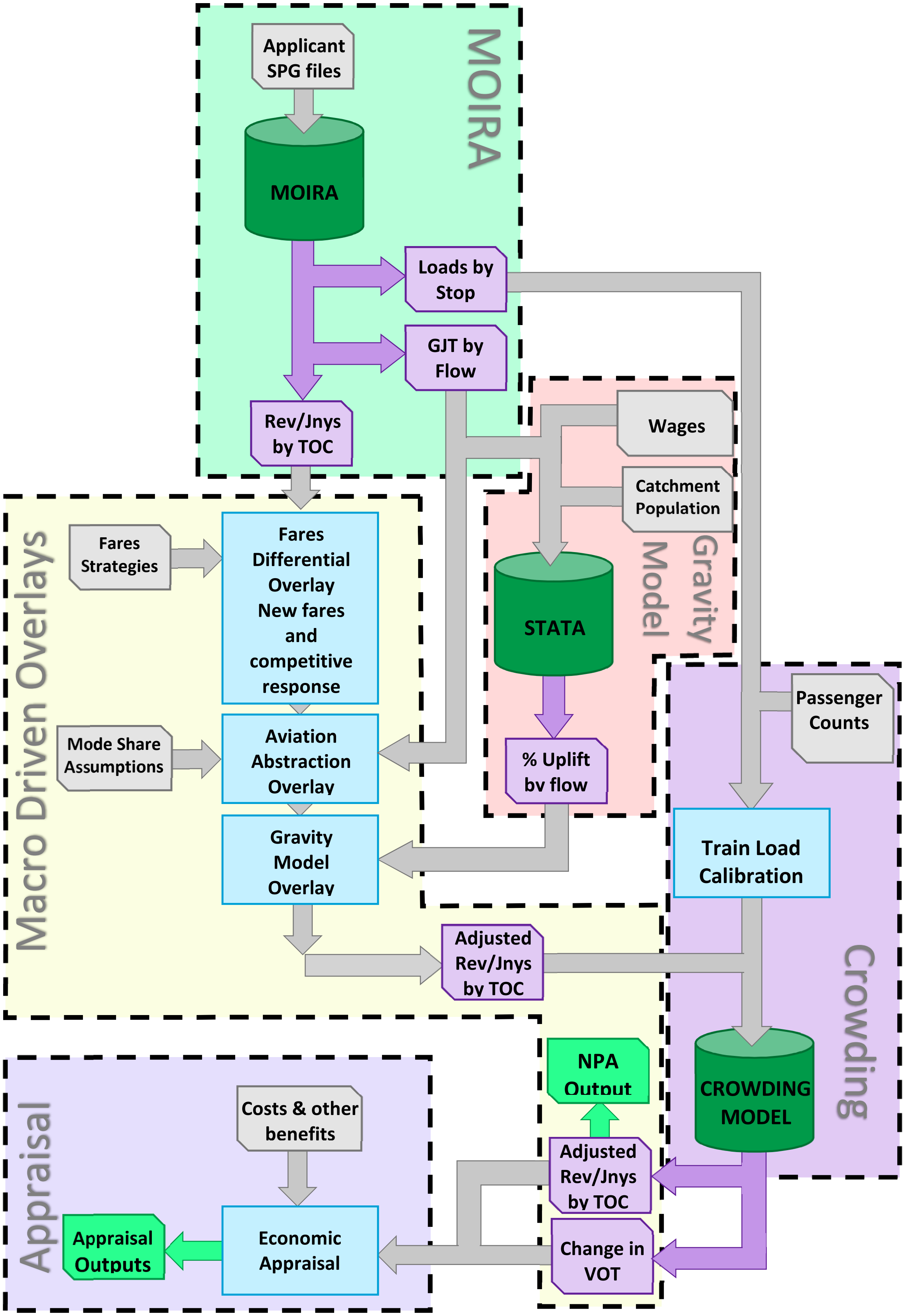
4.8.4 Competitive response from other operators

Due to the difficulty in predicting what the competitive response from air operators and coach operators may be, we have made no assumptions about this. ORR has told us it intends to assess the likely competitive response separately.

4.9 Flow diagram of the full forecasting process

Figure 1 below is a flow diagram of the complete modelling process described above. It also includes the economic appraisal of options, described in section 5.

Figure 1 Modelling approach flow diagram – forecasting and appraisal



5. Summary of economic appraisal approach

5.1 Background

This section presents a summary of our economic appraisal approach, with a more detailed description provided in appendix G.

The appraisal is intended to provide an estimate of a number of the incremental benefits and costs relating to each option considered as compared to the relevant do-minimum base timetable, focusing on those effects that can be quantified. It is not a full assessment of all of the impacts and largely excludes qualitative factors. Similarly, it does not seek to appraise effects against the ORR's statutory duties.

We understand that this quantification will form part of the evidence base which will underpin ORR's eventual decisions, but it will not be the only evidence considered by ORR and is therefore not intended to be an all-encompassing assessment of every aspect of the applications. Specifically:

- The appraisal of effects is intended to be, where appropriate, compliant with WebTAG and the HMT Green Book. However, there are cases where the appraisal deviates from this. Where they occur we explicitly state the reasons for these deviations.
- Where certain forecasts of costs or benefits are highly uncertain, ORR has asked us to omit these from our analysis, but explicitly state the omission. An example of this is where the costs of infrastructure investment are unknown; we have omitted these, and ORR can separately take a view of these costs and consider them alongside our appraisal.

5.2 Quantification of benefits and costs

The economic appraisal quantifies incremental benefits and costs of the options considered, over an appraisal period of 10 years. For simplicity it is assumed that all options would commence operation in 2020, so that all are assessed over a consistent time period.

The demand and revenue projections described in the previous section are the main inputs to the assessment of benefits, with cost estimates largely produced separately.

The following benefits and costs are quantified in 2010 prices and values, consistent with WebTAG.

5.2.1 User benefits

5.2.1.1 Time savings

The saving in generalised journey time (GJT) from journey time and frequency improvements, made by both existing rail passengers and passengers who are attracted to rail by the new services.

5.2.1.2 Reduction in rail fares

The net benefit to passengers from a reduction in rail fares.

5.2.2 Non-User benefits

This is the benefit to people other than existing or newly attracted rail passengers. The main benefits to non-users from the introduction of new rail services are a reduction in road congestion, and hence highway journey times savings, generated through a switch from road to rail travel. Other associated impacts include reductions in the number of road accidents and small improvements in vehicle emissions and local air quality.

5.2.3 Revenue

This is the net increase in GB rail revenue generated by the introduction of the proposed new services.

5.2.4 Other Government impacts

5.2.4.1 Value Added Tax (VAT)

This is foregone VAT from the forecast switch from road to rail travel, assuming increased expenditure on rail travel (which does not incur VAT), is funded through an equivalent reduced expenditure on goods and services which do incur VAT.

5.2.4.2 Taxation on road vehicle fuel

This is the foregone indirect taxation paid on fuel caused by the forecast switch from road to rail travel

5.2.4.3 Fuel duty on diesel trains

This is increased fuel duty from an increase in diesel train mileage

5.2.4.4 Highway maintenance costs

We also estimate a reduction in highway maintenance costs to local authorities and Highways England. For simplicity, this estimated cost saving is included in this category. This is likely to be a very small impact resulting from the switch from road to rail travel mentioned above.

5.2.5 Operating costs

This is the net increase in operating costs required to provide the proposed new services.

5.2.5.1 Staff costs

This is the estimated cost of the net increase in drivers and conductors required to operate the proposed new services.

5.2.5.2 Rolling stock costs

This is the net cost of procuring and maintaining the rolling stock that is required to operate the proposed new services. ORR has instructed us to assume that all rolling stock required to operate the options beyond the base timetable used to assess that option be considered incremental, regardless of current procurement arrangements. With this in mind, we have adopted a common assumption for the cost of rolling stock, based on the costs of leasing the rolling stock required to operate the services, to support comparison between the various options. Separately, we would expect ORR to decide upon the appropriate way to treat the rolling stock costs against its statutory duties; including the appropriate treatment of any committed costs and availability payments relating to the IEP rolling stock.

5.2.5.3 Network Charges

This comprises the main variable usage charges payable to Network Rail, calculated on the basis of the estimated net change in vehicle mileage by rolling stock type. This includes the variable usage charge (VUC), electric current for traction (EC4T), the electrification asset usage charge (EAUC), and the capacity charge. We assume the same capacity charge rates for each option.

Station access charges have been excluded from this category as we are unable to estimate them at this stage, although we would expect these charges to be broadly in proportion to other variable usage charges.

5.2.5.4 Other operating costs

This is the cost of diesel (bi-mode) traction for the proposed services which would operate on track sections which are not electrified.

5.2.6 Exclusions

5.2.6.1 Fixed costs

As the economic appraisal is required to assess the incremental impacts of the proposed new services, fixed costs have been excluded from the assessment. We acknowledge that the main types of fixed costs are likely to differ between Franchised Operators and Open Access Operators, however we believe our approach to be reasonable for the purposes of ORR's assessment.

5.2.6.2 Investment costs

The benefits of the applications have been calculated assuming that certain investments have occurred. Some of these are as follows:

- Alliance's services to West Yorkshire stop at two new stations, East Leeds Parkway and Kirkstall Forge. Planning work for East Leeds Parkway station is at an early stage, with funding yet to be committed. In the absence of the services, at least some of the investment might not occur (options 1 and 10).
- The journey times assumed in Alliance King's Cross to Edinburgh services require infrastructure investment, notably to permit tilting trains (option 2).
- First intends to fund the expansion of Morpeth station car park as part of its proposal (options 7, 9 and 15).

In the economic appraisal, the costs should be calculated on a consistent basis to the benefits. Therefore the incremental components of these costs (to the extent that the application's benefits require all or part of this cost to be incurred, net of any wider benefits associated with the increased network capability) should be included in the appraisal. These investment costs are not currently well understood, however. ORR has therefore advised us to exclude the costs from our calculations of costs and benefits presented in this report, while noting that they are relevant and should be considered alongside the other costs and benefits in ORR's assessment of the relevant applications.

5.2.7 Appraisal results

We report three sets of appraisal results for each option to ORR.

5.2.7.1 Net Present Value (NPV)

This is the quantified benefits minus the quantified costs.

5.2.7.2 NPV per path

This is the NPV divided by the number of train services[4] per weekday. This is a means of assessing the economic value of proposed services, versus a measure of the track capacity that they would be likely to use. This is a simple approach to the measurement of capacity used, as capacity usage varies by service characteristics such as train speed, acceleration and stopping pattern.

4 Services in either direction through one or more constrained track sections, (excluding early morning and late evening train movements to balance diagrams).

5.2.7.3 NPV excluding operating costs

This is the NPV minus operating costs. Whilst we are happy that our assessment of operating costs is based on robust evidence, we acknowledge that there may be some differences in the operating costs faced by the three applicants which are not identified as part of this assessment. We therefore believe that it may be useful to enable ORR and stakeholders to compare the results of the options exclusive of operating costs.

5.2.7.4 NPV per path excluding operating costs

This is the NPV divided by the number of train services per weekday.

6. Revenue projections and economic appraisal results

6.1 Introduction

6.1.1 Presentation of results

This section presents the results of our revenue projections and economic appraisals. The order in which we present the results is grouped by applicant, with any named sensitivity tests presented in the section for the option to which they pertain.

Figures are presented on the following basis unless stated:

- Annual passenger journeys are for the year to March 2020, and no demand ramp-up[5] profile has been applied;
- Annual revenue figures are as per journeys, presented in 2014/15 prices, consistent with the revenue data used in this analysis. We typically present the top 10 flows by total revenue for each option, occasionally presenting the top 5 flows for sensitivity tests, or when revenue changes for only a small number of flows affected by the option; and
- Monetary values in the economic appraisal results are in 2010 prices and values, consistent with WebTAG.

Table 35 at the end of this chapter presents a comparison of key revenue projections and economic appraisal results for all of the options tested.

6.1.2 Comparison with results from study phase one

Whilst substantive parts of the forecasting methodology are similar to the first phase of this study, there are some differences in the approaches taken, and particularly in the assumptions made. As a consequence of these changes, the results presented in this section differ to the figures presented in May. For many of the options considered revenue results are similar, in particular the forecast ratio of generated revenue to abstracted revenue. However, some of the economic appraisal results differ significantly. There are several reasons for this:

6.1.2.1 MOIRA timetables

The MOIRA timetable files used in this second phase of work have been rebuilt to reflect, where possible, stakeholders' views on how to assess all options on a consistent basis. These files were shared with stakeholders for comment prior to production of the revenue forecasts and appraisals. This has helped to improve stakeholders' common understanding of our approach, and has also provided useful additional quality assurance.

As a consequence of this process, there are some differences in the timetable files when compared to the timetables used in phase one of this work, particularly the base timetables against which the options have been considered.

Our terms of reference from ORR for both this work and the previous phase do not include timetable validation. We therefore give little explicit consideration to services that are not part of the options, and

[5] A reduction in forecast journeys to reflect a time lag between the introduction of services and passengers using these services.

have not attempted to integrate the proposed new services into the timetables operated by other TOCs, for example Cross Country. In all timetable files, we assume that these other operators' services remain as per the May 2014 timetable.

We note that for some of the options considered, a number of flows in our MOIRA analysis show a loss of industry revenue. Whilst timetable changes typically result in both revenue increases and decreases at a flow level, in reality there would be an attempt to optimise the network benefits of significant timetable changes. Our assessment is therefore unlikely to capture these impacts fully.

Whilst this is true of all the options considered, it is most likely to affect some of the VTEC options which are significant changes to the current timetable. In the following section we report that we believe this may be an issue, and the steps we have taken to address it. The estimated economic benefits for option 6 in particular, are significantly lower than stated in the phase one report errata note.

6.1.2.2 Differing demand and revenue bases

Related to the previous point, we note that three different timetables (IEP base, VTEC core, VTEC full) have been used as the base for the various options considered. The journey times, train service frequencies, number of passenger journeys, and revenue associated with these timetables differ.

6.1.2.3 Fares competition

Our revised methodology gives more detailed consideration to the impact of fares competition between operators. Options where a reduction in fares is modelled tend to have a higher level of forecast revenue generation and economic benefits, than those options where fares do not change. In phase one of this study, a reduction in fares was not modelled in the economic appraisal for option 1, so the estimated economic benefit for this option presented in the phase one report is significantly lower than in this report.

6.1.2.4 Crowding

The addition of the crowding modelling is new to this phase of work. Whilst the impact of this is modest for most options, we flag that this is a change to the previous approach.

6.1.2.5 Air market uplift

Our interim phase 2 report acknowledged that a limitation of our previous approach was the assumption of a fixed combined air and rail market, whereas in reality improvements in rail journey time and/or rail fares can generate additional demand.

6.1.2.6 Following discussions with ORR's external auditors the air market uplift method was adjusted to estimate the impact on the total air and rail market in a way that is consistent with PDFH Non-user benefits

Our previous calculation of non-user benefits has been questioned by several stakeholders. We are not aware of any errors in our previous work, but are confident that in this phase of work, the relativities between the various options are easier to understand. The non-user benefits for option 2 are significantly lower than in the phase one report, and are consistent with the estimated non-user benefits for other options.

6.2 Alliance Yorkshire/Cleethorpes (Option 1)

6.2.1 Option summary

This option is Alliance's proposed King's Cross – West Yorkshire and Cleethorpes services, tested against the IEP base timetable. See section 3.3.1 for a full description.

6.2.2 Revenue projections

We estimate that Alliance's Yorkshire/Cleethorpes – London services would annually generate £20.1m of additional rail industry revenue, and abstract £40.5m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 0.50.

Table 10 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to Alliance. Figure 2 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 79% of Alliance's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 57% is for travel between London and Leeds/Doncaster; and
- 43% is for travel between London and stations without current frequent direct London services, such as Scunthorpe, Grimsby, and East Leeds Parkway.

Stakeholders have written previously to ORR with contrasting views on the potential impact of providing East Leeds Parkway (ELP) with direct London services. We estimate that this option would generate an additional £5.9m of industry revenue, abstract £3.4m from other TOCs. This abstraction would be largely from VTEC at Leeds, but also from other nearby stations. The ratio of generation to abstraction for this station is therefore 1.75.

The gravity model uplift accounts for just under half of the source of newly generated revenue in our forecasts, with the remaining generation forecast as a result of the MOIRA modelling and the fares overlay. Total abstracted revenue would largely be a result of competition on journey time and frequency, modelled using MOIRA. Most of this abstracted revenue would be lost by VTEC.

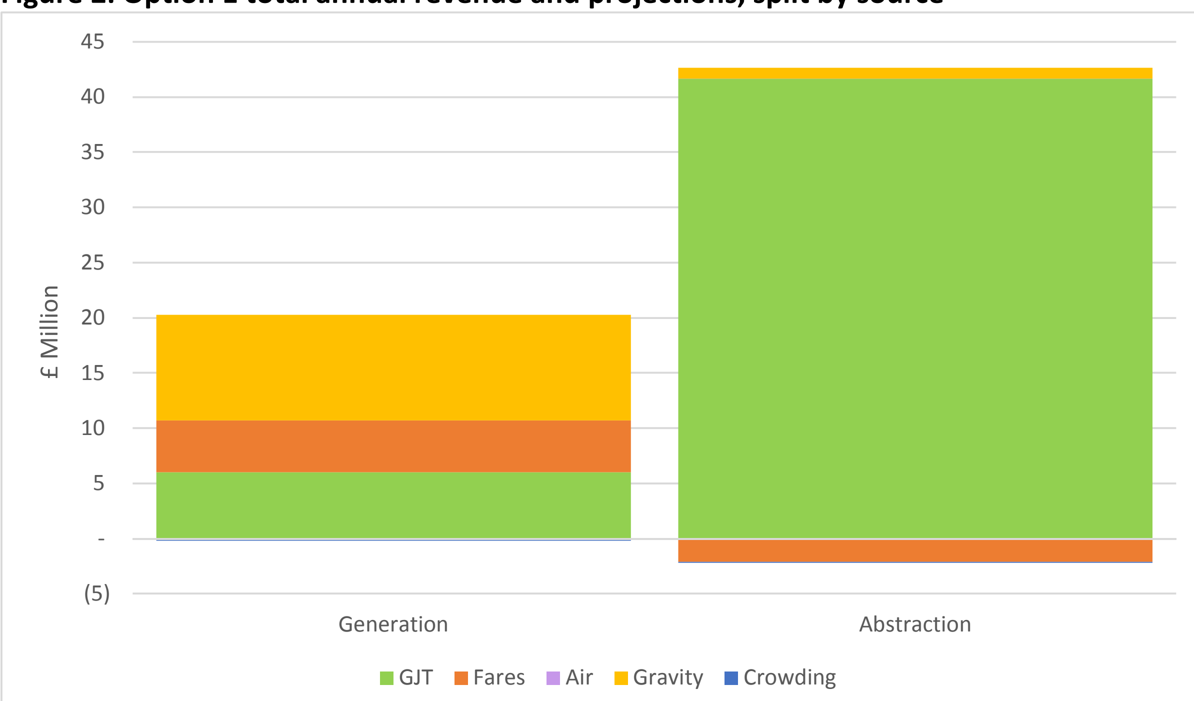
Our crowding model assessment indicates that average weekday load factors (the ratio of passengers to seats) upon arrival/departure at King's Cross would be around 60%. The forecast impact of crowding on overall revenue generation and abstraction is negligible.

As discussed in section 3.3.1.4 we estimate that Alliance would offer fares of around 75% of VTEC's current level, and that VTEC's response would be the equivalent of a five percent reduction in average London – Leeds fares in real terms. This modelled competitive response has a significant increase in forecast revenue generation, but also a reduction in revenue abstraction as VTEC would recoup some lost market share.

Table 10: Option 1 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow (2-way)	Total Alliance revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Leeds - Total London	£24,725	£18,318	£5,436	0.30
2	East Leeds Parkway - Total London	£8,278	£3,367	£5,882	1.75
3	Bradford Yks BR - Total London	£3,820	£2,105	£1,715	0.81
4	Doncaster - Total London	£2,860	£2,521	£339	0.13
5	Shipley Yorks - Total London	£2,467	£1,119	£1,348	1.20
6	Scunthorpe - Total London	£1,505	£546	£959	1.76
7	Grimsby Town - Total London	£1,413	£905	£508	0.56
8	Ilkley - Total London	£1,059	£877	£182	0.21
9	Cleethorpes - Total London	£1,023	£300	£723	2.41
10	Kirkstall Forge - Total London	£858	£469	£389	0.83
Sub-total (top 10)		£48,008	£30,527	£17,481	0.57
Total (all flows)		**£60,600**	**£40,497**	**£20,103**	**0.50**

Figure 2: Option 1 total annual revenue and projections, split by source



6.2.2.1 Competitive response sensitivity tests

We have conducted a sensitivity test where the competitive response from VTEC is half of our estimated level. This is partly because estimating the size of the response required us to make assumptions on VTEC's future fares strategy, and partly to show the sensitivity of the results to our assumptions. We have not conducted an up-side sensitivity test as we do not think that it is material to the evidence we provide to ORR. The results of the sensitivity test is shown in Table 11 below.

Table 11: Option 1 annual revenue projections, under different assumptions regarding competitive response (£000)

Sensitivity test	Total Alliance revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
Main assumption	£60,600	£40,497	£20,103	0.50
"low competitive response"	£60,871	£42,766	£18,105	0.42

6.2.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimated incremental operating costs. See section 5 and Appendix G.

Table 12 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming the existence of two new stations, East Leeds Parkway and Kirkstall Forge. The costs of these stations are not well understood, however. Therefore ORR has asked us to exclude the station costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the incremental costs of these stations (to the extent that the application causes all or part of this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

Our estimated NPV for these services over the 10 year appraisal period is £181m. This comprises £133m of user benefits (both time savings and a reduction in rail fares), £65m of non-user benefits, a £169m net increase in GB rail revenue, a net £29m reduction in income to HM treasury, and an £157m increase in total operating costs.

Table 12: Option 1 economic appraisal summary

Impact category	**£m 2010**
User benefits	£132.5
Non-user benefits	£64.8
Other Govt impacts	-£28.8
Revenue (GB rail total)	£169.3
Operating Costs	-£156.5
NPV	**£181.3**
NPV excluding operating costs	**£337.8**

6.3 Alliance Edinburgh (Option 2)

6.3.1 Option summary

This option is Alliance's proposed King's Cross – Edinburgh service, tested against the IEP base timetable. See section 3.3.2 for a full description.

6.3.2 Revenue projections

We estimate that Alliance's Edinburgh – London services would annually generate £55m of additional rail industry revenue, and abstract £134m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 0.41.

Table 13 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to Alliance. Figure 3 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 89% of Alliance's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 52% is for travel between London and Edinburgh; and
- 35% is for travel between London and Newcastle.

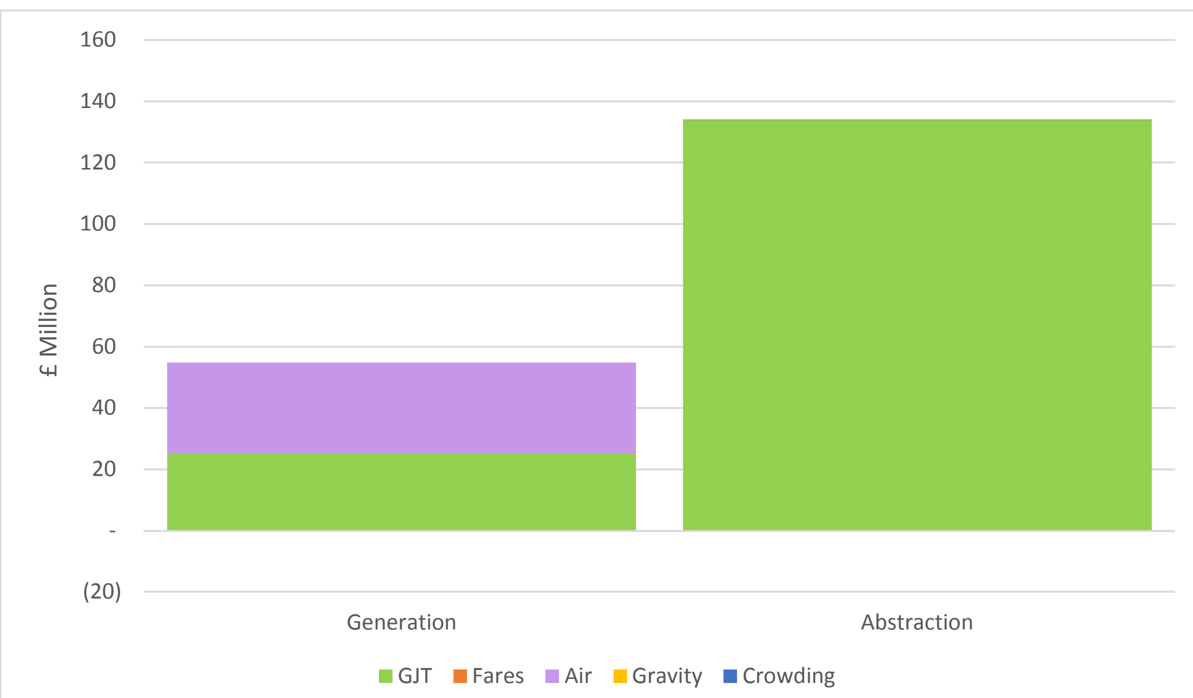
We estimate that the largest proportion of total generated revenue would result from a switch from domestic airline travel. We estimate that the largest proportion of abstracted revenue would result from competition with VTEC on journey time and frequency. Our forecast abstraction of London – Newcastle-Edinburgh revenue from VTEC is equivalent to a high proportion of its likely 2020 revenue for these flows.

The crowding model assessment indicates that sufficient capacity would exist on Alliance's services to accommodate forecast demand. This is because the addition of a limited-stop, hourly, 9-car Pendolino service to the IEP base timetable, would provide a significant extra capacity.

Table 13: Option 2 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total Alliance revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£87,104	£52,396	£34,708	0.66
2	Newcastle - Total London	£59,292	£46,383	£12,909	0.28
3	Edinburgh - Newcastle	£8,606	£6,621	£1,985	0.30
4	Other small flows (grouped by MOIRA)	£3,092	£3,096	-£4	0.00
5	Stirling - Total London	£2,995	£1,352	£1,643	1.22
6	Dundee - Total London	£1,737	£1,690	£47	0.03
7	Sunderland - Total London	£1,539	£1,463	£76	0.05
8	Edinburgh - Stevenage	£1,357	£788	£569	0.72
9	Cambridge - Edinburgh	£1,233	£875	£358	0.41
10	Newcastle - Stevenage	£1,071	£815	£256	0.31
Sub-total (top 10)		£168,026	£115,479	£52,547	0.46
Total (all flows)		**£188,626**	**£133,899**	**£54,727**	**0.41**

Figure 3: Option 2 total annual revenue and projections, split by source



6.3.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G.

Table 14 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming that investment is made in an infrastructure upgrade that permits faster journey times through tilting trains. The associated investment costs are not well understood, however. Therefore ORR has asked use to exclude the costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the associated investment costs (to the extent that the application causes all this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

Our estimated NPV for these services over the 10 year appraisal period is £46m. This comprises £166m of user benefits (through journey time savings), £117m of non-user benefits, a £461m net increase in GB rail revenue, a net £73m reduction in income to HM treasury, and an £626m increase in total operating costs. Non-user benefits are broadly in line with the other options, which was not the case in the phase one final report.

The relatively low NPV, when compared to other options, is a function of the high operating cost of an hourly 9-car Pendolino service, and also as there is no benefit from a reduction in fares.

It is important to note that the economic NPV is not an indicator of the commercial viability of the option, as abstracted revenue is not included in the economic assessment.

Table 14: Option 2 economic appraisal summary

Impact category	**£m 2010**
User benefits	£166.0
Non-user benefits	£117.3
Other Govt impacts	-£72.5
Revenue (GB rail total)	£461.2
Operating Costs	-£625.8
NPV	**£46.1**
NPV excluding operating costs	**£671.9**

6.3.4 Sensitivity test - Alliance Edinburgh non-tilt (Option 11)

Under this sensitivity test (**option 11**) we assume that journey times are the same as IEP rolling stock would achieve when calling at the same number of stations. All other characteristics are as above. See section 3.3.2.5.

Table 15 below shows generated and abstracted revenue in total, and for the five largest flows by total revenue to Alliance.

We estimate that Alliance's Edinburgh – London services would generate £26m of additional rail industry revenue, and abstract £115m from other TOCs. This is significantly lower than for option 2 as end to end journey times are circa 20 minutes slower.

The ratio of newly generated revenue to abstracted revenue is therefore 0.22.

We estimate that the economic NPV would be -£300m as the reduced revenue generation and passenger benefits would be significantly outweighed by the incremental operating costs. The tilt capability on Pendolinos makes them expensive to procure and operate, and it would be nonsensical to operate a Pendolino service with tilt mode disabled.

Developing a sound understanding of the cost and timescales of the required infrastructure work to enable the operation of tilt mode is therefore key to understanding better the economic and commercial viability of Alliance's proposed London – Scotland service.

Table 15: Option 11 annual revenue projections, top 5 flows by total revenue (£000)

Rank	Flow	Total Alliance revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£61,430	£45,970	£15,460	0.34
2	Newcastle - Total London	£49,668	£42,944	£6,724	0.16
3	Edinburgh - Newcastle	£6,100	£5,328	£772	0.14
4	Other small flows (grouped by MOIRA)	£1,692	£1,693	-£1	0.00
5	Stirling - Total London	£1,667	£842	£825	0.98
Sub-total (top 5)		£120,557	£96,777	£23,780	0.25
Total (all flows)		**£140,486**	**£114,911**	**£25,576**	**0.22**

6.4 VTEC Core (Option 3)

6.4.1 Option summary

This is the operation of additional VTEC services between King's Cross, Newcastle and Edinburgh, and between King's Cross and Leeds, allowing the intermediate station calls in existing services to be switched to these new services. The option is tested against the IEP base timetable. See section 3.4.1 for a full description.

6.4.2 Revenue projections

We estimate that VTEC's service changes would annually generate £40m of additional rail industry revenue, and abstract £27m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 1.50.

Table 16 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to VTEC. Figure 4 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 62% of VTEC's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 26% is for travel between London and Edinburgh;
- 18% is for travel to/from London and Leeds;
- 7% is for travel to/from London and Newcastle; and
- 3% is for travel to/from London and York.

We estimate that the largest proportion of both total generated revenue and total abstracted revenue would result from improvements to GJT, as estimated by the MOIRA analysis.

Of the total abstracted revenue of £27m, we estimate that the largest losses would occur to Cross Country (£10m) Grand Central (£5m) and Hull Trains (£2m).

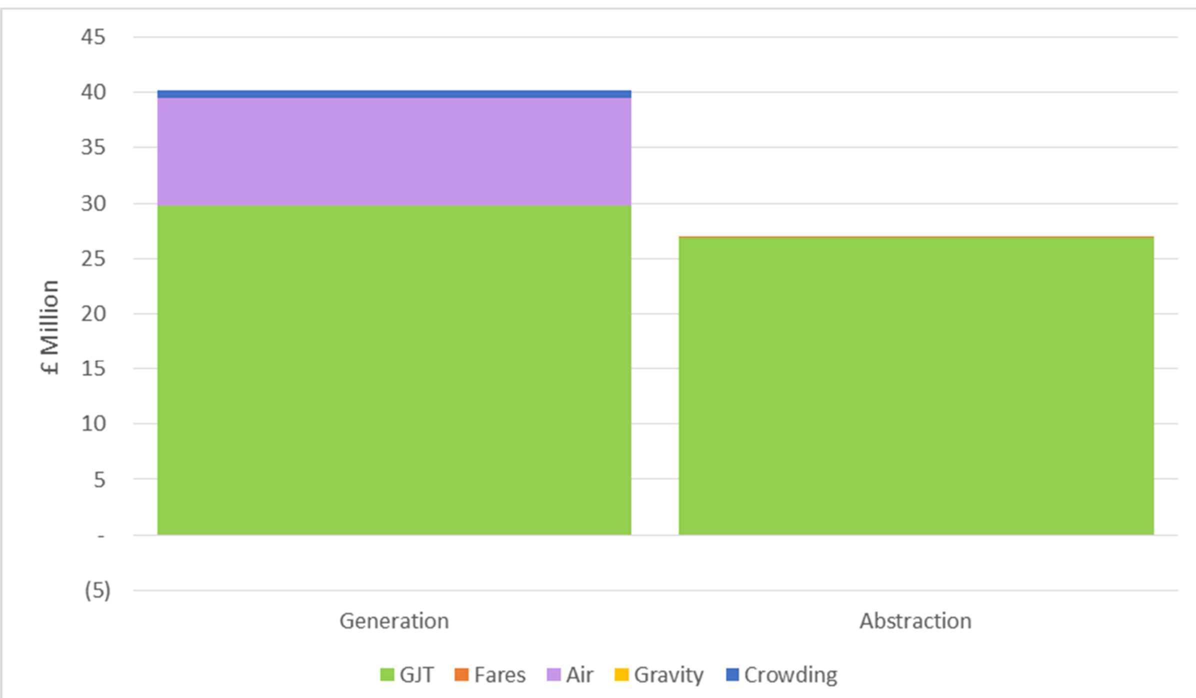
The ratio of estimated revenue generation to abstraction is very high in absolute terms for a number of flows. This is because most of the current revenue for these flows is earned by VTEC.

Our crowding model suggests that average weekday load factors would remain at broadly the levels seen in both the IEP base and the May 2014 timetable, and that some supressed demand would be released. Forecast revenue generation is therefore increased by around £0.7m.

Table 16: Option 3 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total VTEC revenue increase	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£10,613	£65	£10,548	162.28
2	Leeds - Total London	£7,611	£466	£7,145	15.33
3	Other small flows (grouped by MOIRA)	£6,644	£3,468	£3,176	0.92
4	Stevenage - Total London	£3,047	£2,523	£524	0.21
5	Newcastle - Total London	£2,691	-£1	£2,692	N/A
6	Peterborough - Total London	£2,659	£519	£2,140	4.12
7	Total London - Wakefield BR	£2,488	£786	£1,702	2.17
8	Edinburgh - Newcastle	£2,432	£1,914	£518	0.27
9	Doncaster - Total London	£1,605	£998	£607	0.61
10	Newcastle - York	£1,466	£1,128	£338	0.30
Sub-total (top 10)		£41,256	£11,866	£29,390	2.48
Total (all flows)		**£66,856**	**£26,692**	**£40,164**	**1.50**

Figure 4: Option 3 total annual revenue and projections, split by source



6.4.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G.

Table 17 below presents a summary of the appraisal results for this option.

Our estimated NPV for these services over the 10 year appraisal period is £198m. This comprises £173m of user benefits (via journey time savings), £123m of non-user benefits, a £339m net increase in GB rail revenue, a net £58m reduction in income to HM treasury, and an £379m increase in total operating costs.

Table 17: Option 3 economic appraisal summary

Impact category	**£m 2010**
User benefits	£173.2
Non-user benefits	£123.2
Other Govt impacts	-£58.3
Revenue (GB rail total)	£338.5
Operating Costs	-£378.5
NPV	**£198.1**
NPV excluding operating costs	**£576.6**

6.5 VTEC Lincoln / Harrogate (Option 4)

6.5.1 Option summary

This option consists of an extension of some of VTEC's King's Cross - Leeds services to/from Harrogate, and some of VTEC's King's Cross – Newark services to/from Lincoln. Each of these service extensions would occur once every two hours. This option is tested against a base of the VTEC Core timetable (option 3). See section 3.4.2 for a full description of option 4.

6.5.2 Revenue projections

We estimate that VTEC's service changes would annually generate £10.9m of additional rail industry revenue, and abstract £2.7m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 4.0.

Table 18 below shows generated and abstracted revenue in total, and for the five largest flows by total revenue to VTEC. Figure 5 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 75% of VTEC's total revenue would come from the five largest earning flows. Of the revenue from these flows:

- 47% is for travel between London and Harrogate; and

- 40% is for travel between London and Lincoln.

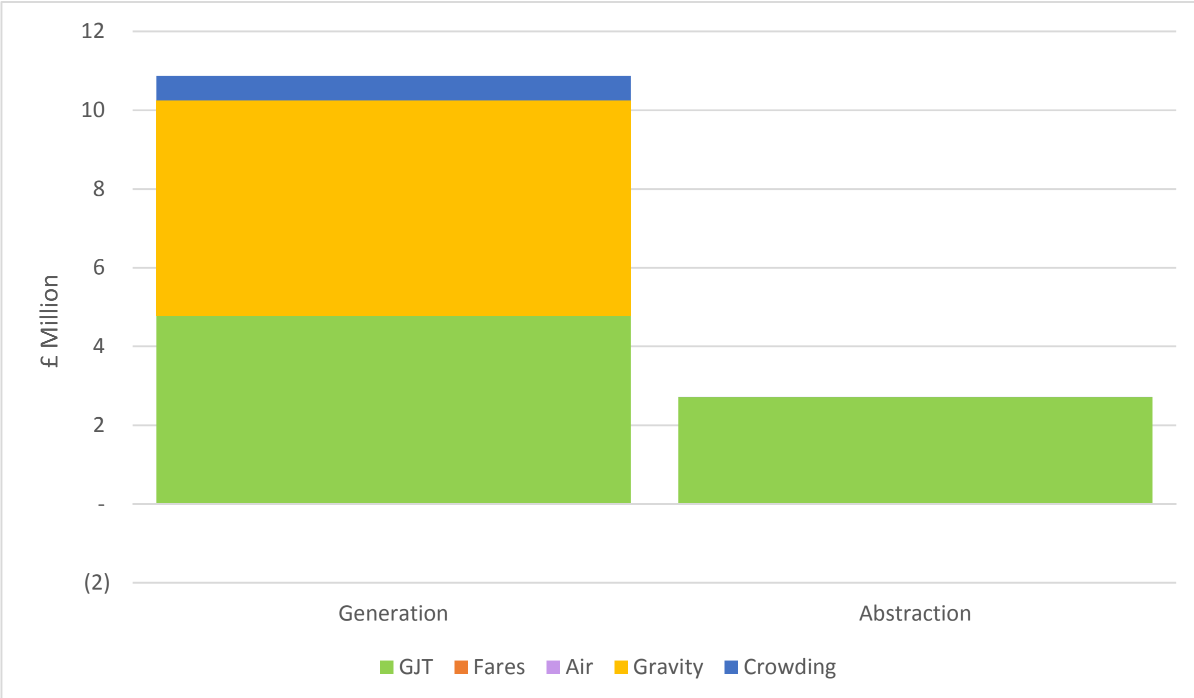
Just over half of total forecast revenue generation is a product of the gravity model (i.e. the difference between estimated total revenue using MOIRA and using the gravity model, see appendix E). This is because the two termini of the service extensions would receive two-hourly direct London services, versus one train a day currently, and MOIRA alone is unable to capture the full demand uplift of this. The gravity model forecasts make intuitive sense, as the revenue projections using MOIRA alone suggest that the service may struggle to cover its incremental operating costs (see section 6.5.3).

Our crowding model assessment increases the total generation by around £0.6m. This is because VTEC's proposed timetable changes would encourage a small shift in passengers to more lightly loaded services.

Table 18: Option 4 annual revenue projections, top 5 flows by total revenue (£000)

Rank	Flow	Total VTEC revenue increase	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Lincoln Central - Total London	£4,826	£798	£4,028	5.05
2	Harrogate - Total London	£4,089	£259	£3,830	14.79
3	Horsforth - Total London	£438	£18	£420	23.33
4	Grantham - Lincoln Central	£425	£179	£246	1.37
5	Hornbeam Park - Total London	£385	£2	£383	>50.00
Sub-total (top 5)		£10,163	£1,256	£8,907	7.09
Total (all flows)		**£13,589**	**£2,716**	**£10,874**	**4.00**

Figure 5: Option 4 total annual revenue and projections, split by source



6.5.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates incremental operating costs. See section 5 and Appendix G.

Table 19 below presents a summary of the appraisal results for this option.

Our estimated NPV for these services over the 10 year appraisal period is £109m. This comprises £54m of user benefits (from passenger time savings), £36m of non-user benefits, a £91m net increase in GB rail revenue, a net £16m reduction in income to HM treasury, and a £57m increase in total operating costs.

Table 19: Option 4 economic appraisal summary

Impact category	**£m 2010**
User benefits	£53.5
Non-user benefits	£36.4
Other Govt impacts	-£15.7
Revenue (GB rail total)	£91.1
Operating Costs	-£56.5
NPV	**£108.7**
NPV excluding operating costs	**£165.3**

6.6 VTEC Bradford Forster Square (Option 5)

6.6.1 Option summary

This option involves the extension of one of VTEC's weekday King's Cross – Leeds service every second hour, to form a two-hourly King's Cross – Bradford Forster Square service. The option is tested against a base of the VTEC Core timetable (option 3). See section 3.4.3 for a full description of option 5.

6.6.2 Revenue projections

We estimate that VTEC's service changes would generate £2.8m of additional rail industry revenue, and abstract £1.2m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 2.3.

Table 20 below shows generated and abstracted revenue in total, and for the five largest flows by total revenue to VTEC. Figure 6 shows the split of total generated and abstracted revenue further split by demand driver.

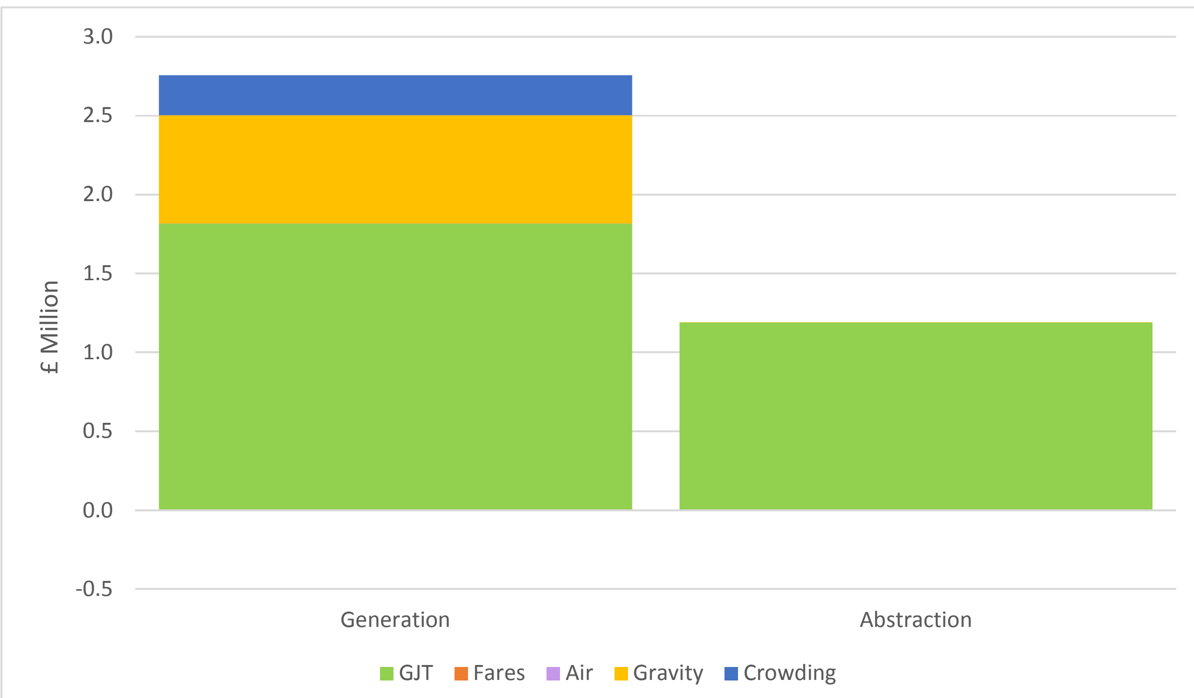
We estimate that 52% of VTEC's total revenue would come from the five largest earning flows. Of the revenue from these flows 31% is for travel between London and Bradford.

As per the previous option, the crowding model assessment indicates a small increase in the total revenue generation (£0.7m). Again, this is because the VTEC's proposed timetable changes would encourage a small shift in passengers to more lightly loaded services.

Table 20: Option 5 annual revenue projections, top five flows by total revenue (£000)

Rank	Flow	Total VTEC revenue increase	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Bradford - Total London	£626	£418	£208	0.50
2	Skipton - Total London	£428	£19	£409	21.53
3	Shipley - Total London	£424	£55	£369	6.71
4	Ilkley - Total London	£355	£0	£355	n/a
5	Keighley - Total London	£210	£11	£199	18.09
Sub-total (top 5)		£2,043	£503	£1,540	3.06
Total (all flows)		**£3,946**	**£1,189**	**£2,757**	**2.32**

Figure 6: Option 5 total annual revenue and projections, split by source



6.6.3 Economic appraisal results

Our terms of reference from ORR do not include the provision of an economic appraisal for this option. We understand that this is because the option does not compete for track access rights with current or proposed new services.

6.7 VTEC Middlesbrough (Option 6)

6.7.1 Option summary

This service proposition involves introduction of a new two-hourly VTEC service between King's Cross, Peterborough, York, Northallerton and Middlesbrough, intended to operate on weekdays only. This enables small journey time savings in other services, e.g. between London and Edinburgh, though a switch of train calls from these latter services, to the new London - Middlesbrough services.

This option is tested against a base of the VTEC Core timetable (option 3). See section 3.4.4 for a full description of option 6.

6.7.2 Revenue projections

We estimate that VTEC's service changes would annually generate £2.9m of additional rail industry revenue, and abstract £0.1m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 28. This very high ratio is because there would be a significant transfer of revenue via ORCATS from VTEC to other operators, caused largely by the change in calling patterns at Peterborough and at York.

Table 21 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to VTEC. The table also shows the flows with largest losses of industry revenue, as a direct result of the impact of MOIRA timetables modelled. Figure 7 shows the split of total generated and abstracted revenue further split by demand driver.

We forecast that the largest increases in revenue would be for Middlesbrough – London, Newcastle – London and Edinburgh – London.

Stakeholders have written previously to ORR with specific views on the potential impact of serving Middlesbrough. We estimate VTEC would gain significant additional London - Middlesbrough revenue, although some of this would be abstraction of Grand Central's London – Eaglescliffe revenue.

We present the results for both of these flows separately below, however considering the combined impact on both stations, we estimate industry revenue generation of £0.5m and abstraction of £0.9m, with a ratio of generation to abstraction of 0.63.

Our crowding assessment suggests that some overcrowding would occur as result of the change to the calling pattern at Peterborough, and particularly at York. We estimate that this would reduce revenue by around £1.6m.

As discussed in section 6.1.2 we have not attempted to integrate the proposed new services with other TOCs' services. This is consistent with ORR's terms of reference to us.

For this option we note that there are flows with a significant level of lost revenue, relative to the overall level of revenue generation. We have excluded from our assessment any significant revenue losses on flows between stations that would be served by Great Northern services. We are confident that this is a reasonable approach because the eventual Thameslink Key Output Two timetable will integrate long distance and Great Northern services. The flows with losses included in our assessment are therefore predominantly between ECML stations.

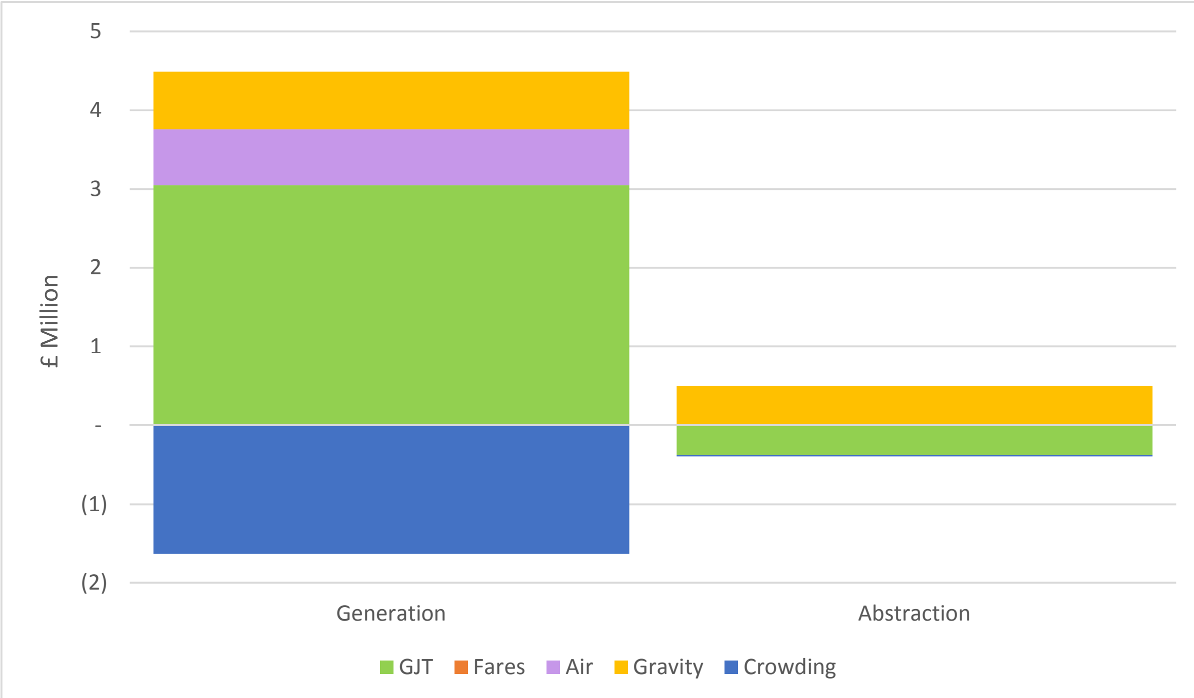
Table 21: Option 6 annual revenue projections, top 10 flows by total VTEC revenue, top 10 flows by lost industry revenue (£000)

Rank	Flow	Total VTEC revenue increase	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Middlesbrough - Total London	£904	£277	£627	2.26
2	Newcastle - Total London	£716	£64	£652	10.19
3	Edinburgh - Total London	£689	£1	£688	688.00
4	Eaglescliffe - Total London	£519	£598*	-£79*	-0.13
5	Thornaby - Total London	£345	£24	£321	13.38
6	Darlington - Total London	£330	£49	£281	5.73
7	Stevenage - Total London	£305	£3	£302	100.67
8	Durham - Total London	£297	£0	£297	n/a
9	Lincoln Central - Total London	£222	£143	£79	0.55
10	Doncaster - Total London	£127	£15	£112	7.47
Sub-total (top 10 VTEC increases)		£4,454	£1,174	£3,280	2.79
1	Middlesbrough-York	£2	n/a**	-£194	n/a**
2	Northallerton-Total London	£62	n/a**	-£179	n/a**
3	Leeds-Newark N Gate	-£41	n/a**	-£42	n/a**
4	Darlington-Durham	-£38	n/a**	-£40	n/a**
5	Grantham-Leeds	-£39	n/a**	-£40	n/a**
6	Hartlepool-Total London	£12	n/a**	-£32	n/a**
7	Middlesbrough-Northallerton	£0	n/a**	-£30	n/a**
8	Sheffield-Stevenage	-£24	n/a**	-£24	n/a**
9	Grantham-Newark N Gate	-£19	n/a**	-£19	n/a**
10	Nottingham-Stevenage	-£18	n/a**	-£19	n/a**
Sub-total (top 10 industry decreases)		-£103	n/a**	-£619	n/a**
Total (all flows)		**£2,961****	**£103****	**£2,858****	**27.73**

* Abstraction shown under Eaglescliffe - London would transfer to VTEC at Middlesbrough. Negative generation figure is driven by a small difference in yield.

** Significant transfer of revenue from VTEC to other TOCs as a result of changes to stopping patterns at Peterborough and York in particular. Revenue abstraction (VTEC increase minus generation) is not reported at a flow level when industry generation is negative.

Figure 7: Option 6 total annual revenue and projections, split by source



6.7.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates incremental operating costs. See section 5 and Appendix G.

Table 22 below presents a summary of the appraisal results for this option.

Our estimated NPV for these services over the 10 year appraisal period is -£12m. This comprises £17m of user benefits (through journey time savings), £8m of non-user benefits, a £24m net increase in GB rail revenue, a net £4m reduction in income to HM treasury, and an £57m increase in total operating costs.

The relatively low NPV, when compared to other options, is a function of a low estimated generation of additional industry revenue and other benefits relative to incremental operating costs. Whilst there is undoubtedly benefit in both serving Middlesbrough with direct services to London and speeding up some other ECML services, in our assessment some of this benefit is offset by reduced connectivity further south.

Table 22: Option 6 economic appraisal summary

Impact category	**£m 2010**
User benefits	£17.0
Non-user benefits	£7.9
Other Govt impacts	-£3.8
Revenue (GB rail total)	£24.2
Operating Costs	-£56.9
NPV	**-£11.6**
NPV excluding operating costs	**£45.3**

6.8 VTEC Full (Option 8)

6.8.1 Option summary

The timetable for this option is the same as VTEC's 2020 timetable, so a combination of all services from options 3, 4, 5 and 6. Option 8 is tested against the IEP base timetable. See section 3.6.1 for a full description of this option.

6.8.2 Revenue projections

We estimate that VTEC's service changes would annually generate £60m of additional rail industry revenue, and abstract £30m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 1.99.

Table 23 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to VTEC. It also shows the 10 flows with the largest losses to industry revenue, as a direct result of the impact of MOIRA timetables modelled. Figure 8 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 52% of VTEC's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 25% is for travel between London and Edinburgh;
- 18% is for travel to/from London and Leeds;
- 7% is for travel to/from London and Newcastle; and
- 5% is for travel to/from London and York.

Our crowding model suggests that although passenger load factors upon arrival/departure at King's Cross would be broadly the same as in the IEP base (in May 2014) a small release of supressed demand would occur on some services, resulting in a £3m increase in revenue generation.

Finally, as per option 3 we estimate that the largest losses of revenue would accrue to Cross Country (£8m), Grand Central (£7m) and Hull Trains (£3m).

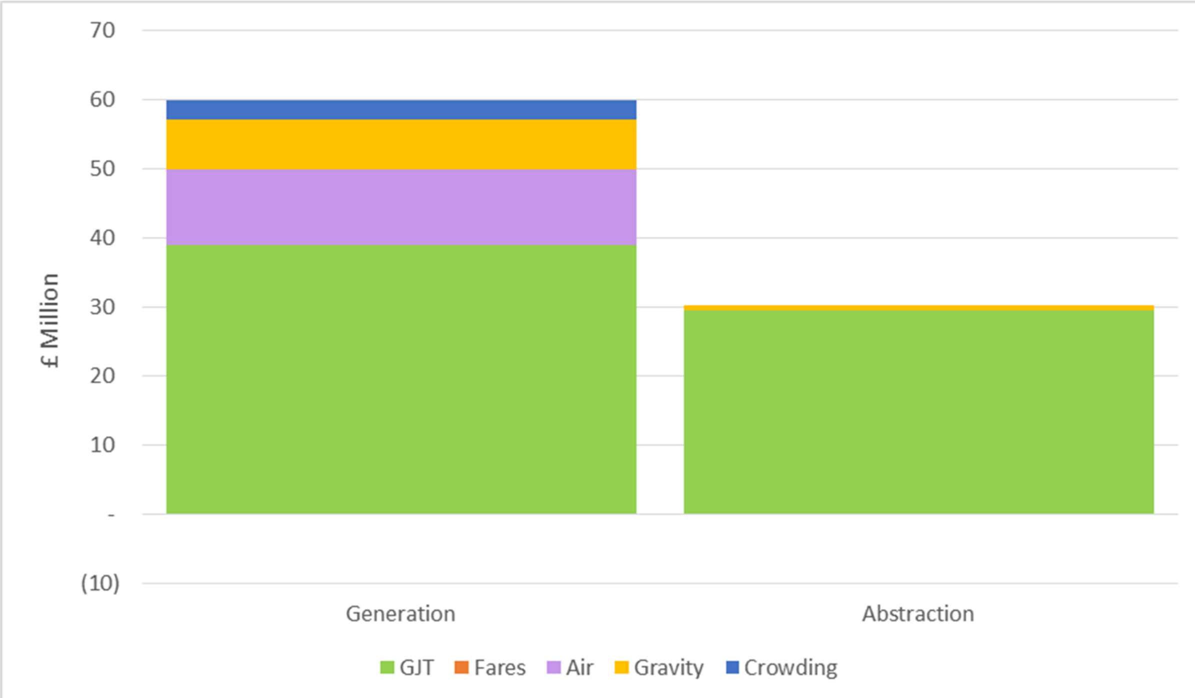
Similarly to option 6 there a number of flows with forecast industry revenue loss. As previously, we have excluded from our assessment any significant revenue losses on flows between stations that would be served by Great Northern services. We are confident that this is a reasonable approach because the eventual Thameslink Key Output Two timetable will integrate long distance and Great Northern services. The flows with losses included in our assessment are therefore predominantly between ECML stations.

Table 23: Option 8 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total VTEC revenue increase	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£11,632	£67	£11,565	172.61
2	Leeds - Total London	£8,351	£467	£7,884	16.88
3	Lincoln Central - Total London	£4,807	£844	£3,963	4.70
4	Harrogate - Total London	£4,033	£330	£3,703	11.22
5	Other small flows (grouped by MOIRA)	£3,823	£3,057	£766	0.25
6	Stevenage - Total London	£3,349	£64	£3,285	51.33
7	Newcastle - Total London	£3,230	£2,534	£696	0.27
8	Peterborough - Total London	£2,788	£359	£2,429	6.77
9	Total London – Wakefield	£2,481	£786	£1,695	2.16
10	Total London – York	£2,307	£1,400	£907	0.65
Sub-total (top VTEC increases 10)		£46,801	£9,908	£36,893	3.72
1	Durham-York	£189	n/a*	£-257	n/a*
2	Retford-Total London	£225	n/a*	£-204	n/a*
3	Eaglescliffe-Total London	£547	n/a*	£-196	n/a*
4	Middlesbrough-York	£22	n/a*	£-162	n/a*
5	Dundee-Edinburgh	£141	n/a*	£-156	n/a*
6	Berwick On Tweed-Total London	£-159	n/a*	£-156	n/a*
7	Hull-Newcastle	£19	n/a*	£-155	n/a*
8	Newcastle-Nottingham	£25	n/a*	£-146	n/a*
9	Lincoln Central-Newark N Gate	£42	n/a*	£-136	n/a*
10	Edinburgh-York	£449	n/a*	£-132	n/a*
Sub-total (top 10 industry decreases)		£1,500	n/a*	-£1,700	n/a*
Total (all flows)		**£89,959**	**£30,088**	**£59,870**	**1.99**

* Revenue abstraction (VTEC increase minus generation) is not reported at a flow level when industry generation is negative.

Figure 8: Option 8 total annual revenue and projections, split by source



6.8.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G. Table 24 below presents a summary of the appraisal results for this option.

Our estimated NPV for these services over the 10 year appraisal period is £380m. This comprises £270m of user benefits (through journey time savings), £183m of non-user benefits, a £504m net increase in GB rail revenue, a net £86m reduction in income to HM treasury, and an £492m increase in total operating costs.

Table 24: Option 8 economic appraisal summary

Impact category	**£m 2010**
User benefits	£270.4
Non-user benefits	£182.7
Other Govt impacts	-£86.0
Revenue (GB rail total)	£504.3
Operating Costs	-£491.9
NPV	**£379.6**
NPV excluding operating costs	**£871.5**

6.8.4 Sensitivity test - VTEC Middlesbrough offset (option 12)

In VTEC's 2020 timetable VTEC's King's Cross - Middlesbrough services operate in the same hour as Grand Central's King's Cross – Sunderland services in the southbound direction. This sensitivity test moves Grand Central's services by between 60 and 75 minutes, so that Grand Central's services depart from York and arrive at King's Cross before VTEC's. This is to show the impact on Grand Central's revenue, and to allow a comparison with option 8 (and option 6 by implication).

We estimate that the services changes described above would reduce Grand Central's revenue loss by broadly £260k per annum, principally through a recovery of York – London revenue.

6.8.5 Sensitivity test - VTEC Middlesbrough switch (option 13)

This sensitivity test builds on option 12 by also switching the order in which Grand Central's services and VTEC's services arrive and depart King's Cross, again by bringing forward Grand Central's services by between 60 and 80 minutes. This is to show the impact on Grand Central's revenue, and to allow a comparison with option 8 (and option 6 by implication).

We estimate that the services changes described above would reduce Grand Central's revenue loss by broadly £580k per annum, again largely through a recovery of York – London revenue.

6.8.6 Sensitivity test - VTEC Full, no overtake (option 14)

In VTEC's 2020 timetable VTEC's services overtake services operated by Hull Trains, between King's Cross and Doncaster the southbound direction. In our timetable files we only adjust services operated by the relevant applicant, and in our VTEC full timetable (option 8) only the 09:18 Hull Trains weekday King's Cross arrival is overtaken (at Retford). In this sensitivity test this overtaking manoeuver is removed. This is to show the impact on Hull Train's revenue, and to allow a comparison with option 8.

We estimate that the services changes described above would reduce Hull Train's revenue loss by broadly £560k per annum, principally through a recovery of Grantham – London revenue and Doncaster – London revenue. This switch in revenue is roughly the equivalent of just over one carriage worth of passengers per weekday, which is believable given the arrival time at King's Cross.

6.9 First Edinburgh (Option 7)

6.9.1 Option summary

This is First's proposed London – Edinburgh service. This option is tested against the IEP base timetable, and not the VTEC 2020 timetable upon which First's track access application is based. We have therefore adjusted the timings of services to fit with the IEP base timetable. See section 3.5.1 for a full description of this option.

6.9.2 Revenue projections

We estimate that First's new service would annually generate £16.3m of additional rail industry revenue, and abstract £9.2m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 1.76.

Table 25 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to First. Figure 9 shows the split of total generated and abstracted revenue further split by demand driver.

We estimate that 87% of First's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 44% is for travel between London and Edinburgh
- 29% is for travel to/from London and Newcastle

The large majority of the revenue abstraction is expected to be a result of the provision of new travel opportunities which compete with VTEC, as estimated using MOIRA.

Stakeholders have written previously to ORR with contrasting views on the potential impact of providing Morpeth with direct London services. We estimate that this option would generate an additional £0.9m of industry revenue, and abstract £0.9m from other TOCs. This abstraction would be largely from VTEC at Morpeth and at Newcastle. The ratio of generation to abstraction for this station is 0.99.

Stakeholders have also written previously to ORR with specific views on the level of demand that can be accommodated by First's train services, and have also questioned whether passenger loads would be evenly distributed throughout the day. Our crowding model assessment provides estimated weekday train load factors (passengers to seats) of around 75% at the busiest point on each train's journey.

Stakeholders have additionally questioned the viability of First's proposed 05:30 departure from King's Cross. Our modelling suggests an average weekday load factor (ratio of passengers to seats) on departure from Stevenage of around 67 per cent (just under 270 people). We think that is a reasonable estimate given that there is a significant current Anglo-Scottish airline market at that time of day, and given that the First service would be the only available rail departure at the same time. We also understand that King's Cross and Stevenage stations are easily accessible by road at that time in the morning, and we note Transport for London's proposals to operate a 24 hour tube service at weekends, including on lines which serve King's Cross.

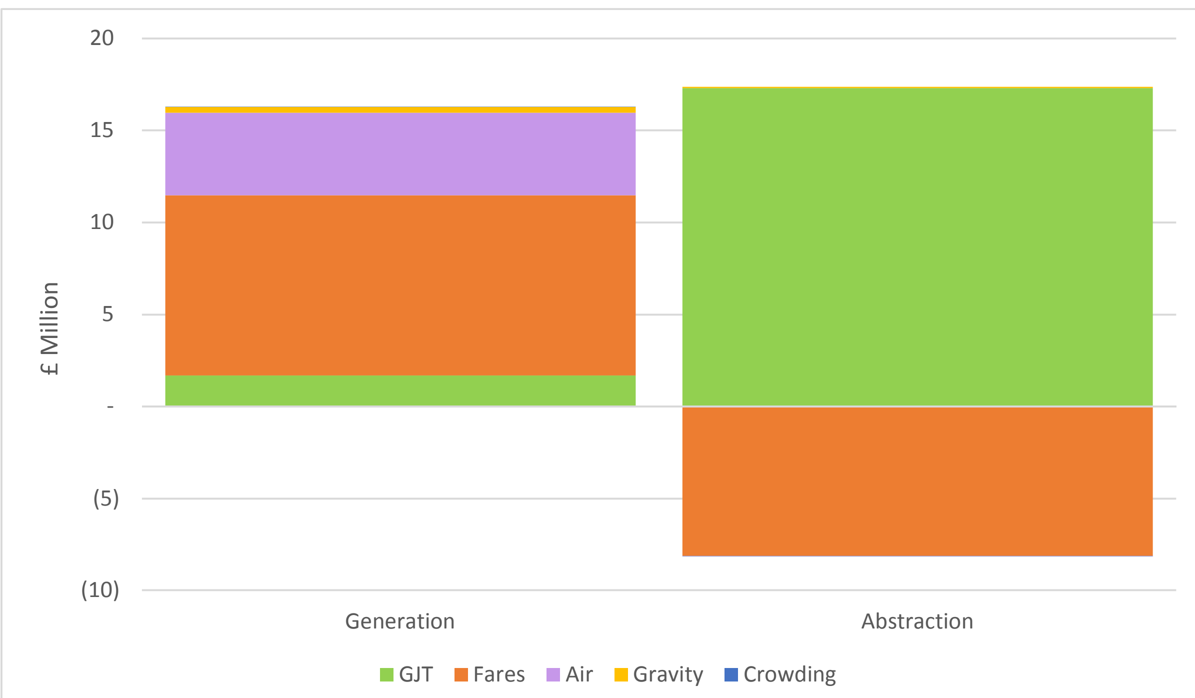
Whist an overall load factor of 75% is undoubtedly high compared to current long distance operators, our revenue assessment indicates that most journeys would be made using advanced fares, which would provide a significant opportunity to manage train loads via the number of advance fares made available for each train. We therefore estimate that a small amount of demand would be crowded off, resulting in a minor reduction in generated revenue. Despite the dominance of advanced fares, we do not believe that a material further increase in demand could be accommodated, and therefore in our economic appraisal assume zero journey and revenue growth from 2020 onwards. This is the case for all the First options and scenarios that follow.

As discussed in section 3.5.1.4 we estimate that First would offer fares of around 50%-60% of VTEC's current level, and that VTEC's response would be the equivalent of a seven per cent reduction in London – Edinburgh and London – Newcastle fares. This modelled change in fares has a large impact on forecast generation and the forecast generation versus abstraction, accounting for most of the forecast total industry revenue generation, and reducing forecast revenue abstraction by almost half as the drop in VTEC's fares would offset some of the demand and revenue lost to First.

Table 25: Option 7 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total revenue to First	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£9,814	£2,704	£7,110	2.63
2	Newcastle - Total London	£6,455	£1,348	£5,107	3.79
3	Morpeth - Total London	£1,737	£872	£865	0.99
4	Edinburgh - Newcastle	£1,275	£1,061	£214	0.20
5	Stirling - Total London	£777	£230	£547	2.38
6	Dundee - Total London	£718	£242	£476	1.97
7	Sunderland - Total London	£499	£171	£328	1.92
8	Inverness - Total London	£416	£182	£234	1.29
9	Edinburgh - Morpeth	£327	£208	£119	0.57
10	Edinburgh - Stevenage	£318	£124	£194	1.56
Sub-total (top 10)		£22,336	£7,142	£15,194	2.13
Total (all flows)		**£25,554**	**£9,247**	**£16,308**	**1.76**

Figure 9: Option 7 total annual revenue and projections, split by source



6.9.2.1 Competitive response sensitivity tests

As for option 1, we have conducted a sensitivity test where the competitive response from VTEC is half of our estimated level. Again, this is partly because estimating the size of the response required us to make assumptions on VTEC's future fares strategy, and partly to show the sensitivity of the results to our assumptions. The results of the sensitivity test are shown in Table 26 below.

Table 26: Option 7 annual revenue projections, under different assumptions regarding competitive response (£000)

Sensitivity test	Total First revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
Main assumption	£25,554	£9,247	£16,308	1.76
"low competitive response"	£27,136	£14,538	£12,598	0.87

6.9.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G.

Table 27 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming investment in the expansion of Morpeth station car park. ORR has asked us to exclude the costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the associated investment costs (to the extent that the application causes all this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

Our estimated NPV for these services over the 10 year appraisal period is £171m. This comprises £103m of user benefits, £100m of non-user benefits, a £124m net increase in GB rail revenue, a net £30m reduction in income to HM treasury, and an £126m increase in total operating costs.

The majority of the user benefits are the savings to passengers through a reduction in fares.

Table 27: Option 7 economic appraisal summary

Impact category	**£m 2010**
User benefits	£102.8
Non-user benefits	£100.0
Other Govt impacts	-£30.1
Revenue (GB rail total)	£124.1
Operating Costs	-£125.7
NPV	**£171.2**
NPV excluding operating costs	**£296.9**

6.10 First Edinburgh as submitted (Option 9)

6.10.1 Option summary

This is First's proposed London – Edinburgh service as submitted to ORR, so tested against a base of VTEC's full 2020 timetable. See section 3.6.2 for a full description of this option.

6.10.2 Revenue projections

We estimate that First's new service would annually generate £16.8m of additional rail industry revenue, and abstract £7.9m from other TOCs.

The ratio of newly generated revenue to abstracted revenue is therefore 2.13.

VTEC's London – Newcastle – Edinburgh services are faster and more frequent in this option than in option 7, resulting in lower forecast abstraction both in absolute terms, and in relation to generated revenue.

Table 28 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to First. Figure 10 shows the split of total generated and abstracted revenue further split by demand driver.

At a flow level figures are similar to option 7. We estimate that 87% of First's total revenue would come from the 10 largest earning flows. Of the revenue from these flows:

- 44% is for travel between London and Edinburgh; and
- 27% is for travel to/from London and Newcastle.

The key sources of generation and abstraction are as per option 7.

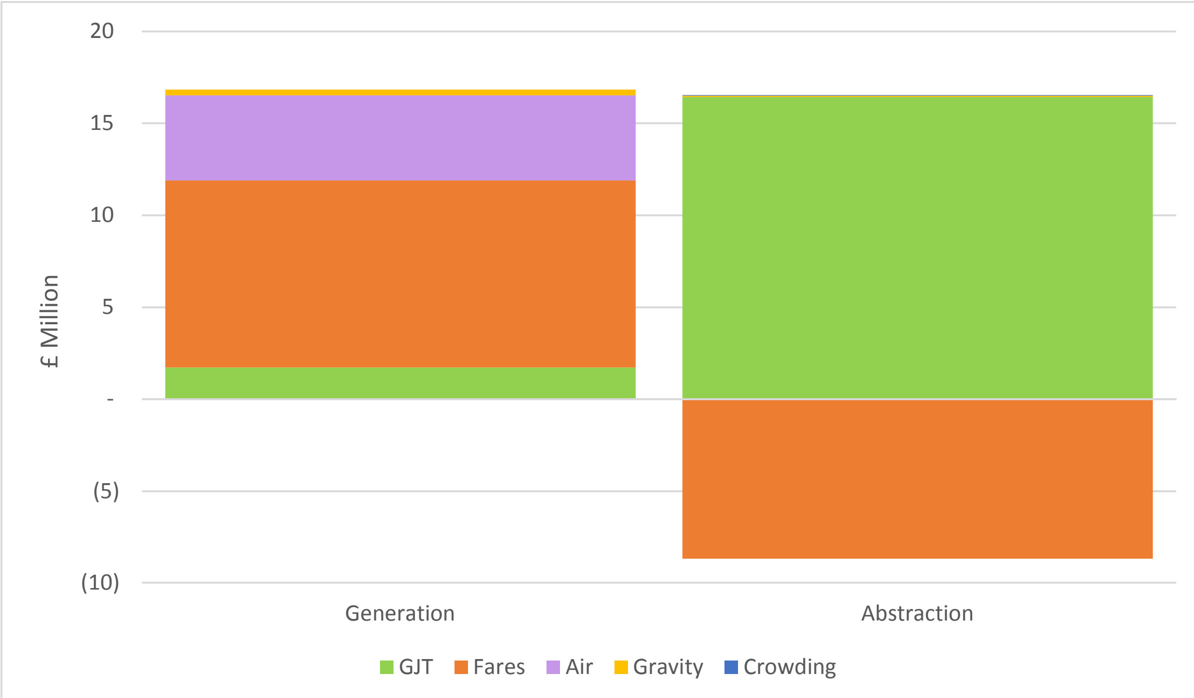
Estimated 2020 train load factors are just over 80% at the busiest point on each train's journey. As previously, modelled demand and revenue suppression is small due to the majority of passengers using advanced tickets, however in our economic appraisal we assume zero journeys and revenue growth beyond 2020.

As previously we estimate that First would offer fares of broadly 50%-60% of VTEC's current prices. We estimate that VTEC's response would be slightly smaller than under option 7 due to busier trains in the VTEC full timetable. Our estimated reduction in London – Newcastle and London – Edinburgh fares is still around 7%. This has a similarly large impact on forecast generation and the forecast generation versus abstraction.

Table 28: Option 9 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total revenue to First	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£9,417	£1,792	£7,625	4.26
2	Newcastle - Total London	£5,784	£511	£5,273	10.32
3	Morpeth - Total London	£1,745	£857	£888	1.04
4	Edinburgh - Newcastle	£1,330	£1,108	£222	0.20
5	Stirling - Total London	£919	£299	£620	2.07
6	Dundee - Total London	£713	£299	£414	1.38
7	Sunderland - Total London	£395	£124	£271	2.19
8	Edinburgh - Morpeth	£366	£213	£153	0.72
9	Inverness - Total London	£341	£241	£100	0.41
10	Edinburgh - Stevenage	£333	£150	£183	1.22
Sub-total (top 10)		£21,343	£5,594	£15,749	2.82
Total (all flows)		**£24,671**	**£7,875**	**£16,795**	**2.13**

Figure 10: Option 9 total annual revenue and projections, split by source



6.10.2.1 Competitive response sensitivity tests

As for option 1, we have conducted a sensitivity test where the competitive response from VTEC is half of our estimated level. Again, this is partly because estimating the size of the response required us to make assumptions on VTEC's future fares strategy, and partly to show the sensitivity of the results to our assumptions. The results of the sensitivity test are shown in Table 29 below.

Table 29: Option 8 annual revenue projections, under different assumptions regarding competitive response (£000)

Sensitivity test	Total First revenue	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
Main assumption	£24,671	£7,875	£16,795	2.13
"low competitive response"	£26,323	£13,402	£12,921	0.96

6.10.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G.

Table 30 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming investment in the expansion of Morpeth station car park. The associated investment costs are not well understood, however. Therefore ORR has asked us to exclude the costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the associated investment costs (to the extent that the application causes all this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

The estimated NPV for these services over the 10 year appraisal period is £167m. This comprises £95m of user benefits, £100m of non-user benefits, a £128m net increase in GB rail revenue, a net £31m reduction in income to HM treasury, and an £126m increase in total operating costs.

Table 30: Option 9 economic appraisal summary

Impact category	**Table 30**
User benefits	£95.0
Non-user benefits	£100.1
Other Govt impacts	-£30.5
Revenue (GB rail total)	£127.7
Operating Costs	-£125.7
NPV	**£166.6**
NPV excluding operating costs	**£292.3**

6.10.4 Sensitivity test - First Edinburgh, no overtake (option 15)

Under option 9 (and option 7), all except the earliest of First's southbound services are overtaken by the VTEC fast hourly southbound service. In this sensitivity test, this manoeuver is removed, with First's services retimed to operate approximately 16 minutes faster between Edinburgh and King's Cross.

Table 31 below shows generated and abstracted revenue in total, and for the 10 largest flows by total revenue to First. We estimate that First's new services would generate £15.4m of additional rail industry revenue, and abstract £19.1m from other TOCs. The ratio of generation to abstraction is therefore 0.81.

Removal of the overtaking manoeuver on Southbound services therefore has a large impact on the ratio of abstraction to generation. First's total revenue would also increase significantly.

Our initial fares assumptions are similar to options 7 and 9.

Table 31: Option 15 annual revenue projections, top 10 flows by total revenue (£000)

Rank	Flow	Total revenue to First	Total abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
1	Edinburgh - Total London	£11,541	£6,180	£5,361	0.87
2	Newcastle - Total London	£9,656	£4,872	£4,784	0.98
3	Morpeth - Total London	£1,762	£849	£913	1.08
4	Edinburgh - Newcastle	£1,268	£1,069	£199	0.19
5	Total London - Edinburgh	£1,161	£602	£559	0.93
6	Stirling - Total London	£908	£309	£599	1.94
7	Total London - Newcastle	£874	£353	£521	1.48
8	Dundee - Total London	£714	£336	£378	1.13
9	Sunderland - Total London	£528	£257	£271	1.05
10	Other small flows (grouped by MOIRA)	£354	£356	-£2	-0.01
Sub-total (top 10)		£28,766	£15,183	£13,583	0.89
Total (all flows)		**£34,446**	**£19,072**	**£15,374**	**0.81**

6.10.4.1 Sensitivity test with increased fares and a smaller competitive response

As alluded to above, we expect a significantly higher number of journeys and total revenue to First than under options 7 and 9, and forecast that trains would be very busy, with most or all seats taken on eight out of 10 services per weekday.

Our crowding assessment indicates a relatively modest level of revenue suppression, as the majority of passengers are expected to use advance purchase tickets. However, we would question whether 5-car rolling stock is adequate to cope with forecast demand levels, or alternatively whether First would ultimately choose to raise fares to manage demand. The latter may offer a better commercial outcome.

As a high-level sensitivity test we have estimated the level of fares required to reduce train loads to the levels estimated in the other First options.

We estimate, broadly, that a 40% reduction in the discount proposed by First would be required. We therefore assume that First would offer fares of around 70%-75% of VTEC's current levels, and that VTEC's competitive response would be half of the level stated in other scenarios, i.e. a 4% reduction in average London – Newcastle and London – Edinburgh fares.

On this basis we forecast total annual industry revenue generation of £10.9m and revenue abstraction of £23.4m. The ratio of generation to abstraction is therefore 0.47.

Figures 11 and 12 show the split of total generated and abstracted revenue further split by demand driver under the two scenarios modelled.

Figure 11: Option 15 total annual revenue and projections, split by source

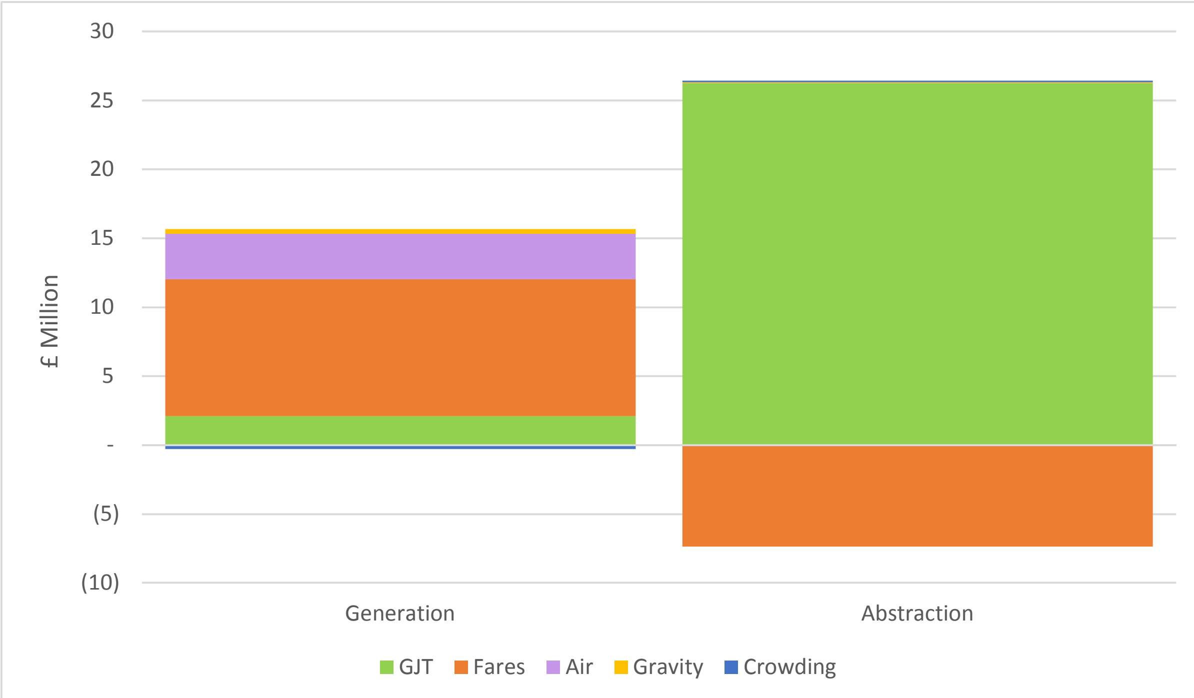
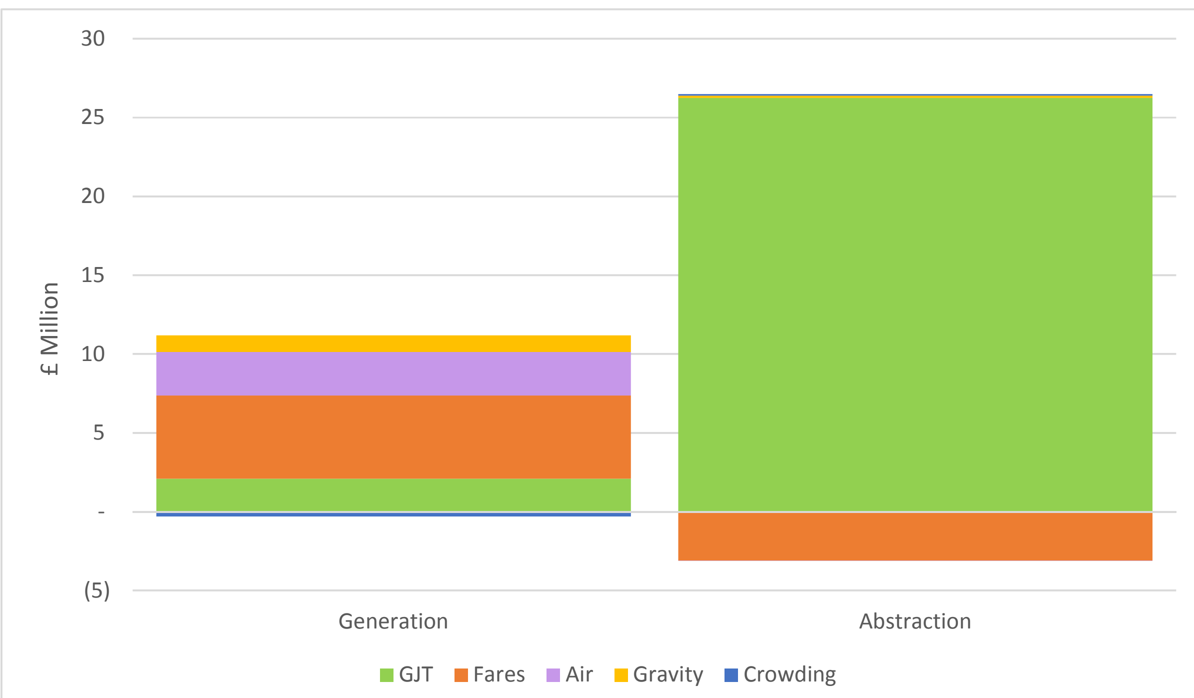


Figure 12: Option 15 total annual revenue and projections assuming half the proposed reduction in fares and half the competitive response by VTEC, split by source



The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G. The appraisal relates to the option tested with fares as stated by First.

Table 32 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming investment in the expansion of Morpeth station car park. ORR has asked us to exclude the costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the associated investment costs (to the extent that the application causes all this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

Our estimated NPV for these services over the 10 year appraisal period is £215m. This comprises £140m of user benefits, £115m of non-user benefits, a £117m net increase in GB rail revenue, a net £32m reduction in income to HM treasury, and a £126m increase in total operating costs.

User benefits are higher than in the options 7 and 9 due to superior GJT savings.

Table 32: Option 15 economic appraisal summary

Impact category	**£m 2010**
User benefits	£139.7
Non-user benefits	£115.2
Other Govt impacts	-£31.6
Revenue (GB rail total)	£116.9
Operating Costs	-£125.7
NPV	**£214.6**
NPV excluding operating costs	**£340.2**

6.11 VTEC Core and Alliance/Yorkshire Cleethorpes (Option 10)

6.11.1 Option summary

This option is a combination of options 1 and 3, tested against the IEP base timetable. See section 3.6.3

6.11.2 Revenue projections

In presenting the results, we have made the simplifying assumption that VTEC's revenue is the same as in option 3. The difference in revenue between option 10 and option 3 is therefore attributed to Alliance. This is a modelling simplification as the revenue model is designed to produce revenue results for new services run by a single operator. We view this as a reasonable simplification given ORR's terms of reference. In particular, we understand that the key element of our analysis of this option is the economic appraisal, rather than revenue projections split by TOC. We have discussed the above simplification with ORR's external auditors Systra.

We estimate that the VTEC core service alterations would annually generate £40.2m of additional rail industry revenue, and abstract £26.7m from other TOCs.

The ratio of newly generated revenue to abstracted revenue for these services is therefore 1.50.

We estimate that Alliance's Yorkshire/Cleethorpes – London services would annually generate of £19.0m additional rail industry revenue, and abstract £30.4m from other TOCs.

The ratio of newly generated revenue to abstracted revenue for these services is therefore 0.62. This is higher than in option 1 as VTEC's services offer faster journey times than in the IEP base, and are therefore more attractive to passengers.

Table 33 below shows generated and abstracted revenue in total.

Table 33: Option 10 annual revenue projections (£000)

Operator	Total revenue	Abstracted revenue	Generated revenue (whole industry)	(Generation)/ (Total Abstraction)
Alliance	49,448	30,440	19,008	0.62
VTEC	66,856	26,692	40,164	1.50
Both	116,304	57,132	59,172	1.04

6.11.3 Economic appraisal results

The economic appraisal takes inputs from the revenue modelling described above, and from our estimates of incremental operating costs. See section 5 and Appendix G.

Table 34 below presents a summary of the appraisal results for this option. As explained in section 5.2.6, these impacts have been calculated assuming the existence of two new stations, East Leeds Parkway and Kirkstall Forge. The costs of these stations are not well understood, however. Therefore ORR has asked us to exclude the station costs from our report, noting that, as a consequence, our calculation of costs and benefits is incomplete. ORR has asked us to note that, in its assessment of this option, it will consider the incremental costs of these stations (to the extent that the application causes all or part of this cost to be incurred, net of any wider benefits associated with increased network capability) alongside the costs and benefits presented here.

Estimated NPV for these services over the 10 year appraisal period is £411m. This comprises £356m of user benefits, £176m of non-user benefits, a £498m net increase in GB rail revenue, a net £84m reduction in income to HM treasury, and an £535m increase in total operating costs.

Table 34: Option 10 economic appraisal summary

Impact category	**£m 2010**
User benefits	£355.5
Non-user benefits	£175.9
Other Govt impacts	-£84.1
Revenue (GB rail total)	£498.4
Operating Costs	-£535.0
NPV	**£410.6**
NPV excluding operating costs	**£945.6**

6.12 Summary of results for all options

Table 35 below summarises a selection of key results for all of the options tested in phase 2 this study.

In addition to the commentary provided above we note the following:

- Presenting estimated NPV and NPV excluding operating costs divided by the number of weekday paths is a simple means of measuring the economic value of each option value per unit of capacity used. ORR may wish to consider alternative measures of capacity. Further to this, trains that split or join have been counted as occupying a single weekday path. Options 5 and 6 would operate only on weekdays; and
- Options 1, 7, 9, 10 and 15 involve a reduction in average fares. This has increased the NPV and NPV excluding operating costs for these options significantly. This is largely through a sizeable increase in consumer surplus, and to a lesser extent through additional generated revenue for the industry.

Table 35: Summary of key results, monetary values in 2010 £m except where specified

Option	Do-minimum base timetable	Annual applicant revenue (2014/15 £m)	Absolute annual abstraction (2014/15 £m)	Annual generation (whole industry) (2014/15 £m)	NPA ratio	NPV	NPV excluding operating costs	NPV per path	NPV per path excluding operating costs
Option 1, Alliance Yorks/Cleethorpes*	IEP base	60.6	40.5	20.1	0.50	181.3	337.8	9.1	16.9
Option 2, Alliance Edinburgh*	IEP base	188.6	133.9	54.7	0.41	46.1	671.9	1.4	21.0
Option 11, Alliance Edinburgh non-tilt (Sensitivity test on Option 2)	IEP base	140.5	114.9	25.6	0.22	-299.8	326.0	-8.3	9.1
Option 3, VTEC Core	IEP base	66.9	26.7	40.2	1.50	198.1	576.6	7.6	24.2
Option 4, VTEC Lincoln / Harrogate	VTEC core	13.6	2.7	10.9	4.00	108.7	165.3	5.4	8.3
Option 6, VTEC Middlesbrough	VTEC core	3.0	0.1	2.9	27.7	-11.6	45.3	-0.9	3.5
Option 8, VTEC Full	IEP base	90.0	30.1	59.9	1.99	379.6	871.5	6.4	14.8
Option 7, First Edinburgh*	IEP base	25.6	9.2	16.3	1.76	171.2	296.9	17.1	29.7
Option 9, First Edinburgh as submitted*	VTEC full	24.7	7.9	16.8	2.13	166.6	292.3	16.6	29.2
Option 15, First Edinburgh, no overtake*	VTEC full	34.4	19.1	15.4	0.81	214.6	340.2	21.5	34.0
Option 10, VTEC Core and Alliance/Yorkshire Cleethorpes*	IEP base	Alliance: 49.4 VTEC: 66.9 Both: 116.3	Alliance: 30.4 VTEC: 26.7 Both: 57.1	Alliance: 19.0 VTEC: 40.2 Both: 59.2	Alliance: 0.62 VTEC: 1.50 Both: 1.04	410.6	945.6	8.9	20.6

*Note: As explained in section 5.2.6, the net present value of these options is incomplete. This is because ORR has asked us to exclude certain investment costs from the appraisal. Those costs will, however, be considered by ORR alongside the impacts calculated here.

7. Study conclusions, and advice to ORR

7.1 Introduction

We have completed our analysis as per ORR's term of reference to us. Therefore as requested by ORR we have provided:

- Revenue projections for the new services contained within the track access applications, produced in a way that enables ORR to conduct its Not Primarily Abstractive (NPA) test and assess the impact of each application on the funds available to the Secretary of State for Transport; and
- An economic appraisal of a number of the incremental benefits and costs of the new services, quantifying most, but not all, relevant impacts.

7.2 Revenue projections

Our projections indicate that each of the options considered would generate significant additional revenue for the applicant and the rail industry, and would also abstract large sums of revenue from incumbent TOCs. In a number of options current ECML TOCs would lose a substantial proportion of their revenue base, in other options the abstraction is low.

The fares that operators would be likely to offer are key to the revenue projections for a number of the options for new open access services. Lower fares, in particular as a consequence of competition between operators, are forecast to generate significant additional revenue, as well as a substantial benefit to passengers.

Whilst we are confident that the fares assumptions in our assessment are realistic, we recommend that ORR considers whether applicants would be likely or able to adopt a strategy to charge higher fares, having first secured track access rights.

We also highlight the contention from some stakeholders that the requirement to model fares in this study is more complicated than PDFH enables. We have some sympathy with this contention, however we believe that PDFH provides the best available advice and approach, and are happy that our approach is consistent with PDFH.

The level of abstraction from other operators is very sensitive to the characteristics of the train timetables considered. Our sensitivity tests show that small changes in the order or timing of even a few train services can result in large differences in the allocation of revenue between operators.

We therefore recommend that ORR gives careful consideration to the potential and likely outcomes of future timetable planning processes.

7.3 Economic appraisal results

Our economic appraisal is intended to provide an estimate of a number of the incremental benefits and costs relating to each option considered as compared to the relevant do-minimum base timetable, focusing on those effects that can be quantified. It is not a full assessment of all of the impacts and largely excludes qualitative factors. Similarly, it does not seek to appraise effects against the ORR's statutory duties.

We understand that this quantification will form part of the evidence base which will underpin ORR's eventual decisions, but it will not be the only evidence considered by ORR and is therefore not intended to be an all-encompassing assessment of every aspect of the applications.

Our economic appraisals indicate that most of the options would generate significant incremental economic value, and benefit a spectrum of rail passengers and other transport users.

Some impacts that ORR may wish to consider have not been quantified in the approach to appraisal remitted to us. The most obvious of these is the impact of the options on train punctuality, where the available evidence does not enable a quantified distinction between the various options.

ORR will also need to consider the appropriate treatment of rolling stock, as this appraisal has treated all rolling stock as being an incremental cost.

We have produced our cost estimates using industry recognised techniques and market-tested rates. We are confident that our quantification of incremental operating costs are broadly correct, however there may be some differences in unit operating costs faced by the various applicants which we are unable to validate.

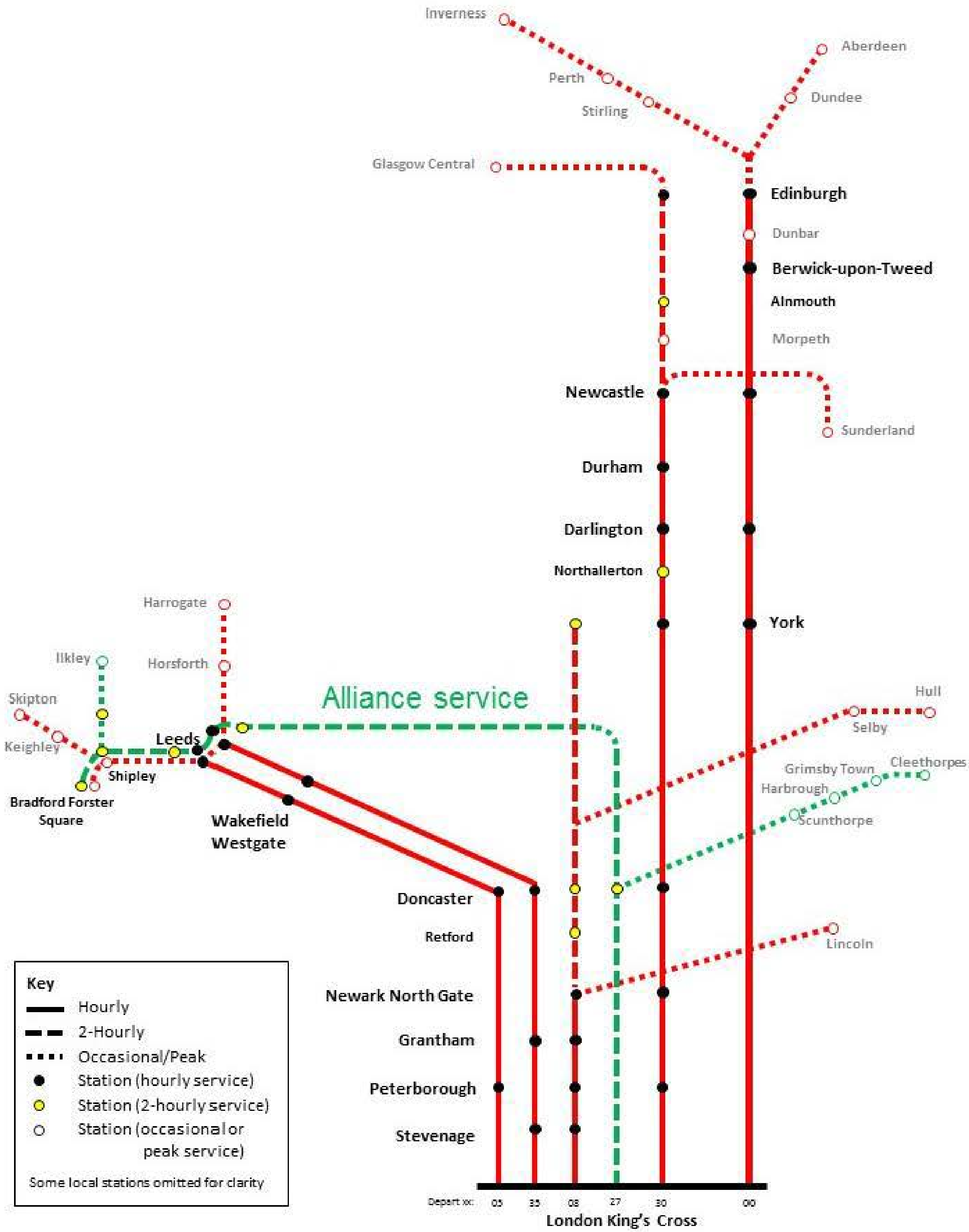
Our estimates of generated revenue and demand form key inputs to our appraisals, and the sensitivities to our estimates are explained above. However, it is important to re-emphasise that under our appraisal framework, and under WebTAG, the introduction of low fares generates a large consumer surplus, indicated by sizeable estimated user benefits and NPVs (excluding operating costs). The economic benefit of these reductions in fares is irrefutable, providing that ORR believes that our estimated reduction in fares are both reasonable, and likely to occur.

Appendix A: Diagrams of Main Options (Weekday)

This appendix shows, in diagrammatical format, the services in the IEP base and the main options.

The diagrams only show services relating to Alliance, VTEC and First. Current services run by other ECML operators are assumed to be the same in the option and base timetables. For ease of interpretation, these services are not shown in the diagrams.

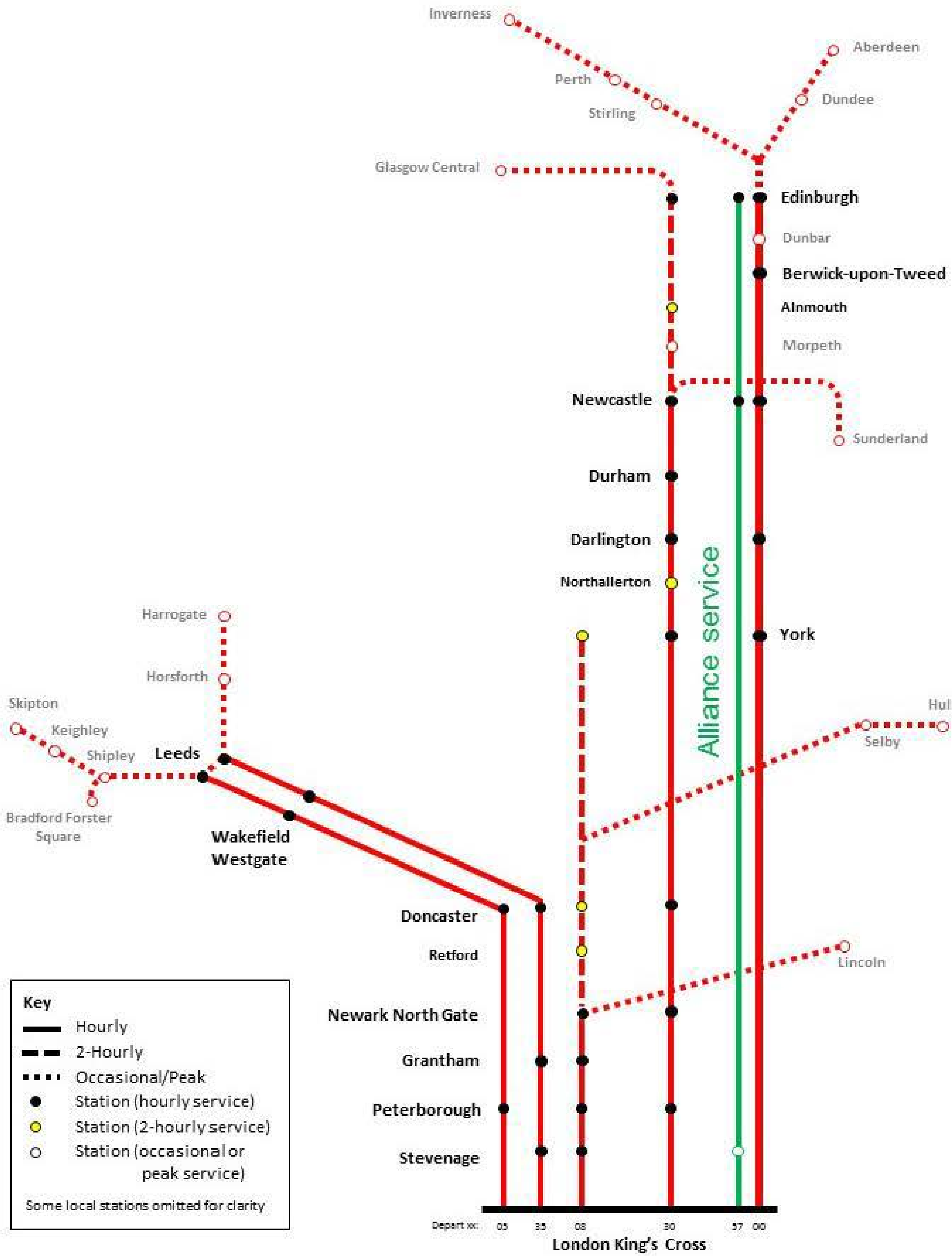
Alliance Yorkshire/Cleethorpes - Weekday (Option 1)



VTEC and Alliance services only

Alliance Edinburgh - Weekday

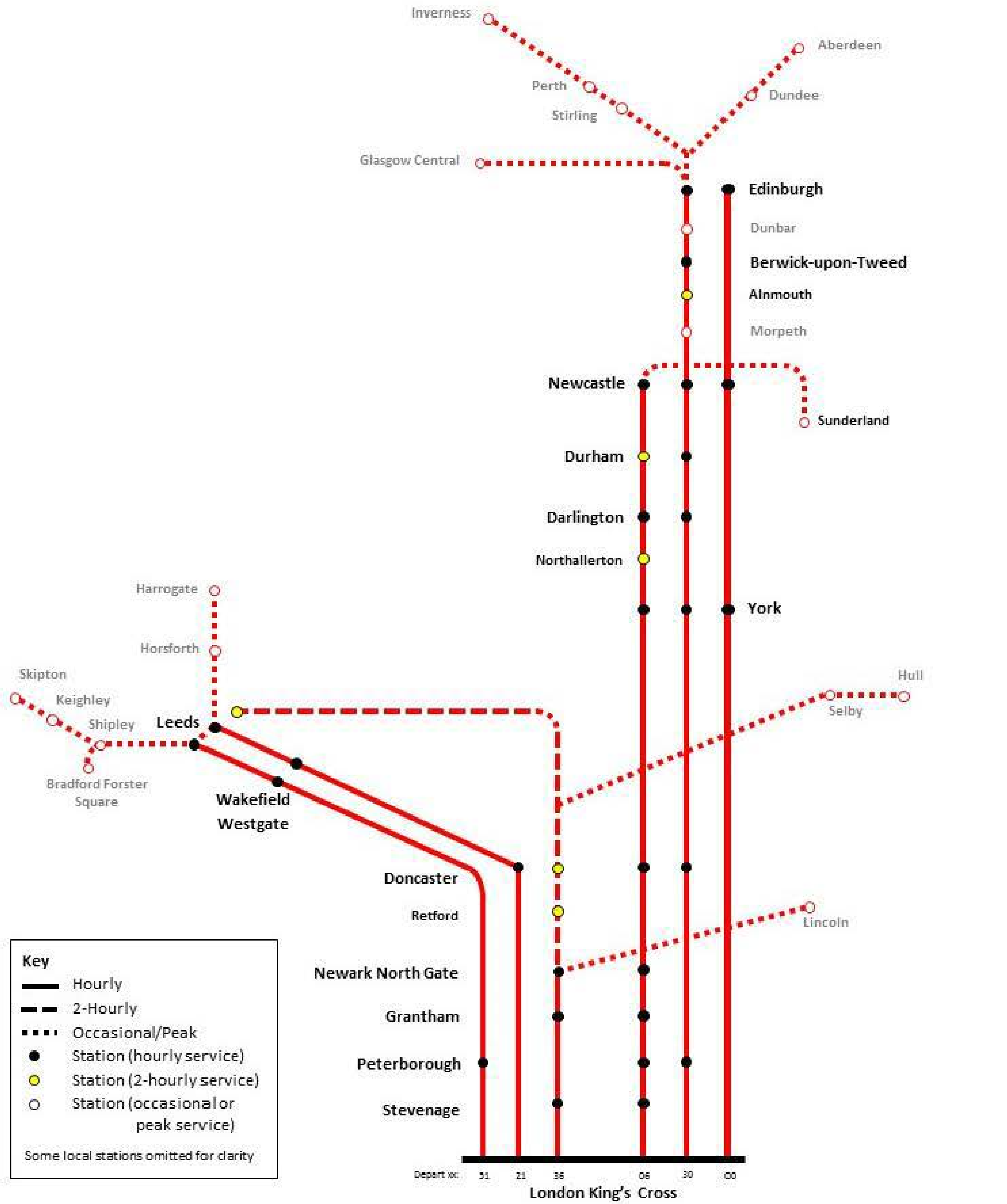
(Option 2)



VTEC and Alliance services only

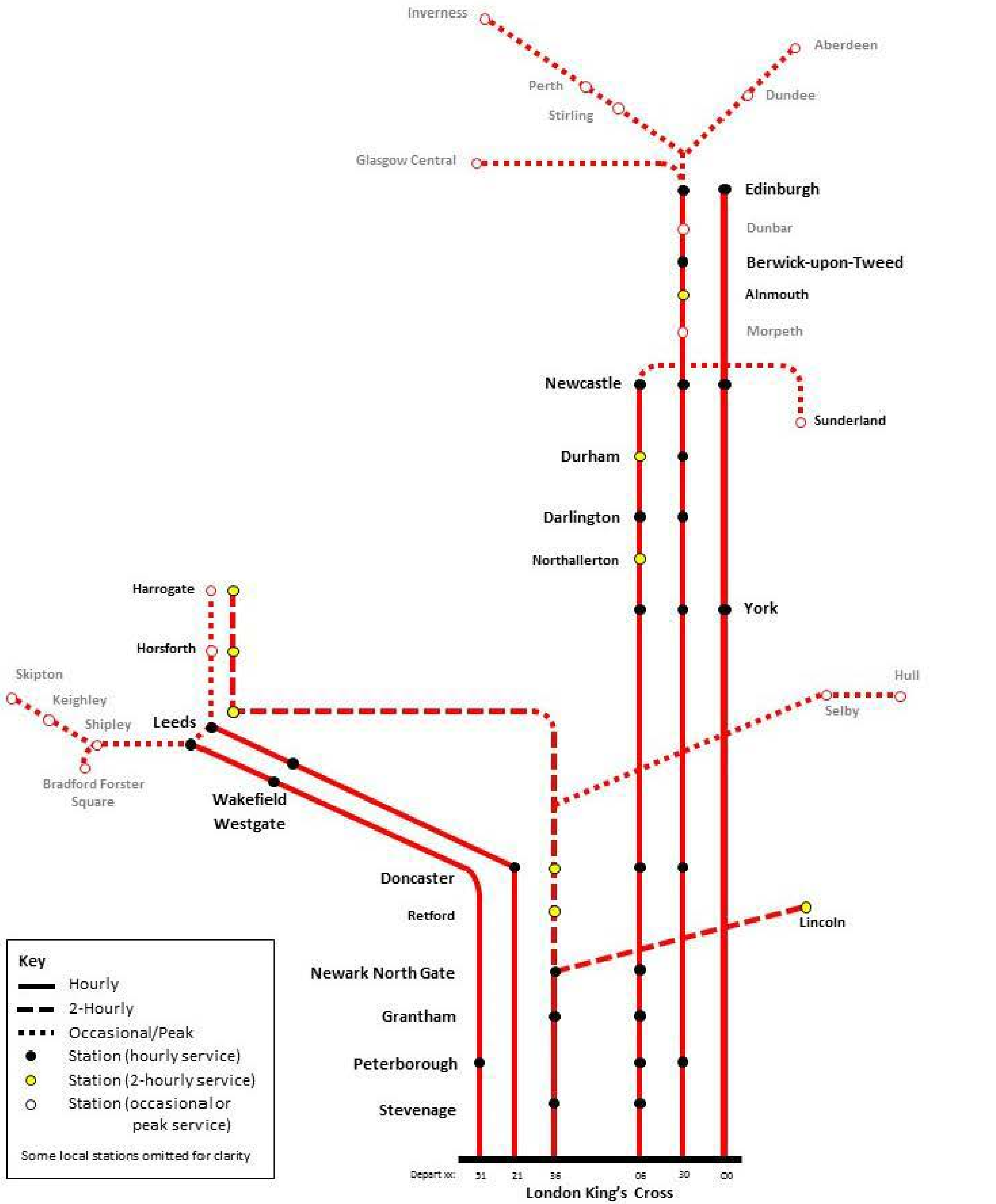
VTEC Core - Weekday

(Option 3)



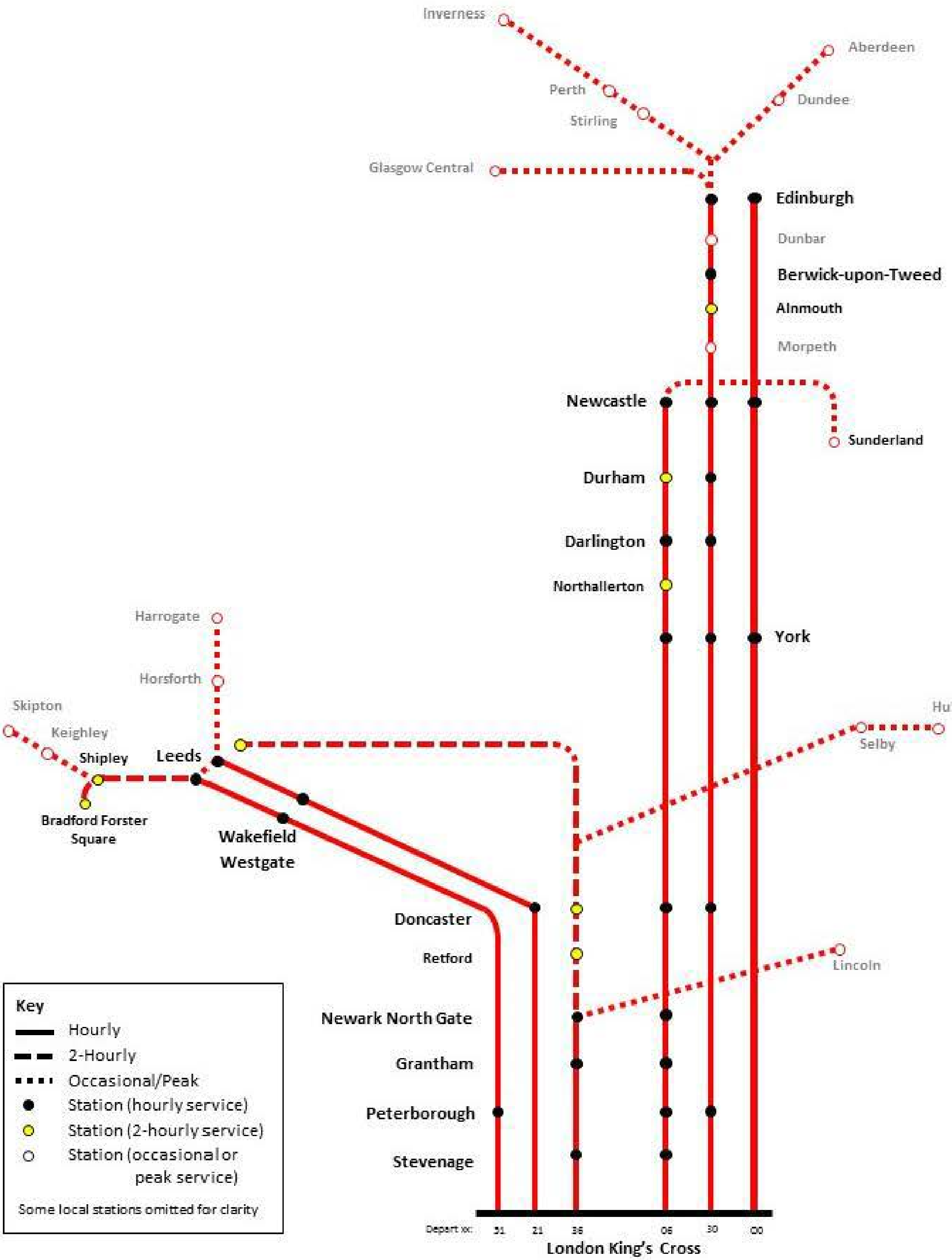
VTEC services only

VTEC Lincoln & Harrogate - Weekday
(Option 4)



VTEC services only

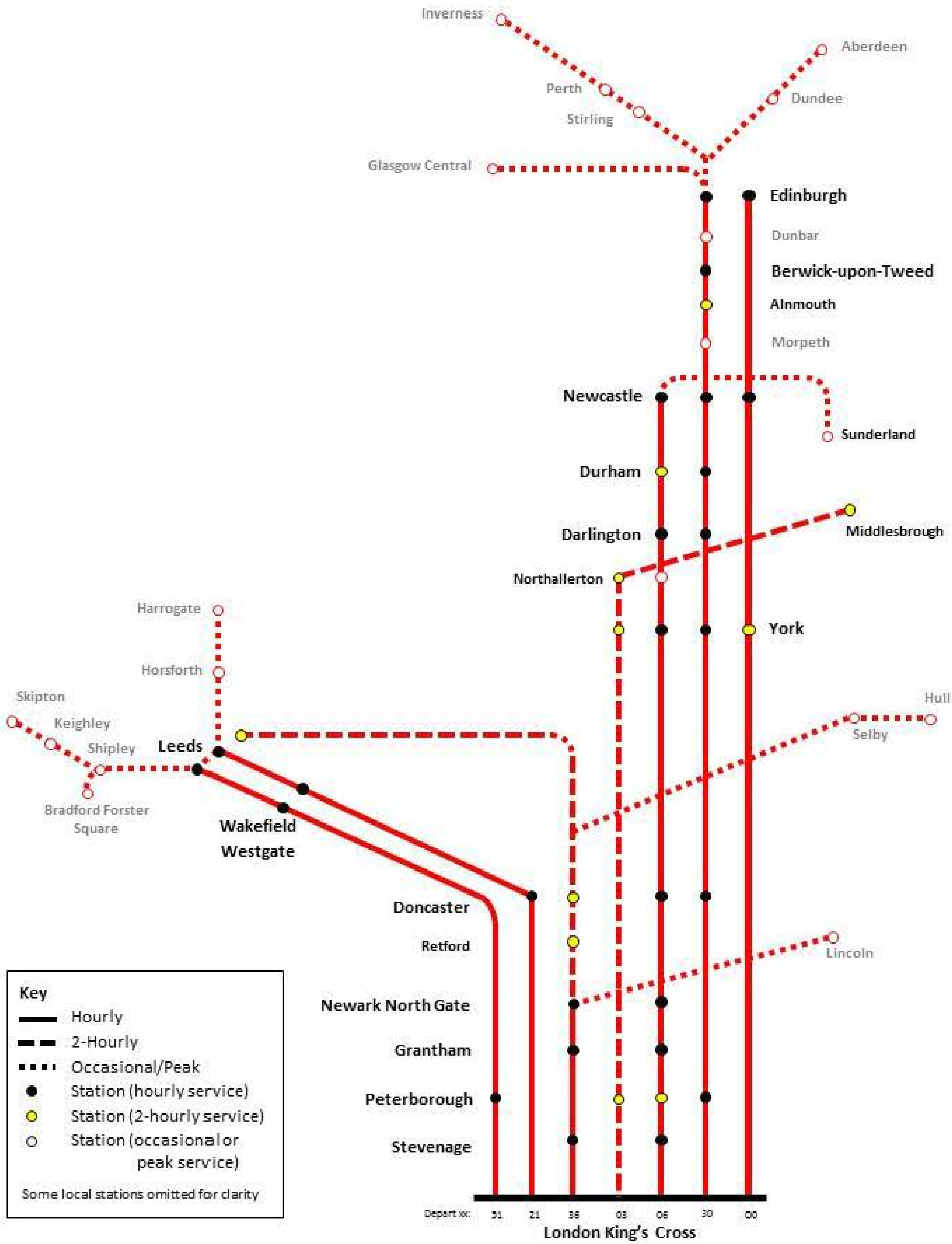
VTEC Bradford Forster Square - Weekday (Option 5)



VTEC services only

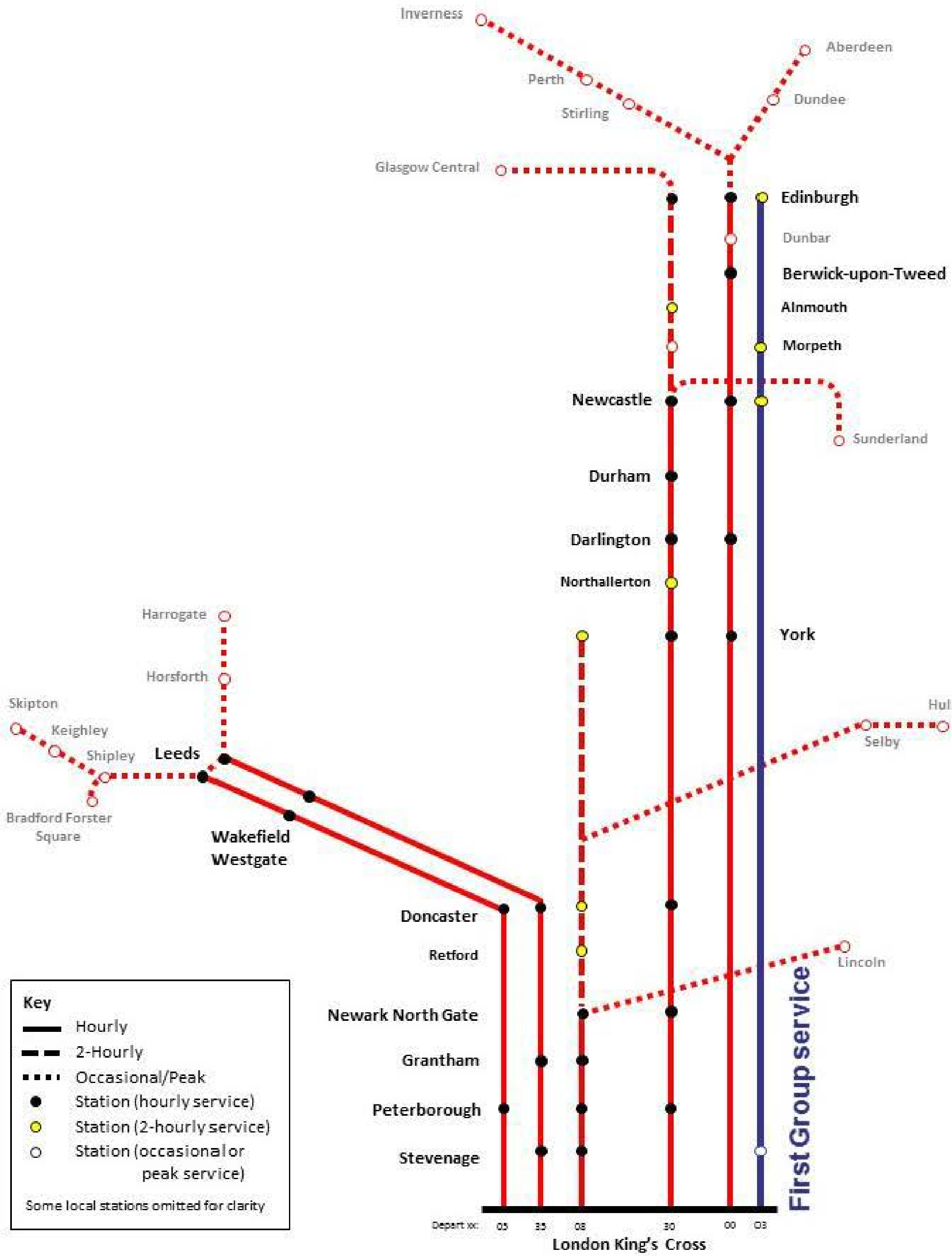
VTEC Middlesbrough - Weekday

(Option 6)



VTEC services only

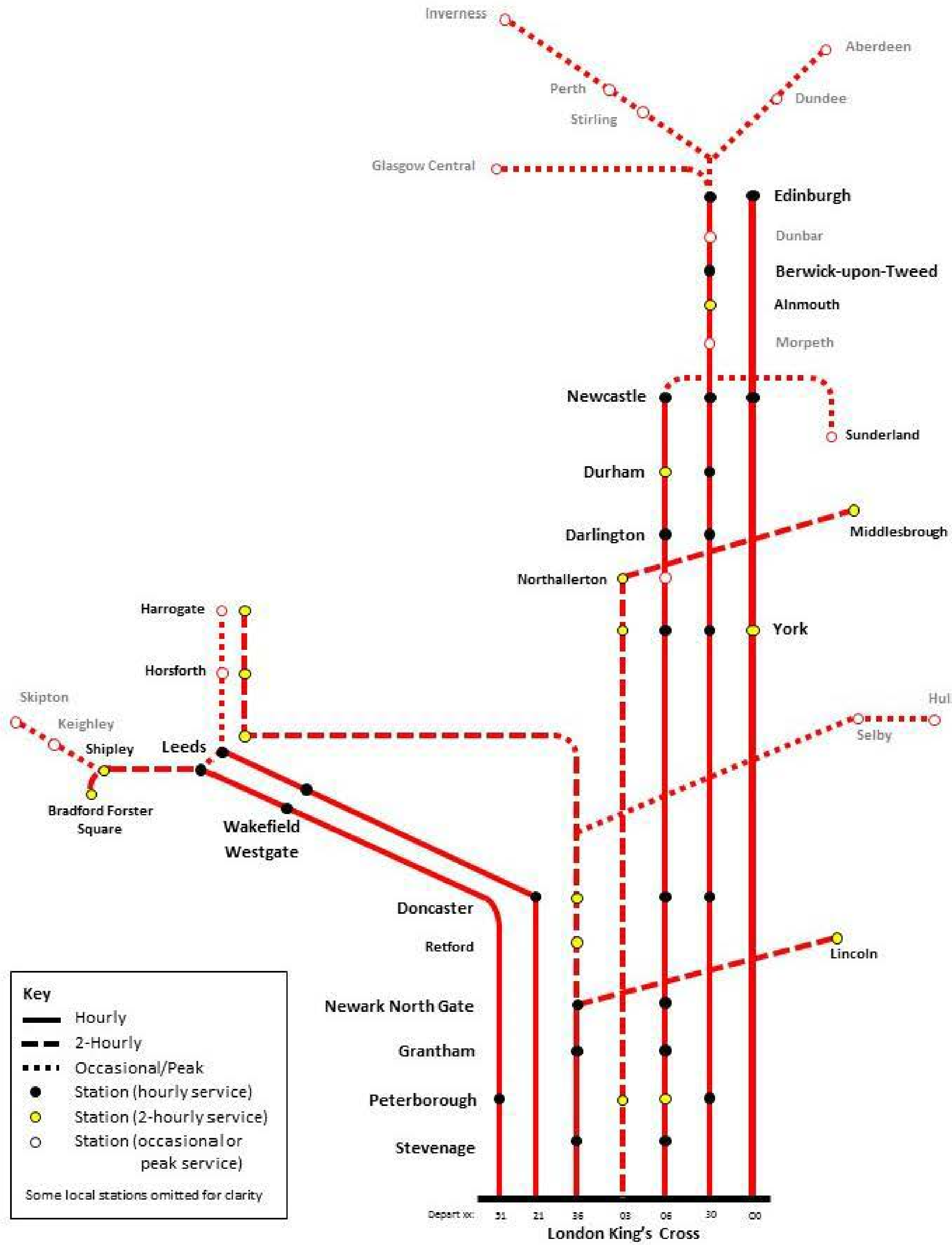
First Group - Weekday
(Option 7)



VTEC and First Group services only

VTEC Full - Weekday

(Option 8)



VTEC services only

See separate documents for Appendices B-G

Appendix B: MOIRA Analysis

PREPARED FOR:	Office of Rail and Road
PREPARED BY:	Oliver Haycock, Chris Judge
DATE:	January 15th, 2016
PROJECT NUMBER:	657135
REVISION NO.:	2.2
APPROVED BY:	Jon Clyne

1. Background

This appendix explains the process to develop option timetables and to assess these timetables using MOIRA.

Timetable files for the options were based on the MOIRA (SPG) files supplied by each applicant in support of their access rights applications, with adjustments made where we felt this was appropriate (see sections 3, 4, 5 and 7).

All base and option timetable files were supplied to all applicants for review, and all applicants submitted a response to ORR. We considered the comments and made a small number of adjustments. All revised (final) timetable files were shared with all applicants for information purposes.

The same draft and final set of timetable files were shared with ORR, and with DfT upon request.

An earlier version of this appendix was also shared with the above stakeholders.

All timetables developed are for the purposes of this assessment. They have therefore not been validated by CH2M as operationally feasible, however we have endeavoured to make consistent assumptions where possible.

2. Timetable development process

2.1 Introduction

The proposed services contained within the access rights applications have been packaged into a series of options for the purposes of this assessment. Three categories of options are defined:

- Main options. These are groups of proposed additional train services in the applications received which ORR has requested are assessed separately. Each option is tested against the same base timetable, with the exception of some of the VTEC options which are increments to, and hence tested against a base of VTEC's additional Edinburgh, Newcastle and Leeds services.

- Additional options. These are packages of more than one option and/or individual options tested against a base of one of the other options. ORR has requested these additional options are assessed to show the impact of some potential mixed uses of ECML capacity.

- Sensitivity tests. ORR has requested that some tests are undertaken to understand the impact of some key assumptions relating to various options, and also the impact on other ECML operators.

We understand that the timings for all services considered are compliant with current Train Planning Rules (TPR), but ORR's terms of reference to us does not include the validation of timetables.

Furthermore, we have not, in our MOIRA analysis, adjusted other operators' services to fit with the additional services proposed by applicants. The level of timetable validation required to integrate service changes with the full ECML timetable and other dependent timetables, was not included in ORR's terms of reference.

Finally, we have not assessed the operability of the timetables considered in this assessment. Again, this is not included in the terms of reference for this work.

Tables 1-3 below provide a list of all options considered in this assessment.

2.2 Base Timetable

CH2M HILL has developed a counterfactual "do minimum" timetable to test the track access applications against.

Given that the purpose of our assessment is to provide evidence to inform ORR's decision on track access rights, the base timetable is intended to represent the likely future (2020) timetable in the absence of any of the proposed services, which to operate, require the allocation of track access rights by ORR.

This timetable is the May 2014 timetable, sped up in line with the indicative IEP journey times. The IEP journey time savings have been derived from material published on the DfT website[1], as well as from analysing the journey times indicated in the Virgin Trains East Coast (VTEC) 2020 timetable.

The journey time savings achieved in this timetable are shown in the PDF files located with the base timetable SPG files.

Timing changes have only been made to services operated by Virgin Trains East Coast. We assume that all other operators continue to operate current rolling stock, and hence maintain existing journey times.

2.3 Main Options – List of SPG Files

Table 1 shows the SPG[2] files used for the assessment of the main options:

[1] https://www.gov.uk/government/news/government-gives-green-light-for-more-state-of-the-art-intercity-trains

[2] The file format of MOIRA timetables

Table 1: Options to be tested

Option ID	Title	Base Filename	Option Filename	Comments
Alliance Rail Holdings (GNER)				
1	Alliance Yorkshire/ Cleethorpes	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	GNER_BFQ+CLE_WED.spg GNER_BFQ+CLE_SAT.spg GNER_BFQ+CLE_SUN.spg	
2	Alliance Edinburgh	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	GNER_EDB_WED.spg GNER_EDB_SAT.spg GNER_EDB_SUN.spg	Up Wednesday & Saturday EDI-KGX retimed from 3:43 to 3:45 to be TPR compliant. No other adjustments made.
Virgin Trains East Coast (VTEC)				
3	VTEC Core	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	VTEC_CORE_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	
4	VTEC Lincoln/Harrogate	VTEC_CORE_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	VTEC_LCN-HGT_WED.spg VTEC_LCN-HGT_SAT.spg VTEC_LCN-HGT_SUN.spg	Would only operate as increment to VTEC core
5	VTEC Bradford Forster Square	VTEC_CORE_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	VTEC_BFQ_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	Would only operate as increment to VTEC core (Service would run on weekdays only)
6	VTEC Middlesbrough	VTEC_CORE_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	VTEC_MBR_WED.spg VTEC_CORE_SAT.spg VTEC_CORE_SUN.spg	Would only operate as increment to VTEC core. (Service would run on weekdays only)
First Group – East Coast Trains Limited (FGOA)				
7	FGOA Edinburgh	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	FGOA_WED_IEP.spg FGOA_SAT_IEP.spg FGOA_SUN_IEP.spg	Timings of option trains slowed to fit the 2014 base with IEP timings.

2.3 Additional Options

ORR has requested that CH2M HILL test the additional options outlined in Table 2.

Table 2: Additional Options

Option ID	Title	Base	Option	Comments
Full Virgin Trains East Coast (VTEC)				
8	VTEC Full	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	VTEC_FULL_WED.spg VTEC_FULL_SAT.spg VTEC_FULL_SUN.spg	VTEC's actual track access application
First Group – East Coast Trains Limited (FGOA) against base of Full VTEC				
9	FGOA Edinburgh	VTEC_FULL_WED.spg VTEC_FULL_SAT.spg VTEC_FULL_SUN.spg	FGOA_WED_VTEC_FULL.spg FGOA_SAT_VTEC_FULL.spg FGOA_SUN_VTEC_FULL.spg	First Group's track access application as received
Combined VTEC Core & Alliance Yorkshire / Cleethorpes option				
10	VTEC Core & Alliance Yorkshire/ Cleethorpes	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	GNER_VTEC_WED.spg GNER_VTEC_SAT.spg GNER_VTEC_SUN.spg	Alliance has submitted an updated weekday timetable to dovetail with VTEC Core. The original Alliance Saturday and Sunday timetables are used for weekends.

2.4 Sensitivity Tests

ORR has also requested that CH2M HILL conducts the sensitivity tests outlined in Table 3.

Table 3: Sensitivity Tests

Option ID	Title	Base	Option	Comments
Alliance Rail Holdings (GNER)				
11	Alliance Edinburgh	IEP_WED.spg IEP_SAT.spg IEP_SUN.spg	GNER_EDB_WED_NO_TILT.spg GNER_EDB_SAT_NO_TILT.spg GNER_EDB_SUN_NO_TILT.spg	To represent the journey times if infrastructure upgrades to enable tilt did not happen
Virgin Trains East Coast (VTEC)				
12	VTEC Middleborough	VTEC full	VTEC Middlesbrough with Grand Central Sunderland offset by 1 hour	To assess the impact on Grand Central (no spg supplied)
13	VTEC Middleborough	VTEC full	VTEC Middlesbrough and Grand Central order of arrival at KGX switched	To assess the impact on Grand Central (no spg supplied)
14	VTEC Full Application	VTEC full	VTEC's Full application with Hull Trains overtake removed	To assess the impact on Hull Trains (no spg supplied)
First Group – East Coast Trains Limited (FGOA)				
15	FGOA Edinburgh	VTEC_FULL_WED.spg VTEC_FULL_SAT.spg VTEC_FULL_SUN.spg	FGOA_NO_OVERTAKE_WED.spg FGOA_SAT_VTEC_FULL.spg FGOA_NO_OVERTAKE_SUN.spg	Overtaking manoeuvres removed

3. Dividing VTEC's Application into options for assessment

ORR requested that VTEC's long term access application was split into its constituent elements, to enable ORR to better understand where the benefits of the application arise.

3.1 VTEC Core

We understand that the core proposition in VTEC's long term application is the operation of additional services between King's Cross, Newcastle and Edinburgh, and between King's Cross and Leeds, allowing the intermediate station calls in existing services to be switched to these new services. This enables significant journey time savings between the most populous locations and an overall increase in train frequency.

VTEC Core *(Option ID 3)* was therefore developed by importing all of the VTEC trains from the Full VTEC SPG file and then making the following adjustments:

- Removal of Middlesbrough trains (only run on weekdays);
- Addition of a York stop (and 3 minutes additional journey time) to the fast Edinburgh service in the hours where the Middlesbrough train ran (weekdays only);
- Addition of Northallerton and Peterborough stops (and 3 minutes additional journey time per station) to the Newcastle stopping service in the hours where the Middlesbrough train ran (weekdays only);
- Cut all Lincoln trains that exceed the current quantum back to Newark North Gate; and
- Cut all services North West of Leeds that exceed the current quantum back to Leeds.

3.2 VTEC Lincoln + Harrogate

This option is an increment to the VTEC Core option involving the extension of the weekday hourly stopping service between King's Cross and Newark/Leeds, to/from Lincoln and Harrogate, respectively.

At weekends the same Harrogate extensions would be via an existing fast Leeds service, and the Lincoln extensions would be via a King's Cross – Newark stopping service.

VTEC Lincoln + Harrogate *(Option ID 4)* was therefore developed by importing all of the VTEC trains from the Full VTEC SPG and then making the following adjustments:

- Removal of Middlesbrough trains (only runs on weekdays);
- Addition of a York stop (3 minutes additional journey time) to the fast Edinburgh service in the hours where the Middlesbrough train ran (weekdays only);
- Addition of Northallerton and Peterborough stops (3 minutes additional journey time per station) to the Newcastle stopping service in the hours where the Middlesbrough train ran (weekdays only); and
- Cut all services North West of Leeds that exceed the current quantum back to Leeds.

3.3 VTEC Bradford Forster Square

This option is an increment to the VTEC Core option involving the extension of one weekday King's Cross – Leeds service every second hour, to form a two-hourly King's Cross – Bradford Forster Square service. (One train per day in each direction is currently extended to/from Bradford Forster Square).

VTEC Bradford Forster Square *(Option ID 5)* was produced by importing all of the VTEC trains from the Full VTEC SPG and then making the following adjustments:

- Removal Middlesbrough trains (only runs on weekdays);
- Addition of a York stop (3 minutes additional journey time) to the fast Edinburgh service in the hours where the Middlesbrough train ran (weekdays only);
- Addition of Northallerton and Peterborough stops (3 minutes additional journey time per station) to the Newcastle stopping service in the hours where the Middlesbrough train ran (weekdays only); and
- Cut all Lincoln trains that exceed the current quantum back to Newark North Gate.

As VTEC's track access application does not include additional trains to Bradford Forster Square beyond the existing quantum at the weekend, the VTEC Core timetable will be used to calculate Saturday and Sunday revenue and journeys.

3.4 VTEC Middlesbrough

This option is an increment to the VTEC Core option involving the introduction of a new weekday two-hourly service between King's Cross, Peterborough, York, Northallerton and Middlesbrough.

The York stop would be switched from the corresponding fast Edinburgh service, enabling faster journey times between Edinburgh and London.

The Peterborough and Northallerton stops would be switched from the corresponding stopping Newcastle service, enabling faster journey times between a number of locations.

VTEC Middlesbrough *(Option ID 6)* was therefore produced by importing all of the VTEC trains from the Full VTEC SPG and then making the following adjustments:

- Cut all Lincoln trains that exceed the current quantum back to Newark North Gate; and
- Cut all services North West of Leeds that exceed the current quantum back to Leeds.

As VTEC's track access application does not include weekend services to Middlesbrough, the VTEC Core timetable will be used to calculate Saturday and Sunday revenue and journeys.

4 Adjustments to First's proposed services

4.1 Retiming of the First Group Edinburgh Option for testing against the IEP base

The timetable submitted in support of First's access rights application was designed by First to fit with VTEC's proposed 2020 timetable. In this submission First's northbound services are flighted behind the regular hourly VTEC service, except for First's earliest departure from King's Cross, which commences operation before VTEC's first service. Southbound services set off prior to VTEC's regular hourly trains, and are shown as being overtaken on the way to London. First's services are typically 9 minutes and 10 minutes slower between King's Cross and Edinburgh in the northbound and southbound directions respectively.

ORR has requested that all options, other than increments to the VTEC core timetable, are assessed against a consistent base. In retiming these services we assume the same characteristics as above, with

First's services flighted behind the northbound regular VTEC hourly service and overtaken by the southbound regular VTEC hourly service. Journey time differentials are as above.

The First Group Edinburgh option with IEP timings *(Option ID 7)* was therefore developed by flighting the First Group service behind the fast VTEC King's Cross - Edinburgh service (xx:00). The same time spacing is maintained between the First Group and VTEC trains between options. For example, northbound services are 3 minutes apart at King's Cross and 11 minutes apart at Edinburgh in option 7 and in the timetable submitted by First (i.e. a difference of 9 minutes, as above). This method preserves any overtaking manoeuvres to make the IEP First Group option as similar to the timetable submitted by First as possible. This allows the impact of the overtaking manoeuvres to be assessed as a separate sensitivity test.

We accept that a future timetable planning process may result in First's services being timetabled to run in front of VTEC's regular hourly services, as the former stops at 2-3 fewer stations and could in theory operate with significantly faster journey times. ORR has not instructed us to test the impact of this outcome in our assessment.

4.2 Retiming of the First Group Edinburgh Option with the overtaking manoeuvres removed

In addition to the options described above, ORR has requested that the First Group timetable as submitted (option ID 9) is tested with the assumed overtaking move in the southbound direction removed.

This sensitivity test *(Option ID 15)* was developed by retiming the services that are overtaken with the same Newcastle – Kings Cross journey time as the VTEC train that overtakes it. Only trains that are overtaken are retimed, this is applicable to 4 southbound weekday trains and 3 southbound Sunday trains.

To prevent the faster First Group trains from overtaking the slow Scotland – London VTEC services, the First Group trains have been retimed to depart Edinburgh between 11 and 15 minutes later, allowing them to flight the fast VTEC services and maintain a three minute gap between arrivals at Kings Cross, as specified by the train planning rules. No overtaking manoeuvres were identified on northbound trains or on southbound Saturday services.

4.3 Revenue base considered

One stakeholder has written to ORR suggesting that the MOIRA analysis should consider only journeys and revenue relating to the market segments that new entrants to the market would be likely to serve.

We have not taken this approach, instead conducting our MOIRA analysis on the full set of journeys and revenue. This is because our MOIRA analysis is based on an assumption that passengers would be prepared to alter their time of travel and/or switch between product types to take advantage of improvements to GJT.

Our fares assessment, subsequently, considers only the subsets of market segments that operators would serve, thereby assuming that passengers would not alter their time of travel and/or switch between products to take advantage of cheaper fares.

The reality is likely to lie between these two extremes, and the approach taken is, in our view, a reasonable compromise.

5 Adjustments to Alliance's proposed services and sensitivity tests

5.1 Alliance Edinburgh – Concerns over deviations from the Train Planning Rules

Concerns have been raised by some stakeholders that certain services contained within the Alliance Edinburgh application *(Option ID 2)* have journey times which are not compliant with the current Train Planning Rules (TPR).

ORR's terms of reference to us do not include validation of timetables to ensure TPR compliance. However, we believe that an Edinburgh – King's Cross journey time of 3:43 is TPR compliant (assuming no Stevenage call), except for up Wednesday & Saturday Edinburgh to Kings Cross services, which should be 3:45. By TPR compliant we mean compliant with normal planning rules, and not the exceptional rules to which the current early morning King's Cross arrival from Edinburgh is permitted to operate.

5.2 Retiming of the Alliance Edinburgh Option with journey times representative of services with the inability to tilt

Alliance's journey times are not possible given the current and committed future capability of the infrastructure, particularly as the infrastructure does not currently allow the full benefit of the Pendolino's tilt capability to be realised. The journey times are therefore dependent on an infrastructure upgrade, which we understand that Alliance intends to fund.

The total cost of this upgrade is not currently well understood, so it is unclear whether this work is affordable to Alliance and/or other funders. ORR has requested that we undertake a sensitivity test to better understand the impact of the reduced journey times enabled by tilt, on the revenue assessment and economic appraisal.

Under this sensitivity test we assume that journey times are the same as IEP rolling stock would achieve when calling at the same number of stations.

This sensitivity test *(Option ID 11)* was developed by retiming the Alliance services with journey times equivalent to the fastest up and down VTEC services within VTEC's full 2020 application. For the northbound direction, this is 03:59 (2:34 Kings Cross to Newcastle, a three minute dwell and then 1:22 Newcastle to Edinburgh) and 4:00 for the southbound (1:22 Edinburgh to Newcastle, a three minute dwell and then 2:35 Newcastle to Kings Cross). Three minutes of additional journey time is applied to services that call at Stevenage. There are a handful of weekend services (usually on short workings) where the journey times indicated in the Alliance Edinburgh proposal are slower than the journey times achieved by the fast 2020 VTEC trains. Where this occurs, no changes have been made to the Alliance journey times.

6. MOIRA Version

We believe that MOIRA Northern is the most appropriate version for testing all of the track access applications received, as this version of MOIRA treats most of the relevant stations as individual stations.

However, sensitivity tests have shown that changes impacting London - Peterborough, London - Stevenage and Stevenage - Peterborough are overstated by MOIRA Northern.

The overstatements are due to multiple stations being grouped into Peterborough and Stevenage in MOIRA Northern. We have therefore generated factors to dampen the overstatements by running a range of timetable changes in both MOIRA Northern and MOIRA Anglia, and comparing the change in demand between the two MOIRA versions. Table shows the stations grouped into Peterborough and Stevenage, as well as the demand change overstatements in MOIRA Northern. – We therefore scale demand forecasts for the relevant flows, using these figures.

Table 4 – Demand overstatements in MOIRA Northern at Peterborough and Stevenage

<table>
<tr><th>MOIRA Northern Station</th><th>Grouped Stations</th><th>Demand Change Overstatement - journeys to/from London</th><th>Demand Change Overstatement – journeys between Peterborough – Stevenage</th></tr>
<tr><td>Peterborough</td><td>Peterborough
Whittlesea
Spalding
Stamford</td><td>30%</td><td rowspan="2">90%</td></tr>
<tr><td>Stevenage</td><td>Stevenage
Arlesey
Biggleswade
Sandy
Ashwell & Morden
Huntingdon
St Neots
Baldock
Hitchin
Royston Herts
Letchworth</td><td>87%</td></tr>
</table>

7. Dialogue with applicants

Following the circulation of MOIRA SPG files and accompanying technical note by the ORR on Friday 4th September, all applicants responded with comments and suggestions. The following section summarises the responses from each applicant, along with the actions taken. For brevity, applicants' responses have been paraphrased by CH2M.

7.1 Alliance

Alliance Comment 01:	**Criticism that ORR is taking the VTEC timetable as the base and that other applications must fit around it.**
CH2M Comments:	The base timetable is May 14 with journey times decreased to reflect assumed IEP SRTs. All main options will be tested against this base, unless they are increments to VTEC's core options. CH2M has defined these increments, in discussion with VTEC (see Option ID 1-7 in Table 1 of the technical note supplied with the SPG file release on 4/08/15). In addition, ORR requested that CH2M test some "Additional Options". These are option packages intended to illustrate how applications could *hypothetically* be paired. This is not intended to bias or prioritise applications, but to assess the combined impact of multiple applications.
Action Taken:	None.

Alliance Comment 02:	**Rejection of the concerns surrounding non-compliance with the Train Planning Rules in relation to journey times contained within the Alliance Edinburgh Option.**
CH2M Comments:	The Up Weekday and Saturday services have a 3:45 Edinburgh – London journey time assuming no Stevenage call. This is an increase of two minutes on the timings shown in Alliance's SPG files. All other services have a 3:43 end to end journey time assuming no Stevenage call. This is the same as shown in Alliance's SPG files. CH2M believe that these times are TPR compliant. CH2M has not seen working timetables or the Alstom/Interfleet evidence referred to in Alliance's response.
Action Taken:	None.

Alliance Comment 03:	**Concern that the VTEC timetable does not work, and that there are TPR non-compliance issues within it.**
CH2M Comments:	It has been previously noted that Alliance have raised concerns surrounding the feasibility of the VTEC timetable, but these were general concerns with no specific examples given. Through the consultation period with stakeholders, it was noted that there were several overtaking manoeuvres performed by VTEC on Hull Trains services. There were also concerns about the order of arrivals at King's Cross

	between VTEC and existing open access operators as well as more general concerns about the overall impact of VTEC's aspirations on existing open access operators. To quantify these impacts, CH2M is conducting several sensitivity tests (Option ID 12-14).
Action Taken:	See options 12-14.

Further comments were received on Tuesday 15th September 2015:

Alliance Comment 04:	**Observation that the SPG files do not contain proxy stations for East Leeds Parkway or Kirkstall Forge and a request for CH2M to share the methodology.**
CH2M Comments:	The approach used for forecasting demand at new stations is explained in section 4.1.2 of the previously issued CH2M report: *"…To create a synthetic base demand for these stations, two MOIRA runs need to be produced for each option to identify the set of flows that could be attracted to use Alliance's services. The first run contains the Alliance services with no stops at East Leeds Parkway and Kirkstall Forge. The second run contains stops at Micklefield [now Garforth] to represent East Leeds Parkway, and Headingley to represent Kirkstall Forge."* Following further analysis, CH2M has concluded that Garforth is a more suitable proxy station than Micklefield. The SPGs circulated to applicants is the first run described above. The second SPGs containing the proxy stations were not circulated, but will be included in the next set of SPG files supplied to applicants. The second run is used to identify the flows that are likely to exist from the new stations prior to the introduction of Alliance services, along with the weighting of revenue/journeys between TOCs (to mimic ORCATS). CH2M then assigns catchment areas to the new stations based on drive time analysis. When the catchment areas of existing stations overlap with the catchment areas of the new stations, a proportion of demand is abstracted and attributed to the new station based on population within the overlap at Lower Layer Super Output Area (LSOA) level. This is done for each flow identified by the second MOIRA run described in the previous step. This creates a "synthetic" base demand for the new stations to identify the likely levels of demand should these stations exist with no direct service to London. The gravity model is then used to forecast demand growth for the option, when both of the new stations receive a direct service to London.
Action Taken:	SPG files for the Alliance Yorkshire-Cleethorpes option containing the proxy stations will be circulated.

Alliance Comment 05:	**Request for ORR to clarify why the Non-Tilt sensitivity is being performed.**
CH2M Comments:	Instruction from ORR.
Action Taken:	ORR responded to Alliance on 6 October 2015.

Alliance Comment 06:	**Concern that the Alliance Non-Tilt journey times are too slow and a request for the engineering and performance assumptions applied to all three applicants to be shared.**
CH2M Comments:	The current assumption is that the fast KGX-NCL-EDB services in the VTEC 2020 timetable would be representative of the fastest possible journey times without tilt. CH2M has no reason to believe a class 390 in non-tilt mode would be faster than an IEP with the same stopping pattern. CH2M has not received the evidence to support the timings referenced in Alliance's email and would need to make a like for like comparison with something similar from Hitachi to substantiate this.
Suggested Action:	ORR to take some operations advice (if necessary) and then to respond to Alliance.

7.2 Virgin Trains East Coast (VTEC)

VTEC Comment 01:	**Concern that the First Group journey times are slower than VTEC trains, where VTEC trains have more stops.**
CH2M Comments:	The approach taken attempts to retain the principles of First's access right application. In this journey times are apparently a second order consideration. However, a future timetable planning process may result in First's service being timetabled to run in front of VTEC's regular hourly service, as the former stops at 2-3 fewer stations and could in theory operate with significantly faster journey times. We have flagged this possibility, and ORR has instructed us not to test the impact of this outcome in our assessment.
Action Taken:	Flag as a risk in a report

VTEC Comment 02:	**Concern that the technical note states that the intervals between services are maintained at King's Cross, Newcastle and Edinburgh, but this is not reflected in the timetables.**
CH2M Comments:	The method intends to maintain the time spacing between the First Group and VTEC trains between options, not between stops. For example, the services are 3 minutes apart at King's Cross and 11 minutes apart at Edinburgh in the CH2M IEP option and in the timetable submitted by First. The justification for this is that it preserves any overtaking manoeuvres to make the IEP First Group option as similar to the timetable submitted by First as possible. This allows the impact of the overtaking manoeuvres to be assessed as a separate sensitivity test.
Action Taken:	The above clarification.

VTEC Comment 03:	**Concern about the First Group trains being overtaken in the southbound direction in Option ID 7.**
CH2M Comments:	ORR has requested a sensitivity test on option 9 (against a base of VTEC full, option 8) with the overtaking manoeuvres removed. This is Option 15. ORR has not requested a sensitivity test of the First Group Option against the IEP base with the overtaking manoeuvre removed.
Action Taken:	As above

7.3 First Group – East Coast Trains Limited (FGOA)

FGOA Comment 01:	**Concern that in the First Group sensitivity test (Option ID 15), First Group services overtake VTEC services in the southbound direction.**
CH2M Comments:	Agreed that this is different to First's timetable submitted to support its access rights application.
Action Taken:	First services re-timed to depart Edinburgh 11-15 minutes later. This allows the Southbound First Group services to be flighted behind the fast VTEC trains, so matches First's submission in all aspects other than the removal of the overtaking move.

FGOA Comment 02:	**Observation that if First Group journey times are reduced, all relevant modelling elements must be updated.**
CH2M Comments:	CH2M can confirm that all relevant modelling elements will be updated should journey times be altered.
Action Taken:	None.

FGOA Comment 03:	**Observation that the First Group sensitivity test (Option ID 15) is a "modelling construct" and could not be delivered operationally in its current form.**
CH2M Comments:	CH2M acknowledge this. The timetables in our analysis are not, necessarily, operable.
Action Taken:	None.

FGOA Comment 04:	**Concern that the CH2M HILL IEP base does not include services in VTEC's interim applications.**
CH2M Comments:	Quantum by location is the same or higher in the long term application. Current approach is by instruction from ORR.
Action Taken:	None.

FGOA Comment 05:	**Concern that the removal of Middlesbrough trains to produce the VTEC Core does not accurately reflect the May 2019 service pattern.**

CH2M Comments:	The VTEC Core is not intended to be representative of the VTEC 2019 timetable, rather an increment towards their full 2020 application.
Action Taken:	None.

Appendix C: Fares overlay

PREPARED FOR:	Office of Rail and Road
PREPARED BY:	Oliver Haycock, Chris Judge
DATE:	15th January, 2016
PROJECT NUMBER:	657135
REVISION NO.:	2.1
APPROVED BY:	Jon Clyne

1 Background

The objective of our fares overlay method is to produce more robust estimates of the impact on demand and revenue of changes in fares, particularly in response to fares strategies from new entrants. Our approach is consistent with PDFH 5.1.

The demand and revenue projections from the MOIRA analysis are scaled to estimate the impact of operators' fares strategies. An overlay is necessary as MOIRA does not have the functionality to assess the impact of fares on demand and revenue.

The scaling of journeys and revenue undertaken in this overlay includes both the impact of the applicant offering a reduction in fares versus the current offer, and any reduction in fares from the incumbent operator, in response.

2 Approach taken

2.1 Market segmentation

Prior to the application of the fares overlays, fares data [provided by applicants] is segmented by:

- flow group;
- by journey purpose (i.e. business, leisure); and
- by day of week (i.e. weekday, Saturday, Sunday).

This segmentation enables us to:

- model fares strategies at a level that TOCs are likely to target in reality;
- model the differences in the behavior of the various types of passengers on the route; and
- limit the number of segments to a manageable number.

Our segmentation was developed using Lennon ticket sales data for ECML operators, and National Passenger Survey data[1] (NPS). The latter enables us to estimate journey purpose by ticket type, thereby allowing the application of disaggregate PDFH5.1 (PDFH) elasticities. Table 1 below shows our estimated journey purpose by ticket type using NPS factors.

Table 1. Estimated ECML journey purpose by ticket type using NPS Factors

Ticket	Ticket Type	Journey Purpose									Total
		Weekday Business	Weekday Leisure	Weekday Commute	Saturday Business	Saturday Leisure	Saturday Commute	Sunday Business	Sunday Leisure	Sunday Commute	
First Full	1	43.7%	18.1%	15.6%	0.0%	22.5%	0.0%	0.0%	0.0%	0.0%	100%
First Reduced	2	29.3%	21.6%	3.0%	0.0%	0.0%	0.0%	2.6%	43.6%	0.0%	100%
First Seasons	3	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
First Advance	4	31.0%	40.2%	5.6%	1.2%	5.5%	0.7%	0.0%	15.8%	0.0%	100%
Standard Full	5	44.5%	30.1%	13.5%	0.0%	3.8%	0.0%	0.0%	7.1%	1.0%	100%
Standard Reduced	6	31.3%	34.9%	5.1%	1.9%	14.3%	0.0%	1.6%	10.0%	0.8%	100%
Standard Seasons	7	11.7%	0.0%	85.8%	0.0%	2.5%	0.0%	0.0%	0.0%	0.0%	100%
Standard Advance	8	28.3%	38.3%	7.4%	1.5%	11.0%	0.0%	0.3%	12.8%	0.3%	100%
Other	9	31.8%	34.5%	9.8%	1.2%	9.6%	0.1%	0.6%	12.0%	0.5%	100%

2.2 Revenue reallocation (Market Share)

The first stage of the fares overlay reassigns revenue between Train Operating Companies (TOCs) through the application of the standard LOGIT function using the formula illustrated below, as recommended in PDFH[2]. The same methodology was used by MVA in their 2009 ECML capacity study[3]. We used the MVA spread parameter of 0.04, which they calibrated using Grand Central data for York flows. The formula was applied to each modelled flow.

S = Market Share from MOIRA
S^1 = New Market Share
d = Fare Differential (between the incumbent TOC and the new entrant)
λ = Spread Parameter

$$S^1 = \frac{1}{1 + e^{-\lambda d}\left(\frac{1}{S} - 1\right)}$$

2.3 Market growth estimate

The second stage of the fares overlay estimates growth in total journeys and revenue as a result of a reduction in average fares. PDFH fares elasticities are used to produce these estimates.

A key assumption in this calculation is that the percentage increase in total journeys calculated using the fares elasticity is applied to journeys for all operators serving the flow in question. I.e. a reduction in fares reduces the average fare for the whole choice set facing passengers, rather than for individual choices within these sets. This is our understanding of how the elasticities in PDFH should be applied, and is the

1 http://www.npsreporting.co.uk/ - Spring'15 Wave 32
2 PDFH 5.1, Section B11.4
3 MVA, 2009, "Assessment of Alternative Track Access Applications on the East Coast Mainline", report for the Office of Rail Regulation

only assumption which returns a revenue change of zero with a fares elasticity of -1.0[4]. Our combined fares overlay replicates the worked example in PDFH section B11.4.

2.4 In scope market segments

We apply the fares overlay to the subsets of journeys by ticket type that we expect each of the options to serve.

To do this we:

- exclude journeys for any class of travel not offered by the applicants; and
- pro-rata the number of full fare (walk up) and seasons journeys in our analysis by examining the current profile of journeys per day and calculating the proportion of journeys made when services in the respective options would operate.

The above approach therefore assumes all but advanced purchase passengers are willing or able to significantly alter their travel time and/or product choice to take advantage of cheaper fares.

Table 2 below shows our in scope proportions of journeys for the options considered:

Table 2. In scope market segments for the fares overlay

	Ticket type								
Option	**First Full**	**First Reduced**	**First Seasons**	**First Advance**	**Standard Full**	**Standard Reduced**	**Standard Seasons**	**Standard Advance**	**Other**
Alliance Yorks/Cleethorpes (option 1)	60%	100%	60%	100%	60%	100%	60%	100%	0%
First London – Edinburgh (options 7, 9, 15)	0%	0%	0%	0%	21%	100%	0%	100%	0%
Other options	100%	100%	100%	100%	100%	100%	100%	100%	100%

2.5 Competitive response

The above framework allows us to test fares changes made by more than one operator, to assess the potentially significant impact of a competitive fares response.

2.4.1 VTEC responding to other applicants

When assessing VTEC's competitive response to lower fares offered by either Alliance or First, we assume that VTEC would increase the availability of operator-specific tickets sold at the same price offered by these operators.

[4] Economic theory states that when the demand elasticity with respect to price is -1, a change in price should not result in a change in revenue.

We assume that the number of these additional discounted tickets made available by VTEC is equivalent to the number of spare seats at the critical load point[5] for trains that depart King's Cross or the relevant northern terminus immediately before or after an Alliance or First service. We only consider VTEC services to/from the same locations as served by the other applicants.

We use estimated future train loads from our crowding model to understand the number of spare seats on the relevant VTEC trains, and to therefore estimate the number of additional operator-specific tickets made available.

The new VTEC fare is therefore calculated as follows:

New VTEC fare =

((open access fare x empty seats) + ((option journeys – empty seats) x existing fare)) / (option journeys)

Where:

- Empty seats is the number of empty seats at the critical load point on the equivalent VTEC services that depart King's Cross or their northern terminus immediately before and immediately after an Alliance or First Group service. By equivalent service we mean services which serve the same main flows as the open access applicant.
- Option journeys is the forecast daily number of journeys made on VTEC's services, prior to the calculation of the competitive response. This is taken from the crowding model, to be consistent with the measure of empty seats.
- Existing fare is the modelled VTEC average fare prior to the calculation of the competitive response.

We only calculate a change in weekday fares as the crowding model is a weekday model, and we calculate the impact for the in scope market segments only

We assume that VTEC would reduce fares between a small number of locations, i.e. London – Leeds, London – Newcastle and London – Edinburgh, rather than for the full range of journeys where additional capacity is available. This is a simplification.

The above method is one reasonable means of calculating a competitive response, based on yield management principles articulated previously by several stakeholders. We are confident that this is an appropriate method, but there may also be other legitimate approaches.

2.4.4 VTEC responding to a reduced crowding on its own services

VTEC has suggested that, given sufficient future capacity, it would look to increase the availability of operator-specific tickets as a proportion of all tickets on King's Cross - Newcastle – Edinburgh services to the current level available for King's Cross – Leeds services. Options 3 and 8 both involve an increase in train capacity between these locations.

We assume that (as above) the number of these discounted tickets made available by VTEC is equivalent to the increase in the number of unoccupied seats on these services.

We use the crowding model to estimate how many additional unoccupied seats would be available.

[5] The busiest point on each train's journey

3 Implications for the Not Primarily Abstractive (NPA) Test

3.1 Worked examples

Worked examples are provided below to show the impact that a reduction in fares can have on the NPA test.

Figure 1 below shows the worked example from PDFH section B11.4. We have replaced the £25 average fares from the PDFH example with a £50 average fare, which is more reflective of the typical incumbent fares modelled in our analysis. The worked example implies a decrease in the NPA ratio assuming an elasticity of -1.0 and a 20% discount on fares offered by a new operator.

Figure 2 shows the same worked example with a larger elasticity of -1.25. This is the PDFH fares elasticity for leisure travel between London and areas outside of the South East. Use of this larger elasticity results in a small increase in the NPA ratio.

The impact of the incumbent operator competing through a reduction in fares is a sizeable further increase in the NPA ratio. This can be seen in figure 3.

4 Further issues

4.1 PDFH spread parameter

We have discussed in detail with ORR's independent auditors Systra, whether the PDFH spread parameter of 0.04 is appropriate in this context.

One concern was that the parameter was estimated some time ago, and a combination of this parameter with recent PDFH elasticities may lead to an absurd result. This is specifically where a reduction in the incumbent's fares in response to a new entrant, increases the new entrant's market share. Having reviewed this thoroughly we are confident that, given the current and proposed fares relating to the various options, this absurdity has not occurred in our revenue projections.

A further concern was that this parameter is based on data collected a number of years' ago. Re-estimating this parameter using more recent data was not included in our terms of reference from ORR. However, we understand that ORR has commissioned consultants Leigh Fisher to review the recent and historical impact of fares competition. ORR has informed us that initial spread parameter estimates from this study are similar or slightly smaller than the PDFH value.

A small reduction in this value would reduce the level of revenue reallocation between operators as a result of fares reductions, increasing industry revenue generation slightly with no competitive response, and reducing generation slightly with a competitive response.

Given the above it is our view that the current PDFH spread parameter of 0.04 represents the best available evidence, and is appropriate for the purposes of this study.

4.2 Journey purpose

Under the above methodology, a fares elasticity for the market in question of greater than -1.0 in absolute terms, will tend to result in net industry revenue generation when fares are reduced. As discussed above, our fares analysis is segmented by geography and journey purpose. PDFH fares elasticities for leisure passengers tend to be greater than -1.0 in absolute terms, and less than -1.0 in absolute terms for commuters and business passengers.

We estimate that just over half of total ECML long distance revenue relates to leisure travel, which suggests that a reduction in fares is likely to result in net revenue generation. Clearly, this will depend on the characteristics of the individual markets that would be served by the various options considered in this study.

4.3 WebTAG

As stated in this report and in our October 2015 methodology report, and consistent with our wider modelling approach, we have used fares elasticities from PDFH version 5.1.

DfT rail appraisal guidance (November 2014 version, unit A5.3) advocates using PDFH version 5.1 as the source of various elasticities but does not refer directly to fares elasticities. Its appraisal guidance on forecasting and uncertainty (unit M4) states that rail fares elasticities should come from PDFH version 4.0.

We are not aware of the rationale for using evidence from PDFH version 4.0 (published in 2002), instead of the more recent evidence from PDFH version 5.1 (published in 2013). Having discussed this with ORR and the external review team (Systra), we continue to think it is appropriate to use the more up to date evidence in our assessment of the applications. We have received no comments from stakeholders concerning this point.

Figure 1. Worked example: 20% new entrant fares discount, fares elasticity of -1.0, no competitive response

STEP 1 - RESULTS FROM MOIRA (assuming no fares differential - MOIRA does not model fares)

Incumbent Operator Journeys	Incumbent Operator Revenue (A)	Total Market Journeys (Following introduction of New Entrant)	Total Market Revenue (Following introduction of New Entrant) (B)	New Entrant Market Share indicated by MOIRA	Incumbent Operator New Journeys	Incumbent Operator New Revenue (C)	New Entrant Journeys	New Entrant Revenue	NPA ((B-A)/(A-C))
20	£ 1,000	21	£ 1,050	15%	17.9	£ 893	3.2	£ 158	0.47

STEP 2 - Market Share Calculation (PDFH 5.1 B11.4)

Incumbent Operator Fare	New Entrant Fare	New Entrant Market Share (MOIRA)	Spread Parameter	Adjusted Market Share (Journeys) *(LOGIT)*
£ 50.00	£ 40.00	15.0%	0.04	20.8%

STEP 3 - Applied Market Share Calculation (PDFH 5.1 B11.4)

Incumbent Operator Journeys	Incumbent Operator Revenue	Total Market Journeys (Following introduction of New Entrant)	Total Market Revenue (Following introduction of New Entrant) (D)	New Entrant Market Share (Journeys) (LOGIT)	Incumbent Operator New Journeys (Post Market Share Adjustment)	Incumbent Operator New Revenue (Post Market Share Adjustment) (E)	New Entrant Journeys (Post Market Share Adjustment)	New Entrant Revenue (Post Market Share Adjustment)	NPA ((D-A)/(A-E))
20	£ 1,000	21	£ 1,006	20.8%	16.6	£ 831	4.4	£ 175	0.04

STEP 4 - TOTAL MARKET GROWTH

New Average Fare	Elasticity	Journeys Growth	New Journeys	Incumbent Operator New Journeys	Incumbent Operator New Revenue (F)	New Entrant Journeys	New Entrant Revenue	Total Market Revenue (G)	NPA ((G-A)/(A-F))
£ 47.92	-1.00	4.3%	21.9	17.3	£ 867	4.6	£ 183	£ 1,050	0.38

Figure 2. Worked example: 20% new entrant fares discount, fares elasticity of -1.25, no competitive response

STEP 1 - RESULTS FROM MOIRA (assuming no fares differential - MOIRA does not model fares)

	A		B			C			(B-A)/(A-C)
Incumbent Operator Journeys	**Incumbent Operator Revenue**	**Total Market Journeys (Following introduction of New Entrant)**	**Total Market Revenue (Following introduction of New Entrant)**	**New Entrant Market Share indicated by MOIRA**	**Incumbent Operator New Journeys**	**Incumbent Operator New Revenue**	**New Entrant Journeys**	**New Entrant Revenue**	**NPA**
20	£ 1,000	21	£ 1,050	15%	17.9	£ 893	3.2	£ 158	0.47

STEP 2 - Market Share Calculation (PDFH 5.1 B11.4)

Incumbent Operator Fare	**New Entrant Fare**	**New Entrant Market Share (MOIRA)**	**Spread Parameter**	**Adjusted Market Share (Journeys) *(LOGIT)***
£ 50.00	£ 40.00	15.0%	0.04	20.8%

STEP 3 - Applied Market Share Calculation (PDFH 5.1 B11.4)

			D			E			(D-A)/(A-E)
Incumbent Operator Journeys	**Incumbent Operator Revenue**	**Total Market Journeys (Following introduction of New Entrant)**	**Total Market Revenue (Following introduction of New Entrant)**	**New Entrant Market Share (Journeys) (LOGIT)**	**Incumbent Operator New Journeys (Post Market Share Adjustment)**	**Incumbent Operator New Revenue (Post Market Share Adjustment)**	**New Entrant Journeys (Post Market Share Adjustment)**	**New Entrant Revenue (Post Market Share Adjustment)**	**NPA**
20	£ 1,000	21	£ 1,006	20.8%	16.6	£ 831	4.4	£ 175	0.04

STEP 4 - TOTAL MARKET GROWTH

					F			G	(G-A)/(A-F)
New Average Fare	**Elasticity**	**Journeys Growth**	**New Journeys**	**Incumbent Operator New Journeys**	**Incumbent Operator New Revenue**	**New Entrant Journeys**	**New Entrant Revenue**	**Total Market Revenue**	**NPA**
£ 47.92	-1.25	5.5%	22.1	17.5	£ 877	4.6	£ 185	£ 1,061	0.50

Figure 3. Worked example: 20% new entrant fares discount, fares elasticity of -1.25, competitive response of 10% fares discount

STEP 1 - RESULTS FROM MOIRA (assuming no fares differential - MOIRA does not model fares)

Incumbent Operator Journeys	Incumbent Operator Revenue (A)	Total Market Journeys (Following introduction of New Entrant)	Total Market Revenue (Following introduction of New Entrant) (B)	New Entrant Market Share indicated by MOIRA	Incumbent Operator New Journeys	Incumbent Operator New Revenue (C)	New Entrant Journeys	New Entrant Revenue	NPA (B-A)/(A-C)
20	£ 1,000	21	£ 1,050	15%	17.9	£ 893	3.2	£ 158	0.47

STEP 2 - Market Share Calculation with Competitive Response (PDFH 5.1 B11.4)

Incumbent Operator Fare (With Competitive Response)	New Entrant Fare	New Entrant Market Share (MOIRA)	Spread Parameter	Adjusted Market Share *(LOGIT)*
£ 45.00	£ 40.00	15.0%	0.04	17.7%

STEP 3 - Applied Market Share Calculation with Competitive Response (PDFH 5.1 B11.4)

Incumbent Operator Journeys	Incumbent Operator Revenue (D)	Total Market Journeys (Following introduction of New Entrant)	Total Market Revenue (Following introduction of New Entrant)	New Entrant Market Share (Journeys) (LOGIT) (E)	Incumbent Operator New Journeys (Post Market Share Adjustment)	Incumbent Operator New Revenue (Post Market Share Adjustment)	New Entrant Journeys (Post Market Share Adjustment) (D-A)/(A-E)	New Entrant Revenue (Post Market Share Adjustment)	NPA
20	£ 1,000	21	£ 926	17.7%	17.3	£ 777	3.7	£ 149	-0.33

STEP 4 - TOTAL MARKET GROWTH

New Average Yield	Elasticity	Market Growth	New Journeys	Incumbent Operator New Journeys	Incumbent Operator New Revenue (F)	New Entrant Journeys	New Entrant Revenue	Total Market Revenue (G)	NPA (G-A)/(A-F)
£ 44.11	-1.25	16.9%	24.6	20.2	£ 909	4.4	£ 174	£ 1,083	0.92

TECHNICAL MEMORANDUM

Appendix D: Air Competition Overlay

PREPARED FOR:	Office of Rail and Road
PREPARED BY:	Chris Judge, Oliver Haycock
DATE:	January 15th, 2016
PROJECT NUMBER:	657135
REVISION NO.:	2.0
APPROVED BY:	Jon Clyne

1. Background

The first two stages of the forecasting process described in appendices B and C use elasticities published in PDFH5.1 to estimate the impact of changes in GJT and fares on rail demand and revenue.

However, as most flows in Great Britain do not have any air competition, we are concerned that use of PDFH elasticities may understate the potential impact of a reduction in GJT or fares on flows that compete with air.

We therefore use an air competition overlay to re-estimate journeys and revenue for flows where air competition is present.

This appendix describes the air competition overlay, which is applied in two parts:

- The first part estimates the demand and revenue impact of a reduction in rail journey times following the introduction of services which compete with air. PDFH5.1 (PDFH) suggests that journey time, rather than GJT, can be used to predict rail demand in this case.
- The second part estimates the demand and revenue impact of a reduction in rail fares.

2. Relevant options and flows

2.1 In scope flows

Two main domestic air routes compete with ECML rail services, namely London - Edinburgh and London – Newcastle.

Reductions in Edinburgh/Newcastle rail journey times and/or rail fares would therefore have the potential to attract air passengers on these routes, providing that these passengers are travelling to/from areas that are within the catchment areas for both air and rail terminals.

We examined Civil Aviation Authority (CAA) data to estimate the catchment area for Edinburgh Airport, Newcastle Airport, and also for all London Airports. We do not have access to equivalent data for rail travel, so assume that the relevant airport catchment populations are also shared by long distance rail. This enabled us to identify all ECML rail flows which compete with air.

Figures 1 and 2 show our estimated shared catchment areas for Edinburgh and for Newcastle. All rail flows between these catchment areas and the catchment for London airports are assumed to be in scope. CAA data was combined with MOIRA data to estimate the total size of the domestic air and rail market. In addition, we used a combination of CAA data and NPS data to segment by journey purpose. This information is presented below in table 1.

Table 1. Combined air and rail market (ECML corridor), split by journey purpose

Station		**Edinburgh – London**			**Newcastle - London**		
		Rail*	Air**	Total	Rail*	Air**	Total
Journeys	Business	345,162	1,044,276	1,389,439	1,009,765	110,597	1,120,362
	Leisure	1,066,201	935,743	2,001,943	536,647	100,393	637,040
	Interlining***	0	1,002,221	1,002,221	0	351,556	351,556
	Total	**1,411,363**	**2,982,240**	**4,393,603**	**1,546,412**	**562,546**	**2,108,958**
% of total	Business	24.8%	75.2%	100%	90.1%	9.9%	100%
	Leisure	53.3%	46.7%	100%	84.2%	15.8%	100%
	Interlining***	0.0%	100.0%	100%	0.0%	100.0%	100%
	Total	**32.1%**	**67.9%**	**100%**	**73.3%**	**26.7%**	**100%**
	Total (excl. interlining)	41.6%	58.4%	100%	88.0%	12.0%	100%

* 2013/14 MOIRA data, ** 2013 CAA data, *** travelling to/from connecting flights

2.2 In scope options

The following options are likely to result in a reduction in either journey times or fares for the flows described above.

- Alliance Edinburgh (Option 2)
- VTEC Core (Option 3)
- VTEC Middlesbrough (Option 6)
- First Edinburgh (Option 7)
- VTEC Full (Option 8)
- First Edinburgh as submitted (Option 9)
- VTEC Core & Alliance Yorks./ Cleethorpes (Option 10)
- Alliance Edinburgh non-tilt (Option 11)
- First Edinburgh no overtake (Option 15)

The Sensitivity tests termed; VTEC Middlesbrough offset (Option 12), VTEC Middlesbrough switch (Option 13), and VTEC Full no overtake (Option 14) are only tested in MOIRA as the purpose of these tests is to understand the impact on current open access revenue.

Figure 1 Edinburgh air/rail catchment area

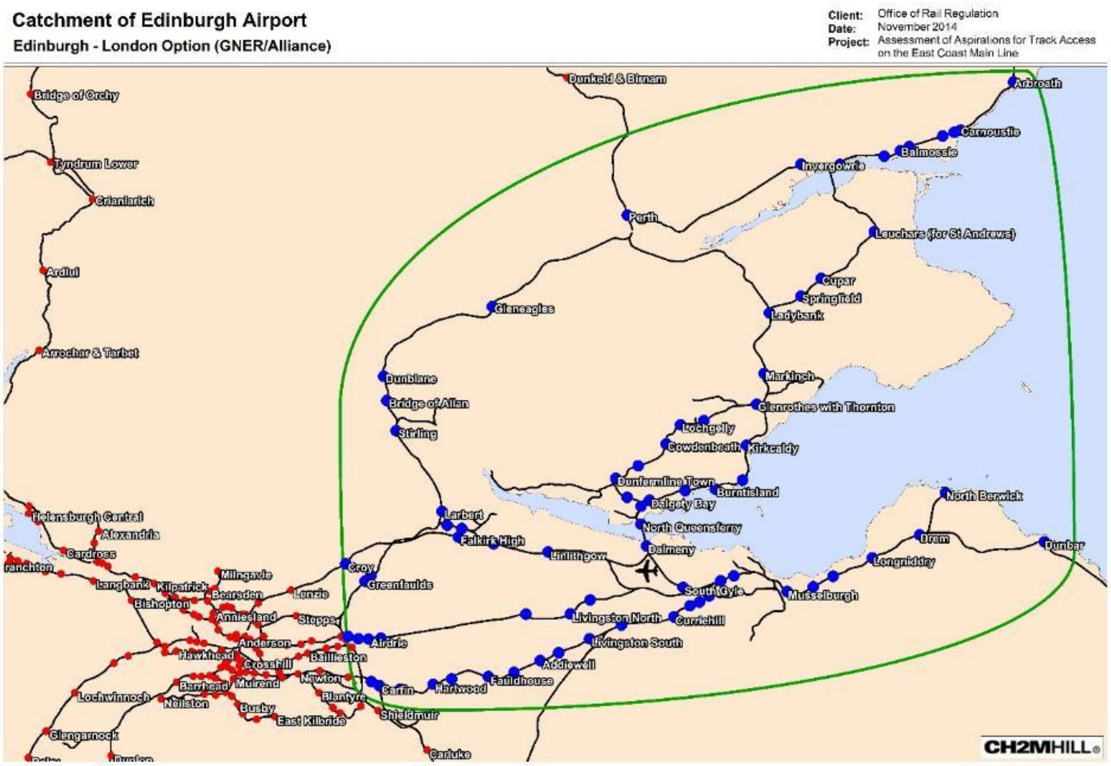
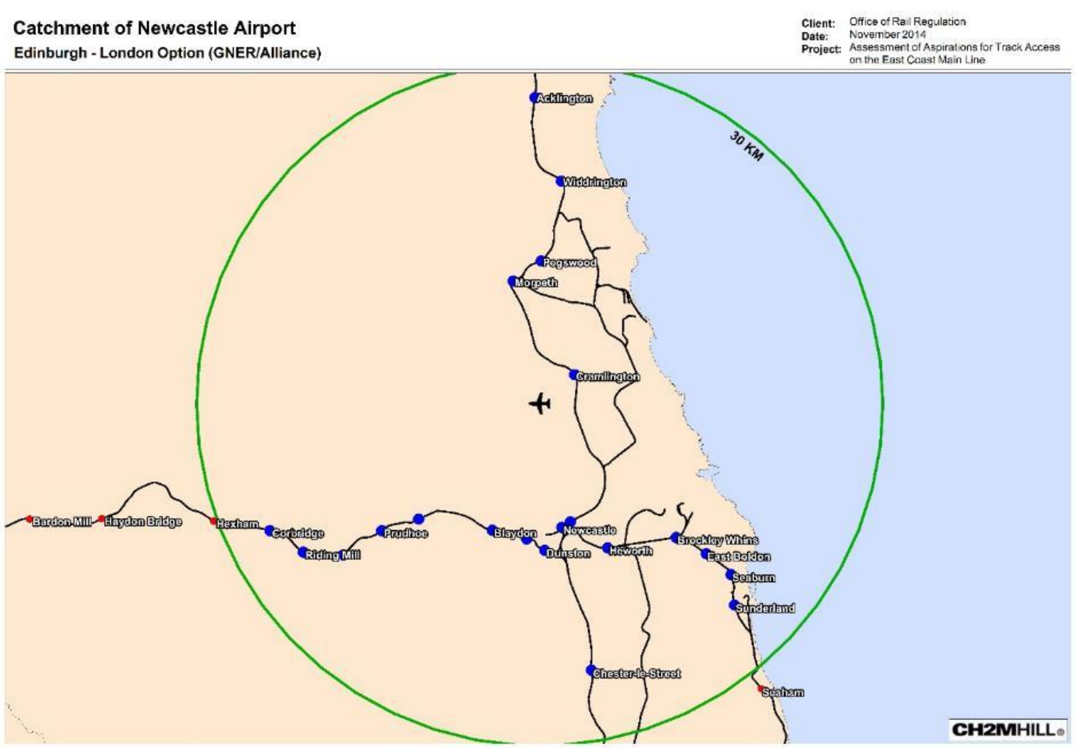


Figure 2 Newcastle air/rail catchment area



3. Journey time overlay

3.1 Overview

This stage of the assessment re-estimates rail journeys and revenue, following a reduction in air-competitive rail journey times when new services are introduced.

The PDFH[1] relationship between the journey time by rail and rail's share of the total rail and air market is reproduced and used to forecast total rail journeys following a reduction in journey times on routes where air/rail competition occurs. This relationship is an S-curve, showing rail's share of the total rail and air market given the journey time by rail. The function was estimated using data from across Europe, and does not split the market for travel by journey purpose.

We estimate the change in rail demand as follows:

- Calculate rail journey times for each option and in the relevant base timetable, for King's Cross – Edinburgh and for King's Cross – Newcastle. Our definition[2] of rail journey time is the average of the fastest service each hour departing between 08:00 and 17:59. Timings are in the down direction, taken from the MOIRA files for the relevant weekday option and base timetables. – We assume that passengers consider journey times for the fastest rail service each hour when deciding whether to travel by rail or by air. Selecting the time period of 08:00 – 17:59 is a modelling simplification and does not materially affect the results. Table 2 below shows estimated journey times for the relevant option and base timetables.
- Calculate the percentage change in rail mode share for each option and base timetable, using the PDFH S-curve (section B2).
- Apply the percentage change calculated above to the current rail journeys, from table 1. This produces an estimate of the total London – Edinburgh and London – Newcastle Rail market for each option and base timetable. These estimates are capped so the new rail market cannot exceed the combined rail and air market exclusive of interlining.
- Apply the percentage change in journeys from above, between the option and the relevant base timetable, to all relevant flows in the revenue model. So the percentage change for London - Edinburgh is applied to all flows between the London and Edinburgh catchments described in section 2.

  This final step allows us to apply the percentage to our 2020 demand matrix for all relevant flows. We assume the same level of exogenous growth in air and rail travel to 2020.

  The estimated growth is capped so that the implied GJT elasticity at a flow level is no larger than -3.5. This is the highest elasticity that we have seen estimated in other work for the purposes of forecasting rail demand where air competition is present.

Table 2 below shows estimated journey times for the relevant options and base timetables, and figure 1 shows a worked example of how the process described above is used to forecast demand.

[1] PDFH5.1, section 2,8

[2] As PDFH does not state how journey times are calculated we have made assumptions about passengers' perceptions of the choice of services available. Some of these assumptions, e.g. the time of travel are also intended to simplify the analysis in an appropriate manner.

Table 2. Journey time in minutes, fastest hourly service, northbound, weekdays, departing 08:00-17:59

Base	Option	London – Edinburgh*		London – Newcastle*	
		Journey time (base)	Journey time (option)	Journey time (base)	Journey time (option)
IEP base	Alliance Edinburgh (option 2)	255	223	165	148
IEP base	VTEC Core (option 3)	255	243	165	158
VTEC core (option 3)	VTEC Middlesbrough (option 6)	242	241	158	157
IEP base	*First Edinburgh (option 7)*	*255*	*255*	*165*	*165*
IEP base	VTEC Full (option 8)	255	241	165	157
VTEC full (option 8)	*First Edinburgh as submitted (option 9)*	*241*	*241*	*157*	*157*
IEP base	VTEC Core & Alliance Yorks./ Cleethorpes (option 10)	255	243	165	158
IEP base	Alliance Edinburgh non-tilt (option 11)	255	239	165	154
VTEC full (option 8)	*First Edinburgh no overtake (option 12)*	*241*	*241*	*157*	*157*

*Figures are rounded to the nearest whole minute, italic text indicates no journey time saving versus the base. **Figures may not match the journey times presented in the main report which are in some cases an average of fast and stopping services, and also cover different time periods.** Following further quality assurance work, **s**ome figures in this table have changed by one minute from the same table in the interim phase 2 report.

3.2 Impact on the size of the combined air and rail market

Our interim phase 2 report acknowledged that a limitation of the approach is the assumption of a fixed combined air and rail market, whereas in reality improvements in rail journey time can generate additional demand.

We discussed with ORR's external auditors whether it is possible to estimate the impact on the total air and rail market in a way that is consistent with PDFH, and hence the above approach. We concluded that this is possible, and we adjusted our approach as follows.

Definition of terms:

R_0 , R_1 are rail demand Do Min and Do Something

A_0, A_1 are air demand Do Min and Do Something

S_0, S_1 are rail share of rail plus air market Do Min and Do Something

t_0, t_1 are rail journey time Do Min and Do Something (in-vehicle time (IVT) only)

η is elasticity of rail journeys to rail time taken from PDFHv5.1, adjusted to only IVT. This is calculated as (GJT elasticity) x (IVT/GJT).

The following relationship holds:

$$S_i = R_i / (R_i + A_i)$$

This can be manipulated to:

$$R_i = S_i R_i + S_i A_i \quad \text{or}$$

$$A_i = R_i (1 - S_i) / S_i \qquad (1)$$

In the absence of air competition, $R_1 = R_0 (t_1/t_0)^\eta$

There is a risk that this equation may slightly overstate the combined air and rail market increase as a few, rather than no, air competitive flows are likely to have been included in the calibration of PDFH elasticities. However, we are confident that this potential overstatement would be immaterial to the overall forecasts.

So with air competition:

$$R_1 = R_0 (t_1/t_0)^\eta + A_0 - A_1$$

I.e. equals the normal impact plus abstraction from air. In reality this risks a small over estimate, as a few (rather than zero) air competitive flows are likely to have been included in the calibration of PDFH elasticities, however we judge the impact of this risk to be extremely small.

Substituting from equation (1):

$R_1 = R_0 (t_1/t_0)^\eta + (R_0 (1 - S_0) / S_0) - (R_1 (1 - S_1) / S_1)$, which can be manipulated to:

$$R_1 (1 + (1 - S_1) / S_1) = R_0 (((1 - S_0) / S_0) + (t_1/t_0)^\eta))$$

$$R_1 (1 / S_1) = R_0 (((1 - S_0) / S_0) + (t_1/t_0)^\eta))$$

$$R_1 = R_0 S_1 (((1 - S_0) / S_0) + (t_1/t_0)^\eta))$$

t_0, t_1 are inputs and S_0, S_1 are taken from the S curve graph.

We therefore calculate R_1 from R_0.

3.2 Worked example

A worked example is shown below for a hypothetical option which reduces London – Edinburgh journey times by 10 minutes versus the IEP base.

Figure 2. Air uplift overlay (part 1, journey times) worked example[3]

London - Edinburgh worked example

	A	**B**	**C**	**D**
	Rail journeys	Air journeys	Total journeys	Elasticity to IVT
Current	1,411,363	2,982,240	4,393,603	-1.2
	E	**F**	**G**	
	Rail mode share (actual)	Rail journey time (mins)	PDFH Rail mode share	
Current	32.1%	262	32.2%	
	H = C*G	**I = C-H**		
	PDFH Rail journeys	PDFH Air journeys		
Current	1,416,205	2,977,399		
	J	**K**	**L**	
	Rail Journey Time (mins)	PDFH Rail Mode Share	PDFH Air Mode Share	
IEP base	255	35.5%	64.5%	
	M = H*K*((1-G)/G+(J/F)^D)	**N = (M*L/K)**		
	PDFH Rail Journeys	PDFH Air Journeys		
IEP base	1,576,328	2,864,033		
	O = (M-H)+A	**P = (N-I)+B**		
	Adjusted Rail Journeys	Adjusted Air Journeys		
IEP base	1,571,487	2,868,874		
	Q	**R**	**S**	
	Rail Journey Time (mins)	PDFH Rail Mode Share	PDFH Air Mode Share	
Option	245	40.8%	59.2%	
	T = O*R*((1-K)/K+(Q/J)^D)	**U**		
	Rail Journeys	Air Journeys		
Option	1,839,121	2,664,849		
	V = (T-H)+A	**W = (U-I)+B**		**X = (V/O)-1**
	Adjusted Rail Journeys	Adjusted Air Journeys		Demand uplift
Option	1,834,280	2,669,691		16.7%

X is then applied to all relevant flows in the revenue model (base matrix), with flow level uplift not permitted to exceed an implied GJT elasticity of -3.5

[3] The option journey time included in this table in the phase 2 interim report was incorrect. This was identified in quality assurance checks for this final report, and has been corrected.

4. Fares Overlay

4.1 Approach

This stage of the assessment re-estimates rail journeys and revenue, following a reduction in air-competitive rail fares when new services are introduced.

We prefer the above approach to development of a multi-modal model, as the former draws on potential analogies from elsewhere in Europe when forecasting the potential modal share. Whereas, the latter requires calibration to current mode shares, which would be likely to change significantly following the introduction of several of the options. However, PDFH and other research publications contain too few analogies from elsewhere to enable this type of assessment of fares competition between rail and air.

The estimate is therefore undertaken through use of a binomial logit model which allocates demand to either rail or air based on the estimated Generalised Journey Cost (GJC) for each mode, split into the constituent elements.

The component parts of GJC included in the model are listed below, along with the source of this information:

- Journey times for air and for rail (MOIRA)
- Headway penalties for air and for rail (estimated based on MOIRA)
- Wait times for air and for rail (assumed as 60 minutes for air and estimated based on MOIRA for rail)
- Access/egress times for air and for rail (drive time software and MOIRA)
- Fares for rail and for air, split by journey purpose (airline websites and Lennon)
- Car parking charges for air (airport websites)
- A mode specific constant for air, for model calibration purposes.

Spread parameters are also included to reflect the range of GJCs faced by individual passengers, and randomness in travel patterns (e.g. some people don't like flying so would never choose to travel by air regardless of the relative GJC). These parameters are used to calibrate the model to replicate existing air/rail mode shares using the data summarised in section 2.

The model is segmented by:

- Market (London – Edinburgh, London – Newcastle)
- Direction of travel (as access charges and times vary by direction of travel)
- Journey purpose (business or leisure)
- Day of week (weekday, Saturday, Sunday).

Mode shares, hence total journeys and revenue, are estimated by adjusting only the rail fares component of generalised cost, with values for all other elements of GJC the same in the base and the forecast. This means that there is no overlap with the previous air market overlay.

Similarly to the previous overlay the logit function produces a percentage demand uplift for London-Edinburgh and for London-Newcastle, which is applied to all in scope flows.

As previously, the demand uplift is capped so that the estimated rail market size cannot exceed the total rail and air market size, excluding interlining journeys.

Unlike the air/rail journey time overlay, this cap is applied separately for the business market and for the leisure market, as business and leisure users may be attracted by different types of fares.

Finally, we use the same approach described in section 3.2 to estimate growth in the combined rail and air market as a result of a reduction in rail fares. In this approach we use the same equations, substituting IVT elasticities with PDFH5.1 fares elasticities.

4.2 Relevant options

The fares overlay described above is applied to options which we expect to result in a reduction in rail fares which compete with air fares. Having reviewed the information received in support of the various applications we believe that a number of the options have the potential to result in a fares reduction of this nature.

These options are listed below, **however, the relevant fares for these options have yet to be validated using our crowding model** (see section 3 of the interim report). This means that it is not yet possible to show our estimated change in the relevant fares, which we expect to occur as a result of the introduction of new services.

In general we understand that current rail fares tend to compete on price with the fares charged by traditional air carriers such as British Airways, and that low cost carriers such as Easyjet and Ryanair offer a significant discount versus rail. We also understand that the current supply of operator-specific, advanced rail tickets is limited due to a lack of on-train capacity, although we intend to test this using the crowding model and PDFH-based fares overlay (see section 3 of the main report).

Each of the applicants has indicated to ORR that their respective options for additional Edinburgh – London services will offer fares which compete with air. Given the above, this could be achieved through a reduction in the price of individual types of fares. This could also potentially be achieved through an increase in the availability of advanced tickets providing that equivalently priced airline tickets weren’t also limited in supply.

We provide a brief review of the evidence provided by the applicants below:

- Alliance Edinburgh (Option 2) – Fares data supplied by Alliance suggests that average yield, and the price of individual types of fares will be broadly equivalent to the current situation. Therefore, the only means of competing on fares with the airlines would be through an increase in the availability of advanced fares. We expect this potential to be limited as it does not appear that Alliance is proposing to lower the average fare for any of the various market segments, however we will investigate this thoroughly when producing our revenue assessments.
- VTEC Core (Option 3). VTEC has not supplied its proposed future fares, or future fares strategy. However, VTEC has indicated that it would be likely to increase the availability of advanced fares enabled by an increase in train capacity, thereby lowering the average yield for the various market segments. As discussed in section three of the main report we will investigate this using the crowding model and fares overlay.
- VTEC Middlesbrough (Option 6) – No change as tested against a base of Option 3.
- First Edinburgh (Option 7). First Group proposes to offer significantly discounted advanced fares versus the current level, and also to offer a high number of advanced fares as a proportion of its overall ticket sales. As discussed in the main report, we will investigate this further using the crowding model and fares overlay.
- VTEC Full (Option 8). This is broadly as per Option 3.

- First Edinburgh as submitted (Option 9). As per Option 7.
- VTEC Core & Alliance Yorks. / Cleethorpes (Option 10). As per Option 3.
- Alliance Edinburgh non-tilt (Option 11). As per Option 2.
- First Edinburgh no overtake (Option 15). As per Option 7.

5. Application of the overlay

5.1 General

As described above, the percentage uplifts produced by the two overlays are applied at a flow level, replacing the forecast for these flows produced using the MOIRA and PDFH fares overlay described in appendix C.

We assume that the difference between the forecast produced using the air uplift overlays and the forecast produced using MOIRA and the PDFH fares overlay, is newly generated demand/revenue to rail, as a result of abstraction from the air market. Therefore:

- If MOIRA plus the fares overlay forecasts a newly generated number of journeys equal to X, and the air market overlay forecasts a number equal to Y, then abstraction from the air market is taken to be equal to Y-X

5.2 Competitive response of airlines

Airlines may respond to improvements in competing rail services, principally through lowering fares, changing service quality, reducing service frequency and/or re-deploying aircraft to serve other routes.

With respect to the journey time overlay, the modelling approach is derived from actual air / rail competition. This means that the competitive response from air is already incorporated into the modelling approach, and to consider it separately would mean erroneous double counting, as well as adopting spurious levels of accuracy.

In the case of the fares overlay, the competitive response of airlines is not incorporated into the methodology. ORR is considering this matter separately.

TECHNICAL MEMORANDUM

Appendix E: Gravity Model

PREPARED FOR:	Office of Rail and Road
PREPARED BY:	Chris Judge, Anne Pentecost
DATE:	January 15th, 2016
PROJECT NUMBER:	657135
REVISION NO.:	1.3
APPROVED BY:	Jon Clyne

1. Background

1.1 Proposed improvements to London flows with low frequency

Included within the ECML track access applications received by ORR are proposals to provide 13[1] stations which have few or no direct services to/from London, with additional direct services to/from London King's Cross. Table 1 below lists these stations.

1.2 Review of PDFH evidence

PDFH suggests that a number of factors associated with few or no direct services could dissuade people from travelling by rail, for example:

- Where GJT or journey time is above a threshold level, e.g. where day return trips are infeasible
- Where opportunities to travel do not exist, or where the quality of service, e.g. rolling stock, falls below a minimum threshold level.
- Where opportunities to travel do not exist at or close to the desired time of day, or where the quality of service, e.g. rolling stock, falls below a minimum threshold level.

PDFH acknowledges that factors of this type can cause GJT elasticities to vary from the levels reported, and suggests further research to improve our understanding of this.

The most recent PDFH study in this area, undertaken in 2012 by ITS Leeds and Mott MacDonald,[2] investigated whether GJT elasticities are affected by the size of the change in GJT. The study investigated a number of areas relevant to our current work, including testing for evidence of GJT thresholds below which there is evidence of travel suppression, and examining whether PDFH elasticities value appropriately passengers' willingness to change trains.

The study was unable to develop robust conclusions for flows which start or end in the London Travel Card Area (TCA). This is largely due to a lack of data on flows to/from London where substantial changes in GJT had occurred, thereby preventing the authors from estimating sound econometric models, or developing useful case studies. The study acknowledges this key limitation:

[1] Excluding Sunderland, Guiseley, and Ilkley which would see an improvement of only one train per day in each direction

[2] *THE IMPACT OF LARGE CHANGES IN GENERALISED JOURNEY TIME ON RAIL PASSENGER DEMAND, FINAL REPORT, May 2012, Institute for Transport Studies, University of Leeds and Mott MacDonald*

"We were unable to obtain robust models for London based flows or for season tickets. These are very important market segments for rail; indeed more important than the Non-London and non-season ticket flows here examined.

In large part this was because there were relatively few observations where the data was robust and the changes in timetable related service quality were clear-cut.

We recommend that consideration be given to analysing GJT changes not covered in this study,"[3]

The study was able to investigate non-London flows in more detail, highlighting evidence of GJT elasticities under estimating timetable related service quality changes and recommending threshold GJT values below which demand suppression was thought to have occurred. Whilst these recommendations are useful in the context of non-London flows, the study states specifically that they are unreliable for the purpose of forecasting demand to/from London:

"We note, however, that London markets and season ticket markets may respond differently and that these conclusions relate to Non-London non-season tickets." [4]

In particular, the eight case studies used to develop these recommended threshold values, included only one with London flows (High Speed 1). We view HS1 as a poor proxy for the proposed ECML services as it is a route characterised by significant commuter flows, <u>and</u> provided new fast services to an a different London terminal (St Pancras) than existing services use. – The actual GJT change for any given passenger is highly dependent on their origin/destination in London, and this information was not available in sufficient detail when the case study was produced.

The study was also able to investigate passengers' aversion or otherwise to changing trains, although, again, in largely the context of non-London flows. The study concluded that passengers view the act of changing trains as significantly more inconvenient, than the time spent changing trains. The study also suggests that passengers' unwillingness to change trains has increased over time:

"*Finally, our study has suggested a potentially important avenue of research to guide future rail planning strategy, in the form of exploring further the modern-day attitudes of passengers towards interchange. The case studies have, alongside the regression analysis, provided evidence that travellers perceive interchange much more negatively nowadays than BR-era research in PDFH assumes*."[5]

Given PDFH advice, and specifically the recent study by ITS/Mott MacDonald, we are concerned that use of PDFH5.1 (PDFH) elasticities may understate the increase in demand for travel between these newly-served stations and London following the introduction of additional direct services.

We therefore use one of the alternative approaches from PDFH to forecast demand between London and these locations. This approach is termed a direct demand model, or gravity model.

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[3] ITS Leeds/Mott MacDonald, page 6

[4] ITS Leeds/Mott MacDonald, page 5

[5] ITS Leeds/Mott MacDonald, page 7

1.2 Approach taken

PDFH (section B10) suggests several different methods to forecast demand for new services and access rights. Our preference is for a gravity model as it enables us to investigate the factors that currently determine the level of demand between existing ECML stations and London, and then to forecast future demand by applying our understanding of how these factors would change following the introduction of new services.

Using this approach we calibrate a gravity model by undertaking a least squares regression between the annual number of rail journeys and a dataset of the factors we expect to influence the number of journeys.

The remainder of this appendix explains the approach taken in more detail.

Table 1. ECML access rights applications – proposed direct services to/from King's Cross, with few or no direct services currently

Station	Return trains per weekday (current)	Return trains per weekday (current +proposed)	Option number
Cleethorpes	0	4	Option 1, Option 10
Grimsby Town	0	4	Option 1, Option 10
Habrough	0	4	Option 1, Option 10
Scunthorpe	0	4	Option 1, Option 10
Bradford FS	1 (+ 4 Bradford Interchange)	6 (+ 4 Bradford Interchange)	Option 1, Option 10
		7 (+ 4 Bradford Interchange)	Option 5, Option 8
Shipley	1	6	Option 1, Option 10
		7	Option 5, Option 8
East Leeds Parkway(new)	0	7	Option 1, Option 10
Lincoln	1	6.5	Option 4, Option 8
Harrogate	1	6	Option 4, Option 8
Horsforth	1	6	Option 4, Option 8
Middlesbrough	0	6.5	Option 6, Option 8
Morpeth	2.5	7.5	Option 7, Option 9

2. Source data

2.1 Flows included

In selecting flows on which to calibrate the gravity model, our aim was to identify the largest potential set of flows which share some characteristics with the stations for which new services are proposed.

67 flows were used to calibrate the gravity model (preferred model – see next Section), as listed in table 2. These are all flows between London and stations within the Yorkshire and the Humber, the North East, the East Midlands and the East of England regions, where the principal rail route to/from London is via the ECML. The following flows were excluded:

- Leeds and Newcastle. Namely, large cities, with a far larger population base and economic centre than the locations where new services are planned.
- York. A major rail hub and a large attractor of tourism trips, therefore unlike other ECML locations.
- Flows with fewer than 2,000 journey annually to/from London. These locations are typically lightly populated and peripheral to the core ECML route. We therefore view these locations as poor analogies to the stations where new services are planned.
- Flows between London and stations in urban and suburban Leeds, e.g. Burley Park. These stations are typically entirely within the catchment area of Leeds station, and it is not appropriate to use them in the gravity model calibration without detailed segmentation of the catchment area. Given the availability of numerous other flows, exclusion was the most efficient way to proceed.

Table 2. Gravity model calibration – flows included (to/from London)

Barnetby	Cononley	Goole	Horsforth	Menston	Saltaire	Steeton & Silsden
Barnsley	Crossflatts	Grantham	Howden	Middlesbrough	Saltburn	Sunderland
Ben Rhydding	Darlington	Grimsby Town	Huddersfield	Mirfield	Scarborough	Thirsk
Beverley	Dewsbury	Guiseley	Hull	Mytholmroyd	Scunthorpe	Thornaby
Bingley	Doncaster	Habrough	Ilkley	New Pudsey	Seamer	Todmorden
Bradford FS	Driffield	Halifax	Keighley	Newark North Gate	Selby	Wakefield W
Bridlington	Durham	Harrogate	Knaresborough	Northallerton	Shipley	Worksop
Brighouse	Eaglescliffe	Hartlepool	Lincoln Central	Pannal	Skipton	
Brough	Gainsborough BR	Hebden Bridge	Malton	Redcar Central	Sowerby Bridge	
Cleethorpes	Garforth	Hornbeam Park	Market Rasen	Retford	Starbeck	

2.2 Catchment population

We developed two catchment population datasets using Office for National Statistics (ONS) population data split by Lower Super Output Area (LSOA).

In the first dataset the catchment population for each station is grouped by radial distance from the station (e.g. 0 - 5km, 5km – 10km). This dataset is not used in phase 2 of this study. – See section 4.1 below.

In the second dataset the catchment population for each station is grouped by estimated drive time from the station. We used the QGIS and PGIS software applications in combination to estimate drive times, and assign each LSOA to a drive time zone. For densely populated areas in particular, the catchment population by drive time, is very sensitive to the location of the centre point of the LSOA. This makes is difficult to specify an inner population catchment for some locations (see section 3.2).

We assume the following road speeds, intended to represent typical driving conditions, which we have calibrated using specific local data for some of the modelled locations.

General assumptions:

- Motorway, 90kph
- A road, 60kph
- B road, 50kph
- Unspecified road, 10kph

Specific assumptions:

- The A1, 90kph
- Urban motorway (e.g. M621), 50kph
- City/town centre A road, 20kph
- City/town centre B road, 15kph
- City/town centre unspecified road, 10kph

We also assume that a 5 minutes delay occurs in the vicinity of the station area, associated with congestion accessing/egressing the station.

VTEC has shared with us confidential data on ticket sales for travel to London, for 16 of the stations that it serves. This data, which includes 12 of the 67 stations used to calibrate the model, was used to estimate the spread of station population catchments by drive time. A number of trends were identified using this analysis:

- For stations located in towns or villages, and with few or no direct services to/from London, the majority, circa 75% or more, of the catchment population is located within 15 minutes' drive of the station. A likely explanation for this is that stations of this nature don't provide frequent and or direct services to London and are so aren't worth travelling to unless passengers originate from close by.
- With one exception, for stations located in larger towns or cities, with frequent services to/from London, a smaller proportion of the catchment population, typically 20-40%, is located within 15 minutes' drive of the station. Broadly 75% of the catchment population of these stations is located within 25 minutes' drive of the station. A likely explanation for the wider catchment area than the previous type of station is that the places are geographically larger, and that the existence of good links to/from London makes the station in question a convenient point of access to the rail network, despite the access time involved. The exceptional station, which has a far less dispersed catchment, is located in a city with few direct services to London, and with high population density in the centre of the conurbation.
- Some stations have widespread catchment populations, with an area of around 35 minutes' drive from the station accounting for around 75% of the all London passengers. These stations are characterised by frequent direct services to/from London and good road transport links. They also have good road access to/from places without a railway station, or with few or no direct services to/from London. It seems likely that a combination of the frequent services to/from London, the good road links, and the geographical location of the station make these stations the most convenient point of access for a widely dispersed catchment population.

The data described above is commercially sensitive and, as yet, VTEC has not granted permission to us to present or describe this data in any more detail. However, we have independently reviewed the data and are content that it represents a reasonable sample for the purposes of our approach.

On the basis of the analysis described above, we have split the 67 stations used to calibrate the gravity model into two categories. We have used these categories to assign catchment populations by drive time. These categories and population definitions are described below.

1. Town or city, few services to London. The catchment population is defined as the population located within a 15 minute drive of the station.
2. Town or city, frequent services to London, highly accessible wider catchment. The catchment population is defined as the population located within a 35 minute drive of the station.

Table 3 below shows this categorisation. We have assigned each of the stations we intend to forecast (from table 1) to category 1, as each has few or no direct services to/from London

Table 3. Station categorisation by catchment population (stations are category 1 unless shown)

Barnetby	Cononley	Goole	Horsforth	Menston	Saltaire	Steeton & Silsden
Barnsley	Crossflatts	Grantham (2)	Howden	Middlesbrough	Saltburn	Sunderland
Ben Rhydding	Darlington (2)	Grimsby Town	Huddersfield	Mirfield	Scarborough	Thirsk
Beverley	Dewsbury	Guiseley	Hull	Mytholmroyd	Scunthorpe	Thornaby
Bingley	Doncaster (2)	Habrough	Ilkley	New Pudsey	Seamer	Todmorden
Bradford FS	Driffield	Halifax	Keighley	Newark North Gate (2)	Selby	Wakefield W (2)
Bridlington	Durham (2)	Harrogate	Knaresborough	Northallerton (2)	Shipley	Worksop
Brighouse	Eaglescliffe (2)	Hartlepool	Lincoln Central	Pannal	Skipton	
Brough	Gainsborough BR	Hebden Bridge	Malton	Redcar Central	Sowerby Bridge	
Cleethorpes	Garforth	Hornbeam Park	Market Rasen	Retford (2)	Starbeck	

2.3 Average wage

ONS data on average wages per capita by Local Authority area, is used as a proxy for the propensity of people to travel over long distances by rail. Numerous previous studies, e.g. Network Rail's Long Distance Passenger Market Study[6], have adopted a similar approach. We prefer the use of wages data to other local measures of income such as GVA, as the former is more focussed on the likely potential passengers. – Based on our understanding of current travel patterns we assume that the majority of passengers travel from home or work to London.

2.3 Generalised Journey Time (GJT)

GJT data is taken directly from MOIRA.

We have also split GJT into its constituent parts by estimating journey time, waiting time, interchange time and an interchange penalty.

[6] http://www.networkrail.co.uk/improvements/planning-policies-and-plans/long-term-planning-process/market-studies/long-distance/

3. Preferred model

3.1 Functional form and key statistics

Regression was undertaken in STATA software, to identify the statistically significant magnitude of the relationship between the above variables and annual rail journeys to/from London.

The model for flows to/from London and the South East has the following non-linear functional form. We prefer a non-linear form to a linear or log linear model as we do not believe that the relationship between rail journeys and the variables tested is linear. This is justified through graphical analysis of journeys and GJT (see figure 1), and is consistent with previous industry research. Importantly, this preferred model has a better model fit than all but one alternative, for which the population catchment data has been less rigorously tested (see section 3.2 and section 4.3). This means that our preferred model has greater and more robust forecasting ability than alternatives. We therefore use the preferred model as a key element of our approach to forecasting demand in this study.

The model takes the following form:

$$Journeys = OriginPop^{\alpha} OriginWage_{LA}^{\gamma} GJT_{OD}^{\delta}$$

Where:

- Journeys is the annual journeys made between a station and London

And where, with respect to the non- London stations:

- Origin population is as described in section 2.2
- Average wages is the average wage in the local authority area where the station is located
- GJT is the Generalised Journey Time to/from London King's Cross

Table 4 below shows the key regression statistics.

All coefficient values are of the correct sign (positive for population and wages, negative for GJT) and all variables are significant at the 95% (and 99%) confidence level, indicated by a t-statistics of greater than 1.96 in magnitude.

The adjusted R squared statistic is 0.85, indicating that the model explains 85% of the variation in the annual number of journeys. We view this as an acceptable level of model fit.

Model diagnostic tests identified the presence of heteroskedasticity. To combat this, the standard errors have been corrected to ensure they are robust against any heteroskedasticity present, using one of the correction mechanisms contained within STATA.

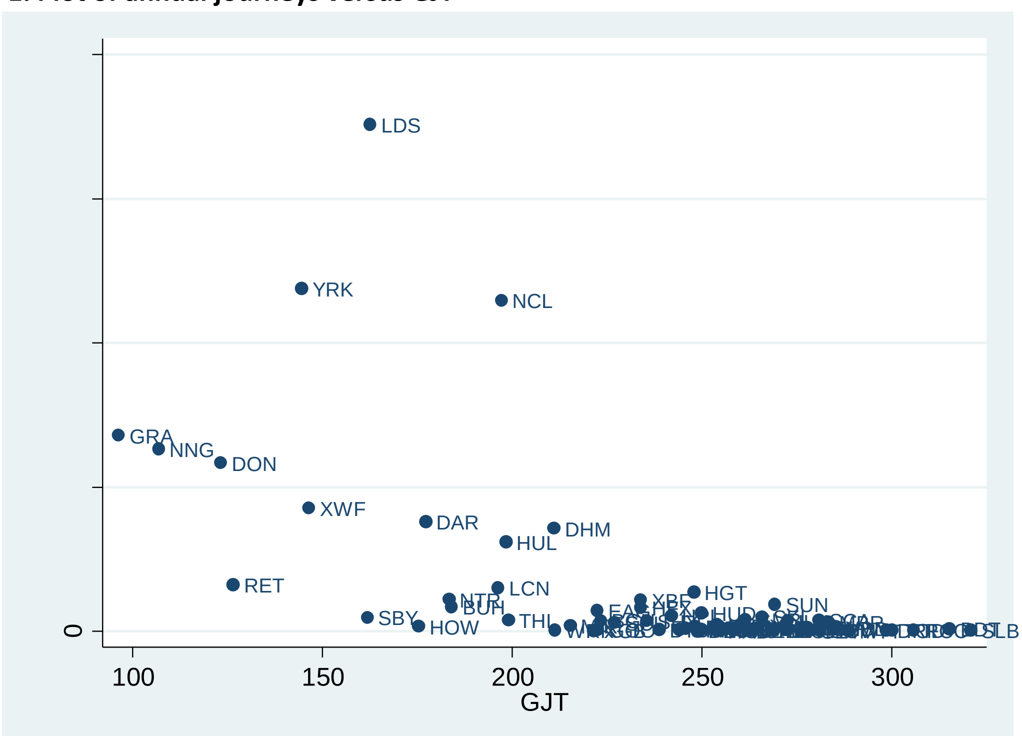
Table 4. Preferred model, key statistics

Variable	Coefficient	T-statistics
Origin population	0.45	11.95
Wage	1.82	18.3
GJT	-2.35	-9.74
Adjusted R-squ	0.85	
Observations	67	

Given the functional form the implied elasticity increases as the reduction in GJT increases:

- A 1% reduction in GJT implies a GJT elasticity of 2.4
- A 10% reduction in GJT implies a GJT elasticity of 2.8
- A 20% reduction in GJT implies a GJT elasticity of 3.4

Figure 1. Plot of annual journeys versus GJT



4. Other models tested

Several alternative model specifications have been tested and are summarised in the following, including our reasons for rejecting these models. Leeds, Newcastle and York are included in some of these specifications as they were tested during the first stage of the study, before the exclusion of these stations from our dataset.

4.2. Model with separate short distance and long distance population variables

A variant of the preferred model was tested with separate variables specified for inner and outer catchment populations, defined by journey time from the stations, as it seems likely that access time of the catchment population from a station may influence the number of journeys made from it:

- All stations were assigned an inner population variable, calculated as the population within 15 minutes' drive of the station
- Category 2 stations were assigned an outer population variable, calculated as the population within 15-35 minutes' drive of the station.

The model takes the following form:

$$Journeys = OriginPop_{inner}^{\alpha} OriginPop_{outer}^{\beta D} OriginWage_{LA}^{\gamma} GJT_{OD}^{\delta}$$

Table 5 below shows the key regression statistics.

All coefficient values are of the correct sign (positive for population and wages, negative for GJT) and all variables are significant at the 95% confidence level, indicated by t-statistics of greater than 1.96 in magnitude. Standard errors have been corrected to ensure they are robust against any heteroskedasticity present.

Both population variables have lower t-statistics that the single population variable in the preferred model, with the inner variable insignificant at a 99% confidence level. We believe this is because of the sensitivity of this variable to the location of the centre point of LSOAs, and given this uncertainty we draw little inference from the coefficients.

The adjusted R squared statistic is 0.85, indicating that the model explains 85% of the variation in the annual number of journeys. This is similar to the fit for the preferred model, although given the potential uncertainty around the population variables, we prefer the model where population is treated as a single variable.

Table 5. Separate population model key statistics

Variable	Coefficient	T-statistics
Inner population	0.20	2.06
Outer population	0.11	2.91
Wage	1.71	13.91
GJT	-1.66	-4.40
Adjusted R-squ	0.85	
Observations	67	

4.2. Radial catchment population model

The first alternative looks at an alternative population variable. This was the preferred model from stage one of our work, and was debated at the industry hearing in June.

Office for National Statistics (ONS) population data by Lower Super Output Area (LSOA) code has been used to create population catchments within 2km, 5km and 10km of the stations. The following stations (Table 6) show the stations which are allocated a 10km catchment radius. This is from either park and ride facilities or being seen as rail-heading destinations. Leeds and its catchment is, however, treated slightly differently, being such a large rail hub; stations within the 10km radius are excluded from the model calibration process and it is assumed that trips from Leeds come from within the 5km and 10km catchment areas.

Table 6: Stations with 10km catchment

Stations with 10km catchment
Leeds, Doncaster, Darlington, York, Newcastle, Northallerton, Lincoln, Grantham, Durham, Retford, Wakefield, Newark, Brough, Eaglescliffe, Harrogate

The functional form is the same as described for the previous model, with two population variables specified, and the model is estimated using non-linear least squares. The other variables, wage at the origin and GJT are the same as described in Section 3. The model estimated is as follows:

$$Journeys = OriginPop_{5km}^{\alpha} OriginPop_{5-10km}^{\beta D} OriginWage_{LA}^{\gamma} GJT_{OD}^{\delta}$$

Table 7 below shows the results of the estimation using the two radial population catchment variables. All the variables are significant at the 95% (and 99%) confidence level, given the t-statistics are well in excess of 1.96: the critical value of significance at the 95% confidence level. The adjusted R^2 is high at 0.92, suggesting that 92% of the variation in journeys is explained by the model. Again the standard errors have been adjusted to be robust against any heteroskedasticity.

Table 7. Radial population variable, key statistics

Variable	Coefficient	T-statistics
0-5km catchment	1.10	6.31
5-10km catchment	0.11	3.61
Wage	1.12	7.26
GJT	-2.39	-5.47
Adjusted R-squ	0.92	
Observations	70	

Despite the goodness of fit with this model, we assume that the model reported in section 3 the population variable based on real time travel data, supported by VTEC's ticket sales data is more reflective of reality.

Given more time it would have been useful to compare the application of radial catchments with the same ticket sales data, but this has not been possible.

4.3 Log-linear functional form

An alternative specification looked at using OLS with a double log specification. A logarithm transformation translates the series into a linear approximation. This is equivalent to the non-linear form presented above, however with a constant specified. However this has the advantage that, for analysis purposes, the coefficients are the elasticities. The same variables are used as described in Section 3 but now using the flowing functional form.

$$logJourneys = \alpha_1 + \beta_1 logOriginPop \ \ + \beta_2 logOriginWage_{LA} + \beta_3 logGJT_{OD}$$

Table 8 shows the output from the log-linear specification. Standard errors are robust to heteroskedasticity. All coefficients are significant (at the 95% and 99% significant levels), except β_2, the logarithm of origin wage, which is insignificant. The signs of the significant coefficients are as expected: positive for all expect log wage which we would expect to be positive.

The R^2 statistic is 0.69, suggesting the model explains 69% of the variation in Journeys; this is clearly inferior to the preferred model.

Table 8. Linear OLS specification, key statistics

Variable	Coefficient	T-statistics
Constant	51.01	2.93
Log Population	0.31	2.96
Log Wage	-3.92	-1.48
Log GJT	-3.91	-8.55
R-squ	0.62	
Observations	67	

4.4 Splitting GJT into component elements

An alternative specification is to separate out GJT into its separate components. This specification was used in order to ascertain how significant any interchange penalty is; that is, we wanted to test by how much having a direct service influences demand currently.

The other variables are as per the preferred model, however the functional form is log linear as the Interchange takes the form of a zero-one dummy (meaning that a non-linear form would not work). The Interchange is not transformed using logarithms but remains as a zero-one dummy variable.

The new specification is as follows:

$$logJourneys = \alpha_1 + \beta_1 logOriginPop \; + \beta_2 logOriginWage_{LA} + \beta_3 logInterval_{OD} + \beta_4 logJourneyTime_{OD} + \beta_5 Interchange_{OD}$$

Table 9 shows the key results for this specification and shows a reasonable fit of the data with 75% of the variation in journey being explained by the model (R^2 statistic). Standard errors are robust to heteroskedasticity.

The interchange coefficient is highly significant and shows the correct, negative, sign. The interpretation of the interchange term is slightly different from the other coefficients, given it is a dummy variable, we cannot take a partial derivative. The coefficient shows that going from no interchange (0) to an interchange (1) leads to a 94%[7] fall in journeys; this suggests the interchange penalty is very high. This finding clearly supports the conclusions of ITS Leeds/Mott MacDonald[8] that the PDFH interchange penalty is likely to be understated.

The log population and log Interval coefficients are significant at the 95% confidence level.

The other coefficients are not significant, with log wage showing an incorrect sign. The model is therefore not usable as a means of forecasting demand in this study.

[7] 100*(exp(-2.7564)-1)

[8] *THE IMPACT OF LARGE CHANGES IN GENERALISED JOURNEY TIME ON RAIL PASSENGER DEMAND, FINAL REPORT, May 2012, Institute for Transport Studies, University of Leeds and Mott MacDonald*

Table 9. Linear GJT separation specification, key statistics

Variable	Coefficient	T-statistics
Constant	32.78	2.16
Log Population	0.20	2.63
Log Wage	-1.70	-1.23
Log Interval	-0.59	-2.32
Log Journey Time	-0.70	-1.24
Interchange	-2.76	-8.45
R-squ	0.75	
Observations	67	

4.5 Adding a fares variable

During phase 1 of this study we also attempted to add a fares variable to the various models tested. The analysis undertaken yielded no meaningful results, and we were unable to specify a demand function that included fares.

5. Application of the preferred model

The preferred demand function (see chapter 3) is used to estimate the proportionate increase in journeys between London and the stations listed in table 1, following the introduction of the new services contained within the access rights applications received by ORR.

5.1. Catchment population definition

The first stage of the application of our estimated demand function is to quantify the catchment population for both the base and the option. This is done using the population data and VTEC ticket sales data described above.

The population variable in our demand function, for the relevant base timetable, is quantified by taking the catchment population within a 15 minute drive time of the station in question, and excluding any locations for which the most convenient point of access to the ECML is likely to be another station. As discussed in section 2.2, stations with few or no direct services to London have a narrow population catchment.

For certain stations the population variable for our options is expanded to include the population within a 35 minute drive time. This is where we believe that the provision of frequent direct services to London would be likely to make a station the most convenient point of access to a significantly wider catchment than currently. To quantify this variable we take the catchment population within a drive time of 35 minutes from the station in question, and then exclude any locations for which the most convenient point of access to the ECML is likely to be another station because of lower access times and the existence of frequent direct services to London. Again, this is driven by the analysis presented in section 2.

5.1.1. Specific catchment assumptions

The maps at the end of this appendix show the base and option and population catchments specified for stations. The base catchment population is referred to as “inner” and the expanded catchment for some stations is referred to as “outer”.

Following completion of the interim phase 2 report we have revised our defined catchment areas for some stations, on the basis of improved local knowledge.

East Leeds Parkway (ELP). A significant proportion of inner Leeds falls within the 15 minute base catchment for ELP. The most convenient point of access for London services would continue to be Leeds station, regardless of the service level at ELP, so we exclude these locations from our “inner” catchment.

We expect that, following the introduction of direct London services, East Leeds Parkway would become the most convenient point of rail access for a large area to the east and north of Leeds, and locations on the M1 and A1 corridor. We therefore expand the option catchment population to a 35 minute drive time excluding locations where the most convenient point of access to the rail network is likely to remain as another station, particularly Leeds.

As mentioned in section 2.2, we assume that Leeds has a 35 minute outer catchment. Some stakeholders have written to ORR stating that our assumed catchment for Leeds in the interim report was 15 minutes. This is not the case, and we have amended the relevant map at the end of this appendix to show the full Leeds catchment area.

Kirkstall Forge. Following a further review of the catchment area, we have excluded Kirkstall Forge from the gravity model assessment. This is partly because the station catchment area lies entirely within urban and suburban Leeds, and has good current transport links to Leeds station. We specifically excluded stations located entirely within Leeds for the calibration of the gravity model, and therefore do not believe that it is appropriate to use this model as a means of forecasting future demand at Kirkstall Forge.

Bradford Forster Square and Shipley. We have reduced the base and option catchment population for both stations, so that the two catchments do not overlap.

Horsforth. Horsforth retains the default 15 minute base and option population variable.

Harrogate. Harrogate has the default 15 minute base population variable.

We expect that, following the introduction of more direct London services, Harrogate would become the most convenient point of rail access for a large area north of Leeds. We therefore expand the option catchment population to a 35 minute drive time, excluding locations where the most convenient point of access to the rail network is likely to remain as another station, particularly Leeds and York.

Scunthorpe, Habrough, Grimsby Town and Cleethorpes. These stations have the default 15 minute base population variable. We have expanded the outer catchment population to the north and to the south to encompass the locations that would be within easy access of these stations. These locations are within 35 minutes’ drive of the relevant stations.

Middlesbrough. A significant proportion of the area within a 15 minute drive of Middlesbrough, is a faster drive to/from Eaglescliffe station. We therefore exclude this subset of the catchment area from the base and option population variable for Middlesbrough.

We expect that, following the introduction of direct London services, Middlesbrough would become a convenient point of access for a number of locations outside of a 15 minute drive time from Middlesbrough. Our 35 minute drive time catchment now includes a number of locations to the south east and to the north west. We exclude locations that have faster road access to/from Darlington and Hartlepool.

Morpeth. Morpeth retains the default 15 minute base population variable.

We expect that, following the introduction of more direct London services, Morpeth would become the most convenient point of rail access for a wider surrounding area than currently. We therefore expand the option catchment population in our demand function to a 35 minute drive time, excluding locations where the most convenient point of access to the rail network is likely to remain as another station, specifically Newcastle. In particular, we do not believe Morpeth would attract significant demand from locations south of Cramlington, as access to London services would be more convenient via Newcastle.

5.2. GJT change

5.2.1 Existing stations

For existing stations the MOIRA assessment from the first stage of our forecasting process provides estimates of GJT before and after the introduction of the new services. These GJT estimates are used in the preferred demand function to forecast the resultant change in journeys.

5.2.2 New stations

As part of the MOIRA analysis, matrices of journeys, revenue and GJT are produced for ELP, to provide an estimate the impact of these new stations prior to the introduction services in the various options.

This is done by:

- Assuming the same pattern of current services as the proxy station, (Garforth for ELP).
- Taking the resultant journeys, revenue and GJT matrices from Garforth and Headingley.
- Scaling the journeys and revenue matrices using the gravity model. – This is done for ELP only, as Kirkstall Forge is no longer modelled using the gravity model.

As for existing stations, the MOIRA assessment produces estimates of GJT before and after the introduction of the new services, which are used in the preferred demand function to forecast the resultant change in journeys.

5.3. Application of the forecasts

The demand function is used to estimate journeys in both the base scenario and for the relevant option. The two estimates are compared to provide a proportionate change in demand. This proportionate change in demand is then applied to the base demand, to provide a demand forecast for the station (number of journeys between the station and London).

The difference between this forecast demand and the forecast produced using MOIRA and the fares overlay (the first two stage of our demand/revenue suite) is taken as additional demand, not otherwise captured using MOIRA and the fares overlay.

Our default assumption is that this additional demand is newly generated travel.

Despite this, we are mindful that even the revised catchments of some of the stations in question, may include passengers who currently access London services via other stations. However, for most stations we believe this equates to a very small proportion of journeys, and that the potential abstraction of journeys as a result is even smaller. The rationale for this is as follows:

- Station catchment areas as described above are intended to be separate from the catchments of other ECML stations with frequent direct London services, and most are a significant journey time from other ECML stations.

- Ticket sales data suggests that few current journeys originate from these new catchment areas.

- If the new service calls at both relevant stations, (e.g. Leeds and East Leeds Parkway), the forecast of abstraction at the currently served station will include journeys that originate from the shared catchment.

The exceptions to this are as follows:

Middlesbrough. Middlesbrough and Eaglescliffe stations are located within a short drive of each other and it is not possible therefore to define a representative catchment for Middlesbrough that does not include a sizeable proportion of current Eaglescliffe passengers, who could access the former more easily than the latter. It seems likely therefore that the introduction of direct Middlesbrough – London services would abstract demand and revenue from Eaglescliffe. Furthermore, the proposed new direct Middlesbrough – London services do not call at Eaglescliffe so the potential abstraction will not be captured elsewhere in the modelling suite.

Data showing the postcode origin of Eaglescliffe-London passengers is not available for Eaglescliffe. We therefore assume that of the additional journeys forecast, the level of abstraction is equivalent to:

- Weekday Eaglescliffe - London journeys scaled by:
    - the proportion of the “inner” population of Eaglescliffe residing within our defined “inner” catchment for Middlesbrough,
    - and then in proportion to the number of direct opportunities to travel per day.

For reasons of commercial confidence we cannot report this figure, however table 11 shows the scale of this abstraction on our forecasts.

East Leeds Parkway (ELP).

We have re-examined VTEC’s ticket sales data and conclude that although some likely abstraction from Leeds is captured within our demand forecast for Leeds, there would be some further abstraction from passengers who access Leeds station by road, and live in the East Leeds Parkway catchment. We also conclude that some Wakefield – London and York – London demand would be abstracted, given how well connected by road East Leeds Parkway is.

Given the confidentiality of VTEC's ticket sales data it is difficult to report our estimated number of journeys that would be abstracted, however table 11 shows the scale of this abstraction on our forecasts.

Morpeth.

Based on VTEC's ticket sales data we estimate that a small amount of Morpeth – London demand would be abstracted from Newcastle.

Table 10. Approach to forecasting additional demand and netting off abstraction from shared station catchment areas

Station	Additionally generated journeys/revenues	Net-off abstracted journeys/revenue
Cleethorpes	Gravity forecast minus MOIRA/fares forecast	-
Grimsby Town	Gravity forecast minus MOIRA/fares forecast	-
Habrough	Gravity forecast minus MOIRA/fares forecast	-
Scunthorpe	Gravity forecast minus MOIRA/fares forecast	-
Bradford FS	Gravity forecast minus MOIRA/fares forecast	-
Shipley	Gravity forecast minus MOIRA/fares forecast	-
East Leeds Parkway (new)	Gravity forecast minus MOIRA/fares forecast	Subtract Leeds - London, - Wakefield – London, and York London journeys using VTEC-dedicated tickets originating from the shared catchment. - Treat as abstraction.
Lincoln	Gravity forecast minus MOIRA/fares forecast	-
Harrogate	Gravity forecast minus MOIRA/fares forecast	-
Horsforth	Gravity forecast minus MOIRA/fares forecast	
Middlesbrough	Gravity forecast minus MOIRA/fares forecast	Subtract estimated proportion of Eaglescliffe – London revenue that is estimated to originate from defined Middlesbrough catchment.
Morpeth	Gravity forecast minus MOIRA/fares forecast	Subtract Newcastle - London journeys using VTEC-dedicated tickets originating from the shared catchment. - Treat as abstraction.

6. Model results

We include model results to assist stakeholders in interpreting the model development work presented above.

Results are shown below in table 11.

Discussing the results in detail is difficult as data on the total number of journeys is commercially confidential, and cannot be published if it can be used to infer the number of current journeys split by both flow and TOC.

We draw the following conclusions:

- Forecast demand uplifts for most stations are higher in proportionate terms, using the Gravity Model, versus using MOIRA alone. This is unsurprising given the difference in the implied elasticities from section 3, versus PDFH5.1 elasticities.

- The highest forecast proportionate demand uplift is for the proposed new stations East Leeds Parkway (option 1). This is because the proposed new rail services would offer a rail journey time to London of less than two hours, (which is faster than from Leeds station), for an expanded catchment population of over 500,000.

  Despite the large uplift, we estimate that this would equate to less than 0.3 journeys per year, per head of catchment population. This is at the lower end of the range forecast using MOIRA, for all of the stations/flows shown in table 11. This rate would also be lower than many other ECML stations/flows with frequent direct services to London. Work to define the base level of demand for ELP is still ongoing, so a more precise rate per head of population cannot be reported at this stage.

- Other stations, where we expect the catchment area to expand as a result of the introduction of new services, also have a high proportionate forecast demand increase using MOIRA. Again, the implied number of journeys per head of population are in a reasonable range.

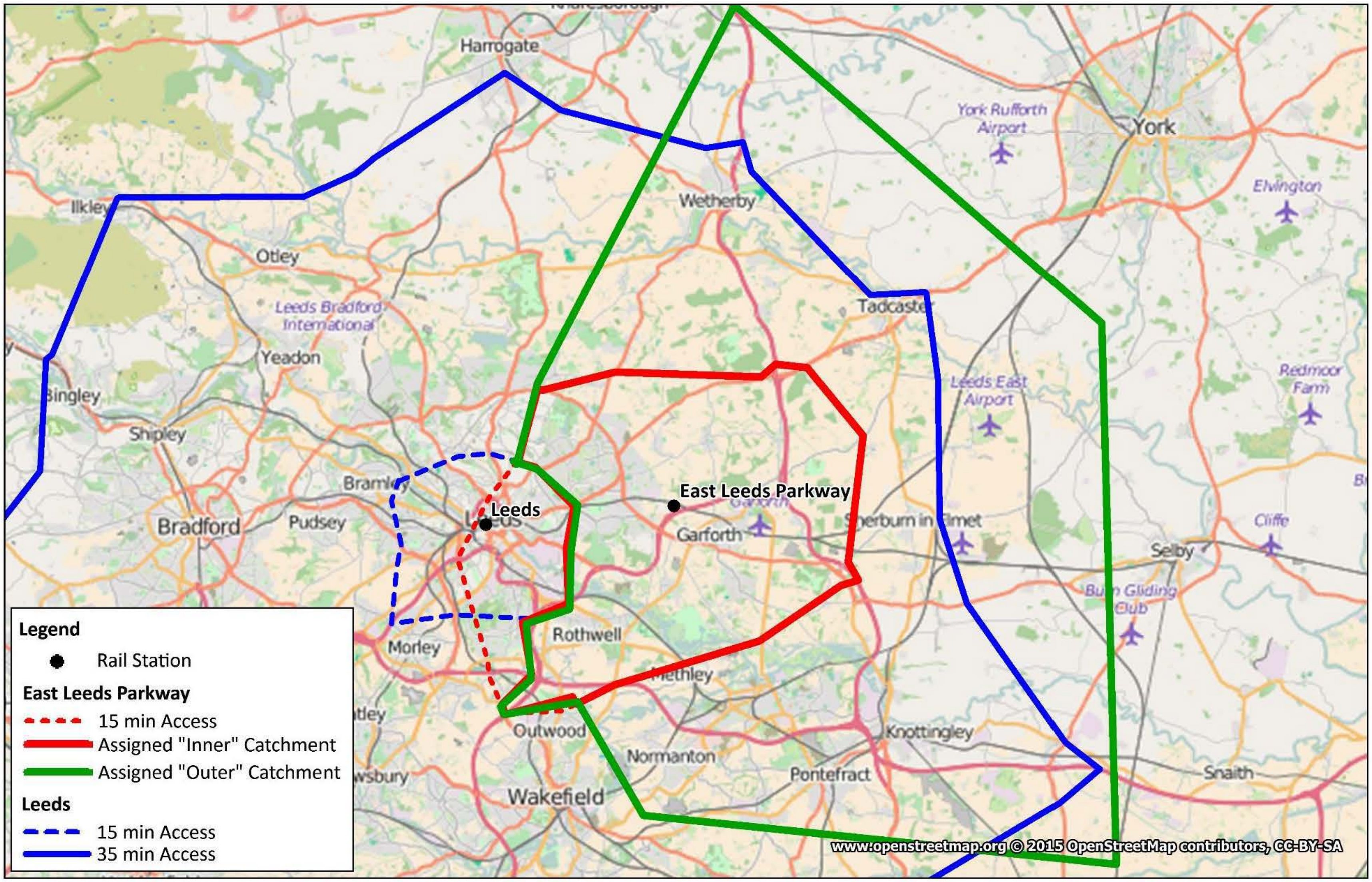
Table 11. Impact of gravity model on our forecasts

		Population		GJT (Mins)		Demand uplift*** (option versus base)			
Option	Flow to/from London TCA	Base	Option	Base	Option	Gravity model uplift versus base	Subtract growth from MOIRA and fares	Subtract abstraction	Total (net) gravity uplift
1	Shipley	82,777	82,777	231	186	66%	-56%	-	10%
5	Shipley	82,777	82,777	223	183	58%	-30%	-	28%
1	Scunthorpe	60,871	126,277	228	186	124%	-61%	-	63%
1	Habrough	16,829	47,011	256	206	165%	-70%	-	95%
1	Grimsby Town	92,089	92,089	263	217	57%	57%	-	<1%
1	Bradford*	317,057	317,057	232	207	30%	-47%	Not applied as forecast already exceeded	
5	Bradford*	317,057	317,057	226	203	29%	-26%	-	3%
1	Cleethorpes	36,019	164,827	273	225	215%	-61%	-	154%
1	ELP	171,246	518,068	239	162	310%	-31%	-49%	230%
4	Horsforth	21,332	21,332	240	197	59%	-34%	-	25%
4	Harrogate	99,831	154,160	241	214	60%	-19%	-	41%
6, 8	Middlesbrough**	284,895	369,834	289	211	136%	-54%	-52%	30%
7, 9 15	Morpeth***	57,595	170,866	287	242	144%	-102%	-15%	27%
4	Lincoln	147,177	147,177	192	145	86%	-43%	-	43%

*Bradford Forster Square and Bradford Interchange are grouped as a single station in MOIRA, so are also in the Gravity Model. ** Applied to weekday demand only, results for option 6 reported (options 6 and 8 have similar results). *** results for option 7 reported (options 7, 9 and 15 have similar results).

Station Catchments - Leeds & East Leeds Parkway
Applicable to Option ID1 & ID10

Client: Office of Rail and Road
Date: December 2015
Project: Assessment of Track Access Applications for the East Coast Main Line

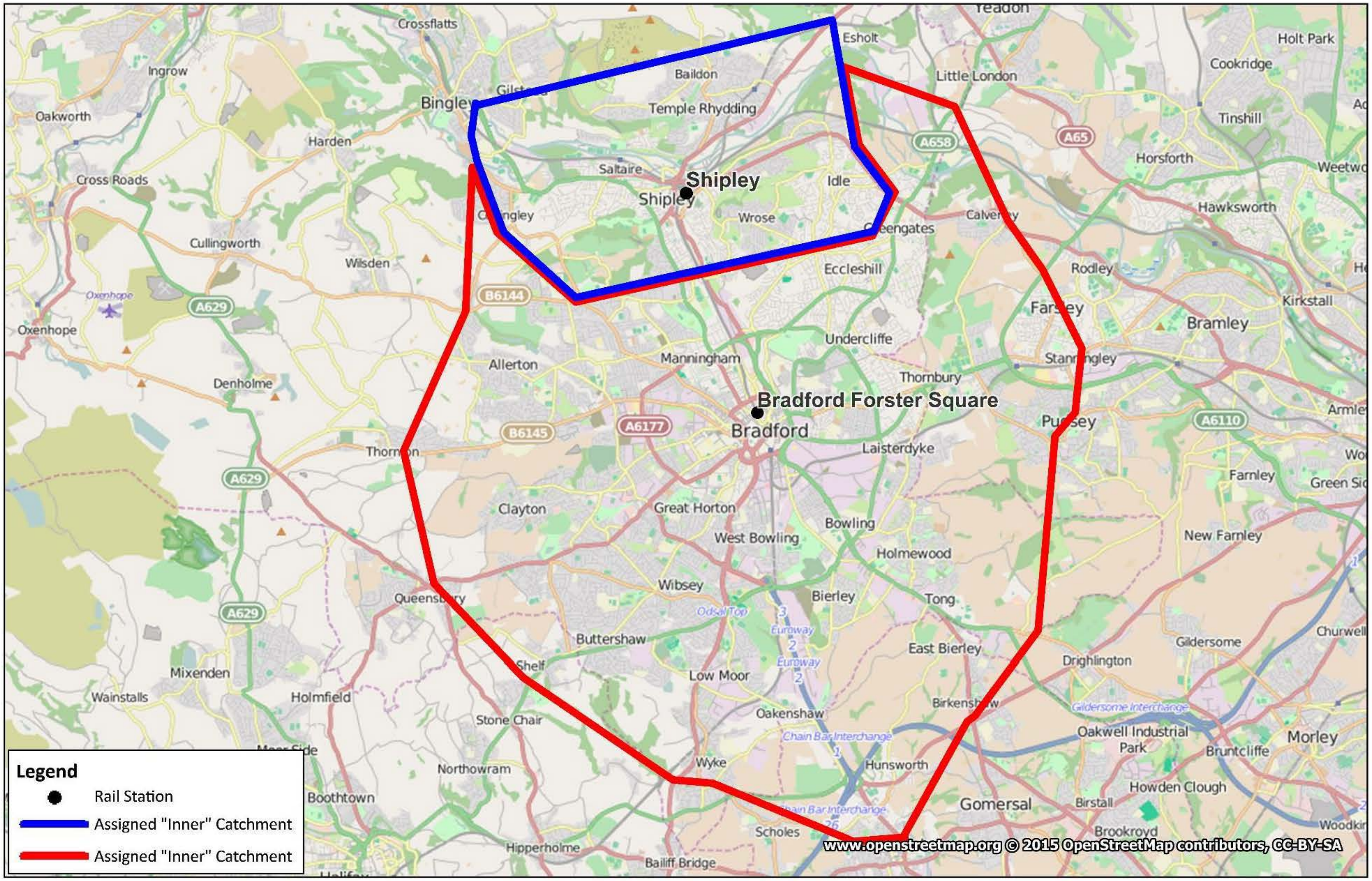


Catchments for Wakefield W. and York are not mapped. Some current London journeys from these stations start/end in the ELP catchment.

ch2m

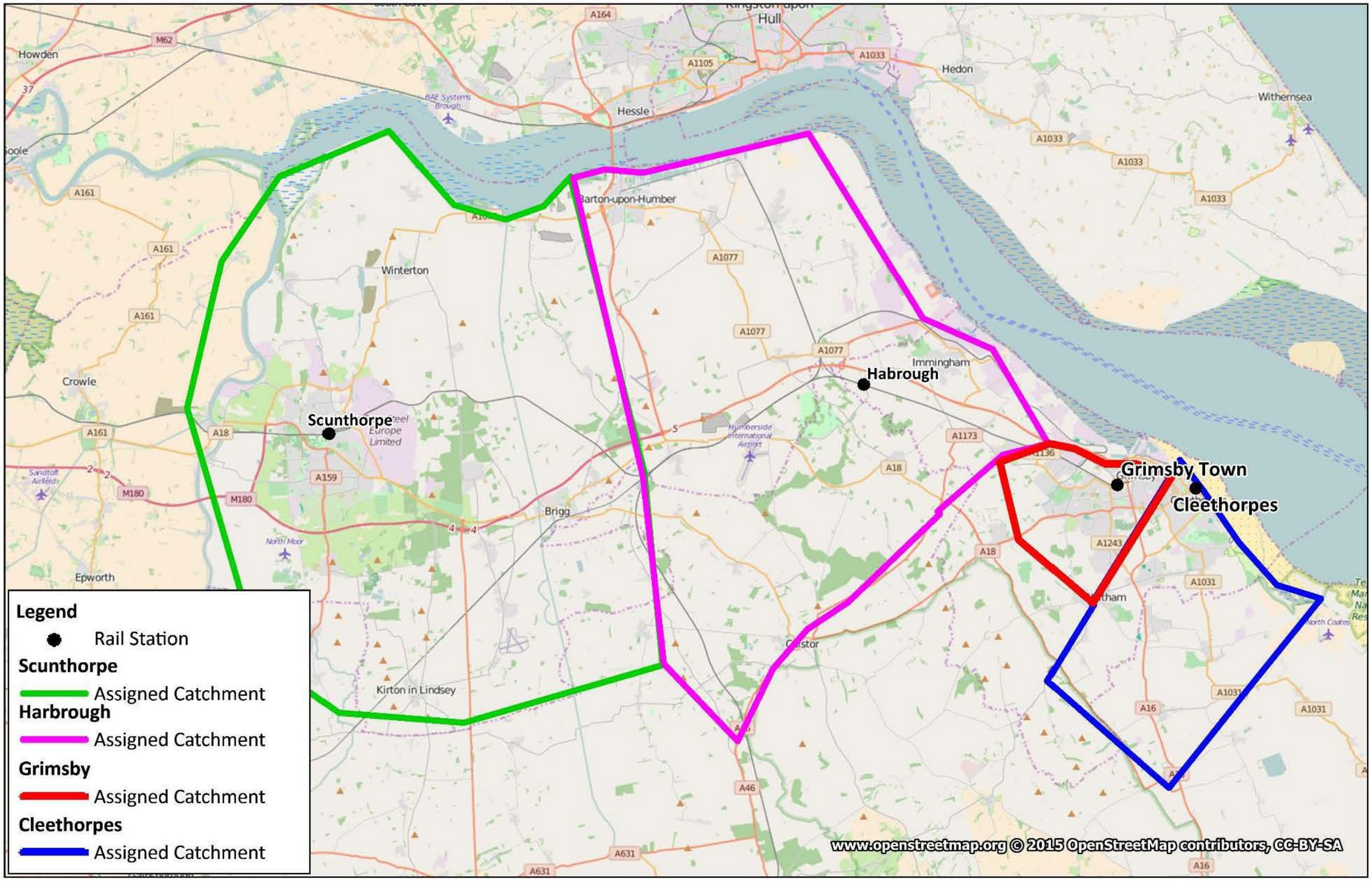
Station Catchments - Bradford Forster Square & Shipley
Applicable to Option ID1, ID5, ID8, ID10, ID11 & ID14

Client: Office of Road and Rail
Date: October 2015
Project: Assessment of Track Access Applications for the East Coast Main Line



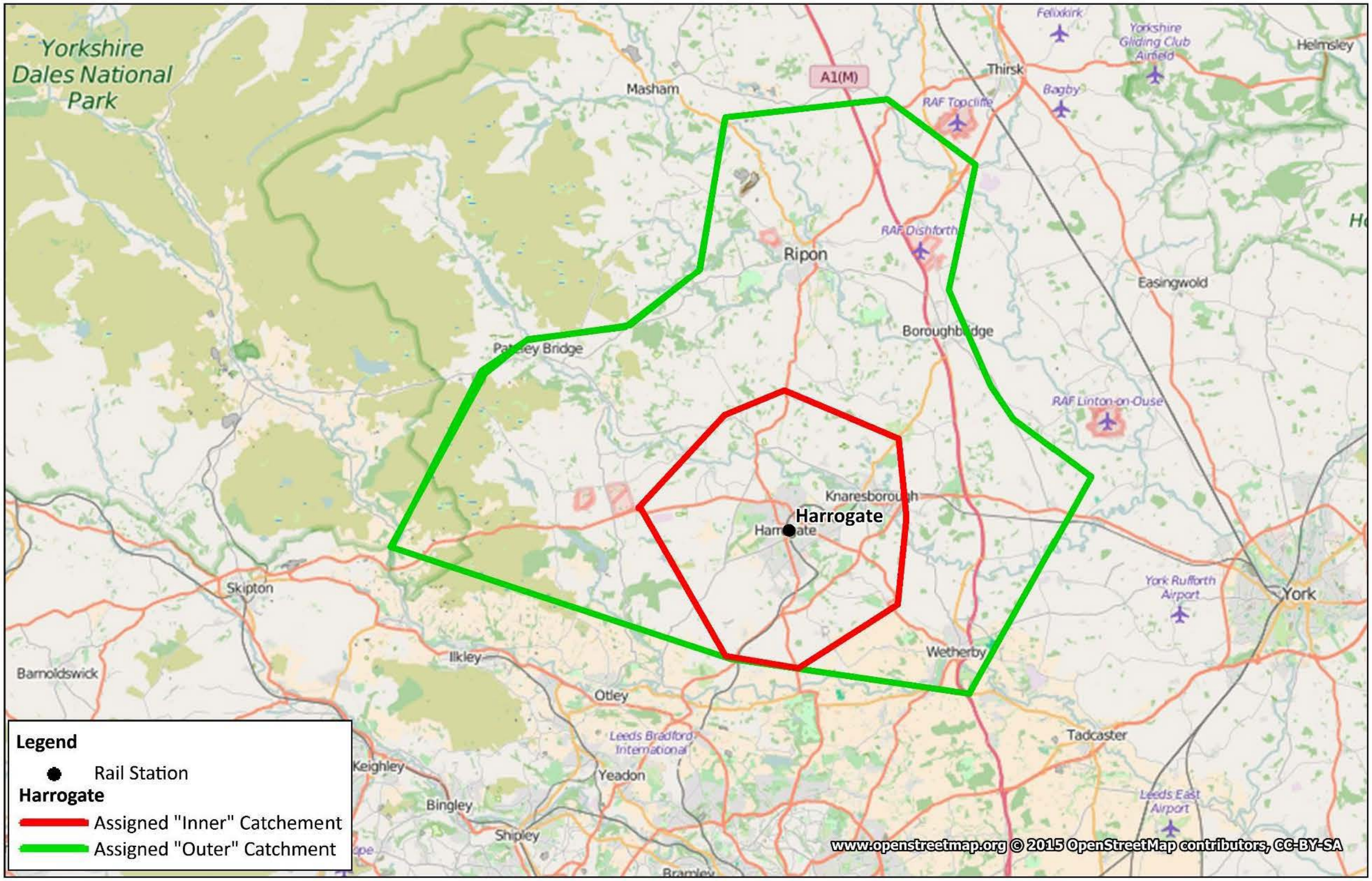
Station Catchments - Cleethorpes Branch
Applicable to Option ID1 & ID10

Client: Office of Rail and Road
Date: December 2015
Project: Assessment of Track Access Applications for the East Coast Main Line



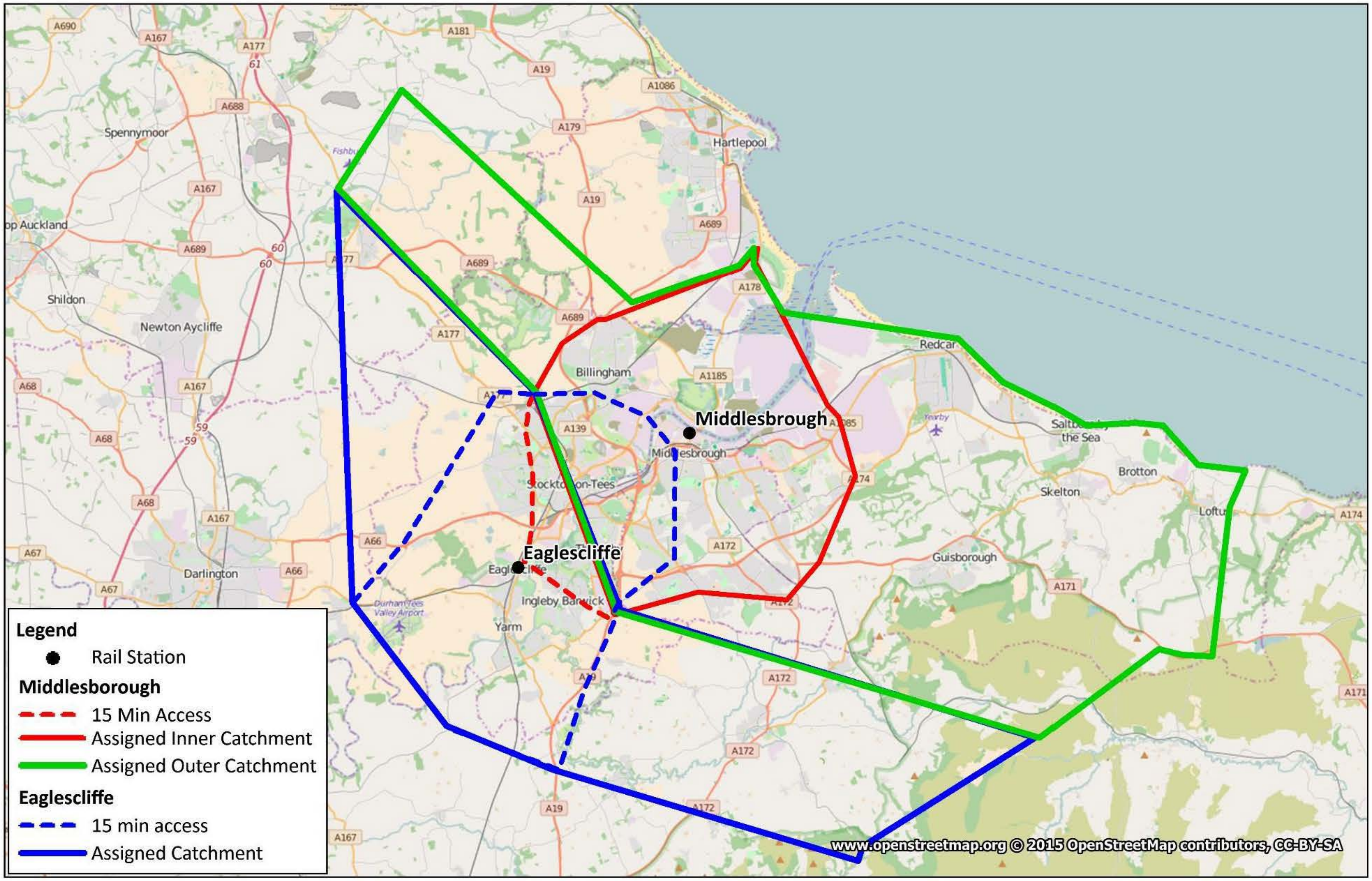
Station Catchments - Harrogate
Applicable to Option ID4, ID8, ID14 & ID15

Client: Office of Rail and Road
Date: December 2015
Project: Assessment of Track Access Applications for the East Coast Main Line



Station Catchments - Middlesbrough & Eaglescliffe
Applicable to Option ID6, ID8, ID9, ID12, ID13, ID14 & ID15

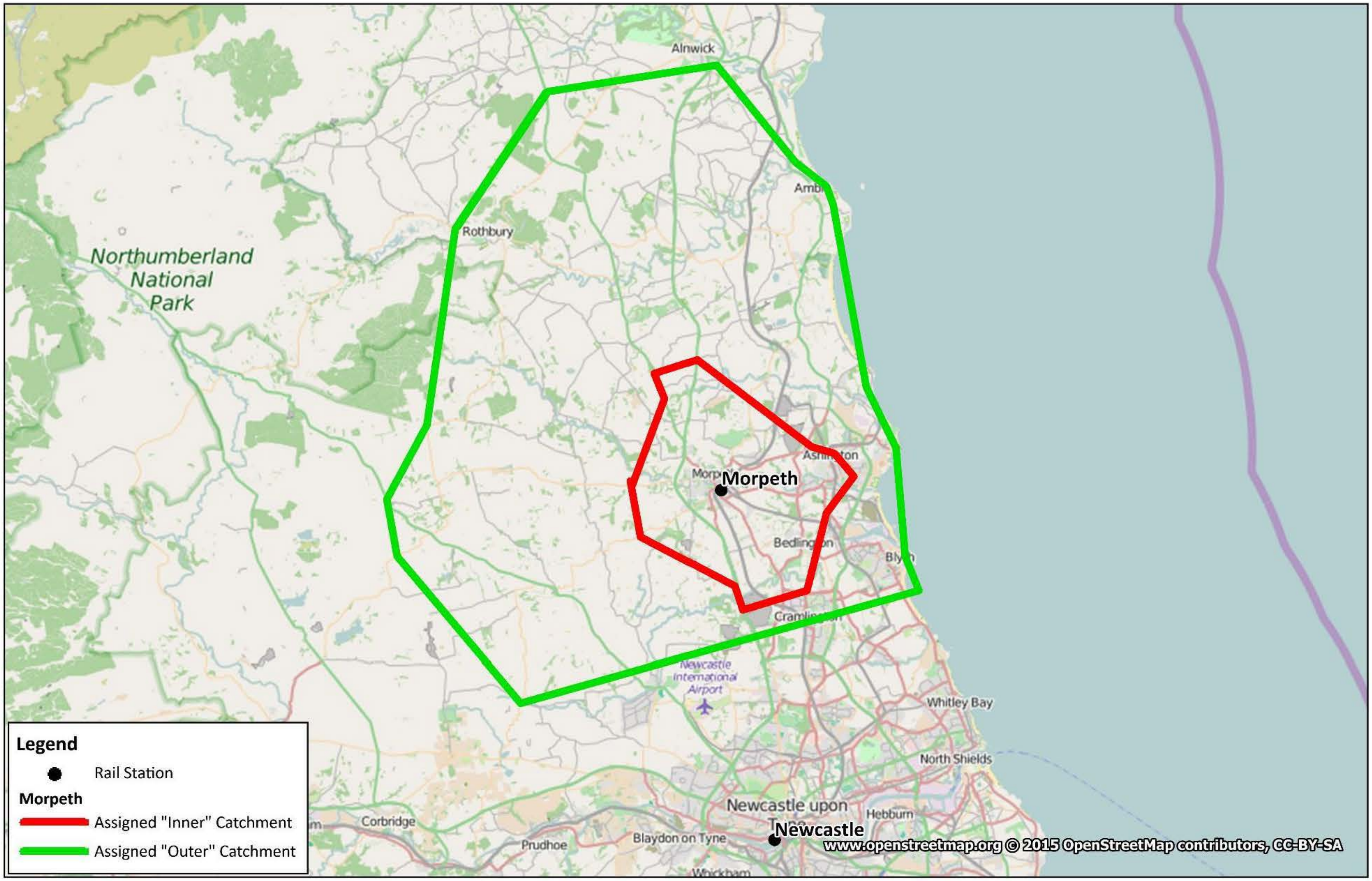
Client: Office of Road and Rail
Date: December 2015
Project: Assessment of Track Access Applications for the East Coast Main Line



ch2m

Station Catchments - Morpeth
Applicable to Option ID7, ID9 & ID15

Client: Office of Road and Rail
Date: October 2015
Project: Assessment of Track Access Applications for the East Coast Main Line



Appendix F: Crowding model

PREPARED FOR: Office of Rail and Road

PREPARED BY: Steve Curtis, Cara Murphy

DATE: January 15th, 2016

PROJECT NUMBER: 657135

REVISION NO.: 3.0

APPROVED BY: Chris Judge, Jon Clyne

1. Background

This appendix explains, at a high level, the approach used to model the crowding impact of the timetable and capacity changes of each of the options.

The crowding model is used to scale demand and revenue projections for the base timetables and options, based on the level of capacity to accommodate projected demand as a result of both exogenous growth, and growth stimulated by the various base timetables and options. All options are tested using the crowding model, with the exception of options 11-14. These options are sensitivity tests to advise ORR on the impact on existing operators' revenue, and can be performed adequately using MOIRA only.

The crowding model assessments undertaken for options 1 and 3 are taken as a proxy for the crowding impact of option 10 (which is a combination of options 1 and 3). This is a proportionate simplification, necessary to meet ORR's timescales, and will not affect the results materially.

The Crowding Modelling Suite is a pre-existing set of interlinked models which has been used successfully to assess the implications of on-train capacity for a number of previous rail demand forecasting applications, including rail franchise bidding and procurement support. The modelling suite has previously been subject to full external review when applied to other projects.

We expect that a number of stakeholders will be aware of previous uses of this modelling suite: we therefore provide both an overview of the generic model, as well as the specific adaptations made to address the requirements of this current work.

Subsequent audits throughout this commission have identified changes to the modelling suite to incorporate iteration of crowding penalties to achieve model convergence. The Crowding Model Suite has been updated to incorporate this functionality.

2. Crowding model methodology

The Crowding Modelling Suite has been designed to apply Passenger Demand Forecasting Handbook version 5.1 (PDFH v5.1) parameters and methodology to calculate the impact of crowding on a timetable.

The Crowding Modelling Suite consists of four key models. Figure 1 outlines the underlying models within the Crowding Modelling Suite. For this East Coast version of the suite, the Crowding Curve Generator is not used, as the required functionality is more effectively applied elsewhere in the suite.

PDFH v5.1, (Chapter B6, Section B6.1), suggests that a passenger experiencing crowding on a train service will react in different ways:

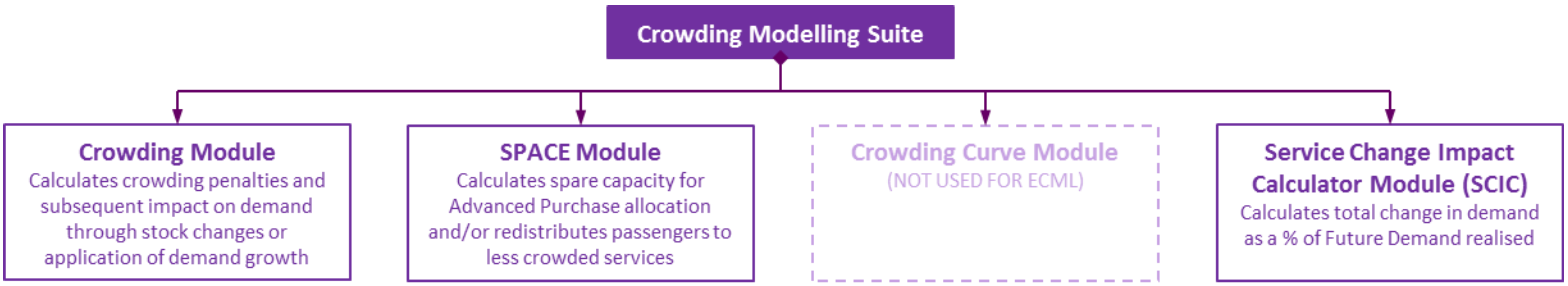
1. They may choose to reserve a seat (where possible) to ensure they do not have to stand.
2. They may decide to travel at a different time of day when it is less crowded.
3. They may choose to arrive early to get a seat.
4. They may let a train go and catch a later train they expect to be less crowded.
5. They may choose not to travel by train at all.
6. They may travel on the crowded train and accept they may have to stand.

Each of these reactions is considered within the Crowding Modelling Suite (see Figure 1):

- The Crowding Module has the functionality to allocate Advance Purchase ticket holders to particular services that are not crowded (enabling modelling crowding to satisfy passenger reactions in (1) above)
- The SPACE Module considers the impact of crowding on passengers and enables the redistribution of passengers to less crowded trains (which enables the modelling of passenger reactions in (2) and (4) above)
- The Crowding Module calculates the demand suppressed by comparing the base crowding penalties with the future crowding penalties. This level of suppression (or realised growth) is fed back into the revenue model (enabling the modelling of (5) above)
- (3) and (6) are considered as base case behaviour.

For East Coast, it is assumed that the majority of crowding management is carried out through the yield management (using the Advance Purchase ticket allocation functionality in the Crowding Model described above), so the functionality for passenger redistribution is switched off (that is, our SPACE model is not used to redistribute passengers due to crowding).

Figure 1 Crowding Modelling Suite



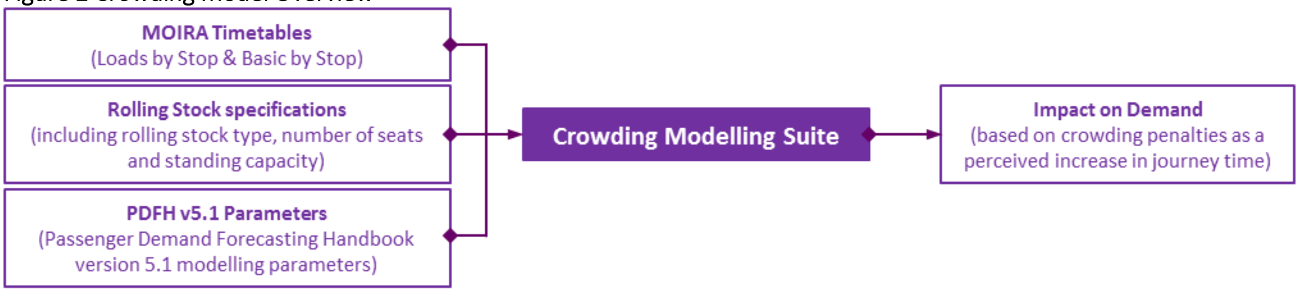
2.1 Approach

For the purpose of the ECML project, the main purpose is to assess the impact on demand and potential passenger relief/suppression due to changes to a single timetable through:

- Growth in patronage (calculated using the Revenue Model which forecasts exogenous and endogenous growth)
- Changes to rolling stock
- Changes to services/timings including the introduction or removal of services

Figure 2 below illustrates the inputs to the crowding modelling suite taken from the earlier stages of the revenue modelling suite, and the outputs back to the revenue modelling suite.

Figure 2 Crowding Model Overview



The Crowding Modelling Suite has been designed to consider the impact of crowding on a timetable using Moira Loads by Stop outputs, for a defined level of growth. This is used in conjunction with all other models in the following steps.

For a timetable that doesn't change.

1. Start with a base scenario, a timetable with rolling stock and demand, and a future scenario, the same timetable with grown demand and/or new rolling stock capacity (Crowding Module)
2. For each service, estimate origin destination of each passenger, break demand into matrices to represent flow level demand (Crowding Module)

Table 1 Example train Loads by Stop Output

Stop Location	OTA (On Train Arrivals)	OFF (Alighters)	ONS (Boarders)	OTD (On Train Departures)
A	0	0	10	10
B	10	2	42	50
C	50	25	75	100
D	100	100	0	0

Table 2 Example of how loads are calculated for each origin-destination combination

To\From (Stop Location)	A	B	C	D	Total (equal to "OFF")
A					
B	2 (8 passengers remain from A)				2
C	4 (50% of people alight, this is assumed as equal from all stations)	21			25
D	4 (the remaining passengers alight at the final stop)	21	75		100
Total (equal to "ONS")	10	42	75	0	0

3. Apply calibration factors to adjust MOIRA outputs (see Section 3 – Calibration), producing the base level of demand. (Crowding Module)
4. Unconstrain the calibrated demand.
5. Apply growth from revenue model, with advance ticket growth stripped out, and/or new rolling stock capacity to produce the future scenario. (Crowding Module)
6. Iterate the impact on passenger demand when reconstraining the timetable to converge to a theoretical realised demand position (Crowding Module – 10 iterations are undertaken)
7. Determine the spare capacity at the critical load point of every service. (SPACE Module)
8. Allocate advance demand to services where spare capacity exists. Not all advance demand is allocated. An assumption is made on the proportion of passengers who travel over the critical load point. Once known, only these passengers are allocated to the service, and are assumed to travel from origin to destination. (Crowding Module).
9. For each service, calculate the crowding penalties of every flow on every service in the base case and the future case (Crowding Module).

   The Crowding Model uses Passenger Demand Forecasting Handbook version 5.1 (PDFH v5.1) methodology and parameters to calculate the level of crowding on a train – measured as the perceived increase in journey time as a result of crowding.
10. Using PDFH formulae, calculate the demand suppressed/released from each flow of each service (Crowding Module)

The equation provided in PDFH v5.1, and used in this model is as follows:

$$Demand_{new} = Demand_{old} \cdot \left(\frac{GJT_{new} + (\, Crowding\ Factor_{new} - 1) \cdot\ IVT_{new}}{GJT_{old} + (\, Crowding\ Factor_{old} - 1) \cdot\ IVT_{old}} \right)^{GJT\ Elasticity}$$

where the Crowding Factor is calculated as:

$$CF = \frac{(Seated\ Passengers\ \cdot Seat\ Factor) + (Standing\ Passengers\ \cdot Standing\ Factor)}{(Total\ Passengers)}$$

11. Aggregate this to revenue model flow level and calculate ‘percentage of forecast demand realised’, ready to feed back to revenue model (Crowding Module).

Timetable Changes

In the case of a timetable change, the process is slightly more complex. The Crowding Model can only compare at a service level. In order for two different timetables to be compared, both the Crowding Model and SPACE will need to be run twice (as described in steps 1 – 9 above), once for the base timetable and once for the future timetable (with growth, if applicable). The outputs in terms of penalties by flow by service are then imported into the SCIC Module. The SCIC Module will then calculate the realised forecast demand through the following steps:

1. For the base and future scenarios, the model aggregates crowding penalties and calculates weighted GJT (excluding the impact of in-vehicle journey time changes as these have been calculated by Moira) by hour at the flow level used in the revenue model.
2. Uses these aggregated values to calculate the impact of the timetable change by flow/time band.
3. Sums the impact across all time bands to calculate ‘percentage of forecast demand realised, ready to feed back into the Revenue model.

3. Calibration

MOIRA loads form the input to our crowding suite. There are many known shortcomings of MOIRA that lead to inaccurate predictions of on-train loadings, including the peaked nature of demand profiles, out of date day-of-week splits and an inability to model crowding or fares.

A profiling model has been developed and used to assess MOIRA demand against count data on specific passenger flows. (The count data provided and mapped to the May 2014 MOIRA output indicates that MOIRA loads are approximately 15% higher than the count data provided). Once compared, a scaling profile is determined and applied to the MOIRA loads to better match reality.

For this task, Wednesday standard class loads from the 2014 count data have been used. This is carried out for the major long distance TOCs operating along the ECML (Hull Trains, Virgin Trains East Coast and Grand Central). (Note that Cross Country and Transpennine Express counts were not available and are not calibrated – in these cases, the MOIRA Loads are used.). Flow data presented in the following calibration summary represents the results for the whole flow used in calibration, not just an individual TOCs share. Where there are significant differences in calibration requirements for different TOCs, calibration has been undertaken taking into account the service code as well as the passenger flow, to enable this calibration difference.

3.1 Approach

The steps carried out in determining the scaling profile are as follows.

1. Compare the demand on a flow by hour.
2. Plot the associated data points, by hour, representing the necessary scaling in that hour.
3. Apply a line of best fit (using LINEST function) to smooth the impact of markedly different results in different hours.
4. Use this formula to scale MOIRA loads by hour in the crowding model.

3.2 Worked Example

We have selected a standard passenger flow as an example to demonstrate this process. The total demand at selected station is also used to demonstrate the impact at a station level.

The difference between the count data and the Moira modelled load data at the selected station (Figure 3) demonstrates that significant adjustment is required in order to appropriately calibrate loads and provide the correct level of service and capacity along the ECML. This is also illustrated in the flow graph (Figure 4) for the selected passenger flow group, where MOIRA is clearly overstating the demand on the flow.

Figure 3 Comparison of MOIRA Loads and Count Data at the selected station

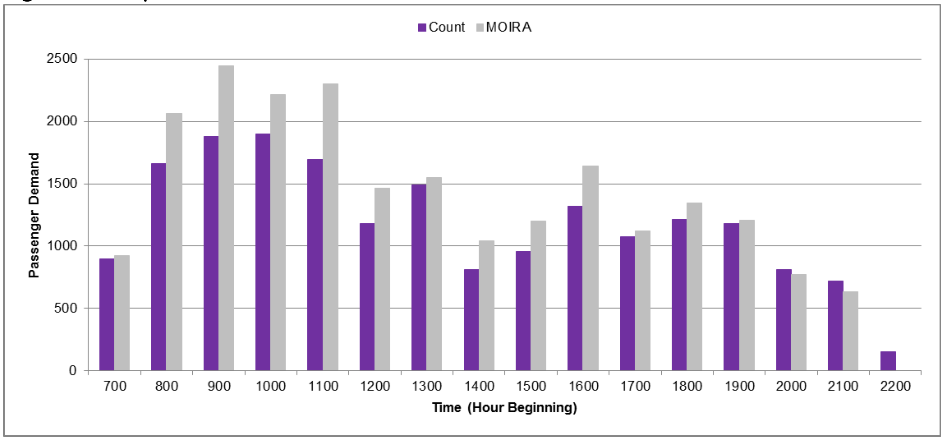
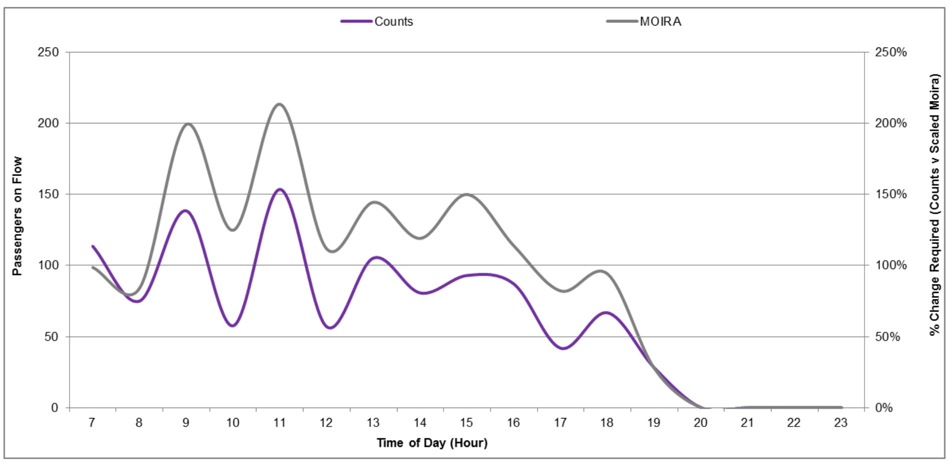
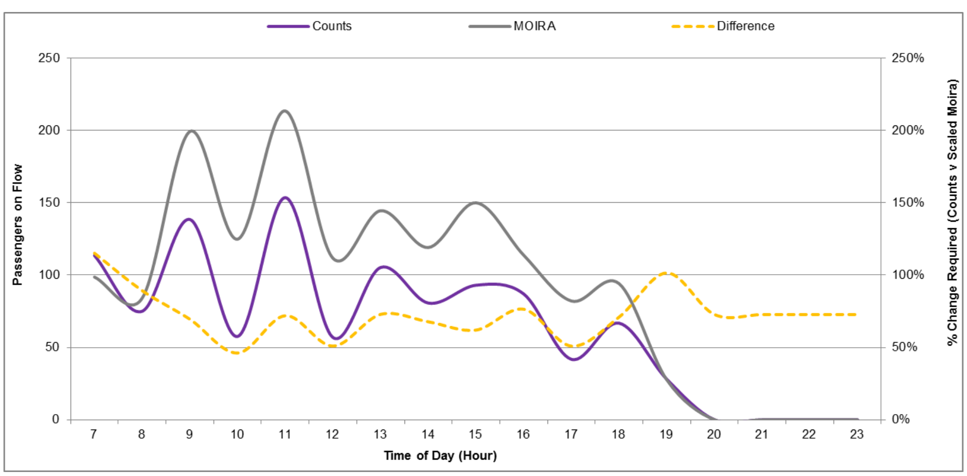


Figure 4 Comparison of MOIRA modelled loads and Count Data on the selected passenger flow across a day



During step two, the difference between the two lines is plotted, as in Figure 4.

Figure 5 Visualisation of the % Change requirements across the day on the selected passenger flow across the day

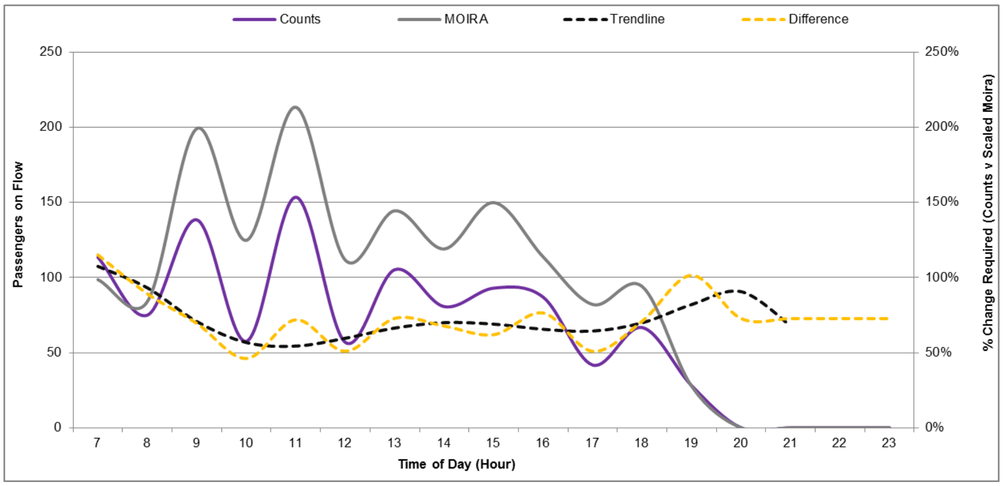


This difference is then used to approximate a 6th order polynomial trendline that can be used in future scenarios to adjust loads based on the time of day. The trendline is calculated using the MS Excel LINEST function to determine the coefficients of the trendline in the form:

$$y = Ax^6 + Bx^5 + Cx^4 + Dx^3 + Ex^2 + Fx + G$$

In the majority of cases, the trendline coefficients for A, B and C are very small. By applying a polynomial, it ensures there are no step changes in scaling hour by hour. This can result in step changes in demand, and very different results if the service arrives at 0859 rather than 0900.

Figure 6 Visualisation of the trendline fit to the level of adjustment required on the selected passenger flow across the day



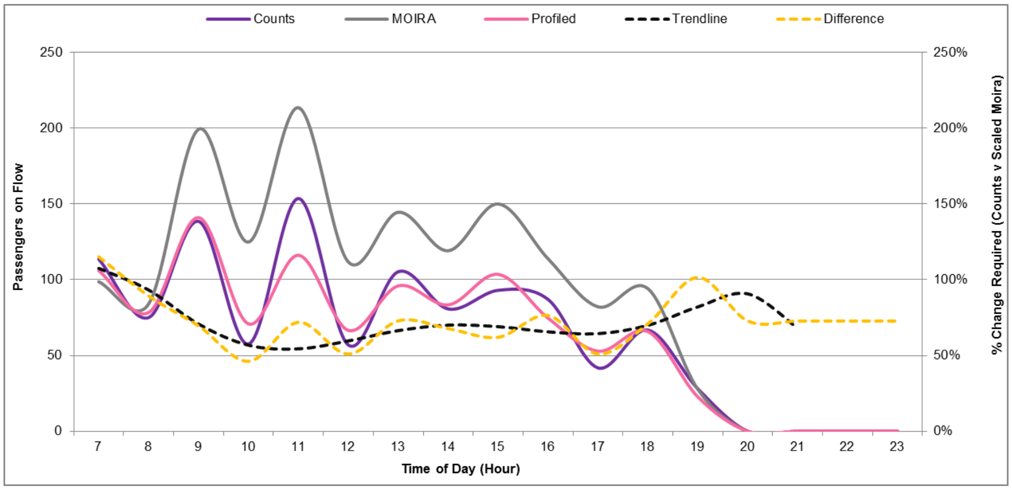
The trendline represented in Figure 6 is as follows:

$$y = [-4.6\text{E}-16]x^6 + [2.3\text{E}-12]x^5 + [-4.5\text{E}-09]x^4 + [4.7\text{E}-06]x^3 - 0.003x^2 + 0.765x - 87.043$$

The trendline is fit between the hours of 0600 and 2100. This time restriction has been implemented in order to fit the trendline to the majority of loads across the day, without skewing for the large discrepancies in small loads on the early morning and late night services. The maximum discrepancy has also been limited to 250% in order to restrict large fluctuations across hourly periods.

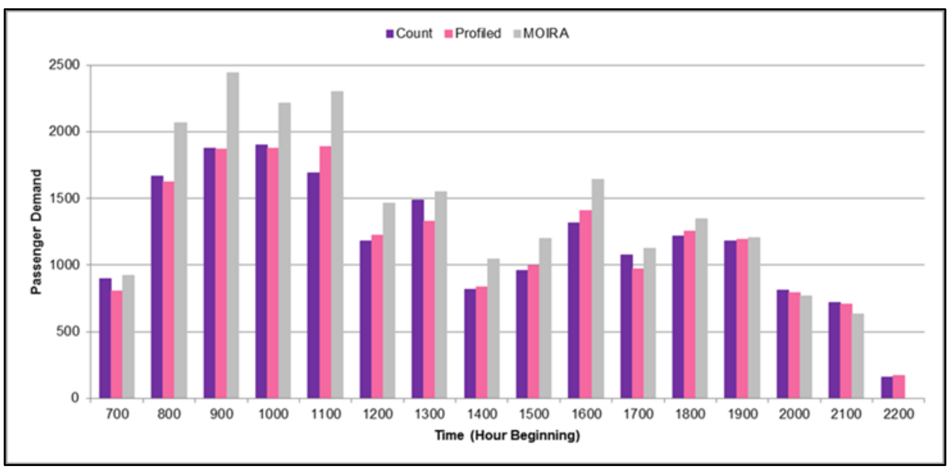
The result of applying this trendline to the MOIRA modelled loads is shown in Figure 7 (pink line).

Figure 7 Resulting Profiled loads when applying the calculated trendline to the modelled MOIRA passenger loads



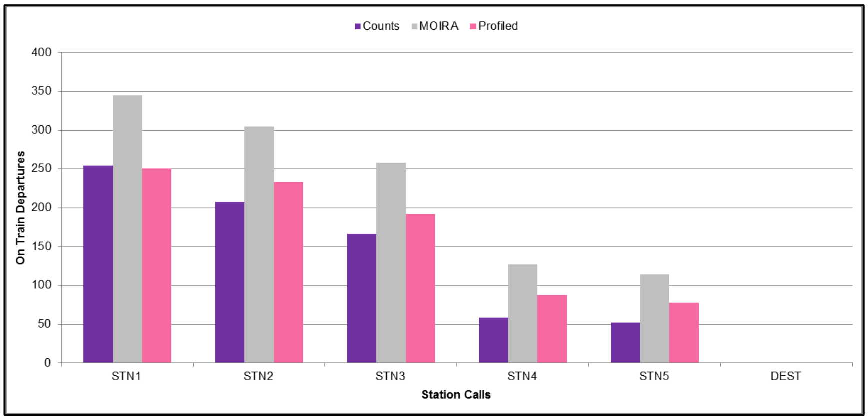
The application of these calculated trendlines across the selected passenger flows significantly improves the levels of demand at the stations identified for calibration. In the case of the above example, the passenger demand in the AM and PM Peak is representative of the observed passenger counts as demonstrated in Figure 8, below, for the selected station.

Figure 8 Comparison of the Profiled Demand to the initial MOIRA Demand and Count Data at the selected station



The result at a train level of this calibration is demonstrated in Figure 9.

Figure 9 Demonstration of load changes on a specifically selected service



The above analysis has been carried out for all stations; it is key to see how the demand levels have changed at each station. Table 3 shows that the re-profiling has made improvements across nearly all stations.

Table 3 Key Station Analysis

Station	AM Peak					PM Peak				
	Counts	***MOIRA***	***% MOIRA***	***Profiled***	***% profiled***	***Counts***	***MOIRA***	***% MOIRA***	***Profiled***	***% profiled***
STN1	7,055	7,828	111%	6,949	98%	9,348	13,846	148%	9,298	99%
STN7	8,262	9,058	110%	8,261	100%	8,393	9,750	116%	7,817	93%
STN8	7,030	7,066	101%	7,139	102%	9,978	10,454	105%	9,709	97%
STN2	4,970	5,733	115%	5,074	102%	7,103	7,851	111%	7,076	100%
STN9	3,905	3,886	100%	3,831	98%	2,730	3,186	117%	2,861	101%
STN3	3,275	3,816	117%	3,242	99%	3,986	4,608	116%	4,052	102%
STN6	956	1,109	116%	965	101%	2,705	3,281	121%	2,876	106%
TOTAL	35,453	38,496	109%	35,461	100%	44,243	52,976	120%	43,689	99%

3.3 Flows for inclusion

We considered that re-profiling at a passenger flow level would provide the best calibration result as it enables redistribution of passengers across different service codes (where required) and does not increase loads where adjustment is not required; which would be the result of adjusting profiles at a station level.

The initial selection of flows to include in the calibration process included the Top 165 flows based on count data. These flows had demand of 50 passengers or greater and represented almost 93% of total demand based on count data. This list was subsequently augmented as identified during the calibration process to improve the match between count and the profiled results. The full list will be shown in the Record of Assumptions.

3.4 Assessment of Calibration

The results of the calibration process were subject to three levels of analysis including:

- Service Level – compares the arrival and departure loads at stations for individual services based on flow, direction and service code. This enables visibility of demand profile across the day, and also of individual services.
- Hourly Demand Level – compares the loads at key stations along ECML.
- Service Code Level – compares the loads for different train operating companies using the route.

Within these tests the number of modelled loads within 2 standard deviations of the counts has been counted. Industry standards suggest that 95% of modelled loads within 2 standard deviations is a good fit.

Additionally, the desired targets to achieve in the calibration include:

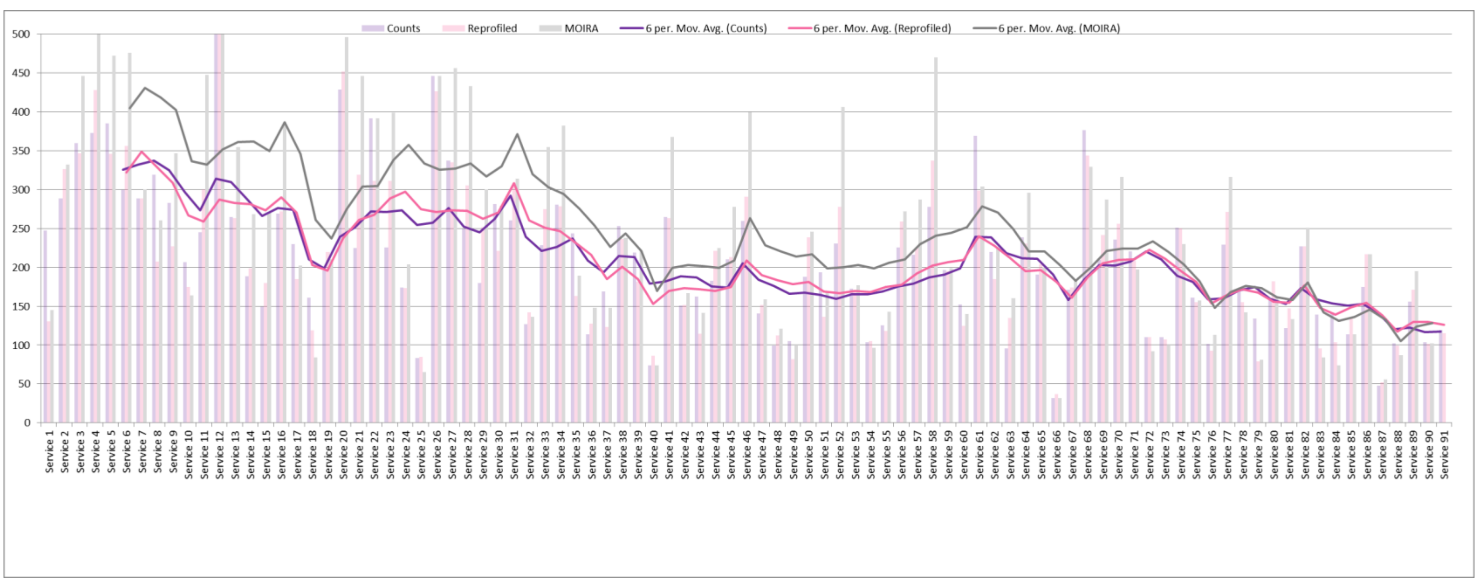
- On an hourly basis, a difference between profiled and count data of ±10%; and
- On a daily basis, a difference between profiled and count data of ±5%.

The table indicates that at a station level, MOIRA generally overstates total passengers. The calibration has generally brought the profiled data down to the count data.

3.5 Service Level

An example of the analysis at Service Level can be seen below for all services arriving at a selected station throughout the day. The six-point moving average line demonstrates that the profile of the modelled AM peak arrivals (pink) is closely matched to counts (purple).

Figure 10 Comparison of the Profiled Demand to Count Data for all services arriving at a selected station throughout the day



3.6 By station

At a station level, Table 4 demonstrates that, in both directions, all stations, with the exception of one, are within the target of 5% difference between model and counts.

Table 4 Station Level Analysis

	Difference between northbound modelled and counts	Difference between southbound modelled and counts	% of northbound services within 2sd	% of northbound services within 2sd
STN1	1%	0%	97%	99%
STN7	-7%	-5%	97%	96%
STN8	-4%	-4%	98%	96%
STN2	-1%	-1%	99%	100%
STN9	1%	-5%	97%	97%
STN3	-1%	1%	100%	98%
STN6	2%	1%	100%	100%

3.7 By Service Group (at Critical Load Point)

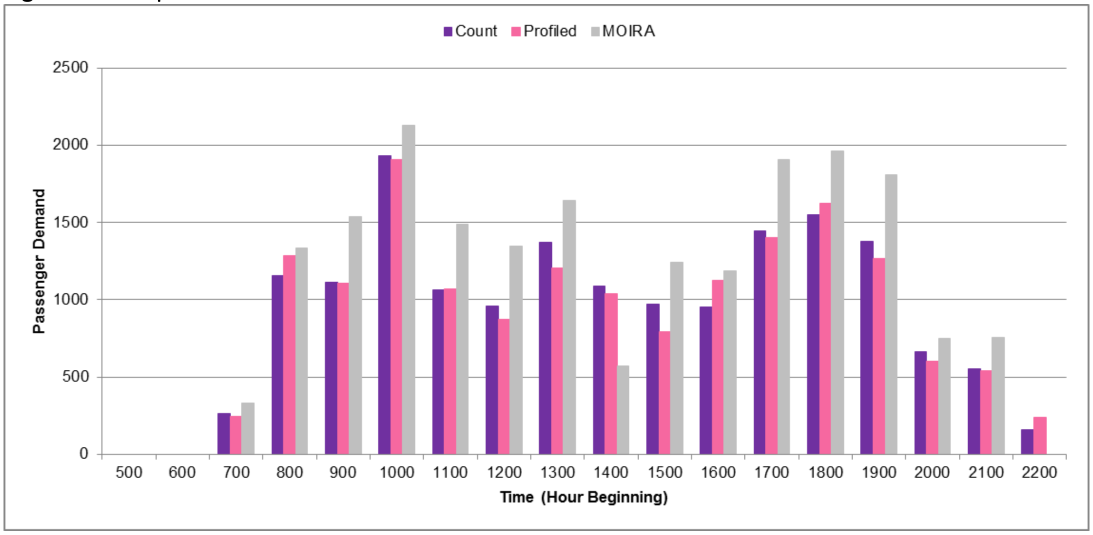
Similarly, at service group, the largest service codes are well modelled, although there are some bigger margins of error for service codes with few services, such as East Coast services north of Leeds. Note that these services are the only ones with fewer than 5% of modelled loads outside 2 standard deviations.

Table 5 Service Group Level Analysis

	Difference between northbound modelled and counts	% of northbound services within 2sd
SERVICE1	-2%	100%
SERVICE2	-1%	100%
SERVICE3	-13%	100%
SERVICE4	9%	100%
SERVICE5	0%	97%
SERVICE6	2%	80%
SERVICE7	8%	100%

Figure 11 shows a high volume service code with patronage displayed by hour. The figure shows that whilst the differences for some of the individual hours are in excess of the 10% target, the total difference across the day is -2% which meets the desired target of ±5%.

Figure 11 Comparison of the Profiled Demand to Count Data for a selected service code



4. Factors by day of the week

Our calibration, described above, has only been carried out for a Wednesday. To approximate the impact of daily variability, the average of the critical load factor on services for every week day (selected services only – redacted information) have been calculated from 2014 count data.

Table 6 Weekday Variability

	Services	Critical Load Factor	Multiplier
Monday	155	75%	1.34
Tuesday	155	58%	1.04
Wednesday	155	56%	1
Thursday	155	57%	1.02
Friday	155	60%	1.07
Saturday	102	67%	1.20
Sunday	103	67%	1.20

Based on the above factors, it is assumed that, if the average load at the critical load point is ~20% higher on Saturdays than it is on a Wednesday, then the crowding penalties and subsequent impact on demand will be higher as well. In order to calculate the suppression or generation on all Weekdays, Saturdays or Sundays, the following multipliers will be applied (this takes into account the variability across the weekdays also):

Table 7 Daily Variability

	Factor
Weekday	104.5%
Saturday	130.8%
Sunday	156.1%

5. Interface with the revenue model

5.1 Application of unconstrained demand forecasts in the crowding model

Forecast growth in journeys using any-operator (walk-up) tickets is applied in the crowding model first. This is undertaken as follows:

- Take forecast growth in journeys and exclude journeys that are not considered in the crowding model, i.e. first class journeys. Add this growth to the number of any-operator journeys in the base, to calculate the total number of journeys.
- Apply this revised total forecast journeys to individual trains in proportion to the current journeys profile by time of day.
- Apply the crowding model so that journeys allocated to busy trains are crowded off.

Forecast growth in journeys using advanced (operator-specific) tickets is then applied in the crowding model. This is undertaken as follows:

- As above, take forecast growth in journeys and exclude journeys that are not considered in the crowding model, i.e. first class journeys. Add this growth to the number of advanced journeys in the base, to calculate the total number of journeys.
- Apply this revised total forecast journeys in proportion to the empty seats available on trains for the relevant TOC. E.g. journeys made on VTEC-only tickets would be allocated exclusively to VTEC services.
- Use the SCIC to determine the crowding effect of the timetable in comparison to the base so that journeys made using all ticket types are crowded off busy trains.

5.2 Use of the crowding model outputs

The outputs of the crowding model suite are as follows:

- **Demand scaling factors**. These factors are used to scale the forecasts of journeys, hence revenue, produced using the previous parts of the revenue model suite (i.e. the journeys matrices following the application of the gravity model overlay, which is the previous stage of the modelling).

  Scaling factors are calculated for, and applied to, both the base and the options. This is so that the forecast change in journeys and revenue between 2014 and the base timetable(s) and between the base timetable(s) and the options is reflective of the level of capacity available. We do not believe that it would be necessary to re-run the crowding model as a result of a change in fares, as the overall impact on fares at a market segment level is likely to be small. We will investigate this further during the production of initial forecasts.
- **Estimated loadings for individual trains.** This is to inform the number of advanced fare journeys used in the fares overlay to estimate average fares for applicable market segments. (See the main report and appendix C)

TECHNICAL MEMORANDUM

Appendix G: Economic Appraisal

PREPARED FOR:	Office of Rail and Road
PREPARED BY:	Chris Judge
DATE:	January 15th, 2016
PROJECT NUMBER:	657135
REVISION NO.:	2.1
APPROVED BY:	Jon Clyne

1. Background

To provide context, this introductory section of the appendix is a repeat of the text from section 5 of the main report.

The appraisal is intended to provide an estimate of a number of the incremental benefits and costs relating to each option considered as compared to the relevant base timetable, focusing on those effects that can be quantified. It is not a full assessment of all of the impacts and largely excludes qualitative factors. Similarly, it does not seek to appraise effects against the ORR's statutory duties.

We understand that this quantification will form part of the evidence base which will underpin ORR's eventual decision, but it will not be the only evidence considered by ORR and is therefore not intended to be an all-encompassing assessment of every aspect of the applications. Specifically:

- The appraisal of effects is intended to be, where appropriate, compliant with WebTAG and the HMT Green Book[1]. However, there are cases where the appraisal deviates from this. Where they occur we explicitly state the reasons for these deviations.
- Where certain forecasts of costs or benefits are highly uncertain, ORR has asked us to omit these from our analysis, but explicitly state the omission. An example of this is where the costs of infrastructure investment are unknown, we have omitted them, and ORR can separately take a view of these costs and consider them alongside our appraisal.

[1] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

2. Quantification of benefits and costs

The following benefits and costs are quantified in our economic appraisal of options.

2.1 User benefits

Time savings

The saving in generalised journey time (GJT) from journey time and frequency improvements, made by both existing rail passengers and passengers who are attracted to rail by the new services.

The source calculation for this benefit is the revenue model.

Overcrowding impacts

This is assessed through application of scaling from the crowding model to our forecasts of revenue and journeys. Our initial intention had been to estimate the impact of overcrowding on passengers expressed as a value of time savings or losses. However, upon review we were concerned that this may double count the impact of crowding measured through the scaling factors, and that the estimated value of time saving may be unreliable. This simplification has had no material impact on our economic appraisal results.

Reduction in rail fares

This is the net benefit to passengers from a reduction in rail fares.

In a manner consistent with WebTAG A5.3, applying the "Rule of Half", this is calculated as (current journeys x the average change in fares) + (new journeys x ½ x the average change in fare). This calculation is made at a flow level.

2.2 Non-User benefits

This is the benefit to people other than existing or newly attracted rail passengers. The main benefit to non-users from the introduction of new rail services is a reduction in road congestion, and hence highway journey times savings, generated through a switch from road to rail travel. Other associated impacts include reductions in the number of road accidents and small improvements in vehicle emissions and local air quality.

We calculate the switch away from road travel using a factor of a 0.26km reduction in road vehicle km for every 1km increase in rail passenger km. This assumption is consistent with WebTAG. This estimated reduction in road vehicle km is reduced in proportion to the total increase in rail passenger km estimated through our air market overlay. – I.e. we exclude the transfer from air travel.

We assume in the appraisal that any reduction in emissions from a transfer from air to rail is cancelled out by an equivalent reduction in Emissions Trading Scheme (ETS) payment which is typically included in air fares, but not in rail fares.

2.3 Revenue

This is the net increase in GB rail revenue generated by the introduction of the proposed new services. This is estimated in our revenue model.

2.4 Other Government impacts

Value Added Tax (VAT)

This is foregone VAT from the forecast switch from road to rail travel, assuming increased expenditure on rail travel (which does not incur VAT), is funded through an equivalent reduced expenditure on goods and services which do incur VAT.

The revenue model provides the source data for this calculation.

Taxation on road vehicle fuel

This is the foregone indirect taxation paid on fuel caused by the forecast switch from road to rail travel

Fuel duty on diesel trains

This is increased fuel duty from an increase in diesel train mileage. Our train planning work (see below) provides the source data for this calculation.

Highway maintenance costs

We also estimate a reduction in highway maintenance costs to local authorities and Highways England. For simplicity, this estimated cost saving is included in this category. This is likely to be a very small impact resulting from the switch from road to rail travel mentioned above. Again, the revenue model provides the source data for this calculation.

2.5 Operating costs

We undertook a rolling stock and staff planning exercise to provide source data for the assessment of operating costs. Table 1 below shows our estimate of the operating requirements for all options, included at this stage for information purposes.

We estimate the net increase in operating costs required to provide the proposed new services.

Staff costs

This is the estimated cost of the net increase in drivers and conductors required to operate the proposed new services.

Rolling stock costs

This is the net cost of procuring and maintaining the rolling stock that is required to operate the proposed new services. ORR has instructed us to assume that all rolling stock required to operate the options considered is incremental, regardless of current procurement arrangements.

We have estimated the per vehicle cost of rolling stock procurement (capital and non-capital/maintenance) based on market tested prices, and where necessary have validated this information using evidence submitted by track access applicants. Our unit cost estimates, and the information used to produce them are confidential, and are not shown in this report.

Network Rail Charges

This comprises the main variable usage changes payable to Network Rail, calculated on the basis of the estimated net change in vehicle mileage by rolling stock type. All charge rates are taken from Network Rail's CP5 price list as charges for CP6 and beyond have not yet been set by ORR.

The following costs are estimated:

- Variable usage charge (VUC);
- Electric current for traction (EC4T);

- Electrification asset usage charge (EAUC); and
- Capacity charge. We assume that all passenger operators pay the capacity charge at same rate, reflecting incremental costs on disruption. ORR's policy on discounts for certain types of operators that applies in CP5 does not reflect underlying cost.

Station access charges have been excluded from this category as we are unable to estimate them at this stage, although we would expect these charges to be broadly in proportion to other variable usage charges.

Other operating costs

This is the cost of diesel (bi-mode) traction for the proposed services which would operate on track sections which are not electrified.

Table 1. Estimated operating requirements

Option ID	Option	Rolling stock	Unit diagrams (excluding maintenance spares)	Train miles (annual)	Drivers	Guards/ Conductors
1	Alliance Yorkshire/ Cleethorpes	Class 800/801 5 car	6	1.8m	32	30
2	Alliance Edinburgh	Class 390 9 car	12	4.5m	57	53
3	VTEC Core	IEP 9 car (average)	9	3.3m	43	40
4	VTEC Lincoln/Harrogate	IEP 5, 9, 10 car	2	0.2m	5	5
5	VTEC Bradford Forster Square	No appraisal required (ORR instruction)				
6	VTEC Middlesbrough	IEP 5 car + cascade IC225 2+7 car	3	0.8m	14	13
7	First Edinburgh	Class 800/801 5 car	4	1.4m	27	25
8	VTEC Full	IEP 5, 9, 10 car IC225 2+7 car	15	4.4m	65	61
9	First Edinburgh as submitted	Class 800/801 5 car	5	1.4m	27	25
10	VTEC Core & Alliance Yorks./ Cleethorpes	See option 8 and option 1				
11	Alliance Edinburgh non-tilt (assume as per option 2)	Class 390 9 car	12	4.5m	57	53
12	VTEC Middleborough offset	No appraisal required (MOIRA test only)				
13	VTEC Middleborough switch	No appraisal required (MOIRA test only)				
14	VTEC Full no overtake	No appraisal required (MOIRA test only)				
15	First Edinburgh no overtake	Class 800/801 5 car	5	1.4m	27	25

3. Other appraisal issues

Some factors have been raised by stakeholders which are not included in the economic appraisal. These factors are detailed below.

3.1 Fixed costs

As the economic appraisal is required to assess the incremental impacts of the proposed new services, fixed costs (e.g. administrative costs, fixed track access charges) have been excluded from the assessment. We acknowledge that the main types of fixed costs are likely to differ between Franchised Operators and Open Access Operators, however we believe our approach to be reasonable for the purposes of ORR's assessment.

As previously stated, ORR has instructed us to assume that all rolling stock required to operate the options considered is incremental, regardless of current procurement arrangements. The impact of this assumption will be clearly reported in our appraisal results.

3.2 Capital costs

Capital costs that are integral to applications, for example funding improvements in rail infrastructure, will be taken into account in appraisal and in ORR decision making. As we do not have robust quantified values, however, ORR has instructed us to leave these items unquantified.

3.3 Train punctuality

The impact of the option timetables on train punctuality, hence demand and revenue, is not modelled explicitly, though the appraisal includes the capacity charge, which reflects the impact of the services on levels of Network Rail reactive delay. We have not appraised train punctuality explicitly because performance assessment work undertaken to date is inadequate for this purpose. The work has only quantified the performance impact of one and two trains per hour in addition to the current timetable, and not the impact of the various options.

ORR would therefore need to consider separately the extent to which our assessment may overstate the revenue impacts and benefits to passengers of the options assessed.

3.4 Competitive response from other operators

Reflecting the complexity of modelling these effects and on instruction from ORR we have made no assumptions about a competitive response from air operators and coach operators, in terms of either fares or service levels.

ORR would therefore need to consider separately the extent to which our assessment may overstate or understate the revenue impacts and benefits to passengers of the options assessed.

3.5 Impact on other parts of the economy

Consistent with standard appraisal practice and with assumptions regarding a well-functioning economy, we have not appraised the impact of revenue being transferred from other parts of the economy to rail, on the assumption that the other parts of the economy can reduce their costs as a result of the fall in output by a commensurate amount. It is hence not necessary in appraisal (leaving aside any question of the relevance to ORR's statutory duties) to assess the impact of the services on lost revenue to airlines or to various leisure activities.

4. Presentation of appraisal results

We report three sets of appraisal results for each option.

Net Present Value (NPV)

This is the benefits minus the costs, and is one of the standard ways of reporting appraisal results as set out in the Green Book.

Net Present Value (NPV) per path

This is the NPV divided by the number of train paths[2] used per weekday. This is a means of assessing the economic value of proposed services, versus a measure of the track capacity that they would be likely use. This is a simple approach to the measurement of capacity used, as capacity usage varies by service characteristics such as train speed, acceleration and stopping pattern.

Present Value of Benefits (PVB) per path

This is sum of all quantified benefits divided by the number of paths[3] used per weekday.

5. General appraisal assumptions

5.1 Appraisal period

The economic appraisal quantifies the incremental benefits and costs of the options considered, over an appraisal period of 10 years. This is assumed to be the likely duration that access rights would be granted for. It is assumed that all options would commence operation in 2020, so that all options are assessed over a consistent time period.

5.2 Exogenous growth

Exogenous growth at a rate of 2.25% per annum is assumed for all flows. This is consistent with the range of forecasts for ECML flows published in Network Rail's Long Distance Passenger Market Study.[4]

5.3 Demand ramp up

Consistent with PDFH, we assume for all options that the annual demand projections from the revenue model take 4 years to fully materialise, as follows:

- year 1 x 70% of forecast growth realised
- Year 2 x 85% of forecast growth realised
- Year 3 x 95% of forecast growth realised
- Year 4 x 100% of forecast growth realised

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[2] Paths in either direction through one or more constrained track sections as described above

[3] Paths in either direction through one or more constrained track sections as described above

5.4 Indexation

Costs and revenues are indexed at RPI with the exception of Rolling stock procurement, for which information on indexation is confidential.