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**Origin -
Destination
Matrix**

2009/10

Summary Report



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Executive Summary

The Origin Destination Matrix (O-D Matrix) forms a vital part of the Office for Rail Regulation's (ORR) information about how passengers travel on the railways in England, Wales and Scotland. The O-D Matrix gives information for revenue and journeys, by ticket type, for over 2.1 million different origin - destination - route flows around the country.

This report is provided with the O-D Matrix file, and gives guidance to the methodology that has been followed during the process of creating the final matrix for financial year 2009/10 (1st April 2009 to 31st March 2010).

The O-D Matrix shows the numbers of journeys made, and resulting ticket revenue and passenger miles, for each pair of origin and destination stations in Great Britain. Where tickets are offered via different routes, the demand data is also broken down into those routes. It is used as the source for the regional usage profiles in ORR's National Rail Trends publications. If further data is needed ORR may be able to respond to additional queries.

Tickets are offered between every pair of stations in Great Britain, though not all combinations register a sale in any particular year. This year about 3000 origins and destinations were registered (of which 2525 were 'true' national rail stations included in the station usage matrix). The O-D Matrix for 2009/10 contains over 2.1 million records, each relating to a different origin-destination-route code combination, out of the possible nine million possibilities. Within each record, journeys and revenue figures are split between eight different ticket types.

While LENNON is the major source of data for the O-D Matrix, it is augmented by a range of additional data sources to provide a more complete representation of travel on the national rail network (since 2008/09, major urban 'PTE' area tickets are now included).

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1 Introduction

DeltaRail has provided a series of Origin Destination Matrices (O-D Matrices) for the rail industry in previous years. This report gives details of the process and outputs in producing the O-D Matrix for financial year 2009/10, on behalf of the ORR. The revenue and journey data has mainly been taken from the ticket sales recorded in the LENNON database. Data for tickets that are sold outside the LENNON system (journeys made on London Travelcards, major urban 'PTE'¹ area tickets, and Stansted and Gatwick Airports links) has also been included in the O-D Matrix.

The generation of the O-D Matrix has been integrated with the demand matrix in MOIRA, the rail planning tool used by the rail industry. This brings substantial benefits as MOIRA includes an estimate of journeys and revenue made on products sold by Passenger Transport Executives (PTEs), to provide a more complete representation of travel on the national rail network.

2 Matrix Definition

The O-D Matrix contains revenue, journeys and passenger miles data for each flow on the network. A flow is defined as an origin station / destination station / ticket route code combination. Since this dataset is designed to show passenger journeys made, rather than "producer-attractor" figures, season tickets and return tickets have been split equally into the two directions of travel.

The fields included in the O-D Matrix are:

Field	Description
Mode	This variable is used to categorize the source of the passenger journey data. Refer to the table below.
Origin (NLC, name)	Based on ticket origin, assumed to be where passenger starts his/her journey.
Destination (NLC, name)	Based on ticket destination, assumed to be where passenger ends his/her journey.
District, County, Region and NUTS2 Region & Code for Origin	Origin's geographical location.
District, County, Region and NUTS2 Region & Code for Destination	Destination's geographical location.

¹ It should be noted that for convenience and clarity, we continue to refer to Passenger Transport Executives (PTEs) in this report, though they are officially now designated Integrated Transport Authorities and Strathclyde Partnership for Transport.

Route Code and Description	Route code and description on ticket as recorded by LENNON.
Dist	Distance in miles between origin and destination derived from LENNON.
Revenue	Revenue for each flow split into the eight ticket types. It is also summarised into the four main categories (Full, Reduced Excluding Advance, Advance and Seasons) and a Reduced category (Reduced plus Advance) and summarised in total.
Journeys	Journeys for each flow split into the eight ticket types. It is also summarised into the four main categories (Full, Reduced Excluding Advance, Advance and Seasons) and a Reduced category (Reduced plus Advance) and summarised in total.
Passenger Miles	Miles the passengers travelled - effectively journeys multiplied by a station to station distance derived from LENNON.
Group Station (NLC, name) for Origin	If the origin is part of a Group Station, the NLC and name is provided, otherwise this field is blank.
Group Station (NLC, name) for Destination	If the destination is part of a Group Station, the NLC and name is provided, otherwise this field is blank.
Flag	Flag = 0 (no problem), 1 (flow has failed a check), or 2 (flow has failed a check and may be significant).

Mode	Description
NR Sold Non-Tcard	Sold by National Rail, point to point
TfL Sold Tcard	London Travelcards sold by Transport for London
NR Sold Tcard	London Travelcards sold by National Rail
PTE Sold	Sold by a PTE
Airline Sold	Ticket sales for routes serving Airports, where tickets do not go through LENNON

3 Base Data

3.1 Overview

The O-D Matrix produced for the ORR is created from the MOIRA Replacement Demand Matrix. Prior to 2008/09, the O-D Matrix was created directly from LENNON² ticket sales, with the addition of infills for London Travelcards and Airport links. The use of the MOIRA Replacement Demand matrix is a significant change in the creation of the O-D Matrix from 2008/09. The O-D Matrix is now consistent with the rail industry's principal planning tool, and now includes an estimate of journeys and revenue made on zonal products sold by PTEs and so provides a more complete representation of travel on the national rail network.

3.2 Underlying Base Data - LENNON

The underlying matrix of ticket sales and associated journeys and revenue used in the current MOIRA model is derived from LENNON. It is based on an extract from LENNON, produced by Atos Origin, of total sales revenue and journeys for the year, broken down by flow (origin and destination) route code and by product type (CTOT). However, as there are known omissions in this data in respect of TfL and PTE zonal tickets, and non-RSP tickets on some airport services, there needs to be a “matrix infilling” exercise undertaken to estimate a complete origin-destination matrix.

Infilling is required as there are some journeys/revenue which do not appear in the underlying matrix, related to particular ticket types. There are three main such cases:

- Tickets with non geographical destinations, e.g. zonal products, Rovers
- Tickets sold at some non National Rail (RSP: Retail Settlement Plan) outlets, e.g. newsagents
- Tickets which do not appear in LENNON at all. This includes some TOC tickets on airport flows, also for those TOCs which fall outside the Rail Settlement Plan.

Certain tickets with destination codes that are not national rail stations are included in the MOIRA Replacement demand matrices, being mapped to the corresponding rail station. These Rail Links usually include a third party element, such as to a bus zone, or tourist attraction. The MOIRA Replacement demand matrix includes the journeys and the net revenue associated with such tickets. Refer to the MOIRA Replacement Documentation for a list of the codes affected.

3.3 Net Revenue

The MOIRA Replacement demand matrix contains Net Revenue based on the Net Revenue field in LENNON. Travelcard revenue in MOIRA Replacement is Net (rather than Gross) i.e. excludes revenue paid by ATOC to TfL for travel on the London Underground and on buses. Similarly, PTE revenue is net i.e. for multi-modal tickets only revenue for travel on national rail services is included.

² LENNON is the Rail Industry's ticketing and revenue system

3.4 Ticket Type Definitions

Within the base demand matrices, journeys and revenue have been sub-divided into eight ticket types:

1. Full: all walk-up undiscounted single or return tickets, whether or not issued with a status discount (child, railcard etc)
2. Reduced: all walk-up discounted single or return tickets, whether or not issued with a status discount (child, railcard etc)
3. Advance: all advance-purchase tickets
4. Seasons: all multi-use tickets

Each of these four types is further split by First & Standard Class.

Prior to 2008/09 ten 'Ticket Pots' were used. Eight ticket types are used from 2008/09 as a consequence of integrating with MOIRA's demand matrix. This difference should be considered when using the historic data.

Station Groups: Where a town or city has more than one station, a 'Station Group' may be defined in LENNON, containing all or some of those stations. Most tickets are valid to the group, rather than just an individual station. For instance the Birmingham Group contains New Street, Snow Hill and Moor Street stations, though not Birmingham International. See paragraph 5.1.

3.5 Infills for London Travelcards, Major Urban Areas (PTE) & Airports

There are certain areas within the underlying matrix where demand and revenue are under-estimated, in particular:

- **Within London Travelcard area.** Whilst the underlying matrix includes an estimate of journeys made on Day Travelcards / Travelcard seasons purchased at National Rail stations, it does not include a significant number of national rail trips made using Travelcards purchased at Tube stations, travel shops and newsagents.
- **Within Passenger Transport Executive (PTE) areas.** The underlying matrix excludes virtually all rail trips made on PTE-sponsored tickets, which are usually zonal and often multimodal.
- **Trips to/from Airports.** The underlying matrix includes many trips to/from airports, but excludes all Heathrow Express journeys, and some tickets sold for Gatwick Express, Stansted Express and other airport operators.

There are also other ticket sales which are not included in the underlying matrix, but these are disparate in nature and insignificant (other than at a very local level) and so the matrix infilling covers the three flow types identified above. It should also be noted that journeys with no associated ticket sales such as staff travel, and particularly fare evaders, are not including in the origin-destination matrix.

The two major "infills" are for the London Travelcard area (sales made by Transport for London (TfL)), and for PTEs³, since in both cases a substantial proportion of the rail

³ It should be noted that for convenience and clarity, we continue to refer to Passenger Transport Executives (PTEs) in this report, though they are officially now designated Integrated Transport Authorities and Strathclyde Partnership for Transport.

journeys made use multimodal travelcard type of tickets. The TfL infill has been undertaken based on the process used within current MOIRA for the last two years. The major urban area (also referred to as “PTE”) infill is based on the methodology used in the Department for Transport’s (DfT) Network Modelling Framework (NMF), updated in light of new PTE products becoming available.

The third infill, for Airports, estimates the significant number of rail journeys on Gatwick and Stansted Express, made on tickets sold outside of the RSP system i.e. not sold by National Rail outlets. Journeys on Heathrow Express are excluded from the MOIRA Replacement Demand Matrix.

4 Data Excluded From the Study

Some of the LENNON data has been excluded from the MOIRA Replacement Demand Matrix, and subsequently from the O-D Matrix.

All the products that were classified into the 'miscellaneous' ticket pot were excluded. These products were:

- Car Parking
- Railcard Sales
- Penalty/Excess Fares
- Seat Reservations
- Sleeper Supplements.

Also excluded from the analysis were all the flows that had either an Origin or Destination that did not represent a geographical location (these are mainly "I codes"), e.g.

- Rover and Ranger Tickets (e.g. Anglia Plus)
- BritRail Tickets
- Gate passes usually used by staff
- Passenger Charter Discounts
- Headquarters Input Items, other than those which can be identified as TfL or PTE

Finally for flows that have either Origin or Destination a Private Settlement Code some are included and some are excluded.

- PTE tickets and TfL sold London Travelcard records from Lennon are removed, and replaced with an estimate of all rail travel using these tickets via 'infill's to the MOIRA demand matrix (refer to Section 2).
- PlusBus – all significant flows have been included since 2007/08 (refer to Section 2), and minor flows are excluded.
- Attractions – the rail element of the significant flows have been included since 2007/08, which include:
 - Bluewater Shopping Centre
 - Alton Towers
 - Whipsnade
 - Chatsworth House
- All other flows involving Private Settlement are excluded, e.g. Irish Stations.

5 Recent Improvements to O-D Matrix Methodology

The accuracy and usefulness of the results shown in the O-D Matrix continue to improved, where new methods can be derived or new data becomes available. The improvements described here were undertaken over 2006/7, 2007/08, 2008/09 and 2009/10. This was achieved by applying new procedures on the way journeys with unknown origin and/or destination are processed, and by including journeys that were previously excluded from the file, or did not appear in the LENNON sales data.

5.1 Summary of Recent Improvements

In summary, the main changes were:

- Adding in previously missing journeys, e.g. TfL sold Travelcards, some airport link tickets, and major urban 'PTE' area tickets.
- Estimating the split of records for station groups, including London BR, into the constituent individual stations.
- Dealing with Travelcard "Joint Stations" in a more helpful way, i.e. those stations where the ticket office serves both LUL and national rail stations.
- Rail Links such as PlusBus and Attractions. The rail element of these ticket sales is now included.

5.2 Passenger Mileage

From 2006/7 onwards, passenger mileage is included in the O-D matrix. This is calculated based on the same file of station-to-station distances that is used in LENNON.

5.3 Station Geography

For all rail stations, the District, County, Region and NUTS2 Region & Code are provided for the origin and destination to describe the geographical location.

The source of this data is:

- District or the Unitary Authority – ATOC (dated January 2008) and ORR (dated January 2008)
- District, County & Region – ONS⁴ website (dated January 2008)
- NUTS2 Code and Description – ORR (dated January 2010)

⁴ http://www.statistics.gov.uk/geography/geographic_area_listings/administrative.asp#04

6 Limitations of the LENNON data

The LENNON database captures ticket sales for the entire national rail network from many different input machines. It is primarily an accounting tool and therefore faces limitations when being used for statistical reporting. With all large data sources there may be input errors. Such errors are more likely to occur in the journeys, rather than revenue fields. We perform checks on the data, but due to the size and complexity of the dataset we are not able to validate each and every entry.

We have used similar information extensively in the last ten years or more, and have found the data to be reliable, particularly when examining the data at an aggregated level.

There are a number of areas where we know that LENNON does not capture the data precisely, or instances where it is not possible to derive passenger journeys from ticket sales data. These areas are expanded upon below.

6.1 Known Problems of Data Capture

The data in LENNON from which the O-D Matrix is derived is based on ticket transactions. In order for the data to be included in the O-D Matrix it must include an origin station and a destination station. Section 4 lists those cases where this cannot be achieved, and the data is excluded.

6.2 Travelcards

In London and conurbations around the country, a significant portion of rail travel is made on zonal, often multi-modal products allowing bus and metro travel also. Many of these tickets are sold at non-rail outlets, for example newsagents. This poses two problems:

- Origins and destinations of journeys are not identified by the ticket information (as indicated in Section 4, type 1.)
- Many of the ticket sales do not enter into the LENNON system at detailed level at all.

For London, the sales of Travelcards are significant enough to warrant special treatment of both issues. LENNON data is augmented by sales of Travelcards from non-rail outlets. Then a special exercise is undertaken to convert the zonal information to actual stations, using a combination of the Travelcard Diary Survey, and the London Area Travel Survey (LATS).

For other conurbations (i.e. Birmingham, Strathclyde, Leeds, Liverpool, Manchester, Newcastle and Sheffield) a special exercise has been undertaken, so zonal and multimodal products, also ticket sales at non-rail outlets, are included from the O-D Matrix. This is an improvement that has been introduced from 2008/09.

6.3 Return and Single Journey Tickets

It is possible that on certain routes the cost of a return ticket could be lower than a single ticket. This leads to the cheaper return ticket being purchased even though the passenger has no intention of making the return journey by rail. This results in two journeys being recorded instead of one.

6.4 Multiple Tickets

Special ticket offers may only be available between certain stations, for example under a promotion by one of the train companies. In these cases a local ticket may be bought to gain access to a main station, and a second special offer ticket bought for the main leg of the journey. This results in two journeys being recorded in the O-D Matrix and will not accurately represent the through rail journey being undertaken.

6.5 Rail Staff Passes

Prior to the privatisation of the rail network, British Rail employees and their families were eligible for free or reduced rate rail travel, a benefit which has continued for certain staff. While representing a very small proportion of travel, such journeys will not be recorded in the O-D Matrix.

6.6 Ticketless Travel / Fare Evasion

Across the rail network, there will usually be a small proportion of passengers who travel without purchasing a ticket. This is referred to as ticketless travel. Since LENNON data is derived from ticket transactions, it cannot reflect this travel.

6.7 Other Rail Systems

There are a number of rail systems in operation in the country that are not covered by LENNON. For Heathrow Express and Eurostar revenue and journeys data were not available.

In addition some tickets of franchised operators may be sold outside LENNON, for example Hull Trains, Grand Central and Wrexham & Shropshire. However, note that for the main two such cases, Gatwick Express and Stansted Express, data has been included since 2006/07.

