



# Northern Ticketless Travel Report



## Contents

1	Executive Summary .....	1
1.1	Key findings .....	1
1.2	Conclusions and next steps .....	4
2	Introduction, methodology and sample collected .....	5
2.1	Introduction .....	5
2.2	On-train survey methodologies – our approach explained .....	5
2.3	Limitations of the on-train survey methodology .....	6
2.4	Alternative methodologies – station cordon-based surveys .....	6
2.5	Sample collected .....	7
2.6	Cleaning and validation of survey data .....	9
3	Results .....	10
3.1	Irregularity rates by time period and service group .....	10
3.2	Results by type of irregularity .....	11
3.3	Estimated revenue at risk rates .....	12
3.4	Confidence intervals around our estimates .....	14
3.5	Estimated revenue at risk in monetary terms .....	15
3.6	Conclusions and next steps .....	16
4	Appendix A .....	17
	Table 1 Lower and upper bound estimates of revenue at risk, underlying assumptions .....	1
	Table 2 Lower and upper bound estimates of revenue at risk .....	2
	Table 3 Revenue at risk by time period, lower and upper bound estimates .....	2
	Table 4 Indicative revenue at risk, £m and percentage share .....	3
	Table 5 Breakdown of irregularity types for passengers with invalid tickets and no tickets .....	3
	Table 6 Frequency of incidents preventing surveys being completed .....	7
	Table 7 Sample size by service group and time period .....	8
	Table 8 Sample size obtained against target .....	8
	Table 9 Weighted and un-weighted irregularity rates, upper bound estimates .....	10
	Table 10 Weighted and un-weighted irregularity rates, lower bound estimates .....	11
	Table 11 Breakdown of irregularity types for invalid tickets and no tickets .....	12
	Table 12 Assumptions on average loss of yield by irregularity type .....	12
	Table 13 Weight and un-weighted revenue at risk, upper bound estimates .....	13
	Table 14 Weight and un-weighted revenue at risk, lower bound estimates .....	14
	Table 15 95% confidence intervals around revenue at risk, upper and lower bound estimates .....	15
	Table 16 Indicative revenue at risk in monetary terms, lower and upper bound estimates .....	15

## 1 Executive Summary

There are a significant number of stations on the Northern network which are open, un-staffed and lacking ticketing facilities. As such, many journeys are made by individuals without paying a fare, whether out of choice or due to a lack of opportunity to purchase a ticket at stations or on the train. The purpose of the survey is to provide an estimate of ticketless and fraudulent travel across the Northern franchise which would be used to understand the extent of this problem.

This document contains the findings of a ticketless travel survey undertaken between 27<sup>th</sup> September and 9<sup>th</sup> November 2014 on the Northern Rail network. Specifically, a report on the levels of ticketless travel and revenue at risk is provided, along with an overview of the methodology adopted for the survey.

### 1.1 Key findings

The key findings of the survey are:-

- A total of 82,133 observations were collected during the survey across 10 service groups and 5 time periods. The survey data collected has been used to produce weighted estimates of revenue at risk which produce representative estimates by service group, time period and for the Northern franchise as a whole.
- The upper bound estimate of revenue at risk is 11.5% - this is based on the assumption that passengers surveyed without a ticket do not purchase one on the train or at the destination station.
- The lower bound estimate of revenue at risk is 6.6% - this assumes that all passengers giving the reason for not having a ticket as 'lack of facilities on train or at station' eventually purchased a ticket during their journey.

Table 1 summarises the difference in lower and upper bound estimates of revenue at risk, based on proportion of revenue lost through assumptions on those without a ticket.

**Table 1 Lower and upper bound estimates of revenue at risk, underlying assumptions**

Estimate	Assumption	Change (%)	Revenue at risk rate (%)
<b>Upper bound</b>			<b>11.5</b>
- <i>Assumption 1</i>	Assume those without a ticket due to 'lack of facilities at station' will buy a ticket later in their journey	-4.7	
- <i>Assumption 2</i>	Assume those without a ticket due to 'lack of facilities on train' will buy a ticket later in their journey	-0.2	
<b>Lower bound</b>			<b>6.6</b>

Source: Sky High, 2013/14 LENNON database, CH2M HILL analysis

The main difference between the two estimates is the assumption behind whether those surveyed on the train who state that they did not have the opportunity to buy a ticket due to lack of facilities at the station will eventually buy a ticket. These passengers could have bought a ticket from the conductor or at the destination station after the survey was completed.



Table 2 illustrates upper and lower bound estimates of revenue at risk for each service group:

**Table 2 Lower and upper bound estimates of revenue at risk**

#	Service Group Description	Lower bound (%)	Upper bound (%)	Range (+/-%)
ED01	Tyne, Tees & Wear	6.5	7.9	1.4
ED02	Lancashire & Cumbria	6.9	13.8	6.9
ED04	West & North Yorks Inter Urban	4.5	7.5	3.0
ED05	West & North Yorks Local	5.5	11.8	6.3
ED06	South & East Yorks Inter Urban	3.7	7.0	3.3
ED07	South & East Yorks Local	4.7	7.7	3.0
ED08	North Manchester	7.5	13.0	5.5
ED09	Merseyrail City Lines	8.3	11.7	3.4
ED10	South Manchester	11.1	19.1	8.0
<b>TOT</b>	<b>Overall</b>	<b>6.6</b>	<b>11.5</b>	<b>4.9</b>

Source: Sky High, 2013/14 LENNON database, CH2M HILL analysis

Based on the lower bound estimates, our findings show that the service groups with the highest revenue at risk rates were South Manchester (11.1%) and Merseyrail City Lines (8.3%). The lowest revenue at risk rates were on South & East Yorkshire Inter Urban (3.7%) and West & North Yorks Local (5.5%).

Table 3 illustrates the revenue at risk rates by time period.

**Table 3 Revenue at risk by time period, lower and upper bound estimates**

Time period.	Lower bound (%)	Upper bound (%)	Range (+/-%)
06:00 to 09:59	6.9	13.3	6.4
10:00 to 15:59	5.6	9.9	4.3
16:00 to 18:59	7.4	10.8	3.4
19:00 to 23:59	7.1	12.4	5.3
Weekend	6.4	11.6	5.2
<b>Overall</b>	<b>6.6</b>	<b>11.5</b>	<b>4.9</b>

Source: Sky High, 2013/14 LENNON database, CH2M HILL analysis

Based on the lower bound estimates, the revenue at risk rate is highest during the PM peak (7.4%) and lowest during the Inter-Peak period (5.6%).

The indicative lower and upper bound revenue at risk in monetary terms for each service group is presented in descending order in

Table 4.

Table 4 Indicative revenue at risk, £m and percentage share

Service Group No.	Service Group Description	Lower bound (£m)	Upper bound (£m)
ED01	Tyne, Tees & Wear	1.0	1.3
ED02	Lancashire & Cumbria	1.9	4.1
ED04	West & North Yorks Inter Urban	2.1	3.6
ED05	West & North Yorks Local	1.9	4.4
ED06	South & East Yorks Inter Urban	0.6	1.3
ED07	South & East Yorks Local	0.9	1.6
ED08	North Manchester	1.8	3.4
ED09	Merseyrail City Lines	1.8	2.6
ED10	South Manchester	4.3	8.1
<b>TOT</b>	<b>Overall</b>	<b>16.5</b>	<b>30.4</b>

Source: Sky High, 2013/14 LENNON database, CH2M HILL analysis

Based on 2013/14 LENNON ticket sales data, indicative revenue at risk on the Northern franchise is between £16.5m and £30.4m.

The survey findings show that a total of 85.6% of passengers surveyed had a valid ticket. Of the remaining passengers, a total of 9.1% declared they had no ticket, 4.0% refused to show their ticket and 1.2% had an invalid ticket. Table 5 illustrates the main irregularities occurring on the Northern franchise in descending order of prevalence.

Table 5 Breakdown of irregularity types for passengers with invalid tickets and no tickets

Irregularity type	Irregularity rate (%)
No Ticket - Lack of facilities at station	5.0%
No Ticket - Lack of time	2.7%
No ticket - Does not have a ticket (no reason)	1.1%
Ticket used at invalid time	0.6%
No Ticket - Lack of facilities on train	0.2%
Overriding	0.2%
Journey taken after valid date	0.2%
Child Impersonation	0.1%
Misuse of railcard: cannot present appropriate card	0.1%

Source: Sky High, CH2M HILL

The most prevalent reason for an irregularity was passengers who did not have a ticket, giving the reason that there was a lack of facilities at the station they came from (5.0%). This was followed by those stating that there was a lack of time to purchase one (2.7%).



## 1.2 Conclusions and next steps

The indicative revenue at risk estimates and ticketless travel rates provide an understanding of the service groups which represent more value for money additional revenue protection measures should be considered. There are a number of factors that could be driving the observed levels of irregularities across each service group:-

- A particular *service code* within a service group which has a substantially higher rate of ticketless travel compared to other codes within the same group;
- The number of destination stations without ticket gates/manual gate lines or origin stations without ticket vending machines;
- The levels of risk associated with fare evading e.g. short journeys are likely to carry less risk of getting caught;
- The price of an average fare relative to the disposable incomes of passengers using the service.

It is recommended that the above factors are explored further in order to understand the underlying differences in ticketless travel between the service groups.



## 2 Introduction, methodology and sample collected

This section sets out the purpose of the ticketless travel survey and the methodology that was undertaken. Specifically, we outline the on-train survey methodologies used. We also explain why on-train surveys were adopted instead of alternative methodologies i.e. station cordon-based surveys. A qualitative report on the reasons for individual surveys recording a limited number of interviews due to certain conditions on board trains is also provided.

### 2.1 Introduction

There are a significant number of stations on the Northern network which are open, un-staffed and lacking ticketing facilities. As such, many journeys are made by individuals without paying a fare, whether out of choice or due to a lack of opportunity to purchase a ticket at stations or on the train. The purpose of the survey is to provide an estimate of ticketless and fraudulent travel across the Northern franchise which would be used to understand the extent of this problem.

In addition, we provide an indication of the relative levels of ticketless travel across service groups and time period. These rates are monetised in terms of the revenue at risk for each segment.

### 2.2 On-train survey methodologies – our approach explained

On-train surveys requiring surveyors to board and interview passengers on a randomly selected carriage were utilised. As conductors are present selling tickets on Northern trains, surveyors were instructed to first seek out the conductor and present a letter of authority from Northern and also provide an explanation of the survey. In the event that the conductor was not located on the train, the survey was not started.

When beginning the survey, an announcement was made to all passengers in the carriage, stating that a survey looking at ticket usage was being conducted. Surveyors worked in pairs from either end of the carriage, checking each ticket until all were checked or the remaining passengers had alighted. Once a carriage was surveyed the team move to the next carriage until the entire train was surveyed or they had to alight themselves. After this, the survey is completed and the team board the next train on their schedule.

Surveys were conducted on the following dates:-

- All days between Saturday 27<sup>th</sup> September and Saturday 25<sup>th</sup> October 2014 inclusive
- The week after half-term holidays between Monday 3<sup>rd</sup> November and Sunday 9<sup>th</sup> November

#### Change in survey methodology

The initial methodology (used between 27<sup>th</sup> September and 3<sup>rd</sup> October 2014) asked the conductor whether he/she had already checked tickets on the entire train and if this was the case, the survey was suspended. This methodology resulted in a significantly high number of suspensions as in many cases the conductor had already checked tickets on the train. As such, there was a **change in survey methodology from 4<sup>th</sup> October to 9<sup>th</sup> November**.



The change in methodology still required surveyors to locate the conductor on the train, but the survey was undertaken regardless of whether passengers on board had already had their tickets checked.

### 2.3 Limitations of the on-train survey methodology

As indicated in our introduction, there are particular characteristics associated with the Northern rail franchise which make it more susceptible to ticketless travel. The relatively high proportion of un-gated stations without ticketing facilities may encourage ticketless travel unintentionally. In order to mitigate this, every Northern train is patrolled by a conductor who checks and sells tickets.

Our on-train survey methodology captures the presence of the conductor on board the train to a certain extent. Passengers who have already had their tickets checked or been sold a ticket by the conductor are included in the survey. Those passengers boarding a train without a ticket during the survey are recorded as ticketless travel if they are interviewed and **still have no ticket**.

Of course, it is not clear whether individuals on the train will eventually purchase a ticket from the conductor or whether they will alight before they have the opportunity to do so. Nor is it clear whether they will buy a ticket from the station they are alighting at. As such, we have sought to provide two estimates of the rate of ticketless travel:-

**Lower bound estimate** – this figure is based on the assumption that those stating they had no ticket because of a ‘lack of facilities on train or at the station’ will eventually buy a ticket from the conductor or at the destination station.

**Upper bound estimate** – this figure assumes all those without a ticket deliberately fare evade or unconscientiously do not purchase a ticket during their journey.

### 2.4 Alternative methodologies – station cordon-based surveys

A number of alternative methodologies could be deployed in order to measure levels of ticketless travel. An alternative methodology could draw on the use of cordon-based surveys at stations where a team of four or more surveyors check passengers’ tickets on entry to and/or exit from the station. Such a methodology would acknowledge that the destination station represents the location where there is a final and last opportunity for Northern customers to purchase a ticket for their journey. This method may result in a more accurate measure of fare evasion being captured, but there are a number of reasons why this method was not chosen:-

- **A large number of stations to be surveyed and greater resource required** – survey teams large enough to cover the entrances and exits of stations across whole of the Northern network would be required. A significant team of surveyors would be needed to interview all passengers exiting from gated termini stations and un-gated stations.
- **Presence of surveyors at stations may bias results** – situating surveyors within the ticket halls of un-gated stations may bias results as would-be fare evaders would then purchase a ticket. Positioning surveyors outside the exits of stations would mitigate risk but this could then result in a higher refusal rate and/or individuals claiming to have disposed of their ticket.





Based on the above, this methodology may not represent value for money for the Department given the scale of resources required and the limitations of this approach.

## 2.5 Sample collected

Between 27<sup>th</sup> September and 9<sup>th</sup> November 2014, a total of 82,133 observations were collected against a sample target of 85,000. A sample target of 85,000 was chosen to ensure that robust estimates of ticketless travel was obtain for each service group by time period.

The shortfall in the sample target was mainly due to surveys being suspended for the reasons outlined in Table 6 which illustrates the frequency of incidents leading to a either none or a limited number of records being collected for 440 surveys on the Northern network.

**Table 6 Frequency of incidents preventing surveys being completed**

Service Group No.	Service Group Description	Guard halted survey part way through	Guard prevented survey commencing	RPA boarded train	Train too congested	Other	Total incidents
ED01	Tyne, Tees & Wear	0%	48%	4%	13%	35%	23
ED02	Lancashire & Cumbria	15%	8%	0%	62%	15%	39
ED04	West & North Yorks Inter Urban	13%	19%	4%	60%	4%	47
ED05	West & North Yorks Local	20%	28%	13%	29%	11%	80
ED06	South & East Yorks Inter Urban	23%	38%	0%	31%	8%	13
ED07	South & East Yorks Local	0%	41%	3%	44%	13%	32
ED08	North Manchester	0%	8%	0%	78%	14%	37
ED09	Merseyrail City Lines	16%	7%	0%	49%	28%	43
ED10	South Manchester	43%	13%	0%	27%	17%	126
<b>TOT</b>	<b>Total</b>	<b>21%</b>	<b>20%</b>	<b>3%</b>	<b>41%</b>	<b>15%</b>	<b>440</b>

Source: Sky High, CH2M HILL analysis

A total of 440 surveys were suspended during the work, of which 41% were due to guards/conductors halting the survey or preventing the survey from commencing. An additional 41% of the suspended surveys were due to trains being too congested to survey. The 'Other' category mainly constituted tablet failures or delays/cancellations of train services. shows the sample collected for each service group by time period.

Table 7 shows the sample collected for each service group by time period.



Table 7 Sample size by service group and time period

Service Group No.	Service Group Description	Weekday				Weekend	Total
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59		
ED01	Tyne, Tees & Wear	1,498	2,311	1,863	658	1,262	7,592
ED02	Lancashire & Cumbria	1,438	1,778	1,027	607	1,414	6,264
ED04	West & North Yorks Inter Urban	2,334	3,858	2,538	1,478	2,382	12,590
ED05	West & North Yorks Local	4,218	3,519	3,467	1,495	3,000	15,699
ED06	South & East Yorks Inter Urban	822	921	1,031	407	540	3,721
ED07	South & East Yorks Local	889	1,126	1,607	656	628	4,906
ED08	North Manchester	1,411	2,105	1,519	1,096	853	6,984
ED09	Merseyrail City Lines	1,670	2,275	1,401	1,296	1,734	8,376
ED10	South Manchester	2,213	3,333	4,297	2,907	3,251	16,001
<b>TOT</b>	<b>Total</b>	<b>16,493</b>	<b>21,226</b>	<b>18,750</b>	<b>10,600</b>	<b>15,064</b>	<b>82,133</b>

Source: Sky High, CH2M HILL analysis

Table 8 illustrates the proportion of the target sample obtained for each service group and time period.

Table 8 Sample size obtained against target

Service Group No.	Service Group Description	Weekday				Weekend	Total
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59		
ED01	Tyne, Tees & Wear	161%	183%	220%	131%	202%	182%
ED02	Lancashire & Cumbria	96%	87%	75%	74%	140%	93%
ED04	West & North Yorks Inter Urban	59%	110%	64%	98%	105%	83%
ED05	West & North Yorks Local	76%	72%	63%	70%	94%	74%
ED06	South & East Yorks Inter Urban	80%	67%	92%	63%	73%	76%
ED07	South & East Yorks Local	67%	64%	112%	79%	66%	78%
ED08	North Manchester	74%	100%	69%	116%	67%	83%
ED09	Merseyrail City Lines	144%	119%	107%	251%	200%	145%
ED10	South Manchester	80%	110%	136%	213%	179%	132%
<b>TOT</b>	<b>Total</b>	<b>82%</b>	<b>97%</b>	<b>90%</b>	<b>114%</b>	<b>118%</b>	<b>97%</b>

Source: Sky High, CH2M HILL analysis



Yorkshire Local service groups proved most difficult to obtain survey data for due to the disparate nature of the network. A rich mix of services running across multiple branches of the network were required in order to ensure all parts of the network were covered. As these parts of the network tend to have less passenger demand, it was more difficult to secure a higher sampling rate per survey as a result. As expected, obtaining samples during the AM peak was the most challenging aspect of the survey. Nevertheless, as indicated in section 3.4 on our confidence in the results from a statistical perspective, the sample secured still enables us to provide statistically robust estimates of ticketless travel rates by service group and time period.

## 2.6 Cleaning and validation of survey data

The quality of the data collected from the on-train surveys is subject to any input errors or failure of surveyors to identify valid and/or invalid tickets. Although all surveyors are trained to recognise and validate all types of tickets on Northern rail, it is still possible that there are some incorrectly coded interviews that could subsequently affect the overall rate of ticketless travel unless the data is cleaned and validated.

A list of the types of validation undertaken are presented below:-

- The validity of all ticket types logged as Off-Peak were changed to 'used at an invalid time' if passenger was surveyed during a peak time and the origin and destination of the ticket are within Peak Zones.
- The validity of all ticket types logged as Northern Family & Friends tickets were changed to 'used at an invalid time' if passenger was surveyed before 09:30 on a weekday.
- The validity of all irregularities logged as 'child impersonation' was changed to 'valid' if an 'Adult' ticket was in fact recorded by the surveyor.
- The validity of all irregularities logged as 'overriding' was changed to 'valid' if the origin and destination of the ticket was within the stops the passenger was being surveyed at.
- The validity of all irregularities logged as 'misuse of railcard' was changed to 'valid' if the ticket did not in fact require a railcard.



### 3 Results

This section summarises the results of the ticketless travel survey, presenting the irregularity rates and revenue at risk by service group and time period. In addition, conclusions from the survey and next steps are provided.

#### 3.1 Irregularity rates by time period and service group

The irregularity rate is the proportion of passengers that have an invalid ticket or no ticket at all. The results of the survey are weighted by the demand by time period and service group according to i) time of day data from key station termini and ii) 2013/14 LENNON ticket sales data by service group.

The survey results have been weighted so that the overall rate of ticketless travel is representative by service group and time period. The weightings used apply more importance to survey data collected during times where more journeys are made by passengers, The weightings are also used to apply more importance to service groups which carry more passengers so that the overall rate of ticketless travel is representative of the entire Northern franchise. Appendix A provides the demand weightings used.

Mindful that a certain proportion of passengers surveyed and found to have no ticket may eventually purchase one from the conductor or at the destination station, we have provided upper and lower bound estimates of irregularity rates. Table 9 illustrates the upper bound estimates of demand weighted irregularity rates by time period and service group. This is based on an assumption that all passengers surveyed with no tickets do not purchase one later in their journey.

**Table 9 Weighted and un-weighted irregularity rates, upper bound estimates**

Service Group No.	Service Group Description	Weekday				Weekend	Overall un-weighted	Overall weighted
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59			
ED01	Tyne, Tees & Wear	9.7%	7.2%	7.7%	8.9%	7.8%	8.1%	8.2%
ED02	Lancashire & Cumbria	20.6%	9.2%	16.8%	14.6%	9.3%	13.6%	14.0%
ED04	West & North Yorks Inter Urban	9.2%	8.3%	6.0%	6.3%	7.3%	7.6%	7.6%
ED05	West & North Yorks Local	15.0%	9.8%	9.8%	10.6%	14.6%	12.2%	11.9%
ED06	South & East Yorks Inter Urban	9.2%	7.9%	5.1%	6.3%	6.6%	7.1%	7.1%
ED07	South & East Yorks Local	12.0%	9.0%	4.4%	6.9%	5.4%	7.3%	7.8%
ED08	North Manchester	11.8%	12.5%	14.1%	19.7%	10.0%	13.5%	13.2%
ED09	Merseyrail City Lines	13.3%	9.2%	10.5%	17.2%	15.1%	12.7%	11.9%
ED10	South Manchester	17.7%	15.4%	19.7%	22.4%	24.7%	20.0%	19.2%
<b>TOT</b>	<b>Overall (unweighted)</b>	13.7%	10.1%	11.4%	14.7%	13.7%	12.4%	



<b>Overall (weighted)</b>	13.5%	10.1%	10.8%	12.5%	12.4%		<b>11.7%</b>
---------------------------	-------	-------	-------	-------	-------	--	--------------

Source: Sky High, LENNON ticket sales data, CH2M HILL analysis

The findings show that the overall upper bound estimate of the demand weighted irregularity rate for Northern rail is 11.7%. The service groups with the highest upper bound estimates of irregularity rates are South Manchester (19.2%) and Lancashire & Cumbria (14.0%) services. The lowest irregularity rates are on South & East Yorkshire services (Inter Urban – 7.1% and Local – 7.8%) and West & North Yorkshire Inter Urban services (7.6%). By time period, the irregularity rate is highest in the AM peak period (13.5%) and lowest in the Inter-Peak period (10.1%).

Based on the assumption that all passengers who stated the reason for not having a ticket as 'lack of facilities on train or at station', we have provided lower bound estimates of the irregularity rates in Table 9.

**Table 10 Weighted and un-weighted irregularity rates, lower bound estimates**

Service Group No.	Service Group Description	Weekday				Weekend	Overall un-weighted	Overall weighted
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59			
ED01	Tyne, Tees & Wear	8.1%	5.6%	7.0%	7.5%	6.5%	6.8%	6.8%
ED02	Lancashire & Cumbria	6.2%	5.7%	10.4%	8.8%	5.5%	6.8%	7.1%
ED04	West & North Yorks Inter Urban	4.9%	4.2%	4.4%	4.0%	5.2%	4.5%	4.6%
ED05	West & North Yorks Local	5.4%	4.7%	6.0%	5.8%	6.7%	5.7%	5.6%
ED06	South & East Yorks Inter Urban	2.7%	2.7%	4.7%	5.3%	4.7%	3.8%	3.8%
ED07	South & East Yorks Local	8.1%	5.5%	3.5%	2.7%	2.7%	4.6%	4.8%
ED08	North Manchester	6.7%	5.5%	10.5%	10.7%	5.2%	7.6%	7.6%
ED09	Merseyrail City Lines	11.9%	6.3%	8.0%	9.6%	9.3%	8.8%	8.5%
ED10	South Manchester	12.1%	9.8%	12.8%	11.7%	9.6%	11.2%	11.3%
<b>TOT</b>	<b>Overall (unweighted)</b>	7.3%	5.8%	7.9%	8.2%	6.9%	7.1%	
	<b>Overall (weighted)</b>	6.9%	5.6%	7.4%	7.1%	6.4%		<b>6.6%</b>

Source: Sky High, LENNON ticket sales data, CH2M HILL analysis

The findings show that the overall lower bound estimate of the demand weighted irregularity rate for Northern rail is 6.6%. South Manchester has the highest lower bound estimate of irregularity rate (11.3%) followed by Merseyrail City Lines (8.5%). South & East Yorks Inter Urban (3.8%) and West & North Yorks Inter Urban (4.6%) have the lowest irregularity rates. By time period, the PM peak has the highest irregularity rate (7.4%) and the Inter-Peak period has the lowest rate (5.6%).

### 3.2 Results by type of irregularity

A total of 85.6% of passengers surveyed had a valid ticket. Of the remaining passengers, a total of 9.1% declared they had no ticket, 4.0% refused to show their ticket and 1.2% had an invalid

ticket. Table 11 illustrates a breakdown of the irregularity types in order of prevalence for those passengers with no ticket or an invalid ticket.

**Table 11 Breakdown of irregularity types for invalid tickets and no tickets**

Irregularity type	Irregularity rate (%)
No Ticket - Lack of facilities at station	5.04%
No Ticket - Lack of time	2.71%
No Ticket - Does not have a ticket (no reason)	1.13%
Ticket used at invalid time	0.55%
No Ticket - Lack of facilities on train	0.23%
Overriding	0.21%
Journey taken after valid date	0.18%
Child Impersonation	0.13%
Misuse of railcard: cannot present appropriate card	0.11%
Transferred use: using someone else's pass	0.02%
Journey taken before valid date	0.02%
No valid photo card	0.01%
Forger/altered travel pass	0.01%
Stolen ticket or pass	0.00%

Source: Sky High, CH2M HILL

The most prevalent type of irregularity was passengers declaring that they had no ticket, giving the reason that there was a lack of facilities at the station they came from (i.e. ticket vending machines, open ticketing office).

### 3.3 Estimated revenue at risk rates

The revenue at risk rate is the proportion of revenue estimated to be lost as a result of ticketless travel. The amount of revenue lost from each irregularity is assumed to be proportional to the average yield per passenger. A record of assumptions on the average loss of yield is presented in

Table 12.

**Table 12 Assumptions on average loss of yield by irregularity type**

Ticket Type	Category	Irregularity Description	% Revenue loss	Underlying assumption
Valid ticket	1	Has a valid ticket	0%	No loss
No ticket	2a	Does not have a ticket (no reason)	100%	Assume 100% loss @ av. yield
	2b	Lack of facilities at station	100% (UB) 0% (LB)	Assume 100% loss @ av. yield
	2c	Lack of facilities on train	100% (UB) 0% (LB)	Assume 100% loss @ av. yield
	2d	Lack of time	100%	Assume 100% loss @ av. yield
Invalid ticket	3a	Journey taken after valid date	100%	Assume 100% loss @ av. yield
	3b	Overriding	90%	Assume 'short-ticketing' – cheapest fare is purchased in order to get through ticket gates



	3c	Misuse of railcard: cannot present appropriate card	33%	Assume railcards provide a third off on average
	3d	Transferred use: using someone else's pass	100%	Assume 100% loss @ av. yield
	3e	Child Impersonation	50%	Assume yield on child ticket is half of adult
	3f	Ticket used at invalid time	100%	Assume 100% loss @ av. yield
	3g	Journey taken before valid date	100%	Assume 100% loss @ av. yield
	3h	Forger/altered travel pass	100%	Assume 100% loss @ av. yield
	3i	No valid photo card	100%	Assume 100% loss @ av. yield
	3j	Stolen ticket or pass	100%	Assume 100% loss @ av. yield
Other	4a	Refusal	50%	Assume half of those who refuse to show ticket have an irregularity

Source: CH2M HILL

The results of the survey are weighted by the amount of revenue generated by service group according to 2013/14 LENNON ticket sales data. The survey results have been weighted so that the overall revenue at risk is representative by service group and time period. The revenue weightings apply more importance to service groups which generate more money so that the overall revenue at risk is representative of the entire Northern franchise. Appendix A provides the revenue weightings used.

Table 13 illustrates the revenue weighted and un-weighted revenue at risk rates (upper bound estimates) by time period and service group.

Table 13 Weight and un-weighted revenue at risk, upper bound estimates

Service Group No.	Service Group Description	Weekday				Weekend	Overall un-weighted	Overall weighted
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59			
ED01	Tyne, Tees & Wear	9.7%	7.0%	7.4%	8.4%	7.3%	7.8%	7.9%
ED02	Lancashire & Cumbria	20.6%	9.1%	16.6%	14.2%	8.9%	13.5%	13.8%
ED04	West & North Yorks Inter Urban	9.3%	8.4%	5.9%	6.1%	7.2%	7.5%	7.5%
ED05	West & North Yorks Local	15.0%	9.5%	9.8%	10.5%	14.1%	12.0%	11.8%
ED06	South & East Yorks Inter Urban	9.1%	8.0%	5.2%	5.9%	6.3%	7.0%	7.0%
ED07	South & East Yorks Local	11.8%	8.8%	4.4%	7.1%	5.3%	7.2%	7.7%
ED08	North Manchester	11.7%	12.5%	14.0%	19.4%	9.7%	13.4%	13.0%
ED09	Merseyrail City Lines	13.2%	9.1%	10.3%	16.8%	14.8%	12.5%	11.7%
ED10	South Manchester	17.6%	15.3%	19.5%	22.2%	24.5%	19.9%	19.1%
<b>TOT</b>	<b>Overall (unweighted)</b>	13.6%	10.0%	11.3%	14.5%	13.4%	12.2%	
	<b>Overall (weighted)</b>	13.3%	9.9%	10.8%	12.4%	11.6%		<b>11.5%</b>

Source: Sky High, LENNON ticket sales data, CH2M HILL analysis

The overall upper bound estimate of revenue at risk across the franchise is 11.5%. The service groups with the highest revenue at risk are South Manchester (19.1%) and Lancashire &



Cumbria (13.8%) services. The lowest revenue at risk is on South & East Yorkshire services (Inter Urban – 7.0% and Local – 7.7%) and West & North Yorkshire Inter Urban services (7.5%). By time period, the revenue risk rate is highest in the AM peak period (13.3%) and lowest in the Inter-Peak period (9.9%).

Table 14 illustrates the revenue weighted and un-weighted revenue at risk rates (upper bound estimates) by time period and service group.

Table 14 Weight and un-weighted revenue at risk, lower bound estimates

Service Group No.	Service Group Description	Weekday				Weekend	Overall un-weighted	Overall weighted
		06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59			
ED01	Tyne, Tees & Wear	8.0%	5.4%	6.7%	7.0%	6.1%	6.5%	6.5%
ED02	Lancashire & Cumbria	6.2%	5.5%	10.1%	8.4%	5.1%	6.7%	6.9%
ED04	West & North Yorks Inter Urban	5.0%	4.2%	4.3%	3.8%	5.1%	4.4%	4.5%
ED05	West & North Yorks Local	5.3%	4.4%	5.9%	5.7%	6.3%	5.5%	5.5%
ED06	South & East Yorks Inter Urban	2.6%	2.7%	4.7%	4.9%	4.5%	3.7%	3.7%
ED07	South & East Yorks Local	7.9%	5.3%	3.5%	2.9%	2.6%	4.5%	4.7%
ED08	North Manchester	6.7%	5.5%	10.3%	10.4%	4.9%	7.5%	7.5%
ED09	Merseyrail City Lines	11.7%	6.2%	7.7%	9.1%	9.0%	8.6%	8.3%
ED10	South Manchester	11.9%	9.6%	12.6%	11.6%	9.4%	11.0%	11.1%
<b>TOT</b>	<b>Overall (unweighted)</b>	7.2%	5.7%	7.7%	8.0%	6.7%	6.9%	
	<b>Overall (weighted)</b>	7.1%	5.6%	7.4%	7.1%	6.0%		<b>6.6%</b>

Source: Sky High, LENNON ticket sales data, CH2M HILL analysis

The overall weighted lower bound estimate of revenue at risk across the franchise is 6.6%. The service groups with the highest lower bound estimates of revenue at risk are South Manchester (11.1%) and Merseyrail City Lines (8.3%) services. The lowest revenue at risk is on South & East Yorkshire Inter Urban services (3.7%) and West & North Yorkshire Inter Urban services (4.5%). By time period, the revenue risk rate is highest in the PM peak period (7.4%) and lowest in the Inter-Peak period (5.6%).

### 3.4 Confidence intervals around our estimates

A sample size of 82,133 provides a relatively high level of confidence around our central estimates. Table 15 shows the 95% confidence intervals for the revenue at risk estimates i.e. there being a 95% probability that the true estimate lies between the upper and lower bound. **Note that this is notwithstanding the uncertainties around confidence stemming from limitations around the on-train survey approach outlined in section 2.3.**



Table 15 95% confidence intervals around revenue at risk, upper and lower bound estimates

Service Group No.	Service Group Description	Lower bound estimate		Upper bound estimate	
		Revenue at risk (%)	95% confidence interval (+/-)	Revenue at risk (%)	95% confidence interval (+/-)
ED01	Tyne, Tees & Wear	6.51%	0.02%	7.87%	0.02%
ED02	Lancashire & Cumbria	6.90%	0.05%	13.78%	0.12%
ED04	West & North Yorks Inter Urban	4.53%	0.01%	7.54%	0.03%
ED05	West & North Yorks Local	5.46%	0.01%	11.78%	0.04%
ED06	South & East Yorks Inter Urban	3.69%	0.04%	7.05%	0.05%
ED07	South & East Yorks Local	4.71%	0.06%	7.68%	0.08%
ED08	North Manchester	7.47%	0.06%	13.04%	0.09%
ED09	Merseyrail City Lines	8.33%	0.04%	11.72%	0.07%
ED10	South Manchester	11.12%	0.02%	19.07%	0.06%
<b>TOT</b>	<b>Total</b>	<b>6.61%</b>	<b>0.02%</b>	<b>11.45%</b>	<b>0.03%</b>

Source: Sky High, CH2M HILL analysis

The lower bound estimate of revenue at risk is 6.61% with a 95% confidence interval of +/- 0.02%. The upper bound estimate of revenue at risk is 11.45% with a 95% confidence interval of +/- 0.03%.

### 3.5 Estimated revenue at risk in monetary terms

Using 2013/14 LENNON ticket sales data, we are able to estimate the indicative order of magnitude of the revenue at risk in monetary terms by service group.

Table 16 Indicative revenue at risk in monetary terms, lower and upper bound estimates

Service Group No.	Service Group Description	2013/14 Revenue (£m)	Revenue at risk	
			Lower bound (£m)	Upper bound (£m)
ED01	Tyne, Tees & Wear	14.9	1.0	1.3
ED02	Lancashire & Cumbria	25.8	1.9	4.1
ED04	West & North Yorks Inter Urban	44.3	2.1	3.6
ED05	West & North Yorks Local	32.6	1.9	4.4
ED06	South & East Yorks Inter Urban	17.2	0.6	1.3



ED07	South & East Yorks Local	18.8	0.9	1.6
ED08	North Manchester	22.9	1.8	3.4
ED09	Merseyrail City Lines	19.9	1.8	2.6
ED10	South Manchester	34.2	4.3	8.1
TOT	<b>Total</b>	<b>230.6</b>	<b>16.5</b>	<b>30.4</b>

Source: Sky High, 2013/14 LENNON data, CH2M HILL analysis

Our findings show that the revenue at risk on the Northern franchise is between £16.5m and £30.4m. For the lower bound estimate, South Manchester (£4.3m) and West and North Yorkshire Inter Urban services (£2.1m) have the highest revenue at risk. For the upper bound estimates, South Manchester (£8.1m) and West and North Yorkshire Local (£4.4m) services have the highest revenues at risk.

### 3.6 Conclusions and next steps

The indicative revenue at risk estimates and ticketless travel rates provide an understanding of the service groups which represent more value for money additional revenue protection measures should be considered. There are a number of factors that could be driving the observed levels of irregularities across each service group:-

- A particular *service code* within a service group which has a substantially higher rate of ticketless travel compared to other codes within the same group;
- The number of destination stations without ticket gates/manual gate lines or origin stations without ticket vending machines;
- The levels of risk associated with fare evading e.g. short journeys are likely to carry less risk of getting caught;
- The price of an average fare relative to the disposable incomes of passengers using the service.

It is recommended that the above factors are explored further in order to understand the underlying differences in ticketless travel between the service groups.



## 4 Appendix A

The following tables provide the demand and revenue weightings used to calculate weighted irregularity and revenue at risk rates by service group and time period.

### Demand weighting matrix

#	Service Group Description	06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59	Weekend	Total
ED01	Tyne, Tees & Wear	1.1%	1.5%	1.0%	0.6%	0.7%	4.9%
ED02	Lancashire & Cumbria	1.8%	2.4%	1.6%	1.0%	1.2%	7.9%
ED04	West & North Yorks Inter Urban	4.7%	4.1%	4.6%	1.8%	2.7%	17.9%
ED05	West & North Yorks Local	6.5%	5.8%	6.5%	2.5%	3.8%	25.1%
ED06	South & East Yorks Inter Urban	1.2%	1.6%	1.3%	0.8%	0.9%	5.8%
ED07	South & East Yorks Local	1.6%	2.1%	1.7%	1.0%	1.1%	7.4%
ED08	North Manchester	2.3%	2.5%	2.6%	1.1%	1.5%	9.9%
ED09	Merseyrail City Lines	1.4%	2.3%	1.5%	0.6%	1.0%	6.8%
ED10	South Manchester	3.3%	3.6%	3.7%	1.6%	2.1%	14.3%
TOT	Total	23.7%	25.8%	24.6%	10.9%	15.0%	100.0%

### Revenue weighting matrix

#	Service Group Description	06:00 to 09:59	10:00 to 15:59	16:00 to 18:59	19:00 to 23:59	Weekend	Total
ED01	Tyne, Tees & Wear	1.4%	2.0%	1.3%	0.8%	1.0%	6.5%
ED02	Lancashire & Cumbria	2.5%	3.4%	2.3%	1.4%	1.7%	11.2%
ED04	West & North Yorks Inter Urban	5.0%	4.4%	5.0%	1.9%	2.9%	19.2%
ED05	West & North Yorks Local	3.7%	3.3%	3.7%	1.4%	2.1%	14.2%
ED06	South & East Yorks Inter Urban	1.6%	2.1%	1.7%	1.0%	1.1%	7.4%
ED07	South & East Yorks Local	1.7%	2.3%	1.9%	1.1%	1.2%	8.1%
ED08	North Manchester	2.3%	2.5%	2.6%	1.1%	1.5%	9.9%
ED09	Merseyrail City Lines	1.7%	2.9%	2.0%	0.8%	1.3%	8.6%
ED10	South Manchester	3.4%	3.7%	3.9%	1.7%	2.2%	14.8%
TOT	Total	23.3%	26.4%	24.2%	11.1%	15.0%	100.0%