SYNTHESISING THE TRANSPOSE TIMES AT ROADSIDE INTERVIEW SITES USING PROBABILITY FUNCTIONS DERIVED FROM CAR PARK INTERVIEW DATA

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1 INTRODUCTION

Roadside interviews are conducted to ascertain travel movements at the time they are made. The collection of roadside data is an expensive element in model development and there is often the pressure to minimising the costs to clients and traffic disruption. One consequence is that the data collected may be limited to responses that can be collected relatively quickly such as survey location, interview time, occupancy, vehicle type, origin address, origin purpose, destination address, and destination purpose.

While it would be possible to survey in both directions at interview sites, there are organisational problems in liaising with police and local authorities, and a perception that roadside interviews cause congestion. Consequently the common approach is to survey in one direction but collect control counts in both directions. The conventional approach in analysing the roadside interview data is to maximise its use in the model development by transposing the interviews in the surveyed direction to derive estimates of the trip pattern in the non-survey direction.

The weakness of this approach is apparent in that trips made in the morning peak do not necessarily return in the evening peak (and vice versa). For instance there are usually few shopping trips in the morning peak or education trips in the evening peak. Consequently direct transposition will create shopping or education trips in time periods when they are unlikely to be made.

With the increasing modelling sophistication such simplistic approaches of direct transposition may not be acceptable or desirable as models may require that the travel demand is segmented by trip purposes such as work, commute and other car trips, as part of addressing traffic and economic impacts on different travel groups.

As an alternative to direct transposition, a method of synthesising the transpose interview direction has been derived from the analysis of car park interviews. In common with roadside interviews, car park interviews collect similar data but as the survey is conducted at car parks, the risk of causing delays to traffic is minimised. This allows car park interviews to collect additional data including the arrival and departure times, which allows probability functions to be derived for the arrival time or departure time, by trip purpose, and time period. The functions can then be used to synthesise more realistic transposition of roadside interview data using Monte Carlo approach.

The paper will present recent work to synthesise the non-interview direction of travel using probability distributions derived from car park interviews at a

number of car parks in towns in the UK including, Doncaster, Shrewsbury, Lancaster, Halifax, Colchester and Bury St Edmunds.

2 ANALYSIS OF PARKING DATA

2.1 Introduction

As part of highway model development car park interview data was collected at public and private car parks in town centres in Bury St Edmunds, Colchester, Doncaster, Halifax, Lancaster (including Morecambe and Heysham) and Shrewsbury. Respondents were interviewed using a combination of prepaid postcards or face-to-face interviews to collect the following information:

- Arrival time
- Vehicle type
- Number of occupants
- Trip origin
- Trip destination in the town centre
- Trip destination after departing from the car park
- Trip origin purpose
- Trip parking purpose
- Trip purpose for the departing trips
- Expected departure time or duration of stay (to the nearest half hour)
- Reason fro choosing this particular car park
- Frequency of use
- Vehicle ownership

Table 2-1 shows the number of interviews collected in each town, the number of car parks surveyed and the numbers of interviews collected by face-to-face interviews and by return paid postcards. The table shows the number of interviews valid for the return time distribution analysis. For this the interview response had to include the vehicle type, the arrival time, the origin purpose, the parking purpose, the destination purpose (after leaving the car park) and the expected duration of stay. This meant that 12,523 interviews were valid for the analysis and 2,629 were rejected as the data was incomplete (either the trip purpose or departure time was not specified by the respondent).

Table 2-1: Number of interviews collected

Location	Number of car parks	Face to face interviews	Postcard interviews	Valid Interviews	Rejected Interviews
Bury St Edmunds	2	546	0	506	40
Colchester	82	6,566	0	6,086	480
Doncaster	17	0	3,027	2,790	237
Halifax	5	1,020	0	956	64
Lancaster	42	2,454	0	1,100	1,354
Shrewsbury	15	486	1,053	1,085	454
Totals	163	11,072	4,080	12,523	2,629

Table 2-2 shows the breakdown of the interviews by parking type as follows.

- Public car parks include those car parks in public or private ownership that are open to the general public for a parking charge (either via on-site ticket, season ticket, or special pass)
- Private car parks include those car parks not available to the general public such as parking spaces provided at workplaces and private non-residential parking
- Retail car parks includes car parks associated with shopping centres and supermarkets
- On-street parking spaces are located in town centres and open to the general public. Payment is usually through a ticket purchased at a nearby meter.
- Park & ride sites are located outside town centres and are targeted at long stay parkers. Usually there is a small charge for the use of the facility or the transfer bus between the P&R site and the town centre.

Table 2-2 Number of interviews by parking type

Location	Public car parks	Private car parks	Retail car parks	On-street parking	Park & Ride sites	Total
Bury St Edmunds	506	0	0	0	0	506
Colchester	2,859	2,015	1,167	45	0	6,086
Doncaster	2,260	381	111	38	0	2,790
Halifax	956	0	0	0	0	956
Lancaster	1,100	0	0	0	0	1,100
Shrewsbury	694	8	0	0	383	1,085
	8,375	2,404	1,278	83	383	12,523

As part of the analysis the data collected at the towns were compared to assess similarities and differences in their characteristics with respect to trip purpose and duration of parking. For this, five trip purposes were used as follows.

- Home Base Work (HBW)
- Home Base Employers Business (HBEB)
- Home Base Other (HBO)
- Non Home Base Employers Business (NHBEB)
- Non Home Base Other (NHBO)

Home based trip purposes were also segmented by direction of travel into trips from home and trips returning home.

Analysis of the arrival and departure trip purposes indicate that the majority of arrival and departure trip purposes are transposed. Table 2-3 shows the numbers of interviews by their arrival and departure trip purposes and the percentage of return trips by their arrival trip purpose.

Table 2-3: Arrival and departure trip purposes, weekday

Arrival trip purpose	Departure trip purpose					Total
	HBW	HBEB	HBO	NHBEB	NHBO	
HBW	2,423	0	2	294	192	2,911
	83%	0%	0%	10%	7%	
HBEB	0	277	0	163	18	458
	0%	60%	0%	36%	4%	
HBO	5	8	5,192	0	1,572	6,777
	0%	0%	77%	0%	23%	
NHBEB	99	54	0	297	12	462
	21%	12%	0%	64%	3%	
NHBO	58	15	846	20	1,045	1,984
	3%	1%	43%	1%	53%	
Total	2,586	355	6,041	775	2,839	12,596

Table 2-4 shows the number of valid interviews for each location by trip purpose and time period for interviews collected on a weekday (Monday to Friday) and analysed by their arrival and departure trip purposes.

For home based trip purposes the dominant movements at car parks in the morning peak are arrivals and in the evening peak are departures either from long-stay parkers who arrived earlier that morning or short-stay parkers who arrived during the inter-peak period.

As expected for HBW from home and HBEB from home trip purposes the sample collected on the car parks in the evening peak (1600-1900) was low compared to the morning peak (0700-1000) and inter-peak (1000-1600). However the transpose of their movements is seen in the higher numbers seen in the HBW return home and HBEB return home totals

For NHBEB and NHBE the inter-peak movements are greater than in the morning or evening peaks, reflecting business and other activities being done throughout the working day.

2.2 Analysis of the parking data

The car park interview trip database was analysed by trip purpose for the home based and non-home based trip purposes determine the mean duration and variation for the six locations. Since the valid interviews included the arrival purpose and departure purposes they were analysed for both directions of travel from all trip purposes.

Home Base Work trips

Tables 2-5 and 2-6 show the results for HBW for the from-home and return-home directions for the AM peak (0700-1000), inter-peak (1000-1600) and PM peak (1600-1900).

For HBW trips from home the average duration of stay is 444.6 minutes in the AM peak, 244.8 minutes in the inter-peak and 80.6 minutes in the PM peak. The samples for Halifax, Lancaster and Shrewsbury were rejected as too small to be included in the analysis.

For HBW return trips to home the average duration of stay is 47.1 minutes in the AM peak, 296.6 minutes in the inter-peak, and 493.4 minutes in the PM peak. The sample for Halifax was rejected for the AM peak and the Lancaster samples were rejected for all three time periods.

Home Base Employers Business

Tables 2-7 and 2-8 show the results for HBEB trips.

The average duration in the peak is 359.2 minutes in the AM peak, 148.8 minutes in the inter-peak and 111.0 minutes in the PM peak for trips from home. The samples for Halifax, Lancaster and Shrewsbury were rejected in the PM peak analysis.

For the return-home HBEB the average duration is 44.2 minutes in the AM peak, 206.5 minutes in the inter-peak and 386.0 minutes in the PM peak. The samples for Bury St Edmunds and Halifax were rejected in the AM peak and the samples at Lancaster were rejected for all time periods.

Home Base Other

Tables 2-9 and 2-10 show the results for HBO trips.

For HBO from home trips the average duration is 157.8 minutes in the AM peak, 101.5 minutes in the inter-peak, and 105.5 minutes in the PM peak

For HBO return home trips the average duration was 45.3 minutes in the AM peak, 94.9 minutes in the inter-peak, and 162.0 minutes in the PM peak. The AM peak and PM peak samples were rejected for Lancaster.

Non-Home Base Employers Business

Tables 2-11 and 2-12 show the results for NHBEB

For arriving trips the average duration is 383.6.0 minutes in the AM peak, 162.4 minutes in the inter-peak, and 95.9 minutes in the PM peak. The sample for Bury St Edmunds was rejected in the PM peak.

For departing trips the duration is 46.6 minutes in the AM peak, 168.2 minutes in the inter-peak, and 408.7 minutes in the PM peak. The samples for Bury St Edmunds, Doncaster and Halifax in the AM peak were rejected.

Non-Home Base Other

Tables 2-13 and 2-14 show the results for NHBO trips.

For arriving NHBO trips the average duration is 197.2 minutes in the AM peak, 84.4 minutes in the inter-peak, and 54.0 minutes in the PM peak. The sample for Bury St Edmunds was rejected.

For departing NHBO trips the average duration was 32.0 minutes in the AM peak, 101.2 minutes in the inter-peak, and 224.9 minutes in the PM peak. The AM peak sample for Bury St Edmunds was rejected.

Summary

The comparison of the six locations indicates that there are similarities and differences in the duration of parking for different trip purposes. Analysis of the data indicated that the duration of stay at the car parks are similar provided outliers due to small samples are eliminated. This suggests that in many towns the duration of a particular trip activity is similar. Consequently, it should be possible to apply the results of the analysis to other towns.

Table 2-4: Number of valid interviews by location, trip purpose and time period for weekdays

(i) Home based trip purposes from home, weekdays

Location	Home Base Work			Home Base Employers Business			Home Base Other		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Bury St Edmunds	198	58	2	11	7	1	77	102	6
Colchester	943	161	18	49	22	2	722	1,523	176
Doncaster	630	35	20	131	18	2	317	648	94
Halifax	343	41	1	18	31	0	77	248	31
Lancaster	74	32	1	57	44	0	102	382	49
Shrewsbury	167	25	1	14	20	0	104	331	18
Total	2,355	352	43	280	142	5	1,399	3,234	374

(ii) Home based trip purposes return home, weekdays

Location	Home Base Work			Home Base Employers Business			Home Base Other		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Bury St Edmunds	1	41	173	0	6	12	1	73	92
Colchester	19	321	669	1	21	26	231	1,629	538
Doncaster	40	171	456	16	61	71	39	608	154
Halifax	0	78	283	0	26	27	4	236	106
Lancaster	1	0	0	0	0	0	0	3	0
Shrewsbury	5	33	106	1	31	20	6	286	103
Total	66	644	1,687	18	145	156	281	2,835	993

(iii) Non home based trip purposes, arrivals, weekdays

Location	Non Home Base Employers Business			Non Home Base Other		
	AM	IP	PM	AM	IP	PM
Bury St Edmunds	8	8	0	8	19	1
Colchester	25	49	7	250	591	155
Doncaster	14	57	3	12	104	20
Halifax	13	58	4	6	59	13
Lancaster	37	41	8	52	195	30
Shrewsbury	81	24	6	70	183	18
Total	265	607	289	643	2,757	763

(iv) Non home based trip purposes, departures, weekdays

Location	Non Home Base Employers Business			Non Home Base Other		
	AM	IP	PM	AM	IP	PM
Bury St Edmunds	0	12	4	1	40	26
Colchester	5	95	27	179	675	206
Doncaster	1	41	29	3	70	56
Halifax	1	54	23	2	60	22
Lancaster	14	125	137	21	521	179
Shrewsbury	66	43	41	39	240	37
Total	87	370	261	245	1,606	526

Table 2-5: Home base work from home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	198	490.2	117.3	58	223.2	139.0	2	67.5	31.8
Colchester	943	440.3	143.1	161	251.1	134.1	18	40.0	48.0
Doncaster	630	463.4	150.9	35	237.0	172.2	20	118.5	94.6
Halifax	343	472.3	110.2	41	305.1	116.8			
Lancaster	74	425.9	167.5	32	251.7	169.1			
Shrewsbury	167	320.4	250.4	25	157.8	153.0			
Total	2,355	446.4	154.9	352	244.8	144.8	40	80.6	83.0

Table 2-6: Home base work return home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds				41	218.8	126.7	173	483.8	117.1
Colchester	19	48.2	38.6	321	289.4	128.2	669	479.9	132.6
Doncaster	40	51.0	84.6	171	320.4	146.8	456	513.8	90.1
Halifax				78	340.8	89.1	283	489.5	103.3
Lancaster									
Shrewsbury	5	15.0	18.4	33	235.9	160.6	106	517.2	105.1
Total	64	47.3	70.5	644	296.6	134.5	1,687	493.4	115.1

Table 2-7: Home base employer's business from home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	11	414.5	119.5	7	300.0	70.4	1	315.0	17.7
Colchester	49	362.1	182.0	22	125.5	88.6	2	45.0	42.4
Doncaster	131	383.9	209.5	18	173.3	128.7	2	75.0	21.2
Halifax	18	350.0	193.9	31	160.6	103.4			
Lancaster	57	330.8	219.8	44	140.5	147.0			
Shrewsbury	14	201.4	183.1	20	99.8	67.8			
Total	280	359.2	205.0	142	148.8	120.7	5	111.0	117.4

Table 2-8: Home base employer's business return home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds				6	277.5	55.9	12	431.3	132.0
Colchester	1	60.0	7.7	21	234.3	157.9	26	296.5	204.2
Doncaster	16	43.1	39.4	61	233.6	148.9	71	503.9	115.7
Halifax				26	150.6	124.8	27	221.7	150.1
Lancaster									
Shrewsbury	1	45.0	6.7	31	167.4	158.3	20	278.3	226.4
Total	18	44.2	37.3	145	206.5	149.2	156	386.0	195.3

Table 2-9: Home base other from home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	77	408.7	191.2	102	167.8	99.8	6	165.0	204.8
Colchester	722	107.5	128.4	1523	81.5	78.6	176	55.5	82.8
Doncaster	317	209.1	197.0	648	124.7	106.8	94	195.5	193.7
Halifax	77	210.4	179.3	248	114.0	67.5	31	88.5	62.3
Lancaster	102	152.1	135.5	382	127.5	151.0	49	121.2	160.6
Shrewsbury	104	131.5	144.4	331	88.9	79.2	18	91.7	96.0
Total	1,399	157.8	171.6	3,234	101.5	98.6	374	105.5	143.3

Table 2-10: Home base other return home, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds				12	193.8	118.4	4	495.0	114.2
Colchester	5	57.0	26.8	95	193.3	124.1	27	450.0	163.5
Doncaster				41	107.6	87.1	29	246.2	175.9
Halifax				54	192.5	121.1	23	347.0	168.7
Lancaster	14	213.2	288.6	125	171.4	165.3	137	419.1	175.5
Shrewsbury	66	10.5	12.9	43	124.2	128.5	41	488.0	125.5
Total	85	46.6	136.8	370	168.2	138.7	261	408.7	178.1

Table 2-11: Non-home base employers business, arrivals, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	8	513.8	51.2	19	123.9	296.2			
Colchester	250	192.0	196.5	591	62.0	164.1	155	38.8	447.0
Doncaster	12	327.5	405.4	104	120.7	166.9	20	72.0	36.9
Halifax	6	475.0	113.7	59	103.5	211.9	13	69.2	34.4
Lancaster	52	125.8	114.6	195	94.2	311.7	30	94.5	165.6
Shrewsbury	70	186.4	161.1	183	115.7	158.3	18	86.7	88.6
Total	398	197.2	199.0	1151	84.4	202.2	236	54.0	368.2

Table 2-12: Non-home base employers business, departures, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds				40	161.3	107.8	26	404.4	168.9
Colchester	179	29.9	24.7	675	93.7	100.4	206	312.3	226.5
Doncaster	3	60.0	30.0	70	82.3	60.4	56	119.2	92.1
Halifax	2	37.5	31.8	60	150.8	123.0	22	245.5	209.9
Lancaster	21	77.1	151.9	521	118.2	138.3	179	127.8	136.2
Shrewsbury	39	14.6	16.0	240	68.1	82.7	37	229.1	204.2
Total	244	32.0	51.3	1606	101.2	113.6	526	224.9	205.4

Table 2-13: Non-home base other, arrivals, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	8	513.8	51.2	19	123.9	296.2	1	75.0	8.7
Colchester	250	192.0	196.5	591	62.0	164.1	155	38.8	447.0
Doncaster	12	327.5	405.4	104	120.7	166.9	20	72.0	36.9
Halifax	6	475.0	113.7	59	103.5	211.9	13	69.2	34.4
Lancaster	52	125.8	114.6	195	94.2	311.7	30	94.5	165.6
Shrewsbury	70	186.4	161.1	183	115.7	158.3	18	86.7	88.6
Total	398	197.2	199.0	1151	84.4	202.2	237	54.1	367.4

Table 2-14: Non-home base other, departures, weekdays

Location	AM peak			Inter-peak			PM peak		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Bury St Edmunds	1	60.0	7.7	40	161.3	107.8	26	404.4	168.9
Colchester	179	29.9	24.7	675	93.7	100.4	206	312.3	226.5
Doncaster	3	60.0	30.0	70	82.3	60.4	56	119.2	92.1
Halifax	2	37.5	31.8	60	150.8	123.0	22	245.5	209.9
Lancaster	21	77.1	151.9	521	118.2	138.3	179	127.8	136.2
Shrewsbury	39	14.6	16.0	240	68.1	82.7	37	229.1	204.2
Total	245	32.1	51.2	1606	101.2	113.6	526	224.9	205.4

2.3 Deriving probability functions

The comparison of the six towns indicated that for some trip purposes some were either not sampled or the samples should be rejected as statistical analysis suggested that the average mean were outside the confidence limits for the combined samples. Consequently, those samples where the sample size was small and/or the mean duration was different to the average mean duration were rejected as outliers.

The observed probability functions were derived for the duration between the outbound and return trip for different trip purposes. The functions allowed the departure time for a trip from home in the morning peak to be predicted later in the day, or the arrival time for a car returning home and leaving a car park to be predicted earlier in the day. The functions were based on the standard normal distribution, which has the property that the functions used will be a smooth probability curve varying between 0.00 and 1.00.

The standard normal distribution is expressed as:

$$P(x) = \frac{1}{\sigma\sqrt{2\pi}}.\exp\left(-(x-\mu)^2/2\sigma^2\right)$$

Where μ is the mean and σ is the standard deviation

Tables 2-17 and 2-18 show the parameters used in the probability function and Figures 2-1 to 2-3 show the probability distributions for the AM peak, inter-peak and PM peak periods.

Table 2-15: Probability function parameters, weekdays

	AM Peak		Inter-peak		PM peak	
Trip Purpose	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
HBW from home	446.4	154.9	244.8	144.8	80.6	83.0
HBEB from home	359.2	205.0	148.8	120.7	111.0	117.4
HBO from home	157.8	171.6	101.5	98.6	105.5	143.3
HBW return home	47.3	70.5	296.6	134.5	493.4	115.1
HBEB return home	44.2	37.3	206.5	149.2	386.0	195.3
HBO return home	43.7	45.3	94.9	72.2	162.0	166.4
NHBEB arrivals	383.6	200.3	162.4	147.4	95.9	167.5
NHBO arrivals	197.2	199.0	84.4	202.2	54.0	368.2
NHBEB departures	46.6	136.8	168.2	138.7	408.7	178.1
NHBO departures	32.0	51.3	101.2	113.6	224.9	205.4

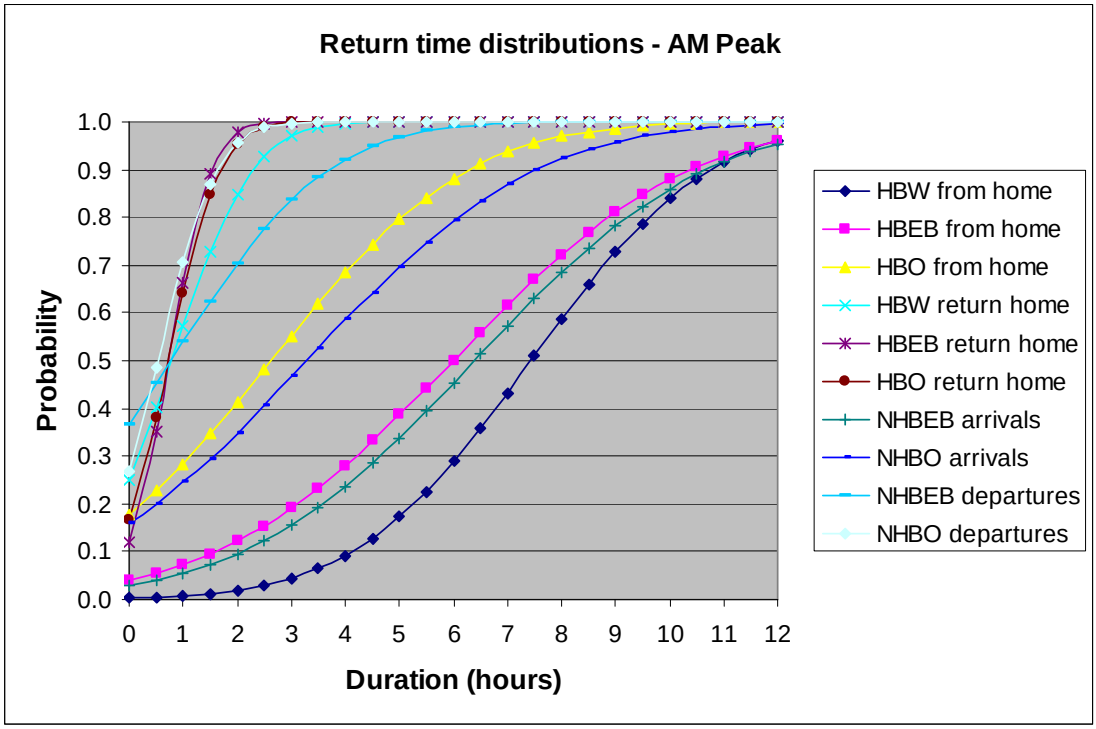

Figure 2-1: Probability distribution for AM peak period

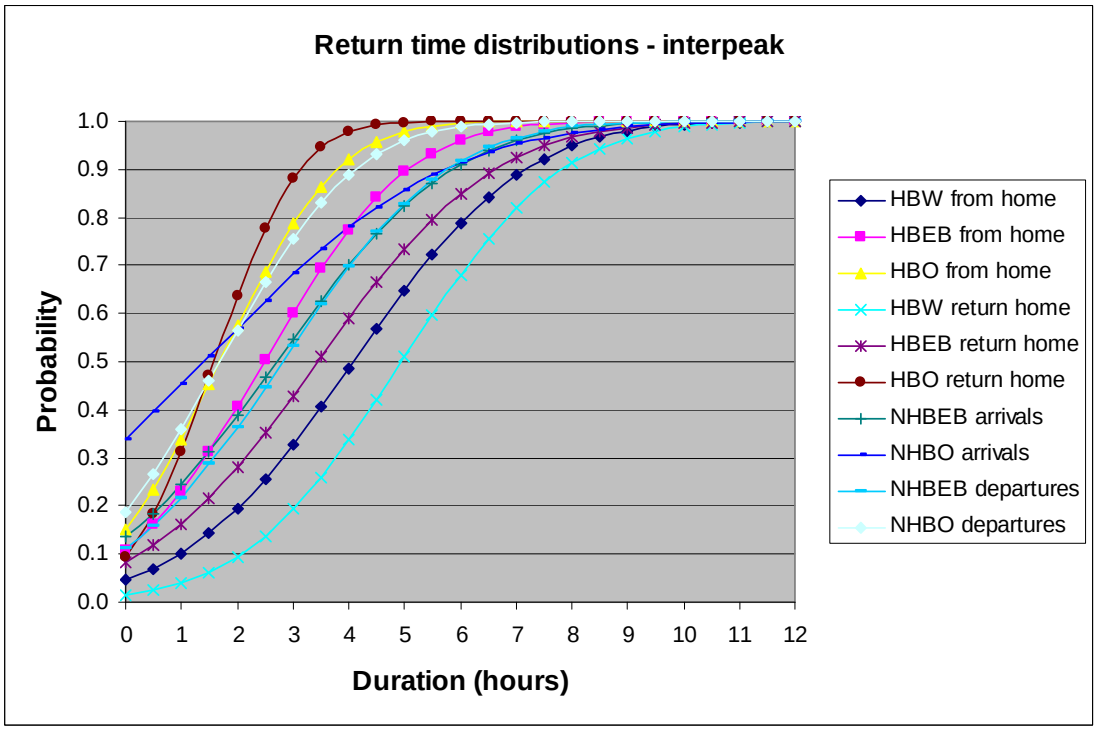

Figure 2-2: Probability distribution for non-peak periods

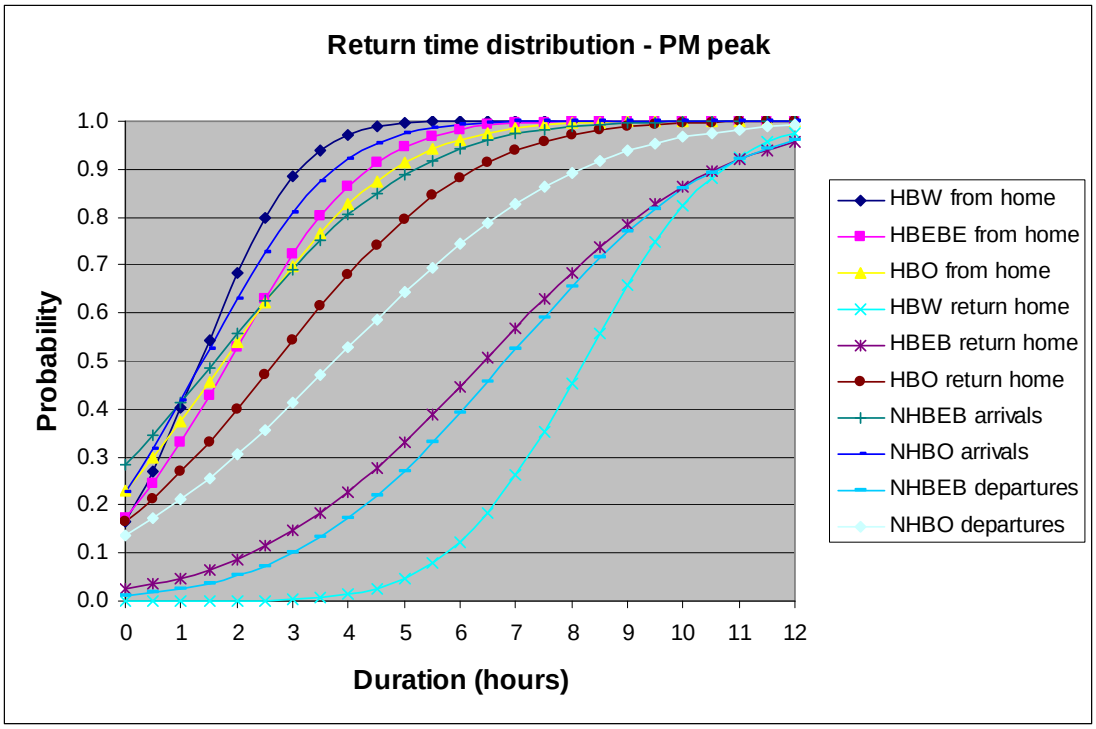

Figure 2-3: Probability distribution for PM peak period

The probability functions can be used to forecast the return time for outbound trips and the outbound time for the return trips depending on the trip purpose using a Monte Carlo approach. For this a random number is generated for each interview and the duration of stay is derived for this random number using the appropriate probability function for the trip purpose of the interview.

For instance if we consider a HBW interview leaving home at 08:30 hours in the morning peak and generated a random number of 0.5, the HBW function would generate a duration of just under 8 hours. The interview can than be transposed to a HBW return home trip at about 16:15 hours (i.e. just under 8 hours later in the day).

A similar process applies to transposing a return home trip but in this case the interview is transposed to an earlier outbound time.

3 COMPARISON OF TRANSPOSITION METHODS

3.1 Observed data

As part of the study, direct transposition methods were compared with the new approach using two-way roadside interview data. Two-way interview data is not frequently collected in the mainland UK but in Northern Ireland, where traffic flows are considerably lower, roadside interviews are normally conducted in both directions on alternative dates separated by about a week.

For the transposition method comparison RSI data from a recent study in Magherafelt was used. The data consisted of 8 two-way sites collected on a complete cordon surrounding the town and interviews were conducted in both directions for a 12 hour period (0700-1900). Manual classified counts were also collected for the purpose of expanding the roadside interviews.

The interviews were transposed using the conventional method and the probability functions.

For the conventional method:

- AM peak interviews were transposed to the PM peak
- Inter-peak interviews were transposed inter-peak
- PM peak interviews were transposed to the AM peak

The trip origins and destinations, origin and destination purposes were transposed. The transposed interviews were then controlled to the outbound counts for the AM peak, inter-peak, and PM peak respectively. The expanded transposed interviews were then adjusted for the trip purpose balance to the observed trip purpose proportions.

For the probability function method the interviews were transposed using the probability functions:

- Home base from-home trips and non-home base arrival trips were transposed to later time
- Home base return-home trips and non-home base departure trips were transposed to an earlier time

For non-home base trips the probability of a trip being an arrival or a departure were determined from the probability of a home-based trip being either from-home or return-home by time period for a similar purpose. For instance NHBEB were split into arrivals and departures using the probability of a HBEB trip being either from-home or return-home.

In common with conventional transposition methods the interviews were expanded to the outbound counts but as the transposed time had been estimated using the probability function, the interviews were expanded using the half-hourly counts in the outbound direction. The expanded transposed interviews were then adjusted to the observed trip purpose proportions.

Table 3-1 shows the inbound and outbound trips by trip purpose and time period for trips crossing the RSI survey cordon. Table 3-2 summarises the number of inbound and outbound interviews by trip purpose and time period.

3.2 Comparison of transposition methods

The transposed dataset were compared with the observed roadside interviews in the reverse direction. The comparison is shown in Table 3-3,

which shows the number of trips by trip purpose and time period, for the observed outbound interview data, and the transposed inbound interviews using the direct transposition and probability function approaches.

Table 3-4 shows the GEH statistics for the comparison between two transposition methods with the observed data. For the purposes of comparison a GEH score of below 5 is considered to be a good and between 5 and 10 moderate.

The GEH statistics show mixed results for both direct transposition and probability function transposition:

Home Base Work trips

For HBW trips from home the probability function shows a poor fit with the observed outbound data for the inter-peak and PM peak. The HBW trips return-home probability function show a poor fit in the AM and inter-peak.

The sampling of car park HBW movements is dominated by interviews arriving in the morning and consequently only the HBW from home in the AM peak and HBW return-home in the PM peak have a sufficient sample to form a robust probability distribution relationship.

The direct transposition method is poor in the PM peak for HBW from-home and in the AM peak for HBW return-home trips.

Home Base Employers Business

The HBEB results show satisfactory results for the probability function for trips from home and trips returning home. The function is well defined for all time periods

The direct transposition shows poor fits in the AM peak for HBEB from home and for HBEB return home in the inter-peak, which may indicate that direct transposition does not take into account the duration of HBEB activities satisfactorily

Home Base Other

The main limitations with both direct transposition and probability functions are shown by the transposition of HBO trip purposes. The comparison with the observed trips show poor GEH results for HBO trips from home and HBO trips return-home for all time periods for both methods.

The HBO trip purpose covers all trip purposes that are non-work related (i.e. business and commuting) and it is likely that the various sub-trip purposes

encapsulated by the catch-all HBO label require further segmentation in order to improve the transposition of the interviews. Further analysis and a larger sample of HBO trips will be required in order to improve the probability function and allow sub-division into other HBO trip purposes such as education, shopping, personal business etc. (which has not been analysed in this research due to lack of available data).

Non Home Base Employers Business

The results for NHBEB are similar for both the direct transposition and probability function. Since the transposed matrices were controlled to the inbound trip purpose proportions we get the same number of trips for both methods.

However as can be seen in the later Table 3-7 the transposition between time periods will be different as the probability function will transpose from each time period to all other time periods and not just to the opposing peak. This will mean that although the transposed numbers will be the same the textural trip movements will be different.

Non-Home Base Other

The NHBO trip purpose is satisfactory for all time periods for both transposition methods.

Goods vehicles

Light goods vehicles and heavy goods vehicles were transposed using the NHBEB probability function. The GEH statistics are satisfactory for LGV bus borderline moderate to poor for heavy goods vehicles. Goods vehicles were not sampled and alternative survey methods will be required to derive reliable probability functions for them

Table 3-5 shows the numbers of interviews transposed for the two methods. This shows that the probability function approach results in fewer interviews being transposed within the 12 hour survey period. Since a Monte Carlo approach is used with the probability functions it is possible that some interviews will be transposed to a time outside the survey period. For instance a HBW trip from home in the PM peak may be unlikely to return during the 0700-1900 period and a HBW return-home trip in the morning peak is likely to have made its outbound journey before the survey began.

Table 3-6 shows the number of interviews transposed from their original time period to their transposed time period. Table 3-7 shows the number of trips transposed by their original time period and their transposed time period.

The probability functions are not significantly worse at transposing interview data than the conventional method. However from a realism point of view may be considered an improvement as it takes into account the duration of the trip activity, which means that interview movement will be transposed to a more realistic return time rather than to the opposing peak period. This is important when considering the development of trip matrices by trip purpose as the data will become considerably sparser.

Table 3-1: Number of observed trips by trip purpose and time period

Trip purpose	Inbound				Outbound			
	AM	IP	PM	TOTAL	AM	IP	PM	TOTAL
Home Base Work from home	3,355	995	615	4,965	1,961	634	525	3,120
Home Base Employers Business from home	439	537	279	1,255	322	323	147	792
Home Base Other from home	1,299	3,811	1,645	6,755	1,122	2,623	1,337	5,082
Home Base Work return home	223	774	2,078	3,075	374	1,024	2,732	4,131
Home Base Employers Business return home	108	487	268	864	314	820	361	1,495
Home Base Other return home	246	1,506	996	2,748	442	2,605	1,698	4,745
Non Home Base Employers Business	551	697	325	1,573	222	529	196	947
Non Home Base Other	704	3,160	1,201	5,065	611	2,920	1,260	4,790
Light Goods Vehicles	810	1,125	726	2,661	907	1,200	969	3,076
Heavy Goods Vehicles	532	1,054	390	1,976	577	1,053	360	1,990
Totals	8,268	14,145	8,524	30,937	6,852	13,732	9,584	30,168

Table 3-2: Number of interviews by trip purpose and time period

Trip purpose	Inbound				Outbound			
	AM	IP	PM	TOTAL	AM	IP	PM	TOTAL
Home Base Work from home	877	191	89	1,157	442	132	69	643
Home Base Employers Business from home	125	100	35	260	64	57	17	138
Home Base Other from home	346	743	234	1,323	237	484	190	911
Home Base Work return home	57	138	315	510	65	191	388	644
Home Base Employers Business return home	26	90	37	153	66	162	53	281
Home Base Other return home	64	287	152	503	95	503	272	870
Non Home Base Employers Business	139	133	49	321	44	85	27	156
Non Home Base Other	175	622	163	960	129	515	167	811
Light Goods Vehicles	127	191	74	392	123	167	88	378
Heavy Goods Vehicles	70	123	38	231	54	106	36	196
Totals	2,006	2,618	1,186	5,810	1,319	2,402	1,307	5,028

Table 3-3: Comparison of transposed interviews with observed interviews by trip purpose and time period

Trip purpose	Observed trips			Direct transposition			Probability function		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Home Base Work from home	1,961	634	525	2,233	714	200	2,100	206	216
Home Base Employers Business from home	322	323	147	141	424	162	271	272	234
Home Base Other from home	1,122	2,623	1,337	490	1,418	470	490	1,420	678
Home Base Work return home	374	1,024	2,732	733	1,002	2,829	866	1,511	2,813
Home Base Employers Business return home	314	820	361	205	472	375	183	722	381
Home Base Other return home	442	2,605	1,698	898	3,841	2,577	790	3,742	2,291
Non Home Base Employers Business	222	529	196	457	676	366	457	676	366
Non Home Base Other	611	2,920	1,260	583	3,068	1,350	583	3,068	1,350
Light Goods Vehicles	907	1,200	969	671	1,092	816	671	1,092	816
Heavy Goods Vehicles	577	1,053	360	441	1,023	438	441	1,023	438
Totals	6,852	13,732	9,584	6,852	13,732	9,584	6,852	13,732	9,584

Table 3-4: GEH statistic for observed interviews and transposed interviews by trip purpose and time period

Trip purpose	Observed trips v Direct transposition			Observed v Probability function		
	AM	IP	PM	AM	IP	PM
Home Base Work from home	5.9	3.1	17.1	3.1	20.9	16.1
Home Base Employers Business from home	11.9	5.2	1.2	3.0	3.0	6.3
Home Base Other from home	22.3	26.8	28.8	22.3	26.8	20.7
Home Base Work return home	15.3	0.7	1.8	19.8	13.7	1.5
Home Base Employers Business return home	6.7	13.7	0.7	8.3	3.5	1.1
Home Base Other return home	17.6	21.8	19.0	14.0	20.2	13.3
Non Home Base Employers Business	12.8	6.0	10.1	12.8	6.0	10.1
Non Home Base Other	1.1	2.7	2.5	1.1	2.7	2.5
Light Goods Vehicles	8.4	3.2	5.1	8.4	3.2	5.1
Heavy Goods Vehicles	6.0	0.9	3.9	6.0	0.9	3.9
Average	10.8	8.4	9.0	9.9	10.1	8.1

Table 3-5: Number of interviews transposed by trip purpose and time period

Trip purpose	Direct transposition				Probability function			
	AM	IP	PM	TOTAL	AM	IP	PM	TOTAL
Home Base Work from home	877	191	89	1,157	750	158	80	988
Home Base Employers Business from home	125	100	35	260	87	93	22	202
Home Base Other from home	346	743	234	1,323	294	724	145	1,163
Home Base Work return home	57	138	315	510	46	85	81	212
Home Base Employers Business return home	26	90	37	153	24	78	15	117
Home Base Other return home	64	287	152	503	62	286	102	450
Non Home Base Employers Business	139	133	49	321	115	118	33	266
Non Home Base Other	175	622	163	960	159	552	118	829
Light Goods Vehicles	127	191	74	392	104	168	52	324
Heavy Goods Vehicles	70	123	38	231	63	112	25	200
Totals	2,006	2,618	1,186	5,810	1,704	2,374	673	4,751

Table 3-6: Transposed interviews by trip purpose and time period using the probability functions

Trip purpose	Transpose from AM to			Transpose from IP to			Transpose from PM to			TOTALS
	AM	IP	PM	AM	IP	PM	AM	IP	PM	
Home Base Work from home	13	445	292	35	82	41	0	22	58	988
Home Base Employers Business from home	11	58	18	16	58	19	0	10	12	202
Home Base Other from home	87	189	18	69	547	108	1	54	90	1,163
Home Base Work return home	41	5	0	26	40	19	47	32	2	212
Home Base Employers Business return home	23	1	0	13	39	26	4	10	1	117
Home Base Other return home	57	5	0	32	233	21	5	56	41	450
Non Home Base Employers Business	22	59	34	24	70	24	8	15	10	266
Non Home Base Other	56	82	21	96	365	91	6	60	52	829
Light Goods Vehicles	25	55	24	26	107	35	8	28	16	324
Heavy Goods Vehicles	14	39	10	21	72	19	6	11	8	200
Totals	349	938	417	358	1,613	403	85	298	290	4,751

Table 3-7: Transposition trips by trip purpose and time period using the probability functions

Trip purpose	Transpose from AM to			Transpose from IP to			Transpose from PM to			TOTALS
	AM	IP	PM	AM	IP	PM	AM	IP	PM	
Home Base Work from home	209	1,204	2,069	657	237	304	0	70	439	5,190
Home Base Employers Business from home	76	301	126	107	342	174	0	79	81	1,286
Home Base Other from home	447	842	170	338	2,622	1,105	5	278	1,016	6,823
Home Base Work return home	788	16	0	446	110	203	865	80	13	2,521
Home Base Employers Business return home	166	7	0	76	220	229	29	46	5	777
Home Base Other return home	305	21	0	155	1,121	177	30	278	501	2,589
Non Home Base Employers Business	172	274	187	206	320	136	79	82	43	1,499
Non Home Base Other	232	511	181	327	2,187	646	24	370	523	5,002
Light Goods Vehicles	247	332	154	316	608	490	109	152	172	2,580
Heavy Goods Vehicles	103	370	41	308	579	265	29	73	133	1,903
Totals	2,746	3,879	2,927	2,936	8,346	3,731	1,170	1,508	2,926	30,168

4 CONCLUSIONS

In conclusion, the main findings of the study were as follows:

It was possible to derive probability functions that could be used to synthesise the transpose time for different purposes for car drivers. The six towns generally had similar parking characteristics, which meant that the probability functions were transferable

The probability functions could be used in a Monte Carlo approach to synthesise the duration of stay at the destination. Allowing for travel time to and from the roadside interview site the likely transpose time for the interview can be generated.

The results indicate that the probability function can transpose the interviews satisfactorily provided that the sample of trip purposes is good and reasonable, and that there are no conflicting sub-purposes. For well-surveyed trip purposes the probability function can give better results than conventional transposition methods.