

Technical note

Project	Handy Cross Roundabout PARAMICS Model	Date	19 February 2009
Note	Model Calibration and Validation	Ref	CTLBCW/100/1
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1 *Introduction*

1.1 This technical note describes the base traffic model development for the Handy Cross area of High Wycombe using the Paramics micro-simulation package version 2007.

1.2 As a part of the evidence base for the Local Development Framework, Halcrow was commissioned to update an existing Paramics model of Handy Cross to reflect current traffic demands and traffic conditions. The model is based on an existing validated Paramics model, initially developed by JCT for Parsons Brinckerhoff and later updated by Hyder Consulting. The existing model was based on 2001 traffic flows. Since then, significant upgrades to both Handy Cross and the Marlow Hill roundabouts have been made so that a new version of the model is required. A major vehicle registration number plate survey was carried out on Tuesday, 26/02/2008, by Count On Us to capture the current traffic demand and movement patterns at Handy Cross (post improvement). Information on queue lengths is available from a Mott MacDonald Report on the operation of Handy Cross.

1.3 Apart from deriving new traffic demands for the base year 2008, the model was updated to reflect a number of changes made to the network since the existing model was developed. Signal timings were also adjusted to match the current timings.

1.4 In line with the initial model, the updated 2008 model contains two time periods and three vehicle classes. These are listed below.

Time Periods

- The validation is based on

- AM 0800 – 0900
- PM 1730 – 1830

Both periods have a 30 minutes warm-up and a cooling-off periods Such that the full model exams 0730-0930 and 1700-1900.

Vehicle types

- Car : Car & Light vehicle
- Heavy vehicles: median & large
- PSV (Passenger Service Vehicles)

1.5 The remainder of this note gives a brief description of the model. It then describes the network changes made, matrix development, calibration and validation results.

2 *The Initial Model*

2.1 The Highway Agency supplied Halcrow with a Paramics model from Hyder Consulting for Handy Cross and the surrounding area. This model was initially developed by JCT for Parsons Brinckerhoff based on year 2001 traffic flows and conditions. Hyder updated the model to incorporate vehicle actuated signal control with some other minor changes. In Hyder's update however, no new data were used and the model base year was still 2001.

2.2 Figure 1 below shows the model extent and the zone plan from Hyders' LMVR report.

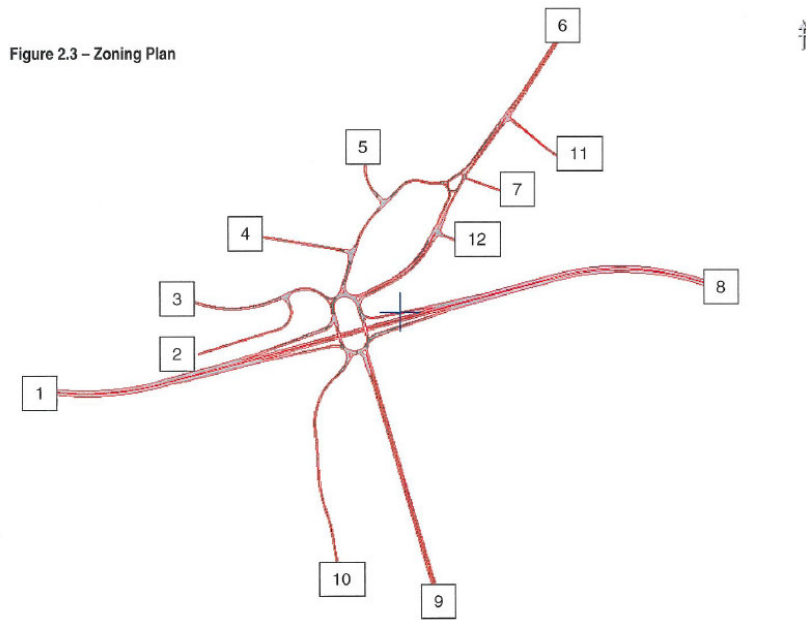


Figure 1 Model Extent and Zone Plan

2.3

The version of the model passed to Halcrow included the new link inserted in the middle of the Handy Cross roundabout immediately north of and above the M40 (This formed part of the Handy Cross improvement which opened in 2007). The detailed model layout, with the signal head locations, is shown in Figure 2 below.

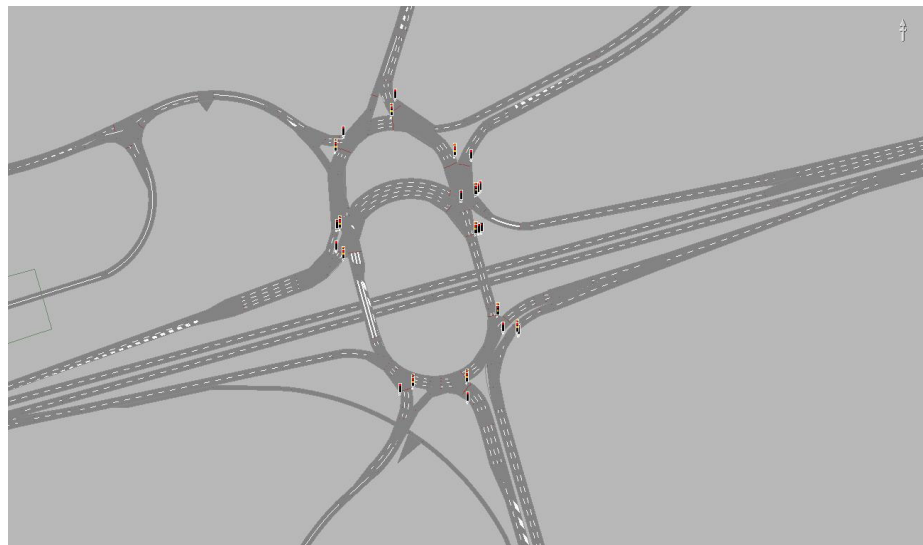


Figure 2 Handy Cross Junction

2.4

The model contains three time periods which were supplied

- AM 0730 – 0930
- IP 1230 – 1400 (not used for the LDF testing)
- PM 1700 – 1900

The evaluation is based on the hours described in paragraph 1.4..

2.5 Three vehicle types are modelled

- Car : Car & Light vehicle
- Heavy vehicles: median & large
- PSV

2.6 In the 2001 model, the quality of the model is judged by a validation measure (percentage of links on which the GEH is less than 5) for the AM, PM and IP. These are shown in the table below.

	AM	PM	IP
GEH	86%	58%	100%

The DMRB guidance requires the measure to be greater than 85%. Compared with the guideline figure the PM result is rather poor for the initial model. However, the number of links measured is small and change of result in one link would change the GEH figures considerably.

2.7 The initial model used all or nothing assignment based on shortest distance.

2.8 The updated model has been developed by Halcrow from the existing network. The coding has been updated to reflect the current network layout and signal timings. A series of matrices in 15 minute intervals for 3 vehicle classes were developed to load onto the network. The next section describes the network changes made.

3 Network Updates

3.1 Buckinghamshire County Council (BCC) has provided separate drawings of Handy Cross and Marlow Hill/Marlow Road Roundabout showing the layouts as they are currently built. No discernable differences were found in the Paramics model at the upgraded Handy Cross roundabout except the stopline position at the John Hall Way which is moved back according to the drawing. No other changes were made.

3.2 However, the Marlow Hill roundabout has been significantly reconfigured since the original model and a number of changes were made to this roundabout including.

- Northern approach (South Bound) widened to 4 lanes from 2 lanes.
- South bound circulating link widened to 4 lanes from 2
- North bound circulating link widened to 3 lanes from 2

3.3 At the Marlow Hill/Daws Hill Lane junction, the original model inaccurately reflected the layout at this junction. The angled left in and left out slip roads were added to Daws Hill Lane junction to reflect the current layout. The appropriate signal control was revised within the network coding.

3.4 In the original model, the two junctions on Marlow Road with Cressex Road and Desborough Avenue are modelled as priority junctions. They are modified to mini-roundabouts as they exist in reality, based on Google Map.

3.5 The modelling of signals has been changed back to fixed time plans reflecting the current operating conditions. Signal timings at all the locations were updated using the latest timings obtained from the CONTRAM model covering this area. Both the Handy Cross roundabout and the Marlow Hill Roundabout operate a fixed coordinated signal plan with 60 seconds cycle time. The Sport Centre/Marlow Hill junction and Daws Hill Lane/Marlow Hill junction operate independently both with a 80 seconds cycle.

3.6 From the early model runs, it become evident that there appears to be strong mismatch between the green splits obtained from CONTRAM and the traffic demand at the Daws Hill Lane in the PM peak. The signal timings have been revised following site visits to confirm actual timings at the junction. This allowed greater time for the right turning traffic, particularly in the PM peak.

4 *Matrix Development*

4.1 New demand matrices have been developed to represent the current travel patterns. The zone plan for the Hyder's model as shown in Figure 1 is considered adequate and is adopted for this new model.

4.2 A large vehicle registration number plate survey was carried out by Count on Us on Tuesday, 20 February 2008, a normal day in traffic terms as far as we can ascertain. The survey site plan is shown in the following Figure 3.

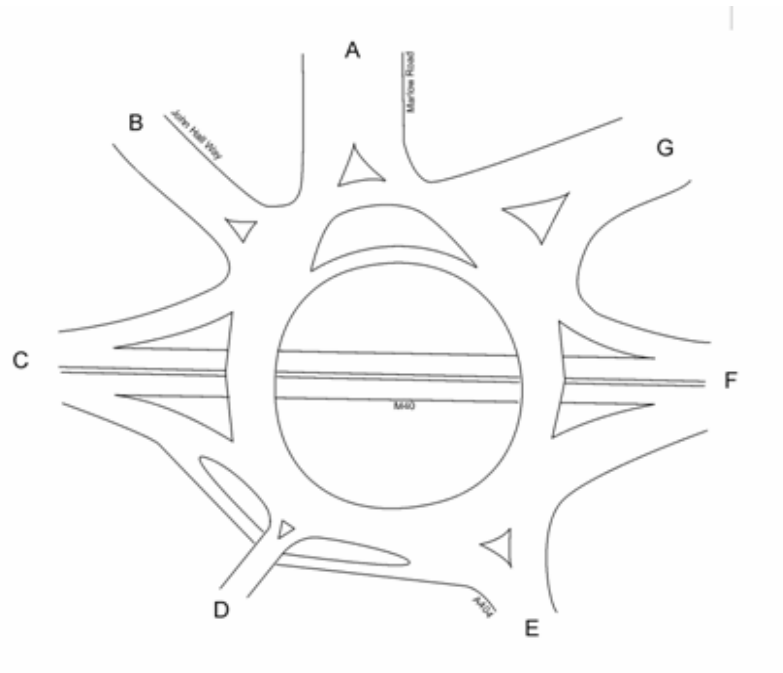


Figure 3 Vehicle Registration Survey Plan

- 4.3 Halcrow has been provided with a series of demand matrices in 15 minute intervals by 5 vehicle class from 06:30 to 19:30 showing movement between the arms at the Handy Cross roundabout. This result is considered relatively consistent and accurate.

- 4.4 The survey recoded vehicle in five vehicle classes CAR, LGV (Light Goods Vehicle), HGV (Heavy Goods Vehicle), PSV (Public Service Vehicles) and MCL (Motorcycles). The number of motor cycles (MCL) is very small, 283 in 13 hours and they are ignored. LGVs are amalgamated into the CAR category. Given that there are 2 hours in each of the AM and PM model periods, there are a total of 48 demand matrices allowing for fine slice of model periods and vehicle specs.

- 4.5 In addition to the registration survey, classified traffic turning counts at a number of locations have been used to assist matrix development. The surveys were conducted on different days as that for the vehicle registration survey. These sites are shown in the following Figure 4. The sites in green dot are surveyed on Tuesday, 24/06/2008 and the sites in red star surveyed on Tuesday, 04/12/2001 (latest work available for these locations). Data at these sites are used to assist expanding the Handy Cross roundabout matrices to cover the whole model area.

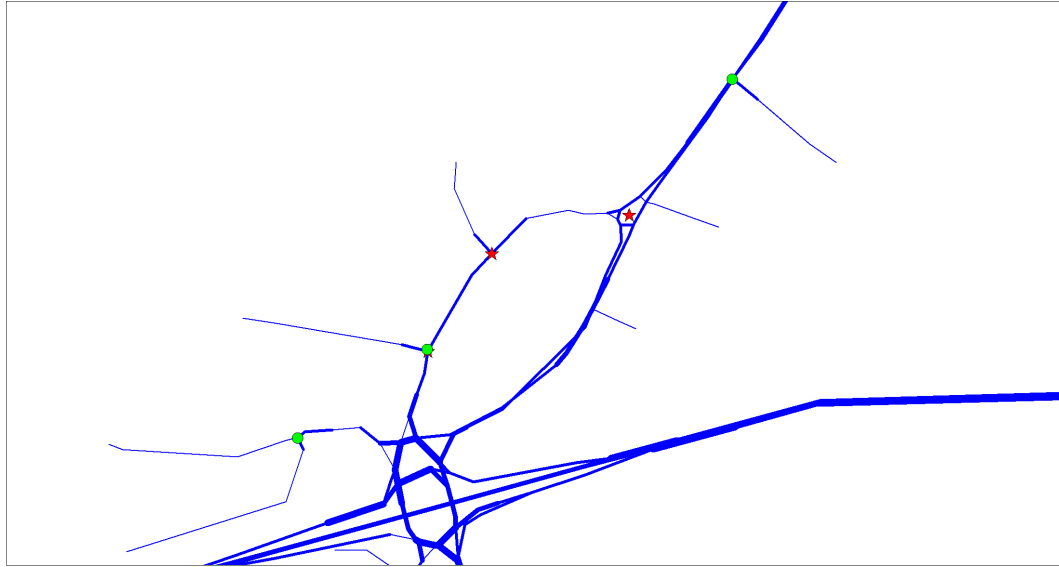


Figure 4 Manual Classified Count Sites

- 4.6 The amalgamation of the vehicle registration data with the manual classified counts, peak one hour classified turning flows (0800-0900 for AM and 1730-1830 for PM) are shown in Appendix A.
- 4.7 The registration survey data covers only the Handy Cross roundabout. The matrices needed to be expanded to cover the whole model area extending from the Handy Cross roundabout at the John Hall Way (B in Figure 3) to zone 2 and 3 (shown in Figure 1); from Marlow Road (A) and Marlow Hill (G) to zone 4, 5, 6, 7, 11, and 12. As the registration surveyed data is consider relatively consistent and accurate, initial attempt was made to extend the flows to and from these three arms B, A and G outwards using the relevant proportions at the corresponding junctions. As data at the Marlow Hill roundabout and Desborough Avenue/Marlow Road junction are very old (surveyed in 2001), this method of expansion would allow us to avoid to use the absolute flows numbers at these two junctions.
- 4.8 Once the demand that passed the Handy Cross roundabout was derived, the same methodology was applied to determine those traffic movements between zones that do not use Handy Cross. However, some discrepancies were found, due to inconsistencies in the manual classified traffic count data which were obtained separately in 2001 and 2008. As an example, it can be seen from the figures in Appendix A, the number of cars exiting the south arm of the Marlow Hill/Daws Hill Lane junction was 1645 between 0800-0900 (surveyed in 2008), but the corresponding entry flow to Marlow Hill roundabout from the north was 2063 (surveyed in 2001), a difference of over 400 cars.

- 4.9 As a result, a stronger method was adopted to balance the trips. A specially designed Furness procedure has been developed to derive the trip demand among the zones, including 4, 5, 6, 7, 11, 12 and A and G. In addressing the data imbalance, from our knowledge on local traffic, it is found that the traffic count in 2001 at the Desborough Avenue/Marlow Hill suggests a lot more traffic going on to the Desborough Avenue than there should be, particularly in the PM peak. Hence 98 cars are removed in the AM hour and 524 cars removed in the PM hour before applying the Furnessing procedure.
- 4.10 Having corrected the general imbalance between the total generation and attractions, a number of constraints are applied to the Furness procedure at the level of individual OD pairs.
- 4.11 Firstly, it has been assumed that there are no trips between Cressex Road and Desborough Avenue (zones 4 and 5) and the Marlow Hill arm (G) at the Handy Cross roundabout. Secondly, the total flow levels to/from the Marlow Hill and Marlow Road arms are maintained to protect the integrity of the registration survey data. Lastly, the trips between zone 4 and arm A (shown in Figure 3), 6 and 11 and 7 and G (there are no trips recorded to/from the Sport Centre in the survey) are taken directly from the traffic count data. This gives an initial matrix of movements which are assigned and further checks undertaken on the split between Marlow Hill and Marlow Road.
- 4.12 Once the trips are derived between the relevant zones at the north and the corresponding arms at the Handy Cross roundabout, they are further distributed using the proportions from the registration survey between the entry arm to all other arms at the Handy Cross roundabout and to the destination zones. The full trips demand matrices are shown in Appendix B
- 4.13 In the original Hyder's model, a number of profiles were used to balance the trip demand over time. In this model, each set of matrices were derived for each 15 minutes time interval. This is considered far better in capturing the demand patterns both spatially and temporally.
- 5**
- 5.1** ***Matrix validation***
- The trips in the matrices derived above are checked by allocating their logical path to the network and the resultant flows are compared with the survey. A screenline is set cutting across Marlow Hill and Marlow Road as shown by the red line in Figure 5. All the trips between the South and North of the screenline will have to pass these two roads. The results are shown in the Table 1 and Table 2 below



Figure 5 Screenline A_G

Table 1 Entry Flow (Towards Handy Cross Roundabout)

AM					
Arm	Observed	Demand	Difference	Diff(%)	GEH
B	862	862	-0.2	0%	0.0
C	1335	1335	-0.5	0%	0.0
D	753	753	0.1	0%	0.0
E	1243	1242	-0.6	0%	0.0
F	1635	1635	-0.4	0%	0.0
Screenline					
A_G	1613	1557	-56.4	-3%	1.4
PM					
Arm	Observed	Demand	Difference	Diff(%)	GEH
B	1314	1314	-0.1	0%	0.0
C	991	991	-0.3	0%	0.0
D	616	616	0.0	0%	0.0
E	1349	1349	-0.2	0%	0.0
F	1477	1476	-0.6	0%	0.0
Screenline					
A_G	1696	1585	-111.0	-7%	2.7

Table 2 Exit Flow (Out of Handy Cross Roundabout)

AM					
Arm	Observed	Demand	Difference	Diff(%)	GEH
B	1190	1190	0.0	0%	0.0
C	251	251	0.0	0%	0.0
D	496	496	0.0	0%	0.0
E	2253	2253	0.0	0%	0.0
F	1400	1400	0.4	0%	0.0
Screenline					
A_G	1793	1851	57.6	3%	1.3
PM					
Arm	Observed	Demand	Difference	Diff(%)	GEH
B	1141	1141	0.0	0%	0.0
C	509	510	1.0	0%	0.0
D	486	487	1.0	0%	0.0
E	2096	2098	2.0	0%	0.0
F	1423	1424	1.0	0%	0.0
Screenline					
A_G	1676	1783	107.2	6%	2.6

5.2 It can be observed that the matrix expansion has successfully kept the integrity of the demand matrices at the Handy Cross Roundabout obtained from registration survey. The differences cross the screenline are very small.

5.3 Appendix C compares the modelled trip generations and attractions from/to each zone for the AM peak hour and PM peak hour with survey results. .

6 Calibration and Validation

6.1 The derived full matrices were loaded to the updated network described in section 3 above.

6.2 The Hyder’s model used distance based all or nothing assignment. This allocates all the trips between the north of the Marlow Hill roundabout and Handy Cross roundabout to Marlow Hill. Our local knowledge tells us that a considerable number of vehicles use Marlow Road instead, particularly when the Marlow Hill is congested.

6.3 A major change in assignment was made to the route choice modelling. The default time based assignment method was applied.

6.4 After a number of trials, a set of parameters was found to mostly closely to match the surveyed traffic conditions, i.e. giving better calibration and validation result. They are listed below

	Model	Default
Feed back factor	0.85	0.5
Feed back interval	3 minutes	NA
Familiarity for car drivers	45%	85%
Time cost coefficient	3	1

6.5 The model is considered of having achieved high standard. It was run 5 times for both the AM period and PM period to obtain the averages to count the natural fluctuation in micro-simulation due to randomness. In the following paragraphs, the resultant flows and queues are compared with the surveyed results.

6.6 The modelled link flows have been compared with the surveyed traffic levels. The AM and PM results are shown in Table 3 and Table 4 respectively. Junction 2 is the Desborough Avenue/Marlow Road junction; 4 is the Cressex Road/Marlow Hill junction; 11 is the Marlow Hill/Daws Hill Lane junction. The links refer to the corresponding links in the Paramics model. The traffic counts at the Desborough Avenue/Marlow Road and Marlow Hill roundabout are not used in the comparison as they are dated from 2001.

6.7 From these two tables, it can be seen that in both cases, there are 24 out of 28 links (86%) whose GEH values are less than 5. This meets the DMRB requirement. In each of the time periods, there are 4 links whose GEH measure are larger than 5. Efforts were made to try to reduce them further. However, it was found that the gain in one time period tends to be lost in the other. This suggests that the model as a whole has reached or close to the optimum. Instead of using a time only measure to calculate the generalised cost, we also tested the use of both time and distance measures for generalised cost calculation. The coefficient of distance was set at half of that for time, 1.5. The results of the model runs deteriorated in both time periods. This led us to maintain the assignment based on time only.

Table 3 Link flow comparison – AM peak

<i>Arm/ Junction</i>	<i>Paramics Link</i>	<i>Modelled Link Flow</i>	<i>Observed Link Flow</i>	<i>Difference</i>	<i>Difference %</i>	<i>GEHs</i>
2	11:14c	642	614	28	4.6%	1.1
	9:14c	1193	1182	11	0.9%	0.3
	12:14c	221	224	-3	-1.3%	0.2
	14c:11	1005	1004	1	0.1%	0.0
	14c:9	863	812	51	6.3%	1.8
	14c:12	188	204	-16	-7.8%	1.1
4	102:144ycc	433	434	-1	-0.3%	0.1
	108:144yca	636	785	-149	-19.0%	5.6
	127z:144ycb	698	711	-13	-1.9%	0.5
	144ycc:102	340	335	5	1.5%	0.3
	144yca:108	900	919	-19	-2.1%	0.6
	144ycb:127z	528	676	-148	-21.9%	6.0
11	136z:144	531	536	-5	-1.0%	0.2
	135z:136z	762	740	22	3.0%	0.8
A	'8:18	720	721	-1	-0.1%	0.0
	'18:19	554	711	-157	-22.1%	6.3
B	'1:7	1192	1190	2	0.2%	0.1
	'7:8	862	862	0	0.0%	0.0
C	'79:59	225	251	-26	-10.4%	1.7
	'2:0	1353	1335	18	1.3%	0.5
D	'73:65	497	496	1	0.2%	0.0
	'65:66	759	753	6	0.8%	0.2
E	'71:76	2309	2253	56	2.5%	1.2
	'69:70	1213	1243	-30	-2.4%	0.9
F	'149:42	1423	1400	23	1.7%	0.6
	154:156z	576	1632			
	'52:68	1059	1635			
		1636	1635	1	0.0%	0.0
G	'19:21	1146	1130	16	1.4%	0.5
	'23:22	1088	902	186	20.6%	5.9

Table 4 Link flow comparison – PM peak

Arm/ Junction	Paramics Link	Modelled Link Flow	Observed Link Flow	Difference	Difference %	GEHs
2	11:14c	895	916	-21	-2.3%	0.7
	9:14c	1141	1195	-54	-4.5%	1.6
	12:14c	425	439	-14	-3.2%	0.7
	14c:11	786	843	-57	-6.8%	2.0
	14c:9	1319	1303	16	1.3%	0.5
	14c:12	355	408	-53	-13.1%	2.7
4	102:144ycc	388	386	2	0.6%	0.1
	108:144yca	770	877	-107	-12.2%	3.7
	127z:144ycb	397	712	-315	-44.2%	13.4
	144ycc:102	453	451	2	0.4%	0.1
	144yca:108	584	920	-336	-36.5%	12.2
	144ycb:127z	519	606	-87	-14.4%	3.7
11	136z:144	516	519	-3	-0.5%	0.1
	135z:136z	920	904	16	1.8%	0.5
A	'8:18	430	694	-264	-38.1%	11.1
	'18:19	552	629	-77	-12.2%	3.2
B	'1:7	1141	1141	0	0.0%	0.0
	'7:8	1323	1314	9	0.7%	0.2
C	'79:59	414	510	-96	-18.9%	4.5
	'2:0	989	991	-2	-0.2%	0.1
D	'73:65	492	487	5	0.9%	0.2
	'65:66	614	616	-2	-0.4%	0.1
E	'71:76	2123	2098	25	1.2%	0.5
	'69:70	1264	1349	-85	-6.3%	2.4
F	'149:42	1445	1424	21	1.5%	0.6
		1477	1477	0	0.0%	0.0
G	'19:21	1346	1072	274	25.5%	7.9
	'23:22	1146	1067	79	7.4%	2.4

6.8

The following Table 5 and Table 6 compare the modelled vehicle queues with surveyed queues (In the PM queue survey started at 17:00 and finished at 18:00). Some of the differences in queues are considerable. At John Hall Way, the modelled queues are shorter than the surveyed queues in both AM and PM periods. It is not evident from the survey data whether there were exit blocking issues on those survey days which would influence the pattern of queues on the junction. The Motts Report which examined conditions on the 30th January 2008 noted:

- AM
- No long queues were observed on any approach, i.e, all the queues discharged during the green phase;

- Exit blocking was however observed at three locations, circulatory leading to John Hall Way (from Marlow Rd), circulatory leading to Marlow Hill, and circulatory leading to Wycombe Road
- PM
- Queues observed on John Hall Way, Marlow Road and Marlow Hill- the John Hall Way dissipated in each green phase while those on Marlow Hill did not

6.9 Examination of the Surveyed flow during the AM hour shows as flow of 802 cars, 54 HGVs and 4 PSVs. The green time for this approach is 15 seconds. With a 3 lane approach (the third lane is a long flare). This only amounts to a degree of saturation (DoS) of 64%. Even if only 2 lanes are considered, the DoS is still less than 100% at 96%. At these levels of DoS, it should not give a queue of over 200 meters. This suggests that some exit blocking may have been occurring on the survey day. However this does not occur every day at the junction and thus there is variability in the queuing as identified by the Motts Report. Further investigation of the sensitivity of the model to the parameters is being undertaken.

7

Use of the Model

7.1

The Paramics model is to be used as part of the evidence base for the Local Development Framework. The approach is to apply differences obtained from the base year and forecast year CONTRAM model to the base matrices within the Paramics model. CONTRAM runs are undertaken for 2006 and for a series of scenarios at 2026 including a do-minimum and a local development. From the CONTRAM model it is possible to derive cordon matrices based on the boundary of the Paramics model. These will be obtained for the base and test as outlined above and the difference applied within CONTRAM.

Table 5 Queue Length (meter) - AM

	John Hall Way		M40 (West)		Marlow Road		A404 Marlow Hill		M40 (East)		Wycombe Road	
Time	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed
08:00:00	63	210	76	105	51	30	80	110	74	90	52	160
08:05:00	62	185	79	115	49	30	79	70	70	80	57	200
08:10:00	65	210	77	115	49	40	79	70	73	105	56	110
08:15:00	63	210	79	120	46	45	80	60	74	75	54	150
08:20:00	64	245	78	80	49	40	77	45	70	105	54	100
08:25:00	60	225	76	120	49	30	80	50	72	70	53	110
08:30:00	62	230	76	120	45	40	79	60	71	75	54	100
08:35:00	63	205	77	80	45	25	81	65	70	85	53	90
08:40:00	63	210	78	80	44	30	79	50	71	80	54	75
08:45:00	63	205	76	40	41	25	78	70	72	60	53	30
08:50:00	64	130	74	20	42	25	80	45	74	75	54	35
08:55:00	65	45	70	20	45	25	78	100	73	60	51	50
09:00:00	60	50	63	20	39	20	78	140	72	65	48	25

Surveyed queues are not available for A404 South

Table 6 Queue Length (meter) - PM

	John Hall Way		M40 (West)		Marlow Road		A404 Marlow Hill		M40 (East)		Wycombe Road	
Time	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed	Modelled	Surveyed
17:00:00	56	120	62	25	46	90	75	70	50	95	62	45
17:05:00	55	235	61	35	46	55	79	70	49	70	63	45
17:10:00	59	675	64	40	44	30	79	75	50	65	63	110
17:15:00	53	655	61	40	49	55	78	55	53	80	61	30
17:20:00	52	560	63	45	45	45	78	60	55	70	66	50
17:25:00	56	440	64	25	48	35	79	50	54	100	62	50
17:30:00	54	330	64	50	49	30	79	75	53	75	65	25
17:35:00	55	660	64	50	42	25	79	65	52	90	63	35
17:40:00	62	650	65	30	50	30	78	70	51	90	66	40
17:45:00	54	390	64	50	48	45	79	50	49	65	65	25
17:50:00	56	260	63	35	44	30	78	140	48	100	63	50
17:55:00	53	135	64	45	49	20	77	90	55	115	64	50
18:00:00	0	80	64	35	46	60	78	70	47	125	61	30

Surveyed queues are not available for A404 South

8**Summary**

8.1

This technical note has described the base model development for the Handy Cross and Marlow Hill roundabouts area using Paramics micro-simulation. The model was based on an initial Paramics model which was based on year 2001. The main data set for this study is a set of demand matrices for the Handy Cross roundabout in 15 minutes interval obtained from a vehicle registration number plate survey carried out in February 2008. This data is supplemented by manual classified traffic counts.

8.2

A number of changes were made to the network including mainly Marlow Hill roundabout, Daws Hill Lane/Marlow Hill junction and two junctions on Marlow Road. All the signal timings were updated to reflect the current time settings.

8.3

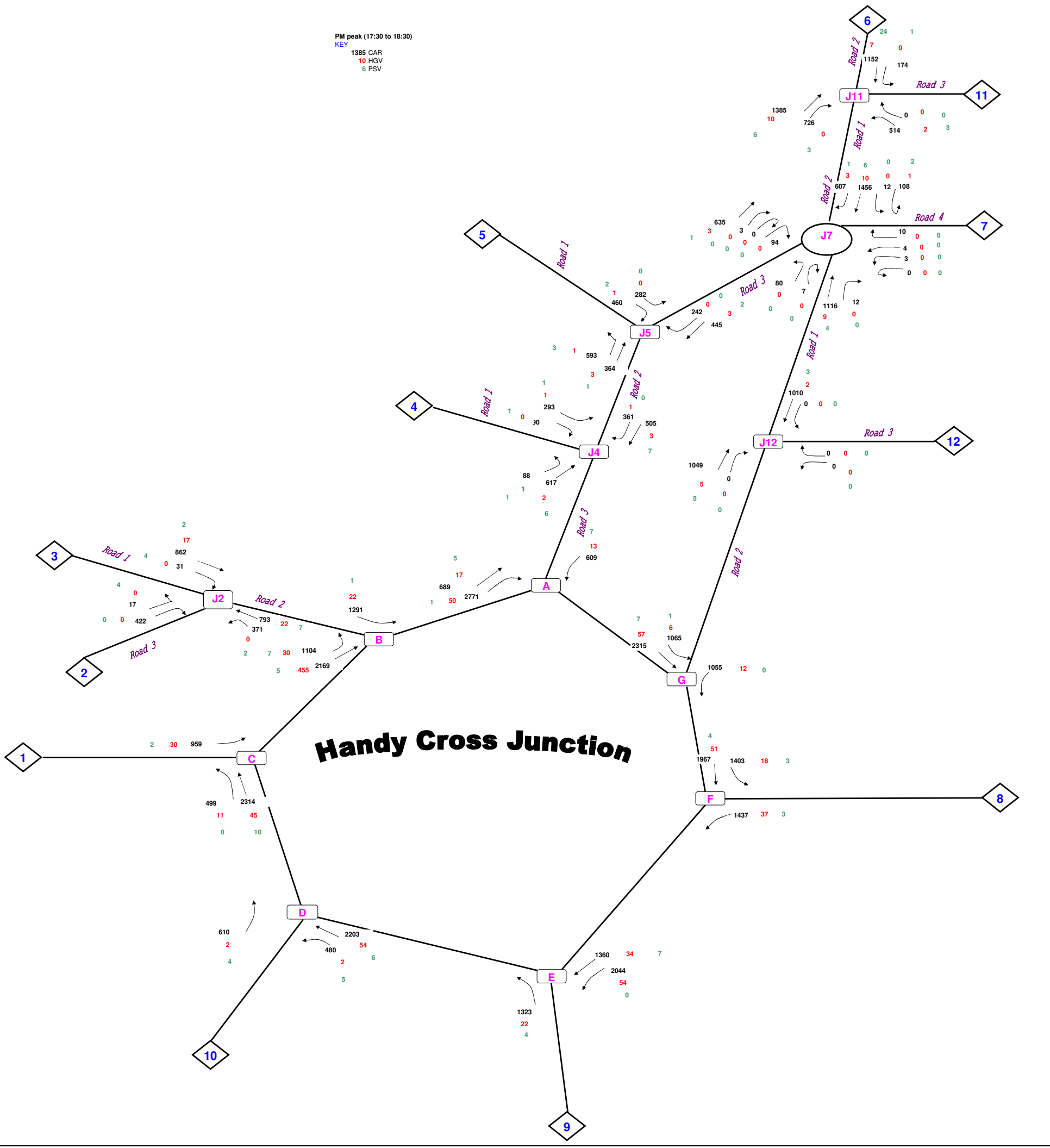
The assignment method was modified from distance based all-or-nothing assignment to time based dynamic assignment.

8.4

The model has been successfully calibrated on link flows. The validation of queue measures shows a reasonable fit on a number of arms but with a concern over the validation of the John Hall Way approach. The model is not replicating the queues as observed on the survey day which suggests that some exit blocking was occurring on the survey day or there was an incident, thus influencing congestion at the junction.

Appendix A Observed Classified Traffic Counts

PM peak (17:30 to 18:30)
 KEY
 1385 CAR
 10 HGV
 6 PSV



Appendix B Demand Matrices

Demand Matrices

Trips		ToZone										Grand Total	
Time	FromZone	1	2	3	4	5	6	7	8	9	10		11
07:30:00	1												19
	2	2	4	19	2	22	74	0	0	189	0	2	4
	3	5			0	3	27	0	62	47	5	7	155
	4	2	0	0	0	39	28	0	46	18	1	8	142
	5	2	0	0	25	0	43	1	46	19	1	12	148
	6	10	1	4	27	65	0	1	95	170	19	53	446
	7	0	0	0	0	1	1	0	2	3	0	0	8
	8	0	10	50	4	39	50	0		130	17	13	314
	9	38	16	84	2	19	84	0	84		0	22	349
	10	12	6	30	1	7	6	0	75	33		1	170
	11	2	0	1	7	16	0	0	23	41	4	0	93
07:30:00 Total		74	37	188	69	211	327	3	461	671	49	138	2229
07:45:00	1		4	29	3	17	77	0	0	232	0	23	385
	2	4			0	1	11	0	37	28	1	4	86
	3	6			0	1	16	0	62	41	1	5	132
	4	3	0	0	0	50	30	0	43	12	3	9	150
	5	2	0	0	22	0	33	0	36	10	4	11	118
	6	11	1	4	28	72	1	1	89	125	38	61	429
	7	0	0	0	0	1	1	0	1	2	0	0	6
	8	0	14	93	5	42	58	0		123	27	17	380
	9	40	14	91	2	12	105	0	70		0	32	365
	10	18	5	33	3	23	27	0	59	27		9	205
	11	4	0	2	13	33	0	0	40	54	14	0	161
07:45:00 Total		88	39	250	77	252	358	2	437	654	88	172	2416
08:00:00	1		7	45	2	20	75	0	0	199	0	28	377
	2	2			0	1	7	0	20	16	0	3	49
	3	5			0	3	26	0	68	52	2	9	165
	4	1	0	0	0	41	28	0	27	10	5	10	123
	5	2	0	0	28	0	43	0	33	11	7	17	140
	6	8	0	3	31	66	2	0	79	102	43	93	427
	7	0	0	0	0	1	1	0	1	1	1	0	5
	8	0	12	71	5	53	61	0		131	50	24	407
	9	29	16	98	1	14	87	0	60		0	33	338
	10	16	9	38	1	15	30	0	69	30		11	219
	11	3	0	1	15	30	1	0	37	46	20	0	154
08:00:00 Total		66	45	256	83	244	360	0	394	599	128	228	2403
08:15:00	1		6	45	5	16	67	0	0	201	0	29	369
	2	2			0	1	10	0	22	14	1	4	54
	3	4			1	2	28	0	62	40	4	11	151
	4	1	0	0	0	41	30	0	19	8	5	14	118
	5	1	0	0	22	0	47	0	27	10	7	21	137
	6	7	0	3	31	90	5	1	77	98	39	92	443
	7	0	0	0	0	1	0	0	0	1	0	0	3
	8	0	9	69	11	40	54	0		131	57	24	397
	9	23	16	117	4	18	73	0	37		0	30	317
	10	12	5	41	1	3	27	0	61	29		12	191
	11	2	0	1	12	34	2	0	27	34	14	1	127
08:15:00 Total		52	36	277	87	245	344	2	332	566	127	237	2306
08:30:00	1		9	40	6	16	74	0	2	200	0	24	371
	2	3			1	2	9	0	29	16	3	3	66
	3	8			1	5	23	0	71	42	6	8	164
	4	2	0	0	0	35	24	1	17	12	3	9	103
	5	3	0	0	27	0	47	1	27	20	6	16	146
	6	16	1	3	23	52	4	1	58	78	23	53	310
	7	0	0	0	0	1	1	0	1	1	0	0	5
	8	0	18	75	11	36	37	0		153	58	13	402
	9	23	18	77	4	13	71	0	50		3	24	282
	10	14	10	43	5	15	20	0	59	19		7	192
	11	8	0	2	15	31	2	0	35	44	14	1	151
08:30:00 Total		77	57	239	92	205	312	4	347	584	117	158	2192
08:45:00	1		4	17	3	19	41	0	1	118	0	15	218
	2	2			0	1	8	0	20	14	2	3	50
	3	6			1	4	25	0	71	43	5	10	164
	4	3	0	0	0	49	8	0	16	8	3	3	90
	5	7	0	0	42	0	31	1	34	21	8	11	156
	6	9	1	4	11	47	1	0	52	83	32	41	281
	7	0	0	0	0	1	0	0	1	2	1	0	5
	8	0	17	67	8	64	43	0		162	51	17	429
	9	19	24	110	1	11	51	0	61		8	19	304
	10	8	7	26	4	26	9	0	51	18		3	151
	11	3	0	2	5	20	1	0	20	36	14	0	100
08:45:00 Total		56	53	227	74	241	219	2	327	504	124	121	1948
09:00:00	1		3	15	2	8	22	0	0	61	0	7	117
	2	3			1	3	17	0	28	26	1	5	84
	3	3			0	2	14	0	26	24	1	4	74
	4	2	0	1	0	33	21	0	15	9	2	6	89
	5	2	0	1	28	0	68	1	23	15	2	21	161
	6	11	1	6	20	90	3	1	49	90	23	29	323
	7	1	0	0	0	1	1	0	1	1	0	0	5
	8	0	15	72	7	37	47	0		48	43	14	283
	9	13	20	95	3	18	63	1	68		4	17	303
	10	8	6	28	1	7	7	0	42	13		2	114
	11	4	0	2	10	41	1	0	22	42	10	0	133
09:00:00 Total		46	46	220	73	240	264	4	274	329	86	106	1686
09:15:00	1		5	19	2	11	47	0	2	130	0	9	224
	2	4			0	2	21	0	38	27	5	4	100
	3	3			0	2	20	0	33	24	4	4	91
	4	2	0	1	0	29	20	0	10	5	1	4	72
	5	4	0	2	24	0	57	0	23	12	2	11	134
	6	10	3	10	21	89	3	0	40	89	16	16	297
	7	0	0	0	0	1	0	0	0	1	0	0	3
	8	0	11	42	7	42	47	0		126	18	9	301
	9	19	24	92	2	10	61	0	47		1	11	266
	10	9	4	15	1	9	11	0	35	11		2	98
	11	3	1	4	8	34	1	0	15	34	6	0	107
09:15:00 Total		54	48	185	64	229	288	0	244	459	53	70	1694

17:00:00	1		6	14	5	16	48	0	0	121	0	27	237
	2	0			0	1	24	0	30	45	2	14	115
	3	0			1	2	48	0	64	93	4	27	239
	4	1	0	0	0	38	24	0	11	4	1	14	93
	5	3	0	0	43	0	65	1	56	20	7	37	232
	6	25	1	3	30	70	4	1	85	106	26	56	406
	7	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	33	79	7	22	16	0		134	54	9	355
	9	62	32	73	2	7	40	0	106		1	22	346
	10	16	19	41	2	8	19	0	17	17		11	149
	11	9	0	1	11	25	1	0	30	39	9	1	127
17:00:00 Total		116	92	210	103	191	288	3	399	579	104	217	2301
17:15:00	1		8	16	5	15	44	0	0	114	0	29	232
	2	1			1	2	18	0	30	30	1	12	95
	3	3			2	5	47	0	84	79	4	32	255
	4	1	0	0	0	43	30	1	24	7	3	19	128
	5	2	0	0	58	0	62	2	60	16	7	41	247
	6	17	1	3	30	51	5	1	75	128	21	41	374
	7	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	28	58	10	28	19	0		139	77	13	372
	9	72	34	69	1	4	38	0	118		1	25	362
	10	21	21	42	2	5	17	0	21	21		12	161
	11	7	1	1	12	20	2	0	29	50	8	1	132
17:15:00 Total		124	94	188	122	173	281	5	441	584	123	225	2359
17:30:00	1		11	22	9	10	53	1	0	99	0	34	239
	2	0			1	1	23	0	34	45	6	15	124
	3	0			1	2	42	0	63	85	12	27	232
	4	1	0	0	0	21	52	2	16	5	1	34	131
	5	4	0	0	44	0	60	2	57	18	5	39	228
	6	27	1	2	26	24	6	1	75	88	31	61	341
	7	0	0	0	0	0	0	0	1	1	0	0	4
	8	0	41	85	10	11	38	1		134	50	25	394
	9	81	27	53	2	2	46	0	104		0	28	343
	10	14	17	34	2	2	33	0	18	24		21	165
	11	14	0	1	14	8	3	1	39	46	16	2	143
17:30:00 Total		141	97	197	109	80	355	8	406	545	121	286	2345
17:45:00	1		8	21	6	9	62	1	0	117	0	40	264
	2	0			1	1	25	0	34	42	1	16	120
	3	3			1	2	50	0	68	82	3	33	242
	4	3	0	0	0	13	33	1	25	5	1	22	103
	5	3	0	0	38	0	62	2	26	5	3	39	179
	6	23	1	2	48	29	7	3	65	91	29	47	344
	7	0	0	0	0	0	1	0	1	1	0	0	4
	8	0	31	80	4	7	21	1		144	82	14	384
	9	86	27	69	2	4	42	0	92		2	28	352
	10	23	15	37	2	3	31	0	10	19		20	160
	11	12	0	1	24	15	3	1	32	45	14	2	151
17:45:00 Total		154	83	209	125	82	338	10	353	552	135	261	2303
18:00:00	1		7	22	8	8	75	0	0	113	0	35	269
	2	0			1	1	20	0	30	35	2	10	99
	3	0			2	2	43	0	66	79	3	22	217
	4	1	0	0	0	11	33	1	12	5	1	17	80
	5	2	0	0	33	0	76	1	33	14	2	38	198
	6	19	1	2	40	32	7	1	77	98	35	49	362
	7	0	0	0	1	1	2	0	1	2	1	1	8
	8	0	29	74	7	7	43	0		114	67	19	361
	9	68	28	69	5	5	53	0	90		2	26	345
	10	12	14	35	1	1	30	0	12	16		15	136
	11	7	0	1	15	12	3	1	29	36	13	1	117
18:00:00 Total		108	80	202	114	80	385	5	350	513	125	232	2193
18:15:00	1		8	16	5	13	66	0	0	92	0	18	218
	2	0			0	1	20	0	28	25	1	6	81
	3	2			1	3	48	0	66	62	3	13	199
	4	1	0	0	0	19	34	1	6	2	0	9	72
	5	3	0	0	41	0	39	1	35	13	1	11	146
	6	18	2	3	33	22	10	1	68	112	8	33	311
	7	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	23	45	5	14	32	1		122	88	8	337
	9	59	34	66	2	4	52	0	78		0	14	309
	10	16	26	48	1	3	31	0	7	13		9	155
	11	7	1	1	13	9	4	0	26	44	3	1	111
18:15:00 Total		106	94	179	102	89	337	4	314	486	105	121	1938
18:30:00	1		7	20	5	18	51	0	0	85	0	16	202
	2	1			0	2	16	0	22	21	1	5	68
	3	2			1	5	42	0	58	56	2	13	178
	4	1	0	0	0	29	26	0	7	3	1	8	75
	5	2	0	0	36	0	45	0	26	10	2	14	136
	6	12	1	2	34	48	8	0	62	80	17	53	318
	7	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	19	50	7	27	45	0		126	73	15	362
	9	55	39	102	2	8	56	0	64		1	18	345
	10	9	16	42	1	4	24	0	8	7		7	118
	11	4	0	1	11	16	3	0	20	27	6	1	87
18:30:00 Total		84	82	216	98	158	317	2	268	415	102	149	1891
18:45:00	1		9	17	6	19	56	0	0	90	0	15	212
	2	0			1	2	17	0	25	23	1	5	73
	3	0			1	4	35	0	49	46	3	9	147
	4	0	0	0	0	33	29	1	13	4	1	8	87
	5	1	0	0	36	0	40	1	20	6	1	10	115
	6	10	1	2	44	57	8	1	47	86	28	45	330
	7	0	0	0	1	1	1	0	1	1	0	0	5
	8	0	42	83	5	18	24	0		115	52	6	345
	9	56	37	73	4	12	82	0	45		2	21	332
	10	11	18	37	1	4	17	0	16	8		5	117
	11	4	0	1	19	24	4	0	20	36	12	1	121
18:45:00 Total		82	107	213	117	172	313	4	236	416	100	124	1884
Grand Total		1428	1091	3455	1508	2894	5083	57	5583	8456	1687	2846	34088

Appendix C Trip Generation and Attraction

Modelled and Surveyed Trip Generation and Attractions - AM

Modelled

Generation				
FromZone	CAR	HGV	PSV	Total
1	1250	83	2	1335
2	216	1	1	218
3	590	51	3	644
4	410	17	7	434
5	569	0	10	579
6	1393	50	16	1459
7	17	0	0	17
8	1566	66	3	1635
9	1175	66	1	1242
10	729	8	16	753
11	510	6	17	533
Total	8425	348	76	8849

Attraction				
ToZone	CAR	HGV	PSV	Total
1	231	19	1	251
2	186	2	4	192
3	952	40	7	998
4	326	4	6	337
5	896	31	9	935
6	1170	47	17	1235
7	8	0	0	8
8	1320	72	8	1400
9	2124	126	3	2253
10	491	1	4	496
11	721	6	18	745
Total	8425	348	76	8849

Surveyed

Generation				
Zone	CAR	HGV	PSV	Total
1	1250	83	2	1335
2	205	1	5	211
3	565	33	3	601
4	410	17	7	434
5	565	15	12	592
6	1397	37	20	1454
7	17	0	0	17
8	1566	66	3	1635
9	1176	66	1	1243
10	729	8	16	753
11	511	4	21	536
Total	8391	330	90	8811

Attraction				
Zone	CAR	HGV	PSV	Total
1	231	19	1	251
2	189	1	1	191
3	947	38	6	991
4	325	4	6	335
5	1003	12	8	1023
6	1168	25	20	1213
7	8	0	0	8
8	1320	72	8	1400
9	2124	126	3	2253
10	491	1	4	496
11	717	4	19	740
Total	8523	302	76	8901

Difference

Generation				
Zone	CAR	HGV	PSV	Grand Total
1	0	0	0	0
2	-11	0	4	-7
3	-25	-18	0	-43
4	0	0	0	0
5	-4	15	2	13
6	4	-13	4	-5
7	0	0	0	0
8	0	0	0	0
9	1	0	0	1
10	0	0	0	0
11	1	-2	4	3
Total	-34	-18	14	-38

Attraction				
Zone	CAR	HGV	PSV	Grand Total
1	0	0	0	0
2	3	-1	-3	-1
3	-5	-2	-1	-7
4	-1	0	0	-2
5	107	-19	-1	88
6	-2	-22	3	-22
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	-4	-2	1	-5
Total	98	-46	0	52

Difference%

Generation				
Zone	CAR	HGV	PSV	Total
1	0%			0%
2	-5%			-3%
3	-4%			-7%
4	0%			0%
5	-1%			2%
6	0%			0%
7	-2%			-2%
8	0%			0%
9	0%			0%
10	0%			0%
11	0%			1%
Total	0%	-5%	16%	0%

Attraction				
Zone	CAR	HGV	PSV	Total
1	0%			0%
2	2%			0%
3	-1%			-1%
4	0%			0%
5	11%			9%
6	0%			-2%
7	2%			2%
8	0%			0%
9	0%			0%
10	0%			0%
11	-1%			-1%
Total	1%	-15%	0%	1%

GEH

Generation				
Zone	CAR	HGV	PSV	Total
1	0			0
2	1			0
3	1			2
4	0			0
5	0			1
6	0			0
7	0			0
8	0			0
9	0			0
10	0			0
11	0			0
Total	0	1	2	0

Attraction				
Zone	CAR	HGV	PSV	Total
1	0			0
2	0			0
3	0			0
4	0			0
5	3			3
6	0			1
7	0			0
8	0			0
9	0			0
10	0			0
11	0			0
Total	1	3	0	1

Modelled and Surveyed Trip Generation and Attractions - PM

Modelled

Generation				
FromZone	CAR	HGV	PSV	Total
1	959	30	2	991
2	424	0	0	424
3	867	22	1	890
4	383	1	2	386
5	743	2	6	751
6	1325	14	18	1357
7	17	0	0	17
8	1437	36	3	1476
9	1323	22	4	1349
10	610	2	4	616
11	513	5	3	522
Total	8602	134	43	8779

Attraction				
ToZone	CAR	HGV	PSV	Total
1	499	10	0	509
2	352	0	2	354
3	752	30	5	787
4	449	1	0	450
5	312	0	19	332
6	1386	23	5	1414
7	27	0	0	27
8	1403	17	3	1423
9	2044	52	0	2096
10	480	1	5	486
11	897	0	3	900
Total	8602	134	43	8779

Surveyed

Generation				
Zone	CAR	HGV	PSV	Total
1	959	30	2	991
2	422	0	0	422
3	862	17	2	881
4	383	1	2	386
5	742	1	2	745
6	1326	7	25	1358
7	17	0	0	17
8	1437	37	3	1477
9	1323	22	4	1349
10	610	2	4	616
11	514	2	3	519
Total	8595	119	47	8761

Attraction				
Zone	CAR	HGV	PSV	Total
1	499	11	0	510
2	371	0	2	373
3	793	22	7	822
4	449	2	1	452
5	835	10	4	849
6	1385	10	6	1401
7	27	0	0	27
8	1403	18	3	1424
9	2044	54	0	2098
10	480	2	5	487
11	900	0	4	904
Total	9186	129	32	9347

Difference

Generation				
Zone	CAR	HGV	PSV	Grand Total
1	0	0	0	0
2	-2	0	0	-2
3	-5	-5	1	-9
4	0	0	0	0
5	-1	-1	-4	-6
6	1	-7	7	1
7	0	0	0	0
8	0	1	0	1
9	0	0	0	0
10	0	0	0	0
11	1	-3	0	-3
Total	-7	-15	4	-18

Attraction				
Zone	CAR	HGV	PSV	Grand Total
1	0	1	0	1
2	19	0	0	19
3	41	-8	2	35
4	0	1	1	2
5	523	10	-15	517
6	-1	-13	1	-13
7	0	0	0	0
8	0	1	0	1
9	0	2	0	2
10	0	1	0	1
11	3	0	1	4
Total	584	-5	-11	568

Difference%

Generation				
Zone	CAR	HGV	PSV	Total
1	0%			0%
2	0%			0%
3	-1%			-1%
4	0%			0%
5	0%			-1%
6	0%			0%
7	-2%			-2%
8	0%			0%
9	0%			0%
10	0%			0%
11	0%			0%
Total	0%	-13%	8%	0%

Attraction				
Zone	CAR	HGV	PSV	Total
1	0%			0%
2	5%			5%
3	5%			4%
4	0%			0%
5	63%			61%
6	0%			-1%
7	0%			0%
8	0%			0%
9	0%			0%
10	0%			0%
11	0%			0%
Total	6%	-4%	-34%	6%

GEH

Generation				
Zone	CAR	HGV	PSV	Total
1	0			0
2	0			0
3	0			0
4	0			0
5	0			0
6	0			0
7	0			0
8	0			0
9	0			0
10	0			0
11	0			0
Total	0	1	1	0

Attraction				
Zone	CAR	HGV	PSV	Total
1	0			0
2	1			1
3	1			1
4	0			0
5	22			21
6	0			0
7	0			0
8	0			0
9	0			0
10	0			0
11	0			0
Total	6	0	2	6