Working on behalf of

highways england

M40 J4 Handy Cross

Traffic modelling

Traffic modelling Technical note

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Contents

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1. Introduction

This report details the traffic modelling work done to date for the M40 junction 4 Handy Cross project under the Highways England Area 3 Asset Support Contract. The current stage of work finished at the end of March 2016.

1.1 Junction location

Junction 4 of the M40 is a very large grade-separated fully signalised junction located at the southwest corner of High Wycombe. It is a seven-arm junction joining the M40, A404 trunk road, A404 to High Wycombe, A4010 to Aylesbury and two other local and minor roads. The junction is an important connection between the M40 and the M4 to the south. It is one of the busiest junctions in the country. The junction location is shown in a wider context in Figure 1 while the junction layout is shown in Figure 2.

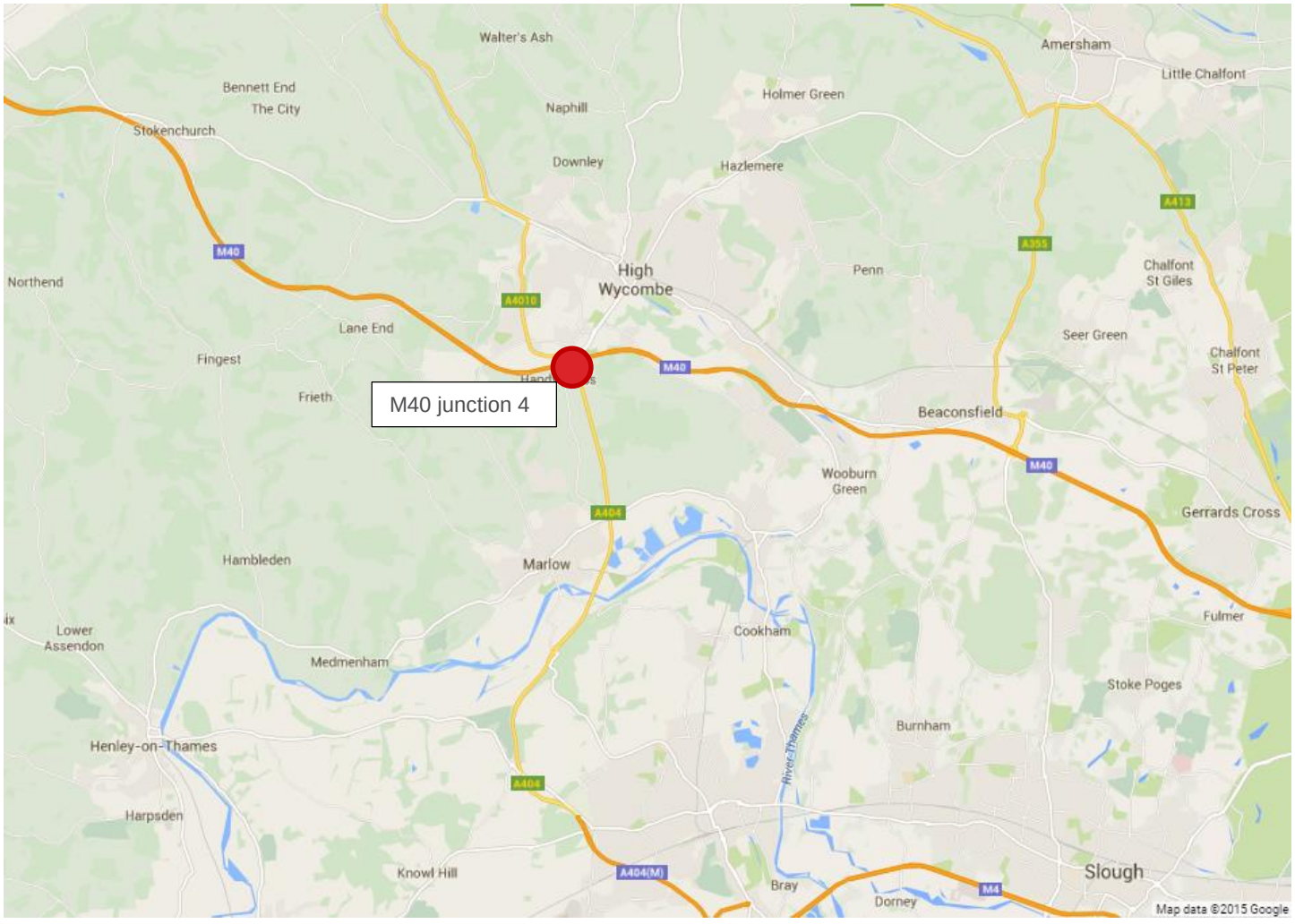

Figure 1 - M40 junction 4 in the wider context

Figure 2 - M40 J4 junction layout

1.2 History and current situation

The junction has been upgraded twice in the last 10 years. In 2007, the central cut-through was added so that traffic could bypass the north side of the junction going from M40 eastbound to A404 southbound and A404 northbound to M40 eastbound. A free left turn lane was added for vehicles travelling between the A404 northbound and M40 westbound.

In 2014 the traffic signals were upgraded to SCOOT as part of the Pinch Point Tranche 3 programme.

The junction is currently heavily congested in both AM and PM weekday periods. There are significant flows between the M40 and A404 south, and also to and from the local destinations using the A4010, Marlow Road and A404 Marlow Hill. The circulatory carriageway is often blocked leading to very long queues on the entry arms, particularly the A404 south, Wycombe Road, A4010 and A404 Marlow Hill, as vehicles cannot cross the stopline due to stationary traffic.

1.3 Delays to programme

The programme of modelling work was originally based on the surveys carried out in September 2015. Data would be returned approximately a month later and then modelling work could begin. The programme initially allowed for the work to be completed in time for a Value Management (VM) workshop in March/April. However the start of modelling work was significantly delayed due to a number of factors outside the control of Mouchel Consulting and Kier Highways:

- Data from the September 2015 surveys being returned to Mouchel by the Survey Contractor with mistakes or incomplete. Reports went through a number of iterations before a correct version was finally received;

- The Survey Contractor did not use the correct equipment to record some control counts. This meant that two of the seven arms entering the roundabout had to be resurveyed in January;
- A full set of all required data was not received until February 9th 2016.
- The resurvey meant that there was a delay in waiting for the TRIS data to be uploaded for January. These data were required to convert January 2016 data back to a September 2015 level for base model validation and were not uploaded until February 24th.

The result of these delays was that full validation was not achievable in the time available up until the end of March 2016. Partial validation was achieved with the model providing a good representation of the current situation, which is sufficient at this early stage of the design and appraisal process.

1.4 Structure of technical note

This note starts with a short introduction to the project, description of the current situation and significant delays to the programme. It will then detail the data used for modelling, followed by a section on traffic model validation. The final section will present the proposed options and modelled results for each option.

2. Data

2.1 Traffic surveys

Traffic surveys were carried out at the Handy Cross junction and surrounding network on Tuesday 22nd and Wednesday 23rd September 2015. These included:

- ANPR cameras on all entries and exits to the junction, creating a closed cordon. These provided both origin/destination flows and journey times;
- Classified control counts at the same locations as the ANPR cameras;
- Manual classified turning counts (MCCs) at three locations: Handy Cross roundabout, A4010/Lansdowne Way and Wycombe Road/Winchbottom Lane;
- Video cameras at all stoplines around the Handy Cross roundabout.

Locations of survey cameras are shown in **Appendix A**.

2.2 TRADS/TRIS data

The Highways England TRADS and TRIS databases were interrogated to obtain long term traffic counts from three link-based sites in the vicinity of Handy Cross. These were located on the M40 westbound and eastbound offslips and on the A404 (trunk) northbound. These data were used to calculate factors to convert the survey data from September to a 2015 average weekday level for use in the economic appraisal. They were also used to convert resurveyed data from January 2016 to a September 2015 level (see next section).

2.3 Resurvey

The September 2015 traffic survey specification document required the collection of classified control counts at each ANPR location. Due to a failure on the part of the Survey Contractor, this aspect of the surveys was not undertaken correctly, leading to there being no control count data provided for either A4010 John Hall Way or the A404 Marlow Hill.

The control count data would not only be a check against the captured ANPR records but also be essential for providing the demand flow for the modelling. The survey company were therefore required to resurvey these two arms in January 2016. This meant that these data had to be converted back to a September 2015 level as part of the model validation process. TRIS data were used to develop factors to convert from January 2016 to September 2015.

2.4 Survey data analysis

There were some technical problems with equipment with certain cameras on both days of the original survey. This led to some portions of both days having unusable data for modelling. It was decided to take the modelled periods from whichever day had suitable data for that period.

The specific peak periods were calculated from the control count (demand) data for the Handy Cross roundabout, rather than the turning count. This is because the turning count is only the flow that crossed the stopline and does not take account of queuing and therefore all the traffic trying to get through the junction at a particular time. This distinction is particularly important at signalled junctions where only a proportion of the cycle is available for traffic to proceed. The interpeak was calculated as the average hour over the whole interpeak period. The peak periods were calculated as:

- AM peak: Wednesday 07:30-08:30;
- Interpeak: Tuesday 10:00-16:00 average hour;
- PM peak: Tuesday 17:15-18:15.

Matrix building process

The total flow on each approach was taken from the demand data converted to PCUs (the unit used by Linsig). Because the cameras were positioned far back from the stopline (behind any queuing), there would be a number of vehicles between the camera and the stopline at the start of the modelled hour that would not have been counted in the demand data, but would still need to be added to the total flow. This was calculated from video, either by manually counting the vehicles or, if there was heavy queuing, determining the furthest extent of the queue, measuring the distance in AutoCAD and then converting this to PCUs using a length of 5.75m per PCU (the default length in Linsig).

The turning proportions were calculated from the MCC data, which were in turn calculated from ANPR records factored to the total stopline flow. All total entry arm demand flows were then factored using the turning proportions to develop full Linsig peak hour matrices in PCUs.

The final September 2015 base year peak hour demand matrices are shown in Table 1 to Table 3 below, all figures are in PCUs. These figures exclude all vehicles using the freeflow left from A404 (trunk) to M40 westbound.

AM peak		A	B	C	D	E	F	G
Marlow Road	A	3	64	501	201	75	41	2
A404 Marlow Hill	B	42	0	298	542	131	121	90
M40 east	C	321	304	28	571	153	5	436
A404	D	226	369	341	0	12	0	537
Wycombe Road	E	73	205	209	0	5	18	76
M40 west	F	118	270	10	855	59	4	128
John Hall Way	G	23	120	479	360	80	21	5

Table 1 - AM peak (07:30-08:30) Sept 2015 base year demand matrix

Interpeak		A	B	C	D	E	F	G
Marlow Road	A	2	38	211	158	56	28	25
A404 Marlow Hill	B	60	4	205	262	83	106	185
M40 east	C	168	134	2	273	39	5	338
A404	D	160	233	330	2	7	5	317
Wycombe Road	E	78	90	48	1	2	8	83
M40 west	F	52	110	5	426	12	1	130
John Hall Way	G	68	210	348	345	67	80	2

Table 2 - Interpeak (10:00-16:00 ave. hour) Sept 2015 base year demand matrix

PM peak		A	B	C	D	E	F	G
Marlow Road	A	0	134	490	271	59	27	37
A404 Marlow Hill	B	67	1	267	492	168	188	196
M40 east	C	354	243	5	558	126	2	504
A404	D	301	62	602	0	5	5	448
Wycombe Road	E	116	191	152	1	0	17	93
M40 west	F	86	191	4	679	45	0	144
John Hall Way	G	79	266	612	476	44	99	2

Table 3 - PM peak (17:15-18:15) Sept 2015 base year demand matrix

3. Model build, calibration and validation

3.1 Software

The latest version of Linsig was used for the modelling. At the time of the modelling this was 3.2.29.

3.2 Calibration and model parameters

Lanes
Lane lengths were measured from the as-built drawing in AutoCAD. Lane saturation flows were all set initially to 1950 PCU/hr, as per guidance from JCT Consultancy (the developers of Linsig) on modelling signalised roundabouts. Internal lane connectors were set with a nominal cruise speed of 35kph.

Signals
Signal information was taken from traffic signal specifications provided by Kier/Siemens. This included controllers, phases, intergreens, stage streams, stages and stage sequences. SCOOT data for the days of survey were also obtained and actual average cycle and stage timings were calculated from these.

The base model structure is shown in Figure 3 below.

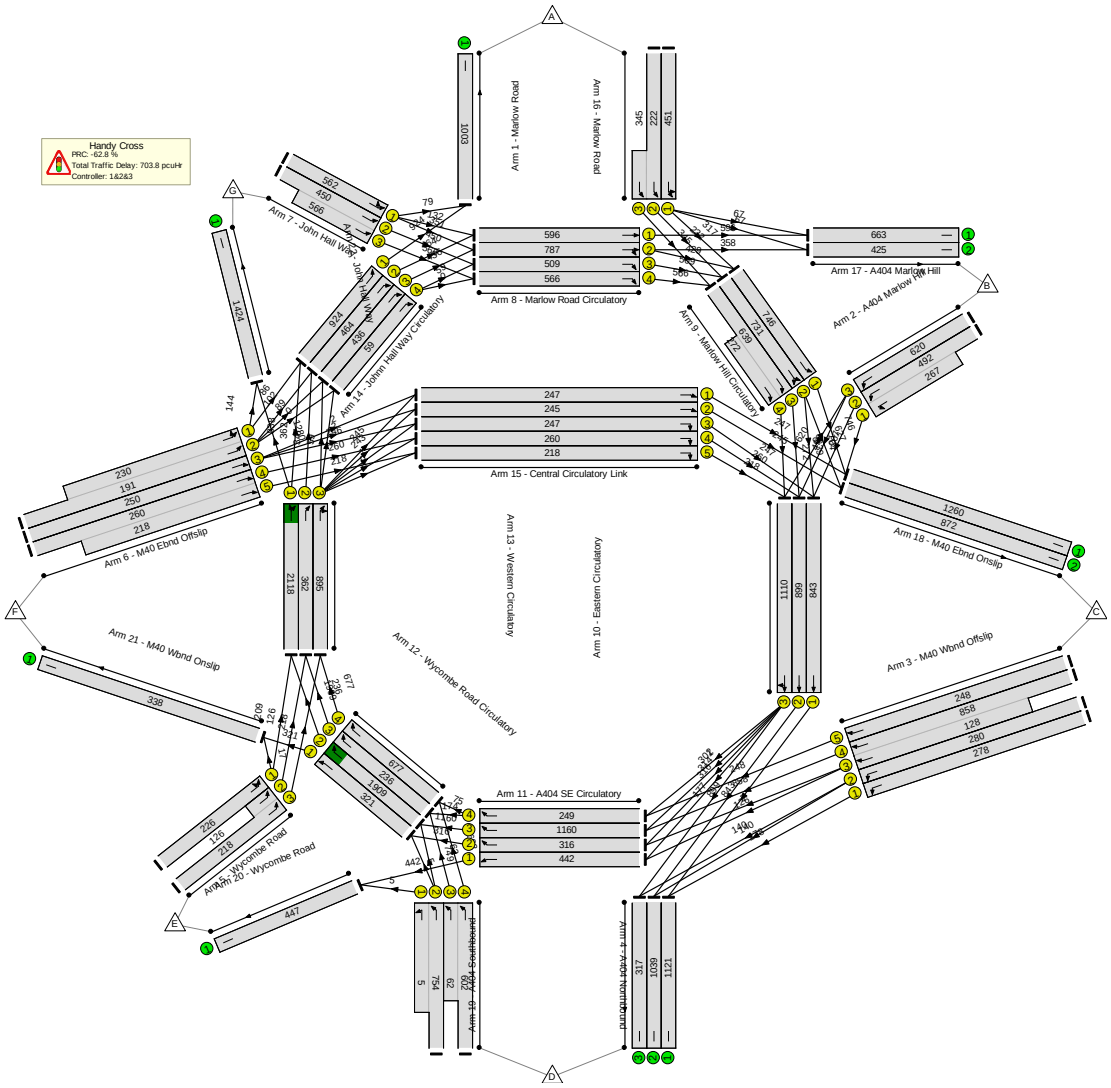

Figure 3 - Base model structure in Linsig

3.3 Validation process

Once all the base information was input into the model, the model was optimised to get initial signal timings and offsets. The stage lengths were then amended to reflect the average SCOOT timings from the appropriate peak period on the days of survey. The SCOOT timing data were reported in 15 minute periods and this was averaged to get the stage timing for the hour. This allowed for some small adjustments to be made to the average SCOOT timings as part of the calibration process. This meant the model could better match the observed information.

Underutilised green time was also added on arms where blocking was observed. This is when there is part or all of the green period where traffic cannot move across the stopline because the downstream carriageway is blocked by stationary traffic. The amount of underutilised green time was calculated automatically during the process of capturing measurements of degree of saturation from video data, using a spreadsheet provided by TfL.

To validate the model, modelled delay and degree of saturation was compared against the observed values. Delay is the more important variable as this is what will be used to calculate the economic benefit.

Delay validation

Modelled delay is compared with observed delay in Table 4 to Table 6 below, for the AM, interpeak and PM peak respectively.

AM peak		Observed	Modelled	Difference
Marlow Road	A	123	136	13
A404 Marlow Hill	B	108	119	11
M40 east	C	100	125	25
A404	D	325	304	-21
Wycombe Road	E	390	442	52
M40 west	F	139	177	39
John Hall Way	G	85	62	-22

Table 4 - AM peak modelled vs observed delay (seconds)

Interpeak		Observed	Modelled	Difference
Marlow Road	A	75	57	-18
A404 Marlow Hill	B	125	43	-83
M40 east	C	56	54	-3
A404	D	126	96	-30
Wycombe Road	E	101	70	-32
M40 west	F	90	43	-47
John Hall Way	G	56	45	-10

Table 5 - Interpeak modelled vs observed delay (seconds)

PM peak		Observed	Modelled	Difference
Marlow Road	A	121	138	17
A404 Marlow Hill	B	165	176	11
M40 east	C	98	178	80
A404	D	317	391	74
Wycombe Road	E	332	313	-19
M40 west	F	94	112	18
John Hall Way	G	148	135	-13

Table 6 - PM peak modelled vs observed delay (seconds)

The tables show that, in the majority of cases, arms validate to within 60 seconds of the observed delay value.

Degree of saturation validation

Degree of saturation validation is shown in Table 7 and Table 8 below, for the AM and PM peak respectively. The degree of saturation shown is the average for the whole stopline. Where there are multiple lanes, there may be variation between the lanes. Taking the A404 approach, this is known to have very long queues, particularly in the PM peak. These are mostly contained across three of the four lanes, with the nearside lane (to Wycombe Road) generally empty. This is why in the PM the degree of saturation is only 99% and not any higher.

AM peak		Observed	Modelled
Marlow Road	A	84%	67%
A404 Marlow Hill	B	80%	67%
M40 east	C	63%	79%
A404	D	97%	87%
Wycombe Road	E	98%	114%
M40 west	F	87%	87%
John Hall Way	G	99%	75%

Table 7 - AM peak modelled vs observed degree of saturation

PM peak		Observed	Modelled
Marlow Road	A	80%	81%
A404 Marlow Hill	B	93%	104%
M40 east	C	73%	79%
A404	D	99%	132%
Wycombe Road	E	100%	112%
M40 west	F	82%	71%
John Hall Way	G	96%	87%

Table 8 - PM peak modelled vs observed degree of saturation

The model validates better on degree of saturation in the PM peak than the AM peak, although the AM peak still provides a reasonable approximation of the current situation.

The model is considered to provide an acceptable level of validation given the time constraints. It is now possible to use it to analyse the economic potential of the proposed options.

4. Proposed options and modelling results

4.1 Proposed options

There were eight proposed options. Some involved physical changes to the junction layout, some involved rearranging lane assignments and some involved improved signage only. The option numbers, a description of each option and a note on the modelling status are shown in Table 9 below.

Option	Description	Modelling status
Do minimum	Various improvements of signage and road markings around the junction to enforce existing markings and assignments	Modelled
1A	Revised lane assignments at John Hall Way node, circulatory nearside lane for John Hall Way traffic only	Modelled
1B	As 1B but with a two-lane exit to John Hall Way continuing to the mini roundabout	Modelled
2A	Change of lane assignments at east bridge: two ahead, one right	Modelled
2B	Change of lane assignments at east bridge: one ahead, one ahead and right, one right	Modelled
3	Change of lane assignments at A404 Marlow Hill entry: one left and ahead, two ahead	Modelled
4	Additional capacity at A404 entry: longer flare lane	Modelled
5	Two new gantries enforcing existing lane arrangements	Not modelled

Table 9 - Proposed options

Options 1A to 4 were modelled with changes to the Linsig model structure in the appropriate location. The Do Minimum option was modelled with the base model structure and a matrix where all trips between A404 and M40 westbound that used the roundabout were removed. The improved signage in the Do Minimum option was assumed to make sure all traffic from A404 to M40 westbound would be using the free flow left-turn slip further south from the junction.

Option 5 was not modelled because the gantries were enforcing existing lane arrangements on the east bridge and the southern circulatory section. This would not have affected the operation in the Linsig model when compared with the base situation, therefore no difference in benefit could be derived.

4.2 Average weekday conversion and traffic growth

The base year matrix was converted to a 2015 average weekday level for the economic model tests. TRIS data were downloaded for the whole of 2015 for the three sites on the M40 offslips and the A404. The TRIS data from the September days of survey were compared to the average for the entire year to derive separate factors for AM, interpeak and PM. The following factors were calculated:

AM peak	0.908
Interpeak	1.063
PM peak	0.960

Table 10 - Average weekday conversion factors

Highways England (TAME) advise that, in an already-congested situation, growth should not be applied as it will overestimate the future level of traffic that could realistically use the existing junction and therefore the benefits. Handy Cross is already heavily congested at peak times and therefore no growth was applied to the base year flow.

4.3 Modelled results

Final modelled matrix totals and modelled results are shown in Table 11 and Table 12 respectively. Results are shown as the overall delay saving in minutes per vehicle. A positive number indicates a saving while a negative number indicates a disbenefit.

	AM	IP 1000-1600	PM
Do Min	7486	5662	8433
All other options	7486	5667	8438

Table 11 - Linsig matrix total flows for economic model tests (vehicles)

	AM	IP	PM
Do Min	0.00	0.00	0.00
Option 1A	0.09	0.34	1.36
Option 1B	0.09	0.34	1.37
Option 2A	-0.50	-0.02	-0.25
Option 2B	-1.00	-0.09	-1.73
Option 3	-0.44	-0.04	-0.40
Option 4	-0.03	0.09	0.05

Table 12 - overall delay saving results for all options (min/veh)

It is clear from the table that options 1A and 1B perform the best, providing a delay saving in the interpeak and a significant saving in the PM peak. This is likely due to the reallocation of the nearside lane on the west bridge of the junction. In the current layout, the nearside lane is for traffic travelling to both John Hall Way and Marlow Road. This means that when Marlow Road-bound traffic queues back from the stopline at the John Hall Way node, it blocks the exit to John Hall Way, requiring John Hall Way-bound traffic to wait in the queue until the exit is clear. This then has knock-on effects further upstream and causes further blocking.

It seems that reallocating the nearside lane exclusively to traffic for John Hall Way allows these vehicles a clear exit, while the remaining traffic can be accommodated by the remaining two lanes at the west bridge.

Other options do not perform well and in some cases lead to significant disbenefits, particularly option 2B. Both these and the results for 2A suggest that the current lane layout is the most efficient to provide for the current level of traffic. Results also suggest this is the case with option 3.

4.4 Economic benefits

The delay saving results of the modelling have been taken by Kier Highways and input into the latest SAR form to calculate the economic benefits of each option. These results are reported by Kier Highways elsewhere.

5. Conclusions and recommendation

5.1 Conclusions

M40 junction 4 Handy Cross roundabout suffers significant congestion in the weekday peak periods. Kier Highways have developed a number of options to try and alleviate this congestion. This report has detailed the survey and modelling work carried out to assess the proposed options.

Comprehensive traffic survey data were collected at the junction in September 2015. A number of problems with both the equipment and the subsequently returned data meant that a full set of data was not received until February 2016, following a resurvey of some of the junction arms in January 2016. This meant that the start of the modelling work was significantly delayed, severely restricting the time available to complete the original full programme.

A model of the junction's current layout was constructed using Linsig 3.2.29 (the latest version at the time of the modelling work). This was validated to a September 2015 survey day, using observed delay and observed degree of saturation. Following the validation exercise, the model was considered to be an acceptable representation of the current situation. The demand matrices were converted to a 2015 average weekday level for the economic appraisal.

Kier Highways provided drawings for eight proposed options. Seven of these were modelled to analyse the journey time benefits. The remaining option (option 5) provided two new gantries to enforce existing lane arrangements and was not modelled. This would not have affected the operation in the Linsig model when compared with the base situation, therefore no difference in benefit could be derived.

Of the seven modelled options, only option 1A and 1B provided significant journey time savings. These options amended the lane allocations at the west bridge to provide John Hall Way-bound traffic with a dedicated lane, rather than a lane shared with traffic bound for Marlow Road. This alleviated queueing and exit blocking at John Hall Way which had positive benefits for traffic further upstream as well.

5.2 Recommendations

It is recommended that options 1A and 1B are investigated further as they provide significant journey time savings, particularly in the PM peak. It is also recommended that the lane designations upstream of the west bridge are investigated to see if any amendments could be made in conjunction with the changes at the John Hall Way node, to use the roadspace more efficiently.

Appendix A: traffic survey locations