WCC Modelling Protocol

Advice Note 003 – Model Analysis and Reporting

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Introduction

1. This advice note (AN) has been produced to supplement the Warwickshire County Council (WCC) Model Use Protocol (MUP) which governs the access and use of WCCs suite of models.

2. To supplement the WCC MUP, a series of advice notes have been produced to provide guidance on different aspects of the development and application of the existing suite of models.

Purpose of This Note

3. This note sets out expectations around the reporting of outputs form the suite of Microsimulation models owned and provided by WCC.

4. It is intended to provide guidance on the core elements which WCC wish to see reported form the models when undertaken an assessment.

5. It should be noted that the outputs that are identified within this Note are considered to be the standard outputs that users of the model should expect to have to provide to the County when necessary. It does not preclude the right of WCC to request additional model outputs when bespoke analysis is considered appropriate to consider a specific impact and or issue that has been identified within the modelling. Some bespoke analysis which may be requested has been documented later within this Note.

Responsibilities

6. When undertaking an assessment of outputs through the use of the existing suit of WCC microsimulation models it is the responsibility of the licensee and/or their consultant to review the outputs and identify any problems as well as any potential solutions thereto.

7. If the modeller responsible for the technical work is the Tier 1 modelling consultant on the existing WCC modelling framework then they are considered to be responsible for the technical work only. They should not provide interpretation of the results since this would represent a conflict of interests when considering the need to maintain the technical independence of the modelling work. Thus, and interpretation and/or scheme proposals arising from the modelling work should be provided by the licensee and their transport consultant rather than the modeller(s). WCC is the only responsible of accepting the model results.

Core Reporting

8. WCC consider that any reporting of model outputs should be undertaken on a staged basis as follows:

    - Key network performance indicators should be extracted for the purposes of comparing the strategic implications of every option being considered.
    - Localised impact analysis in the form of changes in:
        - Link attributes (flow & speed)
        - Queuing at junction approaches
        - Journey times along key routes
    - Bespoke analysis may then be requested to enable detailed statistical analysis of the outputs extracted from the modelling to be completed. The purpose of this analysis will be to establish, in areas where impacts are less clear, the statistical significance of the impacts observed and, furthermore, the pattern of impact which will enable a better understanding of the need for further investigation and/or additional mitigation to be established.

9. It is recognised that the scale of development will directly impact upon the scope and level of detail required when reporting the model outputs and therefore *it is expected that the outputs that will be reported upon and the extent of the area covered by the analysis will be agreed with Warwickshire County Council in advance*.

10. The following provides an overview of the different measures which are expected.

Key Network Performance Indicators

11. The first assessment measures that are expected are those which report on the overall model performance, the purpose of these measures are to provide high level comparisons between scenarios and, furthermore, to provide an initial indication of network performance to enable the early identification of any issues.

12. The measures which are expected are outlined as follows:

    Model Stability

13. WCC recognise that, due to its deterministic nature, it may be necessary to filter out certain runs on the basis of irregular loading patterns (i.e. continual loading of vehicles with no clearance period). Through our own appraisal work, we have recognised that there are a

multitude of reasons why a model may lock up and it is not necessarily the case that a single failed run represents a significant issue.

14. When a model becomes grid-locked vehicles still continue to be assigned to the network and so delay begins to increase exponentially. It should be acknowledged that these issues may be occurring due to a need for mitigation in one or more areas of the model but, if the models do not lock up every time it can be concluded that the problem is not severe enough to cause the network to cease to function. Furthermore, the fact that some model runs are completed without issue indicates that a mitigation strategy can only provide additional improvements and should be deliverable. If it is model error causing the issues then these results should also be discounted due to the fact that they cannot be considered realistic.

15. It should also be acknowledged that experience gained elsewhere in the application of Paramics micro-simulation modelling, in projects of a similar size, has highlighted that the level of stability within the models frequently improves as development plans evolve and mitigation schemes are refined. This is also partly due to developments within the plan proceeding with applications which enables more localised impacts to be identified and mitigated through the development specific transport assessment work. This level of detail cannot be achieved within a high level strategic assessment. All mitigation proposals will be subject to further detailed assessments, refinements and optimisation through the planning process and it is expected that improved network performance and stability will be realised as a result.

16. As has been mentioned previously, where model stability has been particularly poor, the propensity for a model to lock up (and thus to be considered to have failed) must be assessed to allow the reliability of the model network across the various scenarios to be better understood.

17. Model stability is expressed as a percentage and indicates the percentage of model runs, within a given sample, that were considered to have completed without 'locking up'. A model 'lock-up' is demonstrated by the continuous loading f vehicles onto the model network without any accompanying discharge. This means that the vehicle number continues to rise within a simulation run.

18. Provided the analysis is based on a minimum of 20 runs, a high prevalence of failed runs (stability 50% or less) is considered unacceptable and immediate further investigation is required.

19. At 75% or less further investigation is still required to determine the issues but it is more likely that the issues could be related to anomalous model behaviour (this will need to be confirmed as part of the analysis).

20. At 75% to 85% high level analysis may be requested simply to outline the cause of any grid-locked runs but it is recognised that the lower rate of occurrence now indicates that the issues are more likely to be related to modelling anomalies.

21. Above 85% it is not considered that any further investigation is required beyond the expectation that the modeller has checked and confirmed that the instability is not caused as a result of poor or erroneous coding.

22.   *These statistics should be quoted within the initial phase of modelling analysis but it is not expected that they would be presented in any final analysis if the models are considered to be sufficiently stable. If model stability is not quoted as a model output then it I assumed that the model will be sufficiently stable but the onus is on the modeller to confirm this.*

23.   *It is critical that the analyst demonstrate that a sufficient number of runs has been undertaken to inform the analysis and, furthermore, it should be noted that WCC do not consider less than ten random seed runs per time period to be acceptable in any circumstance.*

Network Wide Statistics

24.   A number of statistics used in the analysis have been obtained from assessing each individual trip that has occurred within the network. This information is collected within Paramics via the 'Trips-all' file and contains information specific to each individual trip completed within the model period. This information is aggregated and processed to provide the following comparative statistics:

- **Average Time (seconds)** – The average travel time of a completed trip during the model simulation period.
- **Average Speed (Km/h)** – The average speed travelled by all vehicles that completed a journey during the model simulation period.
- **Completed Trips (vehicles)** – The number of completed trips recorded during the model simulation.

25.   The first two measurements are averages so can be used to compare between the various scenarios. The final measurement is an absolute and is dependent on congestion on the network (as this will prevent trips from completing) and the demand within the model (i.e. the number of trips actually trying to complete). As demand differs between scenarios, as well as small variations between runs of the same scenario, we cannot expect the number of completed trips to be the same. However, as the demands do not differ significantly it can still provide an indication of the relative congestion on each network.

26.   All of these measures should be extracted using the Trips-All file within Paramics as this ensures that all completed trips are considered within the analysis.

27.   The results should be presented for the modelled periods as a minimum. Supplementary analysis of the peak hours may also be requested.

High Level Analysis

28.   Having completed the analysis of the key network performance indicators, it is considered that additional analysis of the impacts on key routes and junctions within the modelled area should be completed.

29.   *For each of the wide area models that WCC hold, a map can be made available which illustrates the standard set of junctions and routes which are readily configured within the modelling.*

30. Whilst WCC may provide a map of the key areas identified within the modelling, it is considered appropriate that this is agreed as sufficient prior to any modelling being completed. As has already been highlighted, the scope of any assessment will be dependent upon the size of development being considered as well as the location.

31. Therefore it is possible that additional junctions and routes will need to be added into the analysis and these should be discussed and agreed with WCC in advance of commencement of any modelling

32. The initial, high level analysis, is expected to focus on the differences based on hourly values whereas the detailed analysis should break it down into the more detailed 5 and 10 minute intervals and this, more detailed, analysis is discussed within the next chapter of this report.

33. For the high level, hourly analysis, the following parameters should be adopted:

- **Hourly Queuing –** analysis should be based on the average hourly maximum queue length and should be presented in vehicles.
- **Hourly Journey Times –** differences should be presented as the average journey times, in seconds, for all vehicles which traverse the journey time route within the modelled hour.
- **Link Flows –** differences in vehicles are requested to enable an assessment of the significance of changes in the area.
- **Link Speeds –** alongside the flow changes, differences in speeds on links should also be provided.

34. Further details on the expected reporting requirements, concerning each of the parameters listed previously, is documented within the following section:

Hourly Queueing

35. It is expected that, at the highest level, queues should be presented on the basis of average hourly maximum queue lengths. WCC preference is that these are reported in vehicles.

36. It is recognised that the hourly maximum is the worst case but it is considered that this is an appropriate parameter to adopt for the initial analysis. Detailed analysis and sifted, detailed later within this note, provides additional opportunities to investigate the appropriateness of this robust parameter, particularly when adopted in isolation.

Hourly Journey Times

37. Journey time information can be reported in seconds or MM:SS format and, where a route is made up of multiple paths, should be presented for both sections and full route with the full route being presented as the aggregate of the sections and not via a separate path for the entire length of the journey time route as this is likely to result in a lower sample size (since Paramics only reports the journey times of vehicles which complete the entire path and there are frequently key decision points along the major routes which divert traffic. This is why paths are defined in sections for longer routes within the model network.

Link Flows

38.   Link flows should be expressed in total vehicles on an hourly basis. WCC may also wish to see the HGV totals on key links if these movements are a concern. This would be agreed separately if HGV flows are required, they are not expected as standard.

39.   WCC may also request that the significance of any changes in flows be determined, in part, through the application of GEH criteria although it is recognised that this parameter is primarily intended for assessing model development standards it is considered a useful measure, further analysis as to how detailed link flow analysis may be undertaken is provided later within this note.

Link Speeds

40.   Although speed is impacted upon by a number of different aspects, including capacity and any congestion at adjacent junctions, link speed is still considered a useful indicator of the performance of the network in key areas and should be provided as standard.

41.   There are no tests to determine whether an impact on a link speed is considered significant but the link speeds should still be reported alongside the link flows as comparatively the two measures enable more detailed analysis to be undertaken. For example, arge increases in flows may not necessarily be considered to impact upon the network if it is within the theoretical capacity of the link and the flows are achieved without a substantial drop in the speeds in the same area.

Reporting

42.   Reporting should encompass all areas identified within the reporting requirements that accompany the wide area models. If an analyst considers that an alternative, smaller, area should be assessed then this should be discussed in advance with WCC and agreed before any results are presented.

43.   WCC consider that one of the key benefits of the suite of wide area models which they hold is that it enables impacts across a wider area to be considered and, in particular, the interaction of junctions therein.

44.   On that basis, analysts should expect to report outputs for all of the key areas identified.

45.   The reporting of the high level analysis should be seen as a precursor to the provision of more detailed analysis at the appropriate locations where it is considered that the inclusion of the development will influence conditions on the network.

46.   Reporting should consider both the periodic impacts and peak hour which is considered to be the core 08:00 to 09:00 and 17:00 to 18:00 time periods unless WCC advise otherwise. Key network performance indicators and some of the GIS reporting may focus on the periodic impacts whilst the location specific and more detailed analysis reported subsequently may be provided on an hourly or even smaller (e.g. 5 minute) interval basis.

47.   It has been highlighted previously that WCC may also wish to see analysis provided for particular areas within the model where impacts do not manifest but that there is an

expectation of impact due to localised constraints or other conditions not yet accounted for within the model (due to age of data, new issues as a result of growth, areas of the model where data did not originally exist for calibration, etc).

48. Reporting should be accompanied by visual aids where ever possible as this will enable both officers and members to understand the development implications in a much more engaging manner than is achieved through the provision of data tables in isolation.

49. WCC have promoted the use of GIS to present the outcome of key model scenarios and this is available for review in the various Strategic Transport Assessments that have been produced to support the Boroughs and Districts of Warwickshire through the Local Plan determination process.

50. In doing so, WCC have defined a set of parameters for the STA work which are considered appropriate in the context of the Local Plans and the relative uncertainties associated with both the delivery of the growth levels assumed and the overall infrastructure requirements.

51. When utilising the models to inform the analysis of impacts to support Transport Assessments and other, development specific planning requirements, it is considered essential that the grading of impacts be tightened and that smaller impacts may be classified as significant at this stage, to aid the identification of areas for additional, more detailed, analysis to be completed.

52. In all cases the baseline assumptions for any GIS analysis should be a scenario in which the development proposals and/or schemes are not considered. This would either be in the form of a Base model or a Reference Case model. When selecting the Reference Case to inform the comparisons it is also important that the year selected does not occur at a point after it is considered likely that the development will come forward (for example a 2027 Development scenario must not be compared to a reference scenario representative of a year which falls after 2027).

53. WCC do not have any strict rules concerning the grading of differences when presenting queueing and delay analysis through GIS but offer the following suggestions for the analysis of both measures:

Queueing Criteria:

54. The following queue comparison criteria is suggested for consideration when assessing queues:

- **Moderate Increase** (an increase in queue lengths of between 5 and 10 vehicles)

- **Severe Increase** (an increase in queue lengths of between 10 and 20 vehicles)

- **Very Severe Increase** (an increase in queue length of over 20 vehicles)

Journey Time Criteria

55. The following journey time comparison criteria is suggested for consideration when assessing journey time impacts along key routes. The following criteria also assumed that the starting journey time for the comparative route exceeds 60 seconds:

- **No Significant Change** - A difference in journey times of up to +5% falls within this category

- **Moderate Increase** - An increase in journey times of more than 5% but less than 10%

- **Severe Increase** – An increase in journey times of more than 10% but less than 20%

- **Very Severe Increase** – An increase in journey times, when compared to the Reference Case, of more than 20%

Critically, when presenting any data in GIS format it is essential that the criteria adopted should be outlined within a key alongside the scenarios that have been compared and, if appropriate, the year of assessment.

Sifting Analysis

56.   Both the high level reporting and any supplementary GIS analysis represent means of assessing high level outputs extracted from the model. The tendency for the high level analysis is to be presented on an hourly basis since it provides a snapshot of the conditions across the wide area.

57.   Having assessed the high level outputs, it is important to prioritise those areas which require further investigation and/or the impacts are considered sufficient that network interventions may be required to minimise the impacts identified through the modelling.

58.   As has been highlighted previously, in some areas there will be known issues or expectations for schemes to be delivered on grounds outside of simply to mitigate impact (i.e. improve NMU provision, safety, coalescence between developments). Subject to scoping with WCC it may be necessary for these areas to be dealt with outside of microsimulation, using isolated junction assessments (Arcady, Linsig, Etc.) to ensure that there is an appropriate level of analysis for the issues that have been identified thus far.

59.   In areas where the model is being used to determine the impacts then, a standard approach to sifting is proposed by WCC which can assist in narrowing down the amount of information, extracted from the modelling, which needs to be presented and discussed within any accompanying transport assessment work.

60.   WCC consider that, provided the modelling has been based on a sufficient number of runs, confidence interval analysis is one such measure against which the significance of an impact can be judged[1].

61.   The following section of this note provides a suggested strategy for sifting of the model outputs which will enable the amount of information reported from the modelling to be reduced accordingly.

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[1] See 'How to reduce the gambling element in some transport planning decisions, Emily Seaman, TEC, June 2006' for a greater explanation of the use of confidence interval analysis to assess significance.

62.   Sifting covers queues, journey times and link flows but it should be recognised that the link flow sifting is a lower priority assessment measure than queueing and journey times on the basis that a change in flows does not necessarily correspond to a negative impact as the impact often arises from the effect that the change in flows has on the network rather than simply the change of flows in isolation.

63.   Each sifting strategy is described as follows:

Queue Sifting

64.   Whilst the initial high level analysis is expected to consider the changes in queueing levels on an hourly basis, it is expected that any supplementary evidence will begin to assess the impacts at a more refined level. On that basis the sifting should first look to assess the impacts on an hourly basis, using the difference criteria but when the final statistical analysis is undertaken this should make use of either 5 or 10 minute intervals.

65.   Importantly, it is considered that the analysis must be based on maximum queue lengths not averages to ensure a robust assessment.

66.   It is expected that the analysts will undertake a series of sifting exercises whereby the impacts on the network are identified and reviewed and, if necessary, mitigation and/or network enhancements will be included within the assessment in an attempt to minimise those impacts which are considered sufficiently severe to justify an intervention.

67.   It is considered that only the final round of sifting will be presented to WCC and, at this stage, that the primary impacts will have been identified and, if necessary, mitigated such that it is considered that the evidence submitted in support of the development will be considered by the submitting parties to sufficiently demonstrate that any impacts associated with the proposals being tested have been mitigated and that any residual impacts are either not considered severe or can be explained via additional commentary submitted in support of the proposals.

68.   WCC offer the following sifting criteria for the assessment of queueing impacts within the model:

- Queue impacts will only be considered IF the starting queue within the baseline is greater than 5 vehicles AND the difference between the 'with' and 'without' development scenario is also greater than 5 (i.e. Base must be at least 5 vehicles in length and development 10 vehicles in length to merit further investigation).
- Where this criteria is achieved, for any hour within the simulation period, additional analysis should be undertaken in the form of confidence intervals or a similar statistical confidence test which establishes the statistical significance of the outputs obtained from the two scenarios.

69.   This statistical analysis should then be supported via the introduction of supporting commentary on the perceived severity of the impacts (all areas where there is a statistically significant impact should be reported upon) alongside any intervention or mitigation strategy that has been derived in response to the impacts.

70. Any submission which makes use of supporting commentary will have to be sufficiently evidenced to demonstrate any contention offered within the analysis. For example, a significant number of the models held by WCC already contain an account of peak spreading. Therefore any commentary which contends that this will be a solution moving forward would need to provide evidence to support this if it is to be accepted by WCC.

71. WCC will then work with all parties to establish a situation whereby the impacts are considered and conclusions will be drawn as to whether the evidence presented thus far is considered sufficient.

Journey Time Sifting

72. In line with the assessment of queueing impacts, it is also expected that journey times will be reviewed in a similar manner. Critically, it is expected that the journey time analysis should consider both increases in journey times and any impacts on reliability.

73. As far as journey times are concerned, there are no starting conditions that WCC suggest should inform the sifting, rather the analysis should consider the sections which comprise the journey time route and, more specifically, any instance where the average hourly delays increase by 5% as a result of the proposals.

74. Once a 5% increase in delays has been identified then further analysis is considered beneficial.

75. At this stage delays should again be presented in a more refined interval (namely 5 or 10 minutes) and the average journey times presented for the comparative scenarios inclusive of the statistical analysis which is intended to determine the statistical significance of any changes.

76. If confidence interval analysis is undertaken to support the analysis of the statistical significance of any changes then this same analysis can also be used to inform an assessment of the effects on journey time reliability at the same time as the impact analysis.

77. Although not specifically quantified it is recognised that the confidence interval analysis provides an indication of this measure as the upper and lower confidence bounds define the range within which the value could lie. The closer the range is to the average the more reliable the output and, conversely, a more reliable and defined the range is the greater the perceived journey time reliability.

Link Flow Sifting

78. As has been highlighted previously, although queueing and delays are considered to be the primary factors to be presented when impacts are being compared, analysis of the changes in link flows are also considered beneficial.

79. Historically, WCC have used the GEH criteria as a means of providing an indication of whether a change in flows merits further investigation. As a strategic measure, although originally intended to compare the observed and modelled flows for calibration, this is considered acceptable.

80. In some areas, it is also considered beneficial for the flows, and changes in flows, to also be compared to the theoretical capacity of the link to begin with. Paramics models do not allow a situation where the network has become over capacity to be realised as traffic will divert to alternative routes whenever the opportunity exists to do so.

81. For rural routes, the calibration of the model networks can also have a tendency to lead to links having marginally higher capacity than has been assessed on-street.

82. Finally, the impact on speeds in the same locations must be considered to enable a better understand of the implications of any changes in flows to be understood.

83. Therefore the hourly maximum flows and speeds should both be reported and consideration should be given to the highlighting the following:

   - The absolute and percentage change in vehicles.
   - The GEH value (highlighting all instances over 5 with specific focus on 7.5 and over)
   - The % change in speeds.
   - The volume over capacity (using theoretical capacities to be agreed with WCC)

Summary

84. The information set out within this note provides guidance on the expectations that WCC have of analysts who wish to make use of the existing suite of microsimulation models.

85. It is intended to be used as guidance and whilst larger site proposals will be expected to adhere to all aspects set out within this note, the requirements for assessing and reporting smaller scale developments would be commensurate with eth size of the development and the expected sphere of influence.

86. All key areas of the wide area model must be reported upon for completeness in any case and all specific details pertaining to the reporting (both in terms of the number of measures used and overall methodology) should be agreed with WCC as part of the scoping exercise.

87. Scoping out the reporting requirements with WCC is considered essential and that, as part of the scoping exercise, a record of which measures outlined within this note should be provided as part of the scoping.

88. Analysis requirements should also be scoped out in full with WCC as it is recognised not all projects fit with the approach in this note. Where it is necessary to do so, WCC will also advise on any priorities in terms of focus and potential mitigation which should be considered within the impact assessment.

89. Once the assessment has been completed and the evidence been submitted to WCC for consideration then analysts should expect to be asked to submit all outputs to WCC and should provide evidence of the sifting process when doing so.

90. Outputs should be accompanied with the models and log runs which correlate to the results reported within the sifting to facilitate independent checking.

91.   When using WCC Tier One modelling consultants analysts can expect to receive this outputs as standard as WCC and their modelling consultants are working towards streamlining the results analysis from the modelling tools.

92.   At a later stage, access to the Tier One consultants reporting mechanisms may be provided for a charge to cover some of the IP licencing.