

7.0 Conclusions and Recommendations

7.1 Conclusions

This thesis has presented a range of comparisons between the various formulations and solution algorithms for solving the synthetic O-D problem. The comparisons included testing the abilities to find optimal solutions, under uniform seed, feasible seed and infeasible seed under two different conditions namely a constant total trip scenario and a variable total trip scenario. The conclusions drawn are:

- There is no difference between the optimal solutions obtained for the trip formulation and volume formulation when the number of total trips is a constant. The optimal solutions do differ when the total trips is variable.
- The proposed single step approach yields results which are consistent with the results obtained from applying exhaustive enumeration to the trip formulation.
- Willumsen's primary formulation (Equation 6.3) cannot be applied to networks, where the total number of trips is a variable, without introducing considerable error in the final matrix estimate.
- Willumsen's subsequent formulation (Equation 6.5) and the proposed modification to it (Equation 6.6) can be applied if and only if the total trips is a constant and $\frac{T_{ij}}{t_{ij}} \approx 1$, which severely curtails the utility of the formulation.
- The solutions obtained from the trip formulation, volume formulation and the single step approach are independent of the scale of the seed matrix whereas, Willumsen's

formulation and its subsequent derivatives are influenced by the application of a scale factor to the seed matrix.

- Willumsen's subsequent formulation (Equation 6.5) deviates from the solution predicted by the trip when a feasible seed matrix is supplied and if the total trips is a variable.
- In the case where the solution search is initiated with an infeasible seed, when the total trips are constant, the error when Willumsen's formulation (Equation 6.5) or the proposed modification (Equation 6.6) was used can be as high as 20%.
- In the case of infeasible seed, when the total trips are variable, the error when the single step approach is used is less than 5%.

The single step approach has been demonstrated to yield very accurate results for small networks, where the actual solution can be verified independently through exhaustive enumeration of all possible solutions. Furthermore, for small networks, the set of equations can be solved using most standard equation solvers, such as those in Excel or MATLAB. However, for large network problems the number of equations to be solved and the number of variables is beyond the capability of these standard equation solvers.

The latest version of QUEENS-OD has been shown to yield results that are consistent with those obtained from standard equation solvers, with exhaustive enumeration, for small networks, where all three methods can be applied. However, QUEENS-OD can also be applied to networks with more than 1,000 zones and 5,000 links on a PC, where it typically requires no more than 1 hour to solve problems of this size. The solutions obtained by QUEENS-OD can reflect multi-path routings, consider correctly that the total number of trips in the network may not be constant, and properly reflect the role of the seed matrix. The model can also be applied to deal with problems where the routes are not known a priori, but this type of problem was not studied in this thesis.

7.2 Recommendations for Further Research

The recommendations for further research are suggested:

- The test networks, which were considered in this thesis, did not contain multiple paths for a particular O-D. In the 5 link network, as well as the 2 link network, all the O-D pairs had only one path available. Further tests need to be done with networks having multiple paths for a given O-D pair. This would validate for a larger scope of problems the effectiveness of various formulations.
- The test networks that were used in this thesis were simple. Further tests on larger networks would help confirm the findings presented herein. For credible validation, the various model results must be compared with O-D trip tables that are known to be accurate for a real network.
- Further comparisons between the maximum entropy approach and other approaches like, linear programming or neural network techniques, should be pursued. These comparisons would bring out the relative advantages and disadvantages over the different methods based on the solution outcome.
- The maximum entropy techniques could be extended to obtain dynamic O-D trip tables if possible, and the results compared with the widely used Kalman filter technique for dynamic O-D estimation.