Monograph:
Shepherd, S.P. (1995) Area Speed Flow Relationships: Aggregation by Movement Type for the Ring-Radial Using SATURN. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Working Paper 452

Published paper
Simon Shepherd (1995) *Area Speed Flow Relationships: Aggregation by Movement Type for the Ring-Radial Using SATURN.* Institute of Transport Studies, University of Leeds, Working Paper 452

UNIVERSITY OF LEEDS
Institute for Transport Studies

ITS Working Paper 452 *ISSN 0142-8942*

December 1995

AREA SPEED FLOW RELATIONSHIPS : AGGREGATION BY MOVEMENT TYPE FOR THE RING-RADIAL USING SATURN

S. P. SHEPHERD

This work was undertaken on a project sponsored by the Engineering and Physical Sciences Research Council.

Preface

This paper is one of a series of ITS working papers and technical notes describing the methodology and results of the EPSRC funded project "The definition of capacity in urban road networks : The role of area speed flow relationships". The objectives of the project were to investigate the interaction between vehicle-hours and vehicle-km within a network as the demand for travel increases; to develop improved area speed flow relationships; to use the relationships to explain the process by which networks reach capacity; and to assess the significance for the evaluation of road pricing policies.

The approach used was to collect the vehicle-hours and the vehicle-km directly from a simulation model and thus create relationships between supply and demand in terms of veh-hours/hr and veh-km/hr demanded and also between times per trip and trips demanded.

During the project two models were used. The first was a micro-simulation model called NEMIS. This model was used on hypothetical networks ranging from single link to a six by six grid and finally a ring-radial network. The networks were used to study the effects of changes in OD pattern and the effects of varying capacity on the resulting speed flow measures.

The second model used was SATURN. This model was used to study the same ring-radial as before and a full SATURN model of Cambridge. The SATURN results were then taken one step further in that they were used to create an aggregate model of each network using SATURN in buffer only mode. The related papers discuss issues such as network aggregation. Note that the methodology and terminology was developed as the study progressed and that in particular the method varies between application of the two distinct models.

The reader is directed to the attached appendix A for a full list of publications arising from this project.

1. Introduction

This paper details a new approach to data aggregation and hence aggregate SATURN network design based upon movement types within an area. The method is designed to avoid the problems of route compression and limited route choice in the aggregate network described by Shepherd (1995a). The vehicle-km and vehicle-hours are collected and aggregated by area and by movement type within an area for all routes taken from each of the full network origin-destination pairs.

The method will be explained by considering a hypothetical network. Figure 1 shows a network with nine rectangular areas (these could be of any general shape but each is assumed to have four distinct sides along the borders). The real network crosses the area borders at the points marked with an arrow (these could be two way links but are shown as one way for clarity).

Figure 2 shows one particular route which will be considered in the following explanation and it also shows the numbering convention for the areas. The sides of an area are numbered from the North clockwise 1-4 as shown for areas 2,5, and 9. The border links crossing these sides will have four variables associated with them :-

1.the "from AREA" i.e. where the link has come from
2.the "from SIDE" the last side in the "from AREA"
3.the "to AREA" to which the link "crosses"
4.the "to SIDE" the entry side of the new area

For example in figure 2 from area 2 to area 5 for this route the border link will have the variables 2,3,5,1 associated with it. This data will be generated from a data file via P1X cordoning and editing as necessary in the format :-

Anode Bnode 2 3 5 1

The flow (PCU-km/hr), time (PCU-hrs/hr) and number of trips will be aggregated for the areas by movement type. The movement is defined by side to side numbers within an area e.g. side 1 to side 3 in area 5 figure 2. Another side '5' is defined for each area to represent internal origins and destinations. Thus a movement matrix of trips times and flows is collected.

Each area will be represented in the aggregate network by upto 25 buffer links as shown in figure 3. Twelve of the links relate to the aggregated movements and are numbered by movement type. This will enable the simulation data to be output for each area by movement type and then used directly for the parameters of the appropriate aggregate buffer link. The buffer links in the aggregate network will be numbered with the following format : AREA_side1_side_2 so that links in area 10 would be 1012 to 1043.

The other two buffer links labelled IN and OUT represent any movements terminating or originating in the area. The IN and OUT links here represent all possible connections i.e. to any of the four sides. Finally there is a dummy zone within each area used to generate the internal trips which will use link 5-5 only. The flows on the aggregate links are assumed to be independent of other movements within the area as they are represented by buffer links in SATURN. The only dependencies are built in as a result of varying the

overall demand.
Figure 4 shows the aggregate buffer network for the nine zones in figure 1. The dark lines represent 2-way buffer links with route choice only at the nodes. It can be seen that the route choice for the route followed in figure 2 is probably greater in the aggregate network than in the full network with six sensible options for leaving area 1 alone. Although this may be a poor example it shows that what was a N-S (1,3) trip through area 5 could easily be assigned to other cheaper links in the aggregate network whereas in reality such a link may not exist. Having such a high number of links per area will obviously cause some problems in the routing patterns and in interpreting the results.

2. Ring-radial aggregation by movement type

The method of aggregating speed flow relationships by movement type has been implemented in SATURN. This section describes the results for the ring-radial network.

The full ring-radial network in figure 5 (SATURN simulation) was considered as one area with 8 external zones and 16 internal zones. The edge of the area was split into four nominal sides used to define the movement types. Each side contained two external zones and could be considered as being North, South, West and East. The internal zones are represented by a fifth side in the movement matrix. Thus the matrix is 5x5 and there are 25 possible movement or link types used to define the speed flow relationships.

The buffer representation of the area is shown in figure 6. The node numbers 1-5 represent the four sides plus the internal zones. The other nodes 11,22,33,44,55 are used to facilitate movements of the type 1-1, 2-2, 3-3, 4-4 and 5-5. Normally only movements of the type 5-5 will be considered in larger networks (internal trips); the other movements are used in this network to take account of trips such as node 1-2 in figure 5 which are within side 1.

The links between the nodes are mostly two-way and form the 25 links required to represent the area. This is the basic building block for the Cambridge network. The basic aggregated matrix is now 5x5 with some extras zones for internal trips. Zone 5 represents 16 zones in the full network, zones 1-4 represent two each.

The full network was run through the usual ten demand levels and the times, trips and distances were aggregated by movement type. The SATURN buffer curves were then generated using trips as the explanatory variable in the form time/trip (in seconds) versus trips and the parameters of the buffer link flow delay curve were estimated as usual. The distance for each link in the aggregated network was defined by a trip weighted average over all ten demand levels i.e. total flow divided by total trips summed over the whole demand range.

3. Results

Due to symmetry only a limited set of results are required shown in figures 7-22.

Figure 7 shows the time/trip versus trips for movement type 1-1 for the simulation, the flow-delay curve fitted, and the results from the buffer network. Note that the curve fitted is the same both under and over-capacity whereas the linear relationship is actually produced in SATURN for over-capacity conditions. The number of trips assigned in the

aggregate network corresponds to the number assigned in the full network, so the curves are obviously very close to the simulation results in terms of time/trip.
Figure 8 shows the total flow for movement type 1-1 versus assigned trips for both networks. Here although the number of trips assigned is equal, the flow in veh-km/hr is different as the aggregate network uses an averaged distance for all demand levels (see Shepherd 1995(a)). The results for movement types 1-2 are shown in figures 9 and 10. Again the results are good as the trips assigned are equal, but there is a slight difference in the buffer-net curve and the fitted curve for the same number of trips. The average distance for this movement type happens to be correct for all demand levels (due only to the nature of the network).

Movements 1-3 give similar results (figs 11 and 12). Movements 1-4 give a good approximation of time/trip but the distance varies with demand (figures 13 and 14). It is interesting to see the effect of the right turns here by comparing movement 1-4 which is anti-clockwise compared with movement 1-2 which is the clockwise or left turn onto the outer ring road.

Figures 15 and 16 show movement type 1-5 (external to internal). Note that the number of trips is far higher than the previous movement types. Although this represents movements to 16 zones in the full network the results are consistent with the input curves. Figures 17 and 18 show the opposite movements internal to external. Figures 19 and 20 show the internal trips (the highest proportion of trips are modelled on this link up to 14,000). Although the time/trip is a good fit the distance varies with demand. Figures 21 and 22 show the overall network results which again show a good fit.

4. Conclusions

The reason for the good results in terms of time/trip is that the assignment in the aggregate network has not changed the distribution of route choices (movement types) for any of the aggregate OD pairs. There are few alternative route choices for a particular movement type and those which do exist are, in this network at least, at a greater cost than using the movement link type provided. For example trips from 1 to 3 could use link 1-3 or a combination of 1-4 and 4-3 or 1-2 and 2-3 but link 1-3 is obviously the best option for all demand levels.

This means that the trips assigned to each movement type are correct so that the time/trip results are as good as the curve fitted to the data (output=input). This will not necessarily be repeated for other networks such as Cambridge. When areas are put together in the aggregate network the link type route choice becomes more reasonable so that for example two diagonal link movements across two areas could easily be replaced by a vertical and horizontal set of link movements. This would in effect give a different assignment of trips and so represent a different network problem with different movement types per OD pair. It could also be difficult to observe in a large network with multiple route choices and partial route swapping possible between different OD pairs.

The other source of error can occur in estimates of distance travelled as the link distance is necessarily an average distance. However the results as a whole are a very good representation of the full network but it must be stressed that this only holds true because the assignment of trips to movement types is the same for the two networks.

References

Shepherd, S.P. (1995a) Area speed flow relationships : Ring-radial network aggregation using SATURN ITS Working Paper 451, Institute for Transport Studies, University of Leeds.

Appendix A: Area Speed Flow Publications

May, A.D. and Shepherd, S.P. (1996) Area speed flow relationships and network aggregation. Urban transport forum 96 Barcelona, Spain 2-4 October 1996.

May, A.D. and Shepherd, S.P. (1996) Area speed flow relationships and strategic models. Proceedings ISATA96 Florence, June 3-6th 1996.

May , A.D. and Shepherd, S.P. (1995) An investigation of area speed-flow relationships by micro-simulation. 23rd European Transport Forum. PTRC. 11-15 Sept 1995.

May, A.D. and Shepherd S.P. (1994) An Investigation of Area Speed-Flow Relationships By Micro-simulation : Single Links. ITS WP428 Dec.94.

May, A.D. and Shepherd S.P. (1994) Area Speed-Flow Relationships By Micro-simulation : Grid Networks. ITS WP429 Dec.94.

May, A.D. and Shepherd S.P. (1994) Area Speed-Flow Relationships By Micro-simulation : Sensitivity issues and Problems With the Tracking Approach When Extended To Multi-Zone Networks. ITS WP430 Dec.94.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Summary of the 9 zone ring-radial results using NEMIS. ITS WP447 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : The effects of dependency and reassignment using 2 link networks. ITS WP448 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : The effect of varying signal capacity. ITS WP449 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Initial SATURN results for the ring-radial network. ITS WP450 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Ring-radial network aggregation using SATURN. ITS WP451 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Aggregation by movement type for the ring-radial using SATURN. ITS WP452 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Aggregation of the Cambridge SATURN network. ITS WP453 Dec.95.

Shepherd, S.P. (1995) Area Speed-Flow Relationships : Changing the OD pattern and road pricing in Cambridge. ITS WP454 Dec.95.

Technical Notes

Shepherd S.P. (1995) Area Speed-Flow Relationships : Considering their future use in START. ITS TN361 Jan 95.

Shepherd S.P. (1995) Area Speed Flow Relationships : Definition of Data Collection Methodology. ITS TN383 June 1995.

Shepherd S.P. (1995) Area Speed Flow Relationships : Initial Ring-radial results using NEMIS.

ITS TN384 November 1995.