LIMITED AREA TRAFFIC ANALYSIS

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ABSTRACT: *Traditional assignments of traffic to a whole city tend to be coarse and expensive. In many cases, it is desired to look at a small part of the city and to determine the likely effects of many possible alternatives. Traditional traffic assignments are not appropriate in these cases.*

Techniques exist to modify the existing methods to provide cheaper, more realistic results by limiting the area analysed. The paper will describe these techniques; the problems encountered in applying them; methods of overcoming these problems and list aspects where research is still needed to improve the results.

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1. INTRODUCTION

The planning of most transport projects involves some assessment of potential effects on the existing and future traffic. Some form of traffic assignment has usually formed part of this assessment. In the fifties, assignment consisted of using diversion curves to split an extrapolated traffic trend between existing and proposed facilities. In the sixties network analysis (using links and nodes) has been used to analyse complex urban road systems. For a large urban area, these traffic assignments are expensive and time consuming. While they were being used to analyse alternative transport systems, this expense could be justified. Currently, most transport analyses are concerned with a single corridor or even a single project. In these cases the use of assignments to the full urban network is not appropriate. Techniques exist to modify the existing methods to provide cheaper, more realistic results by limiting the area analysed. Computer programs have existed for some time to apply these techniques. However, little has been documented in the literature to warn of the limitations and problems of using the techniques. The only reference the author could locate was *Traffic Assignment August 1973*, henceforth referred to as T.A. 1973. The techniques have been referred to as Limited Area Traffic Assignment or Sub-Regional Analysis. At this time they can only be used with road networks.

2. USES

There are two reasons why it may be desirable to use a limited area network. Firstly, it may be desired to test a large number of alternative projects or a large number of combinations of projects in a relatively small area. In this case, the area in question can be isolated and the assignments run much cheaper than if the assignments were performed to the full area. The results will be as accurate as if the full area assignments had been performed. The primary motive here is economy. An example of when this type of analysis might be used is if it were desired to investigate the alternative staging arrangements of one or more large projects. The traffic consequences of the various possible configurations can be cheaply tested using the above approach.

The second reason for selecting to code a limited area network is if it is necessary to look at the study area in finer detail than exists in the full area network - that is, to include sub-arterials and collectors in the network. If this is the case, it will be necessary to sub-divide the existing zones into smaller units and to connect the centroid connectors to these collectors and sub-arterials. (A good rule to follow in sub-dividing the zones is that the area of the zones should approximately equal the areas delineated by the coded roads.) Examples of when this type of analysis would be advantageous would be in analysing proposed street closures or looking at the detailed consequences of a major road proposal. T.A. 1973 states that it may be necessary to develop a trip distribution model to split the normal zones within the study area into smaller analysis zones. However, the author's experience is that it is not necessary to go to great detail to determine the proportions to split the old zones into - usually, area will be sufficient unless the old zone consists of widely differing land uses e.g. a shopping centre and residential area. Care will have to be exercised here to ensure that the coded characteristics of the minor roads are consistent with those coded for the main arterials. Experience with calibrating these networks indicates that the free speed of the sub-arterials is almost as high as that for the arterials, but that the speed drops faster with increasing volume than for arterials.

3. THE METHOD

Two methods exist to allow traffic to enter/leave or pass through the study area. The first of these is to isolate the study area completely by describing a cordon. Traffic which goes outside the study area is assigned to the points at which the cordon crosses the relevant road. In effect the cut links become external stations. Fig 1 illustrates the relationship between the regional network and the limited area network. Programs exist in the various traffic assignment packages to

(a) isolate the study network, and

(b) extract the trip table applicable to the particular network.

The former program is of little use. At the very least it will be necessary to renumber all zone centroids within the study area and add external stations at the cordon. At the other extreme, the splitting of zones and addition of sub-arterials and collectors would mean that the original network is virtually useless. The extraction of the trip table involves the performance of a "Selected Link Assignment" for all links which are cut by the cordon. One or more special programs are then run to convert this information to a trip table. The internal zones can then be split using the relevant matrix utility program.

The second method is to code a coarse or "spider" network outside the study area to link it to the rest of the metropolitan area. These outer links will represent several roads and care must be taken to code suitable properties (e.g. speed and capacity) so that the relativity is achieved. Fig 2 shows how the regional network is simulated.

Neither method is entirely satisfactory, but the second method has fewer problems and requires less work. The first method is only applicable if small scale projects are to be tested (e.g. street closures or road widenings). Large projects (e.g. freeways) have the tendency to divert traffic from outside the study area to inside. The method of developing the trip table does not allow diversions of this nature to take place. The method also requires the running of a series of computer programs which are time consuming to code and expensive to run. Care must be taken in selecting the cordon to avoid the possibility of trips which cross the cordon three or more times as these introduce minor inconsistencies between the full area network and the limited area network. It is also advisable to select a cordon which does not cut any centroid connectors as some of the computer programs do not like this. The second method will probably require some calibration of the network to ensure that the detailed study area network and the coarse outer networks are compatible. Probably several assignments will be necessary to achieve the desired result.

The techniques described in this paper should not be confused with so-called "micro assignment" techniques. Micro assignment utilizes a completely different method of representing a network. It uses block-face as the unit of origin/destination and can only be used to analyse a very limited area. All roads in the area must be coded as must the system of traffic control at intersections. It takes account of the effects of conflicting traffic movements at intersections which cannot be done with traditional assignment methods. The detail required for the description of the trip interchanges (block face to block face) basically means that micro assignment is restricted to analysing existing traffic determined by an origin-destination survey. The main uses of the method are in analysing traffic engineering type solutions. For example, analysing different forms of traffic control devices at intersections, the effects of linking traffic signals, introduction of clearway conditions, etc. The method can take no account of traffic generation or diversion of traffic into or out of the study area, due to any proposed facility. Thus the method is restricted to projects which will have no major system wide effects. As far as is known, the method has not been used in Australia.

4. EXAMPLES

The use of limited area assignment techniques will be illustrated by two examples. The first of these was a study of the Scoresby Freeway in Melbourne. This freeway, which is basically a circumferential route, is planned to run from Ringwood virtually due south to Frankston. A locality plan is shown in Fig 3. The purpose of the study was to examine the traffic implications of various possible staging alternatives of the Scoresby Freeway and the likely effect on the Scoresby Freeway of constructing all or parts of the Healesville Freeway - a freeway which crosses the Scoresby Freeway. In all, it was expected that upwards of twenty different network configurations would need to be tested. In view of the number of assignments, it was decided to use a limited area network.

The network chosen was the cordon type and extended from Middleborough Road in the west to Dorset Road in the east and from Park Orchards in the north to Seaford in the south. In general, the network extended six to seven kilometres either side of the proposed line of the Scoresby Freeway. The network was extracted from the full Melbourne network using the Federal Highway Administration's (FHWA) DONUT programme. This programme worked according to specifications - however, it is necessary to ensure that the cordon is fully specified or the programme will slip through the cordon and extract the full network. Before running the DONUT programme, all centroid connectors which would otherwise have been cut by the cordon were deleted from the network, leaving only arterial roads as cordon points. This was done to reduce the number of cordon points and to simplify later processing. In all there were 118 zones inside the cordon and 51 cordon stations. There were approximately 2000 one-way links in the network, which is about 18 per-cent of the size of the full Melbourne network.

The trip table for the study was extracted from the full area trip table using the FHWA programmes SELINK (a selected-link assignment programme), TRPCORD (a programme to renumber and sort the data from SELINK) and TRPTAB (a matrix building programme). Because of cost considerations it was decided to run this sequence of programmes for only one increment of what is usually a four increment capacity restrained assignment process. In retrospect, this was a mistake. Being basically an all-or-nothing assignment, it produced substantial over-assignment on certain roads at the cordon and these volumes become fixed for all subsequent work. To distribute these volumes over the available roads, it was necessary to add some dummy links at certain points around the cordon.

The results of this study were disappointing. The process did enable the various alternative configurations to be differentiated according to certain criteria as desirable or undesirable, but the use of a single fixed trip table means that the absolute volumes could not be relied on. Thus it was not possible to quantify the various features of each configuration and derive a weighted measure of the desirability of each. The fixed volumes at the cordon also caused problems in assessing the likely effects of the Healesville Freeway, which, it its ultimate form, could extend beyond the cordon in the west and the east. This meant that additional dummy links had to be included at the cordon to feed traffic to the Healesville Freeway. It also meant that the absolute assigned volumes on the Healesville Freeway were unreliable. A final problem of the fixed trip table was that it did not enable any composite effects of two or more sections of freeway to show up. The following example may illustrate this problem. The basic section of the Scoresby Freeway which was tested was from Canterbury Road in the north to the Mulgrave Freeway in the south. Two sections of freeway which it was desired to test as possible additions to this basic section were

(a) the extension of the Scoresby Freeway south to Cheltenham Road, and

(b) the construction of the Healesville Freeway east from the Scoresby Freeway to Dorset Road.

Each of these configurations produced relatively local traffic effects. The effects of extending Scoresby Freeway to the south were all confined south of Wellington Road and the effects of adding part of the Healesville Freeway were all north of Ferntree Gully Road. The assignment to the network which contained both the above projects showed no effects not shown in the individual assignments. North of Ferntree Gully Road the assignment was almost identical with that for Healesville Freeway alone while south of Wellington Road the assignment was virtually indistinguishable from that for the extension of Scoresby Freeway. This inability of the process to show any composite effects was a great disappointment and meant that it was not possible to come to any realistic conclusions about the desirable ordering of the potential projects.

Although the study did not satisfy all its objectives, it did provide valid answers to many of the questions asked. Lessons which were learned for future studies included -

(a) the use of a single trip table has significant drawbacks, especially if it is desired to test the effects of quite substantial additions to the road network (e.g. sections of freeways).

(b) the use of the cordon type network limits the usefulness of the results. It makes it almost impossible to accurately assess the effects of a project which could attract traffic into the area from outside.

The second example of the use of limited area assignment is the recently completed traffic study of South Melbourne. The objective of this study was to investigate the traffic in the South Melbourne area and in particular to determine the traffic implications of -

(a) the opening of the West Gate Bridge

(b) the opening of the Johnson Street Bridge, and

(c) the construction of the F9 Freeway project (which extends the Lower Yarra Freeway easterly to Kings Way).

Because of lessons learnt from earlier studies (in particular the Ringwood/Eastern Corridor Study), it was decided to adopt the spider type network outside a detailed network. The detailed study area was basically the municipalities of Port Melbourne and South Melbourne. This area, which usually consists of seventeen zones in the full Melbourne network, was divided into 104 zones. Immediately outside this region in the St Kilda, South Yarra, CBD area, single zones from the full network were retained or, in some cases, adjacent zones were combined. Outside the Footscray, Melbourne, Prahran, and St Kilda municipalities, single or grouped local government areas were used as zones. The network includes a total of 160 zones and about 2500 one-way links. Within the detailed network most roads which could carry through traffic are included in the network. It costs approximately $35 to assign traffic to the network compared with about $500 to assign traffic to the full Melbourne network using the TRANPLAN package on the Control Data computer.

The trip tables applicable to the coded network were derived by compressing the full trip table in the areas outside the detailed area and then splitting the zones within the detailed area using a matrix expand programme. The proportions that were used to split the normal zones into fine zones were calculated using great detail. The actual land use of each parcel of land was determined (this information was obtained separately for another part of the South Melbourne Study), and appropriate trip rates were applied to these areas. With hindsight, this was unnecessarily complex. In most cases, splitting the zones on the basis of area would have been sufficient.

Two trip tables were derived for use in the study. The first trip table was derived independently of the South Melbourne Study using the old Ministry of Transport travel models. This trip table was assumed to apply for about 1986. One aspect of the South Melbourne Study was that it had been decided to try to obtain realistic estimates of traffic at least down to collector streets. Because of this it was felt necessary to "prove" the network by showing that it could produce current day (1976) traffic volumes. This necessitated the production of a 1976 trip table. Because there was no 1976 land use to derive this trip table using the travel models, it was decided to factor back the 1986 trip table using a Fratar process basing the factors on the population proportions (1976/1986). It was also necessary to apply a constant factor of 0.91 to allow for lower car ownership and lower trip rates in 1976 than would exist in 1986.

When the derived 1976 trip table was assigned to the existing network and the resulting volumes compared with actual traffic counts, significant differences were found. As part of the South Melbourne Traffic Study, an origin-destination survey was conducted using reply-paid postcards within the study area. This survey was used to determine an actual 1976 trip table, although it was appreciated that it was incomplete. For example, not all trips which had their origin and destination within the study area would have been sampled and also not all potential through trips would have been surveyed. Nevertheless, the survey revealed two deficiencies of the derived trip table. The first of these was that traffic crossing the Maribyrnong River was over-estimated in the derived trip table. This will be discussed shortly. The other deficiency was that other travel was generally under-estimated. This would indicate that traffic is increasing at a faster rate than can be explained by increasing car ownership. The first problem of the over-estimate of traffic crossing the Maribyrnong River was not new. The original home interview survey from which the Ministry of Transport models were derived (conducted in 1964) showed that travel in the western suburbs was much more self-contained than for the rest of Melbourne. To account for this in the trip distribution model, it was necessary to include K factors less than 1.0 so as to reproduce travel volumes across the Maribyrnong River. However, for predictive work it was agreed that these K factors should be removed on the grounds that, with improved accessability, this tendency of the population of the western suburbs to isolate themselves would disappear. The 1986 and thus the simulated 1976 trip tables were prepared on this assumption. The South Melbourne origin-destination survey shows that by 1976 this isolationist tendency is still present to about the same extent as in 1964. In retrospect, this is not surprising as there has been no significant change in the accessability of the western suburbs in that time.

To account for these deficiencies of the derived 1976 trip table, broad sector to sector factors were applied to bring it into general agreement with the data obtained from the origin-destination survey. This factored trip table was then assigned to the existing network. Some adjustments to the network were found to be still necessary to reproduce existing volumes. In particular, the coded speed on Beaconsfield Parade and Queens Road had to be increased significantly. Other adjustments were of a relatively minor nature and generally reflected the rather coarse attributes that were originally coded.

When the network was satisfactorily reproducing 1976 traffic volumes, it was used to estimate the effects of the different road proposals in the area. For this prupose, the 1986 trip table was also adjusted in line with the factors used on the 1976 trip table, however, the factors on the trips crossing the Maribyrnong River were brought closer to 1.0 on the grounds that the West Gate Bridge would increase the accessability of the western suburbs and thus lessen the tendency to be self-contained.

The network as finally adjusted was considered to be satisfactory for the purpose for which it was developed. Although it was found that the assigned volumes were not accurate at the collector and local street level, the results did give an indication of the likely effects on these roads. Further, the accuracy of the assigned volumes on the arterial roads was much higher than would have been possible on a full area network.

At a late stage in the study, some full area assignments were conducted to assess the effects on roads outside the South Melbourne Study area. Those assignments differed significantly from the limited area assignments in the proportion of Maribyrnong River crossing traffic which was assigned to the West Gate Bridge. A detailed examination revealed that part of the difference was attributed to a lack of detail in the coding of the Limited Area Network in the Footscray area. This did not show up when checking against 1976 traffic volumes as traffic to and from the western suburbs was forced in fact and on the network to use either Footscray Road or Dynon Road (Smithfield Road and Maribyrnong Road basically serve different areas). These two roads are very close which means that the coding of the road network in the western suburbs was not critical. The addition of the West Gate Bridge to the network, however, means that the accessability of the various parts of the western suburbs to the Footscray Road/Dynon Road area on the one hand and the West Gate Bridge on the other hand became very critical. It is believed that a further part of the volume difference between the full area assignment and the limited area assignment was due to the coarseness of the spider network outside the detailed network. The rest of the difference was attributable to different capacities and speeds coded for the Lower Yarra Freeway and Footscray Road in the two networks. In the absence of any information on how much the toll is to be on the West Gate Bridge, it was accepted that these remaining differences represented ranges of likely volumes.

Although not as successful as was originally hoped for, the results of the limited area assignments are such that the study is generally accepted as having been worthwhile. The study showed that -

(a) the results are dependent on the coding of the outer coarse network. Rather than spend considerable time coding and checking a different network for each study, it has been decided to code a general strategic network which can be used as a base for all future limited area networks,

(b) checking the network against existing traffic volumes was a worthwhile exercise, but it is also necessary to check the results against a full area assignment to ensure compatibility,

(c) it is not necessary to go to great detail to calculate the proportions into which to split the ordinary zones within the detailed network,

(d) it is necessary to have a buffer zone in the network between the coarse area and the detailed network. This area should be from three to five kilometres wide and the coding should typically include all arterial roads in this area.

5. LIMITATIONS

Like all assignment work, the results of limited-area assignments should be interpreted carefully. Ideally, they should be used primarily in a relative way. That is the results of one assignment should be compared with another assignment. Great care must be exercised in using the absolute results of an assignment. This is particularly so if the results are being compared with actual traffic counts. There are several sources of error which must be taken into account in any such comparison.

(a) The actual traffic counts are subject to sampling error. This will vary depending on the type and duration of the particular count, but will be significant

(b) The "trip table" used in the assignment will be subject to error. This trip table will be either synthetic (i.e. developed from calibrated transport models), or obtained from an origin-destination survey.

(c) Errors in the traffic assignment process itself. Among the more obvious errors is the assumption that all persons have "perfect" knowledge of the system. This will lead to over assignments to "local shortcuts" at the expense of the known main roads which are actually used by people once they are outside their area of prime knowledge. Further, the models assign the vehicle to the place where the driver is destined - this may not be the place where the car is headed. No assignment models can simulate a car going around the block three times looking for a parking place. Also, a driver may park his car some distance from his ultimate destination because of ease of parking or parking restrictions nearer his destination. Finally, like all zone/link assignments, the analysis suffers from the problem of concentration of traffic at zone centroids. Splitting the zones reduces this problem but does not eliminate it.

T.A. 1973 states that limited area assignments are useful for peak period analysis. The author does not agree with this. Limited experience with peak period analysis has led to the conclusion that it is of no practical use for road systems - whether for full or limited area networks. The main difficulty is that it is very difficult to obtain a "balanced" assignment for a limited part of the day. In practice, not only are the traffic volumes dependent on the trip interchange predictions, but the trip interchange predictions are in turn dependent on the traffic volumes and the network. A balanced assignment is one which recognises this interdependence and produces assigned volumes which are consistent with the capability of the roads to carry this traffic. This is relatively easy to accomplish for a daily assignment. Any assignment which results in a volume in excess of its "capacity" can be rationalized as a shift in demand away from the peak period - or an in-filling of the peaks. This cannot be done with a peak period assignment. Any "overassignment" must be accepted as a fault of that assignment.

6. FUTURE DEVELOPMENTS

All of the limited area networks with which the author has been associated have utilized incremental capacity restraint - usually with four increments of twenty-five percent each. Each increment has been an all-or-nothing assignment on the minimum time path. Options which it is hoped will be tested in the near future include:

(a) using a "stochastic" process for assigning each increment instead of an all-or-nothing process. Dial's Stochastic process has its draw-backs and limitations, but it is better than "all-or-nothing" even if a high value of Θ (theta) is used.

(b) basing the criteria for path selection on some weithting of time and distance rather than on travel time alone. Conceptually, percieved cost has great merit.

(c) testing the use of turn-penalties and turn prohibition. In full-area assignments, the use of these features can rarely be justified (their use necessitates the use of "vines" rather than "trees" and this is much more expensive). However, in limited area assignments their use may be justified.

(d) further refinement of the speed/flow relationships used in the incremental capacity restraint. Presently, the Country Roads Board is using different relationships for

- freeways
- divided arterial roads
- undivided arterial roads
- minor or sub-arterial roads

7. CONCLUSION

The paper has documented techniques for carrying out traffic analysis for small parts of an urban area more cheaply and accurately than using traffic assignments for the full region. The limitations of the method have been listed. The paper was prompted by the poor coverage of the method in the literature and in the hope that the techniques will become more widely used and thus further refined.

ACKNOWLEDGEMENT

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REFERENCE

COMSIS CORPORATION (1973). *Traffic Assignment August 1973.* (Federal Highway Administration ; Washington, D.C.)

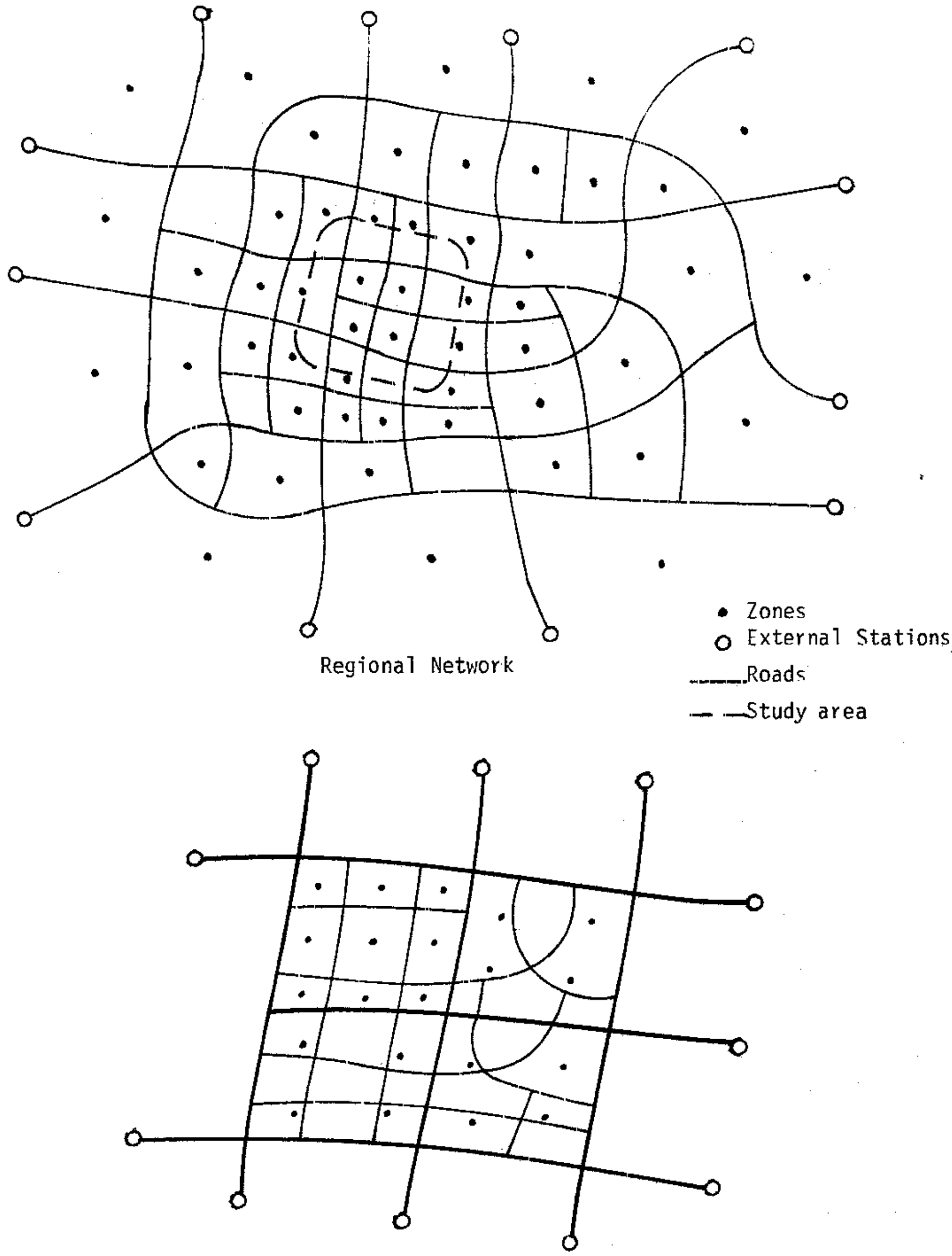
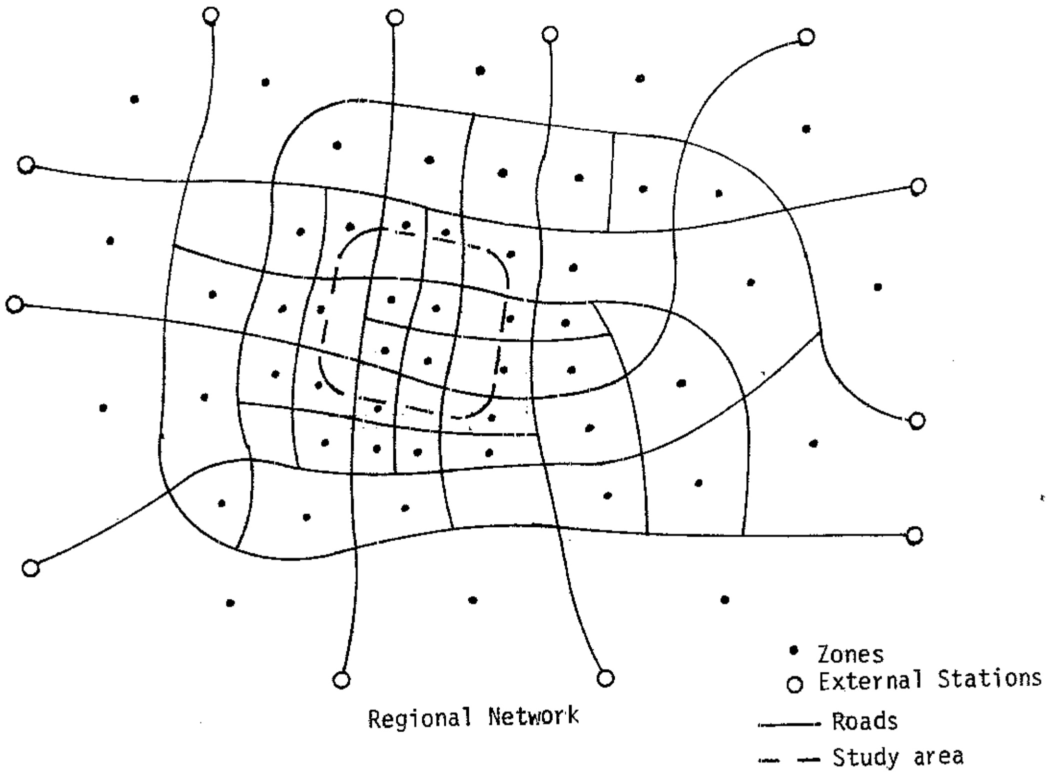
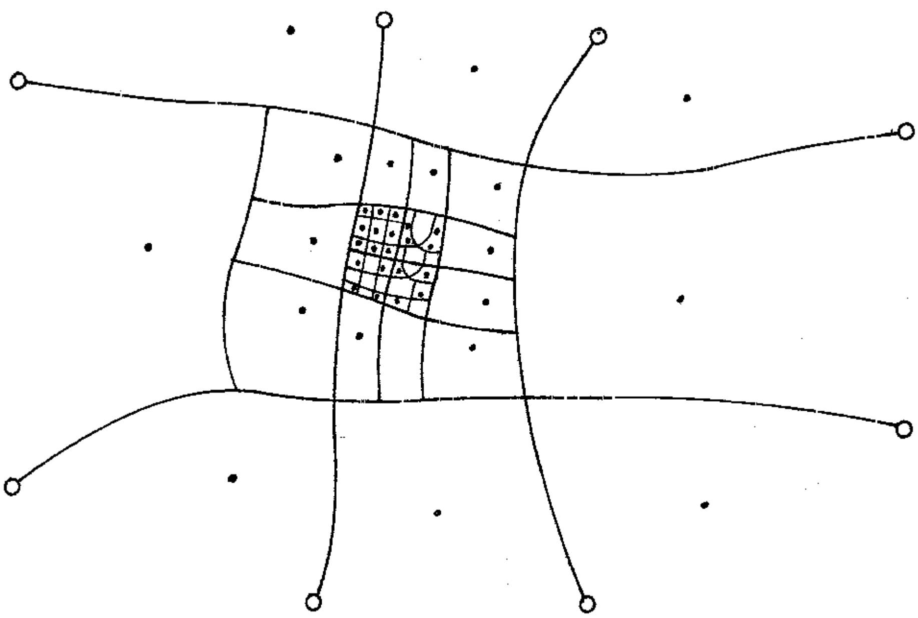


FIGURE 1 - RELATIONSHIP BETWEEN REGIONAL AND CORDON-TYPE LIMITED AREA NETWORK



Regional Network



Detail plus Spider Network

FIGURE 2 - RELATIONSHIP BETWEEN REGIONAL AND SPIDER-TYPE LIMITED AREA NETWORK

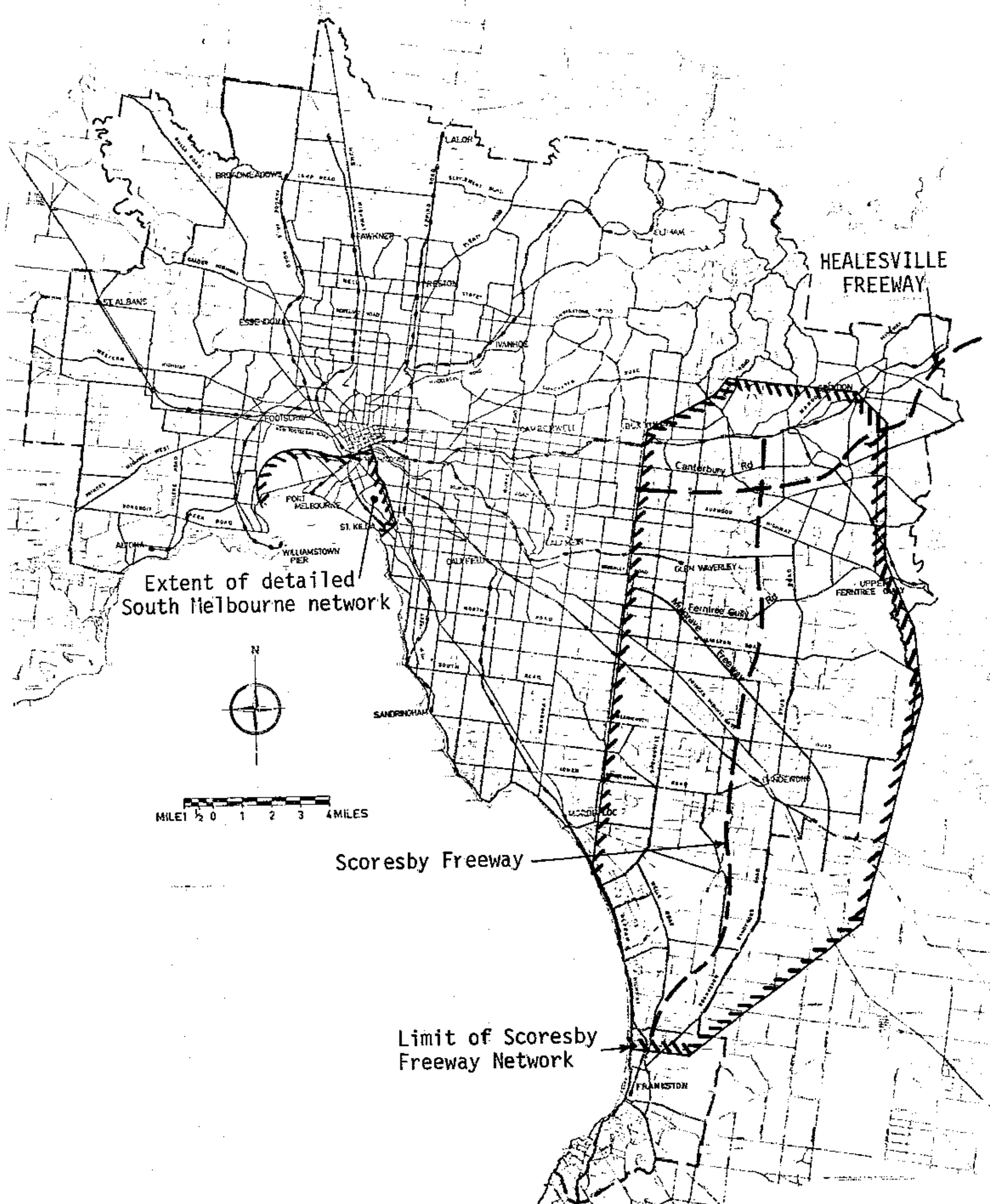


FIGURE 3 - GENERAL LOCALITY PLAN