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AREA SPEED FLOW REALATIONSHIPS : SUMMARY OF THE 9 ZONE RING-RADIAL RESULTS USING NEMIS

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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.

Abstract

This working paper describes the results for the hypothetical ring radial network. The results are presented for two origin-destination patterns one flat matrix and the other flat plus heavy inbound movements. The measures are collected directly from the micro-simulation package NEMIS. Each demand level was simulated with and without the en-route diversion process implemented in NEMIS thus giving speed flow relationships under fixed route and re-routed scenarios. The implications of the differences between these measures when considering their use in strategic models will be addressed.

1. Introduction

This note discusses the results for the ring-radial network for matrices A and B presented by Shepherd (1995a). The second ring has been reduced from 4 to 2 lanes and the ring-radial is divided into 9 zones rather than 3 as used previously. Zone 1 is the central zone as before, zone 2 is representative of the 4 middle quadrants and zone 6 is representative of the 4 outer quadrants.

The matrices have been run for both the fixed route case based on the pre-simulation assignment process and the NEMIS en route diversion or reassignment case. For each matrix the usual 4 measures defined by Shepherd (1995b) are shown for the total network comparing fixed to re-routed curves (note that the performance curves must be shown separately as they do not have a common x-axis). The time/km and speed versus demanded flow plus the performance curves for fixed and re-routed flows are shown for zones 1, 2 and 6 split by link type as usual. This gives a total of 37 figures per matrix. Figures 1-37 are for matrix A, figures 38-74 are for matrix B. The fixed route performance curves are headed FIX and the reassigned performance curves are headed RA.

2. Total Measures

Figures 1-5 for ODA show the total network measures for the fixed route and reassigned flows. All the figures show an increase in capacity for the total network as the reassignment process is applied. Figures 4+5 show that the performance measures have changed due to a combination of reassignment and spatial dependency or the way in which congestion patterns build up.

Similar conclusions can be drawn for ODB (figures 38-42) with an even more marked increase in capacity due to reassignment. The capacity of the re-assigned network for matrix B is around 29k veh-km/hr compared to 25k veh-km/hr for matrix A.

2.1 Zone 1 Outbound

Figures 6-9. The reassignment causes a shift in the supply measures and in this case a change in the performance curve by increasing the capacity. Note that the speed versus demanded flow gives a less variable curve than the time/km for high demands as the inverse near zero becomes sensitive. Similar results apply to ODB (figures 43-46) again with an increase in capacity 1600 veh-km/hr compared to 1200 veh-km/hr for the re-assigned curves.

2.2 Zone 1 Orbital

Figures 10-13. There is not such an obvious change in the performance curve here; demand level five maintaining a higher speed for the reassigned curve giving a shift in the supply curve. This is the ideal case where the reassignment merely acts to shift the demand point along the performance curve, note the 4th point on each curve with; reassignment the actual flow is lower so the speed is higher, the flow has been assigned to another route. This causes a shift in the supply curves suggesting a higher capacity. Similar results apply to ODB (figures 47-50) once again with a slight increase in capacity.

In an ideal 2 route case such a shift in the curve for one route or link would be mirrored by an opposite and equal shift for the other route **(assuming no change in performance which is possible when considering a 2 link case)**. As will be seen in this note this is not the case as the performance curves of the **areas** change and so the reassigned curves all seem to shift in the same direction. This issue is addressed by Shepherd (1995c) with examples as it is a complicated issue and affects whether to pass fixed or assigned curves to the strategic model.

2.3 Zone 2 Inbound

Figures 14-17. Again a shift in supply and a slight change in performance. Also the speed supply curves look better than the time/km curves. Figures 51-54 for ODB show a marked increase in capacity and a shift in supply curves.

2.4 Zone 2 Outbound

Figures 18-21. Slight changes only for ODA between the fixed and re-assigned curves. Figures 55-58 for ODB show a change in performance and a shift in supply.

2.5 Zone 2 Orbital

Figures 22-25. Comparing fixed route to re-assigned for ODA there is an increase in capacity and shift in supply again to the right. Figures 59-62 for ODB show a change in performance and shift in supply. Note that the fixed route performance curve (fig 61) is strange in that it collapses to a low speed then the flow continues to increase as demand rises until capacity is reached. Perhaps the speed is on the ring is governed by the other links around the exits to the ring.

2.6 Zone 6 Inbound

Figures 26-29. Look at figure 27 rather than 26. The performance curves are similar but there is a definite shift in supply curves for ODA. The different speeds on the supply curve result from different actual flows on the performance curve given the same demanded flows based on the free flow multiplied by the trip generation factor for the whole matrix.

ODB figures 63-66 give a classic example of changes in both performance and supply. Note that for this inbound matrix the inbound links produce an increase in capacity for both the fixed route and re-assigned routes compared to the base matrix A. The capacity increases from 1100 veh-km/hr to 1800 veh-km/hr with associated shifts in the supply curves for the reassigned routes.

2.7 Zone 6 Outbound

Figures 30-33 ODA. These curves are for a fast link and seem to be variable. The performance curve is not of the usual form and so it is concluded that the performance is limited by dependencies on other links. Similar curves result for matrix B (figures 67-70).

2.8 Zone 6 Orbital

Figures 34-37 ODA. Here the performance is changed dramatically almost doubling the flow with reassignment which gives a similar set of supply curves as the demanded flow axis is based on the first point multiplied by the trip generation factor. This doubling of flow between reassigned and fixed routes is also apparent for matrix B (figures 71-74) but this time the supply curves do shift. Perhaps the doubling of flow is related to longer trips on the orbitals using two links within the zone rather than one before turning off.

3. Conclusions

The difference between the fixed route and the reassigned curves was larger than expected for the en-route diversion process set up in NEMIS.

Nearly all supply curves shifted in the same direction. In an ideal case the shifts would be mirrored by opposite shifts so that when an assignment process is applied to the fixed curves in a strategic model then the reassigned curves would be the result. The shifts in the same direction are caused by the changes in performance measures which are due to a shift in flow patterns which in turn affects the spatial dependencies within an area (or the way in which congestion builds up).

This whole problem does not exist for single link flow relationships as the performance curves are supposed fixed and independent. When considering an area it seems that the performance of the area can change. This may imply that if we pass fixed route curves to a strategic model then it will be impossible to reproduce the reassigned results of the full network model because the strategic model does not know that the performance has changed as it reassigns flows. However if we pass the reassigned curves to the strategic model then there is the danger that the assignment process in the strategic model will be using a different aggregate route choice set and so give a different assignment a result.

As reported in Shepherd (1995a) and shown here the speed flow relationships for the ring-radial network are sensitive to the changes in OD pattern tested. The measures do shift with a change in OD pattern but it is difficult to determine whether this is due to reassignment, spatial dependency or a combination of the two. The curves do seem to be affected by the way in which congestion build up. Overall there is an increase in capacity between the base matrix A and the heavy inbound matrix B.

The main problem encountered when comparing times/km for different matrices is that the demanded flow is not always met (by either matrix). This has the effect of shifting the break point from free flow to congested regime along the x-axis. Although this implies a different supply curve from one matrix to another the performance curves which use actual flow as the x-axis can be very similar as reported by Shepherd (1995a) for matrices A and D and B and C.

For the zone 2 orbital links, ring 2, the speeds remained high as the flows were reaching a capacity or even dropping. This indicated that the flows on the ring were constrained by the flows on the other links, so that blocking back of junctions could reduce the flow entering the ring as demand was increased.

A change in OD pattern can via spatial dependency cause a change in both the physical performance curve and the supply curves for an area. Reassignment alone can only change the supply measures for related areas it cannot change the performance curve of an area. A change in capacity can cause changes in both performance and supply measures.

Other problems with the speed flow relationships will occur when the policy dimension is brought in such as capacity variation due to signal control policies, reassignment due to road pricing and the temporal dependency problem with variable demand profiles which we have ignored in the previous analysis. It seems that speed flow curves can be generated for a particular network where network defines the demand pattern, demand profile, network topology, network aggregation, signal plan and generalised cost. If one of these parameters changes then a full network model is required to generate a new set of measures.

References

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

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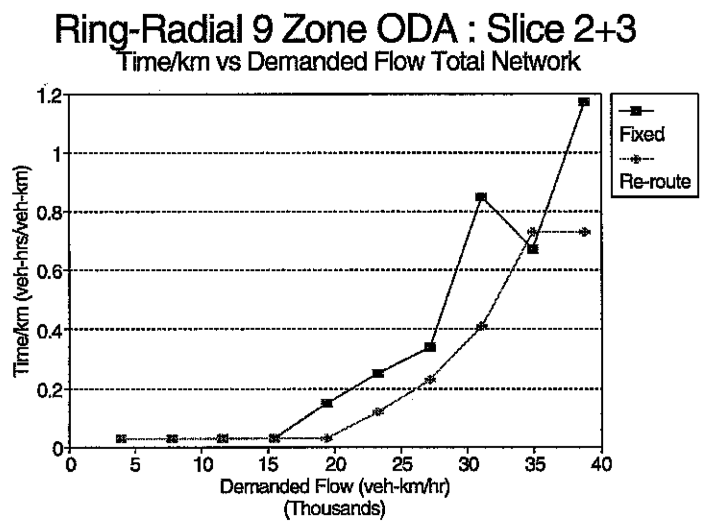
Fig 1



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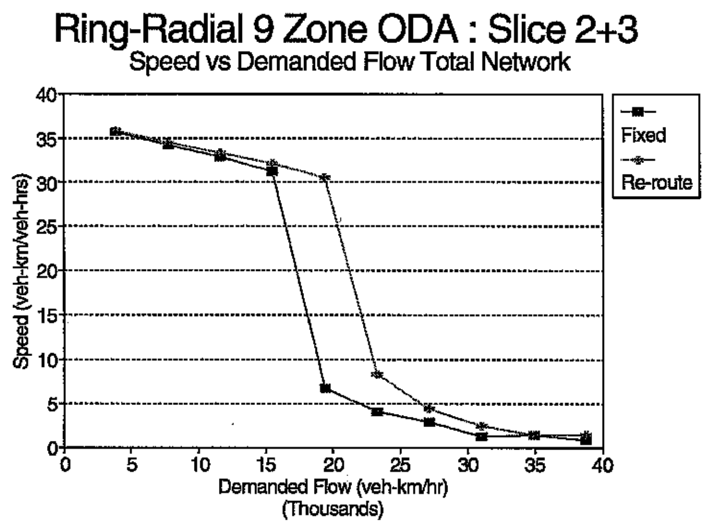

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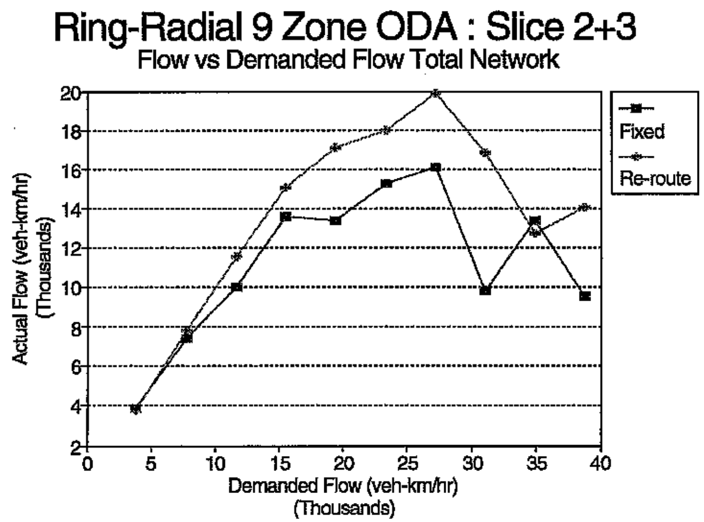

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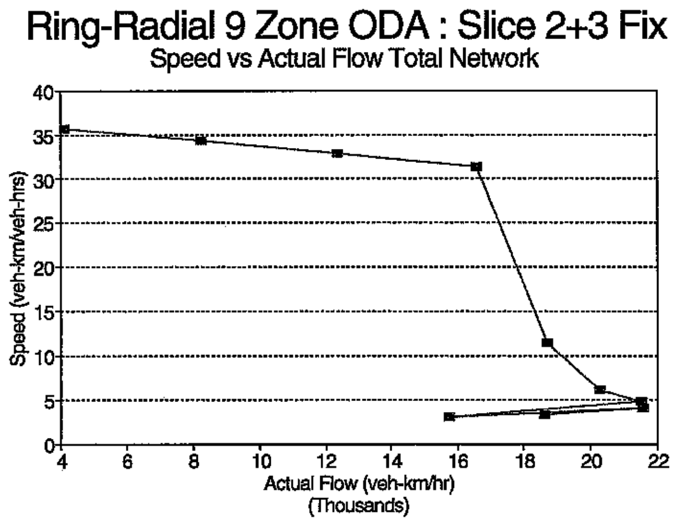
Ring-Radial 9 Zone ODA : Slice 2+3 Fix
Speed vs Actual Flow Total Network
Speed (veh-km/veh-hrs)
40
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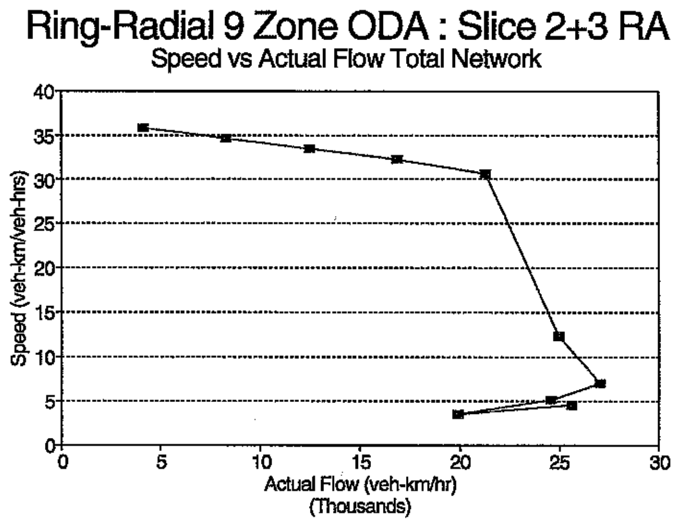
Actual Flow (veh-km/hr)
(Thousands)

Fig 5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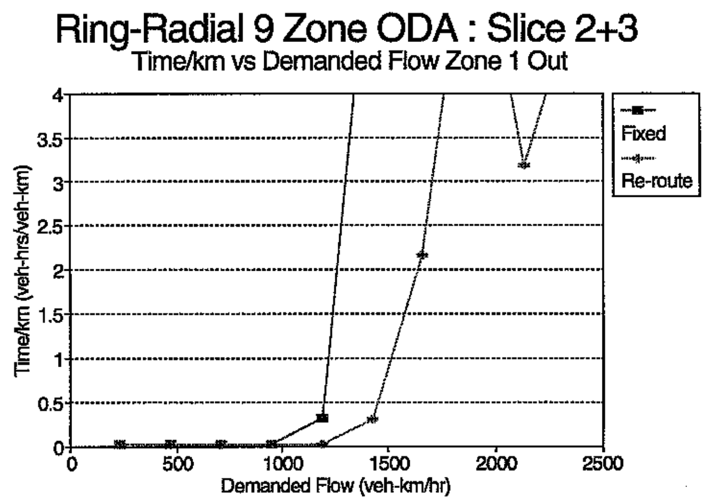
Actual Flow (veh-km/hr)
(Thousands)

Fig 6



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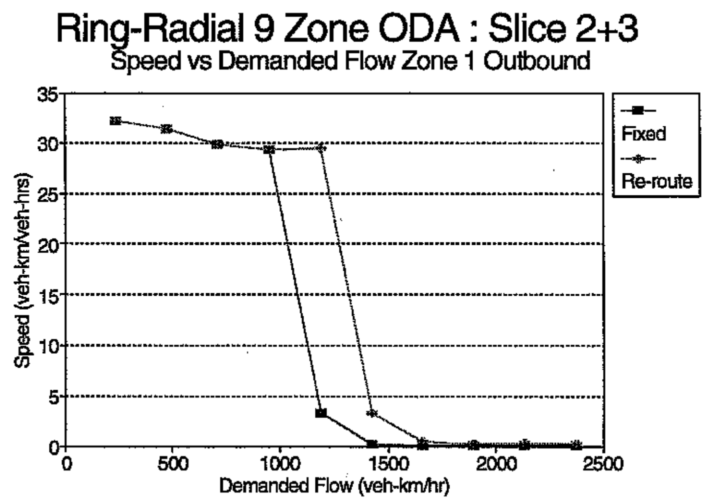

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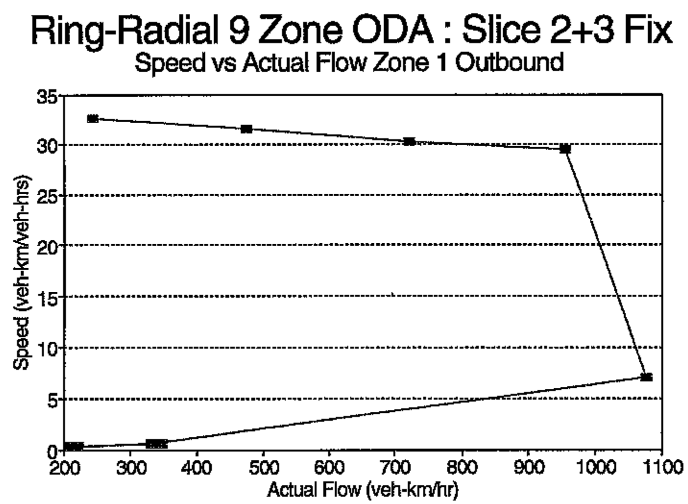

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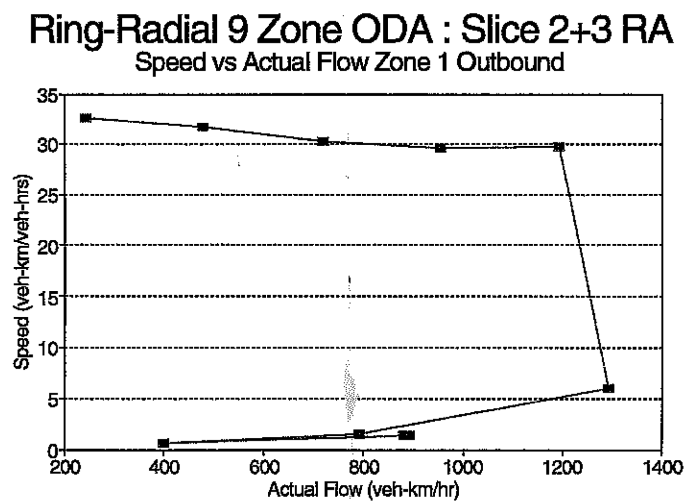

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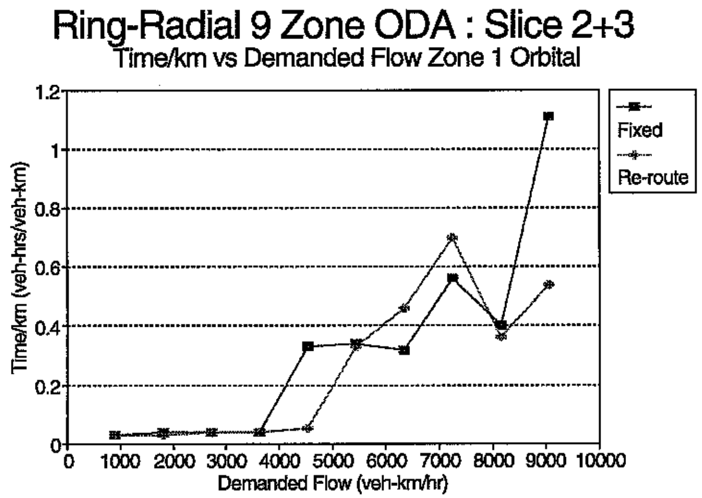

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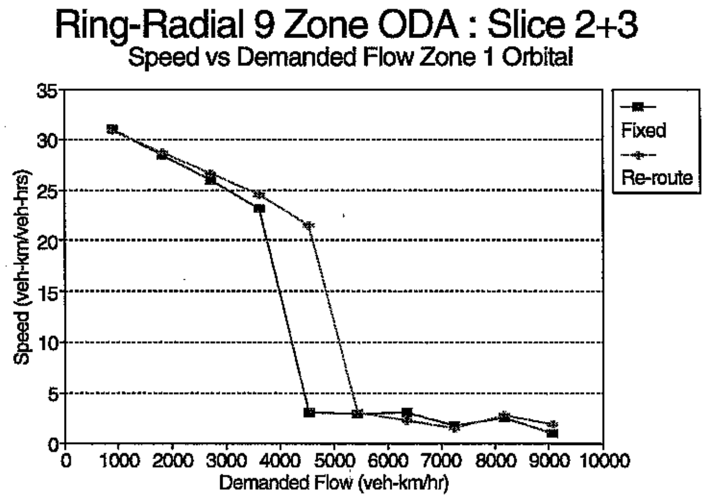

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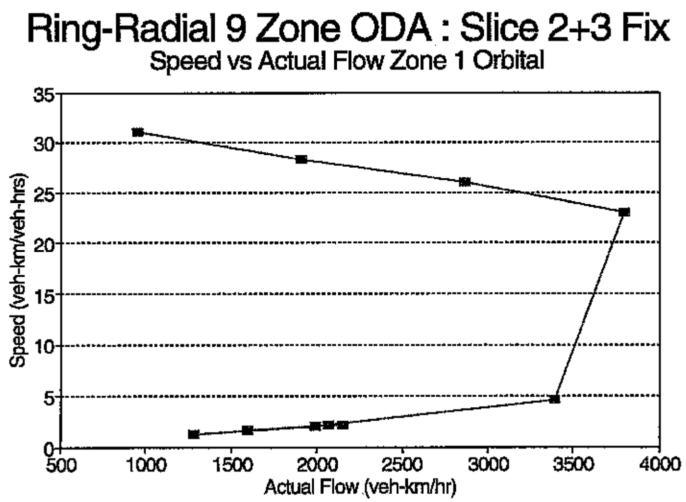

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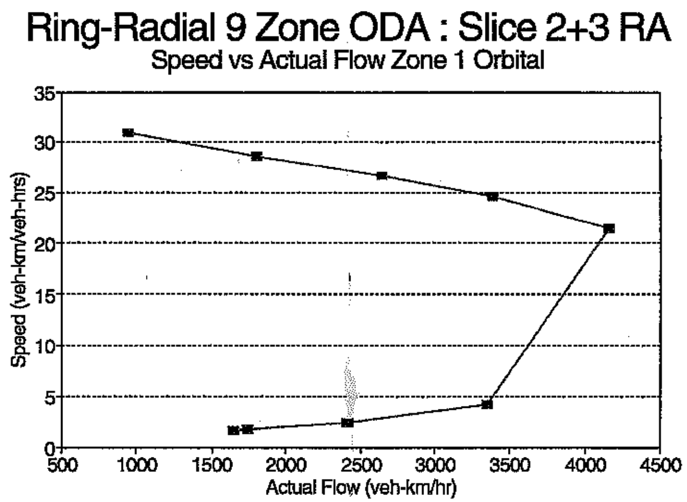

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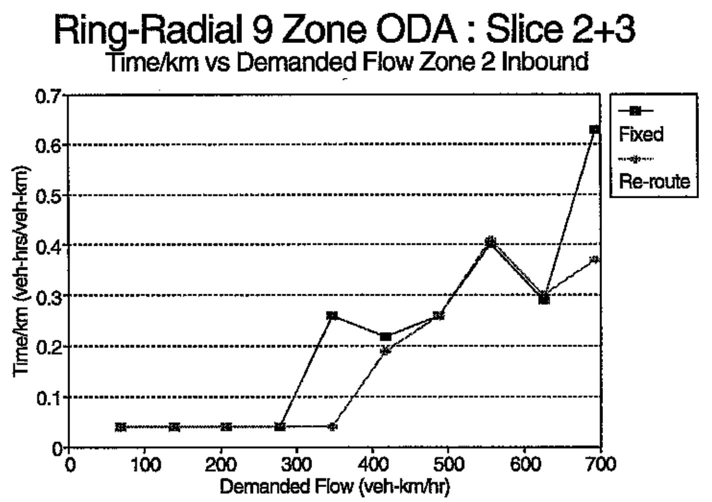

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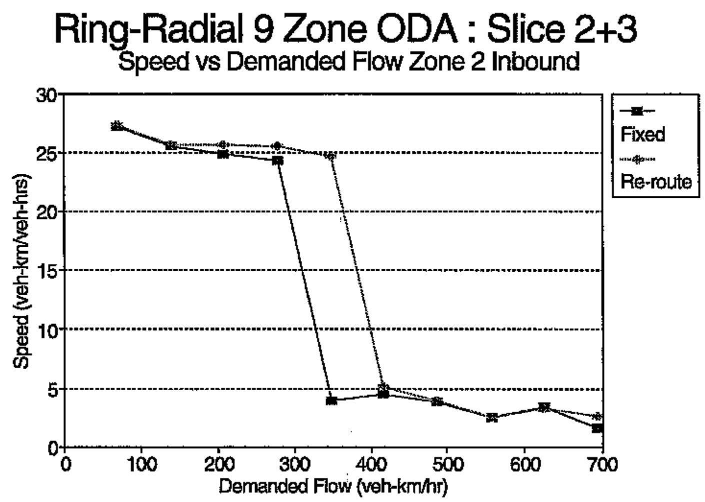

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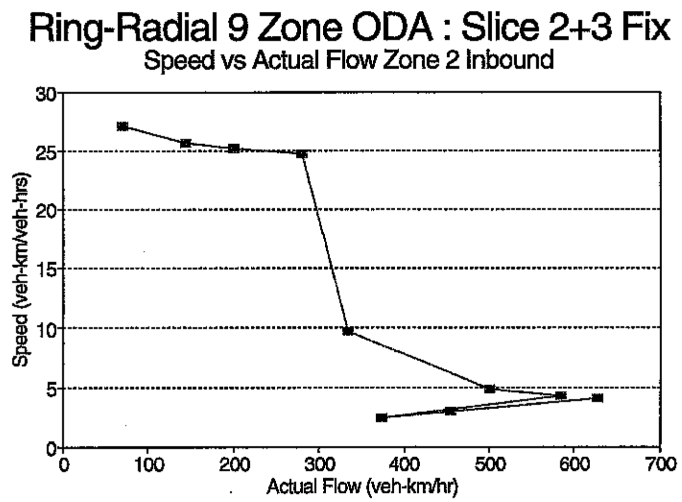

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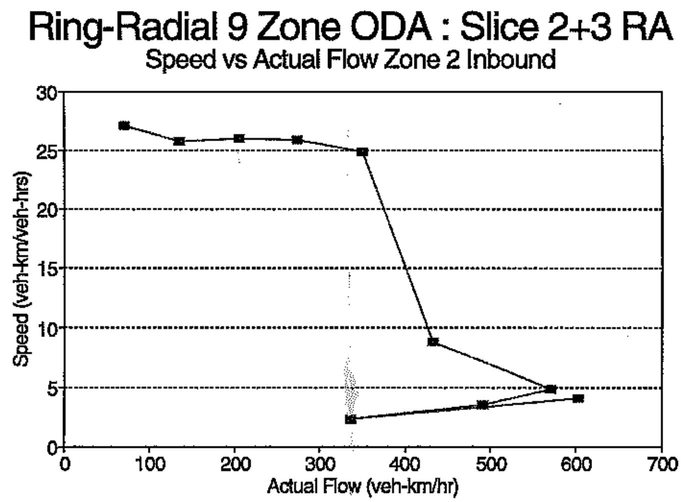

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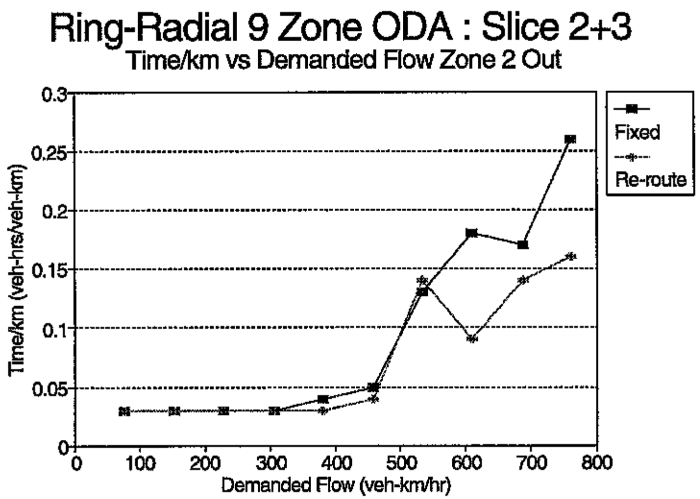

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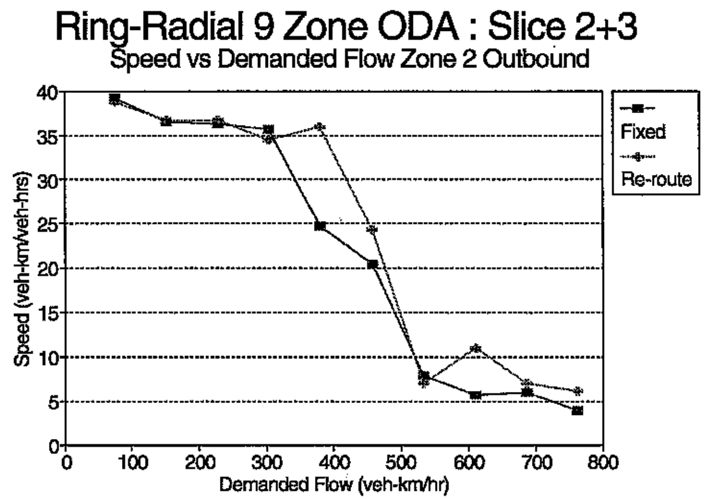

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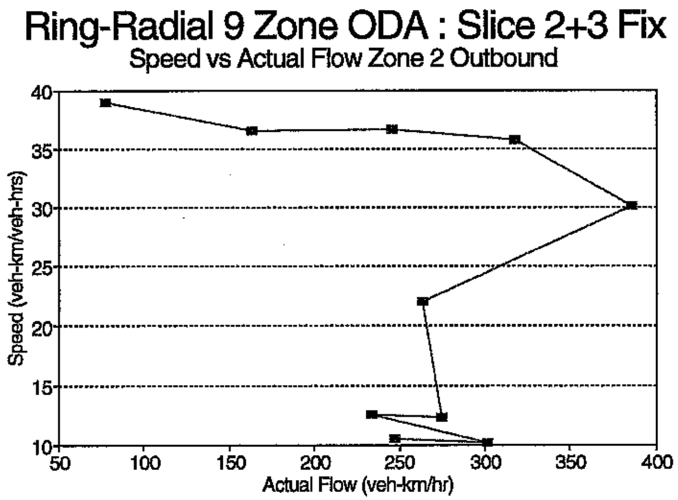

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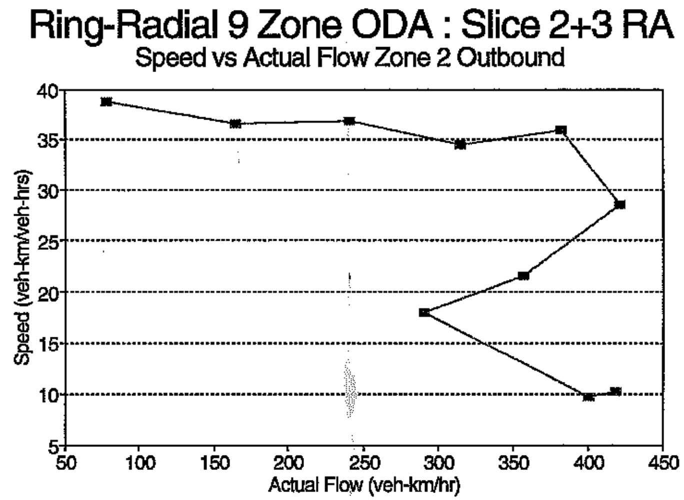

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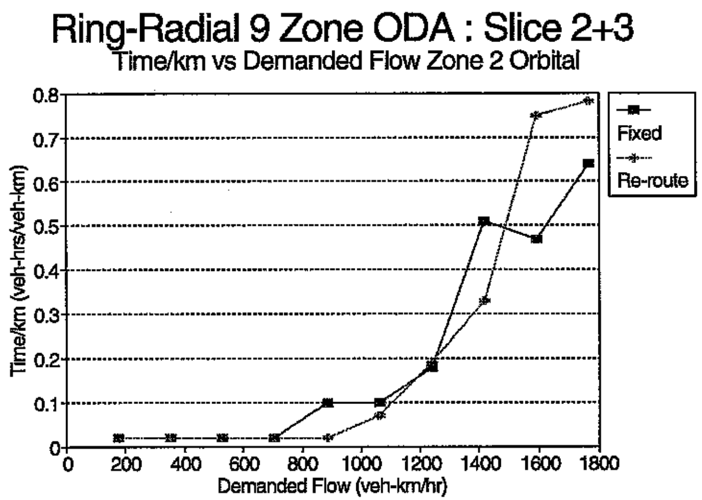

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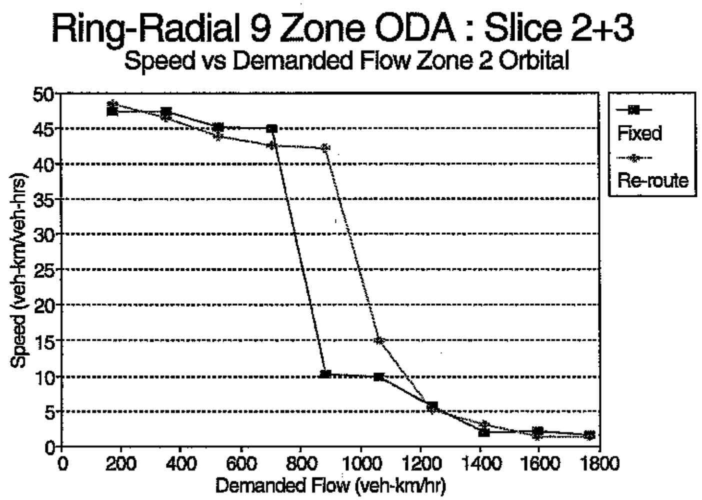

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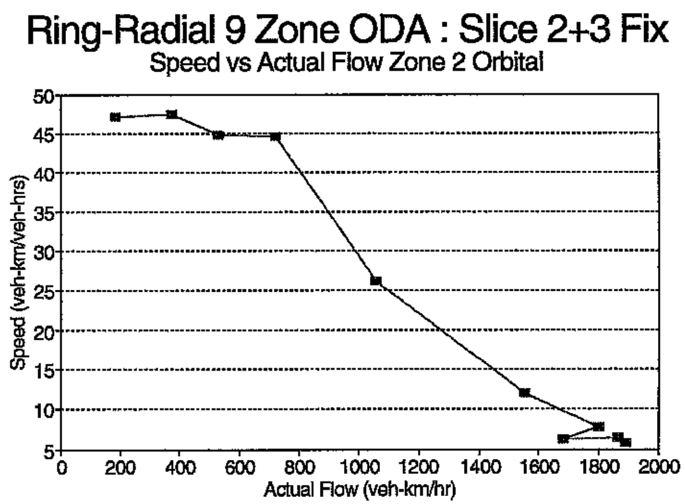

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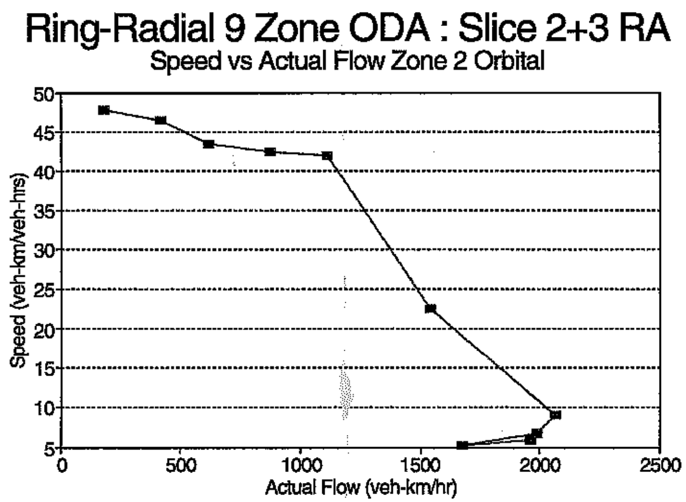

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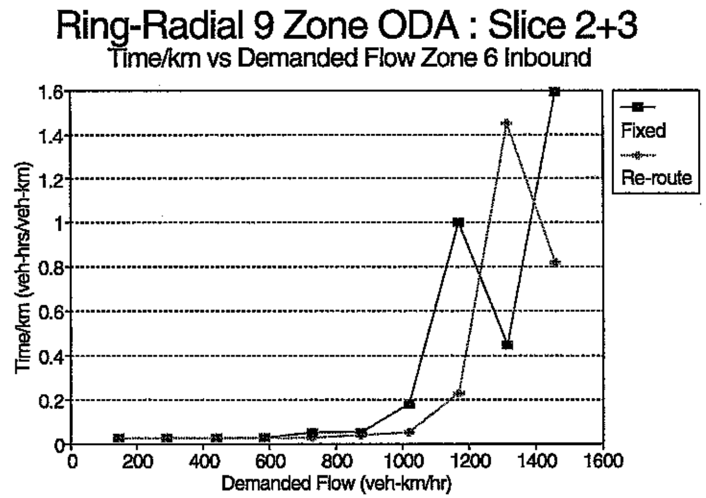

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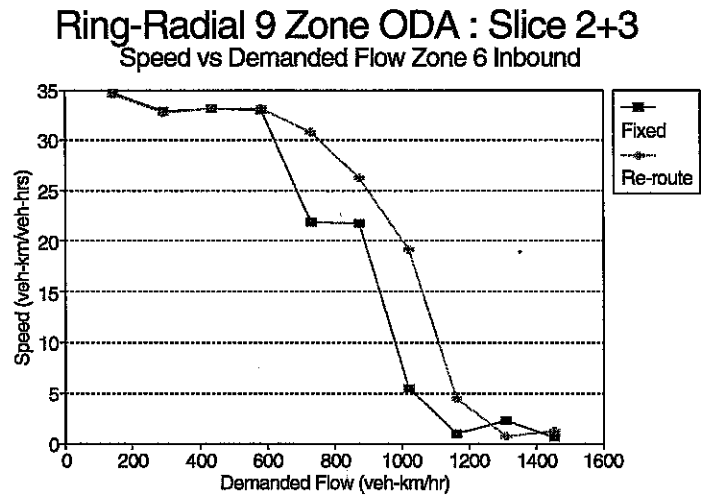

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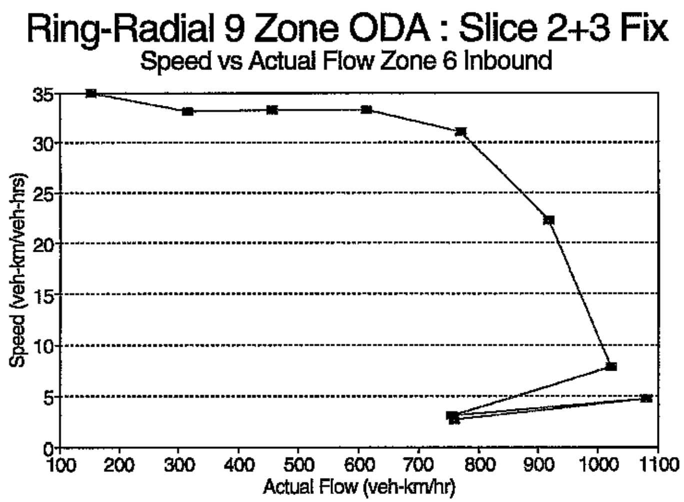

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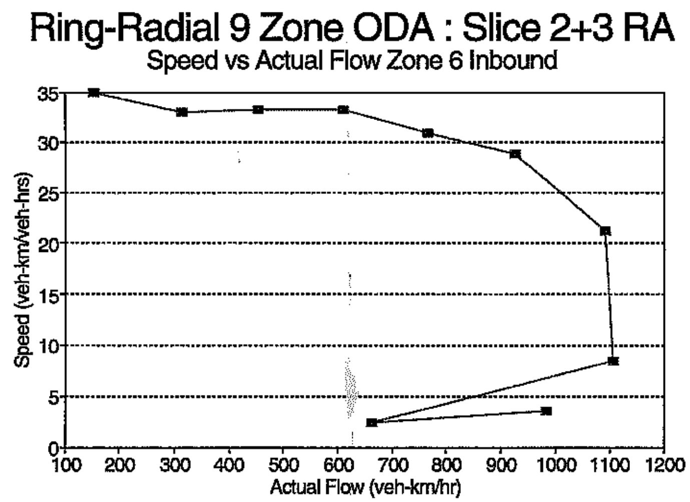

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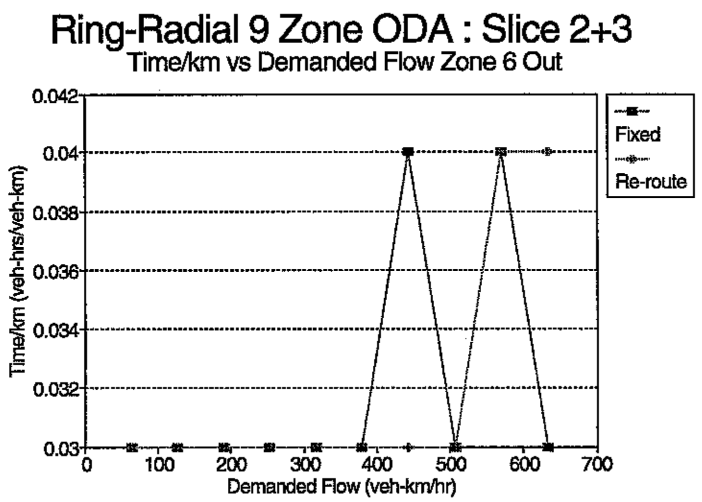

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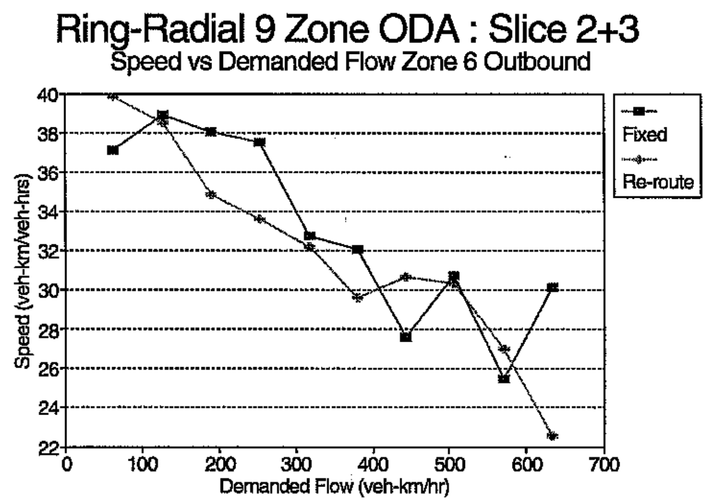

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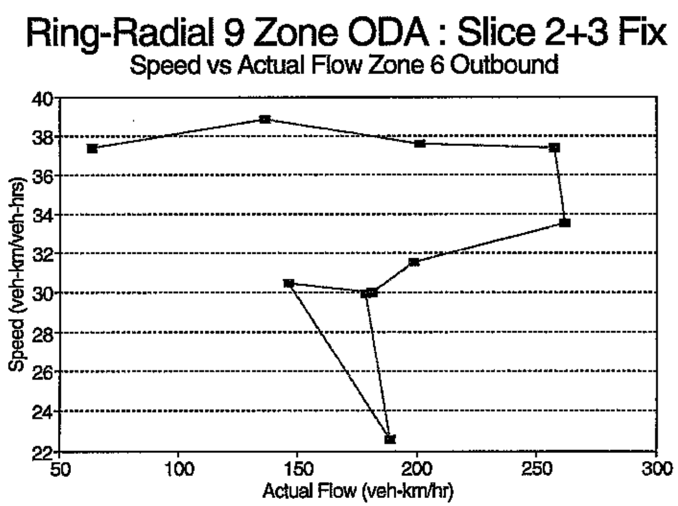

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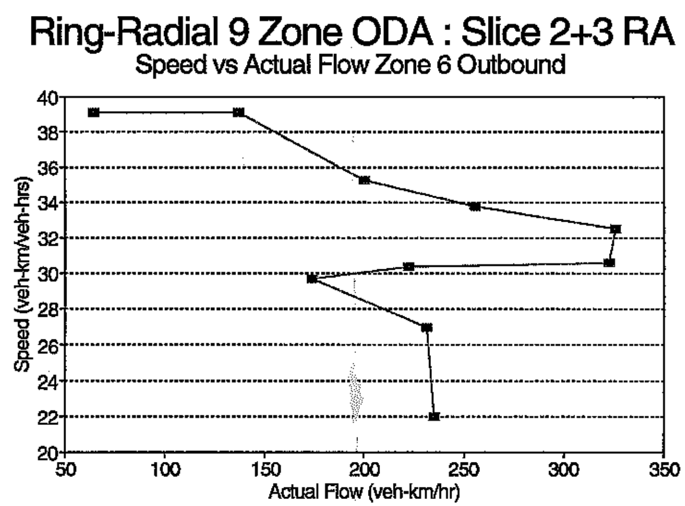

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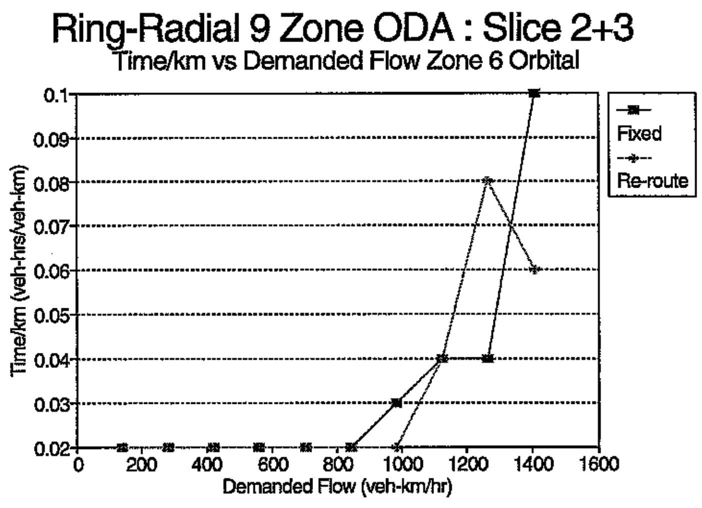

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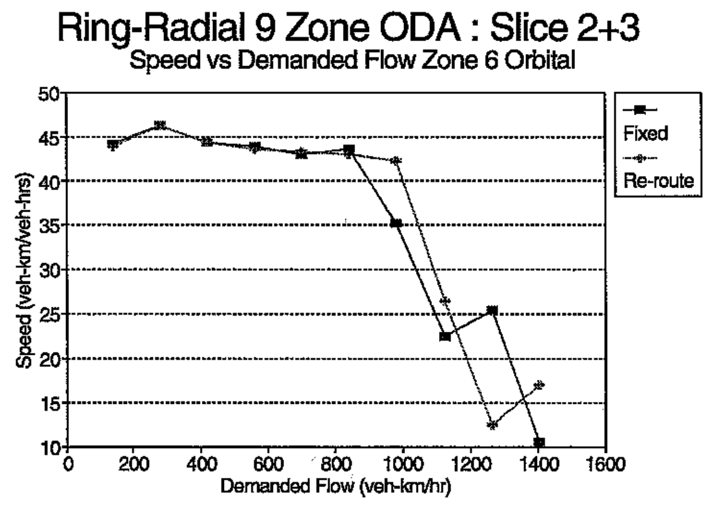

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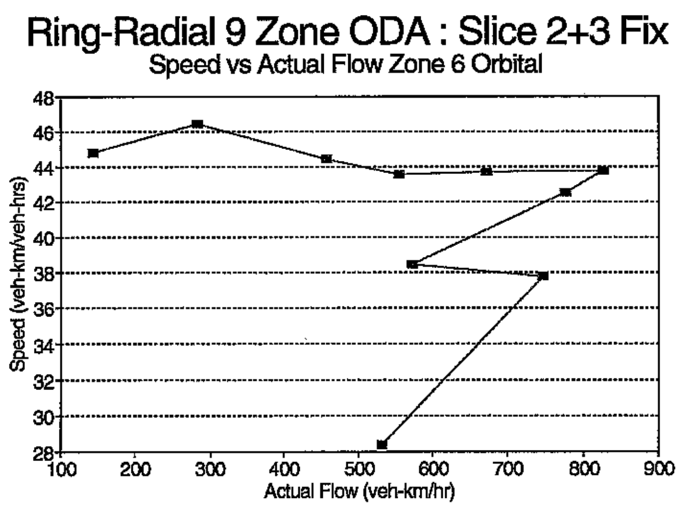

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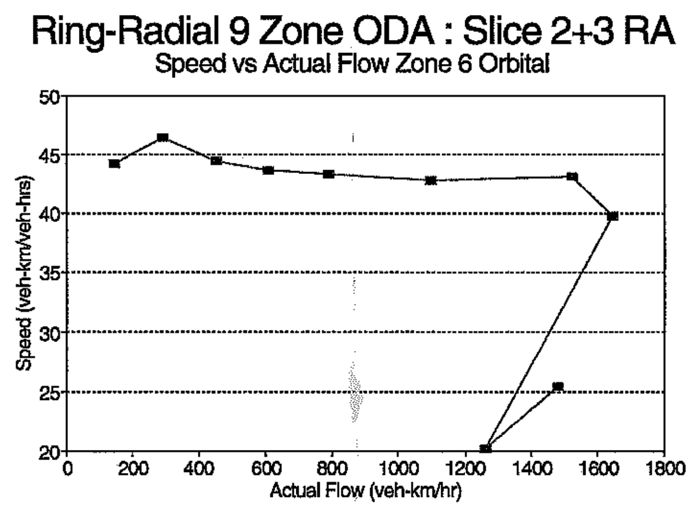

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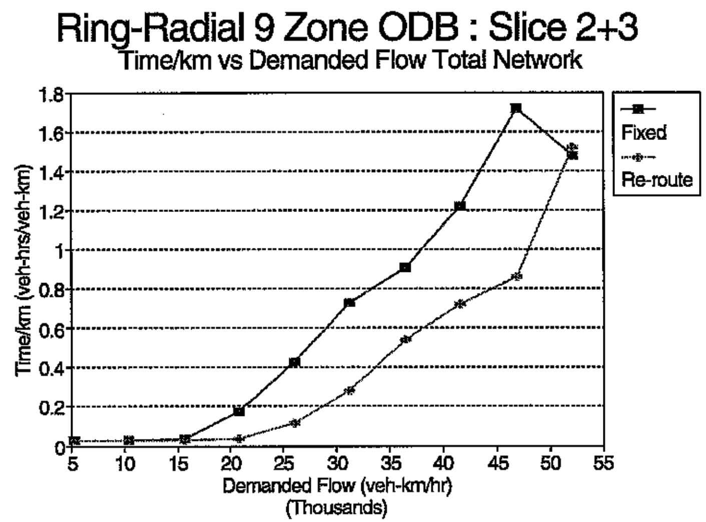

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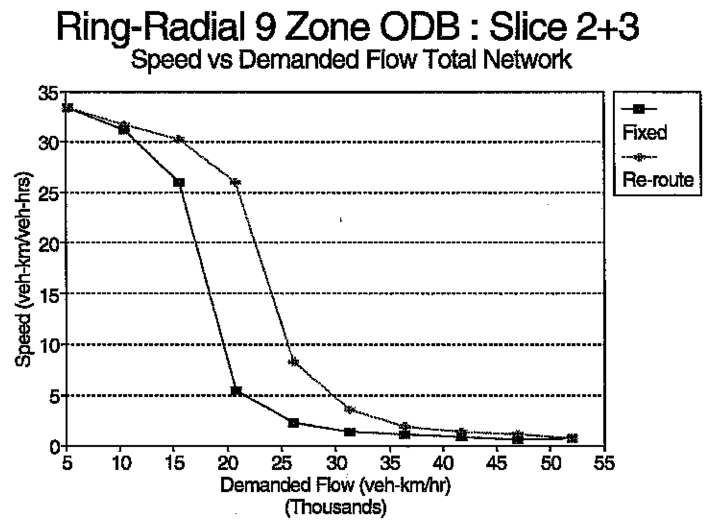

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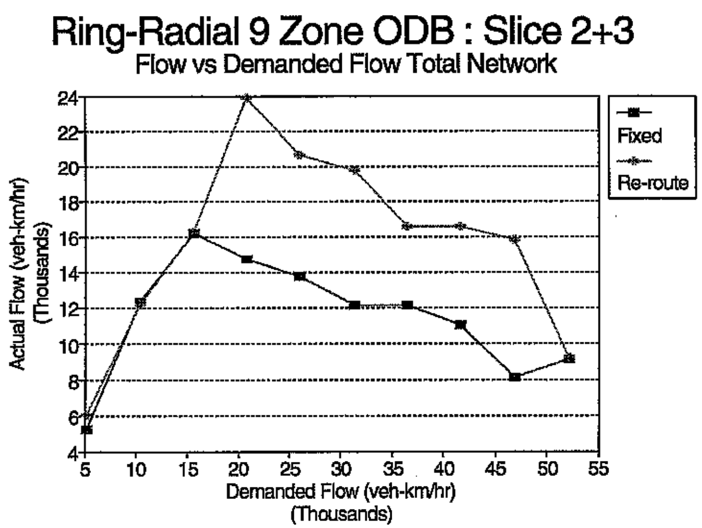

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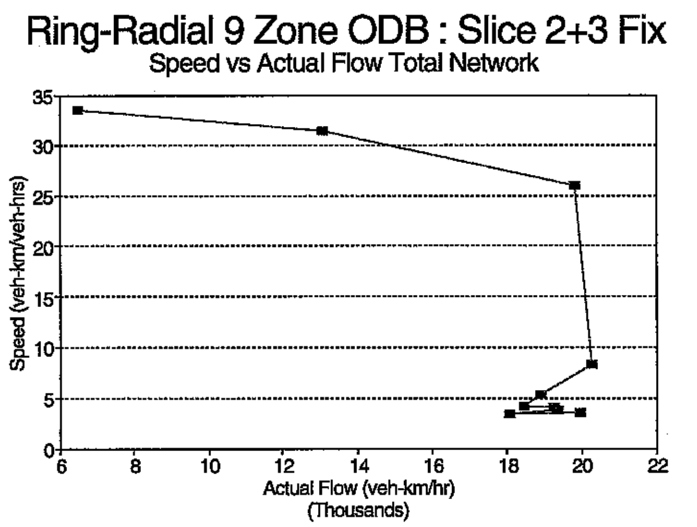
Ring-Radial 9 Zone ODB : Slice 2+3 Fix
Speed vs Actual Flow Total Network
Speed (veh-km/veh-hrs)
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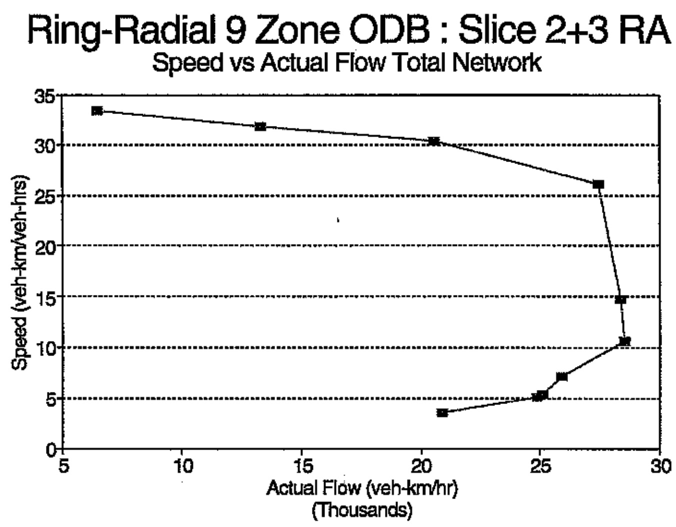
Actual Flow (veh-km/hr)
(Thousands)

Fig 42


Ring-Radial 9 Zone ODB : Slice 2+3 RA
Speed vs Actual Flow Total Network
Speed (veh-km/veh-hrs)
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Actual Flow (veh-km/hr)
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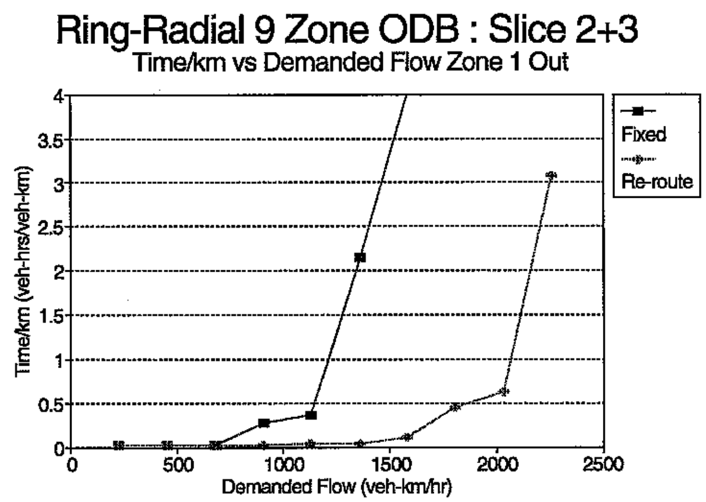
Fig 43



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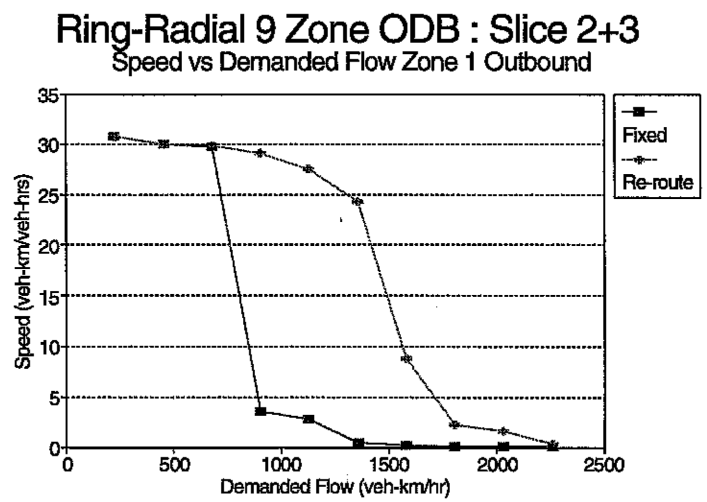

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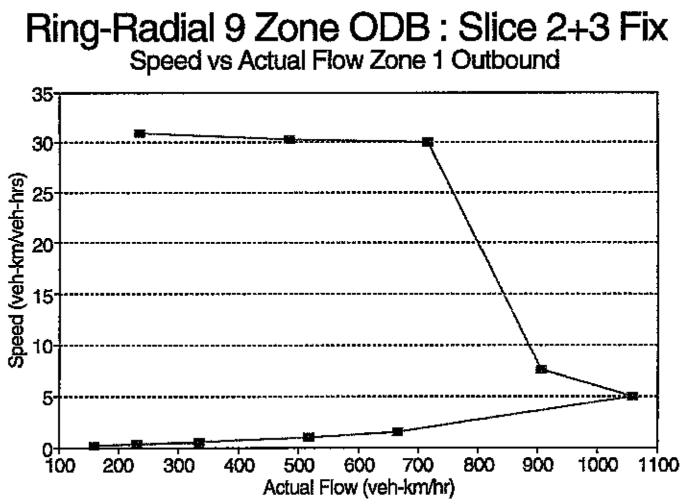


Fig 46

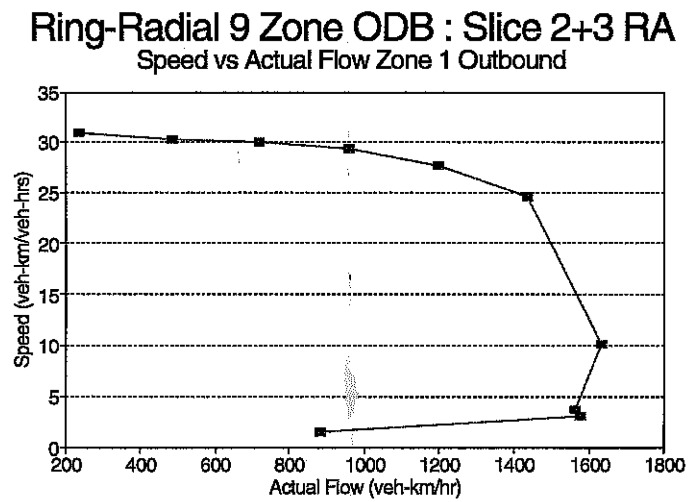


Fig 47

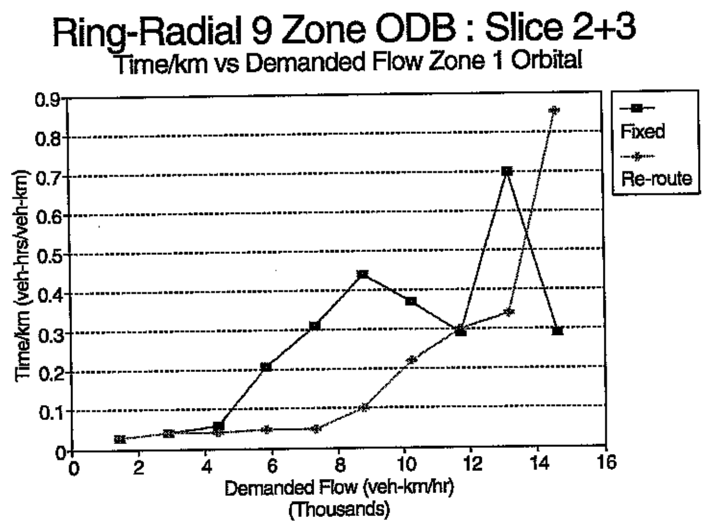


Fig 48

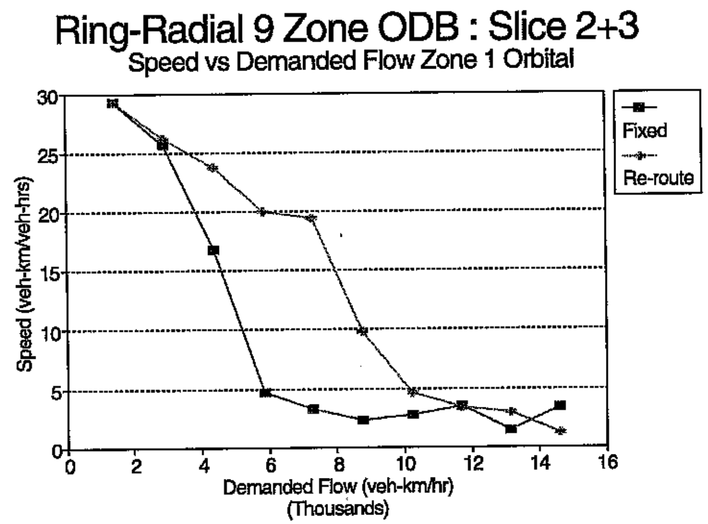


Fig 49

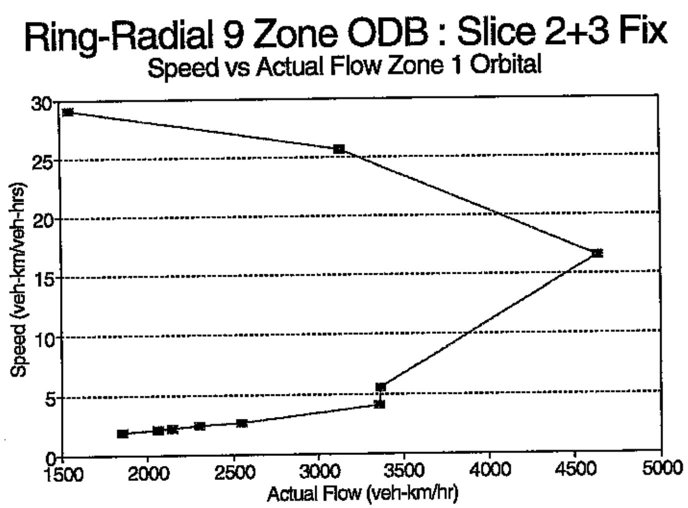


Fig 50

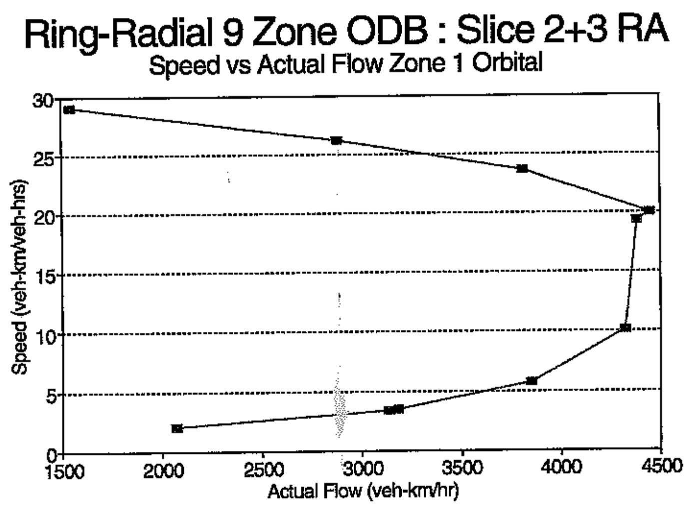


Fig 51

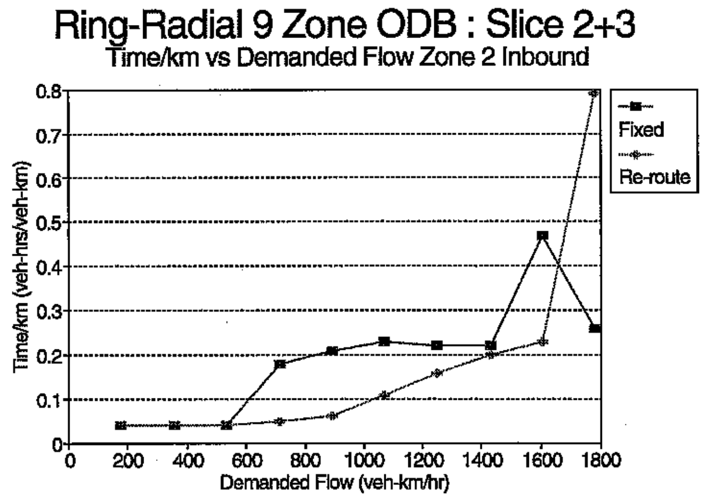
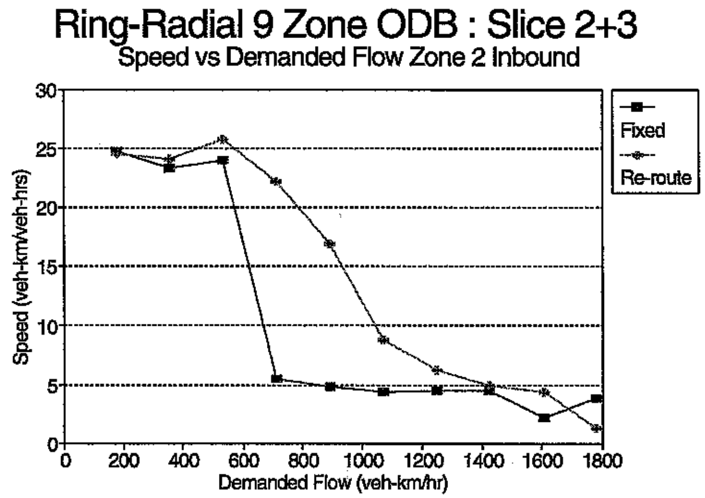


Fig 52



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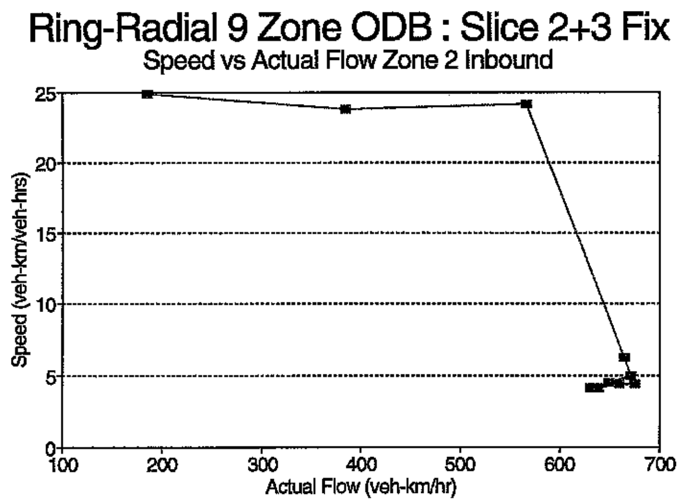

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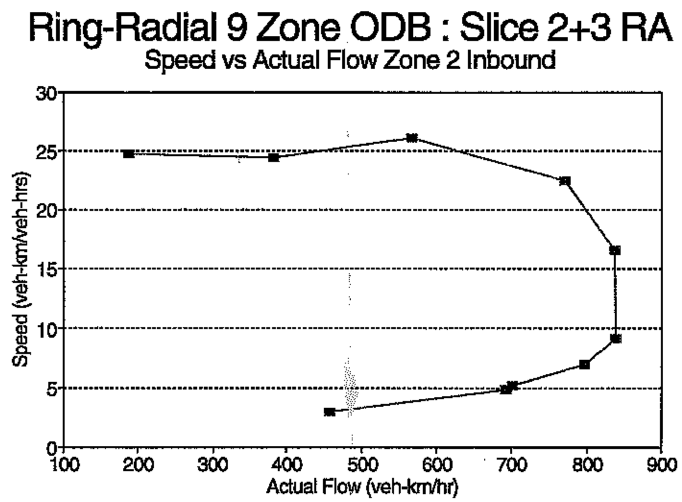


Fig 55

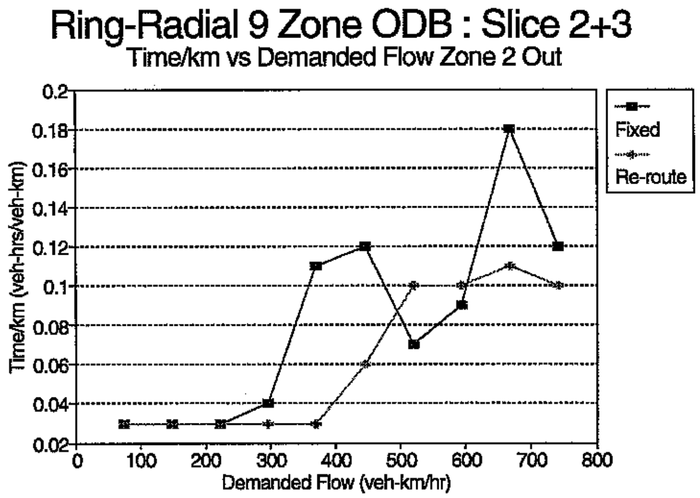


Fig 56

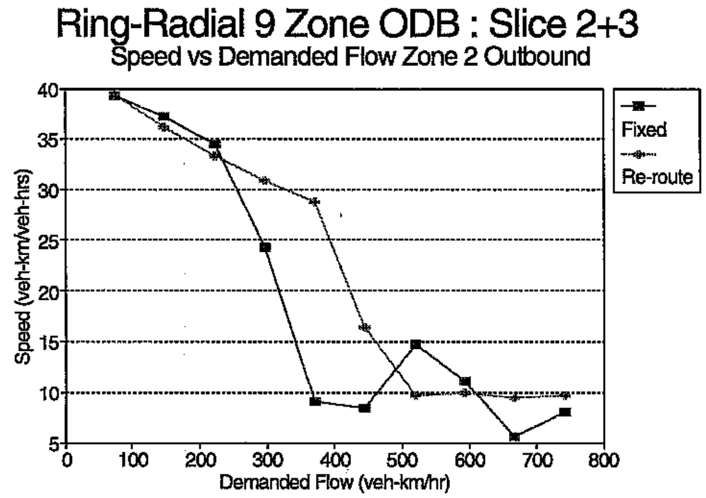
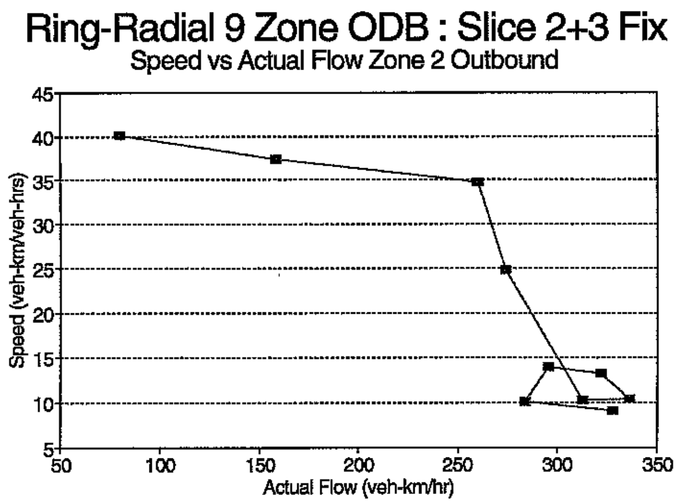


Fig 57



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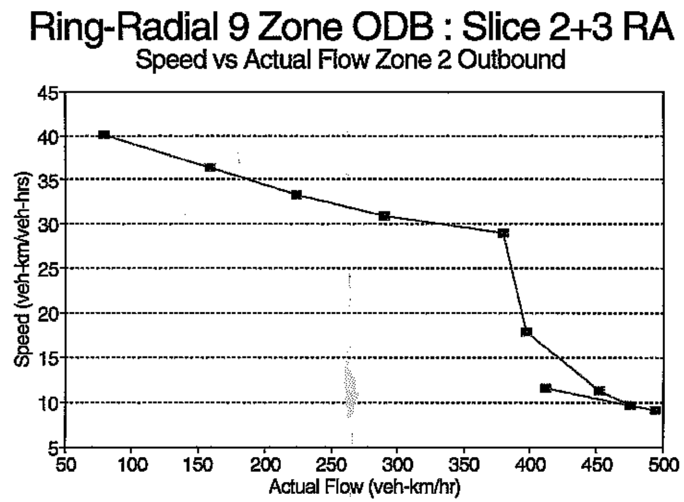


Fig 59

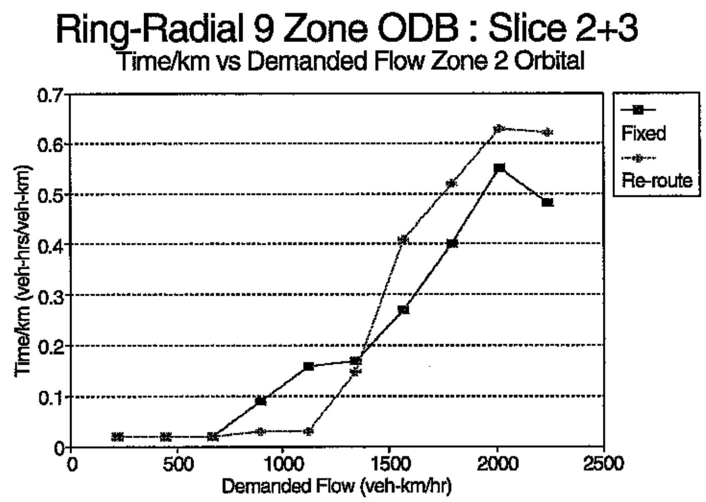


Fig 60

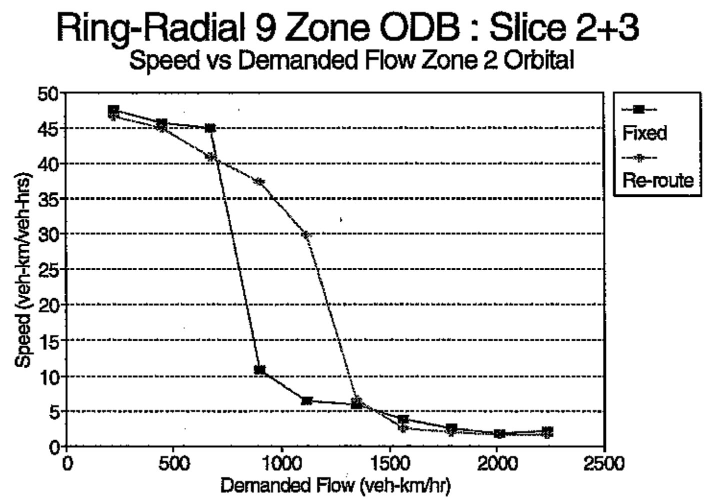


Fig 61

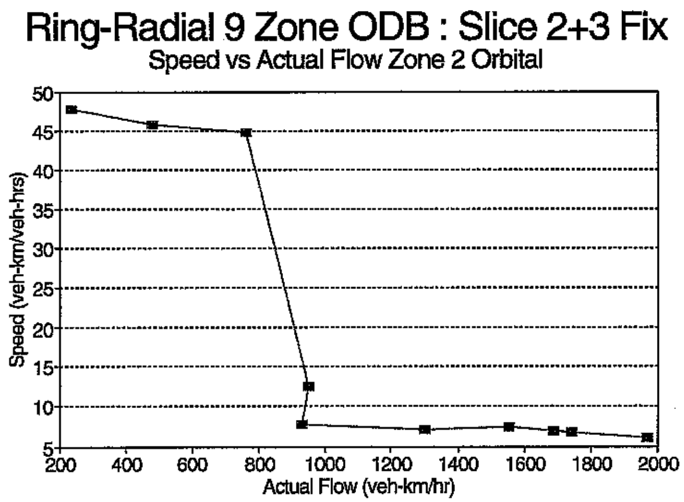


Fig 62

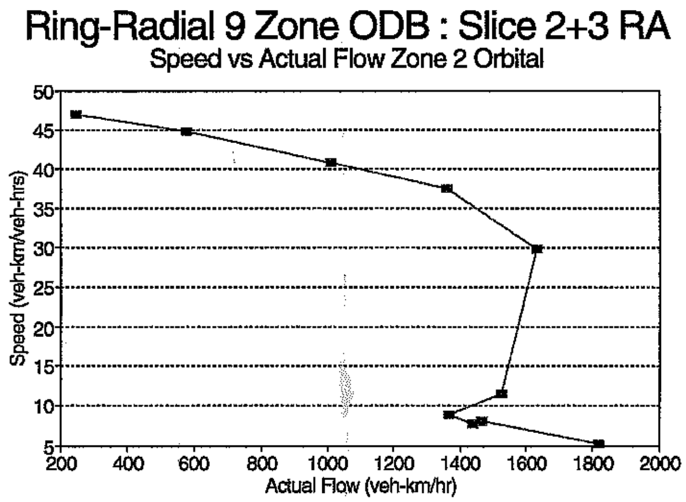


Fig 63

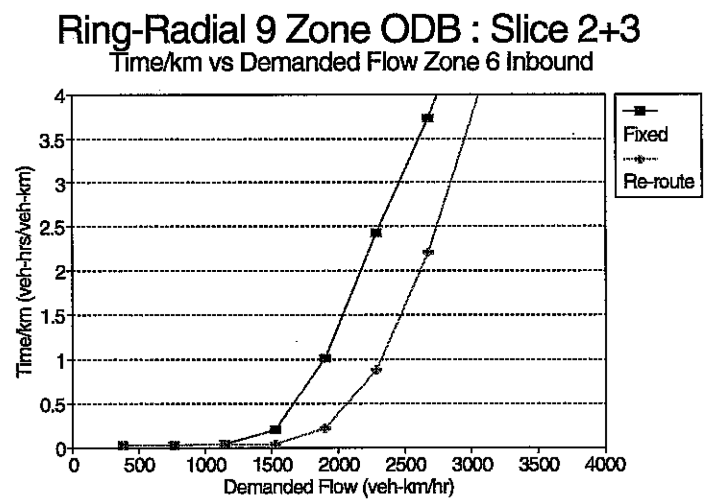


Fig 64

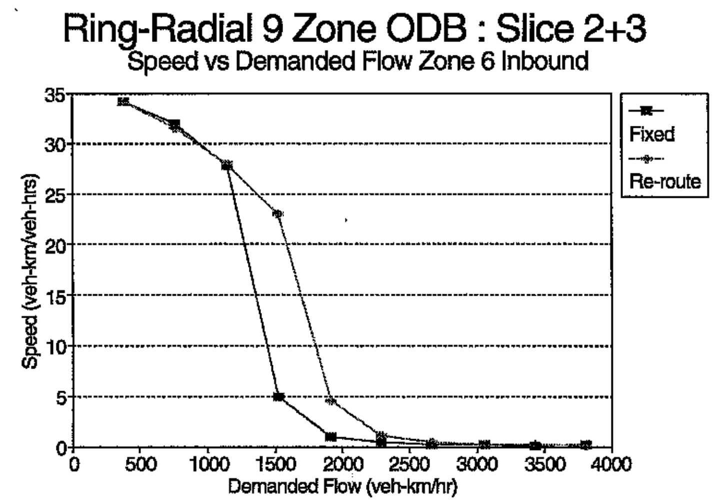


Fig 65

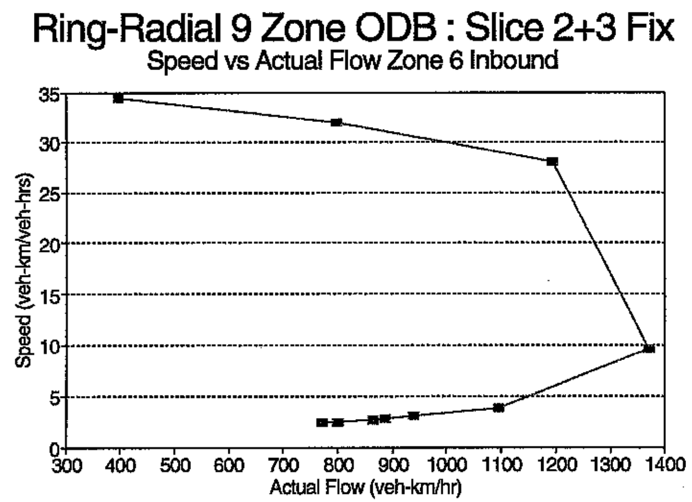


Fig 66

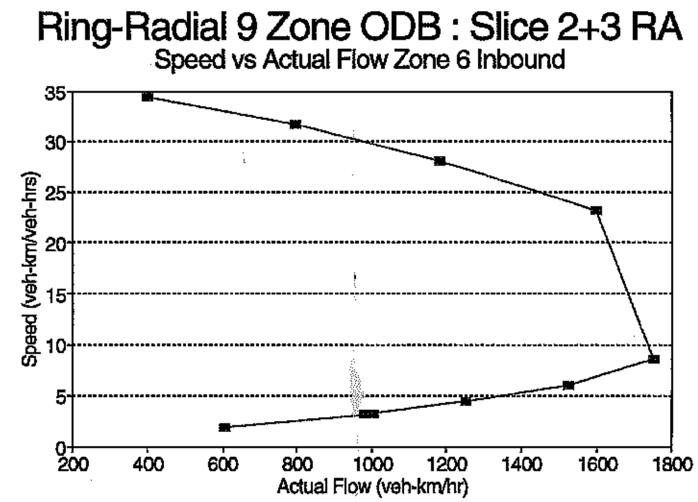
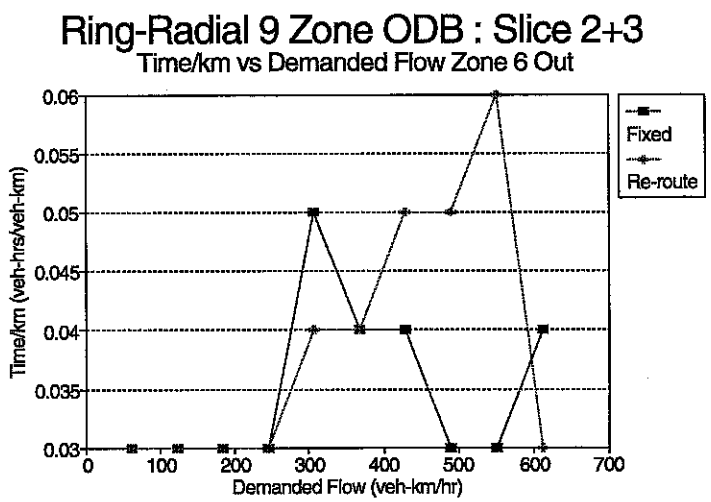


Fig 67



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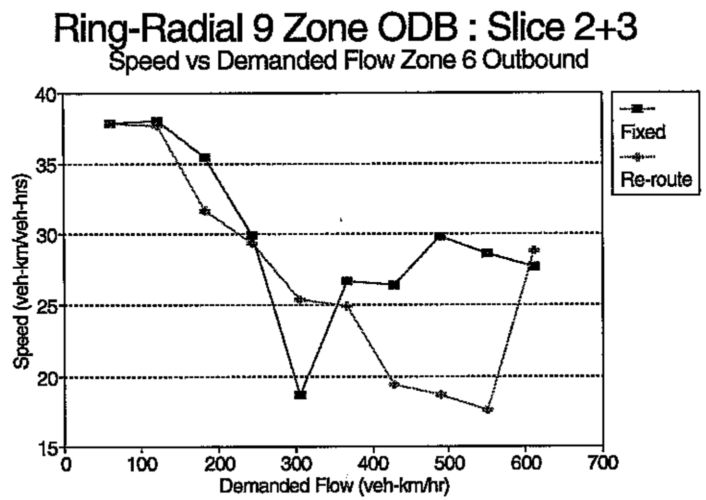

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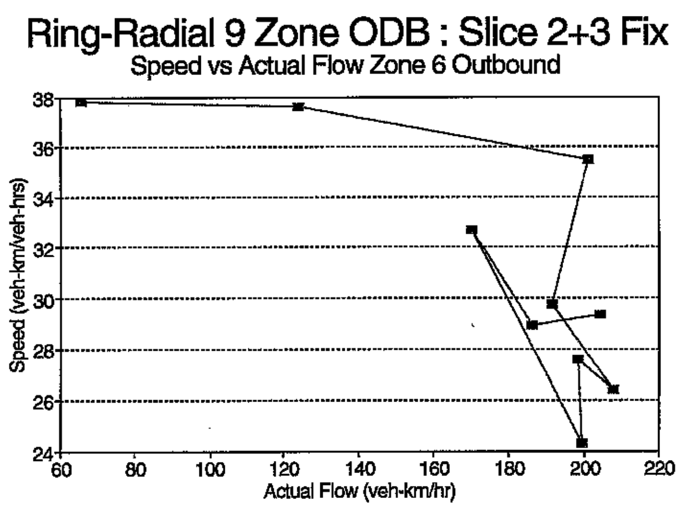
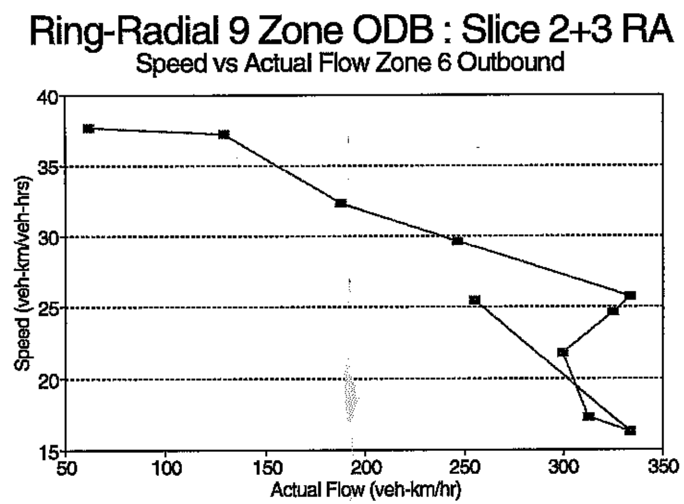


Fig 70



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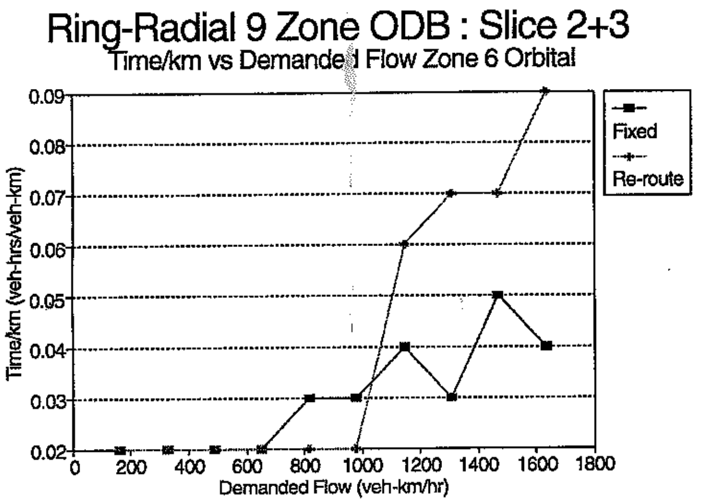

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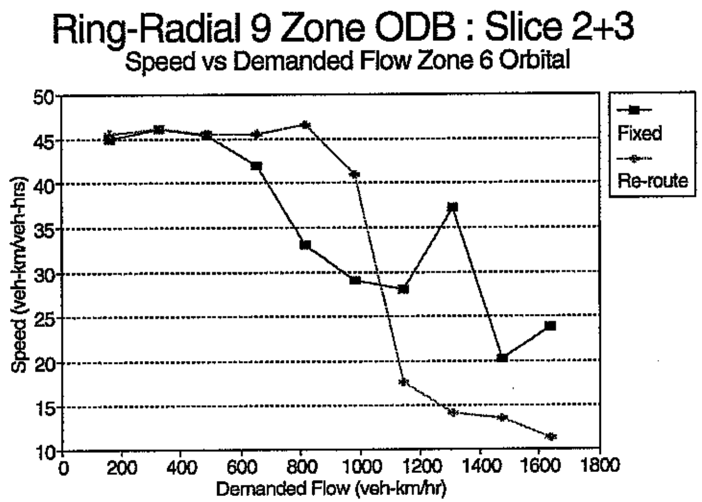

Fig 73

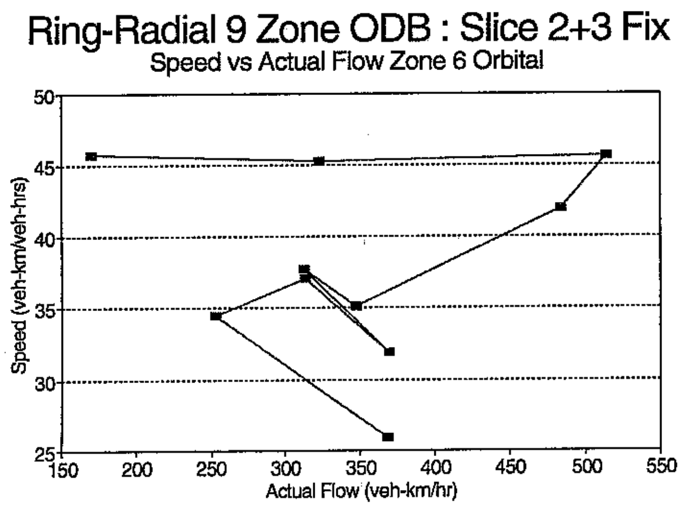

Fig 74