Rural Highway Overtaking Lanes

Kah Wai Ng
School of Civil and Resource Engineering, University of Western Australia
Song Wang
School of Mathematics and Statistics, University of Western Australia
Doina Olaru
Business School, University of Western Australia
Bob Peters, Steven Phillips
Main Roads Western Australia

Abstract

The TRAffic on Rural Roads (TRARR) program is a micro simulation model of traffic flow on two-lane roads originally developed by the Australian Road Research Board (ARRB) for the investigation of overtaking lane projects. Its latest version, the TRARR06 (T06) user interface was introduced to Main Roads Western Australia (MRWA) in 2006. Seeing this as an opportunity to encourage staff of MRWA to harness technology in the workplace, MRWA decided to have a collaborative project with UWA and CEED. This paper provides a methodology to integrate existing MRWA applications such as IRIS and SIGHT into T06 to identify overtaking lanes. The outputs from T06 could also assist users to select overtaking lanes projects from a benefit cost perspective.

1 Introduction

Most rural highways and main roads in Western Australia (WA) have two traffic lanes – one in each direction. Where traffic volumes are low and overtaking opportunities are good, the two lanes provide an adequate level of safety and service for all road users. However, there are roads where this is not the case. Here, users have unacceptable delays in queues formed behind a leading slower moving vehicle, or take unacceptable safety risks in overtaking the slower moving vehicles. To overcome these matters Main Roads WA (MRWA) can duplicate the road to make a dual carriageway with two lanes in each direction. This is an ideal solution, but quite obviously very costly. MRWA has instead used a policy of providing overtaking lanes at locations where the need is greatest. This usually means widening the road to three lanes – two in one direction and one in the other, for a sufficient length to allow vehicles to safely overtake.

Hence, there is a need for a detailed analysis of the existing overtaking lanes in WA with the view to establishing a simple, yet robust model for identifying sites for additional overtaking lanes. One such analysis is the use of the TRARR simulation model. The project expected to recommendations on how to choose sites from the TRARR simulation which can be justified from a benefit cost perspective.

1.1 Project Objectives

- To produce a step by step guideline on how to incorporate geometrical data and traffic data from the existing MRWA's applications such as IRIS and SIGHT into the T06 user interface to identify overtaking lanes.

- To produce Benefit Cost Analysis from the T06 output to justify the construction of proposed overtaking lanes.

2 Background

2.1 TRARR06 (T06) micro simulation model

T06 is primarily used for the investigation of overtaking lane projects. Besides this, it has also been used to develop speed-flow relations for use in broader road project evaluation models, and for the assessment of route suitability for medium or large combination vehicles.

The model can be used to simulate traffic operations on a real road in some detail, and to investigate the effects of changes in road and traffic characteristics. By changing the road geometry, the benefits of alternative improvement options can be compared. By changing the traffic characteristics, the user can investigate the effects of increased volumes, more heavy trucks, or long term changes in vehicles size and power. Observed traffic characteristics include speed, travel time, bunching, time spent following, overtaking rate and fuel consumption.

2.2 Integrated Road Information System (IRIS)

IRIS contains details of all state and local roads, etc. Information about road length and intersecting roads are stored and IRIS maintains connectivity between roads, thereby providing a representation of the actual road network in WA. Spatial data is also stored for state and local roads, allowing them to be shown on a map.

IRIS also includes:

- Inventory Data relating to what the road is made from and other associated items such as signs, parking bays, etc.
- Crashes Details of all crashes reported to the police in WA (going back to 1985).
- Structures All bridges (and other structures) for which Main Roads is responsible.
- Traffic General traffic counts and counts of different vehicle types (current data is not yet available).

2.3 SIGHT

SIGHT is an Excel Macro application that uses the road geometrical data to calculate where overtaking is allowable and where is not. For this project, Mr David Kennedy has rewritten the macro in the application so that the user could obtain the sight distance from a particular point.

For this new application, it is renamed as SIGHT SPECIFIC. Users are required to create a Specific True Distance (TrueD) File before commencing the use of SIGHT SPECIFIC.

3 Method in using T06

The first step in using T06 is to create a file for the simulation. The parameters for the road profile and the traffic characteristic are then input.

3.1 Input parameters for Road Profile

- **Existence of Barrier lines**
  This is the type of marking at the centre of the road that split the road into 2 directions where continuous lines indicates an existence of a barrier line

- **Existence of Overtaking Lanes**
  This is where there is an additional lane along the road to allow a faster vehicle to overtake a slower vehicle travelling in the same direction.

- **Road Speed Indices**
  In the simulation, each driver is assumed to have a Basic Desired Speed at which he will travel when unconstraint by other vehicles or by road characteristics. A lower desired speed may then be adopted on a particular road segment due to horizontal curve, narrow pavement, speed limits and other road characteristic. These effects are represented by the Road Speed Index.

- **Sight Distance**
  Sight distance (in general) is defined as the length of roadway visible to the driver.

- **Gradient**
  Gradient or grade is the rate of longitudinal rise (or fall) of a carriageway with respect to the horizontal, express as a percentage (%). For example, Figure 1 has a 10% gradient.

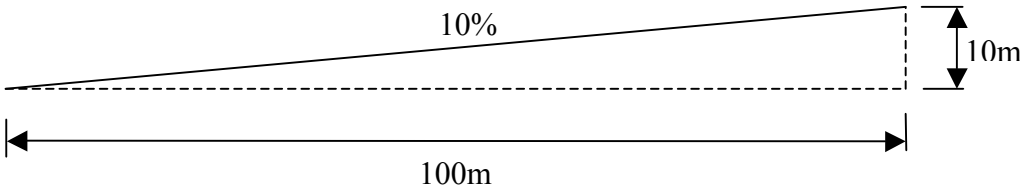


Figure 1: Example of a 10% slope

- **Curve Radius**
  Horizontal Curve is a curve in the plan view of a carriageway with respect to the radii of the horizontal curve. For example, Figure 2 is a 100m circular curve.

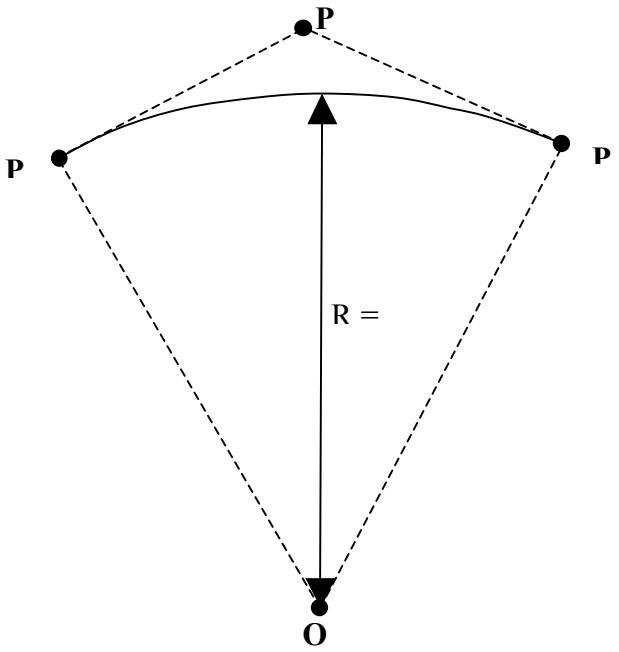


Figure 2: Example of a 100m circular curve

- **Speed limit**
  Speed limit is the maximum speed allowed under the provisions of the State Traffic Act and Regulations.

3.2 Input parameters for Traffic Characteristic (for the 2 directions)

- **Traffic Flow**
  This is the number of vehicles passing through the stretch of simulated road within the particular time.

- **Percentage following**
  This is the average percentage of travel time that vehicles must travel behind slower vehicles due to the lack of passing opportunities because of geometry and/or opposing traffic.

- **Percentage of heavy vehicles**
  This is the percentage of heavy vehicles in the traffic flow.

- **Settling down time**
  The settling down time is required to allow the simulated road to be fully loaded with traffic before any observations are taken.

- **Simulation time**
  For a given traffic volume, the simulation time determines the size of the sample of vehicles that are observed. The simulation continues until all vehicles generated during the specified simulation time have left the road.

- **Random seed number**
  This is a random traffic generation seed number, which can be any integer between 0 and 999999.

Figure 3 shows the summary procedure for carrying out the simulation. Once all the parameters are input into T06, the roads are simulated and the results presented in figures 4-7 below are obtained.

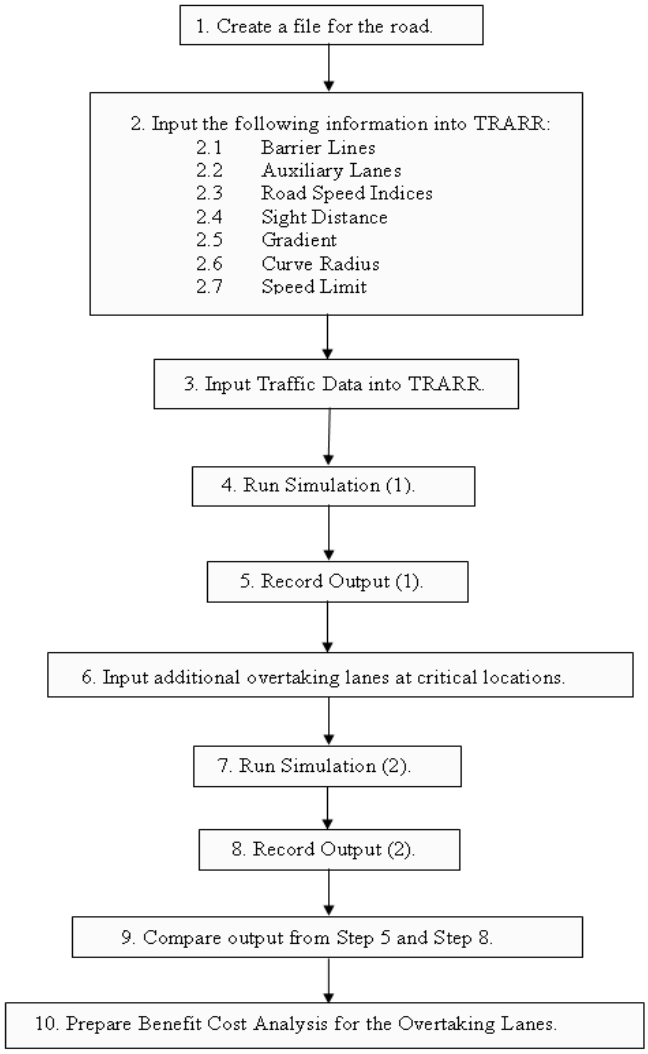


Figure 3 Summarized Procedure on Identifying Overtaking Lanes using T06

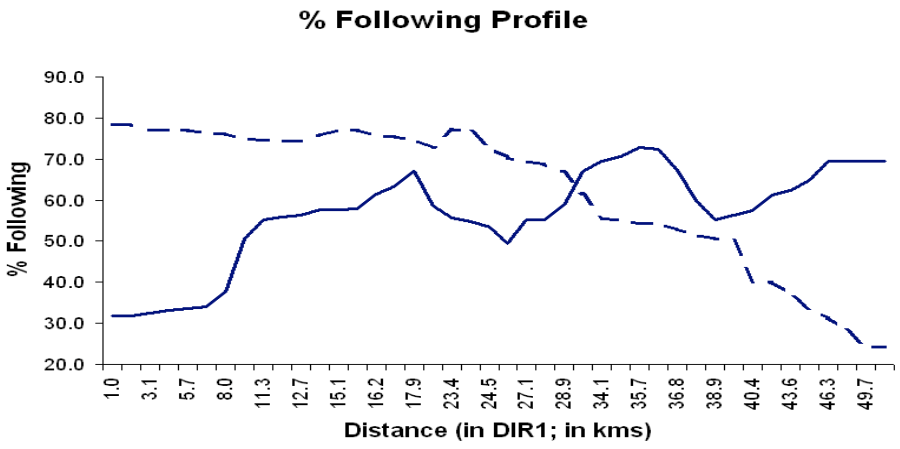


Figure 4 Plot of % Following vs Distance

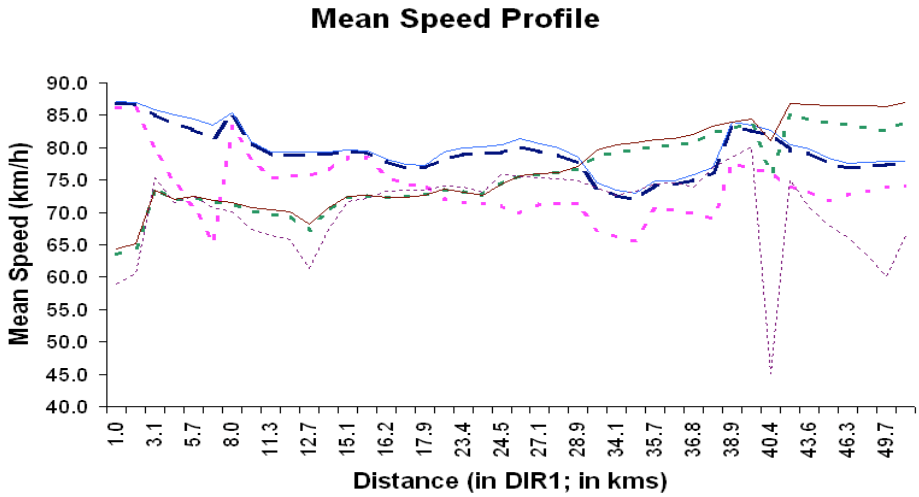


Figure 5 Plot of Mean Speed vs Distance

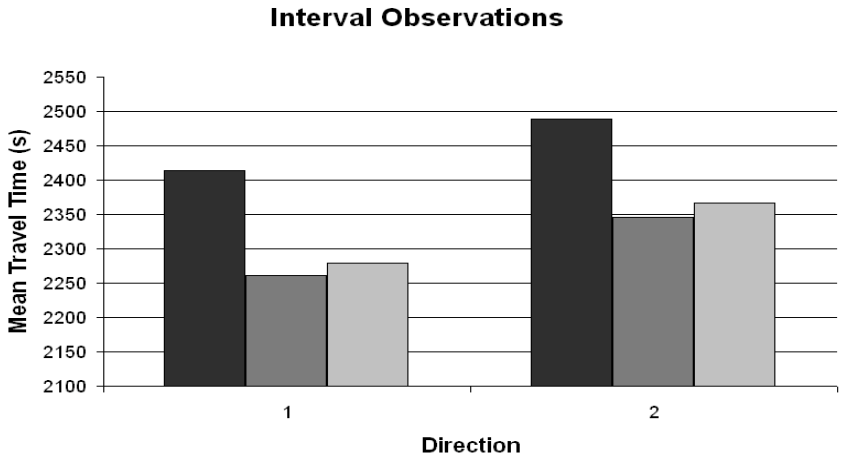
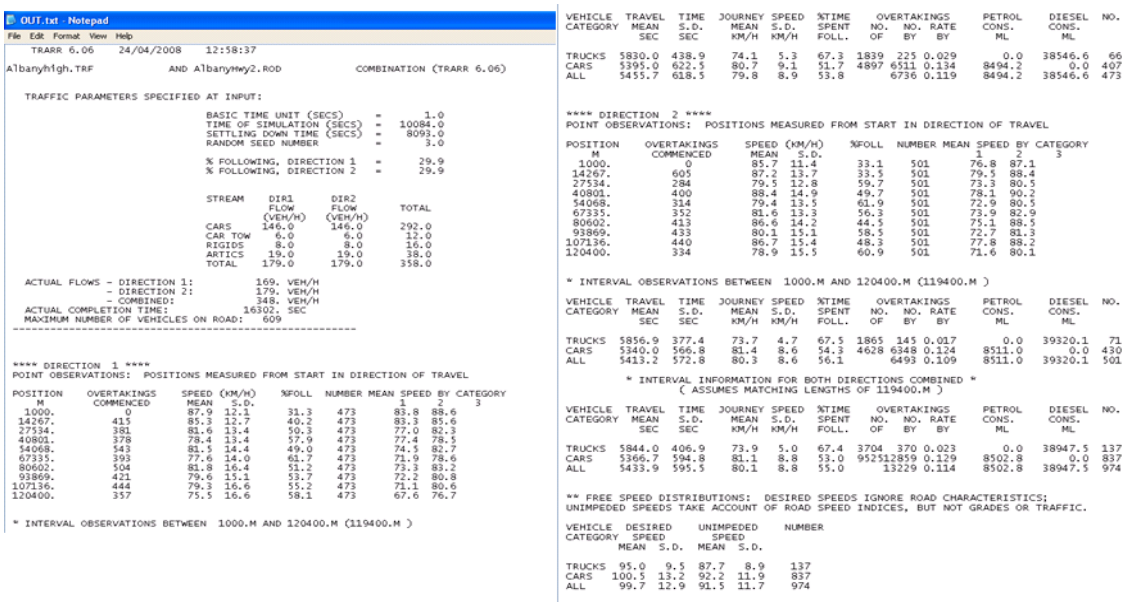


Figure 6 Plot of Mean Travel Time by Direction



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AlbanyHigh.TRF AND AlbanyHwy2.ROD COMBINATION (TRARR 6.06)

TRAFFIC PARAMETERS SPECIFIED AT INPUT:

BASIC TIME UNIT (SECS)	= 1.0
TIME OF SIMULATION (SECS)	= 10084.0
SETTLING DOWN TIME (SECS)	= 8093.0
RANDOM SEED NUMBER	= 3.0
% FOLLOWING, DIRECTION 1	= 29.9
% FOLLOWING, DIRECTION 2	= 29.9

STREAM	DIR1 FLOW (VEH/H)	DIR2 FLOW (VEH/H)	TOTAL
CARS	146.0	146.0	292.0
CAR TOW	6.0	6.0	12.0
RIGIDS	8.0	8.0	16.0
ARTICS	19.0	19.0	38.0
TOTAL	179.0	179.0	358.0

ACTUAL FLOWS - DIRECTION 1: 169. VEH/H
- DIRECTION 2: 179. VEH/H
- COMBINED: 348. VEH/H
ACTUAL COMPLETION TIME: 16302. SEC
MAXIMUM NUMBER OF VEHICLES ON ROAD: 609

**** DIRECTION 1 ****
POINT OBSERVATIONS: POSITIONS MEASURED FROM START IN DIRECTION OF TRAVEL

POSITION M	OVERTAKINGS COMMENCED	SPEED (KM/H) MEAN	S.D.	%FOLL	NUMBER MEAN SPEED BY CATEGORY 1	2	3
1009.	0	87.9	12.1	31.3	473	83.8	88.6
14267.	415	85.3	12.7	40.2	473	83.3	85.6
27534.	381	81.6	13.4	50.3	473	77.0	82.3
40801.	378	78.4	13.4	57.9	473	72.4	78.5
54068.	543	81.5	14.4	49.0	473	74.5	82.7
67335.	393	77.6	14.0	61.7	473	71.9	78.6
80602.	504	81.8	16.4	51.2	473	73.3	83.2
93869.	421	79.6	15.1	53.7	473	72.2	80.8
107136.	444	79.3	16.6	55.2	473	71.1	80.6
120400.	357	75.5	16.6	58.1	473	67.6	76.7

* INTERVAL OBSERVATIONS BETWEEN 1000.M AND 120400.M (119400.M)

VEHICLE CATEGORY	TRAVEL MEAN SEC	TIME S.D. SEC	JOURNEY SPEED MEAN KM/H	S.D. KM/H	%TIME SPENT FOLL.	OVERTAKINGS NO. OF	NO. BY	RATE BY	PETROL CONS. ML	DIESEL CONS. ML	NO.
TRUCKS	5830.0	438.9	74.1	5.3	67.3	1839	225	0.029	0.0	38546.6	66
CARS	5395.0	622.5	80.7	9.1	51.7	4897	6511	0.134	8494.2	0.0	407
ALL	5455.7	618.5	79.8	8.9	53.8		6736	0.119	8494.2	38546.6	473

**** DIRECTION 2 ****
POINT OBSERVATIONS: POSITIONS MEASURED FROM START IN DIRECTION OF TRAVEL

POSITION M	OVERTAKINGS COMMENCED	SPEED (KM/H) MEAN	S.D.	%FOLL	NUMBER MEAN SPEED BY CATEGORY 1	2	3
1000.	0	85.7	11.4	33.1	501	76.8	87.1
14267.	605	87.2	13.7	33.5	501	79.5	88.4
27534.	284	79.5	12.8	59.7	501	73.3	80.5
40801.	400	88.4	14.9	49.7	501	78.1	90.2
54068.	314	79.4	13.5	61.9	501	72.9	80.5
67335.	352	81.6	13.3	56.3	501	73.9	82.9
80602.	413	86.6	14.2	44.5	501	75.1	88.5
93869.	433	80.1	15.1	58.5	501	72.7	81.3
107136.	440	86.7	15.4	48.3	501	77.8	88.2
120400.	334	78.9	15.5	60.9	501	71.6	80.1

* INTERVAL OBSERVATIONS BETWEEN 1000.M AND 120400.M (119400.M)

VEHICLE CATEGORY	TRAVEL MEAN SEC	TIME S.D. SEC	JOURNEY SPEED MEAN KM/H	S.D. KM/H	%TIME SPENT FOLL.	OVERTAKINGS NO. OF	NO. BY	RATE BY	PETROL CONS. ML	DIESEL CONS. ML	NO.
TRUCKS	5856.9	377.4	73.7	4.7	67.5	1865	145	0.017	0.0	39320.1	71
CARS	5340.0	566.8	81.4	8.6	54.3	4628	6348	0.124	8511.0	0.0	430
ALL	5413.2	572.8	80.3	8.6	56.1		6493	0.109	8511.0	39320.1	501

* INTERVAL INFORMATION FOR BOTH DIRECTIONS COMBINED *
(ASSUMES MATCHING LENGTHS OF 119400.M)

VEHICLE CATEGORY	TRAVEL MEAN SEC	TIME S.D. SEC	JOURNEY SPEED MEAN KM/H	S.D. KM/H	%TIME SPENT FOLL.	OVERTAKINGS NO. OF	NO. BY	RATE BY	PETROL CONS. ML	DIESEL CONS. ML	NO.
TRUCKS	5844.0	406.9	73.9	5.0	67.4	3704	370	0.023	0.0	38947.5	137
CARS	5366.7	594.8	81.1	8.8	53.0	952512859	0.129		8502.8	0.0	837
ALL	5433.9	595.5	80.1	8.8	55.0		13229	0.114	8502.8	38947.5	974

** FREE SPEED DISTRIBUTIONS: DESIRED SPEEDS IGNORE ROAD CHARACTERISTICS;
UNIMPEDED SPEEDS TAKE ACCOUNT OF ROAD SPEED INDICES, BUT NOT GRADES OR TRAFFIC.

VEHICLE CATEGORY	DESIRED SPEED MEAN	S.D.	UNIMPEDED SPEED MEAN	S.D.	NUMBER
TRUCKS	95.0	9.5	87.7	8.9	137
CARS	100.5	13.2	92.2	11.9	837
ALL	99.7	12.9	91.5	11.7	974

Figure 7 **Out file in text format summarizing all the above results including the fuel consumption for the simulated stretch of road**

4 Discussion

A stretch of Albany Highway [from Straight Line Kilometre (SLK) 50 to SLK 101] is first simulated without the overtaking lanes and later, with overtaking lanes. SLK is referred to a point of a stretch of road with reference to its starting point.

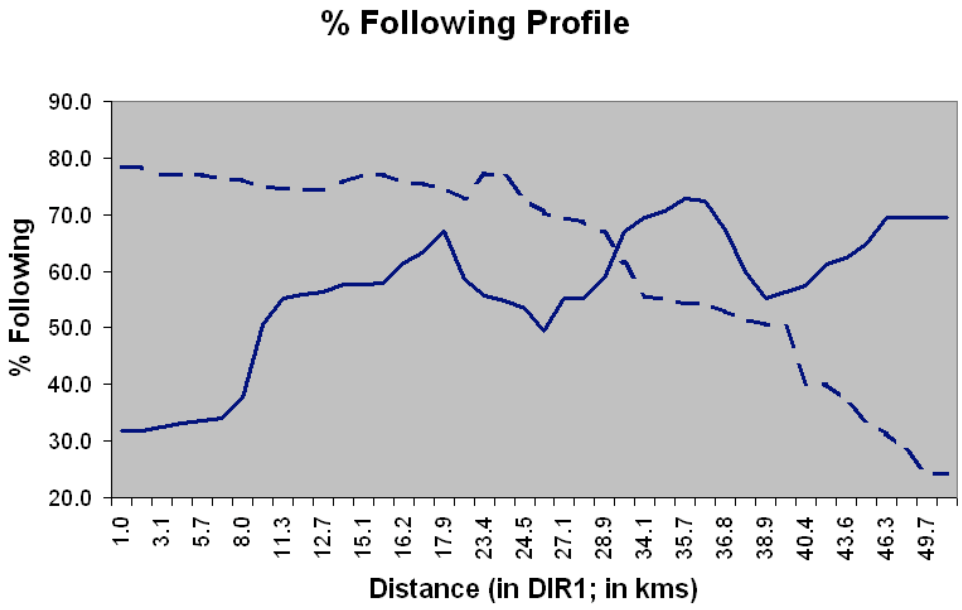

Figure 8 % Following vs Distance chart. (Without overtaking lanes) – Albany Highway

The continuous line indicates % following for Direction 1 (from Perth to Albany) and the dashed line indicates % following for Direction 2 (from Albany to Perth). For direction 2, we have to read from the right to the left because they are travelling in a decreasing SLK.

From traffic design viewpoint, we would like to achieve a Level of Service (LOS) C. This means that the % following would not be greater than 65%. Using figure 8, there would be a need to examine overtaking lanes at SLK 66.8 (50+16.8) to SLK 67.9 and SLK 80.0 to SLK 87.1 for Direction 1. Likewise, we would examine the need for overtaking lanes from SLK 78.9 to SLK 50 for Direction 2.

In fact, 11 overtaking lanes had been built at this stretch of Albany Highway (6 overtaking lanes for Direction 2 and 5 overtaking lanes for direction 1). The % following profile is shown in Figure 9.

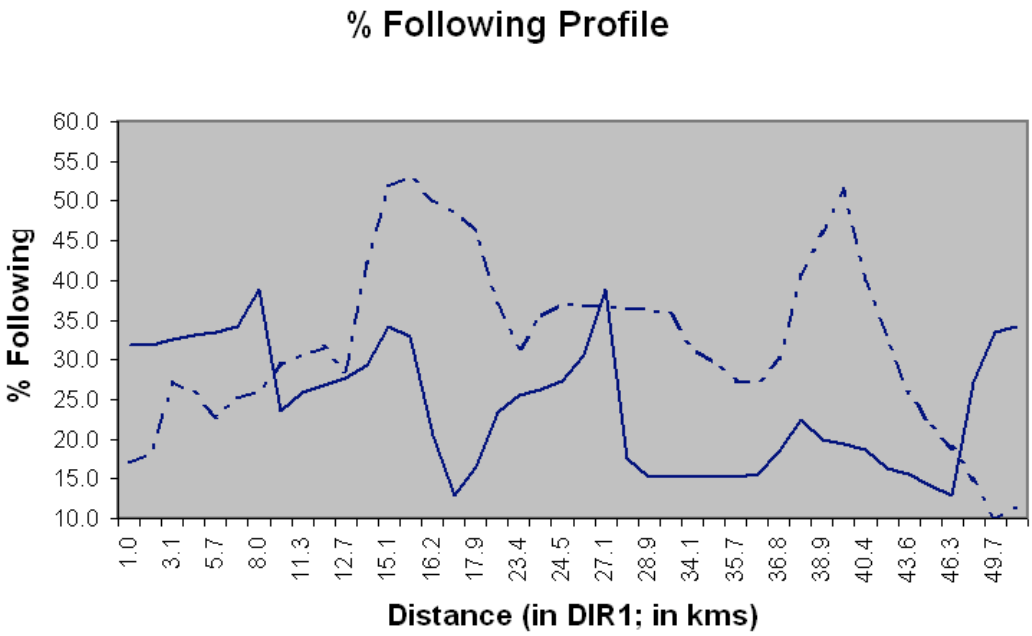

Figure 9 % Following vs Distance chart. (With overtaking lanes) – Albany Highway

Figure 9 shows clearly that this stretch of Albany Highway is kept within LOS C and hence, we could obtain the benefit of overtaking lanes by comparing its output with one that has no overtaking lanes.

In general, there are 4 main issues that are required for carrying out the benefit analysis of the overtaking lanes. They are the

- Reduction in Travel Time,
- Reduction in Crashes,
- Reduction in Fuel Consumption which relate to the
- Reduction in the Environmental Impact.

These benefits will be compared with the construction cost and the maintenance cost.

5 Conclusions and Future Work

It has been shown that by using T06 to determine overtaking lanes, users could obtain the result computationally, eliminating the need for costly site surveys.

The result from the above simulation does show an improvement in travel speed. However, the data also showed the there is an increase in the fuel consumption, which would also result in more adverse environmental impact. Hence, fuel consumption and impact to the environment becomes a negative benefit in this analysis.

Recommendation for future work would be to investigate the relationship of fuel consumption with speed in T06. While figure 8 shows a simple calculation in the travel time benefit, a more detailed approach is required when carrying out the Benefit Cost Analysis from the T06 output of speed, % following and fuel consumption.

6 Acknowledgements

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I also wish to express special thanks to Mr Bob Peters, Mr Steven Phillips and Mr Craig Peek for making this project possible. I would also like to thank all the staff from MRWA especially Mr David Kennedy for rewriting the Excel Marco to obtain sight distance from a particular point of road in Western Australia.

7 References

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