

DOES HASTE MAKE WASTE? THE HUMAN FACTORS OF OVERTAKING LANE DESIGN

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ABSTRACT

The aim of this research was to improve overtaking safety and efficiency through improvements in road signage, markings, geometry and speed control associated with the placement and layout of passing lanes. The approach of the research was to explore the effects of several types of overtaking lane treatments in the safety and controlled environment of a state-of-the-art driving simulator. It was found that under the most benign conditions there were no differential effects of the three treatments. With poorer visibility or more taxing road geometry, the drivers relied more heavily on the road markings and signage and the effects of the treatments become more pronounced. The sensitivity to the more "challenging" situations was borne out by the greater speed differential between merge area sections at these sites.

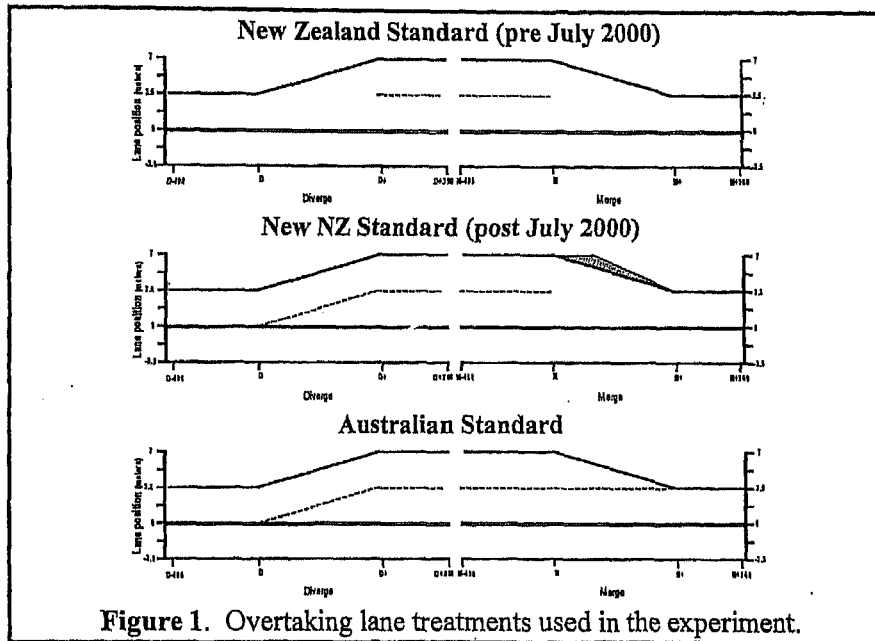
INTRODUCTION

This research highlighted overtaking because road deaths involving overtaking have been increasing rapidly; a 45% increase over the 3 years 1997 to 1999, now accounting for 10% of all road deaths (LTSA, 2000). Passing manoeuvres require a series of complex information-processing and decision processes which makes these manoeuvres one of the most demanding and risky operations performed by a motorist (Khasnabis 1986). Well-designed passing lanes can have a significant effect in reducing the number of overtaking related crashes. The research described in this paper explored the relative merits of several types of overtaking lane and signage treatments in the safety and controlled environment of a driving simulator.

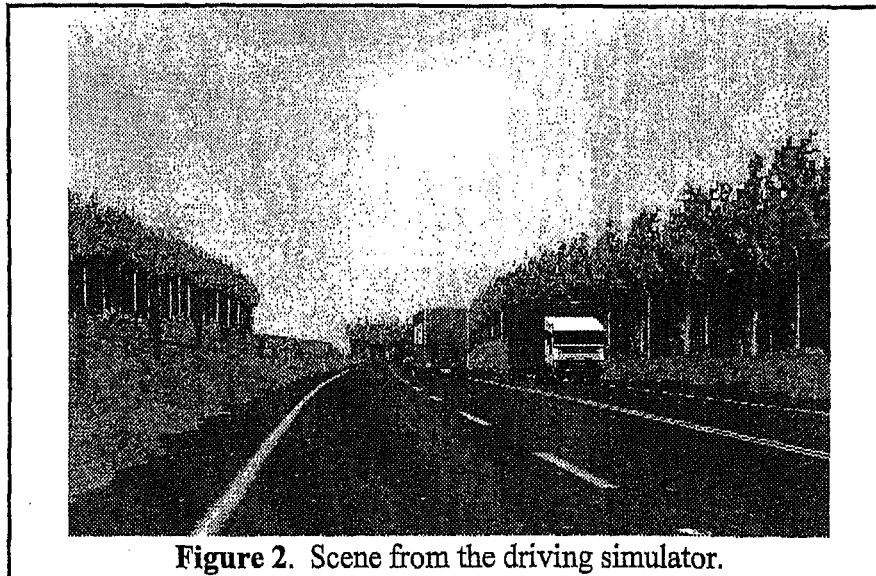
METHOD

The Kaimai route between the Waikato and Tauranga (SH 29 between Rapurapu Road and Omanawa Road) was recreated in a driving simulator. The simulation was populated with a mixture of cars, light trucks, and heavy trucks to represent a traffic volume of 14,000 passenger car units per day. Three lane marking and sign treatments were applied to the road: the New Zealand standard design (pre-July 2000), the New NZ standard (post-July 2000), and the Australian standard, as shown in Figure 1. Thirty-one participants, 17 women and 14 men, ranging in age from 19 to 71 years (average age 38.19) with driving experience ranging from 3 to 53 years

(average 20.58 years) were tested. In the within-subjects experimental design employed, each participant drove six simulations across three experimental sessions, an average of approximately 2 hours of driving across the three sessions.



The research used the DS3 driving simulator located at the University of Waikato (Charlton, Alley, Baas, & Newman, In Press). The simulator has been used extensively for research on driver vehicle interactions. The medium-fidelity driving simulator was comprised of a 21 in CRT display, steering wheel and foot pedal controls, a fully instrumented dashboard, and realistic driving simulation software. A typical driving scene from the experiment is shown in Figure 2.



Measured 3-dimensional road geometry data, from the national RGDAS database, was used to specify the roadway. The roadway geometry was simulated by means of

a series of 2 metre by 2 meter vertices in which smaller undulations and bumps in the road surface were embedded. Signs, roadside furniture, and other objects such as buildings and trees were entered as digital images from a digital camera. Vehicle dynamics were provided by interactive non-linear multi-body simulations based on AUTOSIM vehicle models. Factors such as non-linear tyre behaviour, steering geometry, and suspension dynamics were based on the dynamics of a standard passenger car with a 2.1 litre engine. Driver performance data were collected automatically for designated sections of the simulated road including: lane position, braking, vehicle speed, headway distance, and occurrence of any collisions.

RESULTS AND DISCUSSION

A multivariate analysis of variance revealed a significant difference for participants' lane positions across the three treatment types ($F_{(2,58)} = 5.61, p < .01$) and a significant interaction between participant gender and the phase of the overtaking lane ($F_{(20,580)} = 2.03, p < .01$) arising from the lower speeds and longer following distances maintained by female participants during the pre-merge and merge phases. Comparing the effects of the three treatment types across the various overtaking sites showed that at sites with long approaches and high forward visibility the driving behaviour was approximately equivalent under the three treatments. At sites with shorter approaches, or where visibility was somewhat more restricted due to the topography or road geometry, there were pronounced differences in lane position, speed, and the number of vehicles overtaken. The diverge continuity line used in the New NZ and Australian treatments was successful in moving more drivers to the left (see Figure 3). Across all passing sites the Australian treatment achieved this effect sooner and at higher vehicle speeds that the New NZ treatment resulting in greater rates of passing early in the overtaking lanes.

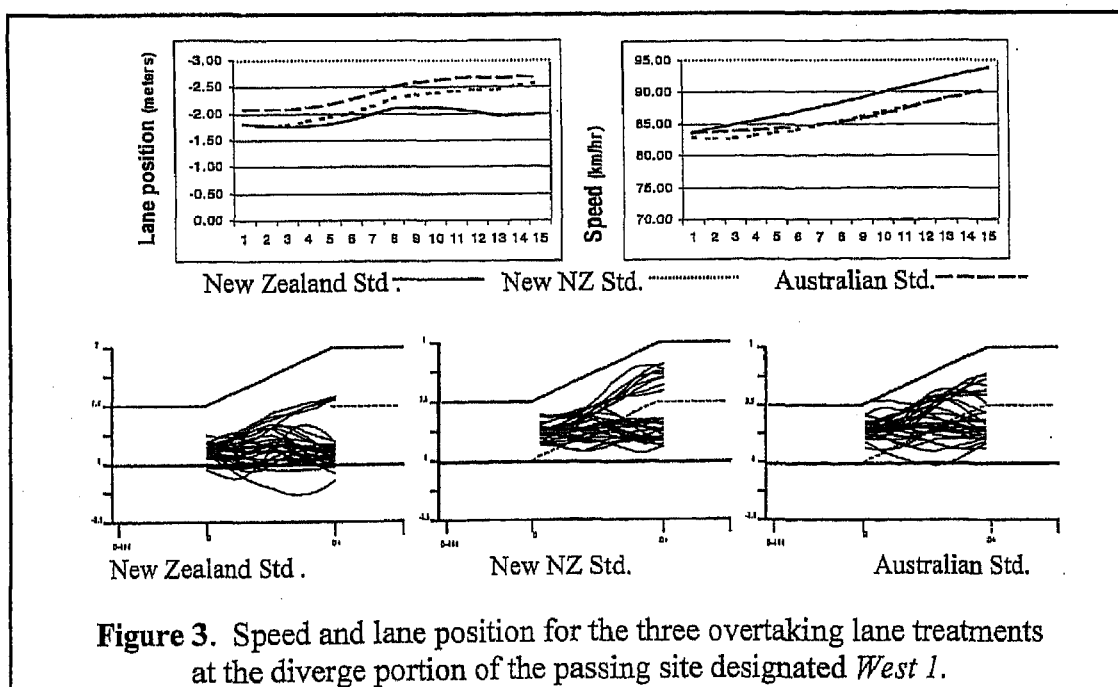


Figure 3. Speed and lane position for the three overtaking lane treatments at the diverge portion of the passing site designated *West 1*.

Towards the end of the lane, the Australian treatment had the effect of slowing drivers and reducing overall overtaking rates compared to the Current and New NZ treatments. The hatched runout at the end of the New NZ treatment delayed drivers' move to the right lane in the merge section. The New NZ treatment resulted in an increase in safe driving at a marginal cost in efficiency. The simulator methodology worked well in exploring these phenomena safely and cost-effectively. Merge area designs are still not optimal and will be addressed in future experimentation with the simulator methodology.

Results from this research indicate that while the diverge areas operate reasonably well, there are safety concerns with overtaking lane merge areas in challenging situations with limited forward visibility and short merge tapers. It was generally found that the merge taper lengths were significantly shorter than lengths recommended in New Zealand and Australian guidelines and standards. In examining the more "challenging" sites, that is sites with poorer visibility or more taxing road geometry, it was found that the difference in the average speed travelled through the pre-merge / merge / and post-merge stages was greater than 10 km/h, which illustrated an inconsistency of design. The inconsistent speed environment was thought to be largely due to the shorter merge taper lengths, and the restricted visibility. This research has highlighted the potential for safety problems at these areas, and suggests the need to look at alternative locations or treatments for the merge area when the above restrictions impact on overtaking lane design. It has also shown that the placement of lane markings and signs does affect driver behaviour with regards to position in the lane, travel speed, and assumed lane priority in challenging situations.

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