An Evaluation of Red Light Cameras in Brisbane

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Abstract:

The Queensland Department of Transport installed the State 's first Red Light Cameras (RLC) in Brisbane in December 1990. This followed successful installations of RLC in Victoria Western Australia. South Australia and new South Wales since the early 1980's Arup Transportation Planning was commissioned to assess the impact of RLC in Brisbane on driver attitudes, driver behaviour and accident rates Information on driver attitudes was collected vie "before" and "after" questionnaire surveys using both self administered mailback and interviewer administered techniques. Data relating to driver behaviourwere obtained from "before" and "after" surveys of red light violations at several RLC treated and non-RLC treated signalised intersections The methodologies used to collect these data and quantify the changes in driver attitudes and behaviour are summarised in the paper The major findings of the study are then presented and compared with those obtained from similar evaluations undertaken interstate.

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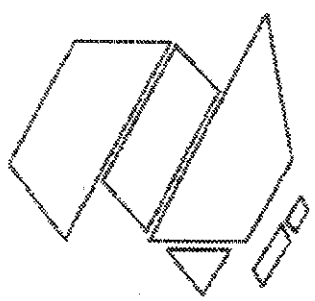

1. INTRODUCTION

In December 1990 the Queensland Department of Transport (DoT) installed Red Light Cameras (RLC) at several signalised intersections in the Brisbane Metropolitan Area. This followed successful trials and installations of RLC in Victoria (South et al 1988), Western Australia (Maisey 1981, Van Brakel and Maisey 1990), South Australia (Nicholas Clark & Associates 1985) and New South Wales (Job et al 1991) since the early 1980's. Arup Transportation Planning was commissioned to undertake "before" and "after" studies of RLC in Brisbane to determine their impact on driver attitudes and behaviour (Arup Transportation Planning 1990).

Driver attitudes were assessed via a questionnaire survey which obtained feedback on issues relating to RLC and general road safety. Red light violation data was collected via observation surveys at RLC treated and non-RLC treated intersections. The results of "before" and "after" surveys were used to identify statistically significant differences that could be attributed to the introduction of RLC in Brisbane.

This paper outlines the various survey methodologies used during the course of the study and presents the results of the subsequent statistical analysis of the data thus collected. It concludes by comparing the results obtained in Brisbane with the published results from other similar studies conducted interstate.

2. ATTITUDINAL SURVEYS

Attitudinal surveys were conducted to measure changes in driver attitudes towards and awareness of RLC, resulting from their introduction and associated publicity.

Survey Design and Conduct

The survey was designed to use both self administered mailback and interviewer administered techniques. Reply paid self administered questionnaires were distributed at 11 signalised intersections around Brisbane. These were augmented by a series of interviews conducted while drivers refuelled at 11 selected petrol stations within the study area. The two alternative data collection methods were used because:

(i) It was expected that the data obtained from the self administered questionnaires could be biased towards certain age groups or sex, particularly young males; and

(ii) The interviews at petrol stations gave greater control over the total number of responses obtained, allowing more interviews to be programmed if the response rate from the self administered questionnaires was lower than expected.

The questionnaire used in both the "before" and "after" surveys was designed in consultation with DoT and was piloted prior to commencement of full scale surveys. It included 10 questions in all, seven relating to RLC and three seeking respondant details such as age, sex and occupation. Just over 1000 valid responses were received during both the "before" and "after" surveys. The breakdown of these, together with other information relating to the attitudinal surveys, is summarised in Table 1 below.

Table 1: Attitudinal Survey Details

Item	"Before"	"After"
Survey Dates	22.10.90 - 04.11.90	07.11.91 - 07.12.91
Self Administered Questionnaires		
Distributed:	2270	2029
Received:	519	487
Response Rate:	23%	24%
Interviewer Administered Responses:	485	530
Total Valid Responses	1004	1017

The response rate from the self administered questionnaires increased marginally from 23% to 24% between the two rounds of surveys. In both cases this was less than the anticipated response rate of 25% - 30%. The response rate also varied significantly between sites. For the "before" surveys the response rate by site ranged from 16% to 32%, while in the "after" surveys it varied between 19% and 30%.

Data Analysis

Logic and range checks were conducted on both the "before" and "after" attitudinal survey responses. These were then entered into a computer database for subsequent analysis

Preliminary tabulations of the proportion of responses by sex, age and occupation group indicated that the samples from both rounds of surveys had similar characteristics However, these samples were skewed towards males, persons aged from 35 to 44 years and professionals. This result was not unexpected given that the data collection process generally favoured drivers using arterial roads during weekdays.

Figures 1 and 2 compare the sex and age distributions of the "before" and "after" samples with that of all licensed drivers within the Brisbane Statistical Division (BSD), as reported by home interview surveys conducted in 1986 (Bornhorst Ward Veitch 1987). These distributions highlight the over-representation discussed above To compensate for this bias, both the "before" and "after" survey responses were weighted to reflect the wider population of licensed drivers resident within the BSD

Weighting factors were calculated for each response based on the 1986 home interview proportions and were appended to each record in the data file according to the sex and age of the respondant Upon completion of the weighting process, cross-tabulations were conducted to identify variations in driver attitudes between the two survey rounds

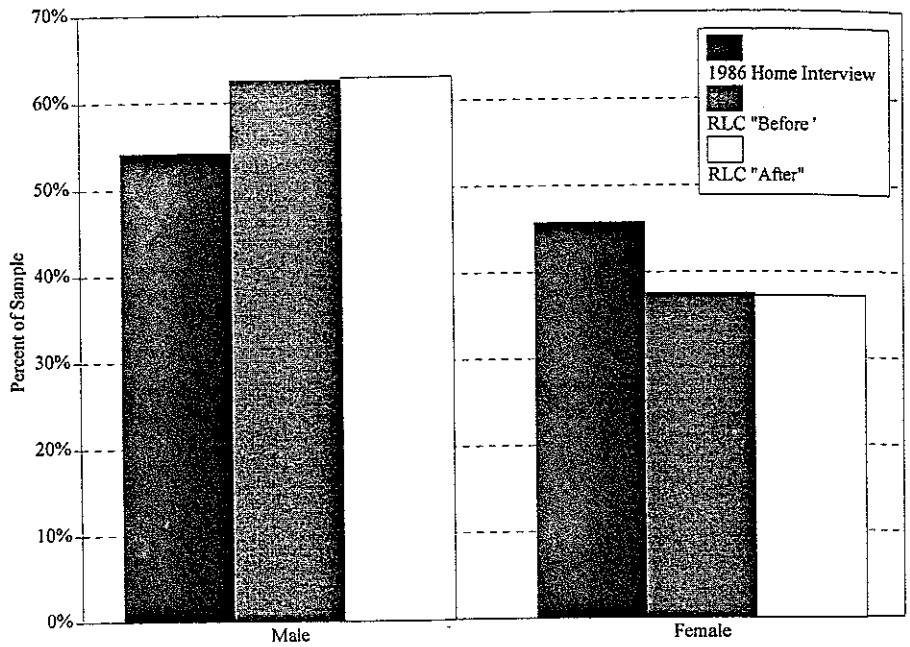

Figure 1: Attitudinal Questionnaire Responses by Sex

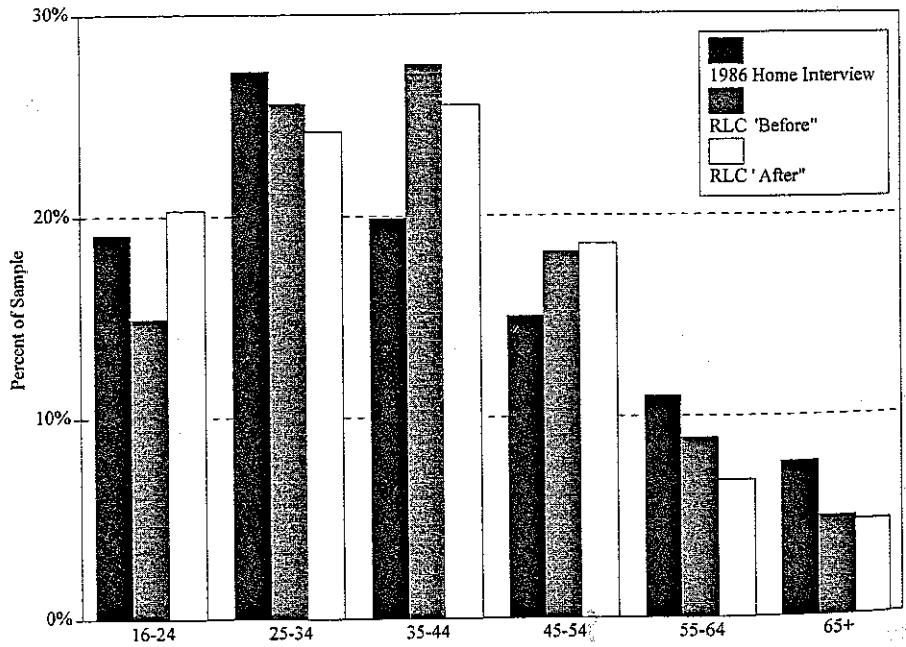

Figure 2: Attitudinal Questionnaire Responses by Age Group

Survey Results

The results of these cross-tabulations for both the "before" and "after" surveys are summarised in Table 2. Statistical analyses of the proportions listed in this table were conducted to identify any significant differences between the two survey rounds. However, testing could not be undertaken at too fine a level as the sample sizes within each group would be too small to draw realistic conclusions.

The "Z-test" for proportions was used to test for changes in drivers attitudes between the two survey rounds. This test determines if the proportion of responses from one of the survey rounds was significantly different to that from the other. The level of significance used was 5%. The results of this testing process are summarised below for each of the seven questions asked:

(i) Question 1 : There was no significant change in drivers attitudes toward the practice of disobeying a red traffic light. The majority of drivers still considered this practice to be either "very dangerous" or "dangerous".

(ii) Question 2 : In the "before" survey there was some confusion evident in responses to the second question. This question was subsequently reworded for the "after" study, making it impossible to draw any statistically valid conclusions. However, results from both rounds of surveys clearly indicate that twice as many drivers perceive "not stopping at a red traffic light" as the most dangerous of the five listed options. The second most dangerous action was considered to be "not giving way to pedestrians".

(iii) Question 3 : There was a significant change in drivers attitudes towards the likelihood of being caught running a red light. Prior to the introduction of RLC, drivers most commonly rated their chance of being caught as "not very likely". After the introduction of RLC the most common response had not altered significantly. However, significantly higher response rates were obtained for drivers who rated their chances as "very likely" or "likely". In addition, a significant decrease was obtained in the proportion of drivers who rated their chances of being caught as "very unlikely".

(iv) Question 4 : It was expected that once RLC had been introduced and publicised, people's awareness of the function of the RLC would increase. A significant increase in people's responses for the correct answer and a significant decrease in the incorrect answers was identified.

(v) Question 5 : In the "before" survey 86% of respondants claimed to be aware that RLC were installed at some intersections around Brisbane. This awareness was considerably higher than expected, given that no official publicity had been undertaken. In the "after" study the number of respondants that were aware of RLC increased significantly to 98%. This indicates that the publicity given to RLC was effective in raising public awareness to the use and operation of RLC in Brisbane.

Table 2: Summary of Attitudinal Responses

Q1. Would you say the practice of disobeying a red traffic light is:

	Very Dangerous	Dangerous	Not Dangerous	Quite Safe	No Opinion
Before	81.8%	16.8%	0.3%	0.5%	0.5%
After	84.1%	14.9%	0.4%	0.3%	0.3%

Q2 All of the following are dangerous actions. Which ONE do you consider most dangerous?

	Not Stopping	Not Giving	Not Stopping	Driving > 20 km/hr Above	
Before	9.2%	24.3%	46.5%	5.3%	14.7%
After	12.8%	23.8%	53.6%	5.7%	4.1%

Q3 If you disobeyed a red traffic light, how would you rate your chances of being caught?

	Very Likely	Likely	Not Likely	Very Unlikely	No Opinion
Before	11.5%	26.2%	40.8%	19.9%	1.5%
After	19.5%	32.9%	37.6%	7.8%	2.2%

Q4. Which of the following do you understand to be the function of Red Light Cameras?

	Detect Speeding	Detect Vehicles That	Monitor Traffic		
Before	5.0%	84.2%	7.4%	3.5%	
After	4.0%	89.6%	4.7%	1.8%	

Q5. Do you know that Red Light Cameras are installed around Brisbane?

	Yes	No			
Before	86.0%	14.0%			
After	98.4%	1.6%			

Q6. How effective do you think Red Light Cameras will be in achieving their design purpose?

	Very Effective	Somewhat Effective	Not Very Effective	Not Effective At All	No Opinion
Before	45.0%	46.6%	5.5%	0.5%	2.3%
After	37.7%	41.9%	8.3%	1.8%	10.3%

Q7 What are your attitudes to the Red Light Camera programme in Brisbane?

	Help to Reduce	A Waste of	Free Police for other	Intrude Into	Will Not Work at
Before	85.8%	6.1%	36.1%	4.1%	4.6%
After	90.3%	4.8%	44.7%	1.5%	2.1%

(vi) Question 6 : More than 90% of respondants in the "before" surveys thought that RLC would be either "very effective" or "somewhat effective". In the "after" survey this value had reduced significantly to just under 80%, with a corresponding significant increase in the proportion of drivers who felt that RLC would be "not very effective", "not effective at all" or who had "no opinion". Despite these decreases, the "after" survey results indicate that about four in five drivers still consider RLC as being either "very effective" or "somewhat effective" in achieving their purpose.

(vii) Question 7 : Although the "after" survey results suggest that drivers consider RLC to be less effective than was the case in the "before" survey (See results for Question 6), there was no change in the proportion of drivers who felt that RLC would "help to reduce accidents". In addition, a small percentage of drivers still perceive the programme to be "a waste of money". However, there was a significant increase in the number of drivers who felt that RLC would "free police for other duties". There was also significant decreases in the number of drivers who felt RLC would "intrude into one's privacy" and "not work at night".

Based on the results of the attitudinal surveys it was concluded that the introduction of RLC to Brisbane and the associated publicity campaign were successful in changing driver attitudes to and awareness of a number of important road safety issues. The aim of the second phase of the commission was to determine if these changes in drivers attitudes were reflected in their behaviour at traffic signals.

3. VIOLATION SURVEYS

Violation surveys were undertaken by observing and recording the number of red light runners at several RLC treated and non-RLC treated intersections around Brisbane. The latter group formed a control against which changes in violation rates at the RLC treated sites could be measured.

Survey Design and Conduct

The violation surveys were designed to obtain information on the number of vehicles crossing the stop bar in each lane during the green, yellow and red signal phases of a particular approach at each surveyed intersection. In addition, the times that vehicles crossed the stop bar after the onset of the yellow and red signals were also recorded.

Hand held PSION LZ64 personal organisers were used for the direct field entry of survey data. They were programmed to record the time, to the nearest 20th of a second, and character of every key press. Each lane was designated a specific key which was pressed the moment that a vehicle crossed the stop bar. Special keys were pressed to signify a change of signal phase. Thus information was obtained on the:

- Vehicular flow rate by lane,
- Number of red light violations by lane; and
- Time between the onset of the red phase and the violation.

"Before" and "after" surveys were conducted at the same 12 signalised intersections. Half of these had RLC installed soon after the completion fo the "before" surveys, thus ensuring almost one full year of service prior to the second round of surveying The intersections surveyed were chosen by DoT based on the following criteria:

(i) The six RLC treated sites were chosen from the set of intersections previously earmarked by DoT for RLC installation,

(ii) Three of the control sites were chosen from those intersections which, after preliminary site investigations by DoT, were not considered geometrically suitable for the installation of RLC; and

(iii) The remaining three control sites were made up of those intersections earmarked for possible RLC treatment which had the lowest right angle accident record

Given that the programme of RLC installation in Brisbane was driven by road safety needs and not the needs of this study, the above selection criteria minimised the potential for RLC to be fitted to the six survey control sites during the course of the study The potential for this non-random site selection process to introduce bias into the survey results was identified at an early stage of the study

However, it was felt that any such bias could be accounted for during the analysis phase and the surveys proceeded on the 12 chosen sites. Table 3 summarises the preliminary findings of the violation surveys together with other relevant survey details.

Table 3: Violation Survey Details

Item	"Before"	"After"
Survey Dates	19.11.90 - 30.11.90	27.11.91 - 10.12.91
Control Sites		
Hour Surveyed:	101	142
Vehicles Observed:	35,456	58,562
Red Light Violations:	162	88
Violation Rate:	0.46%	0.15%
Treatment Sites		
Hours Surveyed:	78	109
Vehicles Observed:	26,868	30,477
Red Light Violations:	170	42
Violation Rate:	0.63%	0.14%

Data Analysis

Violation data from the PSION's were down loaded to a computer file and checked for errors, such as miss-keyed events as noted by survey staff. Recorder error will always be a component of any type of survey based on the reaction of observers. However, to minimise the impact of such errors, the same staff undertook both rounds of surveys at the same sites, thus maximising the internal consistency of the collected data.

Red light violations were expressed as a percentage of total flow by lane and survey period, lane arrangement and RLC site characteristics. Differences in violation rates could then be determined using the appropriate statistical tests.

Survey Results

As with the attitudinal survey results, the "Z-test" of proportions was used to check the statistical significance of differences in observed violation rates. These rates, together with the results of the statistical testing are summarised in Table 4. Key points to note from these findings include:

(i) There was a significant reduction in both peak and off-peak period violation rates between the two rounds of surveys. Furthermore, peak period violation rates were significantly lower than off-peak period violation rates during each of the two surveys. This last point supports anecdotal evidence that better signal co-ordination during peak periods tends to reduce violation rates.

Table 4: Violation Rates

Category	"Before"		"After"
Survey Period			
Peak:	0.45%	↔	0.10%
	↕*		↕
Off-Peak:	0.59%	↔	0.18%
Lane Arrangement			
Through:	0.40%	↔	0.13%
	↕		↕
Shared/Turning:	1.14%	↔	0.22%
RLC Sites			
Control:	0.46%	↔	0.15%
	↕		
Treated:	0.63%	↔	0.14%
Total	0.53%	↔	0.15%

Note. Significant difference, at 1% level, between adjacent rates signified by ↕ or ↔, except for ↕ which is significant at the 5% level.*

(ii) A significant reduction in violation rates between the "before" and "after" surveys for both through and shared/turning lanes was recorded. Furthermore, violation rates for shared/turning lanes were observed to be significantly higher than those for through lanes during both rounds of surveying. This was confirmed by survey staff who noted that a large number of right turning vehicles completed their manoeuvre towards the end of the green and yellow periods or at the beginning of the subsequent red period.

(iii) Violation rates at both RLC control and treatment sites were significantly lower in the "after" survey. The "before" survey results indicated that there was a significant difference between violation rates at treatment and control sites. This difference could well be attributed to the site selection process used, as noted earlier. For example, treatment sites were originally chosen due to their higher right angle accident rates, which are highly correlated to red light violations. Conversely, at least half of the control sites were chosen because they had the lowest right angle accident rates of all candidate sites. In contrast, the "after" surveys revealed no significant difference in violation rates between treatment and control sites. This may be attributed to road signs warning drivers of the operation of RLC in Brisbane being targeted at the metropolitan level rather than at specific RLC treatment sites.

(iv) Overall, there was almost a fourfold decrease in the violation rates at the 12 surveyed intersections between the "before" and "after" surveys. As above, this difference was significant at the 1% level.

While the quality and quantity of the data collected would have allowed a range of additional tests to be conducted at a more disaggregated level, only one such set of tests were performed during the study. Additional testing to determine the influence of survey period on violation rates at both treatment and control sites concluded that:

(i) There was no significant difference in violation rates between treatment and control sites during both peak and off-peak periods, as measured by the "after" surveys. This result differed to that of the "before" surveys which found that RLC treatment site violation rates were significantly higher than control site violation rates, during both peak and off-peak periods.

(ii) Off-peak violation rates at control sites were significantly higher than peak period violation rates during both survey rounds.

(iii) Treatment site violation rates from the "after" surveys were significantly greater during off-peak periods than peak periods. Conversely, the "before" surveys found that peak and off-peak violation rates at treatment sites did not differ significantly. This result is not inconsistent with those presented above and merely reflects that peak period violation rates at treatment sites had decreased by a greater amount than off-peak violation rates.

In addition to these results, the "before" surveys highlighted a relationship between violation rate and lane flow, which is shown here in Figure 3. Data from the "after" surveys gave support to this relationship, although its strength had decreased greatly. Figure 4 shows a plot of violation rates versus lane flow from the "after" surveys.

The violation rates by lane flow from the "before" surveys range from 0% to almost 6%, while in the "after" surveys they vary between 0% and 1%. The weakening in the relationship between violation rate and lane flow is particularly evident for flows up to about 450vph. Furthermore, there appears to be a decrease in violation rates for higher lane flows compared to the "before" study, suggesting that drivers may now be more conscious of RLC at intersections with higher traffic flows.

Thus, the "before" and "after" surveys of red light violations at both RLC treated and non-treated sites indicated a significant reduction in violation rates across a range of relevant categories. Given the similarity in the timings of each survey round and the consistent data collection methodologies used, it would be reasonable to attribute these reductions in red light violation rates to the introduction of RLC in Brisbane.

Impact on Signal Operations

While the information collected as part of this study has been used to quantify the impact of RLC on driver attitudes and behaviour, it has also been possible to draw a number of conclusions regarding the impact of RLC on traffic signal operations. For example:

(i) The end gain attributed to a signal green phase is typically used during signal capacity and co-ordination analyses to account for vehicles "sneaking" across the intersection stop bar during the yellow and red phases. The violation data indicate that a shift in the distribution of times that vehicles cross the stop bar during these periods has occurred between the "before" and "after" surveys. This change, as highlighted in Figures 5 and 6, equates to a reduction of about 0.82 seconds in end gain. The implications of this change are expected to be an increase in signal lost time and a corresponding reduction in effective green time. Based on these results, there seems to be some justification for reducing the value of end gain used in signal capacity and co-ordination analyses in areas with RLC by one second.

(ii) Strictly speaking, saturation flows are not expected to be affected by the introduction of RLC. However, it follows from the above that flow rates towards the end of the green phase have probably reduced as a result of the introduction of RLC. It is expected that headways towards the end of the green period have increased slightly, as drivers anticipate the on-coming phase change in an attempt to avoid being caught running the red light.

It is suggested that the above comments be taken into consideration during signal capacity and co-ordination analyses in areas with RLC.

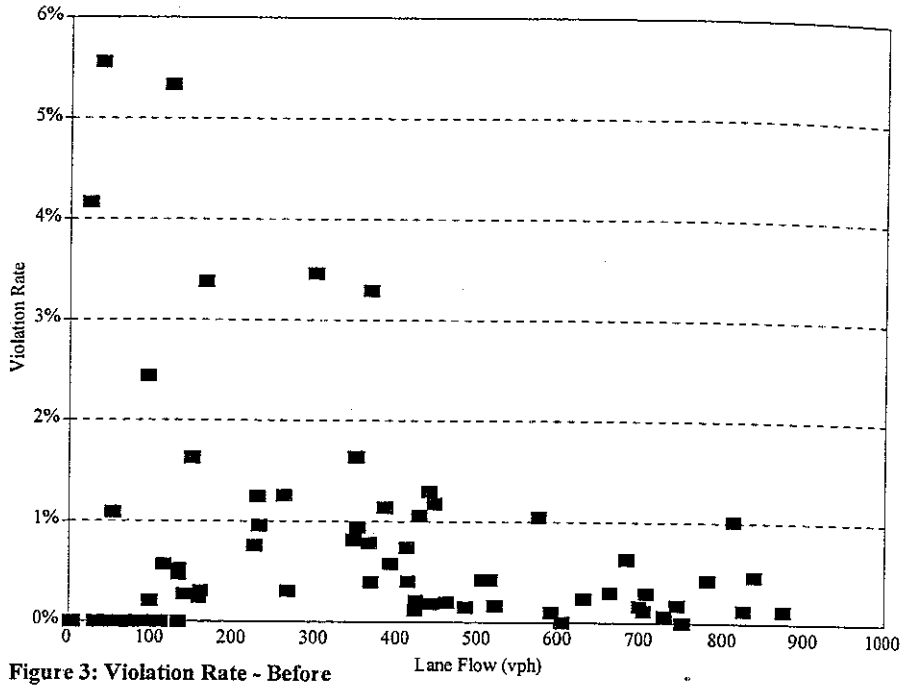

Figure 3: Violation Rate - Before

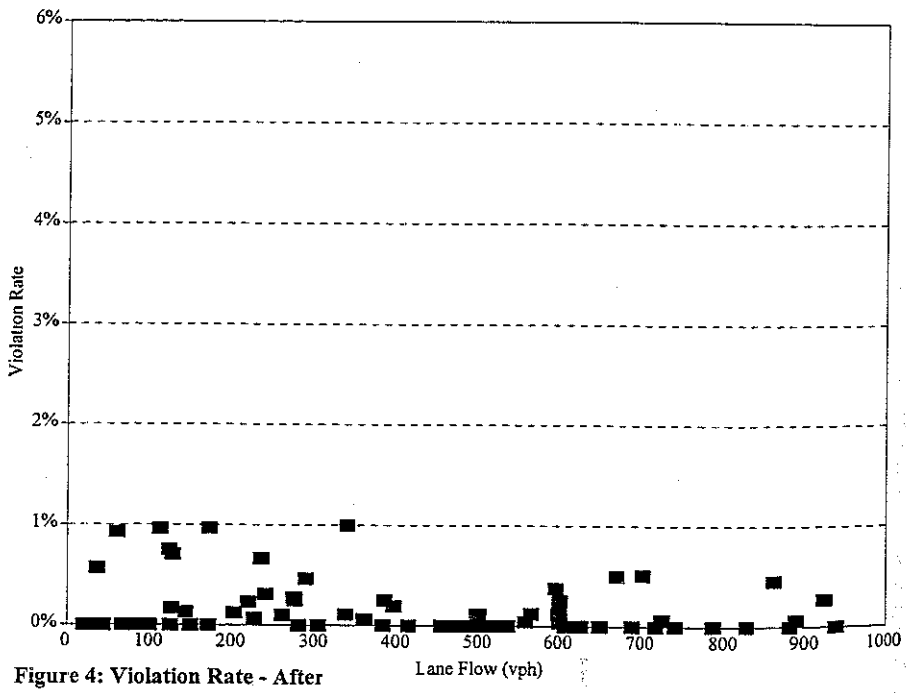

Figure 4: Violation Rate - After

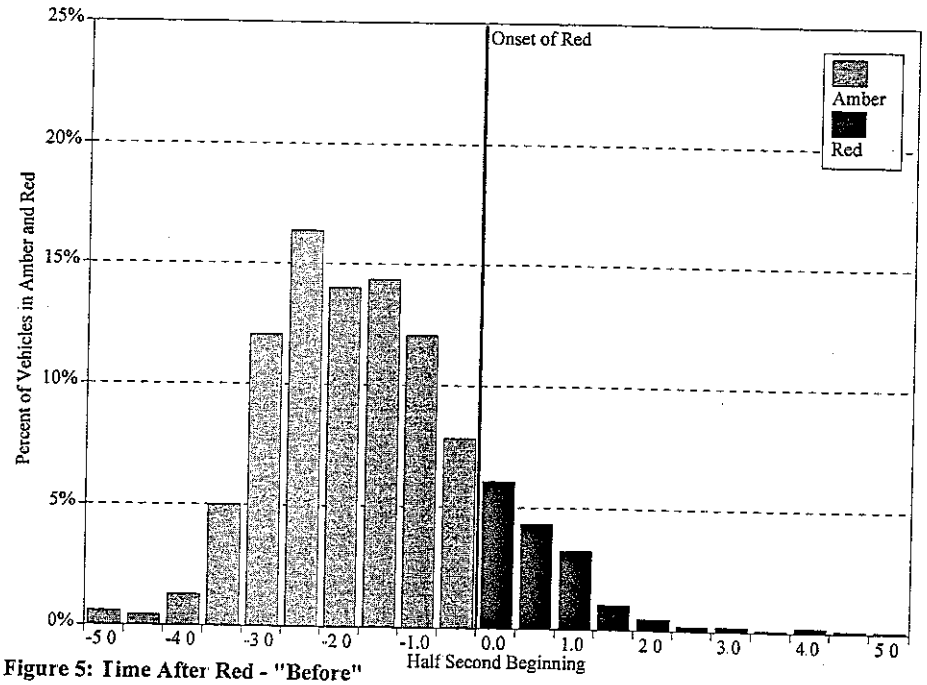

Figure 5: Time After Red - "Before"

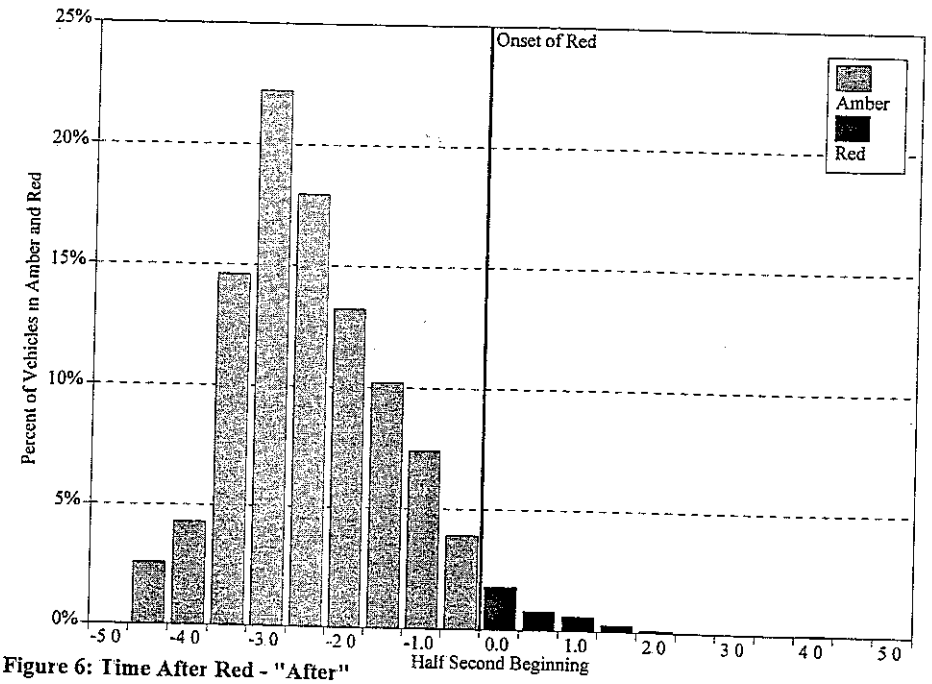

Figure 6: Time After Red - "After"

4. INTERSTATE EXPERIENCE

In drawing comparisons from interstate studies the method of warning drivers of the presence of RLC must be taken into consideration. In Victoria, New South Wales, South Australia and Western Australia all approaches to each RLC site are provided with "Red Light Camera Ahead" warning signs. This contrasts with Queensland practice which instead advises motorists via warning signs on major approach roads to Brisbane.

Driver Attitudes

The attitudinal questionnaire used in Brisbane was similar, although not identical, to that used in a similar study in Adelaide (Nicholas Clark & Associates 1985). The results for several similarly worded questions are summarised in Table 5 below. Given the slightly different wording used in these studies, some caution is required when comparing the results. Nevertheless, it would appear that the attitudinal surveys conducted in Brisbane addressed similar issues to those surveyed in Adelaide.

Table 5: Comparison of Attitudinal Responses

Question	Adelaide 1985	Brisbane 1990-1991
RLC will make it more likely to get caught running a red light	85%	38%-52%
RLC will reduce accidents at intersections	61%	86%-90%
RLC will free Police for other duties	31%	36%-45%
RLC are a waste of money	14%	6%-5%

Driver Behaviour

The red light violation data collected for Brisbane and discussed earlier in this paper indicate that violation rates at the 12 Brisbane intersections surveyed reduced by between 25% to 98% during the two survey rounds. Overall, a 72% reduction in violation rates was noted. This figure compares well with other published data relating to the affect of RLC in reducing red light violations, examples of which include:

(i) A RLC was installed at a major metropolitan intersection in Melbourne for nearly three months in late 1981 (South et al 1988). Initially the public were unaware of the camera and around 300 offences were photographed each week. After some media publicity the rate of offences reduced to about 20 per week. This represents a reduction of approximately 93%.

(ii) In 1984, RLC were installed at 50 intersections around Melbourne (South et al 1988). For 37 sites studied, the mean weekly number of offences reduced by about 60% following the introduction of the cameras at each site.

(iii) A study undertaken in Adelaide in 1990 (Office of Road Safety 1990) revealed that prior to the introduction of RLC, an estimated 1000 red light offences occurred per month After the introduction of RLC, this rate reduced to 302 and 383 offences per month in 1988 and 1989 respectively, which represents an average reduction of 66%.

Accidents

The analysis of attitudinal and violation data discussed above provides a useful measure of the effectiveness of RLC. However, one of the most important aims associated with the introduction of RLC is the reduction of accident rates and severity at intersections with poor accident histories resulting from red light running. To adequately assess the significance of any changes to accident rates, sufficient "before" and "after" accident data is necessary.

Following discussions with the DoT, it was concluded that insufficient time had elapsed since the introduction of RLC in Brisbane for statistically reliable results on changes in accident rates to be determined It is hoped that when sufficient "after" accident data become available for Brisbane, the evaluation of RLC presented here will be extended to include an analysis of changes in accident rates and severity.

However, the similarities in attitudes and violation rates collected in Brisbane and interstate suggests that the general observations regarding the effect of RLC on accident rates found interstate may also be applicable to Brisbane These include:

(i) An overall reduction in accidents at RLC treatment sites,

(ii) A significant reduction in Right-Angle and Casualty accidents,

(iii) Right-Turn Opposed accidents may also reduce, particularly where filter right-turn movements are undertaken,

(iv) A possible increase in the number and severity of Rear-End accidents is also likely, although this increase may not be sustained beyond a six month period after the introduction of RLC; and

(v) Other accident types are likely to remain largely unaffected.

It must be emphasised that, due to the different method of warning drivers about the operation of RLC interstate, these potential reductions may only relate to RLC sites. The effect of the different signing policies used by the various States is worthy of further investigation.

5. CONCLUSIONS

In 1990, DoT first introduced RLC to Queensland through several installations in the Brisbane metropolitan area. Since than, RLC have been installed in most regional centres around the State.

This paper has outlined the methodology used in and the key findings of an evaluation of RLC in Brisbane. "Before" and "after" surveys were used to quantify changes in driver attitudes and behaviour, thus providing some measure of the effectiveness of the RLC programme in Queensland.

Changes in driver attitudes were assessed based on information obtained from self administered and interviewer administered questionnaires. The resulting data indicates that the introduction of RLC to Brisbane, and their associated publicity campaign, has been successful in raising driver awareness and appreciation of RLC.

Furthermore, this increase in RLC awareness has been reflected in a measured reduction in red light violation rates. A total of 332 violations (0.53% of traffic flow) were observed during the "before" survey, compared to 130 violations (0.15% of traffic flow) in the "after" survey. This represents an overall reduction of 72% in the red light violation rate over the 12 month period between the two survey rounds.

The violation survey data also indicate a reduction in traffic signal end gain of about 0.82 seconds. Based on this, there seems to be some justification for reducing the value of end gain used in signal capacity and co-ordination analyses in areas with RLC by one second.

The introduction of RLC to Brisbane has been successful in changing driver attitudes and behaviour towards stopping at red traffic lights. Furthermore, the results obtained in Brisbane are generally comparable with the published findings of similar studies conducted interstate.

While the work to date has not examined the impact of the RLC programme in Brisbane on accident rates and severity, it is hoped that such an examination will be conducted when sufficient "after" accident data become available. Until then, similarities in driver attitudes and violation rates between Brisbane and other Australian cities suggest that the general observations regarding the effect of RLC on accident rates and severity reported interstate would also be relevant to Brisbane.

6. ACKNOWLEDGMENTS

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