APPENDIX 2E – Intersection Safety Camera Program – Submission to Measurement & Monitoring Committee

Submission to Measuring & Monitoring Committee

Initiative Name/Subject:	INTERSECTION SAFETY CAMERA PROGRAM	**ID#**
Prepared by::	Laurie Baker	
Date:	October 16, 2003	
Decision Requested:		
Endorsement of the evaluation and cost/benefit analysis for the Intersection Safety Camera Program		

Evaluation Summary

The objective of the Intersection Safety Camera Program is to reduce crashes at the sites where cameras are installed. Camera equipment was installed at 120 sites between July, 1999 and May, 2001.

An evaluation plan prepared for the program in 1999 was reviewed and endorsed by an external research agency, Human Factors North. The program evaluation was conducted by ICBC's Performance Analysis Services Department and is attached as Appendix A.

The "Empirical Bayes" analysis methodology was used in the evaluation. This analysis involved a review of crash history at 68 camera sites (the "treatment sites") and 68 similar sites that did not have enforcement equipment (the "reference sites). Detailed information on crash history at the sites is contained in Appendix B.

The evaluation concluded that the most reasonable assumption is that the ISC program reduced crashes at the camera sites by an average of 14%, similar to results published in other jurisdictions. There was high variability in the changes in crash numbers at both the treatment sites and the reference sites.

Cost/Benefit Analysis Summary

The total costs of the program, using the actual costs from 1997 through 2002 and the outlook for 2003, are $24.2 million (see Appendix D for details). The total claims reduction benefits from 1999 through 2003, as described in Appendix D, are $19.5 million.

The planned ongoing operating costs in 2003 are $2.6 million and the 2003 estimated claims reduction benefits are $6.0 million. It is therefore reasonable for ICBC to continue its involvement in the program and to explore ways to improve the return on investment.

Next Steps

1. Analyze the characteristics of the group of sites that achieved the highest benefit and the group of sites that achieved the lowest benefit to determine if a common set of characteristics for high-value sites can be identified.
2. Based on the results of the site analysis, identify specific sites that would achieve high crash reduction benefits if intersection cameras were installed. Also identify sites where the cameras are not reducing crashes.
3. Review the cost-benefit analysis and the site analysis work with the Ministry of Public Safety & Solicitor General and senior police officers responsible for the program and agree on a process for improving the results of the program.
4. Prepare a plan to increase public awareness of the program.
5. Continue ongoing efforts to reduce operating costs.

Appendix A

ISC Program Evaluation

INTERSECTION SAFETY CAMERA FINAL EVALUATION

Phase I – Impact on Total Crash Frequency

Phase II – Impact on Casualty Crash Frequency

1. Background

1.1 Red light running and intersection crashes

Violation of traffic controls at signalized road junctions is one of the major safety problems in industrialized countries. While less than half of one percent of vehicles entering signalized intersections may actually commit red light violations (Kamyab et al, 2002) the potential traffic safety consequences are more serious.

About 40 % of motor vehicle collisions in the United States occur at intersections or are deemed intersection-related (U.S. DOT, 1997). In recent years, the number of collisions reported at intersections controlled by traffic signals has been increasing. Between 1992 and 1996, the number of fatal crashes at traffic signals increased by 19% while the number of other fatal collisions increased by only 6%. During the same period, the number of injuries at intersections with traffic signals increased by approximately 14% (U.S. DOT, 1993, 1997).

A study by the Insurance Institute for Highway Safety of the United States in four urban areas - Akron, Ohio: Arlington, Virginia; New Orleans, Louisiana; and Yonkers, New York - showed that 22% of all crashes in urban areas were the result of drivers running traffic control devices (traffic signals, stop signs, and yield signs). Among those, 24% involved running red lights. (Retting, 1996).

The study also showed that motorists are more likely to be injured in crashes involving red light running than in other types of crashes. Occupant injury occurred in 45 percent of the red light running crashes studied compared to 30 percent for other crash types. The reason for the high injury rate has been mainly attributed to the involvement of side impacts at relatively high speeds, causing passenger compartment intrusion and bodily injury (Retting, 1996).

Other urban centres in the United States also witnessed a high incidence of red light running and resulting crashes. San Francisco has been cited as having probably one of the worst problems of drivers running red lights. It was estimated that 25% of all traffic collisions at signalized intersections in the city stem from red light violation (Bond and Yee, 1997).

Disobeying traffic signals at intersections accounts for a sizeable portion of collisions in Australia. In the period from 1979 to 1986, 10% of fatal collisions and 18% of collisions resulting in at least one admission to hospital in Melbourne occurred at signalized intersections. It was estimated that 18% of reported casualty collisions at signalized intersections involve a driver running a red light (South, 1988).

Running red lights is also a major concern in British Columbia. Based on police reports, about 20% of all collisions in BC occurred at signalized intersections. “Ignoring traffic control device” is cited in about a third of these, so running red lights undoubtedly contributes significantly to traffic collisions at signalized intersections in B.C.

1.2 Red light camera programs

A number of solutions have been investigated for reducing red light violations and their resulting crashes. Extension of amber change intervals or increase of all-red periods have been shown to decrease such infractions and adjustment of posted speed limits can also be effective (Golob et al, 2003; California State Auditor, 2002; Miller, 2003). Red light violation frequency has also been shown to be related to traffic volume, intersection width and type of signal timing control (Mohamedshah et al, 2000). But automatic camera technology is increasingly being touted as the most reliable solution to the problem in the case of high-risk locations.

Intersection safety cameras have been tested and used in a number of countries worldwide. The program was originated in Europe, followed by Australia and a number of Asian counties. Recently applications have also been reported in the United States.

European Experience

The earliest red-light camera program studied was in Sweden. Between 1972 and 1978, five intersections in Stockholm were equipped with loops and red-light cameras. The red-light running incidence in these sites ranged between 0.3% to 0.7% of the total traffic prior to the program. The objective of the program was to reduce red light running violations at these intersections.

The operation of the red light cameras was accompanied neither by public information campaigns nor by warning signage postings. The study found no reduction of red light violations after the implementation of the program. It was speculated that this was partly due to the lack of knowledge of the motorists and partly due to site selection in that the prior incidence of red light running violation was considered too low for the program to be effective (Makinen, 1992).

Great Britain has used traffic light camera techniques extensively in traffic law enforcement with 120 cameras (speed and traffic light) deployed at over 700 sites across the country in 1996 (Hooke, Knox, & Protas, 1996). Hooke et al conducted a simple before and after comparison using collision data from 10 police forces across England and Wales. Using 78 sites based on high collision frequency, they reported an 18% collision reduction at the treatment sites after the introduction of the traffic light cameras.

However, the design of the Hooke study is weak due to the lack of experimental or statistical control. Also, no consideration was given either to regression-to-mean effects or to the general crash trend before implementation.

The London Accident Analysis Unit (1997) assessed the effect of a speed and traffic light camera demonstration project on ten routes in West London deploying both speed cameras and red light cameras. 36 months of both before and after data were collected at both treatment and control sites. London boroughs outside the camera network were used as the controls. The number of collisions with the contributing factor of “disobeyed automatic traffic signals” was used as a surrogate for red-light-running crashes.

The analysis revealed that reduction in collisions occurred on six of the eight routes. Overall, there was a reduction of 16% relative to the control data but this was not significant even at the 10% level. Analyzed individually, two of the eight sites experienced significant reductions in collisions relative to the control sites at the 5% level or better. But the study also found a highly significant increase (28%) in the number of rear end collisions as approximated by collisions with the contributing factor of “driving too close to the vehicle in front” (London Accident Analysis Unit, 1997).

The Strathclyde Police in Scotland started red light camera enforcement at the end of 1991 with warning letters. Sites were selected where evidence suggests that failure to comply with traffic signs was a contributing factor in collisions. The program started to issue fixed penalty fines in April 1993.

A study to assess the program effect on red-light violations and crashes was commissioned by the Scottish Office Central Research Unit. The study employed a before-after, treatment-control design. Twelve sites were selected for the study: six on monitored approaches at camera sites, two on non-monitored approaches at camera sites, two at non-camera sites within the signed area, and two at non-camera sites outside the signed area. 19 hours of data were collected manually at each site, consisting of both the number of violations and the number of opportunities for violations. The opportunity to violate was defined as the situation when a vehicle approached the red light with no other vehicles impeding its passage through the intersection. Then the compliance rate for each site was defined as the violation to opportunity ratio.

The study revealed a 69% reduction in the total number of violations between the before and after periods at the camera sites and a 37% reduction at the control sites.

For the crash impact analysis, the study was restricted to six camera sites and two control sites which were close to the treatment sites. A three-year before-and-after comparison was made to assess the safety effect with injury collisions selected as the criteria measure. The analysis found a 62% decline at the camera sites and an 80% reduction in the control sites. The report concluded that the program effect spilled over to the adjacent intersections, which lead to the reduction in the control sites (Scottish Office Central Research Unit, 1995). Of course, this is only one possible explanation.

Australian Experience

West Australia installed the first red-light camera at one intersection in Perth in 1979. The intersection was selected based on high collision history, constant traffic volume, and no road alterations. A $40 dollar fine and 4 demerit points was imposed for violation.

Maisey (1981) conducted a study of the program. Nine comparable intersections were selected as the control sites. The control sites were selected well away from the treatment site in order to minimize any “halo effect”. Using a pre-post comparison group design, Maisay found a 55.6% net reduction in right angle and cross-traffic turning collisions. The change was statistically significant when compared with both one-year and two-year before periods. However, Maisay also noted that rear end collisions increased and as a result, there was little change attributable to the camera in the total number of reported collisions.

A larger scale application of the red-light cameras was undertaken later in Victoria, Australia. Since August 1983, more than one hundred of signalized intersections in the Melbourne metropolitan area have been equipped with red light cameras (Passetti, 1997). South (1988) conducted a before-after, treatment-equivalent group study on the effect of the program. The study included 46 treatment and 46 matched equivalent sites. Eight years of data (1979 to 1986) were used in the study.

The study found that red-light cameras were associated with a 32% reduction in right angle casualty collisions, which was statistically significant at the .05% level, after removing the general downward trend as accounted for by the control group. No significant reduction in rear-end collisions was found and those involving the lead vehicle turning actually increased by 28%. Combining all the collision types, the study found a 6% reduction in the total casualty collision rate, compared with the change expected on the basis of the control site data. This was not statistically significant at the 5% level.

Andreassen (1995) conducted a more recent study for the program in Victoria. Using collision data at a convenient (not randomly selected) sample of 41 treatment sites for the period 1979-1989, he examined the program based on several input and output variables, including collision type, camera direction, and number of collisions prior to treatment.

The analysis found no reduction of collisions at the red-light camera sites for all the major collision configuration types combined. In fact, the number of collisions increased substantially, after an initial drop following the introduction of the program. A simple before and after comparison showed a 13% increase at the camera site for all major collision types combined. Not only did rear-end crashes increase at the camera site as has been recorded in many of the other studies, but so did right-angle collisions. Andreassen noted that a number of data problems, including administrative changes in crash recording and coding over the study period, could have contributed to this result.

The number of collisions before the introduction of the program seemed to play an important role in determining its effect. Sites with more than two collisions per year experienced an initial significant drop in right-angle collisions during the first year following camera installation. No significant change was observed after that time. Conversely, sites with two or fewer collisions experienced a significant increase after the program.

To control for the potential general trend effected by unmeasured extraneous variables, the change of collisions at the red-light camera sites was compared with that at all the signalized intersections in Victoria. Using 1985 as the baseline year, the analysis showed that a greater increase occurred at the 41 treatment sites during the following four years than happened at all the signalized intersections together for both the right-angle and rear-end collisions.

Another application of red light cameras occurred in the Sydney metropolitan area of New South Wales. From January 1988 to June 1989, six cameras were circulated among twenty intersections that were selected based on their collision history. Posted signs and a publicity campaign accompanied the introduction of the cameras. Violation tickets were sent to owners of the offending vehicles.

Hillier et al. (1993) conducted an evaluation of the Sydney pilot, using a before and after, treatment and control design. Two years of before and two years of after data for 16 treatment and 16 matched control sites were employed for the analysis. The matching variables included accident history, traffic volume, and intersection configuration. As the red light cameras were rotated among the various sites with camera housings installed, some sites operated with the camera more than others did. The evaluation was focused on the 8 most used camera sites and the 8 least used camera sites. Log-linear techniques were employed for the data analysis.

The researchers found that red light cameras appeared to reduce right angle and right turn (target) crashes by about 50% and increase rear end crashes by 25% to 60%. For a selected group of sites where the cameras were described as "installed appropriately", the target crashes were reduced by 48% and the rear-end crashes were increased by 62% resulting in a net total crash reduction of 38%.

The study also found a greater decrease in casualty collisions than in total collisions. This suggests that the red light camera was more effective in reducing serious collisions than in reducing minor ones. No significant crash effect distinction was found between monitored approaches and those that were not monitored.

Singapore Experience

Another early example of red light camera implementation occurred in Singapore. Beginning in 1986, red light cameras were first phased in at 120 intersections (Chin, 1989). As of June 1997, one in five signalized intersections in Singapore was equipped with a red-light camera unit.

The owners of photographed vehicles are fined either US$150 for light vehicles or US$180 for heavy vehicles and, in addition, are given six driver demerit points. Warning signs, placed some distance up-steam of each camera junction accompanied the installation of the camera device. National newspapers were also involved in publicizing the program.

Chin (1989) evaluated the effectiveness of the red-light cameras in deterring red running using a before and after, treatment and control site design. Eleven experimental and five control sites were included in this study. The before study was conducted about one month prior to the installation and the after study was carried out in the immediate months after the installation. Each camera site was given at least a month of operation prior to commencement of the after study to ensure that motorists were aware of the presence of the cameras.

The violation and traffic movement data were collected on video shot from adjacent buildings. One survey day was designated for each intersection, and only dry weekdays were chosen for the study. The same day of the week was chosen for both the before and after survey, to reduce the variance of traffic conditions. The results indicated a statistically significant 40% reduction in red light violations at the treatment sites.

More recently, Ng, Wang, and Lum (1997) conducted a study on the traffic safety effect of the red-light cameras in Singapore. The study used a pre-post, treatment-comparison quasi-experimental design. A sample of 42 treatment sites and an equal number of matched control sites were employed in the study. The researchers found a 9% net reduction in the total number of collisions, controlling for the general trend.

The US Experience

Red-light cameras have found application in about a dozen jurisdictions in the United States (Retting et al., 1998). Although some information is available as to program implementation and drivers behaviour outcomes, details as to the traffic safety effects are very scarce.

One of the earliest applications of red-light camera in the United States was in New York City (Populizio, 1995). This demonstration program started operation in 1994, after extensive exploration of the technology in the 1980s. Fifteen cameras were initially installed across the five boroughs of the city. Accident histories and police records of red-light violations were used as the main criteria for site selection.

A preliminary analysis of the program's effect revealed a 62% decrease in the average number of violations since the program's inception. Encouraged by this success, the city expanded its red light camera program by adding 12 more intersections to its existing monitoring network in 1997 (Bond and Yee, 1997). Recently, a new law has been signed by the Major of New York City to further extend the program to a total of 50 intersections (New York City Press Office, 1998).

San Francisco initiated a pilot study to determine the feasibility of using automated enforcement technology to combat the problem of red light violation in 1996. To raise the awareness of the program, street signs were placed in advance of the intersections where the red-light cameras were to be installed (Passetti, 1997). It was reported that the proportion of entering vehicles that were photographed running red lights at intersections with cameras had dropped by over 40% since police started issuing citations in October of 1996 (Passetti, 1997).

Retting et al. (1998) conducted a study of the effect of red-light camera on red-light violation in Oxnard, California. Using a before-after quasi-experiment design with controls, the authors conducted the investigation at 14 intersections (nine camera sites, three noncamera sites, and two control sites).

Retting et al. (1998) found that the red light violation rate was reduced by approximately 42 percent several months after the enforcement program began. Increases in driver compliance with red lights were not limited to the camera-equipped intersections but spilled over to non-equipped intersections as well. Public opinion survey revealed that nearly 80 percent of local residents supported the program. Subsequently, Retting and Kyrychenko (2001) were able to evaluate the safety impact of the program. They applied a generalized linear regression model to crash data from 11 of the camera-monitored signalized intersections and 82 similar control locations from three other communities 40-100 miles away where there was no red-light camera program in operation. They compared 29 months of pre-implementation data with 29 months of "post". The presence of a camera was associated with 7% fewer crashes in total but with 29% fewer casualty crashes and 68% fewer right-angle casualty crashes. All of these effects were statistically significant at $p < .05$.

Retting and Kyrychenko (2001) also found a slight increase in rear-end crash rate associated with the cameras, although the level of effect was not statistically significant. But such a direction of effect would be consistent with the findings from many of the other studies – e.g. Maisay (1981), Hillier (1993), Andreassen (1995), Passetti (1997) and London Accident Analysis Unit (1997). The reason for the increase in rear-end crashes presumably relates to the increased propensity for drivers to stop during the amber light phase at approaches monitored by cameras (Lum and Wong, 2003).

Retting et al (2003) summarized the experience to-date with red light cameras. They separated all the studies into three groups: those that should have overestimated ISC effect since they ignored regression-to-the-mean effects; those that possibly underestimated ISC effect by ignoring the spill-over factor; and those that attempted to deal with both. They found that the first group averaged 39% crash reduction, the second 10% and the third (one study only) gave 29%. McGee (2003) attempted a similar review exercise and concluded that while nearly all studies contained some design or analysis flaws, the weight of evidence pointed to a positive impact of the cameras on safety. However, in fully one-third of the evaluations no substantial effects were identified.

Ruby and Hobeika (2003) reported on a study of ten red light camera installations in Fairfax County, Virginia. Red light violations on the monitored approaches were down by an average of 69% six months after installation, using the first month post-implementation as the baseline. However, available crash data were limited to just 3 locations and for only a 3-4 month after period (as compared to 14 months before). Thus even though the report claims a 40% total crash reduction, this result is very suspect.

A somewhat larger study (although of similar simple before-and-after design) was conducted on nineteen red light camera sites in San Diego (Golob et al, 2003). As with the Fairfax study no violation data from before camera installation was available and changes in red light violation behaviour was measured from month 1 as the baseline. After two years of operation, red light violations on monitored intersection legs had reduced by over 50%. But in the San Diego study there were over six years of crash data available (3-5 years before and 1-3 years after installation) which lend some level of credibility to the results even if no control locations were employed. Similar to other studies, Golob et al found a 40% decrease for right-angle crashes together with a 40% increase in rear-end crashes on the monitored approaches. No significant changes occurred on the unmonitored legs and, overall, the total crash rate only decreased very marginally (about 2%).

The California Bureau of State Audits conducted a review of red light camera implementation in seven jurisdictions in that State. The Bureau reviewed crash records over a 6.8 year period for 69 camera-monitored intersections in six of the jurisdictions and compared the before-and-after changes with those for all non-camera sites in the same time periods (California State Auditor, 2002). The camera sites displayed a net 32% crash reduction (using California Highway Patrol data) as compared to the non-camera sites which experienced a net reduction of only 6%. Unfortunately the report does not make it clear as to whether the crash rates calculated are for all the crashes occurring at the intersections or only those considered red-light-related. It should also be noted that the camera sites were initially most often selected based on traffic safety concerns and thus the great majority of the non-camera sites would probably not qualify as good controls. In addition, while after periods were usually 2-3 years, in almost 1/3 of the treatment cases this period was about a year or less.

Summary

In summary, automated red light camera devices have been tested and used in many countries since the early 1970s. Evaluation reports on the effectiveness of these programs have come from Europe, Australia, Singapore and, most recently, the United States.

Red light cameras have been effective in reducing red light running incidents on intersection approaches where the cameras are operational. Such decreases vary between 30% to 60% across the studies reported with 40% being a common result.

The cameras have not proved quite as effective in reducing collisions as they have in reducing red light violations. The findings from the studies which are judged to have some validity cover a fairly wide range. The estimated safety effects of these usable studies, judged on the design of the studies and completeness of the reports, are summarized in the Table below. The majority of the programs reported reductions in right angle collisions on monitored approaches by 30% to 50%, with increases in rear end collisions of a similar level. But when the measure used is total crashes (including those on unmonitored legs) the effects are greatly reduced in size. The median effect of red light camera on total collisions is a reduction of 6.6%. However, there is some evidence that the impact on injury-producing collisions could be substantially more.

COUNTRY	AUTHOR	YEAR	CRITERIA	METHOD	TIMES B - A	SITES T – C	COLLISION EFFECT (%)		
							TARGET	REAR_E	TOTAL
England	Hooke	1996	Collision	B-A		78			-18
	London Acc. Anal. Unit	1997	Collision	C-G	3y-3y	10-rest		28	-16
Australia (Victoria)	South	1988	Collision	C-G	4y-2y	46-46	-32	0	-7
(Victoria)	Andreassen	1995	Collision	T-S, C-G	4y-6y	41-rest			13
(Sidney)	Hillier	1993	Casualty coll	C-G	2y-2.5y	8-8	-50	62	-38
Singapore	Ng, et.al	1997	Collision	C-G	3y-5y	42-42	-10	6	-9
U.S.A.	Retting & Kyrychenko	2001	Collision	C-G	2.5y-2.5y	11-82	-33	3	-7
	Retting & Kyrychenko	2001	Casualty coll	C-G	2.5y-2.5y	11-82	-68		-29
	Golob et al	2003	Collision	B-A	4y-2y	19	-40	40	-2

2. Study Design

Of the 120 intersections configured for camera operation by early 2002, only 70 had been in operation for long enough such that a mid-2002 data extraction would produce at least 18 months of usable crash information. These 70 locations were geographically distributed as follows:

Abbotsford – 5
Burnaby – 3
Chilliwack – 2
Coquitlam – 1
Delta – 4
Kamloops – 4
Kelowna – 4
Langley – 4
Maple Ridge – 2
Mission – 1
Nanaimo – 4
New Westminister – 2
North Vancouver – 4
Pitt Meadows – 1
Port Coquitlam – 2
Poet Moody – 1
Prince George – 4
Richmond – 5
Saanich – 5
Surrey – 7
Vancouver – 3
Vernon – 2

For each of these 70 treatment sites, a comparable "reference" site was selected. Each reference site was matched with a treatment site based on the following characteristics:

(i) Location:
- same or adjacent municipality
- similar land use
- more than 1 km & several signals away
- not directly downstream

(ii) Layout/operation:
- similar laning & traffic control
- similar posted speed limit

(iii) Traffic volume:
- similar avg. annual daily traffic (AADT)
- similar ratio between major & minor road volumes

For each of the 140 treatment and reference sites the following data were obtained and utilized for subsequent analysis purposes:

- Estimated AADTs for major and minor road approaches
- Number of crash-claim incidents between Jan. 1996 and Jul. 2002
- Breakdown of incidents by severity level (fatal, injury & mdo)
- Breakdown of incidents by collision type (right-angle, rear-end, other)

The analysis methodology utilized was one known as "Empirical Bayes" (EB). This method allows adjustment for regression-to-the-mean bias and time trends in assessing changes in the treatment locations between "before" and "after" periods.

The reference site data from the pre-implementation period were used to construct a model for crash prediction of the form:

$C = a_0 . (AADT_M)^{a1} . (AADT_m)^{a2}$ where M & m represent major & minor respectively

This model was then used with the treatment site AADTs to estimate the number of post- implementation crashes (B) that would have occurred at the treatment sites had no cameras been installed. Then, if we use "C" to represent the number of post-implementation reference-group crashes, "D" to represent the number of post-implementation treatment group crashes and "A" to represent the number of pre-implementation reference-group crashes, the odds ratio can be written as:

$$OR = \frac{A/C}{B/D}$$

And the treatment effect is given as: OR – 1

The level of statistical significance of the resulting treatment effect (i.e. the effect of the cameras) can be estimated based on the sample statistics and distribution assumptions. But there is potential for additional error in the data itself which should be accounted for if possible.

The primary source of error for this study is in the crash data. We know that a substantial proportion of crash-claim incidents are not coded sufficiently to permit assignment to a precise location. The underlying assumption that justifies using the remaining data is that the unassigned records are randomly distributed such that there is no bias in their application by location. But we have no ready methodology for testing this assumption. The use of the odds ratio to establish treatment effect does, to some extent, reduce the potential error if any bias is present but it does not completely eliminate it. This remains a source of uncertainty that could impact our confidence in the results and which needs to be explored further.

A second source of error is in the estimation of AADT. In most cases the annual volumes are estimated from just two hours of traffic movement counts on a single day. These two-hour counts are then converted into full-year estimates using hour, day and month expansion/correction factors. Such factors may be developed from counting stations which are some distance away from the site in question. Even using expansion factors developed from the same site, a small-scale investigation showed that AADT estimation errors of up to ± 12% could occur. Fortunately, a sensitivity analysis conducted on the full EB process showed that AADT errors of such a magnitude would have only a very minor impact on the value of the odds ratio.

3. Results – Total Crashes

3.1 Crash prediction model

Data on pre-ISC traffic volumes and crash counts from 1996 to 1999 inclusive was collected for the 70 reference sites to be used to develop the model. The crash prediction model was developed using Negative Binomial regression with the SAS generalized linear model procedure (PROC GENMOD). The model was then used to predict the total crash frequency. The model and its parameters are shown in Table1.

Table 1: Crash Model Results

Model Formulation		χ^2	κ
Crash Model:	a_o	28.47(p<0.001)	
$Crashes/3yrs = 1.4466*10^{-5} \times (AADT_{mj\,rd})^{0.8171} \times (AADT_{mn\,rd})^{0.7886}$	a_1	14.68(p<0.001)	1.69
(a_0) (a_1) (a_2)	a_2	20.70(p<0.001)	

Entries in the χ^2 column show that the variables "major AADT" and "minor AADT" are significant predictors of the total crash counts (p<.001). Deviance of the goodness of fit statistic is 76.8416 with 67 degrees of freedom. Comparing the deviance with its asymptotic χ^2 with 67 degrees of freedom, results in a p-value of 0.19. This indicates that the specified model fits the data reasonably well.

However, an examination of the monthly crash trends from 1996 to 2000 showed a substantial upward trend at both treatment and reference sites that was primarily due to low incident counts in 1996-97. Most likely this resulted from the lower proportion of records which were location-coded during the first year or two in which these data were collected at Telephone Claims. In order to eliminate this as a potential confounding factor, we did not use the first 18 months of the "before" crash data as part of the control, thus leaving a 1.5-year before period to match the 1.5-year after period in both treatment and reference groups. The AADT crash-prediction model was based on the 3-year (1996-98) reference site data. Redoing the analysis on this basis produced the results shown in Table 2.

Table 2: Crash Prediction Model Results – reduced "before" period

Model Formulation		χ^2	κ
Crashes Model:	a_o	29.41(p<0.001)	
$Crashes/3yrs = 4.6007*10^{-6} \times (AADT_{mj\,rd})^{0.9093} \times (AADT_{mn\,rd})^{0.8069}$	a_1	15.52(p<0.001)	1.62
	a_2	19.89(p<0.001)	

Again, the model produces a good fit for the data with both major and minor AADTs being significant ($p<0.001$) predictors of total crash counts.

3.2 Crash reduction estimate

Using the prediction models, the treatment effect and its standard deviation (SD) can be calculated for the total crash count. In this study, the data for the reference sites during both the 'before' and 'after' periods were utilised in order to adjust for both the regression-to-mean and time trend effects. However, prior to conducting the analysis two of the 70 treatment sites were dropped from the database as a result of post-implementation crashes counts which were probably influenced by non-ISC-related activity near the intersection. In one case a large parking lot was constructed with direct access/egress to the major road close to the intersection and in the second case the change involved a major housing development. As consequence, the two corresponding reference sites were also removed from the data.

Using the full 3-year before period, the odds ratio based on the 68 treatment and reference sites was calculated as 0.931. Therefore the treatment effect is –0.069, in other words a **6.9% reduction in total crashes**. The standard deviation of this treatment effect is 0.027 or 2.7% and **the reduction is significant at p<.05**. But when we restrict the analysis to a 1.5 year before period (matching the 1.5 after) we find a treatment effect of –0.140. In other words, a **14.0% reduction in total crashes**. The standard deviation is 0.023 and **the reduction is significant at p<.05**.

As a matter of interest, the above results with the revised data period can be compared to a "naïve" before-and-after analysis. This is the sort of procedure that is often employed in the engineering field. Such an analysis produces the results shown below.

Table 3: Summary of total crashes

	Total Crashes	
	Reference Sites	Treatment Sites
Before	2837	4346
After	3420	4745

By using the Naïve before and after analysis, the index of effectiveness equals

$$\theta = \frac{\lambda}{\pi} = \frac{\sum L(j)}{\sum r_d(j)K(j)} = \frac{4745}{(583/547)*4346} = 1.024$$

The percent reduction is 100x(1-θ)=-2.4. There is a 2.4% *increase* in total crashes based on a simple before-and-after analysis.

4. Results – Casualty Crashes

4.1 Crash Prediction Model

The model for casualty crashes was produced in the same manner as that for all crashes, but based on the results for total crashes only the 1.5-year before/after situation was assessed. The same 68 matched treatment and reference sites as employed for the analysis of total crashes were used for the casualty crash modelling. The results are shown in Table 4 below.

Table 4: Casualty Crash Prediction Model

Model Formulation		χ^2	κ
Crashes Model:	a_o	31.80(p<0.001)	
$Crashes / 3yrs = 8.005 * 10^{-7} \times (AADT_{mj\ rd})^{0.9960} \times (AADT_{mn\ rd})^{0.7891}$	a_1	15.71(p<0.001)	1.52
	a_2	16.08(p<0.001)	

Entries in the χ^2 column show that both major and minor road AADT are significant predictors of casualty crashes for the reference sites. As for the previous total crash models, this model was found to fit the data reasonably well (p=0.18).

4.2 Crash Reduction Estimate

Using the 1.5 year before/after comparison with 68 matched treatment and reference sites, the odds ratio between the two groups of locations was 0.896. This means that a 10.4% reduction in casualty crashes is implied at the treatment sites during the after period. The applicable standard deviation is 0.022 and the reduction is significant at the 5% level.

Once again, it is instructive to examine the simple before-and-after approach to see what the results would be if one were to apply this common method. The outcome is shown below.

Table 5: Summary of casualty crashes

	Casualty Crashes	
	Reference Sites	Treatment Sites
Before	1002	1524
After	1180	1682

By using the Naïve before and after analysis, the index of effectiveness equals

$$\theta = \frac{\lambda}{\pi} = \frac{\sum L(j)}{\sum r_d(j)K(j)} = \frac{1682}{(583/547)*1524} = 1.036$$

The percent reduction is 100x(1-θ)=-3.6. There is a 3.6% *increase* in casualty crashes using a simple before-and-after analysis.

5. Discussion

The effect of the ISCs on total crash count for the 68 treatment intersections was quite similar to the average level found in a review of the literature (see Section 1 above) although a bit lower than the originally-anticipated effect based on the earlier Hamilton Associates literature review (1998). But what appeared evident from the updated literature review was that the potential big payoff ($ benefit) for ISCs could be in reduction of injury-producing crashes. There was an expectation that the effects on this latter subset could be substantially greater than on total crash occurrence since the latter reflects the trade-off between right-angle collision decrease and rear-end collision increase.

However, such was not the case for our analysis. We could find no evidence of increased effect for casualty crashes over total crashes and this implies that, at the 68 locations we studied, the ISCs did not have a greater effect on the higher-severity events. The finding of a slightly lesser effect on casualty crashes than on total crashes is not necessarily meaningful within the context of the lower crash sample sizes for the former. We found a high level of variation among the casualty crash data both between locations and within location by year. **The most reasonable assumption of ISC effect based on our results would be a 14% crash reduction – both for casualty and material-damage-only events.**

The next phase of the evaluation will focus on investigating the presence of differential effects between rear-end and angle crashes. It will also look at the performance of the small subset of ten treatment-comparison site pairs in order to see whether or not migration of traffic volume and crashes to adjacent sites is a potential problem and to what extent a safety spill-over effect exists.

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Performance Analysis Services

June, 2003

APPENDIX B

ESTIMATED PERCENT REDUCTION IN TOTAL CRASHES AT ISC TREATMENT SITES				
Site #	Name	Municipality	% reduction	
1000	Kingsway and Nanaimo St.	Vancouver	**8.62**	bold type =
1001	Hastings St. and Renfrew St.	Vancouver	**16.67**	reduction
1003	Knight St. and E. 49th Ave.	Vancouver	**1.85**	
1100	Kingsway and Gilley Ave.	Burnaby	**18.32**	reg. type =
1101	Kingsway and Royal Oak Ave.	Burnaby	**29.92**	increase
1106	Willingdon Ave. and Canada Wy.	Burnaby	118.50	
1130	Brunette Ave. and Braid St.	New Westminster	8.72	
1131	McBride Blvd. and 6th Ave.	New Westminster	**9.30**	
1200	Barnet Hwy. and Johnson St.	Coquitlam	1.47	
1220	St. John's St. and Ioco Rd.	Port Moody	0.69	
1230/1201	Lougheed Hwy. and Shaughnessy St.	Port Coquitlam	**24.06**	
1231/1202	Mary Hill Bypass and Pitt River Rd.	Port Coquitlam	373.87	
1301	152nd St. and 24th Ave.	Surrey	3.50	
1303	176th St. and 8th Ave.	Surrey	64.30	
1304	104th Ave. and 160th St.	Surrey	27.96	
1305	64th Ave. and 152nd St.	Surrey	**39.62**	
1306	152nd St. and 88th Ave.	Surrey	**6.71**	
1309	72nd Ave. and 128th St.	Surrey	**50.27**	
1311	Scott Rd. and 96th Ave.	Surrey	38.81	
1350	Highway 10 and Fraser Hwy.	Langley City	**34.39**	
1352	216th St. and Fraser Hwy.	Langley Township	45.55	
1353	200th St. and 64th Ave.	Langley Township	**25.70**	
1354	Fraser Hwy. and 264th St.	Langley Township	**8.45**	
1400	Westminster Hwy. and No.4 Rd.	Richmond	12.91	
1401	Steveston Hwy. and No.4 Rd.	Richmond	**38.59**	
1402	Cambie Rd. and No.4 Rd.	Richmond	**4.04**	
1403	Alderbridge Wy. and No.4 Rd.	Richmond	27.49	
1404	No.3 Rd. and Francis Rd.	Richmond	**30.08**	
1500	Lonsdale Ave. and 13th St.	North Vancouver City	**3.87**	
1501	13th St. and St. Georges Ave.	North Vancouver City	**14.42**	
1504	Mt. Seymour Pkwy. and Riverside Dr.	North Vancouver District	46.58	
1506	Main St. and Mountain Hwy.	North Vancouver District	93.83	
1700	Hwy. 11 and Harris Rd.	Abbotsford	**21.54**	
1702	Hwy. 11 and Lonzo Rd.	Abbotsford	9.89	
1703	Gladwin Rd. and MacLure Rd.	Abbotsford	16.12	
1704	South Fraser Wy. and Gladwin Rd.	Abbotsford	**31.70**	
1705	MacLure Rd. and Clearbrook Rd.	Abbotsford	**22.10**	
1721	Lougheed Hwy. and 240th St.	Maple Ridge	0.45	
1723	Lougheed Hwy. and Laity St.	Maple Ridge	**62.96**	
1730	Highway 11 and Highway 7	Mission	66.21	

ESTIMATED PERCENT REDUCTION IN TOTAL CRASHES AT ISC TREATMENT SITES				
Site #	Name	Municipality	% reduction	
1740	Lougheed Hwy. and Harris Rd.	Pitt Meadows	**39.05**	
1800	Vedder Rd. and Luckakuck Wy.	Chilliwack	8.33	bold type =
1801	Yale Rd. and Airport Rd.	Chilliwack	8.38	reduction
1900/1701	Nordel Wy. and 84th Ave.	Delta	26.83	
1901	64th Ave. and Sunwood Dr.	Delta	33.45	reg. type =
1903	56th St. and 12th Ave.	Delta	**2.43**	increase
1906	Highway 10 and Scott Rd.	Delta	**20.46**	
2000	Victoria St. and 10th Ave.	Kamloops	**31.07**	
2001	Fortune Dr. and Nelson St.	Kamloops	21.22	
2002	Summit Dr. and Notre Dame Dr.	Kamloops	**52.00**	
2003	Columbia St. and Summit Dr.	Kamloops	8.87	
2100	Highway 97 and 43rd Ave.	Vernon	**18.66**	
2101	Highway 97 and 25th Ave.	Vernon	12.20	
2200	Victoria St. and 10th Ave.	Kamloops	**25.11**	
2201	Fortune Dr. and Nelson St.	Kamloops	12.45	
2202	Summit Dr. and Notre Dame Dr.	Kamloops	12.71	
2203	Columbia St. and Summit Dr.	Kamloops	**5.84**	
3000	Bowen Rd. and Pryde Ave.	Nanaimo	36.31	
3001	Terminal Ave. and St. George St.	Nanaimo	**55.11**	
3002	Bowen Rd. and Island Hwy.	Nanaimo	**2.77**	
3003	Highway 1 and Cranberry Ave.	Nanaimo	6.74	
3100	Quadra St. and McKenzie Ave.	Saanich	**9.18**	
3101	Highway 1 and Admirals Rd.	Saanich	**37.95**	
3102	Patricia Bay Hwy. and Sayward Rd.	Saanich	**18.59**	
3103	Blanshard St. and Cloverdale Rd.	Saanich	**2.36**	
3104	Shelbourne St. and Feltham Rd.	Saanich	**47.72**	
4000	Highway 97 and 15th Ave.	Prince George	**8.32**	
4001	Highway 97 and Austin Rd.	Prince George	**72.06**	
4002	Highway 16 and Domano Blvd.	Prince George	**45.26**	
4003	15th Ave. and Ospika Blvd.	Prince George	**25.92**	

Submission to Measuring & Monitoring Committee

Appendix D

ISC Program Costs and Benefits

0	0	121	1580	5731	6019	6019	19470
-502	-2200	-7417	-4670	3542	3172	3392	-4683
-502	-2702	-10119	-14789	-11247	-8075	-4683	

on Review shows project costs for the period January, 1997 through June, 2001 essing costs for the period July through December, 2001 are estimated at to isolate the exact costs as ticket processing costs for both Photo Radar and me cost centre. This cost-benefit analysis therefore has total costs for the f $18.7 million.

he Road Safety section of ICBC's Annual Report for the years 1997 through his did not include ticket processing costs as they could not be isolated.

et processing costs for both ISC and residual Photo Radar tickets were costs of ISC ticket processing cannot be isolated, this analysis assumes ocessing costs were $1.6 million, the same as the 2003 outlook.