Corridor Management Plan and Project Level In-Service Road Safety Review Guidelines

Introduction

These guidelines were initially prepared in response to the realization that, although ICBC sponsored highway corridor safety analyses carried out in support of MoT Corridor Management Plans (CMPs) were making good recommendations, they were not meeting all of MoT's CMP Safety Review needs. Principally they were not identifying all of the corridor's safety problems or developing a full range of options suitable for MoT Capital Program Development, problem identification criteria were not uniform across all corridors, the problem definition and option development phases did not allow for sufficient input from staff and stakeholders familiar with the corridors, and the option evaluation phase was based on ICBC criteria which differ from MoT criteria.

Past corridor safety reviews sponsored by ICBC have focussed on lower cost improvements that would typically fall into the MoT rehabilitation program "safety" category. This is usually an effective interim strategy to improve safety to tie over to capital investments; however, MoT is interested in developing and evaluating options that fall into all program categories (capital, rehabilitation, maintenance and operations).

To ensure that the requirements of all agencies are met, it is necessary that a corridor safety review provide a complete and thorough problem identification and problem definition. This will provide the background safety analysis necessary for ICBC and/or MoT to fully understand the magnitude of the corridor safety problems, and to subsequently develop and evaluate improvement options for all problem sites as time and budget permit.

In some cases, ICBC safety option development has been performed in isolation of the rest of the Corridor Management Plan option development. To assist in a broader perspective, MOT should lead the option development and evaluation steps. ICBC safety recommendations can be used as input to the more comprehensive option development and evaluation undertaken by MoT in Corridor Management Plans.

MoT acknowledges the importance of ICBC involvement with expertise and funding, but requires a more balanced approach.

Overview of the CMP Safety Review Process

Note – although these guidelines have been written from the CMP perspective they generally apply to project level analysis as well.

A comprehensive CMP safety review involves the review and analysis of all available data and information necessary to carry out the following 4 steps.

1. Problem Identification (Where are the safety problems?)
2. Problem Definition (What are the root causes of the identified problems?)
3. Option Development (What options are reasonable?)
4. Option Evaluation (What are the costs, benefits and impacts of each option?)

Furthermore, these steps need be investigated at each of the following 3 levels.

1. Corridor level
2. Homogeneous section level
3. Project level – collision prone locations and sections

Examples of solutions at the corridor or homogeneous section level include improved signing, continuous shoulder rumble strips, and skid resistant pavement.

In general, options should consider countermeasures involving one or more of:

1. engineering
2. enforcement
3. education

It is not anticipated that a CMP safety review will go into specifics about enforcement and education options, but it should recognize that in some cases it may be more cost-effective to address problem areas through these approaches than through a solution involving capital or rehabilitation funding.

Safety improvements will generally fall into one of the following 3 programs:

1. Capital – short term (0 to 3 yrs), medium term (4 to 10 yrs) and long term (11 to 25 yrs)
2. Rehabilitation
3. Maintenance

There are no specific safety programs for maintenance, but it is included here because it should be recognized that some improvements such as enhanced shoulder sweeping or brush clearing could improve safety.

CMP Safety Review Guidelines

Introduction

The four main steps in the CMP safety review process are:

1. Comprehensive problem identification
2. Comprehensive problem definition (diagnosis)
3. Option development (countermeasures) – for as many problems as time and budget permit
4. Option evaluation (benefit-cost and impacts)

Steps 1 and 2 may be completed by an MOT or ICBC consultant; however, it is important that a complete and thorough list of safety problem sites be identified and defined. This will provide the background safety analysis necessary for ICBC and/or MoT to fully understand the magnitude of the corridor's safety problems, and to subsequently develop and evaluate improvement options for all problem sites as time and budget permit.

Steps 3 and 4 should be carefully managed by MOT in conjunction with the option development and evaluation of other corridor deficiencies. ICBC consultant work on steps 3 and 4, when available, is valuable input to MoT managed steps 3 and 4. The four steps are described in more detail below.

Important reference documents:

1. Canadian Guide to In-Service Road Safety Reviews, TAC, January 2004
2. Highway Safety Manual, AASHTO, 2010
3. Collision Prediction Models for BC, available on the ministry Internet
4. Collision Modification Factors for BC, available on the ministry Internet
5. CMF Clearinghouse, available on the www

1.0 Comprehensive Problem Identification

The objective of this first step is to develop a *comprehensive* list of locations (intersections) and short segments where there is a high potential for safety improvement. The safety performance of homogeneous highway sections and the corridor as a whole should also be investigated. A number of tools/methods are available to help develop a comprehensive list.

1.1 Collision Information System (CIS) – Collision Prone Locations (CPL) Program and Collision Prone Sections (CPS) Program

The ministry's Collision Information System (CIS) is the principle source of collision data for highway corridors. The CIS contains data for collisions that have occurred on the ministry's landmark kilometer inventory (LKI) network if they were attended by police officials and if there was a fatality, an injury, or property damage exceeded $1000. The primary tools in the CIS for identifying safety problem sites are the Collision Prone Locations (CPL) Program and the Collision Prone Sections (CPS) Program.

- The CPL/CPS programs can be used to screen a provincial, regional or local network of roads to produce a list of locations (stop and signal controlled intersections) and a list of highway sections (minimum 1km in length) where safety performance is below a user specified threshold. Typical provincial criteria/thresholds are as follows:

  Collision rate $\geq$ critical collision rate*
  OR
  Collision severity ratio $\geq$ threshold collision severity ratio (typically between 6.2 and 7.2)
  AND
  Collision frequency $\geq$ threshold collision frequency (typically 3 collisions/yr)

  * The critical collision rate is a statistically adjusted provincial average collision rate which must be calculated separately for every location and section under investigation.

- Provincial CPL/CPS lists are typically generated every 3 years based on an analysis of 5 years of collision data across the entire LKI network and can be used to support CMP safety reviews.
- Separate CPL/CPS lists may be created locally using different time periods and modified thresholds if too few sites are provided in the provincial lists. It is recommended that a minimum of 3 yrs and maximum of 5 yrs of collision data be used. Local criteria/thresholds that differ from base provincial criteria/thresholds should be clearly described.
- Note that traffic volume data in the CIS is not perfect and primarily supports network screening exercises to generate provincial or regional collision prone lists. Project level analysis should not rely on CIS traffic volume data. Project level traffic volume data is available on the ministry’s Internet site.
- Sites identified through a network screening exercise using the CIS need to be confirmed at the project level through a review of the collision data, traffic volume data, and the site before proceeding with more detailed project level safety analysis.

1.2 CIS Counter-Measure Based Approach to Identify CPLs and CPSs

The counter-measure based approach to identify CPLs and CPSs searches for sites which have an over-representation of one or more collision types. This utility of the CIS can be run for all collision types, resulting in a second list of CPLs and CPSs. A provincial list using the counter-measure utility does not currently exist (November 2010).

1.3 Using Collision Prediction Models to Identify CPLs and CPSs

Individual collision prone sites can also be identified using Collision Prediction Models along with the Empirical Bayes refinement method as described in the ministry’s document, “Collision Prediction Models for BC”. This cannot currently be automated for the province, a region, or a corridor using the CIS because CPMs have not yet been incorporated into the CIS.

1.4 Homogeneous Sections Safety Performance

In the course of developing a CMP, the corridor is often divided into several homogeneous sections. It is recommended that some simple performance measures be used to evaluate the safety performance of each section. Examples include calculating the collision density, collision rate, and collision severity index. The sections can then be ranked in descending order of performance, and the most problematic sections can be carried through to the problem definition stage. This may uncover safety problems not identified through CPL/CPS analysis.

1.5 Corridor Safety Performance

The safety performance of the entire corridor can be assessed in a similar way as the homogeneous sections to provide a broader perspective on safety performance and to support comparison with other corridors.

1.6 Drive-Through Safety Review

A drive-through safety review is a formal examination of an existing corridor in which a team of examiners drives the corridor to identify and define safety problems, and to help develop improvement options. Suggested participants include the MoT District Transportation Manager or Area Manager, the MoT Traffic Engineer, a police representative, the MoT CMP study consultant, the ICBC consultant (if applicable). While there may be difficulties in getting all the participants together, every effort should be made to do so, as there is typically much benefit from group synergy. The team can confirm that the CIS CPL/CPS lists are reasonable and also identify additional sites that may be hazardous.

1.7 Stakeholder Consultation Process

Stakeholders are another useful source of information for the identification of safety problems (as well as problem definition). Stakeholders should be asked to identify specific problem sites, to comment on the causes of the problems and to provide any supporting reports or background information. It may be useful to review the corridor with the stakeholder using the photolog if time permits.

Potential Stakeholders

Primary Stakeholders	Other Possible Stakeholders
MoT Regions & Districts	Other emergency services (fire & ambulance)
RCMP / Police	School boards
Highway Maintenance Contractor	Trucking association
Local ICBC claims office	BC Transit
Local government staff	BC Ferries
	Railroads
	Airport Authorities
	Cycling Coalition
	MLA and local government elected officials
	Other groups – seniors, physically challenged, equestrian

Potential Stakeholder Questions

Ask stakeholders to provide details of the location and the problem for any of the following which they are aware of:

- Complaints concerning road safety
- High crash locations – provide details of types of collisions, frequency and severity
- Intersections or highway segments which may be poorly designed or require improvement
- Safety problems involving pedestrians, cyclists, or wild animals
- Complaints concerning vehicle travel speeds or driver behavior
- Complaints about the lack of passing opportunities
- Concerns about severe curves, grades or other geometric features
- Road condition problems such as pavement condition, drainage, inadequate shoulders, or high drop-offs
- Safety problems involving heavy trucks, motorcycles, RVs or other vehicle types – provide details of vehicle types
- Weather or seasonal related problems such as fog, ice, rain, or frost creating safety hazards
- Highway sections with inadequate lighting

2.0 Comprehensive Problem Definition

Problem definition is focused on identifying collision patterns or clusters (e.g. locational, direction of travel, collision type, temporal) and then diagnosing the problem to fully understand the root causes/contributing factors. This step is critical, as cost effective options cannot be developed without a full understanding of the root causes of a problem.

It is expected that problem definition will be completed for each safety problem that has been identified in the CMP.

Problem definition involves:

- Collision Data Analysis
- Site Visit
- Geometric Analysis
- Operational Analysis

For some sites a Traffic Conflict Analysis and Human Factor Analysis may also be beneficial.

Important reference documents:

1. Canadian Guide to In-Service Road Safety Reviews, TAC, January 2004
2. Highway Safety Manual, AASHTO, 2010

2.1 Collision Data Analysis

2.1.1 Collision Diagram

A collision diagram should always be prepared as it can quickly identify some of the key collision patterns and clusters at the site.

2.1.2 Basic Safety Performance Measures

The basic safety performance measures of collision frequency, rate, density, and severity should be calculated for the collision prone site and compared to the larger homogeneous segment, the entire corridor, and the province (for the same service class). Table 1 provides an example. The comparisons in Table 1 are designed to identify the specific safety performance measures in which the CPL/CPS is deficient, and to provide an estimate of the magnitude of the deficiency.

Table 1 – Comparison of Basic Safety Performance Measures

Safety Performance Measure	**Collision Prone Section**	**Comparison Groups (trend or averages)** [1]			**Deficient**
		Segment	**Corridor**	**Provincial**	
Collision Frequency (Trend)[2]	increasing	increasing	constant	decreasing	n-y-y
Collision Rate (coll./ MVkm)	1.7	1.2	1.0	0.8	y-y-y
Collision Density (Coll. / km / yr)	3.2	2.7	2.3	1.1	y-y-y
Collision Severity (CSI)[3]	5.1	5.9	6.2	5.1	n-n-n

1. Data used to calculate values for the comparison groups must be consistent with the specific CPL or CPS that is being analyzed. For example, if a collision prone location is a signalized intersection, then only signalized intersection collision data on the segment, corridor and provincially should be used.
2. Collision frequency trend is a measure of whether the collision frequency is increasing, decreasing or remaining constant over time. A minimum of 3 years of data should be used.
3. CSI = [100x(#fatals) + 10x(#injury) + #pdo] / [#fatals + #injury + #pdo]

2.1.3 Collision Distribution Patterns

For a variety of collision data categories, the proportion of all collisions is calculated for the collision prone site and compared to the larger homogeneous segment, the entire corridor, and the province (for the same service class). Table 2 provides an example using some of the collision data categories that are most frequently over-represented.

Table 2 - Comparison of % of Total Collisions for Different Collision Data Categories

Collision Data Category		Collision Prone Section	Comparison Groups (averages)[1]			Significant[2]
			Segment	Corridor	Provincial	
Temporal	August	29%	8%	11%	10%	y-y-y
	Wednesday	29%	10%	12%	13%	y-y-y
Collision Type	Rear End	33%	9%	25%	29%	y-n-n
	Intersection-Turning	24%	5%	19%	24%	y-n-n
	Off - Road	24%	47%	38%	33%	n-n-n
Location Type	At Intersection	52%	21%	28%	31%	y-y-y
	Between Intersection	33%	59%	51%	48%	n-n-n
Contributing Factors	Driver Error	71%	68%	73%	65%	n-n-n
	Undue Care	48%	24%	31%	23%	y-y-y

1. Data used to calculate values for the comparison groups must be consistent with the specific CPL or CPS that is being analyzed. For example, if a collision prone location is a signalized intersection, then only signalized intersection collision data on the segment, corridor and provincially should be used.
2. A description of the Chi-Squared Test of Statistical Significance as applied to Table 2 is provided at the end of these Guidelines.

2.2 Site Visit

The drive-through safety review team should strive to visit each collision prone site that has been identified to try to determine what may be contributing to the problem, and to record initial ideas on option development.

The reviewers should consider key factors such as lighting (daytime, sunrise/sunset, nighttime), weather (dry, wet, icy pavement; rain, fog, snow, wind) and road user profiles. Photos or videos will be useful for later reference.

Other factors to consider:

1. General – landscaping, parking, temporary works, head light glare
2. Alignment & X-Sectn – visibility, sight dist., design speed, overtaking, widths, shoulders
3. Intersections – location, warning, controls, layout, visibility, sight distance
4. Auxiliary & Turn Lanes – tapers, shoulders, signs, turning traffic, visibility, sight distance
5. Non-Motorized Traffic – paths, barriers & fencing, bus stops, elderly & disabled, cyclists
6. Signs and Lighting – lighting, signs, marking and delineation
7. Traffic Signals – operation, visibility, other provisions
8. Physical Objects – clear zone, crash barriers, fencing
9. Delineation – line-marking, guide posts, chevron alignment
10. Pavement – pavement defects, skid resistance, ponding, loose screenings

2.3 Geometric and Operational Analysis

A geometric analysis (e.g. a review of horizontal and vertical geometry, cross-sectional elements, design consistency, etc.) and an operational analysis (e.g. LoS, queue length, volume/capacity, etc.) are two more important analytical tasks that should be undertaken as part of the problem definition phase. TAC's "Canadian Guide to In-Service Road Safety Reviews" provides good guidance on these 2 tasks.

2.4 Stakeholder Consultation

Stakeholder views on problem definition can be sought for both stakeholder identified sites and sites identified by the CIS or the project team. The information is subjective, based on local knowledge, but offers additional information that may not be available from collision data or may not be obvious to a safety analyst unfamiliar with the corridor.

3.0 Option Development

The number of problem sites for which options are developed depends on the CMP budget. It is not expected that options will be developed for every problem site on the corridor in all CMPs. Sites that are not addressed in the CMP should be set aside for future option development and evaluation work.

The development of improvement options should not be constrained by concerns about capital funding availability. The ministry is interested in the best options, not necessarily the least expensive.

Option development must be completed by MOT (preferably with input from ICBC) in conjunction with option development for other corridor problems regarding mobility, reliability and condition. If ICBC has recommended options, they should be used as inputs to the more comprehensive option development and evaluation undertaken by the ministry in the CMP.

Project level option development is the process of developing improvement options that will address the root causes of the problems at the site. For some collision prone sites specific safety countermeasures may be appropriate. For other sites larger capital options may be reasonable to address a combination of mobility, safety, and other issues. Phasing from lower cost options in the short term to higher cost options in the long term should be considered. Option development should also be considered for each homogeneous segment and the entire corridor, if warranted.

4.0 Option Evaluation

Although *option development* should not be limited to any particular funding program (i.e. capital, rehabilitation, maintenance), *option evaluation* in a CMP should generally be limited to capital improvements. Recommended rehabilitation, maintenance and other non-capital safety improvements need not be evaluated, but should be clearly summarized so that they can be used as inputs to these other programs.

Evaluation of capital improvement options at each site should be completed by MoT (or their consultant) using the ministry's Multiple Account Evaluation (MAE) framework. MAE requires the estimation of costs, benefits, and impacts (social, environmental, and economic development) for each option to highlight the differences between options.

Guidelines and tools on MAE and benefit cost analysis can be found on the ministry's Internet website. The ministry's Safety-BenCost spreadsheet tool is based on the ministry's Collision Prediction Model and Collision Modification Factor documents, and is recommended for estimating the safety benefits of highway improvements.

The Chi-Squared Test of Statistical Significance as Applied to Table 2 of these Guidelines

The Chi-Squared test value is calculated using the following equation.

$$X^2 = \frac{(x - \overline{p}\,n)^2}{\overline{p}\,n} + \frac{[(n - x) - n(1 - \overline{p})]^2}{n(1 - \overline{p})}$$

Where: X^2 = Chi-Squared test value
p = the segment, corridor or provincial average proportion for the collision data category being investigated
x = the frequency at the site for the category being investigated
n = the total number of collisions at the site

Confidence Level	Critical X^2 Value
95.0%	3.84
97.5%	5.03
99.0%	6.64
99.5%	7.88

If the calculated Chi-Squared test value X^2 exceeds the Critical X^2 value for a given confidence level then the collision data category under investigation is significantly over-represented at the site for that confidence level.