Guidelines
Corridor Management Plan Safety Reviews

Introduction

These guidelines were prepared in response to the realization that, although ICBC sponsored highway corridor safety analyses were making good recommendations over the past several years, they were not meeting all of MoT's Corridor Management Plan (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 relevant 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. A description of the recommended approach follows.

Note that MoT and ICBC policy is to use the term "collision" or "crash" rather than "accident", since "accident" implies that nothing could have been done to prevent the incident.

Overview of the CMP Safety Review Process

A comprehensive CMP safety review involves the review and analysis of all available data and information necessary to carry out the following 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 other impacts of each option?)

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

1. Corridor
2. Homogeneous section
3. 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 may fall into the following categories:

1. Capital: short term (0 to 3 years), medium term (4 to 10 years) and long term (11 to 25 years)
2. Rehabilitation
3. Maintenance
4. Non-construction/engineering improvements

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.

These guidelines should be used in conjunction with the "Interim Highway Safety Program Manual" (available through the Engineering Branch), and the MicroBENCOST Guidebook, Highway Planning Branch.

CMP Safety Review Guidelines

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

1. Comprehensive problem identification
2. Comprehensive problem definition
3. Option development – for as many problems as time and budget permit
4. Option evaluation

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.

1.0 Comprehensive Problem Identification

The objective of this first step is to develop a comprehensive list of specific locations (e.g. intersections) and highway segments where a safety problem exists. Problems are identified where the safety performance is below acceptable thresholds or where there are other good reasons to believe that a safety problem exists. Additionally, the safety performance of homogeneous highway sections and the corridor as a whole should be investigated. It is important to emphasize that this step only includes the identification of problem sites. It does not include an investigation into the cause of the problems. A number of primary screening tools are recommended in order to develop a comprehensive list.

1.1 Highway Accident System – Collision Prone Locations (CPL) Program and Collision Prone Sections (CPS) Program

The ministry's Highway Accident System (HAS) is the principle source of collision data for highway corridors. The HAS 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 HAS for identifying safety problem sites are the Collision Prone Locations (CPL) program and the Collision Prone Sections (CPS) program.

- The CPL/CPS programs produce a list of locations (i.e. stop and signal controlled intersections) and a list of highway sections (minimum 1km in length) where the following deficiency criteria are met:

Collision rate ≥ critical collision rate (defined below)
OR
Collision severity ratio ≥ threshold collision severity ratio (typically 8.0)
AND
Collision frequency ≥ threshold collision frequency (typically 3 collisions/yr)

- These programs do not have to be run for each CMP because base provincial CPL/CPS lists have already been produced and are available for use.
- Separate CPL/CPS lists may be created locally using different time periods (three year minimum) and modified thresholds if too few sites are provided in the provincial lists. Local thresholds that differ from base provincial thresholds should be clearly identified.
- It is recommended that a minimum of 3 years and maximum of 5 years of collision data be used.
- There is a need to manually check the traffic volumes used by the HAS because there have been some accuracy problems. Better volume data can be input into the HAS to improve the collision rate calculations or the collision rate for each CPL/CPS can be manually reviewed and adjusted if necessary outside of the HAS.

Critical Collision Rate

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

For a highway section:

Critical Collision Rate (c/mvk) = $[E + (K \times \sqrt{\frac{E \times 1{,}000{,}000}{A \times B \times D}}) + (\frac{500{,}000}{A \times B \times D})]$

Where:

c/mvk = collisions per million vehicle kilometres
A = section length (km)
B = total number of days in time period used to calculate the collision rate at the site
D = AADT (averaged over time period used to calculate the collision rate at the site)
E = Provincial average collision rate (in c/mvk) for the highway service class of the section under investigation and for a time period consistent with the time period used to calculate the collision rate at the site
K = statistical constant for desired level of confidence

K	Confidence
3.719	99.99%
3.290	99.95%
3.090	99.90%
2.576	**99.50%**
2.326	99.00%
1.645	95.00%

For a location the equation is similar except that the value for ‘A’ is set to 1.

1.2 HAS Counter-Measure Based Approach to Identify other CPLs and CPSs

The counter-measure based approach to identify CPLs and CPSs searches for locations which have an over-representation of one or more collision types. It is recommended that this utility of the HAS be run for all collision types, resulting in a second list of CPLs and CPSs. A base provincial list using the counter-measure utility does not currently exist (July 2004).

1.3 Homogeneous Sections Safety Performance

In the course of developing a corridor management plan, 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 homogeneous 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.

1.4 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.

1.5 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 locations, to comment on the causes of the problems and to provide any available 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 specific groups, e.g. seniors, physically challenged, equestrian etc.

Possible stakeholder questions:

1. Are you aware of any complaints concerning road safety along Highway XX in your jurisdiction? (If yes, please provide details of location(s) and complaint(s)).

2. Are you aware of any high crash locations along highway XX in your jurisdiction? (If yes, please provide details of location, types of collisions, frequency and severity).

3. Are you aware of any intersections or sections of roadway along Highway XX in your jurisdiction that you feel are poorly designed or require improvement? (If yes, please provide details of location and problems).

4. Are you aware of any safety problems along Highway XX in your jurisdiction involving pedestrians, cyclists, or wild animals? (If yes, please provide details of location(s) and problem(s)).

5. Are you aware of any complaints concerning vehicle travel speeds or driver behavior along Highway XX in your jurisdiction? (If yes, please provide details of location).

6. Are you aware of any complaints about the lack of passing opportunities along Highway XX in your jurisdiction? (If yes, please provide details of location).

7. Are there any concerns about severe curves, grades, or other road geometry along Highway XX in your jurisdiction. (If yes, please provide details of location and concerns).

8. Are you aware of any road condition problems such as pavement condition, drainage, inadequate shoulders, or high drop-offs along Highway XX in your jurisdiction? (If yes, please provide details of location and problem).

9. Are you aware of any safety problems involving heavy trucks, motorcycles, RVs, or other vehicle types along Highway XX in your jurisdiction? (If yes, please provide details of vehicle type, location and problem).

10. Are you aware of any weather or seasonal related environmental problems such as fog, ice, rain, or frost creating safety hazards along Highway XX in your jurisdiction? (If yes, please provide details of location and problem).

11. Are you aware of any sections along Highway XX in your jurisdiction which are poorly lit? (If yes, please provide details of location and problem).

Some safety concerns identified may not require immediate action but continued monitoring of the situation may be justified.

2.0 Comprehensive Problem Definition

Problem definition is the process of carefully studying the previously identified safety problems to fully understand their magnitude and root causes. Sources of information include the HAS collision database, a visit to the site, and consultation with local stakeholders. This step is critical, as cost effective options cannot be developed without a full understanding of the root causes of the identified problems.

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

Where time and resources allow for it, Interim Highway Safety Program Manual Appendices D, F and G could be used as a reference for appropriate statistical tests to identify collision patterns and to provide linkage to suitable countermeasures. Appendix E of the Manual provides a format for recording information from the drive-through review. Appendix Q provides guidelines on special studies which may be required to identify collision patterns.

2.1 CPL and CPS

For each CPL/CPS, conduct a detailed analysis of the collision data from the HAS to gain a better understanding of the magnitude and causes of the safety problems. The analysis involves comparing each CPL/CPS to 3 different comparison groups. The 3 comparison groups are the larger homogeneous segment, the entire corridor, and the province (for the same service class). Comparisons are made for a number of different performance measures that fall into 2 general categories.

The first category consists of the basic safety performance measures: collision frequency, rate, density and severity. 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 (Acc. / 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]

The second category of performance measures is simply the percentage of total collisions. For each CPL/CPS, the percentage of total collisions is calculated under different collision data categories and compared to the segment, corridor and province. Table 2 provides an example using the collision data categories that are most frequently over represented. Note that all collision data categories should be investigated for any given CPL/CPS. Detailed information for the calculations is obtained from the HAS reports.

The comparisons in Table 2 are designed to isolate the specific causes of the safety problems at each CPL/CPS.

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 attached to these Guidelines.

2.2 Counter-Measure Based CPL and CPS

The CPL and CPS lists from the counter-measure based approach represent sites where a specific collision type has occurred more frequently than expected. Refer to the 'meaning of codes' provided in the HAS output to determine which collision types are over-represented at each CPL and CPS. A detailed review of each CPL and CPS using Table 1 and Table 2 above is still required since over-representation in the counter-measure approach is limited to collision type.

2.3 Homogeneous Sections

For each homogenous section brought forward from the problem identification stage, a detailed review should be carried out to determine if any specific causes are prevalent that may not have been uncovered through the CPL and CPS review. Again, the format presented in Table 1 and Table 2 above should be used.

2.4 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.

1. Problem Identification –
   a. confirm that the initial problem identification list is reasonable
   b. identify additional sites that may be hazardous
2. Problem Definition –
   a. define what may have caused the previously identified problems
   b. define the specific hazards at the newly identified sites
3. Option Development – record initial ideas on option development

Suggested participants include the MoT District Highways 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. Wherever possible, the reviewers should consider key factors such as lighting (daytime, sunrise/sunset, night), weather-related conditions (dry, wet, icy pavement; rain, fog, snow, wind) and road user profiles. Photos or videos could be useful for later reference.

Other factors to note, based on a procedure used in Australia, include:

1. General Topics – landscaping, parking, temporary works, head light glare
2. Alignment and Cross Section – visibility, sight distance, design speed, overtaking, widths, shoulders
3. Intersections – location, warning, controls, layout, visibility, sight distance
4. Auxiliary Lanes and Turn Lanes – tapers, shoulders, signs, turning traffic, visibility, sight distance
5. Non-Motorized Traffic – paths, barriers and fencing, bus stops, elderly and 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

For additional significantly hazardous sites that have been identified by the drive-through process, a detailed analysis of the collision data should be carried out using Table 1 and Table 2 above.

2.6 Stakeholder Consultation

Stakeholders should be consulted to identify and define safety problems along the corridor. Refer to the sample stakeholder questions listed under the Problem Identification Section. The information is subjective, based on local knowledge, but offers additional information that may not be available from collision data. For any significant new sites identified by stakeholders, a detailed analysis of the collision data should be carried out using Table 1 and Table 2 above.

In addition, stakeholders can be asked to comment on the safety problems that have been previously identified through the HAS (i.e. CPL, CPS and Homogeneous Sections). Comments on possible causes should be summarized together with the detailed collision analysis (Table 1 and Table 2) to support problem definition.

3.0 Option Development

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

Option development is the process of formulating road safety improvements that will address the causes of collisions or the perceived safety problems at the sites identified on a corridor. All relevant and feasible options need to be considered for each problem site. Creative and innovative thinking are essential to develop a wide range of possible solutions for subsequent evaluation. Phasing from lower cost options in the short term to higher cost options in the long term should also be considered. The development of good options depends on good problem definition (i.e. an understanding of the root causes of the problems).

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. Option recommendations from ICBC should be used as input to the more comprehensive option development and evaluation undertaken in the corridor management plan.

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

For each option make a note of its effectiveness in terms of collision mitigation and the source for the information. Some possible sources include TRB-Special Report 214 Designing Safer Roads, KW Ogden Safer Roads, TAC Safety Analysis of Roadway Geometry and Ancillary Features, MoT Interim Guidelines for Geometric Improvements for Rehabilitation of Existing Highways and Roads, MoT Interim Highway Safety Program Manual – appendix F and G, TEC National 3R/4R Guidelines.

4.0 Option Evaluation

Option evaluation is the process of estimating the costs, benefits and other impacts of each option to highlight the differences between options for any given problem site.

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

Evaluation of capital improvement options should be completed by MoT (or their consultant) using the Multiple Account Evaluation (MAE) framework. Guidance on MAE, and benefit cost analysis using the MicroBENCOST software, can be found in:

- Ministry Document: Business Case Requirements for Capital Program Development
- MicroBENCOST Guidebook

Any capital improvement options that are expected to be funded out of the Highway Safety Improvement Program (which is typically cost shared with ICBC) require a benefit cost evaluation using the ICBC methodology.

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.

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

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

An X^2 value for a given collision data category that exceeds the standard X^2 value of 7.88 at the 99.5 percent significance level for one degree of freedom indicates a significant over-representation of the collision data category at the location.