CANADIAN ROAD ASSESSMENT PROGRAM (CanRAP)  
FEASIBILITY STUDY

Data Collection & Analysis

TRANSPORT CANADA

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1. INTRODUCTION

Road Assessment Programs use a systematic analysis of road segments to address safety shortcomings, mitigate risks and inform drivers about the safety of the roads they travel. The objective of the Canadian Road Assessment Program (CanRAP) Feasibility Study, which emulates the International Road Assessment Program, was to test the feasibility of instituting a Canadian Road Assessment Program, using data from the three provinces (British Columbia, Alberta, and Saskatchewan).

This report summarizes the results and findings of the review of information, and the review and definition of Canadian data for CanRAP.

Section 2 of the report provides a summary of the RISK Mapping methodologies used by the different Road Assessment Programs (RAPs) that are deployed around the world. The summary includes the review of collision data, traffic volume data, methodology for each RAP. At the end of the section, a discussion is provided on our assessment of the RISK Mapping protocol used in RAPs.

Section 3 of the report provides a summary of the STAR Rating methodologies used by the RAPs around the world. It includes information on the data elements, data collection, and methodology. A discussion is provided at the end of the section on our assessment of the STAR Rating protocol deployed in the RAPs.

Section 4 of the report provides a discussion on the relationship between the RISK Mapping and STAR Rating protocols as interpreted by the RAPs and by the consultant team. This will influence the direction of future stages of this feasibility study.

Section 5 is a summary of the findings from workshops with British Columbia, Alberta, and Saskatchewan. This defines a potential Canadian data assessment and provides the consultant with important information on whether the Road Assessment Program is feasible from a technical standpoint in Canada.
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2. SUMMARY OF RISK MAPPING METHODOLOGIES

This section provides a brief summary of the methodologies used for the RISK Mapping component of the different Road Assessment Programs (RAPs) that are deployed around the world. The foundation of the RISK Mapping is based on the historical collision frequency on roads, with the collision frequency represented by several indicators (collision density, collision rate, etc.). Included in this review are the following RAPs:

1. Australian Road Assessment Program (AusRAP)
2. European Road Assessment Program (EuroRAP)
3. United States Road Assessment Program (usRAP)
4. International Road Assessment Program (iRAP)

2.1 AUSTRALIAN ROAD ASSESSMENT PROGRAM (AusRAP)

Similar to other RAPs, AusRAP’s RISK Mapping is based on the historical collision frequency and the traffic flow data. RISK Maps illustrate a road’s safety performance by measuring and mapping the number of casualty collisions on a route.

2.1.1 COLLISION DATA

The casualty collision data is supplied by State and Territory road authorities and includes detailed information on each casualty collision, including the collision date, location, severity, type, the number of people killed or injured, and the speed zone in which the collision occurred.

AusRAP has assessed roads according to ALL casualty collisions, rather than only serious casualty collisions as used in other RAPs. In Australia, a casualty collision is defined as being any collision in which at least one person is killed or injured (as opposed to seriously injured). This decision was made on the basis that there is not a functionally consistent definition of serious casualty collisions across jurisdictions. Hence, as AusRAP is a national program, the use of serious injury collisions would not provide a reliable basis for analyses.

AusRAP also thought that there might be the possibility that casualty collisions are also inconsistently defined between jurisdictions. To test whether or not this is the case, they examined the ratio of fatal collisions to injury collisions between jurisdictions. Since fatal collisions are consistently defined among the jurisdictions, it was expected that the ratios would be similar if injury collisions were also consistently defined. The ratios ranged from 0.017 in Western Australia to 0.023 in New South Wales. Based on this small range of ratios and given the lack of alternatives, AusRAP assumed that the use of casualty collisions provided a reasonable basis for analyzing collisions.
2.1.2 Traffic Volume Data

The traffic volume data for AusRAP was also supplied by the various road authorities. In general, the data was provided in the annual average daily traffic (AADT), although some data was given in axle-count format. In this case, an estimate of AADT was calculated based on an assumed average of 1.0 to 1.1 axle pairs per vehicle. On routes carrying a high volume of heavy vehicles (which is often the case on the National Network), a higher average of up to 1.3 axle pairs per vehicle is used.

The way in which the traffic data was supplied by the road authorities varied. In some cases, the traffic data was supplied in “traffic estimate sections” whereby traffic volume was allocated to a specific length of road. In other cases, the traffic data was provided as point estimates (i.e., the traffic volume at a specific location along the road). If point data was supplied, an additional level of analysis was required to allocate the traffic volumes to lengths of road.

2.1.3 Methodology

2.1.3.1 Road Classification and Segmentation

Using this collision and traffic volume data, RISK Maps were produced by following a number of steps. Initially the highway network was divided into a series of ‘links’, using the following four criteria:

- Links should have a collision frequency of at least 20 casualty collisions in 5 years;
- Links should be meaningful to road users (identifiable start and end locations);
- Links should have broadly similar characteristics; and
- Links should be rural and have a speed limit greater than 90 km/hr, although some lower speed roadways were also included.

The link length varied and was based in recognizable start and end points. The lengths ranged from approximately 10 to 100 km in the more populated areas and could be as high as 600 km in very rural / undeveloped areas. With the highway links defined, the next step was to obtain the number of collisions that occurred along each link over a five-year time period. This data was obtained from the various collision databases in the different jurisdictions throughout the country. Care was needed to ensure that only the collisions within the defined highway link were included in the selection process.

A traffic volume for each highway link is also estimated. To accommodate the possibility that the traffic volumes supplied by the jurisdictions might vary within a link, a weighted average of a number of volumes reported on a link is calculated for each link, based on the road length that the volume is applied. This traffic volume was calculated as follows:
Weighted AADT estimate = \[ \frac{\sum (\text{AADT}_i \text{L}_i)}{\text{L}} \]

Where: \( \text{AADT}_i \) = average daily traffic volume on sub-section i; 
\( \text{L}_i \) = length of sub-section i; and
\( \text{L} \) = length of link.

Because of limitations in the availability of data, traffic volumes from the middle year of the collision data sample period were used in calculating collision rates. For example, when the collision period was from 1999 to 2003, traffic volumes from the year 2001 were used. In cases where traffic data from that particular year was not available, data from adjacent years is adjusted according to aggregated, compound growth rates.

2.1.3.2 Safety Performance Measures

Using this information, two types of collision rates were calculated for each link. The first is known as the \textit{individual risk}, which measures the average annual number of casualty collisions per 100 million vehicle kilometres travelled (100 MVKm). By controlling for varying traffic volumes, this measure essentially represents the risk that individual drivers face on a length of road. The \textit{individual risk}, or collision rate is given by the following:

\[ \text{Individual Risk} = \frac{\text{casualty collisions} \div \text{N}_y}{\frac{365 \times \text{L} \times \text{AADT}}{100,000,000}} \]

Where: \( \text{N}_y \) = number of years (five); 
\( \text{L} \) = length of link; and,
\( \text{AADT} \) = weighted AADT estimate for link.

The second measure of risk is known as \textit{collective risk}, which measures average annual number of casualty collisions per kilometre of road (per km), which could also be referred to as a collision density measure. \textit{Collective Risk} represents the total risk along a length of road, as opposed to the risk faced by each individual driver and is given by the following expression:

\[ \text{Collective risk} = \frac{\text{casualty collisions} \div \text{N}_y}{\text{L}} \]

Where: \( \text{N}_y \) = number of years (five); and,
\( \text{L} \) = length of link.

With the risk of a casualty collision for each link (individual and collective), the links were then assigned a risk rating. The risk ratings were determined using the results published in the 2004 AusRAP report, entitled \textit{How Safe Are Our Roads?} The results were allocated to 1
of 5 bands, each representing 20% of the entire highway system (Table 1). The five relative risk categories were colour coded and used in the maps to highlight different levels of risk. Note that both individual and collective risks are made public. A link can only be defined if it meets the criteria of 20 collisions in 5 years. If a segment of highway has less than this threshold, it cannot be defined as a link. Instead it is expanded (lengthened) until the collision threshold is achieved. This criterion is a reflection of the fact that the actual number of crashes that occurs on any given length of road at a given time is highly variable. The selection of 20 crashes as the minimum represents an attempt to find a balance between the probability that a link might be misclassified because of this variation, and the need for road links to have meaningful and useful lengths.

Table 1. AusRAP Risk Categories

<table>
<thead>
<tr>
<th>Risk Rating</th>
<th>Percentage Of Links</th>
<th>Collective Risk (Per Km)</th>
<th>Individual Risk (Per 100 MVKm)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Best 20%</td>
<td>0.00 to &lt;0.03</td>
<td>0.00 to &lt;6.85</td>
<td>Dark Green</td>
</tr>
<tr>
<td>Low / Medium</td>
<td>0.03 to &lt;0.10</td>
<td>6.85 to &lt;9.56</td>
<td>Light Green</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Middle 20%</td>
<td>0.10 to &lt;0.17</td>
<td>9.56 to &lt;12.34</td>
<td>Yellow</td>
</tr>
<tr>
<td>Medium / High</td>
<td>0.17 to &lt;0.29</td>
<td>12.34 to &lt;16.44</td>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Worst 20%</td>
<td>&gt;0.29</td>
<td>&gt;16.44</td>
<td>Black</td>
</tr>
</tbody>
</table>

Finally, an analysis of the different types of collisions that occurred along each link was conducted. Analyzing the collision type can provide meaningful insight into the ways to prevent casualties. The meaning and definitions of collision types can vary between regions and care must be used to develop a consistent set of collision types that will be applicable for all regions. AusRAP presents the RISK Maps according to the 5 quintiles, but also provide a pie chart (by highway) showing the breakdown of collision types. AusRAP used the following collision types in their assessment:

1. Run off road on straight;
2. Run off road on curve;
3. Head on;
4. Rear end;
5. Intersection; and
6. Other (includes collisions involving u-turns, parking, pedestrians and cyclists).

2.1.4 SUMMARY

AusRAP has proven to be successful in producing national RISK Maps, while overcoming some normal obstacles in this type of endeavour. Most obstacles were associated with the assembly and interpretation of the required data, as well as the variability of the
data between the different jurisdictions. Some of the most important issues associated with AusRAP include:

1. Definition of casualty collisions;
2. Establishment of AusRAP roadway ‘links’;
3. Definition of collision types;
4. Accuracy of the location of collisions on the network;
5. Accuracy of the traffic volume information; and,
6. Assignment of traffic volumes.

Overall, the AusRAP has shown that RISK Mapping has the potential to provide an insight into how well, or how poorly, a length of rural road is performing relative to the rural road network in terms of roadway safety, as measured by casualty collisions. However, it was noted that the RISK Maps only provide a limited insight into the contribution that the actual road infrastructure has with respect to individual or collective safety risk.

2.2 European Road Assessment Program (EuroRAP)

EuroRAP is similar to the other RAPS in that the basis for the RISK Mapping is the collision frequency and the traffic volume. Unlike some of the other RAPs, EuroRAP also has an indicator that reflects the potential improvement level for each section of roadway. This indicator is converted into an economic safety benefit or in essence, the potential for a reduction in collisions is converted into collision cost savings. The details of EuroRAP related to the RISK Mapping are provided in the following sections.

2.2.1 Collision Data

The RISK Mapping component in EuroRAP is based on fatal and serious injury collisions only (i.e., moderate injury and low injury are not included\(^1\)). Fatal and serious injury collisions are considered together because both are considered to be unacceptable outcomes for collisions. Considering fatal collisions alone would significantly restrict the average collision frequency per site and as such, make the results more variable. There were also some concerns that differences in the definition of a fatal collision between European countries (i.e., based on the maximum elapsed time between the collision and death) could ultimately bias results if the fatal collisions alone were used. In EuroRAP’s approach, it is likely that victims who survive an extended time period after the collision and then die would still be classified as serious injury collision and therefore, would still be included in RISK Mapping.

\(^{1}\) Some European countries are using all injury collisions for their RAPs rather than just serious injury collisions, in implementing EuroRAP. This is done either because serious and minor injury collisions cannot be separated within the data (e.g., Italy) or because average collision frequencies per section are so low that larger collision sample sizes are considered desirable (e.g., Ireland).
There are some significant differences in the definition and reporting of fatal and serious collisions across Europe and as such, the raw data collated for each country is adjusted to allow for meaningful comparisons of relative safety risk between countries. In order to normalize the severe collision data in Europe, different thresholds for each risk rate banding are used (low, low-medium, medium, medium-high, high), which is similar to the banding used by AusRAP. This adjustment is based on the ratio of the number of fatal collisions to the number of collision type (for example, fatal and serious, or all injury) collected for that country. The aim of this adjustment was not to change one country’s collision reporting practice to fit that of another, nor was it to artificially increase or reduce collision rates in any country. The adjustment simply gives a better estimate of the relative long-term collision rate for each link within a national network.

Collision data was obtained from the various road authorities of the European countries participating in EuroRAP. Assembling and compiling the data was a considerable effort of the project.

2.2.2 Traffic Volume Data

Another important input for the RISK Mapping component of EuroRAP is the traffic volume data, as it is used in the calculation of some of the safety performance measures. The traffic volume data was assembled from participating countries and if required, was converted into an average annual daily traffic (AADT) volume. Presumably, there was considerable data checking and manipulation to ensure that traffic volumes were suitably accurate.

2.2.3 Methodology

2.2.3.1 Roadway Classification and Segmentation

A typical EuroRAP road section is approximately 20 kilometres long and will have, as a minimum, 20 deaths and serious injuries over a 3-year time period. However, this target was modified as necessary to ensure that the road links selected were meaningful and distinct to the road-users (e.g., the start and end points are at identifiable locations). In addition, the links should have similar characteristics along their entire length, such as single lane or dual carriageway.

Some short sections and some sections that carry low traffic volumes did appear in the sample. These short sections (e.g., less than 5 kilometres), those that have low collision totals (e.g., less than 7), or carry low traffic volumes (e.g., less than 3,000 vehicles per day)

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2 In populous countries such as Britain, the target criterion of 20 fatal and serious injury collisions in three years per section could be met in most cases. However, in Sweden, where traffic volumes are lower, the route segments chosen experienced an average of only five fatal and serious injury collisions in three years.
are more likely than others to experience greater year-to-year variation in the collision rate and are therefore more likely to change risk rating from one time period to another.

EuroRAP’s participating countries also used a consistent classification scheme to define the performance on the roads. The following categories were used to classify rural road sections by road design type:

- Freeways;
- Other divided roads;
- Mixed design roads;
- Four-lane undivided roads;
- 2+1 roads (two-lane highway with continuously alternating passing lane);
- Two-lane roads (perhaps classified by pavement width); and,
- Other roads.

2.2.3.2 Safety Performance Measures

EuroRAP’s RISK Mapping protocol has a total of four safety indicators that are based on the road network, the collision frequency and traffic flow. The four-safety indicators are listed below.

1. Risk per kilometre;
2. Risk per vehicle kilometre travelled;
3. Risk in relation to roads with similar flow levels; and,
4. Economic potential for collision reduction.

The intent of EuroRAP’s RISK Maps is to effectively illustrate the risk of an individual road-user, or to the community as a whole, being involved in a road collision. This is a similar concept to that used in AusRAP, where safety risk is disaggregated by ‘individual risk’, as well as the ‘collective risk’.

Individual Risk

Based on the historical collision data and the traffic volume data, EuroRAP’s RISK Maps shows a road’s safety performance by measuring and mapping the rate at which people are being killed and seriously injured.

The collision rate (collisions per 100 million vehicle kilometres travelled) is used to show the likelihood of a road-user being involved in a collision. According to the EuroRAP, the main purpose of this Map is to inform the road-user how and where their behavior needs to be modified to minimize risk and, in doing so, enable them to recognize the sources of risk on different sections of road. The collision rate for the ‘individual risk’ is calculated in a similar manner to that as AusRAP and is given as:

\[
\text{Individual Risk} = \frac{\text{fatal + severe casualty collisions / Ny}}{[(365 \times L \times \text{AADT}) / 100M]}
\]
Where: \( N_y \) = number of years (typically 3); 
\( L \) = length of link; and,
\( \text{AADT} \) = weighted AADT estimate for link.

**Collective Risk**

EuroRAP also produces maps that they believe are targeted for the road authorities. The collective RISK Maps show the density of collisions on a road over a given length. EuroRAP documentation states that risk rates shown in these maps are the result of the interaction between all elements of the road system, namely the road-users, vehicles and roads. Collective risk is mapped in three different ways:

1) **Collision Density:** Shows collision rates per kilometre of road, illustrating where highest and lowest numbers of collisions occur within a network.

\[
\text{Collision Density} = \left( \frac{\text{fatal and severe casualty collisions}}{N_y} \right) / L
\]

Where: \( N_y \) = number of years (typically 3); and,
\( L \) = length of link.

2) **Collision Rate in Relation to Similar Roads:** Compares the collision rate of similar roads with similar traffic flows, illustrating which road sections have a higher rate. This requires that the average collision rates by road type and traffic volume range are available. This safety indicator is simply the ratio of calculated collision rate over the average collision rate.

3) **Potential for Collision Reduction:** This indicator provides information on the number of collisions that might be saved if the collision rates of road sections with a risk level above the average collision rate were reduced to an average collision rate. EuroRAP believes that this information can be useful for the road authorities and policy-makers who would be considering investments in road safety infrastructure. This map can indicate locations where the largest return on investment might be expected. This is a theoretical exercise that involves calculating the difference between the safety performance on a link and the average performance. No consideration of effective countermeasures is made. It simply provides an indication of how “deviant” a link is in relation to an established norm.

Using EuroRAP’s RISK Mapping protocol, road sections are colour-coded according to five relative risk bandings indicating their level of collision risk, as shown in Table 2. The five risk bands are shown in the table below. The colour coding is very similar to the AusRAP, however, the stratification of the levels into 20% (quintiles) is not as definitive as the system used in AusRAP (i.e., the values used for the individual and collective safety risk...
assignment). As the range of safety performance in European countries varies, a defined level of safety performance similar to AusRAP is not possible for EuroRAP. EuroRAP uses five quintiles, but the values within each category change for each country.

### Table 2. EuroRAP Risk Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Road links considered to have the safest level of safety</td>
</tr>
<tr>
<td>Low-Medium</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Road links considered to have a moderate level of safety</td>
</tr>
<tr>
<td>Medium High</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Road links considered to be the most hazardous</td>
</tr>
</tbody>
</table>

#### 2.2.4 Summary

Like AusRAP, EuroRAP has proven to be very successful in producing RISK maps for many participating countries. Perhaps the greatest difficulty is obtaining the data necessary to calculate the safety performance measures used in the production of the RISK Maps. EuroRAP offers an enhancement over AusRAP by producing two additional maps, one using the average collision rate (by road type) and traffic volume and the second, which estimates the potential in collision cost savings. Collision types are not used in EuroRap.

Most of the obstacles associated with the EuroRAP project were associated with the assembly and interpretation of the required data. Furthermore, the significant variability of the data between the different participating countries in EuroRAP proved to be a challenge, especially with the significant variability in the safety performance between countries.

Overall, the EuroRAP demonstrated that RISK Mapping for a large area that has highly variable safety performance characteristics is possible. However, similar to AusRAP, it is noted that the RISK Maps provide limited insight into the contributing factors of collisions and how the road infrastructure impacts the individual or collective safety risk.

#### 2.3 United States Road Assessment Program (usRAP)

In general, usRAP has replicated EuroRAP in the production of the RISK Maps. However, usRAP has generated additional maps using similar indicators but isolating the collisions based on the specific interests of local authorities. This could include such safety concerns as excessive speed, alcohol involvement, un-belted occupants, commercial vehicles, older (or younger drivers), and so on. The following provides a general overview of the RISK Mapping elements of usRAP.
2.3.1 Collision Data

For usRAP, it is proposed that the RISK Maps be based (whenever possible) on fatal and serious injury collisions. Where use of the fatal and serious collision data is not possible, RISK Maps based on fatal and all injury collisions could be considered. The collision data was collected from the various states, normally from the State DOT, and often the collision data was geo-coded which easily facilitated the mapping requirement.

Typically, five years of collision data were used for usRAP since the traffic volume levels on US highways are typically lower than on European highways. In some States, it might be possible to use only 3 years of collision data, if there is sufficient sample to generate meaningful results for the RISK Maps.

2.3.2 Traffic Volume

Similar to the other RAPs, the traffic volume data for usRAP was provided by the various state DOTs or appropriate road authority. The average annual daily traffic (AADT) volume was used for the usRAP. The process to gather the data from each state involved in the piloting of usRAP is varied, but in each case, the traffic volume data was available and it was noted that is likely that the traffic volume would be available for all states.

2.3.3 Methodology

2.3.3.1 Roadway Classification and Segmentation

There is some variability between the different States concerning the classification and segmentation of the road links. As an example from Florida, the roads were classified into four road design types including the following:

- Freeway;
- Multilane divided;
- Multilane undivided; and,
- Two-lane roads.

In Florida, the road type definition was based on:

- Access control;
- Median type; and,
- Number of lanes.

Roadway segmentation was based on homogeneity of the segment. Some of the typical characteristics of homogeneity included the following factors:

- Similar county and route number;
- Similar road type;
2.3.3.2 Safety Performance Indicators

usRAP is identical to EuroRAP as it makes use of the same 4 different safety risk measures, which are all based on the observed fatal and serious collision history. Each measure is computed for each road section that makes up the road network under consideration. The four safety measures are used to produce 4 maps, which are listed below together with how the measure is calculated and why it is considered useful.

• Map 1: Collision Density

Collision Density = \( \frac{\text{fatal and severe collisions}}{N_y} \frac{1}{L} \)

Where:
- \( N_y \) = number of years (typically 3); and,
- \( L \) = length of road segment.

Map 1 is considered useful because it presents the actual observed number of collisions per unit-length.

• Map 2: Collision Rate

Collision Rate = \( \frac{\text{fatal + severe collisions}}{N_y} \frac{1}{[(365 * L * AADT) / 100M]} \)

Where:
- \( N_y \) = number of years (typically 3);
- \( L \) = length of link (miles); and,
- \( AADT \) = weighted AADT estimate for link.

Map 2 is considered the basic RISK Map since the fatal and serious injury collision rate on a segment is proportional to the risk of a fatal or serious injury to an individual motorist traveling through the section in question.

• Map 3: Collision Rate Ratio

Collision Rate Ratio = \( \frac{\text{Collision Rate}}{\text{Average Collision Rate}} \)

Where:
- Collision Rate = calculated collision rate on segment; and,
- Ave. Coll. Rate = average collision rate for similar segments.

Map 3 is useful because it compares the collision experience on a specific road with an average collision experience on similar types of roads.
• Map 4: Potential for Serious Collision Reduction

Collision Reduction = (Collision Rate – Average Collision Rate) * Exposure

Where:
- Collision Rate = calculated collision rate on segment;
- Ave Coll. Rate = average collision rate for similar segments;
- and,
- Exposure = million vehicle kilometres travelled.

Map 4 is intended to serve as an indication of the safety benefit that could be achieved if a road section were improved.

Each measure is classified into five categories and displayed on maps using a color-coding system for the five categories (Table 3). Unique to the usRAP is that the relative risk categories are defined so that each category in increasing order of risk contains a progressively smaller portion of the roadway system. Thus, the lowest safety risk roads represent 40% of the total road network whereas the highest risk category on each map includes only 5% of the total roadway length. The risk categories, color coding, allocation are as follows:

Table 3. usRAP Risk Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage of Total Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>40% of Total Length</td>
<td>Road links considered to have the lowest safest risk</td>
</tr>
<tr>
<td>Low-Medium</td>
<td>25% of Total Length</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>20% of Total Length</td>
<td>Road links considered to have a moderate safety risk</td>
</tr>
<tr>
<td>Medium High</td>
<td>10% of Total Length</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>5% of Total Length</td>
<td>Road links considered to have the highest safety risk</td>
</tr>
</tbody>
</table>

The intent of this approach is to focus attention on the road sections with the greatest potential for safety improvement. This approach ensures that there will always be at least 5% of all roadways that are considered to be “high” risk. In addition, the “high” risk category is consistent with the SAFETEA-LU mandate, in which each State should identify the top 5 percent of locations with the most severe safety needs, which may receive federal funding for improvements.

2.3.4 Summary

The RISK Mapping for usRAP has been successfully tested in at least four different states, with all four RISK Maps being produced. The usRAP mimics the EuroRAP in terms of the relative safety performance indicators used, the focus on rural roads, and the use of
casualty collision data. However some additional maps were produced to support the needs of participating states, such as safety concerns related to excessive speed, alcohol involvement, un-belted occupants, commercial vehicles, older (or younger drivers), and so on. These maps were produced by simply isolating these collision types from the total collision data set.

Several important considerations and questions have been identified by usRAP, as listed below, which could influence other RAPs, including CanRAP:

- While multiple maps describing the safety risks on specific road sections might be useful for safety professionals, the general public is likely to be confused if maps with more than one risk measure are presented. For communication with the general public, it is recommended that maps focusing on a single risk measure be used.
- The use of five risk categories, represented on RISK Maps by a defined sequence of five colors, appears appropriate.
- Four road types appear to be appropriate for defining average collision rates for use in preparing Maps 3 and 4. These road types include freeways, multilane divided highways, multilane undivided highways, and two-lane highways.
- Results presented on RISK Maps must be carefully interpreted in order to avoid any suggestion that the display of a road segment in red or black implies that the road segment has a safety problem that is correctable by infrastructure improvement. Some roads shown in red or black on usRAP RISK Maps may have safety concerns that are correctable by road infrastructure improvements and others may not.
- The study period for preparing a RISK Map should be three to five years.
- How should the trade-off between the desire for long road segments and the desire for homogeneous road segments be solved?
- What risk measure should be used in presenting RISK Maps to the general public? The risk measure for Map 2 (fatal-and-serious-injury collisions per hundred million vehicle-miles of travel) appears to be the most appropriate because it represents the risk to an individual motorist in traversing a particular road section. EuroRAP has used Map 2 for this purpose. AusRAP initially released both Maps 1 and 2, but found that the public was confused by differences between the two maps in the risk categories for particular road segments. AusRAP has now focused on Map 1 for public release on the grounds that collision densities would be more easily understood by the general public who may not easily grasp the meaning of a collision rate.
What national benchmark would be appropriate for comparing the safety risk across the nation? Such national benchmarks can probably be developed only if serious injury collision frequencies are uniformly defined for all or most states.

Should usRAP RISK Mapping continue to focus on rural roads or should urban roads be included as well?

Should a greater emphasis be placed on ‘intersection’ RISK Mapping, since a substantial proportion of fatal and serious injury collisions occur at intersections?

2.4 INTERNATIONAL ROAD ASSESSMENT PROGRAM (iRAP)

The International Road Assessment Program (iRAP) was established in 2004 to provide international coordination for all road assessment programs (RAPs). iRAP is intended to serve as an umbrella organization to coordinate AusRAP, EuroRAP and usRAP, as well as providing guidance to the RAPs that are being implemented in other countries.

The fundamentals of the RISK Mapping reported by iRAP should be similar to the existing RAPs (AusRAP, EuroRAP and usRAP). However, the data availability and the data quality in some jurisdictions can be significantly different, which could increase the difficulty in producing the safety risk indicators used in the RISK Maps.

iRAP provides assistance and guidance in developing useful safety indicators for both developed and developing countries, which are interested in implementing a Road Assessment Program. Specifically, iRAP aims to:

- Drive the upgrading of the safety on routes and networks where large numbers are killed and seriously injured
- Generate and prioritise affordable and cost-effective road safety engineering programs using a globally consistent methodology
- Operate on a scale that is cost-efficient and can be project managed to deliver reductions in the cost of collisions
- Provide the methodology and procedures to implement performance tracking so that funding agencies are able understand the outcomes and outputs of their efforts to improve road safety
- Provide training, manuals and web tools to enable national, regional and local capacity building
- Establish regional centres to secure the long-term sustainability of the programme and facilitate knowledge transfer throughout a region
2.5 DISCUSSION

The Road Assessment Program RISK Maps from Australia, Europe and the United States utilize very simple safety performance indicators (e.g., collision density and collision rate) to define the road safety risk levels. There may be two reasons for the use of these rudimentary safety indices. Firstly, the data necessary to deploy a more advanced safety performance methodology may not be readily available or perhaps the compilation of the data to support other safety measures was deemed to be too difficult. Secondly, it might have been the opinion of those responsible for the generation of RISK Maps, that these safety performance indicators would be clearly understood by road-users and that other, more involved safety indicators may not be understood by the motoring public.

It has been clearly documented that there are some limitations with the use of collision frequency / density and collision rate for the accurate assessment of road safety. Some of these limitations are due to the nature of collisions, which are rare and random, particularly if only severe injury and fatal collisions are considered. The use of collision rates can also be problematic, such as the potential for low volume roads to have a high collision rate. Because of the limitations and potential problems with the use of collision rates, many road safety professionals discourage their use.

Other techniques, such as the use of Collision Prediction Models (CPMs) (which are often referred to as Safety Performance Functions (SPFs)) are known to overcome the issues with the use of collision rates. The use of CPMs is becoming the preferred methodology for the assessment of road safety performance and will be the approach advanced in the soon to be released Highway Safety Manual from AASHTO. It is felt that the use of CPMs for CanRAP should be explored for the RISK Maps, as this approach will offer greater confidence in the results.

For all RAPs, rural roads are defined as being those that are outside of cities and significant towns (i.e. inter-urban roads), and have a speed limit of greater than 90 km/h. However, some lower-speed limit sections where these form an integral part of higher speed inter-urban routes are included. It appears that high speed rural roads were selected as they account for a significant proportion of casualty collisions. Urban segments are largely excluded, although some level of urbanization may exist on some links. As well, typical segments are at least 20 kilometres in length and as such, urban segments would not be applicable due to the high variability that could exist within this length.

Europe, Australia and the United States all have well established road safety programs to improve their infrastructure. The various RAPs will help identify and potentially prioritize higher risk location where the road authorities can implement road safety measures through established programs to address the safety problems.
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3. SUMMARY OF STAR RATING METHODOLOGIES

This section provides an overview of the methodology used in AusRAP, EuroRap, and usRAP for the development of the STAR Rating component. AusRAP developed the basic principles and methodology of the STAR Rating system for roads. EuroRAP and usRAP made adjustments to the AusRAP methodology to suit local needs and conditions. The STAR Ratings are based on a concept called “Road Protection Scores (RPS)”, and this concept was the basis of all other STAR Rating schemes for the other RAPs. The objectives and basic principles of the STAR Rating systems is similar for the three RAPs.

The basic STAR Rating methodology is based on an inspection of roads by trained inspectors to determine the level of protection offered to road users from collisions, and whether the collisions would result in deaths and serious injuries, i.e. the survivability of the road user in the case of a collision type identified in the RPS. In most cases, the STAR Ratings are directly sensitive to specific roadway and roadside design features.

The objectives of using STAR Ratings based on RPS are to:

- identify important differences in road design or management which are likely to lead to different probabilities of fatal or serious collisions
- provide ratings based on inventories that can be made either directly during inspection drives, or subsequently from the video of the drive, at reasonable cost

The STAR Rating methodologies were contained in the following documents:

- AusRAP, Star Ratings Australia’s National Network of Roads, October 2006.

3.1 EURORAP

3.1.1 DATA ELEMENTS

The EuroRAP RPS concept was originally developed to address the road design factors that relate to four major collision types, which were identified as the highest priority for safety improvement in Europe. These include:

- head-on collisions;
- single-vehicle run-off-road collisions;
- intersection collisions; and,
- collisions involving vulnerable road users (pedestrians and bicyclists).

It appears that specific criteria that has been (and will be) used by EuroRAP to rate the design features for these specific collision types are still developing and have not yet been finalized. A preliminary set of data elements that have been developed and used for RPS ratings in Europe are shown in Table 4 below.

### Table 4. Summary of Collision Types and Design Elements used in EuroRAP STAR Rating

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Design Element</th>
<th>Specific Issues used in RPS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-on</td>
<td>Median Treatment</td>
<td>Presence of Median, Median Width, Safety Barrier, Centerline Rumble Strips</td>
</tr>
<tr>
<td>Single Vehicle Run-off Road</td>
<td>Roadside Treatment</td>
<td>Safety Barrier, Width of Clearzone</td>
</tr>
<tr>
<td>Intersection</td>
<td>Intersection Treatment</td>
<td>Grade-separated Interchanges, Speed-change Lane Lengths, Roundabouts, Signalized Intersections, Four-leg un-signalized intersections with and without left-turn lanes, three-leg un-signalized intersections with and without left-turn lanes</td>
</tr>
</tbody>
</table>

Although collisions involving vulnerable road users were identified at the onset as a high priority by EuroRAP, it appeared that RPS criteria for vulnerable road users have not been developed or implemented due to the lack of exposure (volume) data.

### 3.1.2 DATA COLLECTION

For EuroRAP, the data used to determine the RPS has been collected using a van equipped with two cameras, one outside the vehicle and one inside the vehicle. Two RAP inspectors are deployed and the inspector records roadway features using a digitize tablet which is linked to the position of the vehicle using GPS as shown in Figure 1.
The recorded features are kept in an MS ACCESS database. Programs in the database are then used to calculate the RPS for each of the three main collision types. This score is then multiplied by the average European weighting factors (i.e. the distribution of head-on, run-off-road, and intersection collisions). The sum of the three scores will then be used to determine the STAR Rating of the road section. The sections are rated with stars – from 1 star (low protection level) to 4 stars (high protection level).

The length of the road sections is defined by the section used for RISK Mapping. For the UK Trial, approximately 6,500 kilometres of roads were inspected (13,000 km in both
The inspection took place between 19 October and 22 December 2006, which means that approximately 200 kilometres of road could be inspected per day.

### 3.1.3 Methodology

RPS ratings on a 1 to 4 scale are determined separately for median features, roadside features on both the right and left sides of the roadway, and the intersection features. The EuroRAP STAR Ratings are assigned as follows:

- 0 to 1.5 rating = 1 star;
- 1.5 to 2.5 rating = 2 star;
- 2.5 to 3.5 rating = 3 star; and,
- 3.5 to 4.0 rating = 4 star.

In general, the RPS ratings are distributed such that the ratings are generally 3 and 4 stars for freeways, 2 or 3 stars for other divided highways, and 1 or 2 stars for two-lane highways. Currently, EuroRAP is considering changing the Star Rating to a 5 star scale to be consistent with other RAPs. Some of RPS rating criteria vary with speed limit. For example, a given road section might be rated as 4 stars with a speed limit of 70 km/h, but it might be rated as 3 stars if it were to have a speed limit of 100 km/h. A Star Rating may be overestimated if the actual speed on the road is significantly higher than the posted speed limit. The following figure (Figure 2) shows the general methodology of the current Road Protection Score RPS and the EuroRAP STAR Rating.

![Figure 2: General Methodology for RPS - EuroRAP](image)
According to EuroRAP and usRAP literature, an “extended” Road Protection Score RPS is currently being developed. Apparently, the “extended” RPS would also account for the probabilistic aspect of a collision occurring rather than the existing process which only includes the consequence component of safety risk.

### 3.2 AusRAP

Using the RPS criteria and principles, AusRAP has developed its own RPS criteria that include collision causation, collision likelihood and collision-severity-increasing factors. AusRAP rationalized the benefit of producing a STAR Rating for roads as a proactive approach to road safety, i.e. relatively high risk roads would be identified before a severe collision occurs.

#### 3.2.1 Data Elements

A road’s STAR Rating is based on an inspection of the design elements which were identified from research and are known to influence the likelihood of collision occurrence and in some cases, the severity of the collisions that do occur. The focus of the AusRAP STAR Rating is on the design elements which influence the three most common and severe collision types on Australian rural highways:

- Run-off road collisions
- Head-on collisions, and
- Intersections collisions

Together, these three collision types account for approximately 75 percent of all collisions on rural highways in Australia. The data elements used by AusRAP to determine the RPS ratings are shown in Table 5.

#### 3.2.2 Data Collection

AusRAP road inspections are being conducted primarily with video data that is collected from additional cameras mounted on the vehicles used in traditional video-logging operations for their asset management purpose.

The data used to determine the RPS was captured using specially equipped vehicles. The vehicles use an array of cameras aligned to pick up various views of the road (forward, rear, side-left and side-right), and record digital images of a road (at 5m to 10m intervals). The vehicles typically drive along the road at normal speed while collecting this data.
Table 5. Summary of Collision Types and Design Elements used in AusRAP STAR Rating

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Design Element</th>
<th>Specific Issues used in RPS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-on and Run-off Road</td>
<td>Median and Roadside Treatment</td>
<td>divided or undivided lane width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sealed shoulder width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>alignment (number and sharpness of curves)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>terrain (flat, rolling or mountainous)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>line marking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>roadside hazards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>safety barriers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>traffic speeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>overtaking provision</td>
</tr>
<tr>
<td>Intersection</td>
<td>Intersection Treatment</td>
<td>type of intersection (over-pass or under-pass, T-junction, cross roads or railway)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>volume of traffic on side road (or railway)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>traffic speeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>alignment of side roads (or railway)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sight distances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>right and left turn provision</td>
</tr>
</tbody>
</table>

The data collected (i.e. digital images) can be streamed together to form a “virtual video” of the road network inspected. Trained inspectors then undertake a desk-top assessment by taking a virtual drive-through of the road network using a software (a proprietary software developed by the ARRB) to measure elements such as lane widths, shoulder widths and distance between the road edge and roadside hazards.

3.2.3 METHODOLOGY

Using AusRAP criteria, the safest roads are likely to be straight divided highways on a flat terrain, with wide lanes and sealed shoulders, safe roadides, few, if any intersections and good pavement markings. The riskiest roads are likely to be two-lane undivided roads with lots of curves in mountainous terrain, with narrow lanes and shoulders, poor pavement marking and severe roadside conditions. Note that the roadside criteria only took into account the presence of hazards, but did not include critical roadside elements such as side slope, height of slope, and width of clear zone.

The RPS approach to assessing the safety of a road was developed by ARRB Group and the Australian motoring clubs. The AusRAP RPS calculates a relative risk score to be determined for each of a road’s design elements. For example, the risk of being involved
in a collision on a road with lanes less than 2.8m wide lanes is 50 per cent higher than on a road with lanes greater than 3.6m wide. In this regard, the use of “risk” accounts for the probabilistic nature of collisions. (Note that some of these factors can be obtained through CMFs contained in the TAC GDG).

An initial RPS is calculated for each of the three main collision types. The scores are based on the various design elements which are weighted according to the relative contribution that each design element makes to the likelihood of a collision. The RPS scores are then adjusted according to the likely severity of a collision. The final RPS is determined using a formula which is based on the run-off road RPS, head-on RPS and intersection RPS for sections of road that are generally homogeneous. These sections can be as short as 200 metres or as long as 100km, depending on the frequency of changes in the design characteristics of the roadway. For highways that are dual, divided carriageway, a RPS is calculated for both directions.

The scores are allocated to one of five STAR Rating bands, with the best performing category given a 5-STAR Rating and the worst performing given a 1-STAR Rating.

For the purpose of generating STAR Rating maps, highways were split into shorter links which are generally defined using two criteria. First, the links should be meaningful and distinct to road users (that is, start and end at identifiable locations). Secondly, since the STAR Ratings often fluctuate over a given length of road, the predominant STAR Rating is assigned to a link. The typical road stereotypes for roads with different STAR Ratings are shown in Table 6.

AusRAP has built a website (http://www.ausrap.org/ausrap/saferroads/) where the general public can change the settings for the various elements of the STAR Rating to see how the STAR Rating changes. Using this website, it appears that the most sensitive roadway elements are whether the roadway is divided (physically) and the presence or absence of roadside hazards. The rest of the elements appear to have relatively little effects compared with these two elements.
### Table 6. Typical roads in each STAR Rating category

<table>
<thead>
<tr>
<th>RPS Score</th>
<th>Typical road</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.05</td>
<td>Straight with good line-marking, wide lanes and sealed shoulders, forgiving roadside and over- or under-pass intersections. No undivided roads can achieve a 5-Star Rating.</td>
</tr>
<tr>
<td>1.05-4.0</td>
<td>Minor deficiencies in some road features such as lane width, shoulder width, curves or roadside. Straight with good overtaking provision, good line-marking and forgiving roadside.</td>
</tr>
<tr>
<td>4.0-10.0</td>
<td>Major deficiencies in some road features such as poor median protection against head-on crashes, many minor deficiencies and/or poorly designed intersections at regular intervals. Minor deficiencies in some road features such as bends and roadside and/or poorly designed intersections at regular intervals.</td>
</tr>
<tr>
<td>10-25</td>
<td>Many major deficiencies such as poor alignment, poor roadside and median protection and poorly designed intersections at regular intersections. Major deficiencies in some road features such as poor roadside environment and/or many minor deficiencies such as insufficient overtaking provision and narrow lanes, and/or poorly designed intersections at regular intervals.</td>
</tr>
<tr>
<td>&gt; 25</td>
<td>Many curves, in mountainous terrain, narrow lanes and shoulders, severe roadside conditions and many major intersections. Many curves, in mountainous terrain, narrow lanes and sealed shoulders, poor line marking and severe roadside conditions.</td>
</tr>
</tbody>
</table>

Source: Australian Automobile Association, Comparing RISK Maps and STAR Ratings, April 2008.

### 3.3 usRAP

The usRAP built upon the experience of EuroRAP, and adjusted the elements (in some cases significantly) used for RPS scores to reflect North American conditions, research results and characteristics.

The usRAP RPS was developed using two pilot projects in Iowa and Michigan. The data elements and the collection methods were similar for both pilot projects, which are described below. Greater detail on each pilot project is available through the usRAP report.

#### 3.3.1 Data Elements

Similar to EuroRAP, the usRAP RPS concept was developed to address the road factors that relate to four specific collision types which were identified as the highest priority for safety improvement. These included:

- head-on collisions;
- single-vehicle run-off-road collisions;
• intersection collisions; and,
• collisions involving vulnerable road users (pedestrians and bicyclists).

Similar to EuroRAP, the RPS for vulnerable road users was not implemented because of the lack of exposure data. The data elements used by usRAP in the two pilot projects to determine the RPS ratings are shown in Table 7.

Table 7. Summary of Collision Types and Design Elements used in usRAP STAR Rating

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Design Element</th>
<th>Specific Issues used in RPS Rating</th>
</tr>
</thead>
</table>
| Head-on and Run-off Road | Median and Roadside Treatment | median type  
median width  
shoulder type  
shoulder width  
lane width  
speed limit  
passing zones (Iowa only)  
presence of guardrail  
clear zone width  
estimates of fore slope |
| Intersection          | Intersection Treatment  | intersection count and type  
turning lanes  
control  
driveway type |

3.3.2 DATA COLLECTION

Data elements for the RPS (STAR Ratings) were collected from existing road authority databases and through videolog assessments. Typically, the road authority database contains information on median type and width, shoulder type and width, lane width, and speed limit. All other data were collected through videolog assessment. Data were collected for 1-mile (1.6 km) segments in the rural, unincorporated areas and for analysis sections as a whole in small towns in Iowa. For Michigan, data were collected for the sufficiency sections defined in the risk analysis.

Roadside slope estimates were collected in three ranges based on expected requirements of the usRAP RPS method, flat (1:5 (V:H) or flatter), gentle (1:4), or steep (1:3 or steeper). No estimation was made of lateral distance to ditches. Only fore slope was used in determining the RPS scores for both pilot studies. The usRAP concluded that the data reduction from videologs was considered generally successful, but the potential inaccuracy in roadside slope estimation was noted. However, the usRAP research team
has concerns about whether roadside slopes can be accurately estimated using a visual process.

All other data elements were straightforward to observe from the videolog. For linear features (e.g., presence of guardrail), a maximum resolution of 0.1 mile (0.16 km) was used. Clear zone widths were also estimated from the videolog.

For the Iowa pilot project, data were collected from videologs at the average rate of 11 mile/hr for each direction of travel. For the Michigan pilot project, video data were recorded in the field at a rate of 55 miles (88 km) per day (including both directions of travel) by a two-person crew. Data were reduced from videologs at the average rate of 25 mi/hr (40 km/hr) for each direction of travel.

### 3.3.3 Methodology

In general, the RPS criteria applied in the U.S. pilot studies were based on the RPS criteria from EuroRAP criteria, but the methodology was modified to reflect U.S. conditions. The method in assigning RPS to the data elements was similar, where the scores were weighted, averaged, and consolidated to compute overall risk scores for each highway section.

Each road is assigned a rating from four stars (highest rating) to one star (lowest rating). As with other RAPs, it appears that the STAR Rating was only applied to road links that include intersections. A detailed methodology for the usRAP RPS scoring criteria is extracted from the usRAP report and is included in Appendix A.

The significant modifications by the usRAP are highlighted below:

- Relative risk scores were modified to have three categories of median widths to be consistent with the AASHTO Roadside Design Guide (2002) and other “U.S” research results.

- The scoring criteria for run-off road collisions were replaced to reflect U.S. conditions using the Roadside Safety Analysis Program (RSAP).

- Safety impacts of lane width and shoulder width were added to the usRAP using the adjustment factors available from the FHWA Interactive Highway Safety Design Model (IHSDM).

- All intersection criteria were modified to better reflect U.S. conditions and are based on safety performance functions.

- The weightings assigned for the various collision types were based on U.S. data.
3.4 SUMMARY

3.4.1 DATA ELEMENTS

The various data elements of EuroRAP, AusRAP and usRAP are summarized in Table 8. As discussed previously, these elements were collected through the road authority database(s) and videolog data.

Table 8. Summary of Design Elements Used for STAR Rating

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Design Element</th>
<th>EuroRAP</th>
<th>AusRAP</th>
<th>usRAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-on and Run-off Road</td>
<td>Presence of Median / Median Type</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Median Width</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Safety Barrier</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Centerline Rumble Strips</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lane Width</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Sealed Shoulder Width</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Shoulder Type</td>
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Notes:
1. For EuroRAP, the type of intersection includes interchanges, roundabouts, signalized intersections, four-leg un-signalized intersections with and without left-turn lanes, and three-leg un-signalized intersections with and without left-turn lanes.
2. For AusRAP, the type of intersection includes over-pass or under-pass, T-junction, cross roads or railway.
3. For usRAP, the type of intersection includes rural 3-leg un-signalized, rural 3-leg signalized, rural 4-leg un-signalized, and rural 4-leg signalized intersections.

It is evident from Table 8 that a wide ranging set of design data elements that are similar in nature could be used to “define” the RPS, thus the STAR Rating of a road. The use of
the various data elements to define the STAR Rating is largely dependent on data availability associated with the “targeted” collision type.

The EuroRAP data elements appeared to be the simplest to assemble because it contains the fewest number of design elements. However, these elements are related to the amount of protection the road has to offer (i.e. the RPS), and simply ignored the probabilistic and causation effects of collision occurrence. Although this is addressed by AusRAP and usRAP in subsequent developments, the EuroRAP RPS remains the most “true” measurement for road protection only.

It is noted that the usRAP method does not account for interchanges or grade separation, but it is the only one that uses “usage” or exposure data for intersections. The usRAP methodology is likely the most replicable and applicable Star Rating method for Canada.

3.4.2 Data Collection Methods

All the RAPs rely on using existing highway inventory data (if available), video logs, and desk top assessment to collect the data required to calculate the RPS. A specially equipped vehicle, typically with two crew members, is used to capture the videolog data. EuroRAP captures the data using a digitizing tablet, in conjunction with custom computer programs to automate the process. AusRAP uses proprietary software that appears to make the process more efficient. The on-road data collection rate appeared to range between 100 and 200 kilometre per day depending on the methodology used.

3.4.3 Methodology

The EuroRAP, AusRAP and usRAP all employ the basic methodology by selecting design elements that have been shown to influence the frequency and severity of a head-on, run-off road and intersection collision. However, there appears to be some disconnect between the results of the collision rates shown through RISK Mapping and the STAR Rating map, i.e. a location with a low STAR Rating exhibits a low risk in the RISK Mapping, and vice versa. This is discussed in more details in Section 4.0. The usRAP rightfully pointed out that the RPS estimation will require further research, development and validation.

The STAR Ratings also differ amongst the RAPs, with AusRAP adopting a five star system, while EuroRAP and usRAP using a four star system. It is unclear from the literature as to the rationale behind choosing the number of stars. However, a five star system would provide more potential room for improvements. The weights assigned to the three major collision types also differ significantly amongst the three RAPs. However, this is likely a reflection of the nature of the respective rural road network and driver behaviour that
impact these weightings, and Canada will likely have somewhat different weightings than these RAPs.

The usRAP STAR Rating methodology is probably the best methodology for adaptation in Canada. This is because the design parameters, the roadway classification, vehicle safety standards, vehicle fleet characteristics, and driver population are quite similar between the United States and Canada. A five star system could also be more desirable for Canada to provide additional potential for improvements.

3.5 Discussion

The STAR Rating objectives, as stated by all Road Assessment Programs, are the same. The first objective of identifying “important differences in road design or management which are likely to lead to different probabilities of fatal or serious collisions” is largely known and identified through various values associated with CMF’s, although they may differ between countries or continents. In fact, the RPS is based on these known factors.

The second objective of providing “ratings based on inventories that can be made either directly during inspection drives, or subsequently from the video of the drive, at reasonable cost” is a virtual drive through assessment of the existing road network. Drive through assessments have been done in Canada before using similar methodologies that are based on a risk index, although the Canadian assessments did not cover the network to the extent of the various RAPs. The methodology is not new to Canadian practitioners, and can be replicated in Canada.

The STAR Rating methodology raised the issue of whether the comparison of the entire road network, regardless of road classification based on the “level of protection”, is a fair one. The RPS rates different design classes of highways, and by nature of the different classification their road protection score would be inherently different. Is it fair to compare a rural two-lane road with a freeway classification?

A road classification is the nucleus of any road network system and provides an orderly grouping of roads according to a variety of factors such as mobility, access, land use, service function, traffic volume, speed, vehicle type, and connections. In Canada, the rural road classification (TAC Geometric Design Guide, 1999) is typically composed of the local, collector, arterial and freeway categories. For example, freeways are typically high speed divided roadways with limited access which will likely have a high RPS, while on the other end of the classification spectrum lies the rural local roads that are typically low volume with a large range of speeds and undivided, which will likely have a low RPS.

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Given that the majority of Canadian road authorities follow to a large extent the TAC Geometric Design Guide, the level of protection built into the various classes of roads will generally correlate with what the TAC Guide specified. Although there may be differences in the actual dimensions used in the design elements amongst the Canadian road authorities, it may not be sensitive enough to significantly impact the level of road protection provided. Thus, using this logic, it follows that a STAR Rating map could almost be duplicated based on the design classification of the road network. For example, rural freeways will likely have a four or five STAR Rating, while a two lane undivided arterial will likely have a one or two STAR Rating. While it is perhaps useful information to display on a map, whether it would result in any action being taken is questionable. For example, it would be very difficult to justify upgrading undivided two lane rural roads to divided two lane rural roads for simple economic reasons.

AusRAP rationalized that roads with a low STAR Rating would have a potential for severe collisions if one occurs. This rational is pro-active in its thinking, however if a road is already shown to be of high risk (i.e. high collision rate and frequency based on historical data), it seems that it would be more reasonable to place a higher priority on a road section where collisions are already happening. These are important issues, which will be explored further.

Another inclusion in the EuroRAP and usRAP is the vulnerable road user collision type. One would expect a larger number of collisions involving vulnerable road users to occur on urban roads rather than rural roads. However, effort of STAR Rating so far has been focused on rural roads and EuroRAP does not have usage data on vulnerable road users. It is suggested that the vulnerable road users be considered in future phases for urban roads, and this collision type be considered in rural areas as warranted, such as recreationally used routes.

Interestingly, none of the three RAPs define what is “acceptable risk”, or the level of protection associated with each STAR Rating. The relative risk is provided with more stars being safer. However, as a potential user of the STAR Rating map, the information provided is rather poor for decision making purposes. One possible reason for this omission may be due to potential liability concerns.

The STAR Rating of a road is determined using a variety of roadway elements. The STAR Rating as it was originally conceived was a measure of the level of protection offered to the road user in the event of a run-off road, head-on or intersection related collision. In subsequent implementations by AusRAP and usRAP, additional elements that are more related to the collision likelihood have been added. Attempts were made to find correlations between collision rates and STAR Rating. The usRAP suggested that the correlations are low, and questioned the usefulness and potential acceptance of the
STAR Rating concept given the level of effort in collecting the data. As a result the usRAP suggested that:

The STAR Rating or Road Protection Score (RPS) concept needs further development before it can be successfully implemented in the U.S. AusRAP has extensively adapted the EuroRAP RPS concept for implementation in Australia. A substantial research effort would be needed for adapting the RPS concept for implementation in the United States. Highway agencies in the U.S. appear reluctant to implement the RPS concept, especially since the concept is not fully developed, when risk maps based on actual collision data can be prepared. The RPS concept might be considered for application by highway agencies whose crash and roadway data cannot be effectively linked or in developing countries where crash and roadway data are not available. Until further research on RPS criteria can be conducted, it is recommended that future usRAP pilot studies focus on mapping of risk levels.


Research is planned in Phase III of the usRAP to develop, test, and validate a RPS concept for application in the U.S. This concept would draw upon the most applicable portions of the EuroRAP, AusRAP, usRAP, and iRAP methodologies. The results from Phase III are not available at the time of writing this report. However, they have plans to have 50 states as part of usRAP with Risk Mapping, Star Rating, and performance tracking within 5 years.
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4. THE RELATIONSHIP BETWEEN RISK MAPS AND STAR RATINGS

The three road assessment programs did some preliminary research on the relationship between the RISK Maps and the STAR Ratings. AusRAP found that there is a relationship between collision costs per vehicle kilometre travelled and the RPS, in particular the run-off road RPS. The collision costs per VKT were derived from the collision rate per VKT. The use of collision costs accounts for the number and severity of collisions on the road, as well as the exposure. AusRAP claimed that the relationship provide some validation of the STAR Ratings using the RPS.

Using various comparison methods, usRAP also tested whether there was any relationship or correlation between the RISK Levels and the STAR Ratings using the Iowa pilot project and the usRAP data elements. However, the usRAP team concluded that no insights could be obtained from review of the separate RISK and STAR Rating maps. More statistical testing was conducted using collision rates and STAR Rating, however the usRAP Team concluded that the relationship between the STAR Rating and the collision rate was weak. The results from the usRAP calls into question the utility of the current approach for the STAR Ratings in comparison to the utility of RISK Maps.

The RPS score was originally developed as a measurement of the amount of “built-in” level of protection to vehicle occupants should they 1. run off the road, 2. cross over onto opposing traffic, or 3. be involved in a collision at an intersection. Therefore, the RPS is the inverse of a collision severity index.

The first two collision types and the associated protection can be more easily estimated due to the less complex nature of run-off road and head-on collisions. The protection devices are well known in the highway design and road safety engineering fields. However, intersection collisions are more complex in nature, and it is composed of a group of “sub-types” of collisions such as rear-end, sideswipe, left-turn crossing, left-turn opposing, angle, pedestrians, and so on, depending on the intersection configurations, traffic control, and other various factors. As well, the distribution and the severity of the various “sub-types” collisions will vary depending on the factors mentioned before. More importantly, intersection collisions are largely influenced by the amount of entering and crossing traffic as shown in the literature.

The future direction of the STAR Rating protocol appears to be the inclusion of more collision-causation and collision likelihood elements. However, this may not improve the relationship between STAR Rating and the RISK levels. Perhaps the more practical approach would be to simplify the number of collision types in the STAR Rating using only
run-off road and head-on collisions, and rate the intersections separately as intersections with their own STAR Rating.

There may be valid rationale that could support the lack of a strong relationship between the results from the RISK Maps and the STAR Rating. For example, greater driver adaptation may occur on a road that has a poor STAR Rating due to the presence of roadside hazards, lack of passing opportunities and so on, which are easily recognized by motorists. This driver adaptation, sometimes called risk homeostasis, which could involve speed reduction, greater care and attention, etc., could impact the occurrence of collisions, and thus, impact the results produced by the RISK Maps. Conversely, if a road is viewed to be very safe from a STAR Rating perspective (e.g., safe roadside, tangent, etc.), a driver could deviate from the required driving task, which in turn could increase the frequency of collisions, thereby affecting the RISK Map results.

However, even though the results from the RISK Mapping and the STAR Rating may not be in agreement, there may be a opportunity to combine the results from the two safety risk indicators. For example, a poor RISK score and a poor STAR score could highlight the “worst” locations. If the two scoring systems disagree, then these locations may be considered as “moderate” risk, perhaps with one of the scoring systems being more “important” than over the other (i.e., perhaps RISK score is more important than the STAR score). Locations that have both a good RISK score and a good STAR score could be identified as the “best/safest” locations. This concept could be explored further by CanRAP.
5. SUMMARY OF PROVINCIAL WORKSHOPS

The inputs necessary to replicate the RISK Mapping of existing Road Assessment Programs (RAPs) requires: 1) collision data (by collision severity level) and the average collision rate benchmarks, 2) traffic volume data (in AADT) and, 3) highway classification and highway segmentation information. These data elements allow for the generation of the following safety measures, which form the basis for the typical RISK Mapping of a RAP:

- Severe Collision Density ((F+I)/km);
- Severe Collision Rate ((F+I)/MVK);
- Collision Rate / Average Collision Rate Ratio; and,
- Potential for Improvement (PFI).

In order to replicate the Star Rating of existing Road Assessment Programs, the necessary inputs are geometric and highway inventory data such as median type, lanes width, shoulder with, intersection type and treatment, etc.

During the workshops that were held in the capital cities of the three western provinces (i.e., Regina, Edmonton and Victoria), the data elements necessary to support the RISK Mapping and STAR Rating were discussed in detail. The following is a summary of the relevant discussion at each workshop. A list of the workshop attendance is provided in APPENDIX B and a summary of the data availability is provided in APPENDIX C.

5.1 Regina, Saskatchewan, October 6th, 2008

5.1.1 Collision Data

Since 1996, the collision data in Saskatchewan has been collected by the Saskatchewan Government Insurance (SGI). Prior to 1996 the collision data was collected by the Saskatchewan Ministry of Highways and Infrastructure (MHI). Presently, the Saskatchewan Ministry of Highways and Infrastructure obtains the collision data from SGI for use in transportation and engineering analysis. The characteristics of the collision data in Saskatchewan are as follows:

- Fatal and Injury collision data is generally accurate and available
  - Collision details are included in the MVA report
  - Severe collisions are attended and reported by the police
  - Every fatal collision is investigated in detail by the Ministry (Police may also do so)
  - Collision location is coded by homogeneous “control sections”
  - Collision data is housed at SGI, although Sask. Highways has access
PDO collision data may be of questionable value (focus is on fatal and injury)
  o PDO is self-reported (usually not police attended) through SGI
  o PDO data may not have an accurate location description
  o Data in SGI report may not be available for general use / consumption
    - Threshold for reportable PDO is $1000

Predominant collision types in Saskatchewan:
  o Single-vehicle, off-road collisions (30-40%)
  o Head-On collisions
  o Commercial vehicles collisions
  o Farm vehicles collisions
  o Non-dry surface related collisions
  o Weather related collisions

Collision Rates are available in SGI Report
  o Approximately 9,000 collisions per year over 27,000 kilometres of road
  o 120 fatal collisions on Saskatchewan highways per year / 150 total in province

Collision data are stored in the agency’s TAIS database, which holds all the collision data since 1988.
  o The application is written in MS Access
  o Data on the accident event, occupants, and vehicles involved is collected and used in the TAIS database for query development.

5.1.2 Traffic Volume Data

The traffic volume data is collected, analyzed and stored by the Saskatchewan Ministry of Highways and Infrastructure. Traffic volume is collected at various sites throughout the province and the traffic volume is assigned to the entire provincial highway network. Some characteristics of the traffic volume data are as follows:

  o The length of highway that a traffic volume count applies to is highly variable
  o Accuracy of traffic volume appears to be suitable for RAP inputs
  o Traffic volume also assigned by highway “control sections” (same as collisions)
  o Traffic volume collected and converted to AADT counts:
    - Segment: Mainline traffic given in AADT
    - Intersections: Both major and minor AADT at intersecting highways

5.1.3 Highway Classification / Highway Segmentation

The Ministry of Highways and Infrastructure in Saskatchewan has a system referred to as the Highway Inventory System (HIS). This system disaggregates the highway network into several control sections based on the characteristics of the highway. The Ministry
provides a manual that details the information available in the HIS System. The following are characteristics of the HIS system that would be useful for the inputs required for CanRAP:

- Highway classifications based on functional classification and complemented by road design standards. Functional classes include, Major Arterial, Minor Arterial, Collector and Local.
- Limited geometric data (electronic) available in databases
- Geometric data might be available elsewhere, but may be difficult to obtain
- The traffic volume data is contained within HIS
- The HIS system contains other roadway information such as traffic accident rates, design standards, road surface condition data, signage, and railway crossings.
- Data from HIS will determine what maps can eventually be produced
- Highways are segmented by homogeneous section, and range from 1 to 100 km.

5.1.4 Highway Geometric and Inventory Data

- The geometric data is captured in as-built drawings, and the drawings are stored at the regional offices.
- Construction logs contain some lane width and shoulder width data, but likely do not cover the entire network.
- One database covers the total widths of the roadway (for functional classification purposes), and the median, lane and shoulder widths can be deduced from it based on design parameters. Note that this information is not the “as-built” width.
- Data is available on posted speed limits.
- Data is available on location of shoulder rumble strips.
- Intersection data is available by type (interchange, stop controlled, uncontrolled, and red/amber flashing signals). Saskatchewan Highways do not operate any traffic signals.
- Intersection skew angle is available, but the data quality may be crude.
- Some ortho-photography is available (0.6m resolution)
- There is no videolog system currently in place for Saskatchewan Highways. The Ministry may be investigating the feasibility of implementing such a system in the future.
5.1.5 Saskatchewan SUMMARY

In general, it appears that the information necessary to replicate the approach used in other RAP’s RISK Mapping is available in Saskatchewan. Severe collision data appears to be available with a suitable level of accuracy (i.e. fatal and injury). However, it was understood from the workshop that disaggregation of injury types (severe, moderate, minor) is not readily available in the collision data. Post-processing of the data may help in identifying injury categories, but this is not routinely undertaken. Similarly, the traffic volume information is available. Finally, it appears that the province has average collision rates by highway type (classification), but the availability and access to this information may not be readily available.

It appears that data for the development of a STAR Rating in Saskatchewan is limited and incomplete. As well, the lack of a videolog will make visual inspection as per the road assessment program protocol potentially costly.

5.2 Edmonton, Alberta, October 15th, 2008

5.2.1 Collision Data

The collision data in the province of Alberta is collected by the police services. Detailed information is collected for collisions that are attended by the police. In contrast, less detail is collected for collisions that are not attended (i.e., the collision data that is collected at the police station). There are documents that describe the collision data capture process. The following is a summary of the collision data as it relates to the RISK Mapping for CanRAP:

- The location referencing system that is used to record the location of attended collisions is based on distance from a known location / landmark
- Attended collisions use a form (TSS284/R03)
- Un-attended collisions use another form (TSS284A/R03) and used when:
  - A collision does not involve a fatality or injury
  - A collision does not involve a hit and run collision
  - A collision involving a National Safety Code Vehicle, or when
  - Charges will be laid as a result of a collision
- In 2007, there were 153,901 reportable collisions:
  - 402 fatal collisions
  - 17,857 injury collisions
  - 135,642 PDO collisions
    - 111,272 PDO collisions were attended (TSS284/R03)
    - 24,379 PDO collisions were non-attended (TSS284A/R03)
The threshold for a reportable PDO collision is $1000.

AT has access to collision data and includes it in their data systems:

Current collision costs used in Alberta:
- $1.36M for fatal collisions (also has a $3.9M WTP value)
- $100K for injury collisions, and
- $12K for PDO collisions.

Average collision rates appear available in 2007 Traffic Collision Summary:
- Fatal and Injury provided in Coll./BVKm (from Transport Canada?)
- Collision rates can be produced by Alberta:
  - Traffic volume by segment available / collisions available

Based on 2007 Alberta Traffic Collision Statistics, the predominant collision types were off road and intersection collisions (including collisions on non AT roads).

### 5.2.2 Traffic Volume Data

Alberta Transportation appears to have an excellent program for the collection of the traffic volume data on the provincial highway network. The entire highway network is disaggregated into homogeneous segments and the traffic volume is counted from a series of permanent and temporary traffic count stations. The traffic volume is maintained into an integrated provincial data system. Some of the details of Alberta’s traffic volume data as it relates to the CanRAP project are summarized below:

- Traffic volume is converted to AADT for highway segments
- Entire provincial network has volumes assigned
- Count program is undertaken annually, at a cost of approximately $1.5 million per year, which includes manual counts at intersections, ATR maintenance, and WIM and classifier sites.
- Turning movement counts are available at intersections:
  - Approximately 2,200 intersection turning counts are available
    - Only 150 intersections are signalized (owned/operated by the Province)
  - Major intersections have traffic counts
  - There are approximately 25,000 intersections on Alberta’s highways

### 5.2.3 Highway Classification / Highway Segmentation

Considerable discussion of the roadway classification system in Alberta was completed during the Workshop. In Alberta, there are several different road classifications, which is consistent with other jurisdictions, however the terminology may be somewhat different. The details of the roadway classifications in Alberta are listed below:
- Service or Functional Classification
  - National
  - Arterial (provincial)
  - Collector (regional)
  - Local
- In each Functional Classification, there are design classifications
  - Freeway
  - Expressway
  - Arterial
- There is a design table that clearly specifies the different classifications.

Alberta Transportation has an excellent location referencing system that connects all the data required for the RISK Mapping. In fact, Alberta seems to have a very sophisticated online mapping system already in place.

### 5.2.4 Highway Geometric and Inventory Data

- The geometric data is captured from the videolog. This includes all cross sectional elements, and vertical grades. Side slope data is not available due to the potential error introduced by vegetation. Alberta is working with the videologging contractor to try to resolve this issue. Clear zone width is also not available from the database. Other highway inventories such as guard rail, light standards, signs and culverts are also captured in Alberta's database.
- The resolution of the videolog is captured at every 7 metres. The videolog is updated in a 3-5 year cycle.

### 5.2.5 Alberta Summary

Alberta appears to be very advanced in terms of the data collection, data storage and data processing capabilities, which includes the ability to produce maps and visual representations of the data / analysis. In fact, Alberta is currently able to produce maps that would be consistent with the required CanRAP RISK Maps.

For the purpose of the STAR Rating, Alberta appears to have the majority of the data needed, except side slopes and clear zone distances which are related to the road side. However, this data could be gathered and assessed using a videolog assessment. It is concluded that Alberta has adequate data to develop STAR Rating maps.
5.3 VICTORIA, BRITISH COLUMBIA, NOVEMBER 6TH, 2008

5.3.1 COLLISION DATA

Collision data in British Columbia is currently available from two sources: 1) collision data that is collected from the police agencies and 2) collision data that is collected by the Insurance Corporation of BC (ICBC). The BC MOT uses collision data collected by the police since this data has a precise location reference onto the highway system (LKI Reference). The ICBC collision data is self-reported and as such, the exact location of a collision that occurs on a highway segment is not known, although ICBC collision data for intersections may be valuable for the BC MOT. Some characteristics of the collision data used by the BC MOT are provided below:

- BC MOT’s collision data system is called HAS (Highway Accident System)
  - Mainframe system, with collision data going back to 1987
  - HAS system has excellent functionality
- The HAS system also has the ability to generate average collision rate tables by highway class and volume range
  - Collision prediction models (CPMs) are also available in BC
- Efforts to replace HAS are underway (CIS – Collision Information System)
- Collision data is coded to the highway system using a location referencing system called the LKI (Landmark Kilometre Inventory) system
  - Collision data placed onto the highway system at 100 meter intervals
- Collision data from HAS is disaggregated by severity level
  - Fatal, Injury and PDO (no severe injury in BC)
- The stability of the collision data has been an issue over the years (1991/1996)
  - Post 2002 Data is considered to be fairly ‘stable’
- Based on 5 years of HAS data (2003-07), there were 13094 collisions per year in BC
  - 224 Fatal collisions
  - 5,257 Injury collisions
  - 7,613 PDO collisions
- Predominant collision patterns for BC include:
  - Single vehicle off-road (on segments)
  - Wildlife collisions
  - Weather related collisions

5.3.2 TRAFFIC VOLUME DATA

The BC Ministry of Transportation has a traffic count program that is undertaken annually and assigns traffic volumes to the entire provincial network. The current program consists of 626 UTVS (uniform traffic volume segments), which includes 96 permanent traffic count
stations and 530 short count stations. Some of the characteristics of the traffic volume data are provided below:

- There appears to be at least two sets of traffic volume at the BC MOT
  - TRADAS – which houses the data from the traffic count program
    - Uses the 626 count stations / 626 UTVS
    - Maintained by OPUS International Consultants
    - Includes some major intersection volumes (minor road)
  - HAS – the collision database system has a separate set of traffic data
    - Based on historical traffic volumes at the MOT (Source =?)
    - Maintained by Cypher Consulting (Matthew Nichol)
    - Does not include intersection volumes (no minor road)
- A record of incident, road condition, or planned closures was documented by DriveBC. This information could be used to cross-verify traffic volume data.

5.3.3 **Highway Classification / Highway Segmentation**

The BC MOT has several highway classifications, but the service classification seems most suitable for the CanRAP project. This classification allows for the following segmentation of the provincial highway network:

- Urban or Rural (U/R)
- Freeway, Expressway, Arterial (F/E/A)
- Un-Divided or Divided (U/D)
- Two-lane or Four-Lane (2/4)

There are several ways in which the highways in BC are segmented. At least 5 different location-referencing systems were discussed at the workshop including the following:

- LKI – Landmark Kilometre Inventory
- RFI – Road Features Inventory
- RIMS – Road Information Management System
- Arterials – Not a current system
- CHRIS – Corporate Highway Resource Information System

Since the collision data is referenced by the LKI system, it is most likely that this system will be used, however, the CHRIS system offers many data elements that might be useful for the CanRAP’s STAR Rating system. Regardless, it appears that the location referencing systems can communicate between one another.
5.3.4 **HIGHWAY GEOMETRIC AND INVENTORY DATA**

The CHRIS database offers the majority of the data elements that are needed for the STAR Rating including:

- Access
- Curb & Gutter
- Culverts
- Ditch
- Guard Rail
- Highway Profile – number of through lanes, divided / undivided
- Highway Reference Point (Landmarks) – including intersections, railways crossings, etc...
- Longitudinal and Transverse Paint Markings
- Linear Safety Features – such as arrestor bed, glare screens, rumble strips
- Reflectors
- Right of Way
- Point Safety Features – such as crash barrels, attenuators, etc...
- Shoulder type and surface
- Sign Inventory
- Special Lanes – acceleration, deceleration, bus, hov, etc.,
- Surface
- Speed Zones

The Ministry has a data base referred to as the WISH System, which contains a record of the barrier warrant index scores for many parts of the provincial highway network. The data included in this database was collected in the mid-1990s and although the data is dated, the system contains very useful information on the elements of the roadside area that contribute to safety risk.

The Ministry also maintains a videolog system that is regularly maintained and updated, which captures information on all numbered highway in the province.

5.3.5 **BC SUMMARY**

Overall, the data and data systems that are available at the BC MOT should be able to support the RISK Mapping requirements for CanRAP. Similar to the Alberta data, BC appears to have the majority of the STAR Rating data needed, except side slopes and
clear zone distances which are related to the road side. This data could be supplemented using a videolog assessment and/or through the raw data that was used to compile the WISH database. It is concluded that B.C. has adequate data to develop STAR Rating maps.

5.4 **Summary of Workshops**

Based on the discussion from the workshops, it is concluded that the three pilot provinces will have adequate data to develop the RISK Mapping component similar to other RAPs. However, the STAR Rating may only be developed for British Columbia and Alberta at this point. Saskatchewan may not have all the requisite data (i.e. videolog) to conduct a STAR Rating of its road network.
APPENDIX A

USRAP RPS SCORING CRITERIA

From the usRAP report titled "usRAP - Feasibility Assessment and Pilot Program" published by the AAA Foundation for Traffic Safety in May 2006
Appendix A—Preliminary RPS Scoring Criteria for usRAP

RPS scoring criteria for use in the usRAP Iowa and Michigan pilot studies have been developed from comparable EuroRAP criteria with adaptations for U.S. conditions based on available research results and safety prediction models. The scoring criteria are presented in Tables A-1 through A-4. These criteria are very preliminary. Development of RPS criteria that are consistent with U.S. safety research and with safety performance data for U.S. roads will be a major research task.

The structure of the scoring criteria is similar to EuroRAP. Relative risk scores are determined for the most common types of crashes on rural highways:

- Head-on crashes
- Run-off-road crashes
- Intersection crashes

EuroRAP is also considering extending RPS scoring to include facilities for vulnerable road users (e.g., pedestrians and bicyclists), but has not yet done so because of a lack of data on the volumes of vulnerable road users on specific road sections. Volume data for vulnerable road users are also unavailable for rural highways in Michigan. Furthermore, data for rural state highways in Michigan show that vulnerable road users are involved in only about 1 percent of fatal and serious injury crashes. Thus, the limitation of RPS scoring to head-on, run-off-road, and intersection crashes appears reasonable at present.

Scoring for each of the crash type categories is explained below, followed by recommended weights for combining the three categories. Finally, computational procedures for RPS scoring and the determination of star ratings are presented. The computational procedures follow those used in EuroRAP, except in instances identified below where more appropriate procedures for U.S. application were developed. Where the computational procedures used in EuroRAP were not explicitly stated in the available documentation, appropriate procedures have been devised.

Scoring for Head-on Crashes

Scoring criteria for head-on crashes have been adapted from EuroRAP. The relative risk scores shown in Table A-1 have been modified from the EuroRAP RPS criteria by replacing the median width category of 30 ft (10 m) or more with three categories:

- 30 to 49.9 ft
- 50 to 69.9 ft
- 70 ft or more
Table A-1. Preliminary Relative Risk Scores and Star Rating Criteria for Head-On Crashes

<table>
<thead>
<tr>
<th>Relative Risk Scores</th>
<th>85th percentile or posted speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Relative Risk Score</td>
</tr>
<tr>
<td>Median treatment</td>
<td>0.6</td>
</tr>
<tr>
<td>Median width 70 ft or more</td>
<td>0.6</td>
</tr>
<tr>
<td>Median width 50 to 69.9 ft</td>
<td>0.8</td>
</tr>
<tr>
<td>Median barrier</td>
<td>0.8</td>
</tr>
<tr>
<td>Median width 30 to 49.9 ft</td>
<td>1</td>
</tr>
<tr>
<td>Median width 12 to 29.9 ft</td>
<td>4</td>
</tr>
<tr>
<td>Median width 3 to 11.9 ft</td>
<td>16</td>
</tr>
<tr>
<td>Undivided with centerline rumble</td>
<td>27</td>
</tr>
<tr>
<td>Undivided with marked centerline only</td>
<td>38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Stars</th>
<th>Head-on Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0-2</td>
</tr>
<tr>
<td>3</td>
<td>2.1-5</td>
</tr>
<tr>
<td>2</td>
<td>5.01-10</td>
</tr>
<tr>
<td>1</td>
<td>over 10</td>
</tr>
</tbody>
</table>
These additional categories have been added because the AASHTO Roadside Design Guide (2002) indicates that a median barrier may be used in the 30 to 49.9 ft range, and recent research in California (Nystrom, et al., 1997) has found that the use of median barrier is warranted for median widths up to 50 ft. Recent research in North Carolina (Lynch, 1998) has found that cable barrier may be warranted in median up to 70 ft in width. For consistency with EuroRAP, the relative risk score of 1.0 has been retained for median widths in the 30 to 49.9 ft range. Relative risk scores of 0.8 and 0.6 scores for median widths in the range from 50 to 69.9 ft and 70 ft or more, respectively, were chose based on safety prediction models for median width from recent Pennsylvania research (Donnell et al., 2002). The relative risk score for median barrier was set equal to the relative risk score for a 0 to 69.9 ft median, based on the California research results. All other relative risk scores for head-on crashes in Table A-1 were taken directly from EuroRAP, with a conversion of the speed categories from metric to U.S. customary units.

The star rating criteria for head-on crashes shown in Table D-1 have been adapted to correspond appropriately to the relative risk scores for head-on crashes.

**Scoring for Run-Off-Road Crashes**

Scoring criteria for run-off-road crashes shown in Table A-2 are a proposed replacement for the EuroRAP scoring criteria that are better suited to U.S. conditions. The relative risk scores for specific combinations of clear zone width, roadside slope, direction of slope, presence of guardrail, and speed were developed using the Roadside Safety Analysis Program (RSAP) (AASHTO, 2002). While the RSAP program has limitations, the resulting relative risk scores based on RSAP’s crash severity cost estimates represent the best available estimates for U.S. conditions.

The effects on safety of lane width and shoulder width are not directly accounted for in the EuroRAP RPS criteria. These factors have been added to the preliminary usRAP criteria because there is strong evidence that lane width and shoulder width directly affect the frequency with which vehicles encroach on the roadside beyond the edge of the shoulder. The adjustment factors for lane and shoulder width are those used in the FHWA Interactive Highway Safety Design Model (IHSDM) (Harwood et al., 2000). These adjustments were developed for rural two-lane highways, but are applied here for all roadway types because no factors appropriate to other specific road types are available. The IHSDM adjustments were developed for application to single-vehicle run-off-road, multiple-vehicle same-direction sideswipe, and multiple-vehicle opposite-direction collisions; however, data for rural roads indicate that run-off-road collisions are the predominant collision type in these categories. The star rating criteria for run-off-road crashes shown in Table A-2 have been adapted to correspond appropriately to the relative risk scores for run-off-road crashes.
<table>
<thead>
<tr>
<th>Configuration</th>
<th>Clear Zone Width</th>
<th>Roadside Slope</th>
<th>Dim of Slope</th>
<th>Relative Risk Score</th>
<th>85th percentile speed or posted speed (MPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>FILL SECTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:6 Down</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:4 Down</td>
<td>15</td>
<td>13</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:3 Down</td>
<td>25</td>
<td>22</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:6 Down</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:4 Down</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:3 Down</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:2 Down</td>
<td>25</td>
<td>22</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:6 Down</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:4 Down</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:3 Down</td>
<td>20</td>
<td>18</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:2 Down</td>
<td>27</td>
<td>24</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>0 to 2.9 ft</td>
<td>1:6 Down</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>0 to 2.9 ft</td>
<td>1:4 Down</td>
<td>19</td>
<td>17</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>0 to 2.9 ft</td>
<td>1:3 Down</td>
<td>21</td>
<td>19</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>0 to 2.9 ft</td>
<td>1:2 Down</td>
<td>29</td>
<td>26</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>SECTIONS WITH GUARDRAIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>CUT SECTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:6 Up</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:4 Up</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>30 ft or more</td>
<td>1:3 Up</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:6 Up</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:4 Up</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:3 Up</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12 to 29.9 ft</td>
<td>1:2 Up</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:6 Up</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:4 Up</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:3 Up</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>3 to 11.9 ft</td>
<td>1:2 Up</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>
Table A-2. Relative Risk Scores and Star Rating Criteria for Run-Off-Road Crashes (Continued)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>85th percentile speed or posted speed (mph)</th>
<th>70</th>
<th>85</th>
<th>100</th>
<th>125</th>
<th>150</th>
<th>175</th>
<th>200</th>
<th>225</th>
<th>250</th>
<th>275</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Zone Width</td>
<td>Roadside Slope</td>
<td>Dirn of Slope</td>
<td>Relative Risk Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oto2.9ft</td>
<td>1:6</td>
<td>Up</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oto2.9ft</td>
<td>1:4</td>
<td>Up</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oto2.9ft</td>
<td>1:3</td>
<td>Up</td>
<td>18</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oto2.9ft</td>
<td>1:2</td>
<td>Up</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LANE AND SHOULDER WIDTH ADJUSTMENT FACTORS**

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 ft or more</td>
<td>1.00</td>
</tr>
<tr>
<td>11 ft</td>
<td>1.05</td>
</tr>
<tr>
<td>10 ft</td>
<td>1.30</td>
</tr>
<tr>
<td>9 ft or less</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**Adjustment Factors for Specific Shoulder Types**

<table>
<thead>
<tr>
<th>Shoulder Width</th>
<th>Paved</th>
<th>Gravel</th>
<th>Composite</th>
<th>Turf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oft</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2 ft</td>
<td>0.87</td>
<td>0.88</td>
<td>0.88</td>
<td>0.89</td>
</tr>
<tr>
<td>4 ft</td>
<td>0.77</td>
<td>0.77</td>
<td>0.79</td>
<td>0.81</td>
</tr>
<tr>
<td>6 ft</td>
<td>0.67</td>
<td>0.68</td>
<td>0.69</td>
<td>0.72</td>
</tr>
<tr>
<td>8 ft or more</td>
<td>0.58</td>
<td>0.59</td>
<td>0.61</td>
<td>(0.64)</td>
</tr>
</tbody>
</table>

**Star Rating Criteria for Run-Off-Road Crashes**

<table>
<thead>
<tr>
<th>Number of Stars</th>
<th>Run-off-road Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>5.01 - 10</td>
</tr>
<tr>
<td>2</td>
<td>10.01 - 15</td>
</tr>
<tr>
<td>1</td>
<td>over 15</td>
</tr>
</tbody>
</table>
Scoring for Intersection Crashes

Scoring criteria for intersection crashes shown in Table A-3 are adapted from the corresponding EuroRAP RPS criteria using available U.S. crash prediction models and research results. The relative risk scores for merging maneuvers and roundabouts were adapted from the EuroRAP RPS criteria with a conversion of the corresponding speeds from metric to U.S. customary units.

Relative risk scores were estimated for four types of intersections using tentative safety performance functions (SPFs) for intersections developed for use in the FHWA SafetyAnalysis interim software tools (Harwood et al., 2004). The four types of intersections considered are:

- rural three-leg unsignalized intersections
- rural three-leg signalized intersections
- rural four-leg unsignalized intersections
- rural four-leg signalized intersections

The effect on safety of providing turn lanes at rural unsignalized intersections were based on accident modification factors (AMFs) for fatal-and-injury crashes developed for addition of left-turn lanes in recent FHWA research (Harwood et al., 2003). The effect of adding turn lanes at rural signalized intersections was estimated to be 50 percent of the effectiveness of adding turn lanes at unsignalized intersections, based on a judgment by the research team. The EuroRAP RPS criteria focused on right-turn lanes at intersections. U.S. research has found higher safety effectiveness from installation of left-turn lanes than from installation of right-turn lanes. Field data have been collected for both left- and right-turn lanes and, for the present, it is recommended that the relative risk scores for intersections with turn lanes be applied to any intersection with either left- or right-turn lanes on the road being evaluated.

There are no U.S. data concerning the relative safety performance of intersections on highways with differing speeds. Therefore, the intersection scores in Table A-3 vary among speed categories in proportion to the corresponding values for the EuroRAP RPS criteria. Further U.S. research on this issue would be desirable.

Relative risk scores for major and minor driveways have been added to the table. The EuroRAP RPS criteria recommended that driveways be counted and be given the weight equal to 30 percent of the weight for a three-leg intersection. The preliminary usRAP criteria include separate categories for two types of driveways:

- minor driveways—driveways that provide access to single- or double-family residences, or field entrances
• major driveways all other types of driveways, including multi-family residences, and commercial, industrial, and institutional sites
### Table A-3. Relative Risk Scores and Star Rating Criteria for Intersection Crashes

#### Relative Risk Scores

<table>
<thead>
<tr>
<th>Junction type</th>
<th>85th percentile speed or posted speed (mph)</th>
<th>70</th>
<th>65</th>
<th>60</th>
<th>55</th>
<th>50</th>
<th>45</th>
<th>40</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor driveway (unsignalized)</td>
<td></td>
<td>0.50</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Major driveway (unsignalized)</td>
<td></td>
<td>2.00</td>
<td>1.75</td>
<td>1.50</td>
<td>1.25</td>
<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Merging maneuver only; long acceleration lane</td>
<td></td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Roundabout, low speed</td>
<td></td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Roundabout, high speed</td>
<td></td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Merging maneuver only; short acceleration lane</td>
<td></td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.00</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Three-leg unsignalized intersection with turn lanes</td>
<td></td>
<td>2.00</td>
<td>1.75</td>
<td>1.25</td>
<td>1.25</td>
<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>Three-leg unsignalized intersection without turn</td>
<td></td>
<td>4.25</td>
<td>3.75</td>
<td>3.00</td>
<td>2.50</td>
<td>2.00</td>
<td>1.50</td>
<td>1.00</td>
<td>0.75</td>
</tr>
<tr>
<td>Three-leg signalized intersection with turn lanes</td>
<td></td>
<td>8.25</td>
<td>6.75</td>
<td>5.25</td>
<td>4.00</td>
<td>3.00</td>
<td>2.25</td>
<td>1.75</td>
<td>1.25</td>
</tr>
<tr>
<td>Three-leg signalized intersection without turn lanes</td>
<td></td>
<td>10.75</td>
<td>8.75</td>
<td>6.75</td>
<td>5.00</td>
<td>3.75</td>
<td>2.75</td>
<td>2.25</td>
<td>1.75</td>
</tr>
<tr>
<td>Four-leg unsignalized intersection with turn lanes</td>
<td></td>
<td>6.75</td>
<td>5.25</td>
<td>4.00</td>
<td>3.25</td>
<td>2.00</td>
<td>1.50</td>
<td>1.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Four-leg unsignalized intersection without turn</td>
<td></td>
<td>10.25</td>
<td>8.00</td>
<td>6.00</td>
<td>5.00</td>
<td>3.25</td>
<td>2.50</td>
<td>2.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Four-leg signalized intersection with turn lanes</td>
<td></td>
<td>17.75</td>
<td>14.50</td>
<td>11.25</td>
<td>8.25</td>
<td>6.25</td>
<td>4.50</td>
<td>3.50</td>
<td>2.75</td>
</tr>
<tr>
<td>Four-leg signalized intersection without turn lanes</td>
<td></td>
<td>21.50</td>
<td>17.50</td>
<td>13.50</td>
<td>10.00</td>
<td>7.50</td>
<td>5.50</td>
<td>4.25</td>
<td>3.25</td>
</tr>
</tbody>
</table>

Sum relative risk scores for all junctions within the highway section and divided by the length of the section in miles. Star Rating Criteria

<table>
<thead>
<tr>
<th>Number of Stars</th>
<th>Total relative risk score per mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0-5</td>
</tr>
<tr>
<td>3</td>
<td>5.01 - 10</td>
</tr>
<tr>
<td>2</td>
<td>10.01 - 15</td>
</tr>
<tr>
<td>1</td>
<td>15.01 - 19</td>
</tr>
</tbody>
</table>
Major and minor driveways have been assigned scores equal to 50 percent and 10 percent of the score for a three-leg unsignalized intersection, respectively. The driveway categories apply only to unsignalized driveways. Signalized driveways are treated as signalized intersections for purposes of RPS scoring.

EuroRAP appears to use a weighted-average of the scores for all intersections within a given roadway section. This approach does not appear satisfactory because it is not sensitive to section length (i.e., five intersections within a 2-mi section should score better than the same five intersections location within a 1-mi section). A preliminary procedure has been developed for application in usRAP that involves summing the relative risk scores for all driveways, acceleration lanes, roundabouts, and intersections with a roadway section and then dividing by the length of the roadway section in miles.

The star rating criteria for intersection crashes shown in Table A-3 have been adapted to correspond appropriately to the relative risk scores for intersection crashes.

Weights for Combining Star Rating Categories

Table A-4 shows the weights used for combining star rating categories in the Michigan pilot study. These weights head-on crashes (15 percent), run-off-road crashes (19 percent), and intersection crashes (66 percent) are based on the relative frequency of these types of crashes on rural state highways in Michigan. These weights used in the Michigan pilot study are about the same as EuroRAP for head-on crashes, substantially lower for run-off-road crashes, and substantially higher for intersection crashes.

Table A-4. Category Weights for usRAP

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-on crashes</td>
<td>15</td>
</tr>
<tr>
<td>Run-off-road crashes</td>
<td>19</td>
</tr>
<tr>
<td>Intersection crashes</td>
<td>66</td>
</tr>
</tbody>
</table>

NOTE: Weights based on crash frequencies for rural state highways in Michigan.
Computational Procedure for Determining Star Ratings

The star rating for a roadway section is determined as follows:

**Head-on Crashes**

1. Determine the median treatment and speed for a roadway section or for individual subsections of a roadway section.
2. Determine the risk score for the section based on median treatment and speed using Table A-1. If the median treatment or speed varies among subsections, determine a weighted-average risk score for the roadway section.
3. Based on the weighted relative risk score for the section as a whole, determine the star rating (1, 2, 3, or 4) using the criteria in Table A-1.

**Run-off-Road Crashes**

4. Determine the roadside configuration and speed for a roadway section or for individual subsections of a roadway section. Roadside configuration is based on clear zone width, roadside slope, direction of slope (down or up), and presence of guardrail.
5. Determine the relative risk score for the section based on roadside configuration and speed based on Table A-2. If the roadside configuration or speed varies among subsections, determine weighted-average risk score for the roadway section.
6. Adjust the risk score based on lane width and shoulder width using the factors in Table A-2.
7. Based on the adjusted relative risk score for the section as a whole, determine the star rating (1, 2, 3, or 4) using the criteria in Table A-2.

**Intersection Crashes**

8. Determine the junction type and speed for each driveway, acceleration lane, roundabout, and intersection on the roadway section.
9. Determine the relative risk score from Table A-3 for each junction on the section.
10. Sum the relative risk scores for all junctions and divide by the roadway section length in miles.
11. Based on the total relative risk score per mile, determine the star rating (1, 2, 3, or 4) using the criteria in Table A-3.

**Overall Star Rating**

12. Determine the overall star rating as a weighted average of the individual star ratings for head-on, run-off-road, and intersection crashes using the weights shown in Table A-4.
13. To get the overall star rating, round the weighted average star rating to the nearest integer.

Closure

The usRAP RPS rating criteria presented here are preliminary and will undoubtedly be modified as the pilot studies proceed. If usRAP goes forward to full implementation with RPS as a key element, a key first step may be a research project devoted specifically to formally calibrating RPS scoring criteria for U.S. conditions using U.S. crash data and/or predictive models more extensively than has been possible to date.

References


APPENDIX B

WORKSHOP ATTENDANCE
The CanRAP Study Team would like to thank the following individuals for their contribution to the workshop sessions, and the valuable information and insight they provided.

Workshop attendees:

**Saskatchewan Ministry of Highways and Infrastructure:**
- Sukhy Kent
- Paul Hunt
- Barry Klatt
- Elena Zabolotny

**Alberta Transportation:**
- Allan Kwan
- Robert Duckworth
- Jack Chan

**British Columbia Ministry of Transportation:**
- Ed Miska
- Joy Sengupta
- John Mazuruk
- Jenna Sparks
- Chuck Hutchison
APPENDIX C

WORKSHOP SUMMARY MATRIX
## PROVINCIAL DATA AVAILABILITY

<table>
<thead>
<tr>
<th>Collision Data (Police Reported)</th>
<th>Saskatchewan</th>
<th>Alberta</th>
<th>B.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• General Comments / Summary</td>
<td>Accident data and analysis available via TAISIA application</td>
<td>Accident data and analysis available via ACIS application combined with CLIS and TIMS data</td>
<td>Accident data and analysis available via HAS and newer CIS</td>
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<tr>
<td>• Road Class</td>
<td>Ministry Standards Functional Classes include Major arterial Minor Arterial Collector Local Above refined by Design classes... Divided and 2-lane</td>
<td>Functional Classification National Arterial (provincial) Collector (regional) Local</td>
<td>- Urban or Rural (U/R) - Freeway, Expressway, Arterial (F/E/A) - Un-Divided or Divided (U/D) - Two-lane or Four-Lane (2/4)</td>
</tr>
<tr>
<td>• Severity</td>
<td>Y - exists</td>
<td>Y - exists</td>
<td>Y - exists</td>
</tr>
<tr>
<td>• Reportable Accidents Threshold (PDO)</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1000 ($600 for motorcycles)</td>
</tr>
<tr>
<td>• Segments &amp; Intersections</td>
<td>Y - both (polygon is created at each intersection to spatially capture collision data)</td>
<td>Y - both</td>
<td>Y - both</td>
</tr>
<tr>
<td>• Data Fields</td>
<td>Y / Adequate</td>
<td>Y / Adequate</td>
<td>Y / Adequate</td>
</tr>
<tr>
<td>• Electronic Format</td>
<td>Y - TAISIA (MS Access native)</td>
<td>Y - ACIS (DB format native)</td>
<td>Y - HAS (DB format native)</td>
</tr>
<tr>
<td>• Analysis &amp; Outputs</td>
<td>Y - supports analysis &amp; custom queries</td>
<td>Y - supports analysis &amp; custom queries</td>
<td>Y - supports analysis &amp; custom queries</td>
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<td>• Assessibility / Reliability / Availability</td>
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<td>High / High / High</td>
<td>High / High / High</td>
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<tr>
<td>• Documents Available</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>• Other Data</td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Traffic Volume Data</th>
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<th>B.C.</th>
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<tr>
<td>• General Comments / Summary</td>
<td>Exist for main segments and major intersections</td>
<td>Data housed in TIMS, with extensive ATR network</td>
<td>Data in two sets: TRADAS (in 626 Uniform Traffic Volume Segments (UTVS), includes intersections and minor roads) and HAS (separate volume dataset - no intersections or minor roads)</td>
</tr>
<tr>
<td>• Mid-Block/Segments</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>• Intersection Turning Movement</td>
<td>Y</td>
<td>Y</td>
<td>Y - TRADAS</td>
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<td>• AADT / SADT / Others?</td>
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<td>AADT, WAADT, SADT, classification</td>
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<td>• Electronic Format</td>
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<td>Y</td>
<td>Y</td>
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## Geometric Data

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<th>B.C.</th>
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<tbody>
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<td>General Comments / Summary</td>
<td>Data available via HIS (Highway Inventory System)</td>
<td>Data available via data warehouse (TIMS, videolog, etc.)</td>
<td>Data available via new CHRIS (Corporate Highway and Resources Information System) database, as well as WISH (barrier warrant index) and videolog</td>
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<td>See HIS manual</td>
<td>See CIA Manual</td>
<td>See CHRIS manual</td>
</tr>
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<td><strong>Segments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Treatment / Width</td>
<td>Y (manually through as built plans)</td>
<td>Y</td>
<td>Y</td>
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<td>Lane Width</td>
<td>based on construction logs</td>
<td>Y</td>
<td>Y - only design</td>
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<td>Shoulder Width</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Horizontal / Vertical Curves</td>
<td>Y</td>
<td>Y</td>
<td>Y - photolog (get horiz from digital road atlas (DRA))</td>
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<td>Terrain</td>
<td>Y</td>
<td>Y</td>
<td>Y - in LKI</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Conditions of Line Markings</td>
<td>have traverse pavement and longitudinal markings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadside (clear zone, barrier, etc...)</td>
<td>N</td>
<td></td>
<td>presence of a ditch</td>
</tr>
<tr>
<td>Posted Speed Limit</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Passing / Climbing Lane</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Guardrails</td>
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<td>Y</td>
<td>Y - by type</td>
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<tr>
<td>Linear Safety Features</td>
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<td>rumble strips</td>
<td>rumble strips</td>
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<tr>
<td>Signage</td>
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<td>Y</td>
<td>Y</td>
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<tr>
<td>Posted Speed Limit</td>
<td>Y</td>
<td>Y</td>
<td>Y - via DRA</td>
</tr>
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<td><strong>Intersections</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Type (Interchange / Signal / Stop / Uncontrolled)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Skewness</td>
<td>can get from centreline</td>
<td>can get from centreline</td>
<td>can get from DRA</td>
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<tr>
<td>Sight Distance</td>
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<td>Y</td>
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<tr>
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<tr>
<td>VRU</td>
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<td></td>
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<tr>
<td><strong>Photo Log</strong></td>
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<td>Y</td>
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<td><strong>Electronic Format</strong></td>
<td>Yes - varies</td>
<td>Yes - varies</td>
<td>Yes - varies</td>
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<td><strong>Assessibility / Reliability / Availability</strong></td>
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<td>High / High / High</td>
<td>High / High / High</td>
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<tr>
<td><strong>Documents Available</strong></td>
<td>Yes - varies</td>
<td>Yes - varies</td>
<td>Yes - varies</td>
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</table>
# PROVINCIAL DATA AVAILABILITY

<table>
<thead>
<tr>
<th>Linkages of the Various Data Sets</th>
<th>Saskatchewan</th>
<th>Alberta</th>
<th>B.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS data? Strip Maps? Others? Remote Access Possible?</td>
<td>Y - GIS available (shape files); Strip Maps</td>
<td>Y - GIS available (shape files, online)</td>
<td>Y - GIS available (shape files); Strip Maps - limited</td>
</tr>
</tbody>
</table>