Draft

# Performance Measures for Inter-Agency Comparison of Road Networks Safety


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## ABSTRACT

A study carried out for the Transportation Association of Canada (TAC) in 2011 focussed on the key performance measures needed for effective management of rural road network infrastructure, with emphasis on system preservation and safety. The latter area, as described in this paper, noted that the current state-of-practice in Canada uses accident rate per million vehicle-km of travel (MVKT) as the most common measure. This is also the case for various other international jurisdictions. A framework for road network performance measures is defined in the paper. It includes safety as a key component and emphasizes that the measures should integrate the objectives involved with stakeholder interests and tie in to transportation values. Recommended performance measures for safety in the TAC Study are categorized into three tiers, with Tier 1 incorporating collision rate and fatality rate per MVKT. Comparison and communication of safety performance in the TAC Study is recommended to consist of a distribution plot of agency 3-year mean values; then the agency's overall average collision rate and fatality rate would be compared to the national average using standard deviations to determine whether the record is above or below the national average. Best practices for obtaining the necessary data underlying performance measures are also recommended in the paper.

## INTRODUCTION

Performance measurement is a core component of managing public assets. The measures used provide the means for life cycle assessment of the assets and thereby facilitate cost-effective management. While performance measurement is widely used in Canadian provinces, territories and municipalities, actual practice and the specific measures used vary widely (1).

The Transportation Association of Canada (TAC) commissioned a study in late 2010 to develop performance measures guidelines for rural road networks with a focus on system preservation and safety. The intent was to assist agencies in making informed asset management decisions, provide a means for communicating road network performance to the public and allow agencies to compare performance of their networks with those of other agencies.

A comprehensive review of the national and international practice formed the first part of the study, followed by an analysis of 60,000 km of road networks from four Canadian provinces. The results were used to develop system preservation recommendations on roughness and surface distress, as primary measures, plus additional measures for structural adequacy, remaining service life and surface friction, and a combined Pavement Index measure for system preservation. As well, recommendations for future research, including network asset valuation, linking performance measures to policy objectives and implementation targets, extension to other highway components, and extension to other stakeholder interests like sustainability, mobility, environmental stewardship and institutional productivity were developed.

A TAC Report (2) provides details on the entire study, while a TAC paper (3) describes the first part of the study involving system preservation.

The purpose of this paper is primarily to describe the second part of the study on performance measures for road networks safety. As a context, however, the reasons or objectives for performance measures, examples and indices from the literature are first summarized.

## CURRENT STATE OF PRACTICE IN CANADA

The current state of practice among Canadian transportation agencies is well documented in a report titled, "Performance Measures for Road Networks - A Survey of Canadian Use" (1). It details the results of a survey of various Provincial and Territorial Departments of Transportation in Canada. The report also provides a review of relevant literature on the subject of performance measurement and highlights applications in the United States, Europe and Australia to provide an international perspective on trends in performance measurement.

The participating provincial and territorial jurisdictions have made some of their performance measurement processes public through on-line documents. However, the type and implementation practices vary. Survey responses were recorded from seven jurisdictions: Alberta, British Columbia, Manitoba, New Brunswick, the Northwest Territories, Quebec and the Yukon. The survey was based on the agency use of specific performance measures related to six outcomes:

1. Safety,
2. Transportation system preservation,
3. Sustainability and environmental quality,
4. Cost effectiveness,
5. Reliability, and
6. Mobility/accessibility.

Safety is clearly one of the most important measures. All of the responding agencies, with the exception of Yukon, reported that the most commonly used performance measure in terms of safety is accident rate per million vehicle kilometers (MVK). Most agencies collect data through control sections with excellent coverage of the network on an annual basis. Almost all agencies report using safety for planning purposes and several also use it for evaluation and investment decisions.

System preservation is a challenge to all transportation departments. Almost all the participating agencies have been using several indices. Five respondents indicated that Surface Distress Index (SDI) is the most frequently reported measure of transportation system preservation performance. Four agencies also reported using Structural Adequacy Index (SAI), Pavement Condition Index (PCI) and International Roughness Index (IRI) as performance measures.

## REASONS FOR PERFORMANCE MEASURES

Performance measures are important to assessing the operational and service provision effectiveness of transportation systems and services and the success of achieving performance targets. Performance measures of operational effectiveness are used in the planning and systems engineering context to prioritize projects, provide feedback on the effectiveness of longer-term strategies, refine goals and objectives, and improve processes for the delivery of transportation services. Performance measures in planning are mainly used in reporting trends, conditions and outcomes resulting from transportation improvements.

In the situation of competing alternatives and limited resources, performance measures help to efficiently allocate the available resources to road networks. As a result, any framework for performance measures should be comprehensive enough to incorporate functional, technical, environmental, safety, economic and institutional considerations.

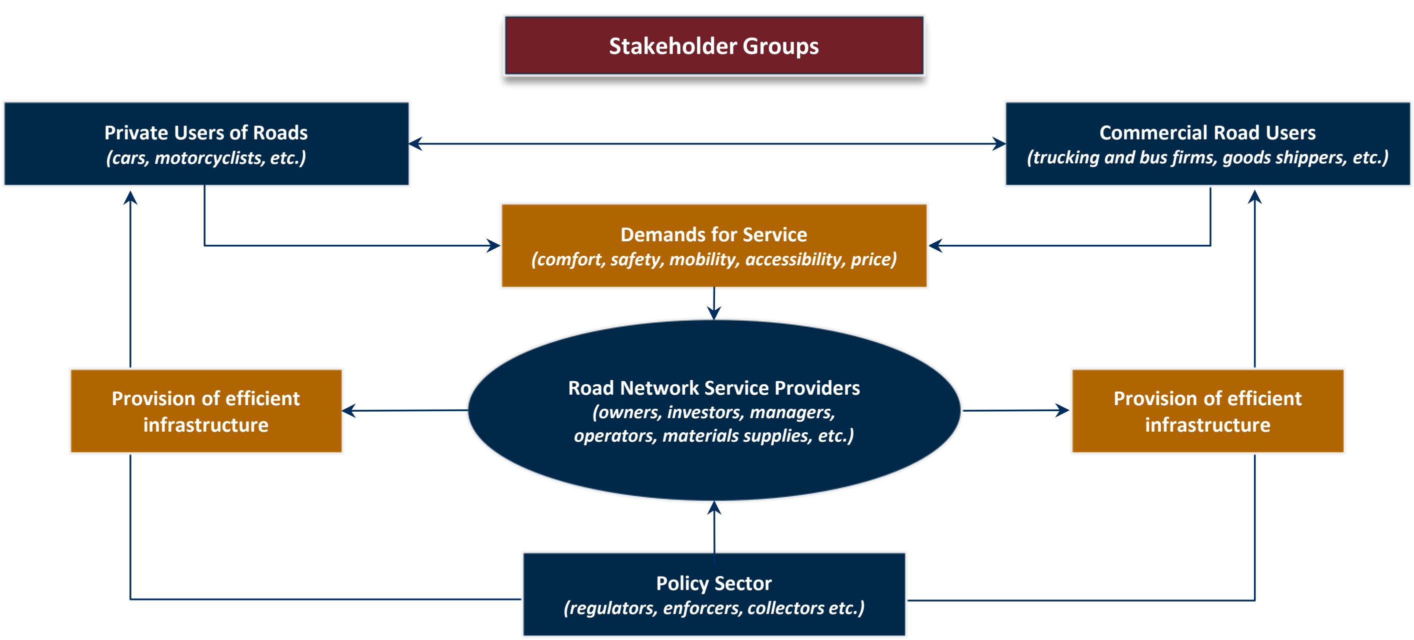
The objectives of performance measures include the following (8):

- Assessment of physical condition (in terms of level of service provided to road users).
- Determination of asset value, which can vary with accounting base (e.g., financial or management accounting) and with valuation method.
- A monitoring mechanism for assessing policies in terms of their effectiveness and/or compliance with predefined policy objectives.
- Provision of information to users or customers.
- Use as a resource allocation tool in terms of quantifying the relative efficiency of investments across competing alternatives.
- Diagnostic use for early identification of accelerated deterioration of assets and for appropriate remedial actions.

### Stakeholders Involved with Performance Measures and Relation to Transportation Values

The application of performance measures depends in large part on the stakeholders involved and their interests or requirements. Figure 1 identifies the major groups of such stakeholders involved in the performance measures for roads (5). There is in turn an obvious need for a consistent and comprehensive framework, which incorporates and integrates the performance measures relevant to various users, applications and overall transportation of user values.

**Figure 1: Stakeholders Involved with Performance Measures for Roads (5)**



Performance measures should relate directly with the expectations of transportation systems. This should be in relation to transportation values. For example, road users wish to travel with low cost, less travel time and minimized risk. The following are examples of transportation values (4):

- Safety - Injuries and/or fatalities per unit of transportation (e.g. per trip, per bridge crossing or per 100 MVK).
- Mobility and Speed – Delays, congestion, average travel speed, closures and detours.
- Reliability - Standard deviation of trip time, standard deviation of link speed.
- Environmental Protection - Atmospheric levels of carbon monoxide, ozone, nitrous oxides and particulates.
- Productivity - Units of transportation per unit of cost.
- User Benefits - Cost reduction of accidents, travel time reduction and vehicle operating cost reductions.
- Asset Value - Rate of depreciation.
- Comfort/Convenience - Road smoothness.
- Program Delivery - Project delays, funding, traffic delays due to construction work.
- Operational Effectiveness - Response time to incidents, claims due to potholes or guardrail damage, response time to public complaints/inquiries.

## FRAMEWORK FOR ROAD NETWORK PERFORMANCE MEASURES

Any framework for performance measures should integrate the objectives, stakeholders involved, balance the efficiency and effectiveness and tie in to transportation values. A framework of performance indicators for roads, adapted from (5) consists of the following two basic levels:

1. General performance measures for road assets, providing an overview or macro-level view usually contained in public statistics, which is understandable to the general public. Table 3.1 describes the performance measures related to features for road assets.
2. Detailed objective performance indicators for:
   – Service quality provided to road users (Table 2)
   – Institutional productivity and effectiveness (Provided in Ref. 2 & 5))

The second level framework generally incorporates those performance measures which exist in a corporate/agency database.

**Table 1: General, Macro-Level Performance Measures for Key Road Assets (5)**

| Feature or Aspect | Measures | Units | Breakdown and Remarks |
|---|---|---|---|
| 1. Network Size or Extent | a) Length | centre line-km and | By road class, jurisdiction, urban or rural |
| | b) Paved/Unpaved | % and length | By road class, jurisdiction, urban or rural |

| Feature or Aspect | Measures | Units | Breakdown and Remarks |
|---|---|---|---|
| | c) Right-of-Way area | Ha | |
| 2. Asset Value | a) Replacement | $ | By measures in 1 |
| | b) Book value or written down replacement cost | $ | By measures in 1 |
| 3. Road Users | a) Registered vehicles | Numbers | By cars, SUV's, light trucks, classes of heavy trucks, buses, motorcycles, etc. |
| | b) Ownership | Vehicles / No. of owners | By cars, SUV's, light trucks, classes of heavy trucks, buses, motorcycles, etc. |
| | c) Trip purposes | Trips, person-km, or vehicle-km | By work, recreational, commercial, etc. categories |
| 4. Demography and Macro-Economic Aspects | a) Population | Numbers | |
| | b) Total land area | Sq.km | By climate, topography, region, etc. |
| | c) Urbanization | % of population | |
| | d) GNP or GDP | Total $ | Also $/capita |
| 5. Network Density and Availability | a) Road density | km/1,000 sq.km | |
| | b) Road availability | km/$10^6$ persons | |
| 6. Utilization | a) Travel | Veh-km/yr | By road and vehicle class, dollar value |
| | b) Goods | Tonne-km/yr | |
| 7. Safety | a) Accidents | Total no. and rate | Rate in terms of no./$10^6$ veh-km |
| | b) Fatalities | Numbers | Rate in terms of no./$10^6$ veh-km |
| | c) Injuries | Numbers | Rate in terms of no./$10^6$ veh-km |

Table 2 briefly describes the service quality provided to the road user groups. Features such as quality and functionality of the facility or asset, its safety risk, mobility and accessibility provided, costs of using the facility and the environment in terms of noise and air quality are identified.

**Table 2: Measures of Service Quality Provided to Road Users (5)**

| Feature or Aspect | Indicator | Units | Breakdown and Remarks |
|---|---|---|---|
| 1. Comfort / Convenience | a) Ride quality | IRI, RCI, etc. | Clear definitions of units and methods are essential |

| Feature or Aspect | Indicator | Units | Breakdown and Remarks |
|---|---|---|---|
| | b) Surface quality | Rut depths, IFI, SN, shoulder types and widths | Clear definitions of units and methods are essential |
| 2. Road Corridor | a) Geometrics | Grades, curvature, lane widths, cross slopes, sight distance | % radii or degrees for grades and curvature, m for lane widths and sight distance |
| | b) Driver guidance | Markings, signs, messages | Locations, comprehension or awareness, legibility |
| | c) Hazards | Barriers, obstacles, distractions | Locations and numbers |
| 3. Safety Risk | a) Fatality | Fatalities/ $10^6$ veh-km | |
| | b) Injury | Injuries/ $10^6$ veh-km | |
| | c) accident | Total accidents/ $10^6$ veh-km | |
| 4. Mobility and Speed | a) Delays | Veh-hrs | |
| | b) Congestion | % veh/km | Classified by adequate, tolerable and unacceptable for % of veh/km |
| | c) Average travel speed | km/h | By road class, urban and rural |
| | d) Closures | Number of days | By road link and causes |
| | e) Clearance and load restrictions | Number of violations of standards, number of trucks detoured, detour user cost | Primarily affects trucks |
| 5. User Costs | a) Vehicle operating costs | Average $/veh-km | For existing conditions |
| | b) Travel time costs | $/veh-km | |
| | c) Accident costs | $/$10^6$ veh-km | |
| 6. Time Reliability | a) Standard deviation of travel time | | Often based on sample trips and reported by corridor |
| 7. Environment | a) Emissions | Kg/$10^6$ veh-km | By hydrocarbon and other compound type |
| | b) Noise | dB variation with time | Site specific |
| 8. Operational Effectiveness | a) Incident response time | Minutes | Average by incident |

| Feature or Aspect | Indicator | Units | Breakdown and Remarks |
|---|---|---|---|
| | b) claims | $ | Due to potholes or other unrepaired problems |
| | c) injury response time | Days | Time to reply to inquiries or complaints |

## OTHER NEW INITIATIVES ON SAFETY PERFORMANCE ASSESSMENT

A major new initiative involved a collaborative project in 1999 between Engineers Canada and the National Research Council Canada on a "Model Framework for Assessment of State, Performance and Management of Canada's Core Public Infrastructure (CPI)" – see Ref. (6). The 32 road sector measures chosen for this model framework were those selected through a consensus of stakeholders. Assessment criteria, 12 in total, ranging from health and safety to capacity to meet demand were matched against the performance measures. At the time of preparing this paper, however, the initiative has not been taken further.

"An Asset-Management Framework for the Interstate Highway System", NCHRP Report 632, presents a practical framework for applying asset-management principles and practices to managing Interstate Highway System (IHS) investments (7). Table 3 lists the core set of performance measures recommended for the Interstate Asset Management Framework. For each of the four categories including preservation and safety, there is asset type where applicable, as well as the measure type and specific measure.

**Table 3: Recommended Core IHS Asset Management Performance Measures (7)**

| Category | Asset Type | Measure Type | Measure |
|---|---|---|---|
| Preservation | Pavement | Structural Adequacy | Present Serviceability Rating (PSR) or an agency's pavement condition index |
| | | Ride Quality | IRI |
| | Bridges | Structural Deficiency | Percent classified as Structurally Deficient (SD), weighted by deck area |
| | Signs | Asset Performance | Percent functioning as intended |
| | Pavement Markings/ Delineators | Asset Performance | Percent functioning as intended |
| | Guardrails | Asset Performance | Percent functioning as intended |
| Mobility | | Travel Time | Travel time index |
| | | Delay | Delay per vehicle in hours |
| Safety | | Crash Rate | Number of crashes expressed as number per year and per VMT |

| | | |
|---|---|---|
| | Fatality Rate | Number of fatalities expressed as number per year and per VMT |
| Environment | Agency-specific report card of environmental milestones | Pass/fail indication for each measure |

Performance measures used by Austroads ( ) for safety includes 8 types, ranging from serious casualty crashes to road fatalities to social cost of serious casualty crashes on a population or veh-km tracked basis.

In the previously noted survey conducted in Canada (1), the first outcome examined was safety. The list of indices to measure safety performance included:

- Accident rates per million veh-km (MVK),
- Fatalities per MVK,
- Injuries per MVK,
- Property damage only incidents,
- Percent of incidents involving trucks per MVK and
- Rail grade crossing incidents.

Out of these indices, the most commonly used measure was accident rates per MVK.

The more recently completed TAC project “National Guidelines for the Network Screening of Collision-Prone Locations” includes state-of-the-art and practice approaches for identifying roadway safety deficiencies in order to develop remedial countermeasures (8).

In the management of road networks,  investment decision guidelines on how best to modify the network should be based in part on using a location approach, a system wide approach or an approach targeting specific collision types. A road safety management system (RSM) is an important part of a road infrastructure cycle and project development. The objectives include the identification of collision-prone locations, developing remedies to reduce collisions on those identified locations and project prioritization. The road safety management process in the guidelines from TAC (8) is shown in Figure 2.

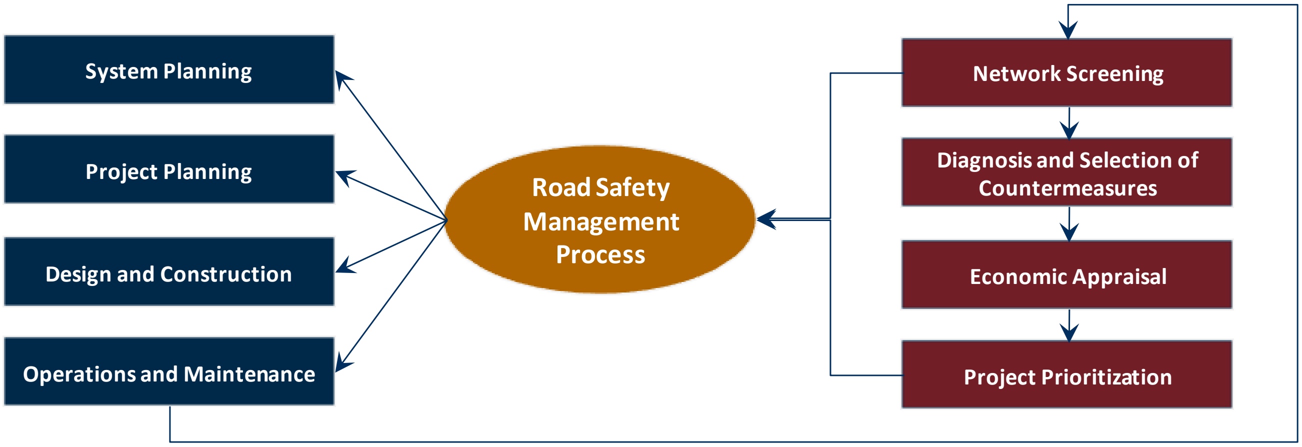



**Figure 2: Road Safety Management Process (8)**

A survey was conducted with the Canadian and US practitioners and researchers to gather information on the most current methods, data availability (now and in future) and the specific goals and programs of interest to those likely users of the TAC National Guidelines for Collision-Prone Location (CPL) Screening. The results of the survey showed that approximately one-third of Canadian and half of US respondents applyied CPL screening to specific road types in support of general road programs, such as:

- Application of increased signal head that enables an observer to differentiate the sign from its surrounding environment,
- School zone safety,
- Improvements to rural curves,
- Application of shoulder rumble strips,
- Application of roadside barriers and
- Roads scheduled for other capital improvements.

Several Canadian respondents reported using Traffic Engineering Software (TES), which among other functions manages data and can perform network screening using safety performance functions. In the US, a number of jurisdictions are preparing to use the Safety Analyst software, which will manage collision, traffic and geometric data, and perform state-of-the-art network screening, countermeasure selection, economic analysis and safety evaluation functions.

## RECOMMENDED PERFORMANCE MEASURES

The recommended performance measures for system preservation are provided in a comprehensive report to TAC (2). Also contained in the report are those measures related to safety, as summarized in Table 4. These measures are intended as a means for national and/or international comparisons. A tiered approach is used where Tier 1 indicates highly recommended, Tier 2 indicates that the data or measure is desirable but not mandatory and Tier 3 indicates that the measure is optional and not critical.

Table 4 indicates that collision rate and fatality rate should be the main (Tier 1) performance measures. Most transportation agencies collect this data and a review of the literature indicates that fatality rate is a widely used measure across North America and around the world. A few issues or limitations exist, however, with collision rate, as subsequently discussed further.

**Table 4: Performance Measures - Safety**

| Performance Measure | Description | Measurement Type | Pavement Types | Value of Measure[2] |
|---|---|---|---|---|
| **Collision Rate (CR)** | Collision Rate per MVKT[1] | Based on accident history and collision data obtained from police reports, agency records, etc. | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal<br>Gravel Roads | Tier 1 |
| **Fatality Rate (FR)** | Number of Fatalities per MVKT | | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal<br>Gravel Roads | |
| **Injury Rate** | Number of injuries per MVKT | | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal<br>Gravel Roads | Tier 2 |
| **Road Related Collision Rate** | Number of collisions attributed to condition of road or highway per MVKT | | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal<br>Gravel Roads | |
| **Surface Friction** | Measurement of the surface friction of the pavement surface | Locked wheel skid tester (ASTM E274) | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal | |
| **Highway Geometrics** | Key highway geometric design components | Manual or Automated Methods ($R_{min}$, $e_{max}$, sight distance, etc.) | AC<br>PCC<br>CO (AC/PCC)<br>SRFT/Chip Seal<br>Gravel Roads | Tier 3 |

*[1] MVKT – Million Vehicle Kilometers Traveled*

*[2] Value of Measure: Tier 1: Important, highly recommended that agency collects this data; Tier 2: Desirable, data is desirable but not mandatory; Tier 3: Optional, not critical data*

## SAFETY PERFORMANCE

One of the most important measures of level of service for a highway network is safety. Each year, thousands of motorists across Canada are involved in motor vehicle collisions which result in property damage, congestion, delays, injuries and fatalities. Highway accidents not only impact the people who are directly affected by the accident, but impact society as a whole. Emotional pain and suffering from families and friends, lost time at work, increased insurance costs, user-delay costs and increased emissions are all examples of indirect impacts of accidents on societies.

MTO estimated that in 2002, vehicle collisions in Ontario cost the province nearly $11 billion. It also estimated that for every dollar spent on traffic management, 10 times that amount could be saved on collision-related expenditures, including health care and insurance claims (9). In 2000, all of the provincial and territorial agencies in Canada endorsed the Road Safety Vision 2010 (10). The aim of this national initiative is to make Canadian roads among the safest in the world and to reduce the average number of deaths and serious injuries resulting from motor vehicle collisions by 30% (9).

Over the years, highway safety has improved in Canada. In 2008, there was a significant decrease in traffic-related deaths when compared to the 2007 fatality figure. The number of fatalities in 2009 was substantially lower than the total number of road users killed in traffic crashes during 2008 and the lowest number of deaths recorded in Canada in over 60 years (RoadVision 2010). This is despite the fact that the number of motor vehicles and drivers on Canadian highways and roadways has increased.

## DATA REQUIREMENTS FOR SAFETY PERFORMANCE MEASURES

To develop and establish performance measures for use by Canadian transportation agencies requires an examination of their available data. As a minimum, accident/collision data, traffic data and roadway inventory data should be considered in the development of any performance measure related to safety. A procedure for evaluating network-level safety for Canadian Transportation agencies based on data availability is provided in Ref. (11).

### *Collision Data*

Most Canadian transportation agencies collect and record accident data in a structured database. As an example, the Traffic Division at MTO is responsible for collecting and maintaining a comprehensive vehicle accident database. When an accident occurs on a highway segment, provincial police officers produce a detailed record of the collision including such factors as collision type, weather conditions, surface conditions, location, object of impact, etc. This data is then entered into a Traffic Management System that can be queried and manipulated to extract data and key fields of interest. Due to the sensitivity and confidentiality of the collision data, only information related to the driver's age, gender and condition is provided. No personal information such as name or address is available to the public or researchers.

The collision data set has several attributes associated with each collision record. Attribute data such as surface condition, driver condition, sex of driver, environment condition, collision severity and many others are included in the data set. It is important that detailed and accurate accident data be collected from the scene of an accident if the data is to have any value from a research perspective or for calculating performance measures.

### *Traffic Data*

A critical component of any performance measure related to system preservation or safety is traffic data. Factors such as the annual average daily traffic (AADT), annual average daily truck traffic (AADTT) and % commercial truck traffic all influence pavement performance and the level of safety of a highway section. Traffic data is important for calculating rates such as the collision rate or fatality rate since these rates are a function of traffic volumes. Traffic data can be collected from a number of different methods including manual traffic counts, fixed traffic data collection sensors (WIM and weigh scales) and Intelligent Transportation Systems (ITS). Most Canadian transportation agencies collect and store traffic data as a part of their pavement and traffic management programs.

### *Highway Referencing and Inventory Data*

Highway agencies typically classify their highways based on a number of parameters such as functional type, pavement type, number of lanes, shoulder type, lane-widths, kilometre-post, presence of guide-rails and many others. Many of these parameters influence the level of safety of a highway and should be inventoried or collected and stored in a database. This data is useful for identifying collision prone locations (i.e. intersections, presence of guiderails, no shoulders, etc.) and conducting safety assessments of highways.

## HIGHWAY SAFETY PERFORMANCE COMPARATIVE ANALYSIS FOR COLLISION RATE AND FATALITY RATE

Using fatality rates as a performance measure can create some challenges for comparative analysis and measurement. First, the number of fatalities and fatality rates are relatively rare events and as such, are subject to random variation (7). The variation in fatality rates across the various provinces can be caused by differences in travel habits, socio-economic characteristics, distribution between rural vs. urban travel, population density, income and age distribution.

In order to account for the randomness in collision or fatality rates, it is recommended that the rates be examined over a period of time rather than at discrete or absolute values (7). The change in collision or fatality rate over a 3-year period is recommended in the TAC Study (2). As an example, the average fatality rate should be calculated for an agency from 2010 to 2008 and compared to the average from 2007 to 2005. The percent change in the fatality rate over these two 3-year periods should be evaluated. As a first measure of performance, the magnitude of the percent change over these periods should be reported. It should be expected that if an agency is taking a proactive approach toward highway safety, such as implementing highway safety improvements and educating drivers, that a decrease in the 3-year average collision/fatality rate should be observed.

As a second measure of performance, an agency’s 3-year average collision rate and fatality rate should be compared to the Canadian National Average. The standard deviation (SD) of the agency’s collision rate and fatality rate to the Canadian National Average can be calculated. This will indicate whether the record is within an average range of ± 0.5 SD or above average or below average. Figure 3 illustrates this approach (2).

It should be noted that the collision/fatality rate also includes relatively rare single vehicle events, such as a rollover.

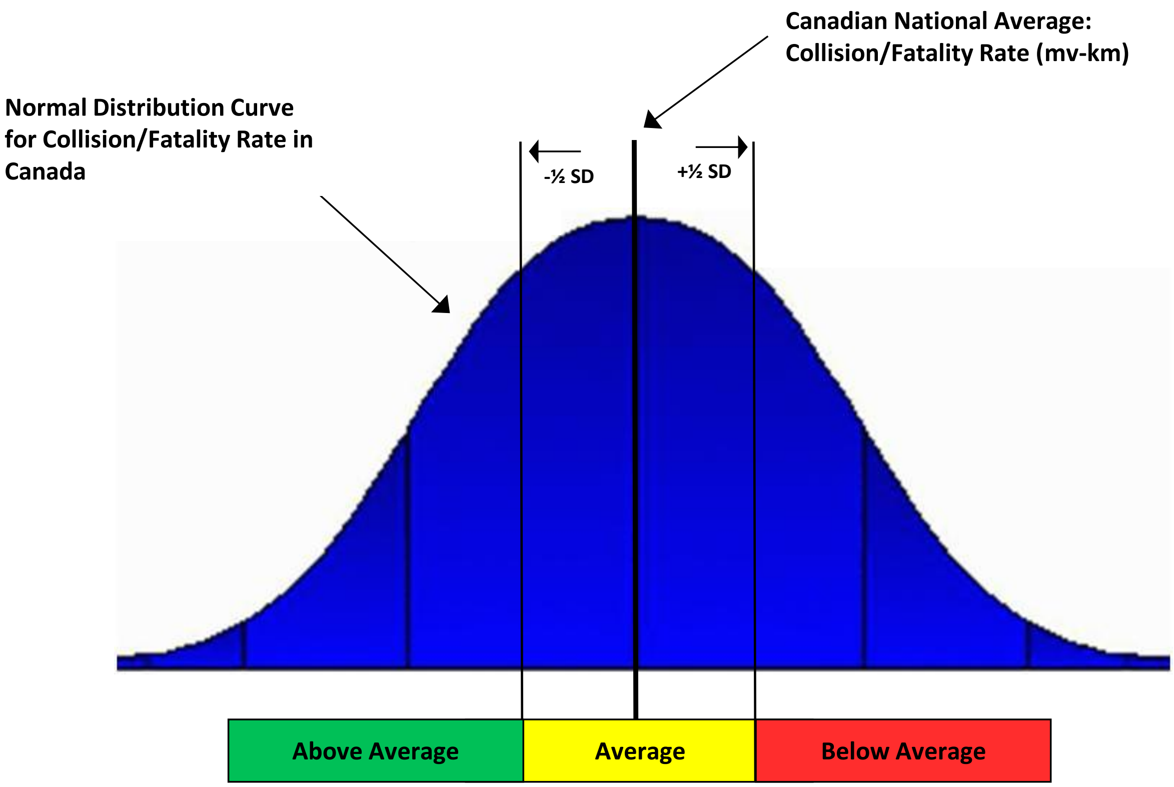



**Figure 3: Collision/Fatality Rate as a Safety Performance Measure**

As an example, if an agency is 2 or more standard deviations above the national average, then the safety performance measure might be considered as well above average.

## BEST PRACTICES RELATED TO DATA FOR SAFETY PERFORMANCE MEASURES

The following are recommendations related to improving the data collection requirements for the safety performance measure specifically related to collision data, traffic data and highway referencing and inventory data (2).

### *Collision Data*

- Referencing - GPS coordinates
- Time-stamped site photos at accident scene with GPS coordinates
- As a minimum, the following attributes should be collected:
  - Collision location
  - Date
  - Collision type
  - Maximum severity to any person or vehicle involved
  - Relationship to junction, i.e., intersection-related or non-intersection-related
  - Maneuvers by involved vehicles (straight ahead or left turn or right turn, etc.)

***Traffic Data***

- Use of WIM data and traffic loop detectors
- ITS
- As a minimum, the following attributes should be collected:
  - Roadway AADT for segments and ramps, and
  - Traffic distribution (by vehicle class)
  - Major and minor road AADTs for intersections (i.e., entering traffic volumes by approach to the intersection). Note that the major road is defined as the roadway with the larger entering AADT (i.e., the sum of both directions, if two-way roadway).

***Highway Referencing and Inventory Data***

- Segment location (in a form that is linkable to traffic volumes and collision locations)
- Segment length
- Area type (rural or urban)
- Number of through traffic lanes (by direction of travel)
- Median type (divided or undivided)
- Access control (freeway or non-freeway)
- Two-way versus one-way operation

## CONCLUSIONS

Effective management of road network infrastructure requires realistic and useable performance measures. In addition, performance measures should provide a means for comparing road network performance across or between agencies. The TAC study of 2011, which focussed on performance measures for system preservation and safety, indicated for the latter area as reported herein, that clear objectives and stakeholders involved have to be defined, that a framework should integrate the objectives and stakeholders interests and tie in to transportation values. Recommended performance measures for safety are categorized into three tiers, with Tier 1 consisting of fatality rate and collision rate per million vehicle-km of travel. Comparison and communication of safety performance is recommended in the TAC study to consist of 3-year period averages for the agency’s network plotted as a distribution where ± ½ standard deviation (SD) would be considered in an average range and beyond these values could be considered above or below the national average.

## ACKNOWLEDGEMENT

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