# A Review of the Alberta Performance Measures


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## ABSTRACT

Performance measurement is a vital component of asset management which is used in planning and programming to identify assets that are under or over performing and to assess overall agency performance over time. More specifically performance measures are used to, a) define policy objectives at an early stage of policy or system planning, b) provide the basis for annual performance reporting on system condition and performance as part of communication, c) screen projects or set project priorities and, d) allocate resources. Regardless of what performance measures are ultimately selected by an agency, they must meet the 4R test: be *relevant* and understandable to the users, be technical *robust* and *repeatable* and be *responsive* to major work programs and/or budget fluctuations.

As part of the move to asset management, Alberta Transportation has implemented performance based planning and monitoring of the provincial highway network. Three performance measures, based upon technical measurement, have been adopted which characterize network condition, functional adequacy and utilization. Recent budget planning cycles have indicated that the current suite of performance measures is not sensitive enough to budget levels and as such, the department revisited them with the goal of improving their effectiveness as a measurement and reporting tool. This paper describes the analysis of, and modification, to the condition performance measure in attempt to address the criteria of relevancy and sensitivity. The methodology used in the analysis can serve as a template to other agencies facing a similar problem and /or to agencies in the process of defining a relevant, repeatable, robust, and responsive performance measure.

## Introduction

Performance measures are used by agencies to a) define policy objectives at an early stage of policy or system planning, b) provide the basis for annual performance reporting on system condition and performance as part of communications, c) screen projects or set priorities and, d) allocate resources [Pickerill 2001].

## Background

As part of a government-wide infrastructure management initiative, Alberta Transportation has implemented performance based planning and monitoring of the provincial highway network. Three performance measures, based upon technical measurement, have been adopted which characterize network condition, functional adequacy and utilization. Recent budget planning cycles have indicated that the current suite of performance measures is not sensitive enough to budget levels and as such, the department wishes to review the current suite of performance measures with the goal of improving their effectiveness as a measurement and reporting tool.

Using the findings of a series of workshops with internal and external stakeholders, the 1-999 numbered provincial highway system was used to evaluate enhancements to the current performance measures of condition, utilization and functional adequacy. The following recommendations are made:

## PERFORMANCE MEASURES

Agencies generally use performance measures to help define and manage their current and future assets as illustrated in Figure 1, which is the Transportation Association of Canada's framework for asset management [TAC 2001]. In this framework, performance measures are used in planning and programming to identify assets that are under or over performing and to assess overall agency performance over time. More specifically performance measures are used to, a) define policy objectives at an early stage of policy or system planning, b) provide the basis for annual performance reporting on system condition and performance as part of communication, c) screen projects or set project priorities and, d) allocate resources [Pickerell 2001]. Performance measures should be defined in response to the goals and objectives that are directly aligned with the broad goals and mission of the agency as illustrated in Figure 2. For Alberta Transportation the context for performance measurement is the mission statement as follows:

*"To provide a safe, efficient and sustainable highway network … and support municipalities in meeting their transportation …infrastructure needs."*

Alberta Transportation Mission Statement

There are two different approaches to translating long-term goals and objectives into specific performance goals for use in planning and programming as illustrated in Figure 3. In the prospective approach the goals are established and plans put in place to achieve them, while in the retrospective approach, the plans are defined and the goals are derived from the existing plans.

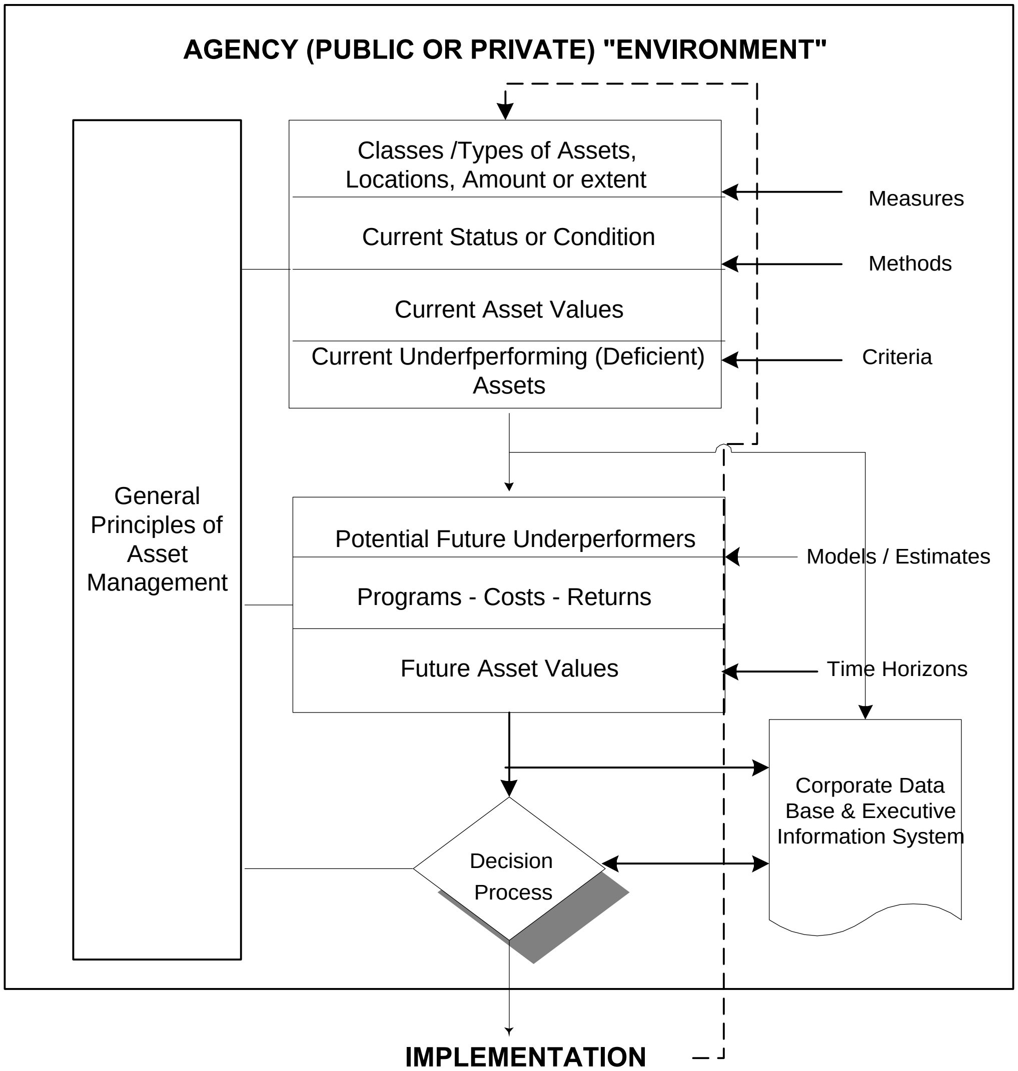


**Figure 1: Asset Management Framework [TAC 2001]**

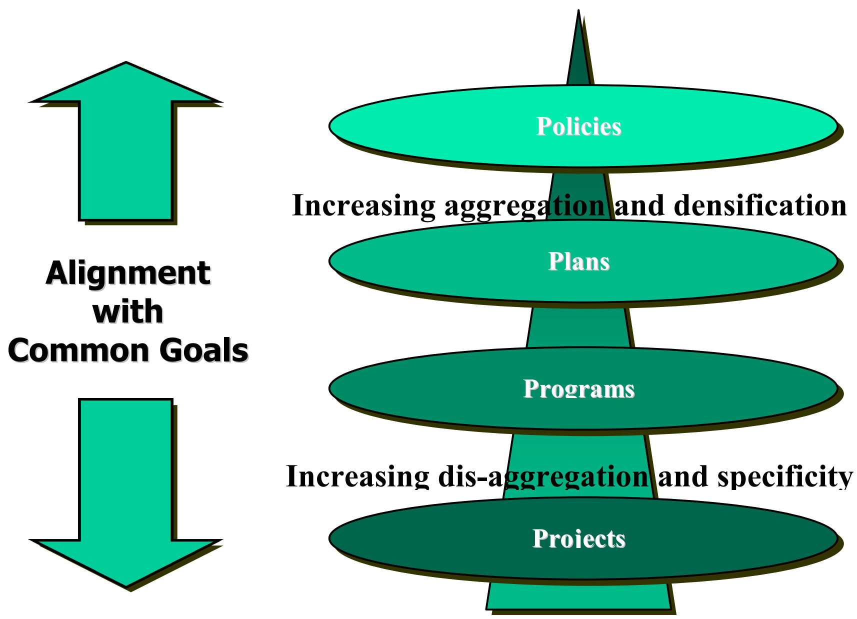


**Figure 2: Alignment of Performance Measures with Common goals [Pickerell 2001]**

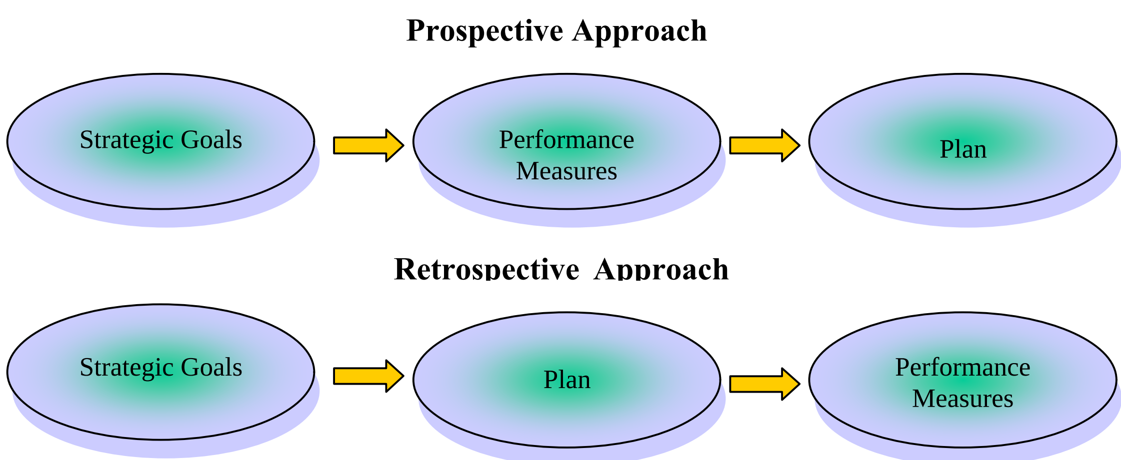


**Figure 3: Translating Goals into Performance Measures [Pickerell 2001]**

All performance measurements generally fall into three categories: *Inputs* – which look at the resources dedicated to a program, such as dollars spent, quantity of materials used, equipment hours or staff time consumed. *Outputs* – which look at the products produced, such as miles of pavement resurfaced, miles of pavement seal coated, number of potholes repaired or miles of lanes added. *Outcomes* – which look at the impacts of the products on the goals of the agency, such as discernible improvements in pavement ride, reduced travel time, reduced vehicle operating costs, reduction in fatalities or citizens perception of road conditions from public opinion surveys. In order to be effective, performance measures should be:

- Based upon technically sound, repeatable, robust data, which is supported by the agency business processes.
- Understandable to all levels of the agency (technical, administrative and executive) and capable of being 'rolled up' for non-technical reporting to policy makers (Cabinet) and the public at large.
- Reflect the user or stakeholder groups, which in the case of transportation agencies include: the public and commercial users as well as the service providers (Alberta Transportation) and policy makers.
- Be broad enough to sum up the net effect at the system level of many smaller, discrete actions, but specific enough, at a technical level, to register a response to decisions (a change in the decision causes a response in the measure and 'moves the needle').

Stakeholder involvement is an important consideration when developing outcome based performance measures, requiring an understanding of the needs, expectations and levels of satisfaction of the users or customers. According to the Transportation Association of Canada [TAC 2001] the group of stakeholders that should be involved in or considered when developing and establishing performance measures, are the following:

- Highway agencies as service providers, consultants acting on their behalf and contractors who have taken over network roads in long term performance based contracts. Also included could be the supplier of goods and materials and financing agencies, such as, electronic toll roads).
- Private and commercial road users (cars, trucks, buses, motorcyclists, cyclists and pedestrians).
- Policy makers and regulators, who control fuel taxes and tools in the case of policy and compliance with road laws, safety and vehicle weights and dimensions in the case of regulators.
- The public at large to whom the public agency is accountable for highway performance.

Performance measures operate at three different levels within an agency and must be interrelated and capable of being rolled up. Haas [1977] identified the two levels at which pavement management must operate, namely network and project level. Asset management adds a third level, that of strategic management which aligns the network and project level goals and objectives to the corporate policy of the agency. It therefore follows that performance measures, as part of an asset management system, should operate at three levels: strategic, network and project level. Strategic Level performance measures are defined within the Business Plan of the agency and address the highest goals and objectives. Strategic level measures must span asset categories (that is, roads, bridges, appurtenances, lighting etc.). An example of a strategic level performance measure within a highway agency is crash rates. By setting a target for reduction in crashes, the agency must provide a safe highway system in terms of capacity, geometrics and road surface characteristics and as such, presents an umbrella indicator. Similarly, a strategic objective, such as, 'provide economic growth' requires action from many departments through various government-wide initiatives. Using the example of crash rates, regulations, such as graduated licenses and minimum vehicle safety standards can be introduced that can also contribute to lower crash rates through better drivers and fewer mechanical hazards. Network Level performance measures are more technically and therefore, directly connected to the asset category. Continuing the safety example, at the network level International Friction Index (IFI) is an appropriate performance measure as it is a component of overall road safety that is a characteristic of the road surface and directly relates to road safety. Project Level performance measurement guides individual projects and the equivalent performance measure is a road safety audits. A fourth level, value engineering is designed to derive the most value from a project through cost-effective management and analysis of alternatives during implementation of a project. Continuing the safety example, the selection of appropriate crash attenuation materials is a value engineering measure.

## ALBERTA TRANSPORTATION'S CORE PERFORMANCE MEASURES

Alberta Transportation, as part of a government wide initiative, has recently adopted three performance measure categories: physical condition, utilization and functional adequacy. The performance measures are tabled in the Provincial Legislature and published on the World Wide Web [AT 2002]. Three goals are identified as follows and performance measure targets published for a three-year business plan. Along with the targets, the ministry presents the current measurement expressed as a percentage of the system meeting the target.

- The improvement of transportation safety through reductions in alcohol related casualty collisions, increased seat belt usage and improved mechanical safety of commercial vehicles is goal number 1. This is a strategic level goal with performance measures of the percentage of the collisions, drivers and vehicles meeting the target.
- Improved planning of the provincial highway network is goal number 2 and 3 combined. Three long-term performance measures are used to monitor these goals, namely, Physical Condition - the percentage of physical infrastructure rated as being in acceptable condition. Utilization - the percentage of physical infrastructure for which utilization level is within targeted capacity. Functional Adequacy - the percentage of physical infrastructure that provides acceptable functional service. The three categories (Physical Condition, Functional Adequacy and Utilization) are common classifications for all Alberta Government ministries and thereby provide cross-ministry comparison of performance.

### Physical Condition of Provincial Highways

This measure is an indication of the riding comfort of the traveling public on highways and bridges under provincial jurisdiction as measured by the International Roughness Index (IRI). The results and targets relate to the percentage of the provincial highway network as meeting or exceeding a predetermined IRI value. Based upon the FHWA, two thresholds of IRI are used to determine the business targets: 1.5 and 2.7. These two thresholds are used to define fair or poor performers. The performance measure target is expressed in terms of percentage of the network in fair or better condition. A secondary (project level) measure is proposed for the 2003 – 2006 business cycle, which translates the IRI targets into the percentage of the network requiring pavement rehabilitation.

### Utilization of Provincial Highways

This measure is defined as the percentage of the provincial highway network that is equal to, or better than, a targeted Level of Service (LOS) as defined by the Highway Capacity Manual. If a highway meets or exceeds this targeted level, it is being utilized as planned. The targeted LOS for provincial highways is C, as that level triggers future upgrading. LOS is an international measure based on the ability of traffic to move freely. The scale ranges from A to F, with A representing no restrictions on traffic flow, and F representing a breakdown of flow.

### Functional Adequacy

Functional adequacy is defined by the percentage of road and bridge infrastructure that is rated as meeting target criteria. A provincial highway is functionally adequate if the roadway is a standard width, free of road bans, and if the traffic is unrestricted by speed postings due to geometric constraints.

## ISSUES WITH THE CURRENT PERFORMANCE MEASURES

One of the problems that has been identified with the current performance measures is the lack of sensitivity to budgetary fluctuations. For condition, the target is 95% of provincial highways with an IRI rating of 'fair' or better (that is an IRI rating of less than 2.70). Currently, 95.8% of provincial highways have a 'fair' or better rating. However, Alberta Transportation reports that there is little variation of this percentage with an increase or decrease in budgetary expenditures. A deferral of the Pavement Rehabilitation Program for three years has as its outcome a decrease in the percentage from 95 – 91%. This seems to be a small change in condition as a result of a major reduction in program expenditure. As a result of this small reduction of the overall percentage, the measure may not be sufficiently sensitive to the overall size of Alberta's Pavement Rehabilitation Program; as it has been reported that maintenance costs and public complaints rise quickly when highways are not rehabilitated on a regular schedule [Nichols 2002].

## REVISING THE PERFORMANCE MEASURES

Data was extracted from the Roadway Maintenance and Rehabilitation Application (RoMaRa) pavement management application database for the provincial highway network to investigate ways of revising the performance measures to investigate ways to improve the reporting of the Provincial performance measures in three areas: the relationship between reporting sections and planning sections, how to relate the current condition measures to the users and how to adjust the performance measure to create sensitivity to budget fluctuations.

**REPORTING SECTIONS**

In the past business plans, network condition has been reported using 50 m sections. One of the drawbacks of this approach was that the reported condition of 95% of the network in a fair or better condition (IRI < 2.7) could not easily be translated into projected rehabilitation costs (and budget requirements) as the 50 m sections not meeting the target were scattered across the network. Moving from the network level performance measure of percentage of the network greater than a set threshold, to projected program costs was difficult to compute because of the scatter of the sections, hence, a greater linkage between monitoring sections, used to report network performance, and planning sections, used to develop programs and budgets is required. The alternative is to base the performance measure reporting on homogeneous lengths based upon performance, however, this has the disadvantage of creating a moving datum from year to year. While homogeneous performance based sections provide a direct link between network level and project level reporting, the problem is that the number of sections will change from year to year as the sections age and there is no basis for comparison. Fixed reporting sections provide year to year reporting, however, one of the concerns about increasing the size of the monitoring sections (from 50 m to 1 km) is the potential loss of resolution with larger sections. Historically, the department had used control sections that were criticized for rigidity and lack of transparency and there was some concern regarding a return to that approach. Many agencies use fixed length monitoring sections for annual reporting of network condition. In the United States, the Federal Highway Administration uses 5 mi highway performance measurement sections (HPMS) to monitor and report the condition of the interstate highway system. In a mature network (that is, one that is not expanding capacity in terms of centerline length), the use of fixed lengths means that from year to year the total length of the network is not changing and therefore changes in the percentage of the network in good-fair-poor condition reflect work done as a result of program decisions.

A comparison of the network reporting using three cases (50m, 1 km and homogeneous) for the entire length of Highway 1 was conducted to compare the network performance for each case. Based upon the results, it can be seen that the 1 km IRI case closely mirrors the homogeneous planning section based upon IRI and is quite different to the 50m distribution. Using this analysis, the entire highway system was sectioned into 1km sections for further analysis.

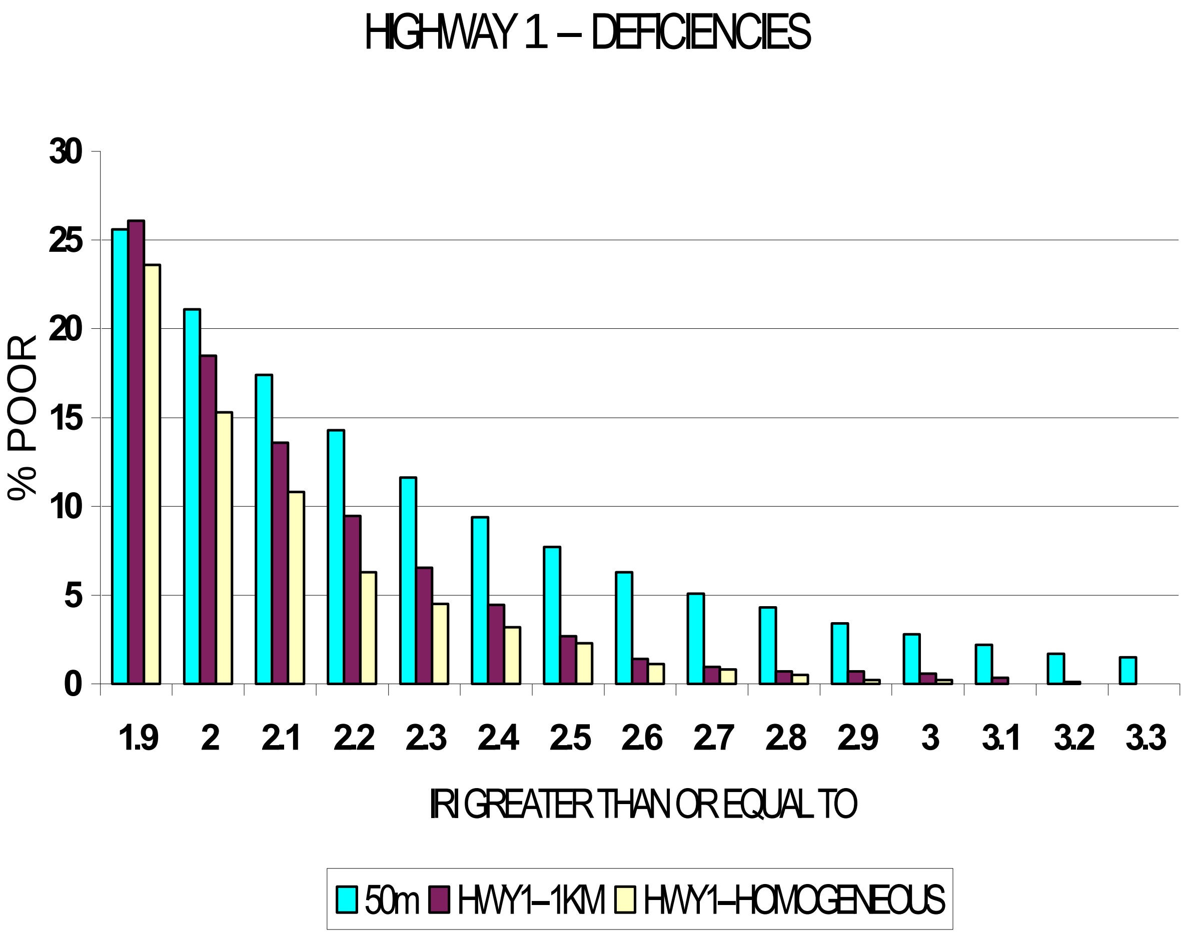


**Figure 1: Comparison of Monitoring Sections – Highway 1.**

## RELATING PERFORMANCE MEASURES TO THE USERS

The current measures are all reported on the basis of length of highway, regardless of the volume of traffic and / or associated land-use (that is, rural or urban). To include the user, it is possible to report the performance measure by traffic volume through two factors: vehicle kilometre traveled and truck kilometre traveled. To reflect functional classification differences (which can reflect geometric variances) the network was divided into two classes:110 kph (indicative of freeway conditions and closely related to the National Highway System) and non-110 kph (indicative of the remainder of the paved highway system).

### Vehicle Kilometres Traveled (VKT)

Vehicle Kilometres Traveled assigns traffic volumes to lengths of the network and is used to weight the performance by usage. In the case of condition, VKT is used to report the percentage of the total VKT that is traveling on roads within a good-fair-poor range. VKT is calculated as follows:

VKT = length * AADT * 365 days

**Truck Kilometres Traveled (TKT)**

Truck Kilometres Traveled assigns truck volumes to lengths of the network and is used to weight the performance by commercial usage. In the case of condition, TKT is used to report the percentage of the total TKT that is traveling on roads within a good-fair-poor range. TKT is calculated as follows:

TKT = length * AADT * 365 days * percent trucks

Figure 2 presents a comparison of the three methods for the 110 kph network using 1 km fixed sections. In this figure, the percentage of the 110 kph network by IRI class is presented by length, %VKT and % TKT. To explain the difference, 28% of the network length has an IRI greater than 1.7, and that sub-network is carrying 25% of all vehicular and 25% of all truck traffic. In all classes, the percentage of the network length is higher than the VKT or TKT. A similar graph is presented in Figure 3 of the total network, differentiated by speed, which shows the opposite trend, in that in all classes, VKT and TKT are higher than length.

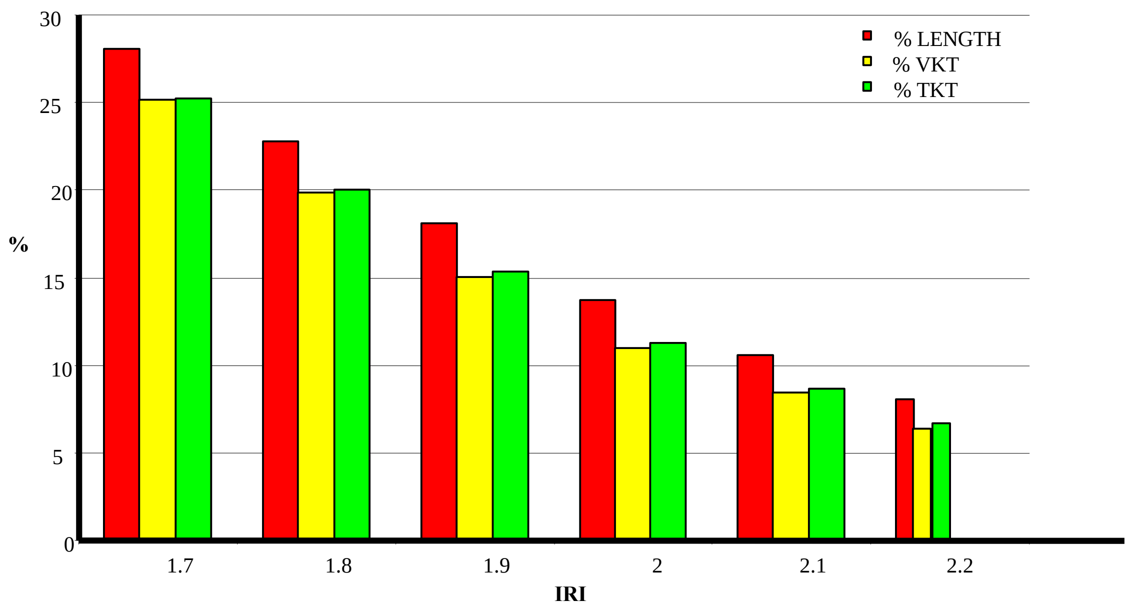


**Figure 2: Comparison of Length, VKT and TKT on the 110 kph network**

To further evaluate the potential for reporting performance by VKT or TKT, a sensitivity analysis was conducted on the network comparing the impact of one year's construction program on network performance as reported by length, VKT or TKT. The results are presented in Figure 4. In this case, the 2001 construction program was simulated through reduced IRI and the performance calculated before and after rehabilitation. In all cases, the VKT and TKT provide greater sensitivity in terms of the change resulting from the construction.

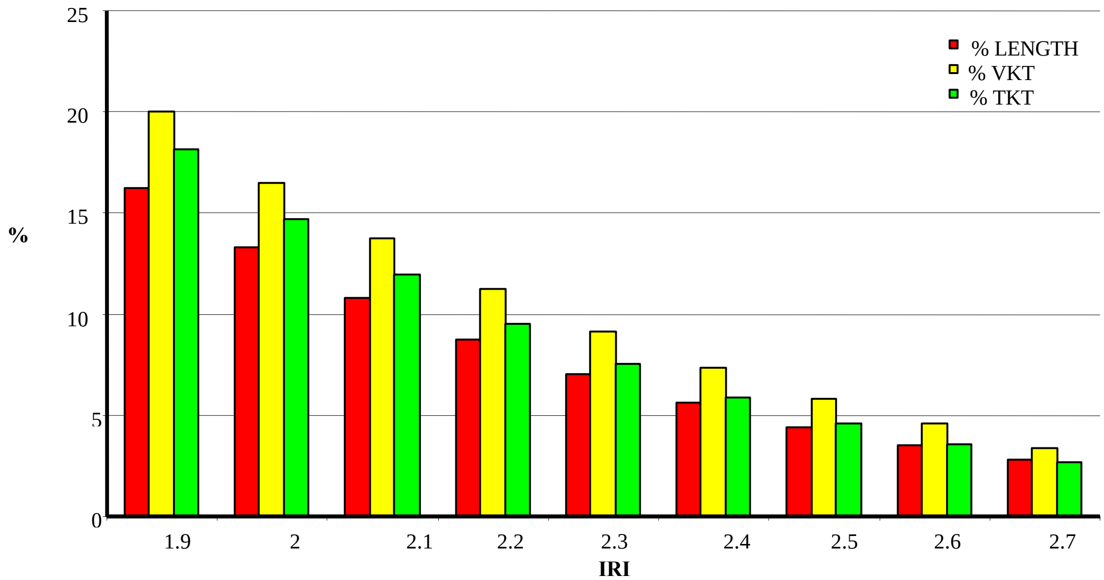


**Figure 3: Non – 110 kph network**

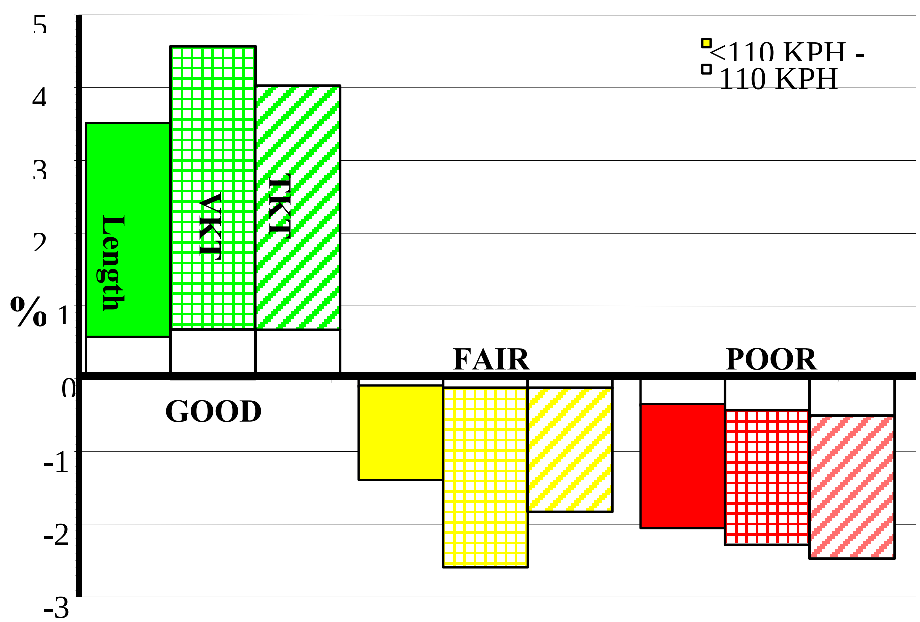


**Figure 4: Comparison of VKT, TKT and Length Sensitivity to Construction Program**

One of the advantages of using VKT or TKT is the direct connection to the users. As many (if not most) of the users are non-technical readers, terms such as IRI and trigger values will have little or no meaning. However, by calculating the total VKT on the network, from traffic counts, the ultimate reporting language could be "percentage of the public traveling on good, fair or poor roads". As budgets are constrained and work backlogged, the number of users traveling on roads in fair or poor condition will increase. This approach will also differentiate high volume corridors from low volume areas because of the sensitivity of VKT/TKT.

## SENSITIVITY TO BUDGET FLUCTUATIONS

Condition is recognized as the greatest driving force for programming and planning of highway projects. Few projects are driven by functional adequacy and / or utilization warrants alone, as defined by the current criteria; however, these measures play a supplementary role in selection of alternatives and scheduling of work. The current trigger values being used for project selection at Alberta Transportation are 1.5 and 2.7 for fair and poor, respectively. A sensitivity analysis was done to determine the impact of changing the poor threshold from 2.7 to 1.9 for the 110 kph network and to 2.1 or 2.3 for the non-110 kph network. 1.9 was chosen for the 110 kph network based upon FHWA criteria for interstate highways (which is the comparable network to the 110 kph network).

As a starting point the I km sections were grouped into age categories, which was considered a reasonable indication of condition. Figure 5 shows the difference between the 2.1 and 2.3 thresholds plotted against the age of the pavement, for the non-110 kph network although a similar graph was produced for the 110 kph network that showed the same similarity of distribution for the two trigger levels.

Using the two trigger levels each section in the network was deteriorated at a rate of 1.06 IRI per year for the four years and then the percentage of the network above the poor threshold values of 2.1 or 2.3 was calculated, as shown in Figures 6 and 7, respectively. The graphs present the percentage of the network above those thresholds by year, which is a measure of the backlog. Three rehabilitation program scenarios were tested: 400 km, 1200 km or 0 km and, the performance corrected through simulated improved IRI. As expected, lowering the threshold value to 2.1 for the non-110 kph network results in a higher backlog regardless of which level of rehabilitation is simulated. However, the key finding is that there is very little difference between the distributions for the two threshold levels. Lowering the trigger values will not alter the distribution but will produce a greater sensitivity while providing some breathing room to the department in the event of deferred programs.

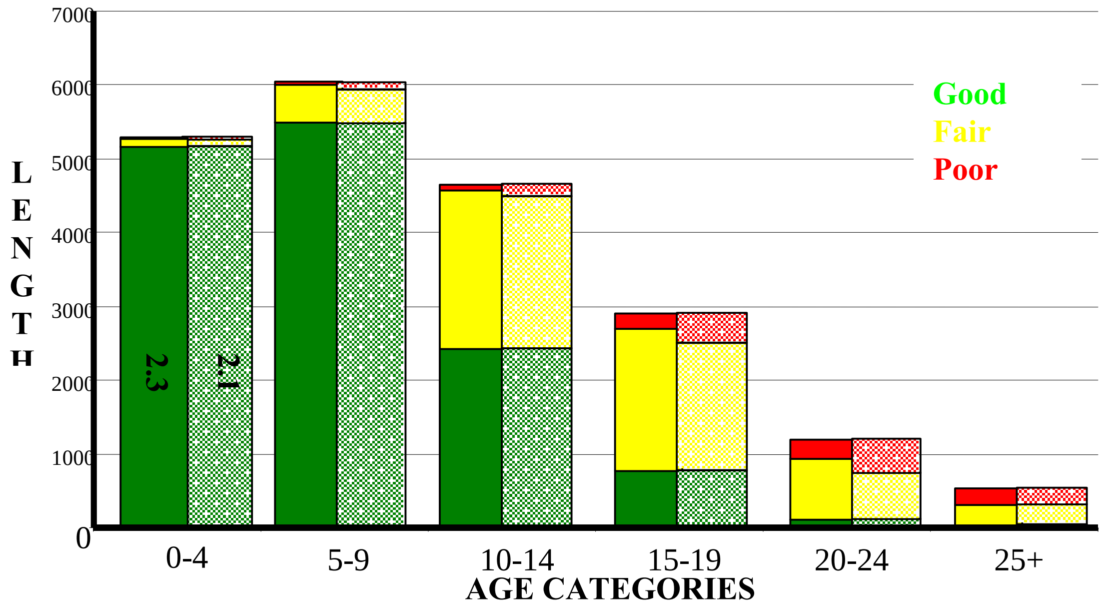


Figure 5: Non 110 kph Highways Good-Fair Poor Comparison of Trigger Values Against Age

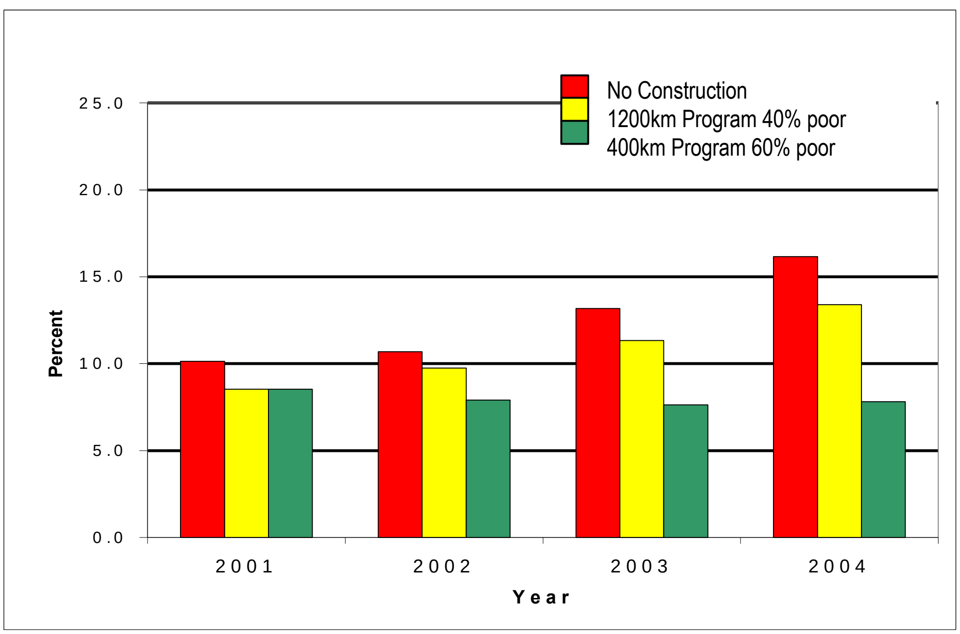


**Figure 7: Sensitivity Analysis for Network Using 1.9 and 2.1 IRI for 110 kph and non-110 kph network.**

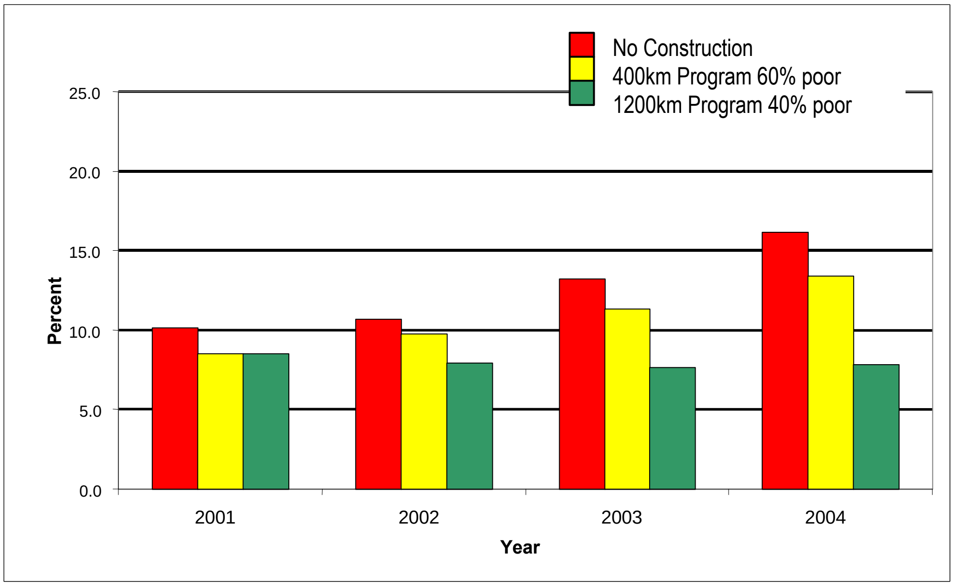


**Figure 8: Sensitivity Analysis for 1.9 and 2.3 IRI on 110 kph and non-110 kph network.**

## CONCLUSION

Using the Alberta highway data an analysis of the performance measure for condition was conducted to address the requirements of relevancy to the user and sensitivity to budget fluctuations. Several modifications were suggested:

- 1 km fixed sections should be used for monitoring and reporting network performance. This approach presents a strong connection between monitoring and reporting at the network level and programming and planning functions at the project level

- All measures (Condition, Utilization and Functional Adequacy) should be differentiated by 110 kph and non-110 kph network. Threshold or trigger values for each measure should be defined separately according to each sub-network.

- Condition measures should be reported by percentage VKT and TKT as well as by length. This will connect the reporting of network performance to the users and the ultimate reporting language could be "percentage of the public traveling on good, fair or poor

- The definition of poor should be 1.9 for the 110 kph highways (AASHTO standard) and 2.1 or 2.3 for non-110 kph highways

This paper describes the analysis of, and modification, to the condition performance measure in attempt to address the criteria of relevancy and sensitivity. The methodology used in the analysis can serve as a template to other agencies facing a similar problem and /or to agencies in the process of defining a relevant, repeatable, robust, and responsive performance measure

## ACKNOWLEDGMENTS

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