Performance measurement for roads in the North: Available tools and knowledge gaps

Craig Milligan, EIT. University of Manitoba Transport Information Group
Jeannette Montufar, Ph.D., P.Eng. Associate Professor, University of Manitoba Department of Civil Engineering

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Abstract:

This paper investigates the suitability of available performance measurement tools for application in Canada's Territories and Northern Prairie Region in an effort to identify knowledge gaps and research needs. The improved outcomes expected as a result of the growing adoption of performance measurement tools will only be realized if the tools used are contextually appropriate. The Northern transportation context has unique demand, environmental, and infrastructure characteristics, requiring a unique set of tools.

The research effort involved a literature review to synthesize performance measurement best practices, a characterization of tools available and in use in the North, and an assessment of available tools in view of best practices.

Several research areas that could be addressed emerge, including: (1) The development of processes to link performance measures to decision-making; (2) Further work to translate customer values into performance measures; (3) The development of safety measures appropriate for low-volumes; (4) The development of surface condition measures for gravel roads; (5) The development of customized, higher-level outcome measures (and predictive models for these measures) in the areas of system reliability, economic impacts, and quality of life impacts; and, (6) The integration of performance measures in a hierarchical framework.

Performance measurement to support road decisions in Canada's Territories and Northern Prairie Region: Suitability of available tools and gaps in knowledge.

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The research effort involved a literature review to synthesize performance measurement best practices, a characterization of tools available and in use in the North, and an assessment of available tools in view of best practices.

The paper first presents a brief background on performance measurement. The second part of the paper presents, by jurisdiction, the performance measurement tools in use in the North, with a consideration of how these tools fit into decision making. The third part of the paper presents synthesized best practice concepts, and considers practice in the North in light of these concepts. The paper concludes with a discussion on knowledge gaps and research needs.

1. Performance Measurement: Background

Performance Measurement, for the purposes of this paper, is defined as *collecting data on selected indicators in an effort to guide decisions that lead to progress towards goals and objectives*. The data can be quantitative or qualitative, and can characterize inputs, processes, outputs, or outcomes.

The private sector in North America began adopting strategic management techniques, including performance measurement, in the 1950s, with the practice growing over the next thirty years to the point where in the late 1970s, 62 percent of Chief Executive Officers (CEOs) surveyed considered strategic planning as their most important activity (*1*). During the 1980s some initial public sector agencies began to adopt strategic management and performance measurement techniques; the Pennsylvania Department of Transportation (*2*), the Ontario Ministry of Transportation and Communications (*3*), New Jersey Transit (*1*), the New York Metropolitan Transit Authority (*4*), and the California Department of Transportation (*5*), were among the early adopters.

Several key events happened in the 1990s that accelerated the adoption of performance measurement techniques among transportation agencies. These include:

- In the United States, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required six transportation management systems of grantees, and these systems encouraged the use of a performance-based approach (*6*);
- The *Reinventing Government* book was published, reflecting a shift in public management philosophy that emphasized entrepreneurial, mission-focused, and outcome-oriented operation of government agencies, including the use of performance measurement (*7*) (*8*);
- The National Performance Review in the U.S. led by vice president Al Gore, and the U.S. Government Performance and Results Act of 1993 reflected increased public sector attention to efficiency and performance measurement (*9*);

- The *New Public Management* (NPM) doctrine, including the *Managing for Results* (MFR) framework, emerged and gained strength, principally in Australia, New Zealand, and the United Kingdom but also spreading to other countries, representing a shift in public administration philosophy that emphasized, among other things, efficient public management and use of performance measures (*7*);
- *The Balanced Scorecard* (*10*), a framework for performance measurement developed and by Kaplan and Norton that, although developed for businesses, was suitable for and adopted by public agencies because the framework was presented with clear guidance and considered broader aspects of performance beyond the typical financial measures employed by private corporations.

In 2000 at a workshop for CEOs of transportation agencies, performance measurement was identified as a top research need (*11*). From the year 2000 forward, several research efforts aimed to identify best practices and to provide guidance for practitioners. The significant degree of research activity can be seen in references (*9*) (*11*) (*12*) (*13*) (*14*) (*15*) (*16*) (*17*) (*18*) and in the following:

- Ongoing performance measurement projects within the United States Second Strategic Highway Research Program (SHRP-2);
- Ongoing TAC Project: *Performance Measures for Road Networks*; and,
- Conferences and ongoing work of the TRB Performance Measurement Committee.

Increasingly, provincial and state governments are requiring each department or ministry to include performance measure targets and reporting in their planning processes (*13*) (*19*).

2. Performance Measurement Tools Used in the North

This section identifies the transportation performance measurement tools that are currently available and in use in Canada's Territories and Northern Prairie Region. The tools in use were identified through a three-part methodology which included:

(1) analysis of responses from the relevant jurisdictions in the 2006 TAC Survey;
(2) analysis of performance documents, plans, annual reports, and other documents from the jurisdictions; and,
(3) follow-up phone interviews with jurisdiction representatives for clarifications, updates since the survey, and supplementary information.

2.1. TAC Survey – Overall Prairie and Territory Responses

The 2006 TAC survey (*14*) presented a list of performance measures to jurisdictions. The jurisdictions were asked whether or not they used each of the measures, or if they had a different measure for the category. Table 1 shows a summary of TAC survey results.

Table 1: Summary of Performance Measure Use as Reported in 2006 TAC Survey

Safety	**AB**	**MB**	**NT**	**YT**
Accident Rates per MVK	Y	Y	Y	N
Fatalities per MVK	Y	Y	N	Y
Injuries per MVK	Y	Y	N	Y
PDO incidents per MVK	Y	Y	N	Y
% Incidents Involving Trucks	Y	N	N	N
Rail Crossing Incidents	Y	Y	N	N
Others:	Collisions/100 drivers (NT), Collisions/100 vehicles (NT), Collisions/100 people (NT), Collisions (YT)			

System Preservation	**AB**	**MB**	**NT**	**YT**
Riding Comfort Index	N	N	Y	N
Surface Distress Index	Y	Y	Y	N
Structural Adequacy Index	Y	Y	N	N
Pavement Condition Index	N	N	Y	Y
Int'l Roughness Index	Y	Y	N	N
Pavement Quality Index	Y	N	N	(blank)
Bridge Condition Index	Y	N	Y	Y
Live Load Rating Factor	N	N	Y	(blank)
Others:	*Bituminous Condition Index (BCI) for BST surfaces (YT)* *Bridge Sufficiency Rating Index (NT)*			

Environmental Quality	**AB**	**MB**	**NT**	**YT**
Noise	N	Y	N	N
Others:	Environmental Evaluations (AB)			

Cost Effectiveness	**AB**	**MB**	**NT**	**YT**
Net Present Value	N	N	Y	N
Net Benefit/Cost Ratio	N	Y	N	N
Internal Rate of Return	N	N	N	N
Others:	Replacement Value (AB), Life Cycle Cost Analysis (YT)			

Reliability	**AB**	**MB**	**NT**	**YT**
Level of Service	Y	Y	N	N
Percent Delay	N	N	N	N

Mobility/Accessibility	**AB**	**MB**	**NT**	**YT**
Average Speed	N	Y	N	N
Traffic Volume	N	Y	Y	Y

Notes: MVK = Million Vehicle Kilometres; PDO = Property Damage Only, BST = Bituminous Surface Treatment; AB = Alberta; MB = Manitoba, NT = Northwest Territories; YT = Yukon

While Alberta, Manitoba, Northwest Territories and Yukon provided yes/no answers about their use of the performance measures listed in the TAC survey, Saskatchewan responded by sending a copy of their current performance plan, and Nunavut did not participate. Some overall themes are evident in Table 1:

- Northwest Territories stands out as avoiding many of the collision rates which employ a distance travelled measure of exposure in the denominator, and instead uses a variety of other denominators in its rates, including population, registered vehicles, and drivers.
- A variety of interrelated engineering economic measures were used for cost effectiveness, while none of the jurisdictions used exactly the same measure. The survey report did not provide any details on the types of benefits and costs considered.
- None of the Prairie Provinces or Territories reported using percent delay as a measure of reliability, and neither of the responding territories reported using level of service.
- Only one of the jurisdictions (MB) reported using average speed as a measure of mobility and accessibility.
- Yukon's use of the BCI represents an effort to use a performance measure adapted to the unique prevalence of BST surfaces throughout their network.

2.2. Yukon

Yukon's transportation system serves about 31,000 residents in 17 communities. The 4850 km road network includes 248 km of paved roads and 1987 km of bituminous surface treated (BST) roads, with gravel surface for the remaining 2617 km (*20*). The road network connects all of the communities except one: Old Crow (*21*).

2.2.1. Jurisdiction Documents – Measures used by Yukon

A web-based search of jurisdiction documents did not reveal any additional performance measures used by Yukon. The jurisdiction's website does provide further details on how the BCI is used to guide maintenance decisions for BST roads in the network.

2.2.2. Jurisdiction Update Interview – Measures used by Yukon

For the purposes of this knowledge gap analysis, a follow-up interview was conducted with a representative from Yukon Department of Transportation and Public Works (*22*). The following information is based on that interview.

The Bituminous Condition Index (BCI), like the Pavement Condition Index, is based on visual observations of the road surface that are manually collected and documented. The BCI was developed in the mid 1980s by the former roads division of Indian and Northern Affairs Canada, and has been used since that time for scheduling and planning maintenance investments on BST roads.

While the BCI represents a measure tailored to unique Northern conditions, no similar measure has been created for gravel surfaced roads. The representative commented that while an abundance of surface condition measurements exist for paved roads, no one really knows how to report the condition of gravel roads with any degree of accuracy. Gravel roads make up over 50 percent of the Yukon road network. Part of the problem with measurement lies in the high temporal variation in the condition of gravel surfaced roads.

In the TAC survey, Yukon did not report using level of service or percent delay as reliability measures. The representative commented that a key aspect of performance for much of the system is the question "Is the road open or not?" The issue of reliable availability is more important in Northern areas where weather-related and seasonal-related closures are more frequent than in the South. There are several Yukon roads that are only open in the summer. The representative commented that it may be beneficial to have a formal performance measure to capture the availability and reliability aspects of the system.

While the TAC survey indicates that various collision rates are used as performance measures, the representative commented that common road safety measures can lack meaning if applied in the Yukon context, primarily because of the low number of collisions and the yearly variability in collision frequency. For example, the Yukon fatal collision rate could be four times the national average one year and then one quarter of the national average the next year, without any substantive change in real safety levels. The representative commented that moving averages may be a solution to this problem of regression to the mean. However, a measure that uses an appropriate moving-average-term-length to balance the needs of statistical smoothing and timely information has not been developed. Currently, fatal collisions are infrequent enough that jurisdiction staff review them individually and as a group to consider the need for safety-related infrastructure investments.

While Yukon reported using a variety of measures in the TAC survey, the follow-up interview clarified that these performance measures are not used in the context of a formal performance measurement system or program that plays a deterministic role in decision making. The department representative indicated that a project is underway to move to an asset management approach to the transportation system, including the implementation of specific performance measures that will drive decisions, or at least influence decisions more than they do currently.

2.3. Northwest Territories

The Northwest Territories has a population of 41,000 people in 34 communities (*21*). The road network in the Northwest Territories includes 2200 km of all weather roads, 1450 km of publicly constructed winter roads, and privately constructed winter roads for resource industry access (*21*). Only 19 percent of residents have all weather road access (*21*).

2.3.1. Jurisdiction Documents – Measures Used by Northwest Territories

The Northwest Territories Department of Transportation produces a report called *Inside the Hard Drive: Status, Challenges, and Current Initiatives of the Department of Transportation* (*23*). The report is produced to brief new ministers and governments on the transportation system, and is produced on a 4 year cycle to correspond with elections. The document includes several descriptors of system status particularly relevant to the unique Northern context, including the percentage of residents without all weather road access and historical opening and closing dates for winter roads and winter ice crossings.

The Government of Northwest Territories uses business planning on a 4 year cycle with annual updates, and these plans contain measures reporting. The plans are created to meet legislative requirements, and the measures in the plans must be output-based measures. The measures included for NWT highways in the business plan (*24*) are:

- Annual VKT on network;

- % of network rated Excellent, Fair, and Poor according to NWT condition rating system;
- % of all weather network by surface type; and,
- # of bridges and culverts with good to excellent condition rating.

While the business plan contains quantitative information on the measures listed above, it also presents descriptive information on 'results to date' *vis-à-vis* planned 'major initiatives' to report on efforts where performance is not gauged numerically.

2.3.2. Jurisdiction Update Interview – Measures Used by Northwest Territories

For this knowledge gap analysis, a follow-up interview was conducted with a NWT Department of Transportation representative to further clarify their use of performance measures (*25*). The following information is based on that interview.

The representative indicated that while the department must track output-based measures to meet legislative requirements for the business plan, the department is also working towards increasing use of outcome measures to support internal decision-making.

Reliability of the winter road system is one performance outcome where the department is doing work to track performance that can guide decisions. The department tracks opening and closing dates of ice crossings. The department is experimenting with techniques to improve the speed of ice formation and is trying to model the relative influence of its actions as well as climate factors on performance. The department has also implemented a program to replace ice crossings on winter roads with permanent bridges in an effort to lengthen and improve reliability of the winter road season.

As the department tracks reliability and availability performance outcomes, it is also working to understand the links between these outcomes and broader system performance outcomes such as living costs in a community. Research work is investigating the impacts on living costs of providing connections to previously isolated communities, or improving these connections.

The NWT representative from the department of transportation indicated that some performance measures applicable in the South are not applicable in the North. For example, volume capacity is usually not an issue in the North.

The department representative indicated that in the NWT, performance measures are used both to support funding requests and to prioritize the allocation of funding that is obtained. The department is also investigating the development of a performance scorecard to provide a summary of performance information in one place.

2.4. Nunavut

The transportation system in Nunavut serves about 31,000 residents in 26 communities along the coastline. In Nunavut, there are no roads outside the communities; it is the only province or territory in Canada not connected to the National Highway System. Transportation needs for connections between communities and outside Nunavut are primarily met by air and marine modes. Overland travel occurs by snowmobile, all-terrain vehicles, and on an expanding network of community access roads. The community access roads program provides $500,000 per year to improve overland trails with the goal of increased harvesting opportunities, improved access to granular quarry locations, and improved recreation and tourism access. In part due to isolation and limited transportation infrastructure, the cost of living in Nunavut is the highest in

North America, and many potential resource development projects have not been pursued. The agency responsible for transportation in Nunavut is the *Department of Economic Development and Transportation* (*21*) (*26*).

2.4.1. Jurisdiction Documents – Measures used by Nunavut

Nunavut has produced a transportation strategy document that deals indirectly with aspects of performance for roads in the description of the community access roads program (*26*). The community access roads program provides $500,000 per year to improve overland trails with the goal of increased harvesting opportunities, improved access to granular quarry locations, and improved recreation and tourism access (*26*). The strategy document also expresses the territory's desire to have a road connection to the rest of Canada (*26*). The document does not contain any direct performance measures.

2.4.2. Jurisdiction Update Interview – Measures used (or planned) by Nunavut

For the purposes of this knowledge gap analysis, an interview was conducted with a representative from the Nunavut Department of Economic Development and Transportation (*27*). The interview revealed the following general points about performance measurement and road decisions in Nunavut:

- Road transportation performance measurement plays a minor role in Nunavut, given its unique context. There is some performance measurement related to airports.
- It is difficult to project what kind of performance measures will be necessary for roads that do not exist yet. In the long range planning process, the business case analysis is a major performance factor considered.
- Performance measures in the future may guide decisions about driveability standards, when a bridge has to be built with two lanes instead of one, when to use a concrete surface instead of gravel, and whether a link should be built as an all weather road or a winter road.
- The community access road program provides funding for town councils to build roads or improved ATV trails in the vicinity of communities. Although criteria for investment decisions are laid out in policy documents, the primary decision criteria are the priorities of community members as expressed in a request from the town council.
- In making road decisions, the department will consider individual link aspects of performance in addition to corridor benefits. A link may be justified before the corridor is.

2.5 Alberta

The province of Alberta has a 30,740 km highway network, with gravel surface for about 4320 km of the network; 28.5 percent of the network carries traffic volumes below 400 vehicles per day (*28*). The provincial population is about 3.5 millio*n* people. The Northern Region of Alberta, as defined by the Northern Alberta Development Council, is home to 150 communities and 350,000 people, representing about 10 percent of Alberta's total population (*29*).

2.5.1 Jurisdiction Documents – Measures used by Alberta

Two papers by Alberta Transportation staff provide further details on the department's use of performance measures, as do the annual report and the business plan of the department.

Jurgens, Chan, and Cowe Falls (*28*) discuss performance measures for low volume highways in Alberta. The authors describe how Alberta Infrastructure and Transportation (now Alberta Transportation) used performance measures related to physical condition, functional adequacy, and utilization.

- The physical condition measure reports the percentage of roads in good, fair, and poor condition according to international roughness index (IRI) measurements (*28*).
- The functional adequacy index assigns a score to a road segment by starting at 100 percent and subtracting points for road characteristics that are substandard for the relevant road class – deficiencies can relate to lane width, horizontal geometry, surface type, and weight restrictions. Surface type is considered deficient if it is gravel and the traffic volume is greater than 400 vehicles per day (*28*).
- The utilization measure aims to capture congestion and reliability aspects of performance by tracking the percentage of the network operating at level of service (LOS) C or better, based on traffic volume in the 100th highest hour of the year (*28*) *(33)* .

In addition to these measures, the department added one measure in 2005 that is specific to low volume roads. The measure tracks the remaining kilometres of gravel highway that require paving according department criteria (*28*).

Jurgens and Chan (*30*) describe Alberta's use of performance measures in business plans within an asset management framework. They present the results of two kinds of scenario analysis linking budget levels to predicted performance on the physical condition measure (IRI) (*30*). The first analysis predicts performance for three different budget levels. The second type of analysis produces required budget levels for various condition targets (*30*).

Table 2 shows the performance measures reported in the current Annual Report (*31*) and Business Plan (*32*) of Alberta Transportation.

Table 2: Alberta Transportation Annual Report and Business Plan Performance Measures

Performance Measures in Annual Report	Performance Measures in Business Plan
• Physical Condition of Highways (IRI based) • Functional Adequacy of Highways • Construction Progress on North-South Trade Corridor (percent of four lane open to travel) • Ring Roads in Edmonton and Calgary (percent open to travel) • Seat Belt Usage • Involvement of Drinking Drivers as Percentage of Casualty Collisions • Percentage of Commercial Vehicles Requiring Adjustments at Inspection • Client Satisfaction Levels based on survey	• Physical Condition of Highways (IRI based) • Combined Fatalities and Injuries per 100,000 population (3 year moving average).

In addition to the measures in Table 2, the annual report lists major initiatives and strategic actions. One initiative in the annual report relevant to Northern communities is the Aboriginal Traffic Safety Strategy, although the report does not present specific performance measures for this initiative. The measures in Table 2 differ to some degree from both the TAC survey results (5 years old) and the papers by Jurgens et al (4-7 years old). These differences could reflect:

changes in performance measurement over time; varying perceptions of performance measurement among department staff; or intentional choice of different measures based on the reporting situation.

2.5.2. Jurisdiction Update Interview – Measures used by Alberta

For the purposes of this knowledge gap analysis, an interview was conducted with a representative from Alberta Transportation (*33*). The interview revealed the following general points:

- A dedicated performance measurement group no longer exists at Alberta Transportation due to human resource constraints. As a result, the representative expects that any available efforts towards the development of performance measurement will likely be directed towards southern areas where the majority of the population resides.
- Although department goals articulated in the business plan include broad items such as promoting growth and enhancing quality of life, the department does not measure performance in these areas directly. While it would be helpful to track performance in these areas, it is also difficult, if not impossible to create an auditable economic impact analysis for inclusion in business plans and annual reports, especially at the network level. The department is required to use auditable measures, meaning that the measures should be objective, well documented, and rigorous under independent scrutiny.
- To date, performance-based scenario analyses used in budget negotiations have not resulted in increased funding levels - the representative indicated that strong competition for funding exists from other departments (for example, health and education).
- The department sets performance targets by inputting determined budget allocations into their predictive models - predicted performance becomes the performance target.
- Regarding specific performance measures for Northern conditions, a pilot project investigated performance measures for winter operations. Beyond this no separate measures are used. Most winter ice roads in Alberta are not owned and operated by the province, so the province is not involved in performance measurement for these roads.

2.6. Saskatchewan

Saskatchewan has 26,292 km of highways (*34*) and a population of just over one million people. Northern Saskatchewan, as defined by the Northern Administration District, is home to 37,000 people in 45 communities (*35*). Some of the communities in Northern Saskatchewan have no all weather road access, including uranium industry and First nations communities in the Athabasca Basin. The Northern population is 80 percent aboriginal (*35*).

2.6.1. TAC Survey of 2006 – Measures Used by Saskatchewan

Saskatchewan responded to the TAC jurisdictional survey by sending performance measures information from their 2006 performance plan (*14*). The plan contains goals, objectives, and performance measures. Table 3 shows the performance measures used at the time of the TAC survey. The 16 performance measures in the 2006 performance plan shown in Table 3 were grouped according to nine objectives and three overall goals. The measure "*value of economic development generated by the department's trucking programs"* in support of the goal "*the transportation system strengthens economic development and serves social needs"* represented an effort to directly measure a broad outcome. In support of the same economic development and social needs goal, the department measured "*cumulative percent of improved*

Northern community access roads." This measure reflected a specific focus on the Northern context.

2.6.2. Jurisdiction Documents – Measures used by Saskatchewan

The 2011-2012 ministry plan (*36*) shows a smaller set of performance measures than the group of measures used in 2006. These measures are also shown in Table 3. The 2006 measure focused on the North is not included in the 2011-2012 plan. The measures in the 2011-2012 plan are presented in a format that includes the measure, a graphical representation of historical performance and targets, and a measure description section. The measure description provides a few paragraphs covering why the measure is important, which government goals and ministry strategies the measure is aligned with, comments on the ministry's level of influence over the measure, and key initiatives related to the measure.

Table 3: Performance Measures in Saskatchewan

Performance Measures in 2006 Performance Plan (*14*)	**Performance Measures in 2011-2012 Ministry Plan** (*36*)
• Percent of principal highway network in 'good' condition • Amount of principal pavements beyond their service life • Percent of regional network in 'good' condition (by surface type) • Percent of overweight trucks on the highway system • Additional funding from non-government sources • Ratio of road operations costs to overhead costs • Value of economic development generated by the department's trucking programs • Percent of principal highway network available at primary weights on an annual basis • Cumulative percent of twinned highway opened to traffic • Cumulative percent of improved Northern community access roads • Percent of collisions involving an injury or fatality • Ratio of partnership trucking fleet collision rate compared to Canadian commercial trucking fleet collision rate • Percent of commercial vehicles that are not mechanically fit and placed out of service • Number of Commercial Vehicle Safety Alliance inspections conducted per year • Percent of provincial railway operators with approved safety management plans • Number and severity of at work injuries	• Cumulative kilometres on provincial highway system carrying primary weights • Cumulative percentage of NHS highways that are twinned and open to traffic • Percentage of NHS in "good" condition, according to rutting and ride quality measurements • Calls and hits to the highway hotline.

The Northern Transportation Advisory Committee, formed in 2009, has produced a policy document entitled *Northern Transportation Strategy* (*38*), which lays out several intentions of the ministry pertaining to Northern Transportation. However, the strategy document does not report that progress on these intentions is not being tracked through a specific set of Northern strategy performance measures. The intentions in the strategy include:

- supporting the growth of Northern industry through investment in transportation infrastructure;
- addressing the mobility needs of Northern residents;
- supporting resource development and exploration activity;
- ensuring access to Northern communities is consistent with that provided on the rural municipal system in the South;
- involving Northerners in infrastructure development through training, procurement and employment opportunities; and,
- improving access for isolated and remote First Nation communities (*38*).

2.6.3. Jurisdiction Update Interview – Measures used by Saskatchewan

For the purposes of this knowledge gap analysis, a follow-up interview was conducted with a representative of Saskatchewan Ministry of Highways and Infrastructure (*37*). The follow-up interview revealed the following general points:

- Road investment decisions are based on policy frameworks, not performance measurements *per se*. The policy frameworks include ranking criteria that guide project prioritization and selection. The two major policy frameworks in place are the *Rural Highway Strategy* and the *Urban Highway Connector Program*. Road investments in Northern areas are guided by a process similar to the *Rural Highway Strategy,* with information and criteria being discussed by a Northern Transportation Advisory Committee.
- The Saskatchewan Government has central responsibility for selecting the overarching government goals; each ministry selects strategies, key actions, and performance measures in support of these goals.
- Some aspects of performance are difficult to measure because factors outside of the agency's scope of control can influence results. Scope of control is considered in measure selection, and a measure may be avoided if the agency has relatively little control over its outcome.

2.7. Manitoba

Manitoba's highway network includes 19,000 kilometres of all weather roads and 2200 kilometres of winter roads (*39*). The winter road system serves 30,000 people in 23 communities. Recent initiatives have moved a quarter of the winter road network to land-based routes in an effort to improve safety and reduce environmental risks, as there have been an increasing number of winter road failures in recent years (*40*). Major initiatives are working towards building new all weather road networks to connect communities previously served by winter roads only, including the East Side Road Initiative and a long range study on a road to Nunavut (*40*). Manitoba's North represents 82 percent of Manitoba's total area and is home to 81,000 residents, of whom 65 percent are Aboriginal (*40*).

2.7.1. Jurisdiction Documents – Measures used by Manitoba

The Manitoba Infrastructure and Transportation Annual Report lists performance measures for the ministry. The 2009/2010 report (*41*) lists two measures related to transportation infrastructure: (1) the ride condition of the strategic highway system based on percentage of the network in good and poor categories according to IRI values; and, (2) opportunities for diversified traffic through the port of Churchill. All government departments in Manitoba have

been required to include a performance measurement section in their annual reports in a standardized format (*41*).

2.7.2. Jurisdiction Update Interviews – Measures used by Manitoba

Manitoba's use of performance measurement was discussed with representatives from Manitoba Infrastructure and Transportation (*42*). The discussions revealed the following:

- Economic evaluations from the MicroBenCOST program are used to support road planning investment decisions, and the evaluations have been well-received on federal funding applications.
- It would be helpful to have accurate measures that give a fuller understanding of the impact of transport investments on the economy. These kinds of measures could help make the case for infrastructure funding.
- Each department tracks its own data to support its own operations – for example, traffic engineering collects safety data to guide its decisions, the materials engineering division collects pavement data to support its decisions, and so on.
- For an integrated performance measurement system to be implemented successfully, the concept would need support and buy-in from each of the divisions. For a system that focuses on Northern regions, consultation with Manitoba Aboriginal and Northern Affairs and the Assembly of Manitoba Chiefs would also be helpful.

3. Best Practice Concepts and the Tools in the North

A literature review identified several best practice concepts related to transportation performance measures. In this section, for each best practice concept, the first paragraph presents the authors' synthesis and description of the concept based on the literature. Then, subsequent paragraphs present the authors' observations regarding tools used in the North in light of that concept.

3.1. Hierarchy of measures with emphasis on outcomes and omni-directional alignment

3.1.1. Authors' Synthesis and Description of Concept Based on Literature

Performance measures should support progress towards the stated goals and objectives of an organization. Often, the goals of an agency are stated in terms of broad societal outcomes while the activities of an agency relate to specific outputs. While it is important to understand performance on outputs, it is ultimately more important to understand and shape performance on outcomes. Best practice performance measurement programs use a hierarchy of measures that includes output and outcome measures, but focus on outcomes (*19*) (*9*) (*43*). Furthermore, the measures in the hierarchy should all be aligned with the overall goals and mission of the agency (*11*) (*9*) (*44*) (*16*).

3.1.2. Authors' Observations Regarding Tools in North in Light of Concept

The performance measurement systems used in the North generally followed the principle of omni-directional alignment, in that the agencies had clearly articulated missions and goals, and progress in the measures would typically lead to progress on the goals. In some cases, however, only some of the goals and strategies had associated performance measures while others did not. The tools used in the North generally did not employ a full hierarchy of

measures. Jurisdiction representatives indicated that it would be helpful to have more robust outcome performance measures, specifically in the areas of reliability and economic growth.

3.2. Customer focus and staff input for measure selection and design

3.2.1. Authors' Synthesis and Description of Concept Based on Literature

Performance measures should be designed with a customer focus and input from agency staff (*16*) (*19*) (*11*) (*9*) (*45*). Customer values should shape the mission and goal setting processes which in turn should shape the selection of measures. A customer-focused performance measurement system can help build credibility, secure funding, and direct efforts towards what the people want from the system. A wide range of agency staff input is also desirable because this can help create measures that are realistic, data-feasible, and operationally relevant.

3.2.2. Authors' Observations Regarding Tools in North in Light of Concept

Some of the performance measurement tools used in the North have a user focus. The selection criteria for the Nunavut community access roads program are largely customer-driven. Alberta incorporates user satisfaction survey results into its performance metrics, but the aggregate results for the province may not allow focus on the specific customer issues in the North. Saskatchewan has a strong Northern customer focus through the Northern Transportation Advisory Committee, but the strategic initiatives suggested by the committee have no specific performance measures to monitor progress.

3.3. Influence decision making, create a learning culture, and encourage good competition

3.3.1. Authors' Synthesis and Description of Concept Based on Literature

Performance measurement is useful when it influences decision-making – when analysis of trends or scenario-based performance predictions shape the budgeting process, or when performance measures are used in making the case for increased funding (*17*) (*44*) (*46*). Successful performance measurement programs also influence learning within an organization – when staff are aware of performance measures and results, and they study the relationship between actions and performance, a virtuous learning cycle can result (*47*) (*48*). Performance measurement programs can also be used to encourage healthy competition, as demonstrated in the United Kingdom local government programs (*49*) (*50*) .

3.3.2. Authors' Observations Regarding Tools in North in Light of Concept

The performance measurement systems in the North require significant progress to influence decision-making. Several jurisdictions reported that the performance measures are not used for shaping decision making, but instead are used to fulfil requirements in business plans or annual reports. Some of the jurisdictions have tried to use performance measures to make the case for more funding, but with limited success. Representatives commented that more rigorous links between agency actions and high level economic measures could help influence funding requests.

The Northwest Territories provides an example of using performance information to drive learning. Staff are continuously monitoring links between their actions (ice formation

interventions at winter crossings, building bridges) and performance results like winter road season lengths and cost of living in communities.

None of the agencies in the North appeared to be using performance measures to drive efficiency gains by encouraging competition.

3.4. Communication through Journalism, Dashboards, and Scorecards

3.4.1. Authors' Synthesis and Description of Concept Based on Literature

Best practice performance measurement programs make substantive efforts to strategically communicate performance information. Examples include performance journalism in Washington State (*52*), the performance dashboard in Virginia (*53*), and the use of performance scorecards in Pennsylvania (*51*), Texas (*54*), and many other jurisdictions. Communication can build customer and political support for transportation agencies, lead to increased funding, and help staff focus on performance efforts.

3.4.2. Authors' Observations Regarding Tools in North in Light of Concept

The Northwest Territories quadrennial report *Inside the Hard Drive, Status Challenges and Current Initiatives of the Department of Transportation* represents an intentional and strategic effort to communicate system status information and trends to a political audience to highlight needs and priorities. The Northwest Territories is also investigating the use of a scorecard approach to communicating and gathering performance information. The Saskatchewan Ministry of Highways and Infrastructure Plan for 2011-2012 reports performance measures similarly to the performance journalism approach – with graphical and narrative communication elements.

4. Discussion of Knowledge Gaps and Research Needs

Performance measurement systems are one of many valid decision support tools for road investments. While jurisdictions are increasingly using performance measurement tools based on several expected benefits, the choices of whether or not to use performance measurement and the specific role for performance measurement within an organization will be based on the local institutional context, priorities, and constraints. In consideration of the performance measurement tools in use in the North together with best practices in the field, several key areas emerge that could be addressed in further research, as discussed below.

Processes to link performance measures to decision-making could be further developed. Currently, these links are limited. The links could be external, as in a situation where a transportation agency uses performance information to make its funding case to a legislative body or higher level of government. The links could also be internal, as in a situation where a transportation agency uses analysis of performance information to shape its budgeting and project selection processes. Developing these links will require a multi-disciplinary approach, incorporating expertise in institutional, administrative, and political issues surrounding the decision-making processes, as well as a rigorous technical and engineering core to the measurement program that can provide not only credible information on current performance, but also credible information on predicted performance under various action scenarios.

An increased customer emphasis can be developed in the performance measures. The agencies considered in the study capture customer values well in vision-setting and public consultation processes. Some of the customer values expressed in agency visions or goal statements are difficult to measure and difficult to link to transportation agency actions, with the result that measurements are not made. Progress can be made by conducting research to establish and understand links (including partial links) between agency actions and progress on issues that customers really value. Furthermore, agencies could consider the increased use of well-designed customer satisfaction surveys as a direct measure of performance, with specific attention to the responses of Northern residents.

Work could be done to develop safety measures that are meaningful at low exposure volumes. Because of the random and infrequent nature of serious collisions at low volumes, it can be difficult to use rate-based performance analysis to understand safety improvement needs. A rate-based measure, in general, is calculated as (A) a number of safety incidents (B) of a specific class (C) per unit of transportation activity (D) occurring at a specific range of locations (E) during a specific timeframe. In a safety analysis, the set-up and definition of rate components (B) through (E) can affect the stability and usefulness of the resulting measure. In a poorly designed rate measure, safety performance results can fluctuate widely with no substantive change in any factors that relate to road safety. An equally poorly designed measure may exhibit good stability, but provide no focused information on issues requiring action. Research that considers the questions of how to set up the rate components specifically for the Northern context could add value to the road safety engineering process in the North.

Appropriate physical condition measures could be developed for gravel surfaced roads. This research need comes directly from jurisdiction comments. The physical surface condition of a road is a primary input into many road-user cost models and a significant factor in maintenance and capital planning processes. Without good performance information on the surface condition of gravel roads (which make up a large portion of the Northern system), it is difficult for agencies to prioritize their actions, and also difficult to build insight into the links between various engineering actions and condition performance outcomes. Part of the difficulty of measuring performance on gravel road surface condition stems from the weather-based transitory nature of gravel road surface conditions. A snap-shot measure of IRI on a paved road is reasonably expected to be representative of the IRI on that road throughout most of the year. This is not the case for gravel roads. However, just because there is a transitory component to the surface condition performance does not mean that performance cannot be measured. Research could explore innovative techniques that capture both the transitory and stable components of gravel road surface condition.

Robust, customized outcome measures could be developed in the areas of system reliability, economic impacts, and other quality of life impacts. Reliability is an important aspect of system performance in the North, but traditional Southern measures (travel time variability, congestion, level of service) are of little relevance in the uncongested Northern network. Reliability in the North is more of a binary question – road opening dates, closing dates, and frequencies of interruptions are significant concerns. Work is underway to improve reliability in the Northern system, but there is no performance measurement approach to understand the extent of progress being made. A systematic analysis of Northern transportation reliability issues - how they impact Northern residents and the wider economy, and the infrastructure characteristics that surround these issues - can lay the foundation for Northern reliability performance measurement tools. Economic impacts of transportation projects can be difficult to measure, because so many other factors can influence economic outcomes. While it is common for transportation agencies to have the facilitation of economic growth as component of their

mandate, it is rare for a transportation agency to measure its performance in this area. Research work that investigates the links between various types of transportation system improvements and economic performance in Northern regions and communities, including an understanding of the role of complementary, non-transportation factors, could provide tools for transportation decision makers to measure and predict some of the ultimate impacts of their actions. This ability can bring increased credibility and justification to funding requests.

Performance measurement initiatives could be integrated in a hierarchical framework. The hierarchical approach recognizes that transportation is a derived demand. At the lowest level of the hierarchy are performance characteristics of the physical infrastructure itself. The middle level contains performance characteristics of the level of service experienced by people and goods flowing through the system – speed, reliability, collision rates and so on. The highest level of the hierarchy measures performance on outcomes – the broader social reasons why demand for transportation exists – asking whether the system is contributing to progress on these outcomes. Currently, the performance measurement approach in the North includes a mix of measures from the lower and middle levels of the hierarchy, with very few outcome measures. Furthermore, there is no systematic framework that provides a mechanism for understanding the vertical links among measures of the hierarchy in the Northern context. It is an understanding of these links that can enable a decision-maker to choose an intervention to apply to the transportation infrastructure, which can be expected to result in a certain performance improvement in the service levels experienced by the flows of people and goods, which in turn can be expected to result in performance improvements in the broader social objectives of the system. Research work to model and understand these vertical links within the hierarchical framework would be useful to inform decision-making.

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