Highway Performance Measures for Business Plans in Alberta

Roy Jurgens
Director, Highway Asset Management, Program Management Branch,
Alberta Infrastructure and Transportation, Edmonton, Canada,
roy.jurgens@gov.ab.ca or facsimile 780-427-5505.

Jack Chan
Infrastructure Management System Engineer
Alberta Infrastructure and Transportation, Edmonton, Canada,
jack.chan@gov.ab.ca
or facsimile 780-415-9962.

Paper prepared for presentation at the
"Very Long-term life-cycle Analysis of Pavements – Determining the True Value of Our Investment (B)"
Session of the 2005 Annual Conference of the
Transportation Association of Canada
Calgary, Alberta

ABSTRACT

A core business in the Alberta Infrastructure and Transportation business plan [1] (http://www.finance.gov.ab.ca/publications/budget/budget2005/inftra.html) is to "Plan, develop and manage government-owned infrastructure". A goal under this core business is to "Improve the safety, efficiency and effectiveness of provincial highway infrastructure". This links to Government Goal 14: "Alberta will have a supportive and sustainable infrastructure that promotes growth and enhances quality of life" [2] (http://www.finance.gov.ab.ca/publications/budget/budget2005/govbp.html).

The performance measures used for the department goal relate to physical condition, functional adequacy and utilization. Condition is recorded as % Good, % Fair and % Poor. It is based on International Roughness Index measurements (IRI). Functional Adequacy is recorded as % Functionally Adequate. This is calculated by subtracting deficiencies from 100 %. Deficiencies are based on roadway width, geometrics, surface type and weight restrictions. Utilization is recorded as % Meeting Targets. It is based on capacity (LOS).

Actual results are calculated annually and displayed in the department annual report. Predicted three-year results are shown in the department business plan and are based on anticipated budgets. These predicted results show deterioration. Budget levels necessary to prevent this are given. A dollar value is also shown for the deferred maintenance backlog presently in effect.

This paper concentrates on the condition and functional adequacy performance measures used at the business plan level for the Alberta provincial highway network, along with accompanying trends, as these two measures drive the majority of work on the existing highway network. The paper describes the health of the highway infrastructure in Alberta, how that health is changing over time and the dollar values required to maintain and improve that health.

INTRODUCTION

The objective of this paper is to describe the business plan processes in place at Alberta Infrastructure and Transportation (AIT) and to describe how those processes are used to monitor performance and to identify required budget levels. The impact of budget levels on deferred maintenance (the infrastructure debt) is also outlined.

BACKGROUND

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 [3]. 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 [4]. 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 AIT the context for performance measurement is the mission statement [1] as follows:

"Alberta Infrastructure and Transportation contributes to Alberta's economic prosperity and quality of life through the provision and support of effective and safe transportation, public buildings, and environmentally safe water and wastewater infrastructure."

This is supplemented by Goal 2 in the department business plan [1]:

"Improve the safety, efficiency and effectiveness of provincial highway infrastructure."

This paper will concentrate specifically on the "annual performance reporting" and "allocate resources" functions cited above.

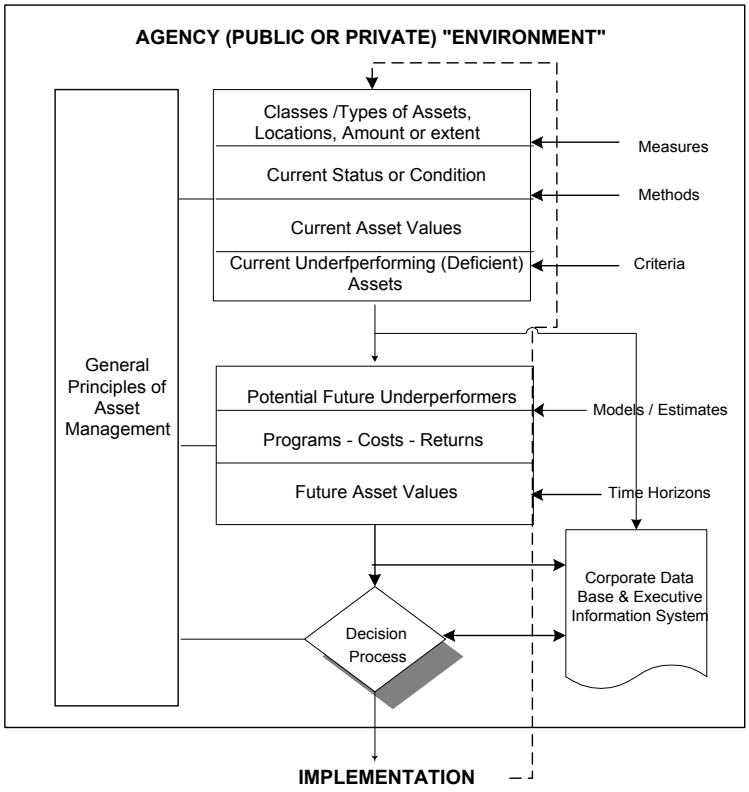


Figure 1: Asset Management Framework [3]

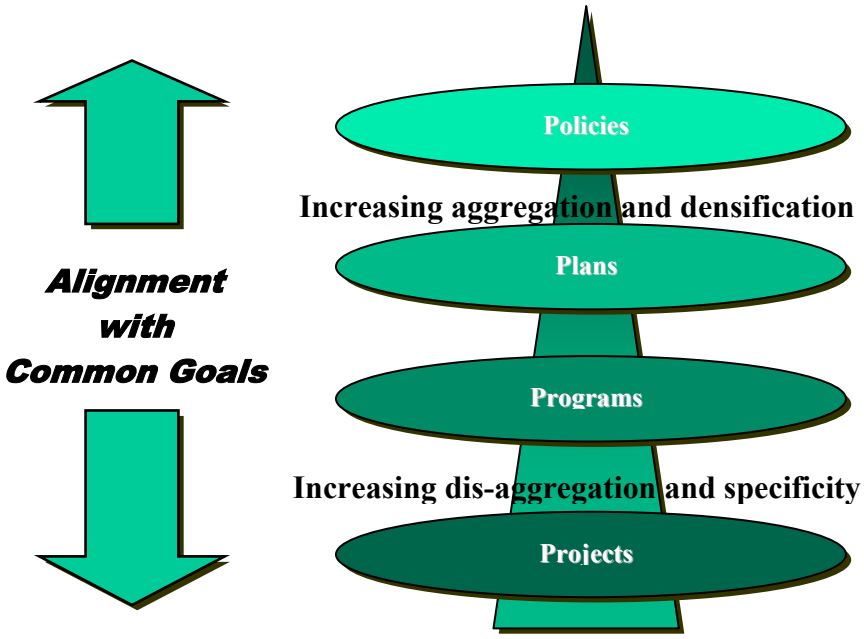


Figure 2: Alignment of Performance Measures with Common Goals [4]

THE PERFORMANCE MEASURES USED

AIT uses three performance measure categories -- physical condition, functional adequacy and utilization -- to monitor highway infrastructure performance. These measures were the subject of an extensive recent review [5] [6] and were refined based on that review. The refined measures are described in detail below.

Physical Condition

Physical condition is recorded as % Good, % Fair and % Poor. It is based on International Roughness Index (IRI) measurements collected annually on the provincial highway network. The IRI values are averaged over a one km segment and then compared to the criteria developed in [5] and outlined in Table 1. The procedures for calculating the physical condition performance measures are contained in department documentation [7].

Although IRI measures roughness, it is important to note that in this context, it is being used as an indicator of overall condition at the network level.

Table 1: Criteria for Good-Fair-Poor

Condition	110 km/h Highways (m/km)	Other Highways (m/km)
Good	IRI < 1.5	IRI < 1.5
Fair	1.5 ≤ IRI < 1.9	1.5 ≤ IRI < 2.1
Poor	IRI ≤ 1.9	IRI ≤ 2.1

Functional Adequacy

Functional adequacy is defined by the percentage of highway infrastructure that is rated as “functionally adequate” or meeting target criteria relating to highway width, geometric deficiencies, surface type deficiencies and weight restrictions. The calculations are done for one km segments [8].

Highway Width

The one km roadway segment is considered to be deficient in roadway width if that width is less than what is suggested in the AIT 3R/4R geometric design guidelines. The suggested widths are influenced by traffic volume and roadway classification.

Geometric Deficiencies

The geometric deficiency calculations are outlined in [8], and are essentially based on AIT geometric design guidelines for a design speed which is five km per hour higher than posted speed. This approach was used to approximate where advisory speed tabs would occur, as this was the original criterion used for this measure. However, a lack of actual advisory speed tab data necessitated the approximation.

The methodology used also approximates the length of improvement that would be required, rather than merely outlining the actual deficient length.

Surface Type Deficiencies

The segment is considered deficient if it has a gravel surface and the average annual daily traffic is greater than 400 vehicles per day.

Weight Restrictions (seasonal and/or annual road bans)

AIT controls posting of seasonal and annual road bans on all provincial highways. An inventory of these restrictions is kept and deficient segments are defined as any segment that has a road ban anytime in that year. The duration of the ban is not a factor in this analysis.

Overall Functional Adequacy

A roadway is functionally adequate if and only if it has sufficient width, sufficient geometrics, an appropriate surface type and no weight restrictions at any time during the year.

Utilization

Utilization is defined as the percentage of the provincial highway network that is equal to or better than the targeted Level of Service (LOS) C, as defined by the Highway Capacity Manual [9]. 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.

THE BUSINESS PLAN PROCESS

The above performance measures are reported in the AIT annual report [10] and are contained in the business plan [1]. Values are given in the business plan for the last official results calculations and for targets (expected outcomes) for three future years.

Targets and last official results in the 2005-08 business plan are shown in Figures 3 and 4.

The business plan process itself is outlined in Figure 5 and explained below in point form, using the 2004 data collection as a base.

- The 2004 data collection on essentially the entire network is completed and compiled by March, 2005.

- The 2004 construction activities are verified and assumed values are used for projects completed in 2004, but for which new data has not been collected.

- Official results are calculated and completed in April, 2005, and compared to targets provided in the 2004-07 business plan (published in April, 2004).

- The results and comparisons are input to the final annual report, which is published in June, 2005. This report shows how the department has performed with respect to these measures.

- The results are input to the identification and ranking of future highway projects.

- The results are input for the calculation of targets for the future 2006-09 business plan, a draft of which is completed by September, 2005 and which is published in April, 2006. (The 2005-08 business plan, which was published in April, 2005, had targets calculated initially in September, 2004.)

- The targets for the 2006-09 business plan for physical condition, for example, are determined as per the following:

    - Calculate the average IRI for each one km segment of highway for 2004.
    - Deteriorate these values by 5 % per year to give values for 2006, 2007 and 2008.
    - Determine projects where work will be undertaken in 2005, 2006, 2007 and 2008 from the AIT three year program based on anticipated budgets for these years.
    - Input assumed IRI values for all one km segments affected by these work activities.
    - Determine the resultant IRI values and then group into Good, Fair and Poor categories. Calculate expected Good, Fair, Poor percentages for each year.

- The targets for the 2006-09 business plan for functional adequacy are predicted as follows:

    - Predicted width deficiencies are calculated using projected traffic growth.
    - Geometric deficiencies will not change except for improvements due to construction activities.
    - Surface type deficiencies are predicted using projected traffic growth.
    - Weight restrictions will not change except as influenced by construction work activities.

- The targets for utilization are projected based on anticipated traffic growth and resultant changes in LOS [11].

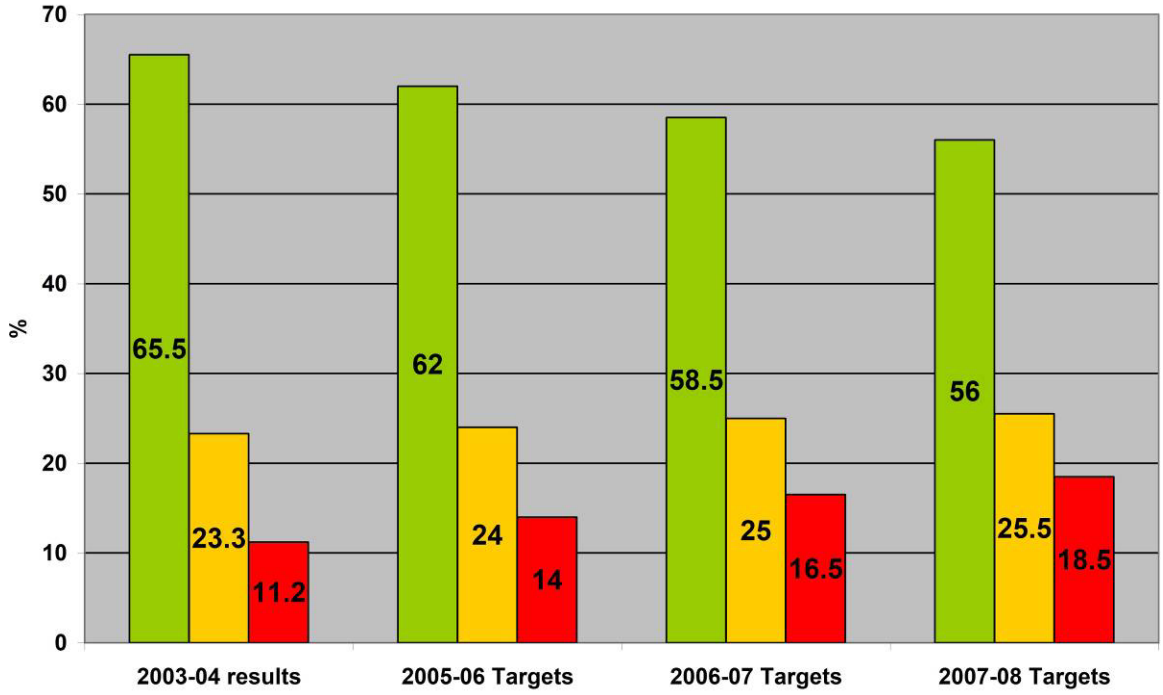


Figure 3: Condition Results and Targets

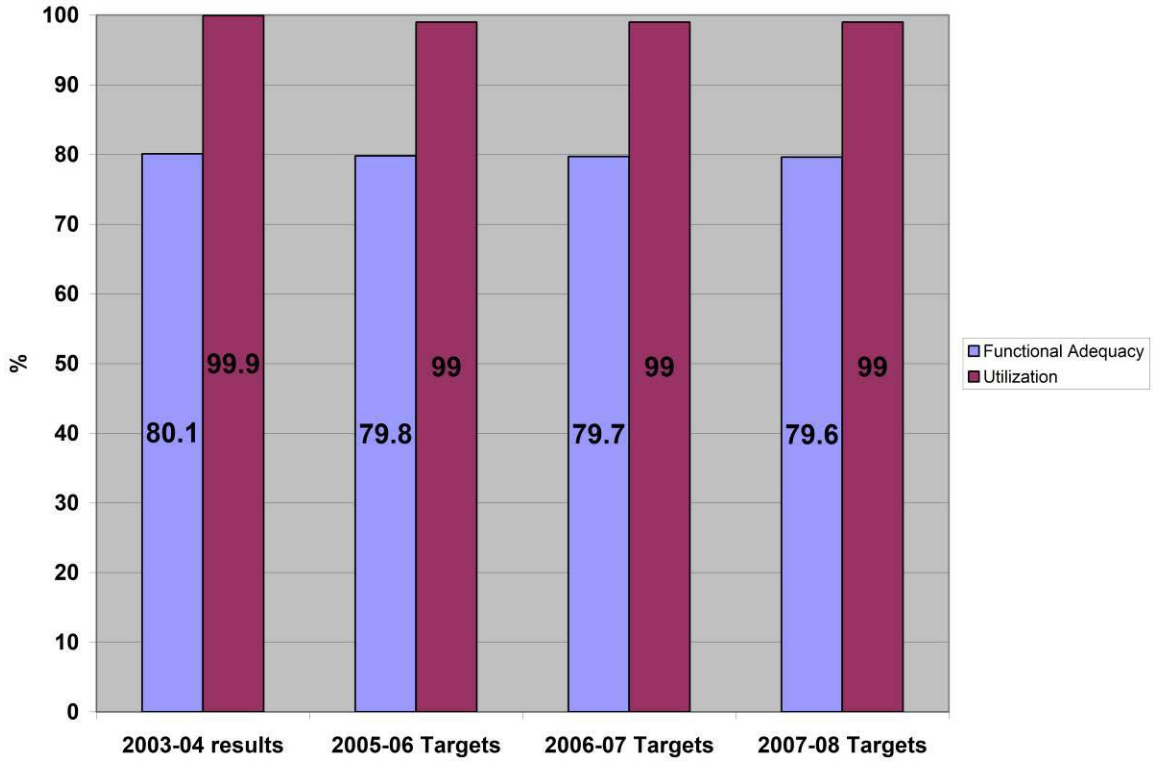


Figure 4: Functional Adequacy and Utilization Results and Targets

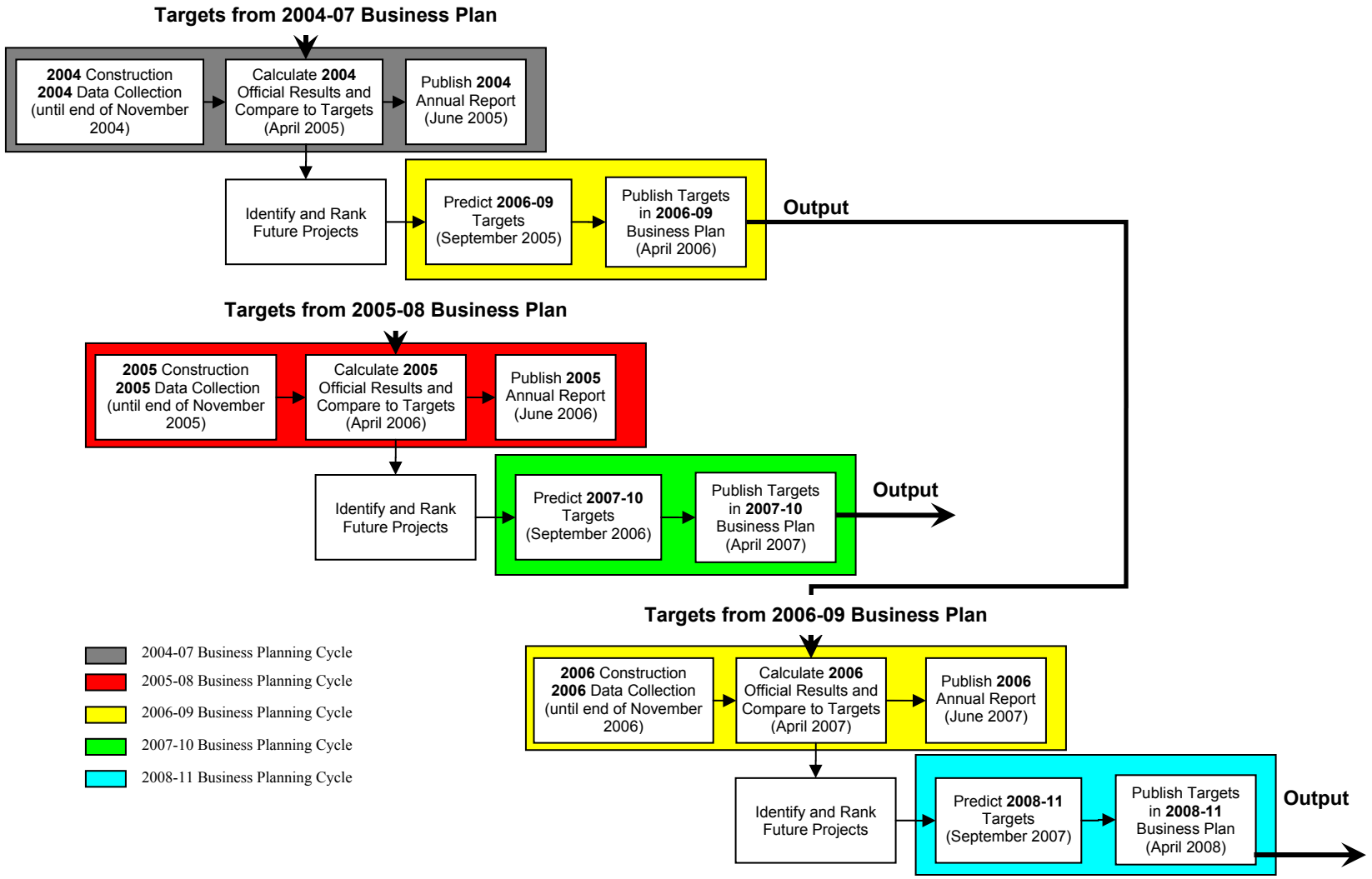


Figure 5: The Business Plan and Annual Report Process

TARGETS (EXPECTED OUTCOMES) AND REQUIRED BUDGET LEVELS

The physical condition performance measure and the procedure used to calculate targets (expected outcomes) will be dealt with in detail in this section.

As mentioned above, a 5 % deterioration rate is applied to existing IRI values to predict future values based on a “no work” scenario. The predicted work based on anticipated budget levels is then factored into the process to yield the expected outcomes on a network wide basis. But why is a 5 % deterioration rate used?

Figure 6 shows a plot of predicted IRI versus year, starting at an IRI of 0.8 m/km (the value assumed for new construction). At an average deterioration rate of 5 % per year, the IRI value would deteriorate to 2.1 (the boundary between fair and poor) in 21 years. Since the design life of our pavement projects is 20 years, this value seems to be appropriate when making the high-level future predictions required for the business plan. Using a 6 % deterioration rate would yield a life of 18 years, whereas 4 % would yield a life of 26 years.

This methodology is also used to calculate budget levels required for no decrease in network condition levels and for improvement in those levels, as shown in Figure 7. Based on these analyses, it is anticipated that budget levels more than 2 times anticipated would maintain existing conditions (approximately 1250 km of overlay work versus a budgeted 500 km in 2005 for example).

Figures 8 and 9 show budget levels required to attain specific objectives for condition and functional adequacy. As well, the impacts on performance levels of no work and presently anticipated work are illustrated.

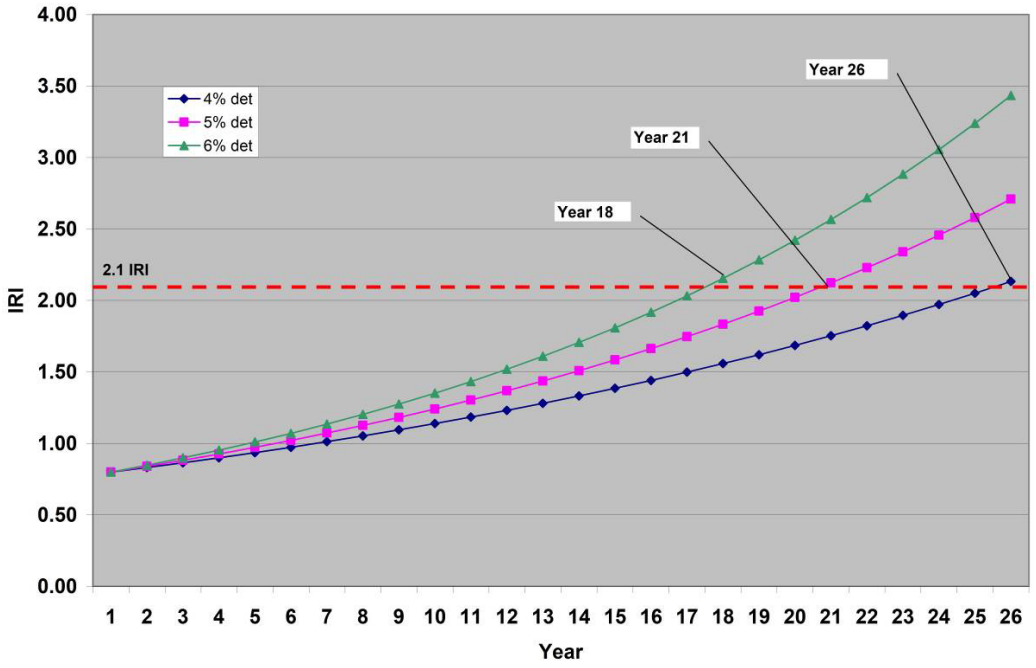


Figure 6: Predicted IRI vs. Deterioration Rate

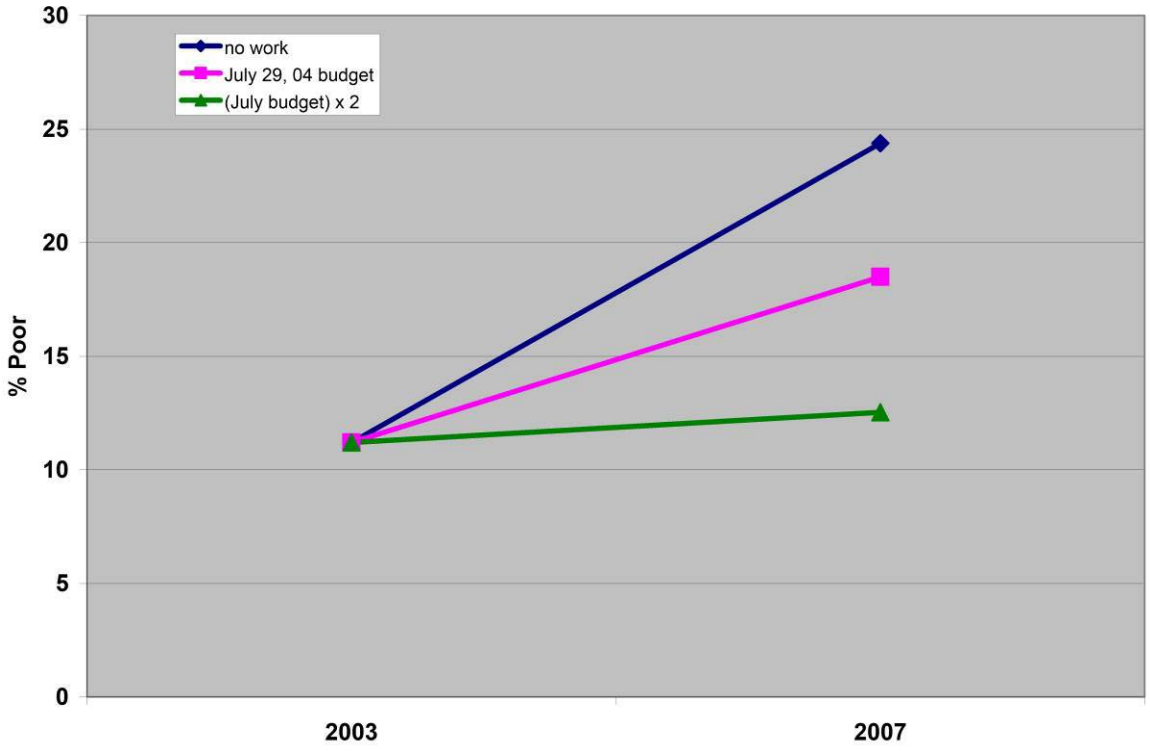
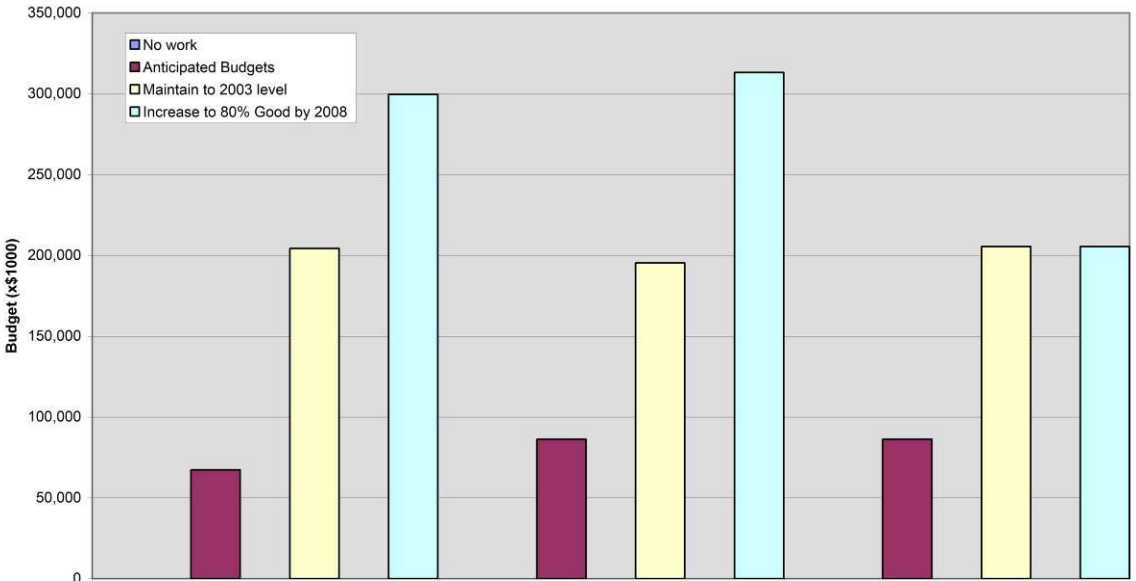
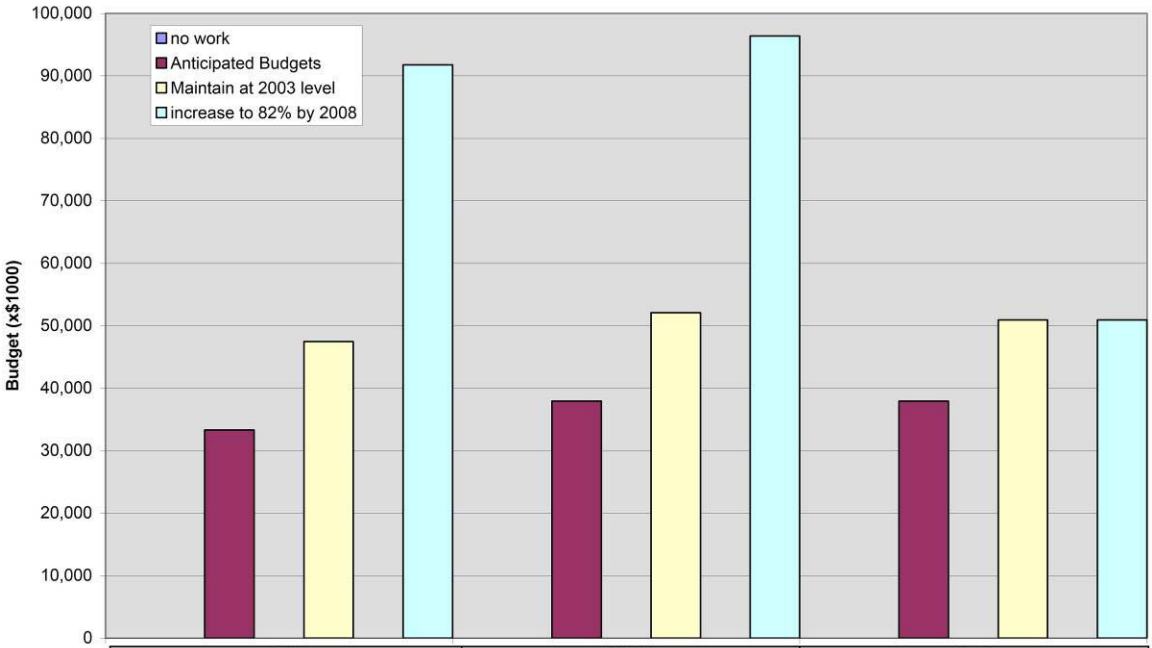


Figure 7: Predicted Condition Results Based on Different Budgets



	2005				2008				2013			
	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 80% by 2008	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 80% by 2008	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 80% by 2008
Good	57.0	62.2	65.5	71.4	43.4	55.3	65.5	80	22.6	45	65.5	80
Fair	25.8	24.2	23.3	20	28.4	25.6	23.3	15	27.9	27.9	23.3	15
Poor	17.2	13.6	11.2	8.7	28.2	19.1	11.2	5	49.5	27.1	11.2	5

Figure 8: Budget Levels for Alternative Objectives - Condition



	2005				2008				2013			
	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 82% by 2008	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 82% by 2008	No Work	Anticipated Budget	Maintain to 2003 level	Increase to 82% by 2008
% adequate	79.4	79.7	80.1	80.9	79.0	79.6	80.1	82.0	78.1	79.2	80.1	82.0

Figure 9 Budgets Levels for Alternative Objectives – Functional Adequacy

THE AGING INFRASTRUCTURE AND REQUIRED BUDGET LEVELS

This section will deal with a simplified needs analysis based on infrastructure age only.

Figure 10 shows the amount of paved construction done for each of the last 30 years on Alberta highways. The late 1970s and early 1980s showed a significant increase in length of pavement construction, whereas in recent years these numbers have declined substantially.

Figure 11 shows a predicted needs line based strictly on construction done 20 years previously. This graph also shows a breakdown between new paving and overlay/reconstruction since 1991. From Figure 12, it can be seen that the needs line followed very closely to the actual overlay/reconstruction line from 1974 to approximately the year 2000. However, since that time the needs line has increased significantly (because of the increase in construction in the early 1980s), whereas the actual has dropped significantly. This shows an ever-widening gap.

It should also be noted that this needs line shows an approximate amount of overlay of 1800 km per year (as compared to 1250 km per year based on the above performance level analysis), and substantiates the previous number.

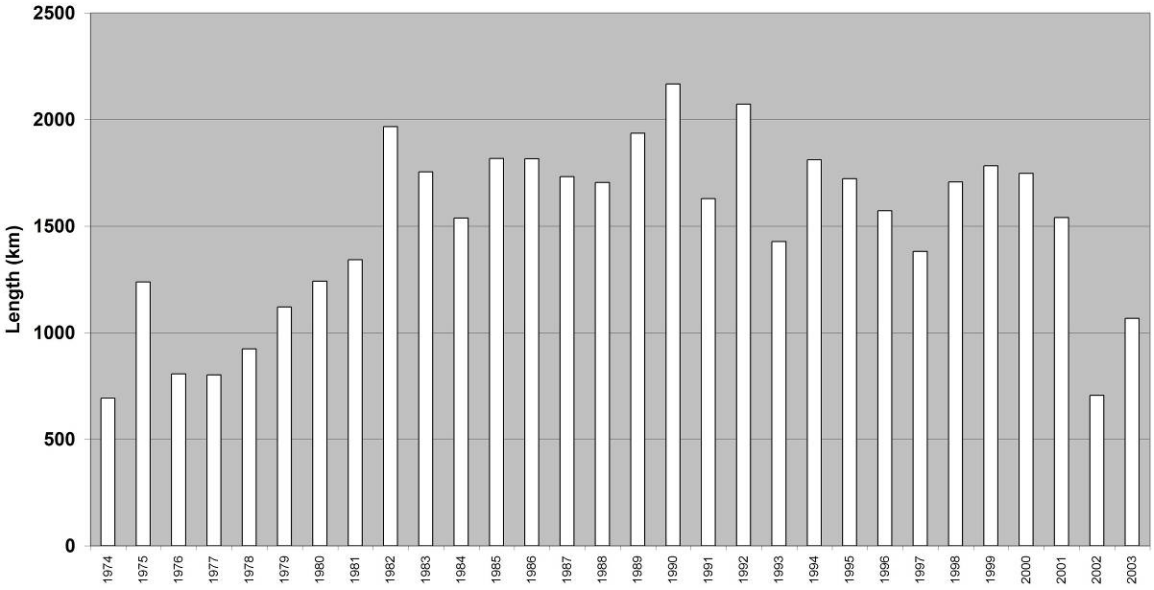


Figure 10: Amount of Paved Construction vs. Year

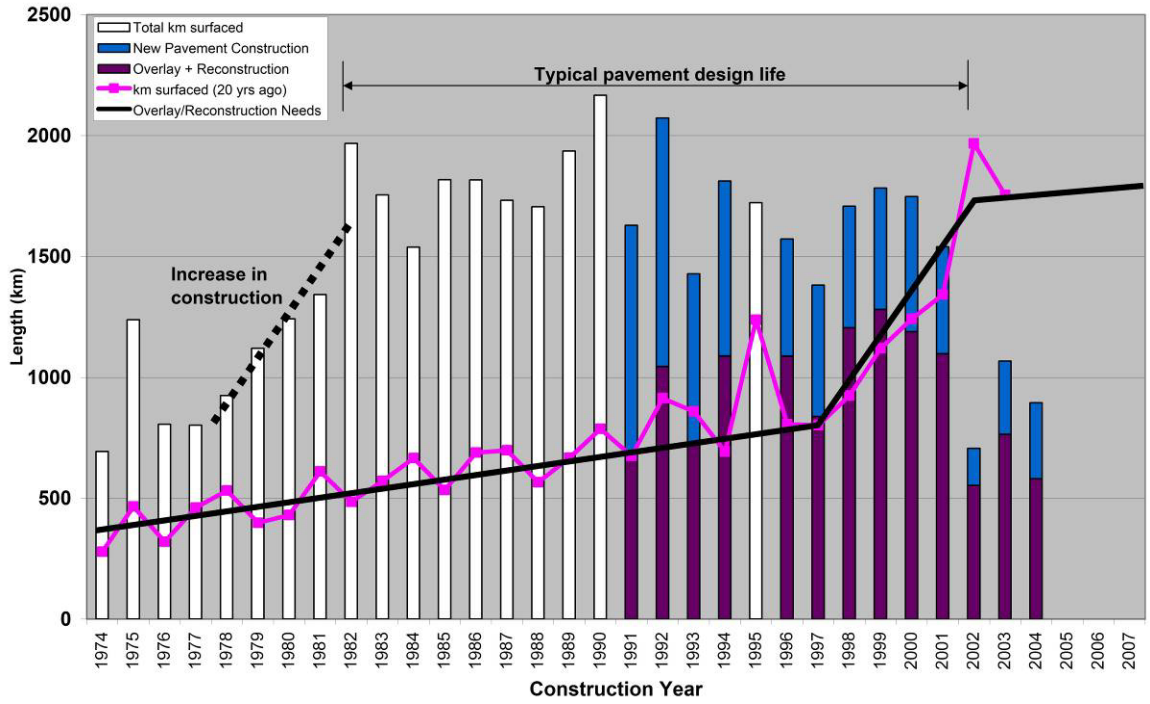


Figure 11: Overlay/Reconstruction Needs vs. Year

INFRASTRUCTURE DEBT AND DEFICIT

AIT has published in its 2003-04 Annual Report [10] that "Currently, the amount of deferred maintenance on the provincial highway network is estimated at $926 million as of March 31, 2004". This deferred maintenance is essentially work that would have been done earlier had funding been available. It can be considered as infrastructure debt. Figure 12 shows the components of that infrastructure debt. Figure 13 shows how the pavement rehabilitation portion of that debt will increase, assuming annual deficits as predicted by both performance level and age analyses. These graphs show that it is critical to first acquire proper funding levels to stop the infrastructure debt growth, and then secondly to acquire additional funding to reduce that infrastructure debt.

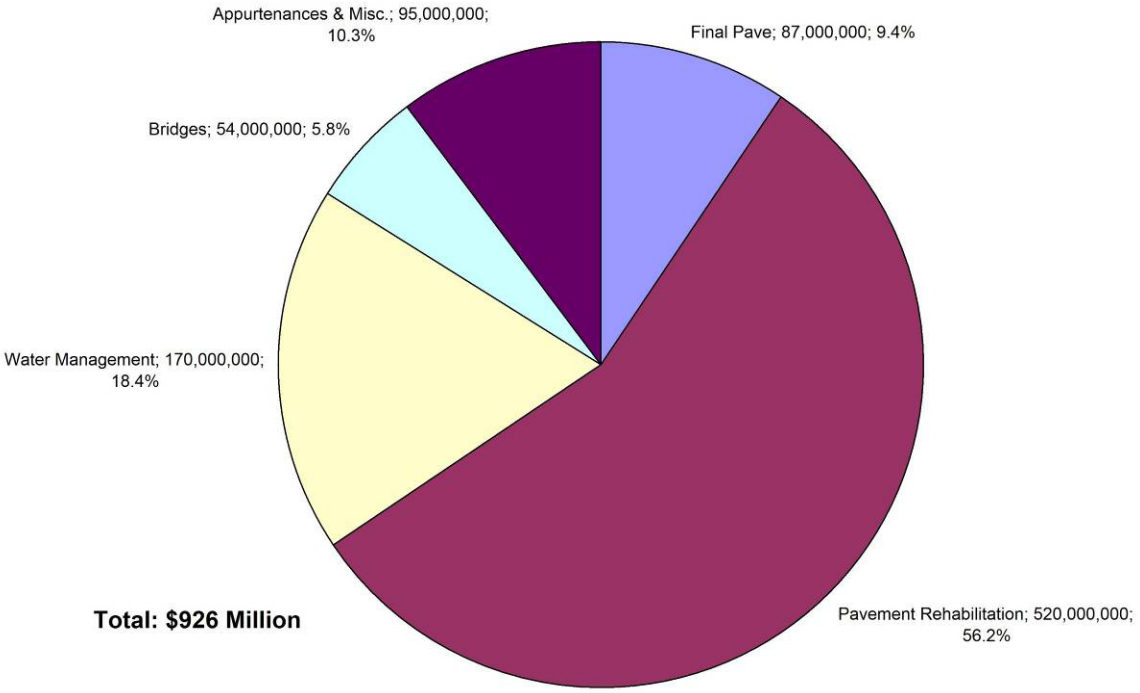


Figure 12: Deferred Capital Preservation as of March 31, 2004

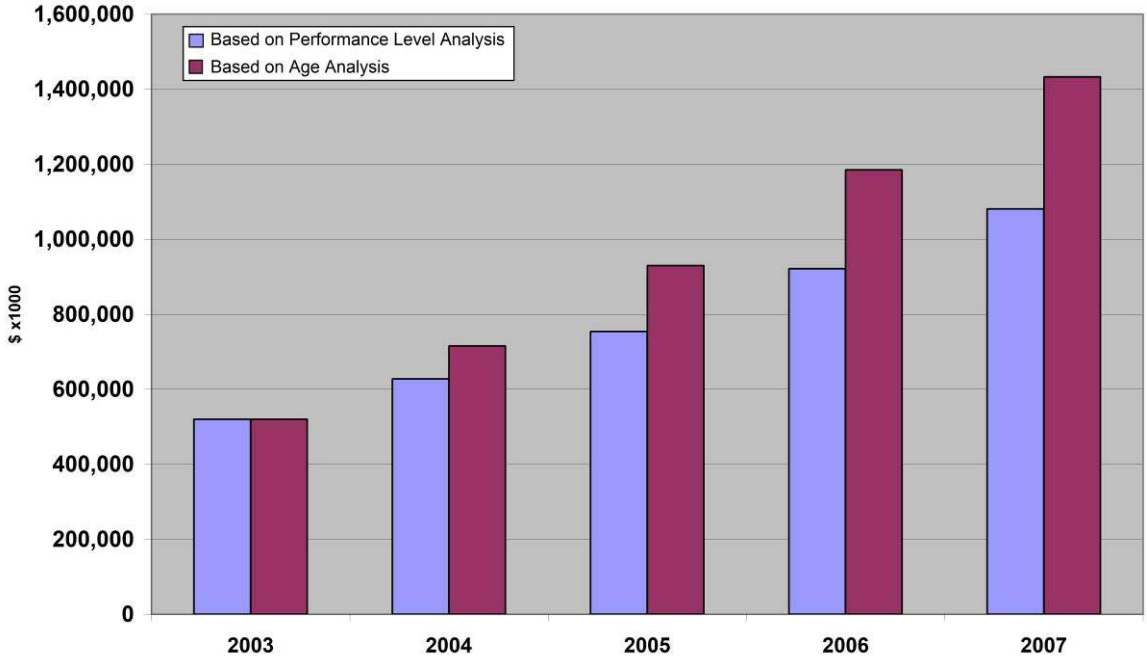


Figure 13: Existing and Projected Pavement Rehabilitation Backlog

WHAT IS HAPPENING AND THE IMPACT OF MAINTENANCE – DO FACTS CONFIRM THEORY?

Actual condition results for the past three years do not show the amount of deterioration that was originally estimated. This is partially due to the fact that more construction work was done than was anticipated, but cannot be fully explained by this factor. Another possible explanation is that maintenance activities, which were not included in the prediction analysis, accounted for the incremental improvement.

Further analysis will be undertaken of the maintenance aspect to confirm or reject this hypothesis.

CONCLUSIONS

Performance measures used in the published department and government business plans show the health of the highway infrastructure in Alberta. They also indicate how that health is changing over time and the dollar values required to maintain and improve the system.

Refinements in these processes will be necessary to include the impacts of maintenance operations on the values.

REFERENCES

[1]. ALBERTA INFRASTRUCTURE AND TRANSPORTATION, “Business Plan 2005-08”, April 13, 2005.

[2] GOVERNMENT OF ALBERTA, “2005-08 Government of Alberta Business Plan”, April 13, 2005

[3]. TRANSPORTATION ASSOCIATION OF CANADA, “Measuring and Reporting Highway Asset Value, Condition and Performance”, 2001.

[4]. PICKERELL, S. AND NEUMANN, L., “Use of Performance Measures in Transportation Decision-Making”, TRB Conference on Performance Indicators, 2001.

[5]. FALLS, LYNNE COWE, “Alberta Transportation Review of Current Performance Measures”, University of Calgary, November, 2002.

[6]. FALLS, LYNNE COWE AND JURGENS, ROY, “A Review of the Alberta Performance Measures”, TAC Annual Conference, 2003.

[7]. CHAN, JACK AND JURGENS, ROY, “Alberta Transportation Performance Measures, Physical Condition Analysis: Results and Process Documentation (2003 Results)”, May 12, 2004.

[8]. CHAN, JACK AND JURGENS, ROY , “Alberta Transportation Performance Measures, Functional Adequacy: Results and Process Documentation (2003 Results)”, May 12, 2004.

[9]. TRANSPORTATION RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, WASHINGTON DC, “Highway Capacity Manual”, 2000.

[10]. ALBERTA TRANSPORTATION, “Annual Report 2003-04“, September 3, 2004.

[11]. KILBURN, PETER, “Alberta Highways Level of Service Analysis 2004”, March, 2005.