The Québec Ministry of Transport's Bridge Project Tactical Planning Dashboard

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ABSTRACT:

Computerized 'Electronic Dashboards' are becoming common in many applications today, including management of financial processes, human resources, projects, and assets,. These dashboards are usually stand-alone screens that monitor and display workflow, decision support information, performance measures or some other barometer often in the form of 'dashboard gauges'. Sometimes the displays can include sophisticated graphical screens that display large amounts of information and also provide highly effective interfaces for planning and research. In the most powerful form, all data are displayed graphically in a single very compact screen for easy review and graphical tools allow testing, or tactical adjustments to parameters that control the analyses running behind the dashboard.

The next generation of bridge management systems (BMS) are making use of new developments in electronic dashboards that include powerful tools for project tactical planning. The Strategic Planning Module (MPS) of the new Quebec Bridge Management System developed for the Ministry of Transport of Québec (MTQ) includes a separate project level tactical planning dashboard that is the first of its kind in Canada, and the first such tool developed for use in the French language.

The Tactical Planning Dashboard complements the Strategic Planning Module by adopting a purely bridge-level perspective on the planning of future work and enabling detailed study of project analysis. While the analysis is compatible with MPS and relies on the same input data, the Dashboard runs independently of the MPS and fills an important gap in several ways. For example,

- Element and project level information, as well as bridge inventory and inspection information is brought together in one window, whereas in the BMS this information is displayed in many different screens.

- The Digital Dashboard uses the same decision rules, budget constraints, and benefit/cost analysis used in the MPS to drive the prioritization and scheduling of work but is able to instantly show the effect of changes in scope (which bridge components are worked on and with which treatments), and timing of the work. Timing of a planned project can be delayed or advanced and the immediate effect on condition, cost, lifecycle cost, user costs, etc. can be seen.

This application will be of interest to bridge engineers and owners who make decisions about bridge maintenance, rehabilitation and replacement.

INTRODUCTION

The Ministry of Transport of Québec (MTQ) owns and maintains an asset inventory of over 9000 structures, of which 4,300 are provincial bridges, 4,400 are municipal bridges, and the remaining are retaining walls and other miscellaneous structures. These structures are managed in a largely decentralized process by the Head Office and 14 Regional offices.

As is the case with other agencies, the bridge inventory in Quebec is aging and the average bridge condition constantly challenges the financial and human resources of the Ministry. In its continuing effort to ensure a safe, efficient transportation infrastructure for the people of Québec, MTQ has developed a new state-of-the-art bridge management system. Known as

Système de Gestion des Structures (SGS), the system has a number of novel features designed to meet the specific needs of MTQ.

Begun in Fall 2005, the SGS has an Inventory and Inspection Module, which was delivered in early 2007, and a powerful Strategic Planning Module (MPS) released in March 2008. The SGS combines lessons learned from the Ontario Bridge Management System (OBMS), also developed by Stantec, (1,2) and recent research and design projects (3,4) into a new system that will be highly responsive to the Ministry's needs. The SGS is the first French language BMS of its kind (5).

The MPS features several analysis levels to fit traditional agency business processes: Network-level budgeting and performance analysis; priority programming; automated project scoping and treatment selection. The model framework handles preservation, functional improvements, and replacement; provides explicit control of the element and project alternatives to be considered; and has features to update deterioration models based on new inspection data.

MPS also includes a project level digital dashboard for interactive design of the scoping and timing of projects. This project level tactical planning dashboard (TPD) is the subject of this paper.

ROLE OF THE DASHBOARD IN TACTICAL PLANNING

The Tactical Planning Dashboard main screen is shown in Figure 1. The TPD is intended as the near-term planning module of GSQ, similar to MPS in theory but at the same time complementary in its perspective. The TPD uses the same powerful analysis procedures as the MPS but complements the MPS by adopting a purely bridge-level perspective on the planning of bridge work. Some of the key differences between the MPS and the tactical planning dashboard are:

- MPS necessarily focuses on the uniform processing of groups of bridges, maintaining consistency across the inventory so projects can be prioritized and budgeting decisions can be made. The TPD is more concerned with near-term considerations of project readiness and local conditions that might require adjustments to the program plan for individual bridges.

- MPS uses decision rules, budget constraints, and benefit/cost analysis to drive the prioritization and scheduling of work. The TPD uses the same tools, but in an evaluative way to show the effect on performance measures when practical considerations modify the circumstances under which a project may have been planned.

- The network level analysis of MPS is based on network-level processes and how every bridge in the inventory responds to these processes, including how bridges affect each other in the context of funding constraints. The TPD enables the engineer to consider a wide variety of options for each bridge by itself.

- The information presented in the digital dashboard about individual bridges is more detailed than what is needed for program planning, and the decision variables are more fine-grained.

Project level decision making using the TPD is likely to include a wider variety of information than what is provided in the MPS. Such information includes the engineer's personal knowledge of the site, design plans, various kinds of testing, and engineering judgment. The engineer's own mental processes are what integrate these information sources.

Several recent research projects in bridge management have developed digital dashboards as a way to express their results. These include the Florida Project Level Analysis Tool (PLAT, 6) and National Cooperative Highway Research Program Report 590 (7).

While the Québec Dashboard uses the same analytical models and input data as MPS, its reporting is more detailed, and more focused on single structures. Life cycle cost analysis in the Dashboard is performed in 1-year intervals with the same intervals between decision opportunities. Thus, the graphical presentation of the Dashboard is able to give a more precise visualization of the differences among project scoping and timing alternatives.

The Dashboard shows the optimal year and scope of work for a bridge, but does not focus on optimization. Many times these precise decisions are subject to practical considerations of project readiness, availability of workforce and materials, project inter-relationships, and political considerations that are not included in quantitative models. The Dashboard presents all of the alternatives and compares them with each other, so the Engineer can easily see the condition and life cycle cost implications of practical decisions that might be made.
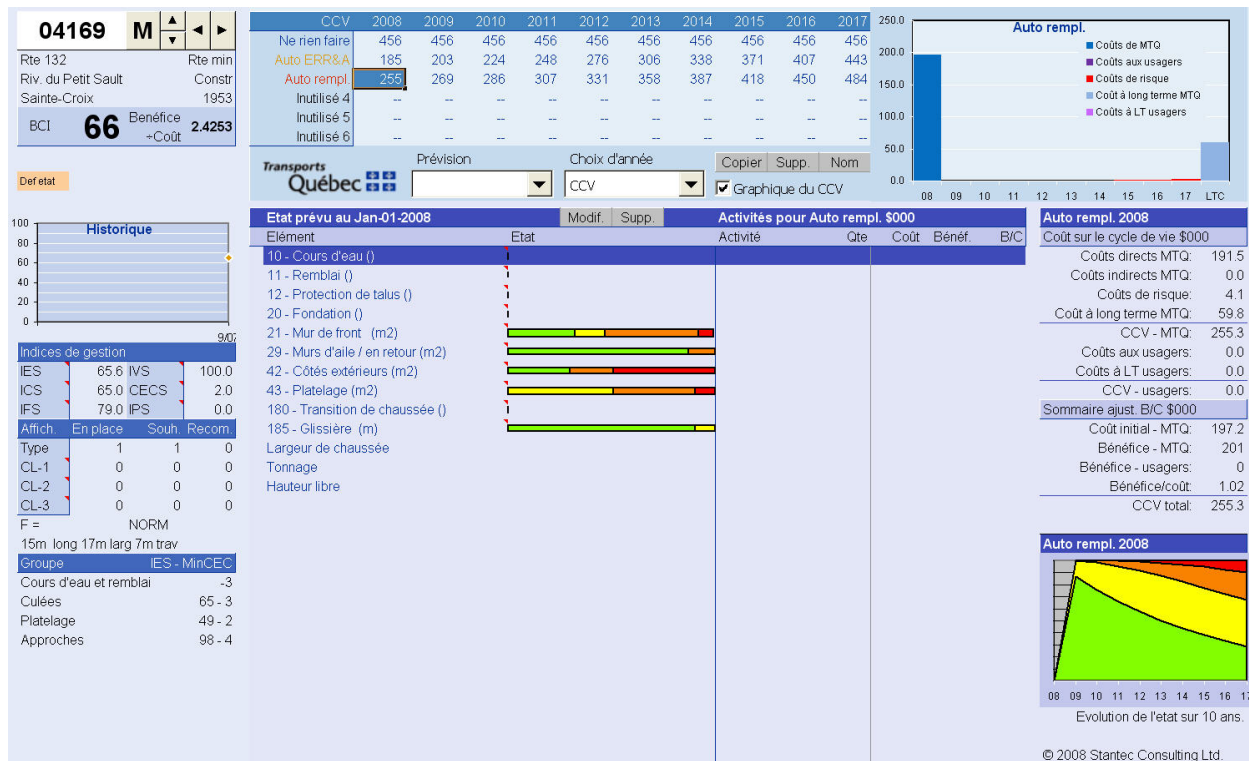
Figure 1. Project Level Tactical Planning Dashboard

PROMINENT FEATURES

One of the key features of the Dashboard is it enables the user to see in one glance a complete picture of the current economic health of a bridge and the range of possible near-term futures. As in the case of MPS both bridge preservation projects and functional improvement pro-

jects (e.g. widening, strengthening) are considered. With some experience in viewing and comparing bridges using this tool, the Engineer is able to recognize common types of problems and solutions, building the same intuition for structure economics as one may already have for structure behavior.

Some aspects of this region of the Dashboard are described in the following:

Bridge Pane

The left-hand side of the Dashboard gives a concise description of the current condition and functionality of a structure, and its condition history.

Navigation tools

Prominent in the upper left corner is the structure number, the structure ID is shown identifier for each structure. Information is displayed just below the structure ID to help the user confirm the identification of the structure – items such as roadway on, feature intersected, county, and year constructed.. The buttons to the right of the structure number are used for moving from one structure to another

Displayed in large type below the structure number and its navigation tools and identification information, are two of the most important summary indicators of bridge condition and economic health: the Bridge Condition Index, and the Benefit/Cost Ratio. The latter measure is calculated from finding the most attractive (from the perspective of life cycle cost) treatments that can be applied within the next year. It is blank if the most economical alternative is to do nothing.

Warning flags

If any red flags appear in the Bridge Pane below the summary indicators, these warn of problems with the bridge, either structural or functional deficiencies. The first row is calculated using the same functional need models used in MPS, while the second row uses established MTQ procedures for determining structural deficiency or functional obsolescence.
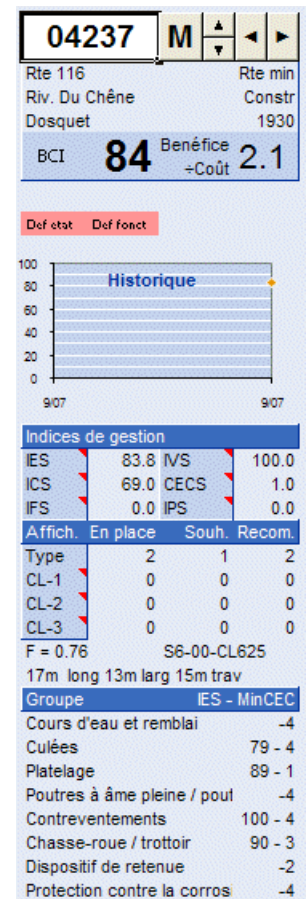

Figure 2. Bridge Pane

History graph

For structures having multiple inspections in the GSQ database, a graph is presented to show the change in Bridge Condition Index over time.

Management indices and inventory data

Several tables are provided of summary management information for the structure. This includes the MTQ management indices, as well as a summary of load capacity and posting information. A geometric summary of the length, width, and maximum span of the bridge is also provided.

The table at the bottom of the bridge pane summarizes the condition of structural elements of the bridge in element groups.

EVALUATING SCOPING AND TIMING DECISIONS

The table and graph in the upper center make up the central focus of the Dashboard (Figure 3). The table presents an array of possible futures for the bridge, in terms of both the scope of work and the timing of intervention. The graph shows the same information graphically. Each row represents a time series of results for a different strategies and the several different performance measures can be displayed and compared.
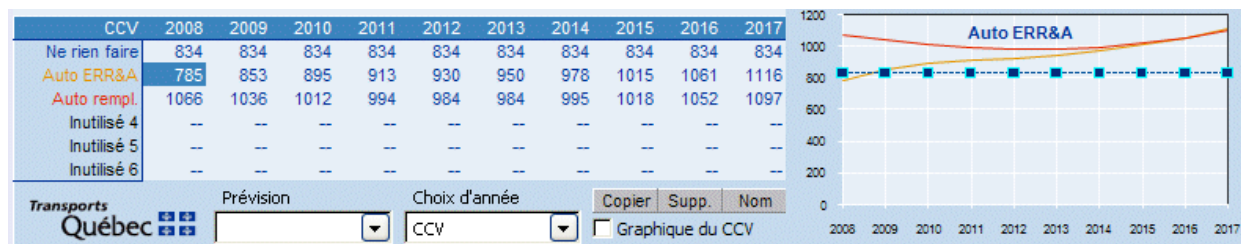

CCV	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ne rien faire	834	834	834	834	834	834	834	834	834	834
Auto ERR&A	785	853	895	913	930	950	978	1015	1061	1116
Auto rempl.	1066	1036	1012	994	984	984	995	1018	1052	1097
Inutilisé 4	--	--	--	--	--	--	--	--	--	--
Inutilisé 5	--	--	--	--	--	--	--	--	--	--
Inutilisé 6	--	--	--	--	--	--	--	--	--	--

Figure 3. Decision Pane

Decision alternatives

Three scoping alternatives are generated automatically by the software for every structure: do nothing; automatic calculation of maintenance, repair, rehabilitation, and functional improvement actions; and automatic calculation of bridge replacement. Space is provided for the Engineer to add three additional candidates with any desired scope of work, as described below.

Within the table, a selection of performance measures can be presented, as determined by the pick lists that appear just below the table. The Engineer can choose to show bridge condition or user cost forecast year-by-year over time (not discounted), so the table and graph are a forecast time series.

Alternatively, one can use the same table and graph to show how various summary performance measures — such as discounted life cycle cost (shown), initial cost (not discounted), economic benefits, and benefit/cost ratio — are affected by choices of intervention year. In the example shown, the best choice for immediate implementation is the Auto ERR&A alternative, because it has the lowest life cycle cost in the first year. If the bridge is to be replaced, the best time to do it is in 2012 or 2013 since life cycle costs are lowest then.

All costs and benefits on the Dashboard are expressed in thousands of dollars.

Evaluating alternatives

The Engineer can click any cell in the table to view more detailed information about any combination of scope of work and intervention year. This information is shown in the parts of the Dashboard to be described in the following sections.
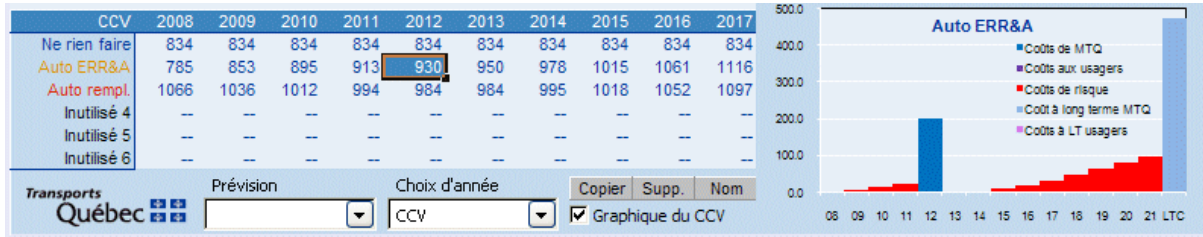
CCV	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ne rien faire	834	834	834	834	834	834	834	834	834	834
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Inutilisé 4	--	--	--	--	--	--	--	--	--	--
Inutilisé 5	--	--	--	--	--	--	--	--	--	--
Inutilisé 6	--	--	--	--	--	--	--	--	--	--

Figure 4. Life Cycle Activity Profile

The user can see a graph describing all the life cycle cost components of the selected alternative, as shown in Figure 4.

Custom candidates

The Engineer can create customized scoping alternatives in order to subject them to a detailed analysis in comparison with the three standard alternatives. This can be done by making a copy of an existing candidate, and then modifying its scope. As described further below, the Engineer can then proceed to modify the individual treatments and quantities of work making up the new project.

LIFE CYCLE COST ANALYSIS

As with the MPS, the TPD uses a life cycle cost analysis as the financial basis for decision making for element treatments and bridge projects. The results of the life cycle cost analysis for the project and year selected in the Decision Pane are shown in the Detail Pane (Figure 5) which is below and to the right of the Decision Pane.

Detail Pane

In the Detail Pane costs that are displayed include the agency and user cost components, and a computation of total life cycle cost and benefits for the project and benefit/cost ratio.

Auto ERR&A 2008	
Coût sur le cycle de vie $000	
Coûts directs MTQ:	22.9
Coûts indirects MTQ:	0.0
Coûts de risque:	292.9
Coût à long terme MTQ:	469.5
CCV - MTQ:	785.4
Coûts aux usagers:	0.0
Coûts à LT usagers:	0.0
CCV - usagers:	0.0
Sommaire ajust. B/C $000	
Coût initial - MTQ:	23.6
Bénéfice - MTQ:	48
Bénéfice - usagers:	0
Bénéfice/coût:	2.0531
CCV total:	785.4

Figure 5. Detail Pane.

Element Pane

The Element Pane is shown in Figure 6. In this section of the Dashboard the elements of the selected structure are displayed, the condition of each element is shown, and for the selected project candidate, a detailed list of treatments to be applied to the structure are given.

Figure 6. Element Pane.

The Engineer can easily and quickly visualize current or forecast condition, at a time selected by clicking in any column (year) of the Decision Pane.

The first year's condition is taken directly from the most recent bridge inspection. Later years are forecast using the bridge deterioration model. Green is the best condition state and red is the worst, with the length of each bar proportional to the fraction of the element in each condition state.

Below the list of elements, three additional rows are provided to list the three types of functional characteristics whose deficiencies might be modeled for the selected structure – travel way width, load capacity, and vertical clearance.

To the right of the bar graph for each element is a description of the treatment being evaluated for that element. For Auto ERR&A, this treatment is the one found to give the lowest life cycle cost. It is blank if doing nothing gives the lowest life cycle cost. For custom candidates, the treatment and quantity shown are the user's choices, using the customization features described below.

For Auto ERR&A, the Dashboard automatically computes the quantity of each treatment using the MPS treatment applicability model. For all candidates, the Dashboard automatically computes the cost and benefit of each scope item.

If a bridge is found to be functionally deficient according to the MPS models, scope items for functional improvements are included in the list of scope items at the bottom.

In the Dashboard the engineer can readily visualize how conditions and treatment options change over time. If the cursor is moved across selected columns in the Decision Pane the user can see the condition of the elements change in the Element Pane. The red condition bars expand, and treatment alternatives become more extensive. If the condition becomes severe enough, the optimal treatment changes from repair to replacement .

Element-level forecast graph

In the lower-right corner of the Dashboard is a graph showing the forecast future condition for any individual element (Figure 7). This information is prepared using the MPS deterioration model.

The red area is worst condition and the green area is best. These values are expressed in percent so they always sum to 100%. If a scope item is present for the chosen element, its effect on condition can be seen as an improvement from one year to the next. After condition is improved, the usual pattern of deterioration resumes.
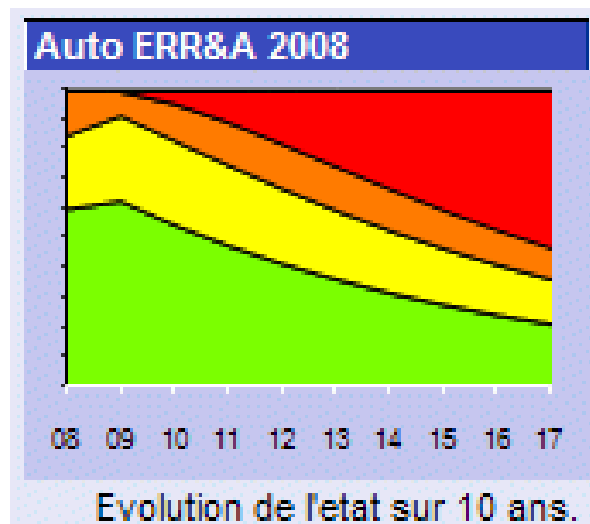

Figure 7. Element Condition Forecast Graph.

SUMMARY AND CONCLUSIONS

Increasing demands are being placed on agencies and those responsible for managing bridges. The next generation of bridge management systems (BMS) are making use of new developments in electronic dashboards that include powerful tools for project tactical planning. The Strategic Planning Module (MPS) of the new Québec Bridge Management System devel-

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ACKNOWLEDGEMENTS

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