INTEGRATION OF VALUE ANALYSIS AND ROAD SAFETY AUDIT PROCESSES

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BIOGRAPHY

Bryan McConachy is a professional engineer/project management professional with more than 25 years' experience in the management of a diverse range of projects and consulting in such areas as value management, project organization and staffing, development of project plans and contract strategies, audits of proposed or current projects as well as development of quality management programs for engineering and construction.

After graduating from the University of British Columbia with a Bachelor of Applied Science in Mechanical Engineering, he was employed by a number of consulting firms in the design and construction of industrial facilities and infrastructure projects. In 1981, he established Bramcon Engineering Ltd. (later Bramcon Project Consultants Ltd.), a firm that provides project management and project control services for a wide range of projects. Mr. McConachy is active in such organizations as the Association for the Advancement of Cost Engineers (AACE) and the Project Management Institute (PMI). He has obtained the Project Management Professional (PMP) Certification from PMI. and lectures on Quality Management and Construction Contracting for the courses offered by PMI and Simon Fraser University. In 1996, he was awarded the Honour of PMI Fellow. He has been a member of SAVE International since 1995.

ABSTRACT

Two review processes which can dramatically impact the design of a transportation project are value analysis (VA) and road safety audits (RSA). Both require the project team to prepare a portion of the design and submit it for review by groups of independent peers. While project teams may find it frustrating to have two reviews, it can be even more frustrating if the RSA has a tendency to recommend adding safety features and the VA has a tendency to recommend deleting features that do not demonstrate a financial return. The objective of the pilot study was to test the advantages and disadvantages of integrating the two processes. The pilot study concluded that when the project is rural and the phase is value analysis, the current value study process adequately addresses the road safety aspects.

INTRODUCTION

Value analysis (VA) and road safety audits (RSA) are both are review processes which require the project team to prepare a portion of the design and submit it for review by groups of independent peers. These

reviews are usually conducted separately. Our objective was to test the advantages and disadvantages of integrating the two processes.

OUR DEFINITIONS FOR VALUE MANAGEMENT PROCESSES

Value Management is our general name for several stages of review and includes Value Analysis (VA) which is the five-stage process used at the front end of a project (conceptual or definition phases) to establish the scope (the "what") of a project. Value engineering (VE) is the same five-stage process applied during detail design to establish how the scope will be delivered (materials, constructability, etc.).

ROAD SAFETY AUDITS

Although audit has the connotation of an after-the-fact review, Road Safety Audits (RSA) are defined by the Transportation Association of Canada (TAC) as third-party before-the-fact check-ups to ensure the design is right before any construction takes place. A road safety audit is defined as a formal, independent multi-modal safety performance review of a proposed road design project by an experienced team of safety specialists. The only objective of an RSA is reducing the collision risk.

According to the Canadian Road Safety Audit Guide (CRSAG) published by TAC, road safety audits were first adopted in the United Kingdom in the early 1980's and made mandatory by 1991.
Through the 1990s, audits were introduced such other countries as Australia, New Zealand and Canada. Audits have been conducted in the United States since the late 1990s. In the year 2000, Pennsylvania became the first state to formally adopt road safety audits into its typical processes.

The typical six-step RSA process from CRSAG is as follows:

Step 1: Start Up Meeting. The owner presents the background and objective of the design after which the design team describes the design including challenges, constraints, and any safety concerns already identified.

Step 2: Site Visit. The audit team conducts a site visit during which they should drive, cycle, and walk the length of the project.

Step 3: Audit Analysis. The audit team conducts the safety audit in a workshop setting.

Step 4: Audit Report. The audit team prepares the audit report which identifies the safety issues and describes alternatives to improve the safety.

Step 5: Findings Meeting. The audit team presents the audit findings and report contents.

Step 6: Response Report. The design team and the road owner review the audit report to assess the need to make any changes to the design. A brief response report is then prepared by the design team outlining a response to each audit finding. A copy of the response report is provided to the audit team for information. Both the audit report and the response report become part of the project record.

Like VM studies, RSA's can take place at several stages of the design and construction process. An RSA near the front end may present the case for providing an interchange instead of an at-grade intersection along a highway corridor (like our VA) whereas an RSA after construction but before opening identifies any safety issues not previously apparent from the drawings. As the design proceeds, the scope of the

audit becomes more detailed, and fewer major changes can be accommodated to enhance safety as a result of an audit. RSA's must take into consideration the progress already made on the design and the irreversible decisions already taken.

The CRSAG does not ignore the potential integration of RSA with value management processes. The document recommends pilot studies to determine whether RSA can be incorporated in VM. CRSAG report that there have been several examples where a value engineering process has resulted in cost-saving recommendation that also compromised project safety. CRSAG notes that it is important to understand the safety implications of all relevant value engineering decisions and that this can be achieved by integrating safety audits with value engineering. According to CRSAG, integration can be done in two ways:

1. During the value engineering process: By ensuring that independent road safety specialists are on the value engineering team, the design decisions that impact safety can be properly evaluated and the consequence of a decision clearly understood. The safety specialists can highlight the safety risks that may potentially be introduced as a result of value engineering recommendations.
2. After the value engineering process. By ensuring that the value engineering recommendations are subjected to a quick road safety audit prior to these recommendations being incorporated into the design.

CRSAG recommended that the RSA process should also be piloted with projects subjected to value engineering to provide an understanding of whether the safety audit process can be incorporated with the value engineering process. Our study would contribute to this body of knowledge.

WHY OUR INTEREST IN COMBINING VA AND RSA?

In 1999, we completed a Value Analysis Study on a highway improvement project through a town and we haven't been welcome in the town ever since. We had the unfortunate role of diminishing expectations heightened by a safety approach that ignored value. Although the three-kilometre portion of highway through the town has right-of-way for a six-lane highway, the current highway is basically a two-lane, two-way highway. In 1998, a project budget of about $6 million was established for an improvement project without a well-defined scope.

The government-owned provider of automobile insurance contributes to highway improvements where they believe accidents will be reduced and they will recover their investment. They set out a number of safety recommendations for the corridor through the town. These design concepts were incorporated into a Functional Planning Study. As any contribution toward improvement of the highway would be contingent on the plans for improvement being in harmony with the recommendations made in the report, the study called for improvements with an estimated cost of about $10 million. The scope of the two estimates is not the same.

Our Value Analysis study used the Functional Planning scope as the base case. The value analysis workshop concluded with a "best value" option which not only reduced capital costs by 50% to $5 million, it also reduced life-cycle costs by more than $25 million over 20 years. Nobody in the town thanked us;

the study was the VA equivalent of the medical situation where the operation was a success but the patient died. There had been heightened expectations of major road improvements for years. The funding for a modest improvement got inflated by the safety review into a very desirable traffic improvement and beautification scheme. The VA study dashed those hopes and value management will be viewed negatively in this area for some time. If the two processes had been conducted simultaneously, this may not have happened.

In a review of the Province's VA / VE Policy & Guideline which was reported in Ref. [1] we recommended "conducting safety audits within the value framework". The recommendation was included in the final draft report issued in early 2001. This recommendation was adopted and the combined VA/RSA study reported below was completed in April 2001 – before the final report was issued in May 2001!

PILOT STUDY – COMBINED VA / RSA

Background

This was not just another value analysis study; this study was the first of several planned pilot studies to integrate, to the extent found practical, two review processes value analysis (VA) and road safety audits (RSA).

Project Location and Description

The Project is an 11 kilometre stretch of highway which follows a meandering river through a mountain pass and shares the steep valley with a rail line, gas and oil pipelines and hydro transmission lines.

The high mountain pass is subject to severe weather conditions, which when combined with the narrow roadway and tight horizontal curvature create difficult driving conditions, particularly in the winter.

History and Existing Conditions

The sections of highway on either side of the study section have been upgraded leaving this section as the lowest classification and out of context with the rest of the corridor. The existing horizontal alignment is very poor, particularly a series of curves near the power transmission line crossing that are posted as low as 50 km/h.

The 55 accidents reported between 1987 and 1996 translate into an accident rate of 1.27 per million vehicle kilometres which is double the provincial average of 0.6 accidents per million vehicle kilometres for highways of similar classification and traffic volume. There is a concentration of accidents in the centre section that contains a series of tight curves with speed advisories.

VA / RSA Study Methodology

The VA / RSA process followed the VA / VE Policy and Procedures Manual of July 1998 except that the number of participants was increased by the addition of the three members of the RSA team. The VA team included all the independent expertise we considered appropriate for this assignment – no adjustment to the

composition was made for the RSA members being present. The members of the RSA team participated fully in the VA workshops. When the VA process went into the analytical stage, the RSA team separated and prepared their independent report.

VA / RSA Workshop Results

Sixty-four value analysis proposals (VAP) were generated during the Stage 2 brainstorming session which included both the VA and RSA team members.

After several rounds of review, the majority of VAP's were rejected and the accepted VAP's were combined into the 7 alternative scenarios listed in Table 1. The capital and life cycle costs were calculated for each scenario.

A review of the detailed cost estimates showed that the majority of the construction costs were in the end sections whereas, as noted above, there is a concentration of accidents in the centre section that contains a series of tight curves.

To determine life cycle costs, delay and accident costs were determined. However, with the low traffic volumes and the short length of this project, delay costs were deemed insignificant.

Although accident costs were included in the life cycle costs, they did not play as large a role in this particular study as expected. Although the accident frequency is high, the traffic volumes are low and the resulting cost savings from crash reductions is relatively small. Perhaps the most notable observation is that the accident costs in the centre section are about 20 times the costs in either of the end sections.

Results of Scenario Analysis

Our preferred process has a Selection Workshop with the project team to present the proposals and develop a preferred alternative. If there were no Selection Workshop, we would use the LCC analysis to recommend that scenarios 1C, 2B and 3B all show substantial improvements in life cycle costing and should be seriously considered as alternatives to the base design.

The Road Safety Audit

As stated earlier, the inclusion of the members of the RSA in the VA workshops had little impact on the proceedings of the VA study. Once the scenarios had been identified, the RSA team worked separately from the VA team and prepared two reports. The first one is their analysis of the Base Case Design. If there had not been a VA, this would have been the completion of their work. As agreed prior to the start of the study, the RSA team also provided their analysis of the scenarios being proposed to the project team for their consideration. The information in the RSA studies was presented to the project team at the selection workshop. A representative of the RSA team participated in the subsequent selection workshop and presented the views of the safety of the different scenarios.

The RSA had the following concerns about the Base Design:

Item	Concern	Recommendation
Alignment	The design incorporates a 100 km/h design with four curves at 90 km/h; the lower speed curves could be overdriven.	The design should be reviewed to see if 100 km/h could be achieved over the entire length of the project.
Recovery Zone	There is no recovery zone to allow for vehicle right off correction.	Install shoulder rumble strips to alert drivers of deviation from the driving lane.
Four Lanes	The proposed 4-lane passing section distorts driver expectations which may result in the section of highway following the 4 lanes to be overdriven	Split the four lane section into 2 separate lane sections to make it consistent with other passing lane locations.
Parking	People are parking on the shoulder and there is a potential for rear-end accidents.	'No stopping' signs should be installed along this section of highway. A scenic viewpoint should be considered to provide a suitable location for drivers to pull off the highway.
Climate	Many of the reported accidents on this section appear to be weather related (slush, ice, etc.)	Use a skid resistant surface (i.e.: chip seal) to pave this section of highway to increase surface friction. Also, selective clearing of roadside vegetation could increase sun exposure on the road. Severe winter weather signing should be made more visible.
Curves	There are four curves of lower design speed (90 km/h) that follow long sections of straighter alignment leading to potential overdriving of the curves.	Introduce high intensity signing for the curve warning signs.

The RSA also assessed the Scenarios developed in the VA / RSA workshop and provided the following concerns :

Scenario 1 : Same as base

Scenario 2 : Looks at moving the highway from the south to the north side of the Pine River to improve the alignment through that section. The safety concerns and recommendations for this scenario are the same as for scenario 1A plus there is the following additional concern due to the fact that the highway will cross the Pine River in two locations.

Item : Flood Plain	Concern: Additional crossings of the river means potential for vehicles leaving the highway into a swollen river (in flood plain)	Recommendation : The barrier warrants should be reviewed to determine if roadside barrier is required along the relocated stretch of highway.

Scenario 3 : The pipeline to the south of the highway would be relocated further to the south to allow more room to improve the highway alignment.

Item: Rock Fall	Concern: Flattening the curve requires the highway to be relocated into an unstable rock bluff, which could create an extra rock fall hazard.	Recommendation : The potential for rock falls should be reviewed and steps taken to minimize them as soon as rock work is complete

THE SELECTION WORKSHOP

Lowest life cycle cost is only a good selection measure when all options have the same performance ratings and that was not expected to be the case for the 7 scenarios developed. The selection workshop was attended by members of the project team, the VA team, an RSA representative and three representatives from local environmental agencies. A performance rating was developed for each scenario using weighted criteria (Consistency at 2, safety at 3, environment at 3 and impact on utilities at 1) and secret balloting.

It is the final step that we find critical in value analysis. The life cycle costs of the scenarios have been determined as have ratings of their performance. Value is the ratio of how much performance one gets for how much cost. Tabled these two factors together to show the value ratings:

Scenario	Description	Capital $	Life Cycle $	Performance Rating	Value
Base	Significant changes throughout	$27 M	$32 M	688	21.6
1A	Minor changes throughout	$4 M	$11 M	533	46.8 #1
1B	Improve ends; Minimal centre	$20 M	$28 M	469	16.7
1C	Improve centre; Minimal to ends	$ 7 M	$14 M	554	38.5 #4
2A	Road to north side; Improve ends	$27 M	$32 M	684	21.3
2B	Road to north side; Minimal to ends	$ 7 M	$14 M	597	42.0 #2
3A	Road and pipeline south; improve base	$27 M	$33 M	711	21.4
3B	Road and Pipeline south; minor to ends	$ 8 M	$16 M	604	38.7 #3

Table 1

The four scenarios which offer better value than the base design are, in order of better value :

1A Current alignment, minor changes throughout

2B Road to north side of river; minor changes to ends

3B	Move road south, relocate pipeline; minor changes to ends
1C	Improve centre per base; minor changes to ends

The common element to all four high value scenarios is to limit the improvements done to the end sections where the construction costs are high and the safety benefits are small. Three of the four short-listed scenarios improved the centre section which is the area with most of the accidents and which gets the most complaints from the public. The unpleasant surprise was that Scenario 1A which only made minor changes to the centre section was not only on the short list, it had the highest value rating. In spite of this rating, the project team did not consider this scenario acceptable as it did not address the concentration of safety issues in the centre section. The review team agreed and, on this basis, the "best value" alternative was rejected.

The VA recommended that the project team investigate the concepts proposed in Scenarios 1C, 2B and 3B with respect to environmental impacts, construction risks and schedule. All three scenarios had a capital cost less than half that of the base scenario.

IMPACT OF COMBINING VALUE ANALYSIS / ROAD SAFETY AUDIT

This study was a pilot for the integration of value analysis studies (VA) and road safety audits (RSA). The following issues need to be considered for future pilot studies :

1. Over-emphasis on safety. As would be the case for any value analysis study we undertake, we had a traffic / safety specialist as a member of our team. With the addition of the three members of the road safety audit, there was a concern that the safety aspect would overwhelm the typical elements of a value study. This did not happen. It is our opinion that this value analysis study was not significantly affected by the incorporation of the RSA. We know that two of the three members of the RSA team were highway design professionals – not traffic / safety specialists. These two individuals contributed ideas and analysis for all aspects of the VA study – not just the safety aspects. We can only speculate that the climate could have been different if all three RSA members were safety specialists.

2. The physical nature of the project. The study project was not just a rural highway – it was a remote section with low traffic volumes and very few "urban" features such as intersections, driveways, traffic control and the like. When we reviewed the CRSAG, we noted that most of the examples were for urban areas and were very detailed considerations. An RSA at the VA stage of design would normally consider the adjacent land use and network integration. However, since this project site is "wilderness" in its land use and has no local network, the RSA is basically limited to facility (lane widths, shoulders, medians) and alignment (design speeds and horizontal and vertical curves). Since design engineers explicitly review these elements in a design already, it may be concluded that an RSA was redundant for this particular project.

In view of the above actual experience from this pilot study, we are prepared to say that when the project is rural and the phase is value analysis, the current value study process adequately addresses the road safety aspects - provided the VA team includes a safety / traffic specialist. From the perspective of the

VA, it is also a requirement that this specialist be willing and able to quantify the safety and vehicle operating costs of all value proposals.

CONCLUSION

We have extrapolated the lessons from the above pilot study and speculated that the expected benefits of combined VA / RSA studies can be predicted by the stage of the project development and the nature of the project environment as set out in the following table:

Stage / Nature	Rural	Urban
Value Analysis	Least Benefit (This Pilot)	Considerable Benefit
Value Engineering	Moderate Benefit	Most Benefit

RECOMMENDATION

On this basis, the next VM / RSA pilot study should be a VE study in an urban section.

REFERENCES

[1] B.R. McConachy. *Value Management Experience in B.C.,* Canadian Society for Value Analysis International Conference, October 2001