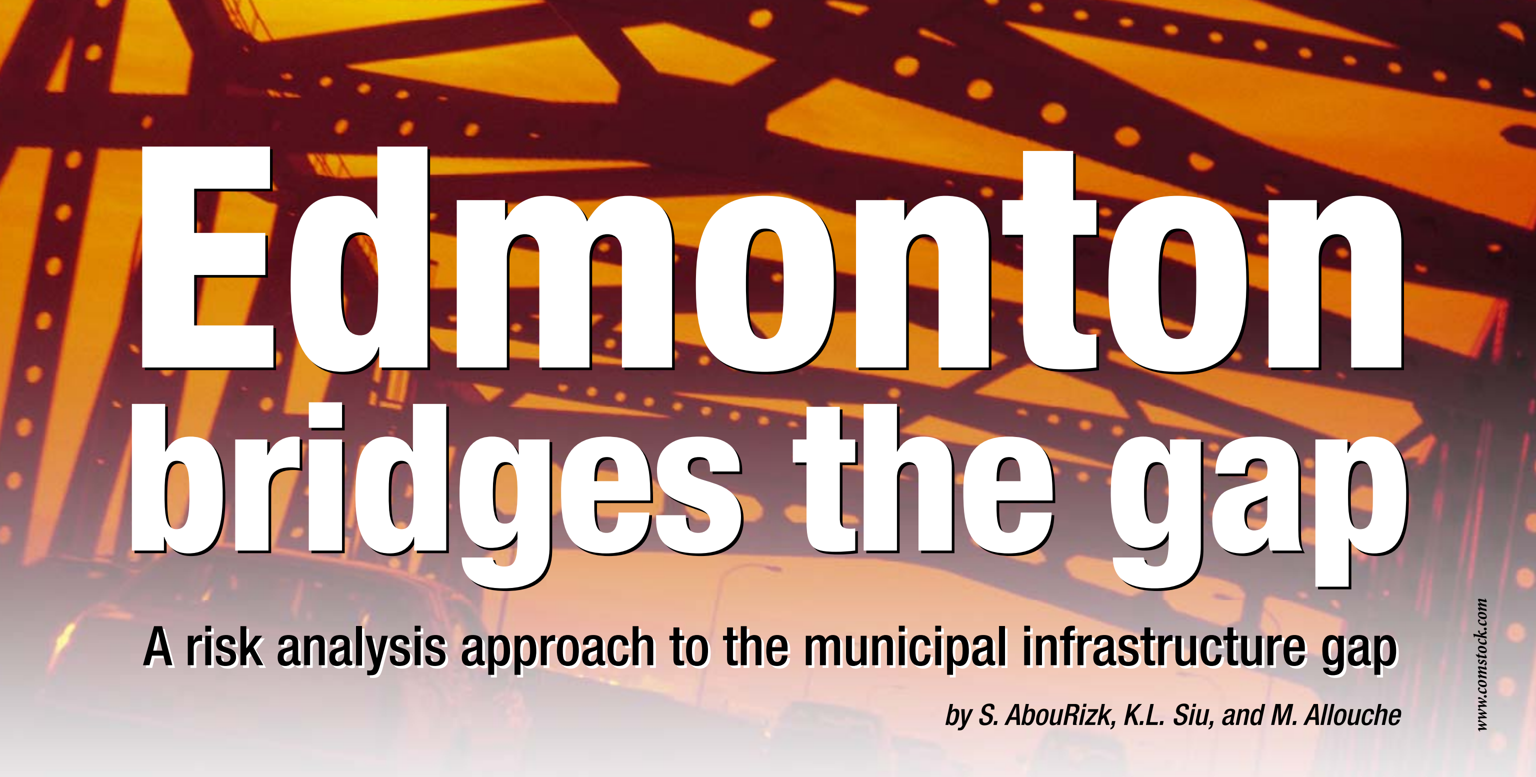

Edmonton bridges the gap

A risk analysis approach to the municipal infrastructure gap

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by S. AbouRizk, K.L. Siu, and M. Allouche

Aging infrastructure, chronic funding shortages and continued population growth has presented most major municipalities in Canada with what is known as an "infrastructure gap." An infrastructure gap is defined as the difference between infrastructure investment needs and the funding available to pay for infrastructure.

THE CITY OF EDMONTON has worked aggressively to address its infrastructure gap, developing an infrastructure strategy in 1998 and, in 2000, establishing an Office of Infrastructure to develop strategies and tools to deal with the gap. One such tool, highlighted in this article, is the prioritization of funding based on analysis of the risk associated with different potential failures amongst varying asset classes.

Edmonton's infrastructure gap is too large to reduce over a short period of time, therefore, to decrease the gap, a long-term strategy must be implemented. Given the shortage of funding necessary to make all infrastructure upgrades and repairs, spending priorities must be established. For example, decisions must be made regarding questions such as "Should $10 million be used to fund swimming pools, hockey arenas, roads or sewers," and "how much money is needed to fix those assets that are failing or expected to fail?"

The challenge then, was to develop a uniform strategy that dealt with all types of assets, and could answer those and other questions raised by the Office of Infrastructure.

The models developed in the risk analysis make it possible to identify those assets that are considered "critical" … Investment should take place immediately in a "critical" asset to minimize failure and the corresponding impacts of failure. At the same time, it is possible to provide a picture of the investment required to attain various levels of service beyond what is determined critical.

The risk analysis approach is based on a combination of macro lifecycle analysis and standard risk analysis modeling. Lifecycle modeling is well documented in literature, and therefore, only the risk analysis approach will be discussed here.

Risk associated with a given infrastructure element is measured using numerous indicators including: asset severity, portion of assets deemed to be "critical" (i.e., expected to fail), impact of failure of an asset, expected mode of failure, overall condition, portion of the asset in poor condition (i.e., as described by D and F in number 1 below), and others. Some of these parameters are:

1. *Overall average condition of the asset*: The condition of an asset in this analysis is categorized as either A (very good), B (good), C (fair), D (poor), or F (very poor) as per American Society of Civil Engineers (ASCE) recommendations.

2. *Critical assets:* This is an indicator of the portion of a given asset (an asset unit) that is theoretically expected to fail. Failure, in this sense, represents those assets that have deteriorated past the expected service life. These assets are considered unacceptable. The portion of assets deemed to be critical are analytically derived based on a deterministic Markovian process (a mathematical analysis of the state of dynamic systems), engineering deterioration properties of the asset and the likelihood of experiencing sudden or anticipated failures for each condition an asset is in.

Figure 1. Fuzzy scale: assessing the overall status of an infrastructure elements

3. *Impact of failure:* This is an indicator that details the implication of the failure of an asset unit on the corporation and its value. The impact areas are derived from *Plan Edmonton* (Edmonton's municipal development plan). Many tables are developed to help managers characterize the impact of failure for a given unit of the asset base (e.g. impact of failure for 1 km of road or pipe on services to people, safety, health, etc.)

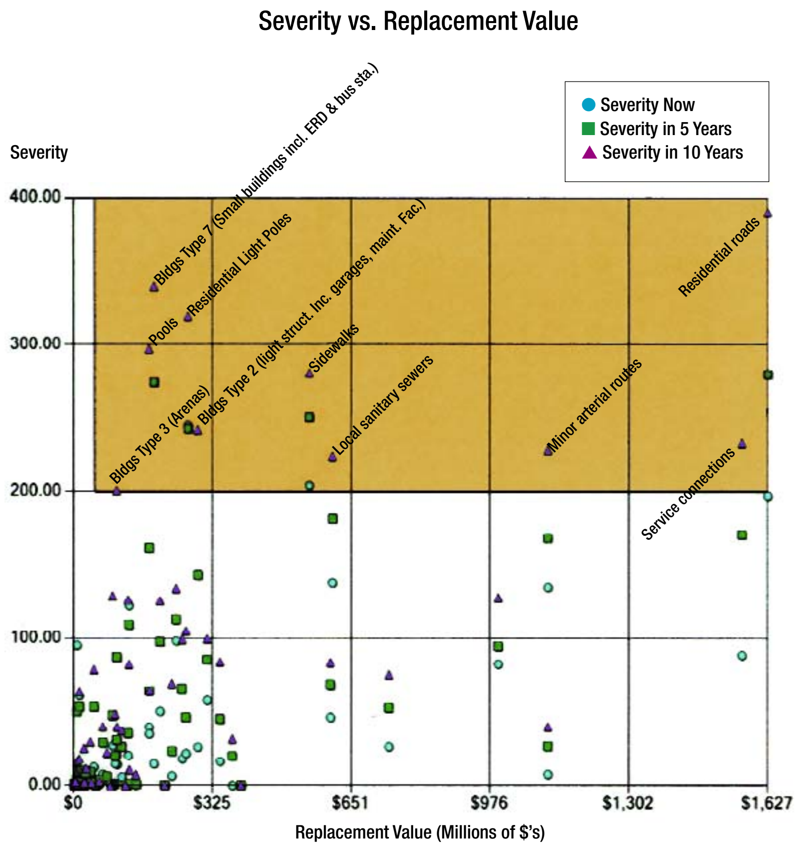
4. *Severity*: This is an indicator of the overall status of an infrastructure element reflecting the overall likelihood of asset failure (or partial failure), the expected amount of failure and the impact the failure would have on the corporation. Severity is an analytical combination of expected assets in critical condition, and the impacts of failure of those assets.

Severity is represented on a "fuzzy scale, as shown in Figure 1, with the following zones:

- *Intolerable* – An asset measuring "intolerable" represents a totally undesirable situation where the combination of the "expected failure amount" and the impact of each unit of failure is intolerably high.
- *Acute* – An asset that is considered to be "acute" represents a very undesirable situation where the combination of the expected failure amount and the impact of each unit of failure are considered to be too high to accept.
- *Serious* – An asset that is considered to be "serious" represents an undesirable situation where the combination of the "expected failure amount" and the impact of each unit of failure is considered to be high enough to warrant attention.
- *Important* – An asset that is considered to be "important" represents a reasonable level of risk. It implies a situation where the combination of the "expected failure amount" and the impact of each unit of failure are considered to be in a manageable state.
- *Acceptable* – An asset that is considered to be "acceptable" represents a low level of risk. It implies a situation where the combination of the "expected failure amount" and the impact of each unit of failure are considered to be low.

Chart 1. Summary of asset risk assessment

Note: The chart is for illustration only and does not represent the final results.



Source: Developed by S. AbouRizk, K.L. Siu and M. Allouche

A sample of the analysis is shown in Chart 1, which summarizes the results of the risk analysis. In particular, the reader should notice that the upper box contains all assets deemed to be critical today, or that will become critical in the next 10 years if the current amount of spending continues.

Results of the risk analysis determined a number of findings that can be used to develop funding. Advantages of the risk analysis include:

- uniformity in dealing with different types of assets,
- comprehensive models of all assets that enable development of various funding scenarios and experimentation with the impacts on infrastructure,
- prioritization of funding to deal first with critical assets, and
- an integrated approach to asset management.

The results of the risk analysis determined a number of findings that can be used to develop funding strategies – for example, the total amount of additional funding required to bring up to a manageable level those assets that are presently deemed critical or expected to become critical in the next 10 years. Also determined was the amount of funding required to keep all assets at a minimum average condition (service level), as well as other scenarios required for long-term strategy development.

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