A Framework for municipal infrastructure management for Canadian municipalities

Vanier, D. J.; Newton, L. A.; Rahman, S.

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A Framework for Municipal Infrastructure Management for Canadian Municipalities

Dana J. Vanier, Ph.D., National Research Council of Canada

Linda A. Newton, Ph.D., National Research Council of Canada[1]

Saidur Rahman, Ph.D., National Research Council of Canada[2]

1 Overview of this Report

The *Framework for Municipal Infrastructure Management for Canadian Municipalities* is described in two client reports. This client report details the "top level" processes for municipal infrastructure management (MIM); it primarily deals with decision-making. That is, it addresses what information is needed by upper management to manage municipal assets. A complementary Client Report B5123.14 delves into the details of the "WHAT" and "HOW" of the Framework for municipal infrastructure management; it basically outlines the implementation issues that are faced by practitioners, describes available technologies to address the opportunities and suggests potential solutions.

Typically, municipalities do not need to implement everything proposed in this report but significant details are provided so that any one municipality can implement any or all of the practices appropriate for the size and structure of the organization. This Framework can also be used by any "organization" that builds and maintains a diverse portfolio of civil infrastructure assets (municipality, regional municipality, utility, department of transportation, asset owner, etc.).

1.1 Why Municipal Infrastructure Management (MIM) is Important

The Municipal Infrastructure Investment Planning (MIIP) *Primer on Municipal Infrastructure Asset Management* (Vanier and Rahman 2004a) defines municipal infrastructure as:

> *Those assets managed by municipalities. These typically include, but are not restricted to, the following classes of assets: buried utilities, roads, transit systems, bridges, water/sewage treatment plants and parks. Some jurisdictions are responsible for a variety of buildings (i.e. police stations, fire halls, indoor swimming pools, arenas and community centres) but their responsibility could also extend to other types of buildings such as social housing, schools and vehicle maintenance depots.*

At the municipal level, infrastructure such as streetlights, playground equipment and guardrails as well as vehicles such as snowploughs and street sweepers are all assets that need to be managed over their entire life cycle. These diverse assets also compete with each other within a municipality for funding for inspection, maintenance, repair and renewal.

Municipal infrastructure management (and the supporting tools and equipment) is part of a term called "asset management". Asset management is defined in the MIIP *Primer* (Vanier and Rahman 2004a) as:

> *A business process and decision-support framework that: (1) covers the extended service life of an asset; (2) draws from engineering as well as economics; and (3) considers a diverse range of assets.*

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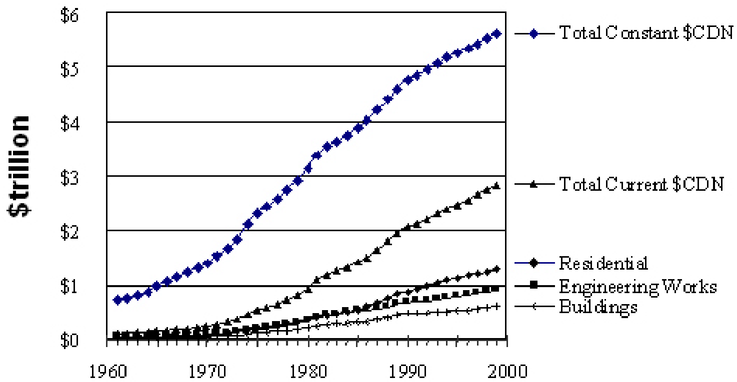
[1] Dr. Linda Newton is currently with Defence Construction Canada in Ottawa, ON.

[2] Dr. Saidur Rahman is currently with the Government of the Northwest Territories.



Value of Civil Infrastructure Assets in Canada (Vanier 2000)

The need for municipal infrastructure management is strongly supported by the findings of a recent survey conducted by the MIIP project (Vanier and Rahman 2004b). The results of the survey indicate that nearly half of the respondents were not aware of the recommend levels of investment[3] for infrastructure maintenance. Almost one third of the respondents had no system to record asset value, were unable to identify their percentage of deferred maintenance[4] and could not identify what percentage of maintenance was deemed "urgent". Most notable in their stated requirements was the respondents' need for tools and techniques to determine asset condition, predict remaining service life (RSL) and prioritize maintenance and capital renewal.

Municipal infrastructure managers must determine how and when to repair older infrastructure and balance this with the requirements for new infrastructure. Managers are hard pressed to present a strong case for the required need and subsequent funding without an infrastructure management system (whether it is a process, methodology, or software) or without decision support technologies (to assist in determining which components of their municipal infrastructure are priorities). As a result, some types of urban infrastructure receive remedial treatment at best; at worst, they are neglected entirely.

Public works managers have been maintaining municipal infrastructure for over 7000 years. So, what is different now? Well, a number of things have changed the landscape in the recent past. These reasons are well-articulated in the InfraGuide Best Practice on *Municipal Infrastructure Asset Management* (InfraGuide 2004) and these reasons include: ageing infrastructure, public demands for high levels of service, stringent regulations, population growth/decline, liability/risk management, limited financial resources, and increased accountability. As a result, public works managers are being held accountable for their decisions regarding when and how (and for how much) their assets are repaired, rehabilitated or renewed. Fortunately today, information technologies

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[3] It has been suggested by many that 2-4% of the current replacement value of an asset be expended each year in maintenance (NRC US, 1996)

[4] Deferred maintenance is the cost of maintenance (and *not* capital renewal) that was not performed or was scheduled or delayed for a future time.

permit an accurate accounting of expenditures; however, the requisite framework for managing *all* the data about the *entire* service life of these assets is not currently available.

Municipal infrastructure is a complex interweaving of most facets of human society. Therefore, the efficient and cost-effective management of municipal infrastructure is not simple: decision-makers must address most of the challenges presented by all complicated systems such as lack of transparency, internal dynamics, inter-related variables, and incomplete understanding of the system (Dörner 1996). According to Dörner, "Defining goals is the first step in dealing with a complex problem".

This report attempts to articulate the goals for managing municipal infrastructure and to present a structure for municipal infrastructure management that can assist both the decision-makers and their technical staff. The result is a "*Framework for Municipal Infrastructure Management for Canadian Municipalities*". As discussed previously, the *Framework* is described in two reports so as to provide information at different levels of technical detail. This report provides overall description of the *Framework* and is intended for managers who need general instructions and guidance in the domain. It can be read independently of Client Report B5123.14 (Vanier *et al.* 2006*)* that is intended for individuals implementing the MIM Framework.

In fact, the *Framework* supplements and complements a number of existing Infraguide *Best Practices* (www.infraguide.ca) including:

- Developing Indicators and Benchmarks
- Developing Levels of Service
- Coordinating Infrastructure Works
- Managing Infrastructure Assets
- An Integrated Approach to Assessment and Evaluation of Municipal Road, Sewer and Water Networks

2 Framework for Municipal Infrastructure Management (MIM)

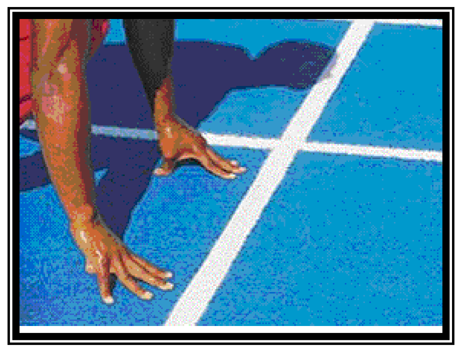
2.1 Introduction

Municipal infrastructure management is an iterative process involving many stakeholders. The *Framework* presented in this report was developed over an extended period of time through extensive consultation and collaboration with researchers and practitioners in the domain of municipal infrastructure management. "Value Engineering" techniques were used by the MIIP consortium to identify the "goals" of municipal infrastructure management and to identify the detailed tasks in the *Framework.*

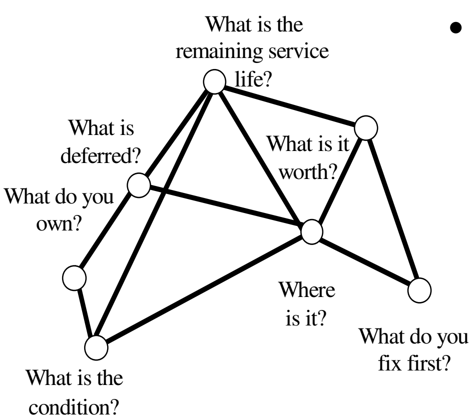
The *Framework* is premised on multi-objective decision-making. That is, a number of objectives come into play when deciding upon which alternatives are the best for both the short and/or long term of the asset portfolio. The objectives that must be taken into consideration in MIM are: maximize performance, minimize life cycle costs (LCC) and minimize risk. In fact, difficulties arise because these objectives are conflicting: trying to increase performance or to minimize risk while minimizing costs, for example. Other objectives can be integrated in the *Framework*; however, only these three objectives are described exhaustively in this report. In addition, it must be kept in mind that these three objectives must be optimized for the *entire* asset portfolio and not only for individual assets or individual disciplines or utility networks.

This report describes the eight major processes in the *Framework*. Furthermore, it outlines the six facets of information required to support these eight processes. Appendix A illustrates the individual tasks identified in the *Framework* and their position *vis-à-vis* the processes and facets; these tasks are described in detail in Client Report B5123.14. The placement of a task at specific locations in the *Framework* (i.e. the sequencing of the task) is not "cast in concrete"; the scheduling of individual tasks can be changed by an organization to meet internal or external needs providing that all requisite tasks are completed before that task commences. Appendix B provides a list of acronyms used in this report.

3 Overview of the Framework



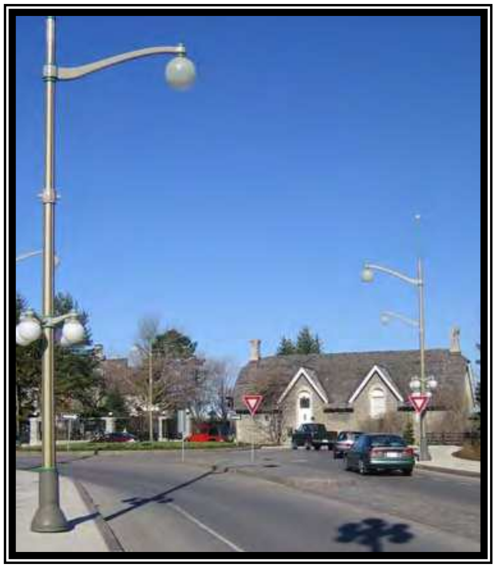
The starting point to the *Framework* is to define, "what is asset management?" One person alone can think of dozens of tasks that comprise asset management. A team of experts, much like those assembled from the MIIP consortium, identified hundreds of tasks. A closer look at these tasks and their inter-relationships reveals that they can be grouped into the six "whats" of asset management described in other MIIP publications (MIIP 2006) and the InfraGuide Best Practice (InfraGUIDE 2004):



- What do you own? (and where is it?)
- What is it worth?
- What is deferred?
- What is the condition?
- What is the remaining service life (RSL)?
- What do you fix first?

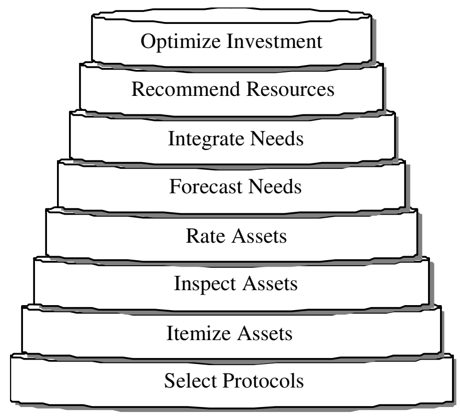
Although the questions provide a roadmap to understand what is needed to manage assets, they do not enumerate the steps needed to assist decision makers or technical experts.

These six basic asset management questions are related to the main facets of infrastructure management. We can think of these five facets as a series of steps that lead to the eventual goal of providing the technical ranking for the infrastructure projects, namely you must: know your inventory, calculate its performance, estimate its service life, determine the life cycle cost (LCC), ascertain the asset's criticality and then you can rank the priorities.



In general, these five facets must be completed sequentially, starting from the lowest step. Information about the inventory is required to support the other facets. The asset's performance information can only be collected once the appropriate inventory data are known. The service life can only be estimated after the performance of the asset is determined. The LCC cannot be calculated until the performance is predicted (required to calculate the future maintenance costs) and until the remaining service life is estimated. The criticality of the asset can only be determined using data from the inventory, performance calculations, service life assessment and the LCC calculations.

In this proposed *Framework*, municipalities could also augment these five facets with others needed to satisfy their own internal or external requirements. For example, municipal sustainability and the effects of climate change are two areas of interest for most municipalities.



The MIIP "Value Engineering" exercise mentioned earlier identified eight sequential processes needed to implement municipal infrastructure management, the ultimate goal being to "Optimize Investment". But to attain this goal, the *Framework* must be built on a solid foundation of a number of other processes. The base of this foundation or structure is to "Select Protocols". Once the protocols have been selected, the assets can be itemized, the assets can be inspected, and then the rating of assets can begin. It is not possible to integrate the needs of all assets until the needs for each asset class have been forecast. Resources cannot be recommended until all needs have been integrated. Once this has been accomplished, a ranking of alternatives can be created and only then can the investment in infrastructure assets be optimized.

But how does one get from one process to the next? Think back to the five steps (facets) illustrated previously. Now consider that each of these steps is a flight of stairs linking each of the processes. For example, the first process is to "Select Protocol"; the individual steps involved include selecting the protocols for inventory, performance, service life, LCC and criticality. Along this journey up the tower to the ultimate goal there are various tasks that need to be completed before moving to the next process. For example, selecting the protocols for the "Inventory Facet" is not a discrete task but a series of tasks that include identifying current protocols, enumerating potential asset classes, selecting asset attributes, and choosing the data quality. These tasks are described in detail in Client Report B5123.14.

The relationship between the various individual tasks within each process can be sequential or not. In a large municipality, there could also be many people in many different departments involved in individual tasks such as data collection for the performance facet; in a small municipality this might involve one person.

The implementation of the *Framework* can vary (degree of accuracy, quality of data, extent of data collection) in any one organization over time, between regions, and across asset classes. For example, some tasks and even an entire process or facet can be performed by the same individual (this can even be done from memory for a limited number of assets) or at the same time (e.g. in small organizations one person could itemize, rate, inspect and fix the asset in the same afternoon). In large organizations however, these tasks must be considered as discrete ones that are performed by any number of different teams or individuals (in-house staff, consultants, etc.) working independently of each other.

Although the description of the details of the *Framework* in Client Report B5123.14 concentrates on wastewater systems, this *Framework* is generalized to suit most typical municipal infrastructure asset classes such as roads, bridges, water systems and facilities. In fact, the *Framework* can also be applied to a wide selection of physical assets that are owned and managed by municipalities such as vehicles. The following subsections give an outline of the eight major processes in the *Framework*. The eight major processes are **bolded** in the remainder of the report.

3.1 Select Protocols

The foundation of the *Framework* is to **Select Protocols**. This process is fundamental to municipal infrastructure management and determines which protocols are needed in order to implement the entire *Framework*.

A protocol is simply the internal methods selected and used by an organization. Selecting suitable protocols for any of the steps identified in the *Framework* can be a balancing act in any one organization or for any asset class, -- always trying to trade-off the implementation costs with the benefits received by the organization.

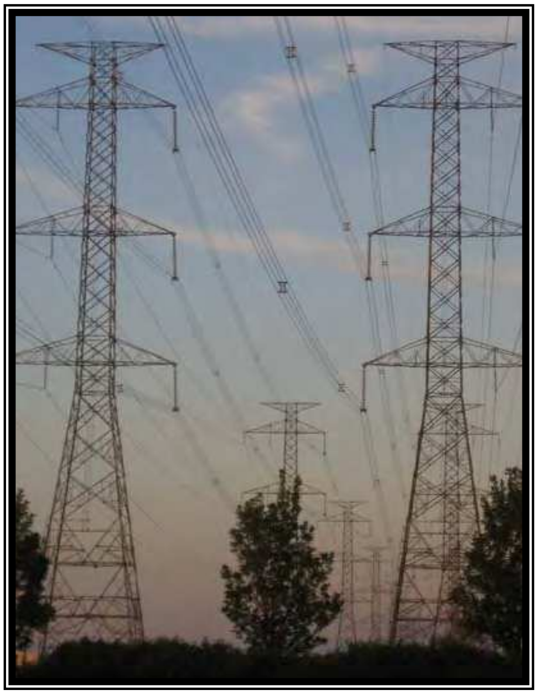
Collecting good inventory and other facet data is expensive; collecting accurate data is more expensive. Innovative technologies help the accuracy, consistency and acquisition of inventory and other facet data but many of these, such as geographic information systems, global positioning systems, or remote sensing, can be expensive. How these data are collected depends on the protocols selected in this first process; however, which protocols are selected must be based on the needs of the organization. Of all the processes identified in the *Framework*, **Select Protocols** has the greatest impact on the success of the implementation of municipal infrastructure management.

The protocols that need to be selected generally fall into two classes: system protocols or facet protocols. The system protocols include those related to:

- those already existing in the organization;
- the technical facets to be evaluated and compared (including those specific to the organization);
- the "information technology" systems required to meet the data storage and retrieval requirements.

The facet protocols include:

- inventory – select protocols for distinguishing the various asset classes, asset attributes, data quality, and data dictionary; then select an appropriate



inventory system (i.e. computerized maintenance management system, database, or filing system);

- performance – select protocols for measuring and evaluating performance such as those mandated by legislation and political/administrative needs; then select the appropriate levels of service (LOS);
- service life – select protocols for determining RSL; for example are expert knowledge, deterioration models, etc. to be used;
- LCC – select protocols for cost models and for calculation of LCC such as the planning horizon, discount rate, etc., and
- criticality – select protocols for determining criticality of assets; for example, is the criticality based on the structural strength, asset vulnerability, emergency intervention cost, or health and safety issues, etc.

3.2 Itemize Assets

The second process in the *Framework* is to **Itemize Assets**. This process physically enumerates the items in the asset class inventories according to the protocols from the **Select Protocols** process. This process is distinct from **Inspect Assets** or **Rate Assets** when evaluations are made of the assets and their performance, etc.

First, the existing protocols used in the municipality to **Itemize Assets** must be reviewed. Following this, there could be a need to select new protocols for asset classes that have not been previously itemized. After the existing and new protocols have been reviewed and chosen, one can move on to reviewing existing data to determine what is missing.

This would include both what to count in the each asset class, and what additional attribute data are required. This might also involve supplying inventory data to others, as many municipalities are relying on the asset management group to be the repository for physical data about the infrastructure. This task implies added responsibilities regarding the format and presentation capabilities of asset data.

Once collected, the data need to be reviewed and categorized. This could involve answering the following questions for these specific facets:

- Performance: Is the asset class under investigation performing to the required level of service (LOS), what is the physical condition of the assets, could the defects compromise health and safety, are the asset deterioration curves within acceptable ranges, etc.?
- Service life: In general, are the assets attaining the predicted service life, have past maintenance and repair (M&R) interventions attained the desired service life results, etc.?
- Life cycle: What are the life cycle costs? Have past maintenance and repair (M&R) interventions been incorporated in the system, etc.?

It is now an appropriate time to calculate the amount of deferred maintenance; this value is used in the industry as a simple metric to determine the relative condition of an asset. That is, in general, assets with lesser amounts of deferred maintenance are in better condition. Having this information, the asset manager can identify criticalities without an elaborate criticality protocol.

3.3 Inspect Assets

The next process in the *Framework* is to **Inspect Assets**. This involves physically inspecting the items in the individual asset class inventory; typically this can only be accomplished on-site. This process uses the protocols developed or selected in **Select Protocols** and uses data obtained in **Itemize Asset**. This process should be treated as distinct from the next process to **Rate Assets** when the assets and their performance, remaining service life, criticality, etc. are evaluated.

The existing protocols used to **Inspect Assets** must be first reviewed. In addition, there could be new asset classes that have not been inspected previously, so "new" protocols have to be selected at this time. In some instances, the inspection might be the first physical confirmation of the asset's existence for the asset management inventory. As a result, there could be a need to pass information about unrecorded or removed assets to the inventory system or to change erroneous inventory data.

The municipal staff needs to collect performance and service life data that is based on the selected inspection protocols. These tasks involve collecting new data for new assets in the asset class, updating performance data for existing assets, or starting to collect new data for new asset classes. Again, it may also be necessary to update the existing data if errors or omissions are discovered during the data collection task.

LCC data also need to be collected. This involves gathering historical costs of similar assets, design, construction, operations, and maintenance costs, and determining if past M&R interventions have been incorporated in the system, etc. It may be possible at this time to estimate the replacement costs of assets.

The final step in inspecting assets involves a confirmation of the existing criticality data about assets in that asset class. It can also involve the collection of cost and risk data for assets. This is very important information as it is essential to understand the importance of the assets if one is to eventually optimize municipal investment.

3.4 Rate Assets

Once assets have been itemized and inspected, they need to be rated. **Rate Assets** uses the protocols developed or selected in the **Select Protocols** process and uses data obtained in the **Inspect Asset** process. This process is distinct from **Forecast Needs** when the actual prioritization of maintenance, repair and renewal activities takes place based on data obtained in this process.

The existing protocols used to **Rate Assets** must be first reviewed and it may be necessary to select some new ones if new asset classes that have not been previously addressed are identified.

As with the previous process, it may also be necessary to update the existing data if errors or omissions are discovered during the rating of assets. In some cases, this task might be the first physical rating of the asset class. Once again, there could be a need to pass information about unrecorded or removed assets to the inventory system or to change erroneous inventory data.

One important task in this process is to determine how the specific assets are performing in comparison to others in the same asset class. As discussed earlier, the performance can represent one or many characteristics of the function of an asset; for example, the metric (i.e. the method to quantify rating) could be the physical condition, the hydraulic performance, or the structural strength.

Another important activity is calculating the remaining service life of the assets based on the performance data. This is currently only possible objectively for a limited number of asset classes (roads, bridges, sewers), providing that the requisite data are available. The service lives of specific assets can then be compared to others in the same asset class. Typical service life estimates for sewer pipes have been calculated at part of the MIIP project (MIIP 2006).

Once the remaining service life has been estimated, it is possible to calculate the life cycle costs. Generally, the cost of annual maintenance is highest for assets in the final third of their service life, when small defects start to appear and need to be repaired before they become expensive problems. The maintenance and repair costs (from work order systems) for all assets should form part of the calculation of the life cycle costs.

All the above information is essential to the next facet or step – determining the criticality of the asset. The criticality of an asset can be defined as the importance of the functionality of the asset and the cost of failure (emergency repairs, costs to society, etc.). The criticality of an asset is therefore dependent on a number of issues: safety, health, redundancy, and cost of emergency repair or the cost of deprivation of services, to name a few. The data collected from the previous facets are invaluable and instrumental in assisting to determine the criticality of the asset. The risk of failure can be calculated after determining the criticality: -- risk is “technically” calculated by multiplying the criticality (i.e. consequences of failure) by the probability of failure. So, if the probability of failure is one in a million (i.e. highly unlikely – like winning a lottery) and the consequence of failure is $1 million (i.e. expensive fix), then the risk is $1.00 (i.e. very low risk). However, if the probability of failure is one in a thousand (i.e. medium to high possibility) and the consequence is $100,000 (i.e. would blow a hole in this year’s budget), then the risk is $100 or 100 times the previous example. Clearly, the latter should be funded if the cost of repairing either asset is the same.

3.5 Forecast Needs

Following along the *Framework*, the next process is **Forecast Needs**. This process attempts to calculate and to project the maintenance, repair and renewal needs using the rating and rankings developed in the **Rate Assets** process. At this stage, assets are still considered by individual class, e.g. road, sewer, water main, etc.

As before, the process begins with a review of information gathered up to this point. In addition, the methods used to prioritize maintenance, repair and renewal projects must be reviewed and selected at this time. For example, a “worst-first” priority model might be selected or a multi-objective optimization protocol might be favoured. This is also the time when one would consider developing a sustainability model for the municipality[5]. This sustainability task is one that could be placed anywhere in the *Framework*; this location is better than most.

A number of important staff activities can take place in this process. For example, this is an opportune time to validate the inventory data**,** as suitable information is now available at this time. In addition, it is also possible to identify the municipal growth so that growth (or shrinkage) can be incorporated into defining new requirements.

Predicting future asset performance is a key task as the municipality needs to know that the existing infrastructure can accommodate the projected growth, or which assets should be de-commissioned.

Predicting remaining service life or calculating how long the asset can perform adequately under given conditions is instrumental to forecasting needs. This task involves calculating new data for new assets in the asset class, updating service data for existing assets, or starting to collect new service life data for new asset classes. Typically, the service life is calculated based on the data from the performance facet. Having this information will allow the asset manager to calculate the probability of failure (i.e. the likelihood that a downtown water main will fail in the near future).

Concurrent with performance and service life forecasting, future life cycle costs need to be calculated for the proposed M&R alternatives. Alternatives should also include the “Do Nothing” option and its associated LCC.

Knowing the costs and confirming the criticality of assets in the various asset classes makes it possible to calculate risk. This involves categorizing the risk for each asset, identifying acceptable and unacceptable risks and the likelihood that a failure “event” will occur.

[5] A sustainability model is defined as the model used to determine if an asset meets current needs without compromising the ability of future generations to meet their needs.

3.6 Integrate Needs

The next process in the *Framework* is to **Integrate Needs**. Many municipal organizations still operate as "silos". This process attempts to combine the outcomes of the **Forecast Needs** process for each asset class into the overall asset needs. This is an important step towards harmonizing overall performance, service life, LCC and criticality, and must be done prior to moving along and up the path towards optimum decision-making.

The first task in this process involves proposing a preliminary budget. Municipal staff can recommend the level of funding required for the preliminary technical requirements. Another task is to develop a model for the decision support system (DSS); it is the DSS that provides decision-makers with the summaries and analyses of data needed to make informed infrastructure management decisions.

The next steps involve:

- harmonizing asset classes to ensure consistency in the data. This means that, where applicable, there will be a common inventory data reporting standard for all assets regardless of asset type (e.g. all lengths in metres, all diameters in millimetres, etc.);
- harmonizing performance to ensure that asset performance is consistent with the asset performance goals. This is an appropriate time to identify the suitability, functionality and condition gap (The City of Edmonton identifies their gaps in the "Thinking Outside the Gap" report at www.edmonton.ca/infrastructure, Edmonton 2004), or the differences between the funds available and the funds required to meet the technical requirements;
- harmonizing service life to ensure that asset RSL is consistent with the asset service life goals. This task identifies which assets are possibly being over- or under-maintained in relation to other assets;
- harmonizing LCC to ensure that the asset LCC is consistent with the asset LCC goals. Some assets of the same age may require funding in excess of the recommended levels of investment (e.g. 2% of Current Replacement Value - CRV), and others may require less in order to meet asset performance requirements. This could be due to age of assets, quality of design and construction, levels of maintenance and in-use conditions; and
- harmonizing criticalities to ensure that asset criticalities are consistent across all assets. This implies that criticality should be independent of the asset class, hence a critical road is the same as a critical sewer is the same as a critical bridge, etc.

3.7 Recommend Resources

The penultimate process is to **Recommend Resources**. This process takes the inputs from the preceding processes and uses them to determine a technical ranking needed to achieve the *Framework* goal to **Optimize Investment**.

Initially this involves two activities: proposing a budget and reviewing the gap/funding needs. In these tasks, the gap between the funding identified in the **Integrate Needs** process and the anticipated available funding is examined. Now, it is possible for staff to recommend a level of investment[6] required to maintain the assets.

The remaining tasks associated with the performance, service life, LCC and criticality facets become an optimization problem where the asset manager tries to maximize asset performance and RSL while trying to minimize the LCC costs and the risks to the organization.

Performance must first be maximized before the RSL can be maximized. Once this is known, LCC can be minimized. Once the performance, service life and LCC facets have been addressed, criticality can be assessed and the risk can be minimized. This leads to the final task, prioritize alternatives. This task enables senior asset management staff to recommend the optimal technical courses of action and determine the infrastructure management ranking of projects. This task is the link between the technical side of the *Framework* and the ultimate goal to **Optimize Investment,** which considers important non-technical factors and issues that can influence how funding is allocated and projects prioritized.

3.8 Optimize Investment

As noted on numerous occasions, the ultimate organizational goal of the *Framework* is to **Optimize Investment**. This process is unique as it involves the input from *ALL* stakeholders (staff, municipal politicians and the public) in order to develop an asset management plan that meets the technical, social and economic requirements of the organization.

Investment is defined as "property or another possession acquired for future financial return or benefit." The optimal return or benefit is not necessarily the best overall; it is the combination of the best returns or benefits for the entire organization given the current needs and constraints. In the *Framework*, the **Optimize Investment** process begins with five important tasks:

- review/update protocols;
- poll stakeholders for LOS;
- inform public and others;
- approve level of investment; and
- select sustainability model.

[6] Level of investment is defined at the amount of funds available to maintain existing assets, as a percentage of the replacement value (i.e. 2 %).

To effectively move up the *Framework* steps, the protocols recommended in the **Select Protocols** process need to be reviewed and validated for their suitability. Stakeholders (i.e. citizens) need to be surveyed to determine if the current level of service is adequate, to be informed of proposed changes to LOS and to be given opportunities to provide input on rehabilitation scenarios, etc. The amount of funds available to maintain existing assets, as a percentage of the replacement value, must be ascertained and proposed to the decision makers. Finally, a sustainability model needs to be selected; after this is completed, it is possible to determine if an existing asset (or a proposed one) can meet current needs without compromising the ability of future generations to meet their needs.

Armed with this technical and social information, senior staff and Council can now attempt to make the optimal financial decisions that will complete this cycle. It need not be a "crystal ball" decision, but can be based on objective criteria, stated requirements and sustainable financing.

This last stage begins with the evaluation of the engineering or technical ranking. Next, client needs and growth should be reviewed to ensure that the current and future requirements of the public have been studied and are taken into consideration in the decision making process.

Funding opportunities from higher levels of government in the form of infrastructure grants may be available or may have been granted, thereby "earmarking" specific projects for immediate funding. Therefore, the next task is to harmonize funding opportunities. Senior staff and Council can now identify and prioritize the projects to be implemented in upcoming year, according to municipal needs, using the prioritization model selected early on in the *Framework.*

Once the projects have been prioritized, they are funded up to the level of available resources. Recommendations for future work are made for those projects that cannot be funded in the current planning phase and must be postponed for a later date.

As can be seen, the *Framework* is intended to be cyclical: -- once the **Optimize Investment** process has been completed, the cycle can begin again.

4 Summary

The *Framework* is a risk-based, iterative model that provides a flexible process that can assist public works managers. The first part of this *Framework for Municipal Infrastructure Management for Canadian Municipalities* is an overview of the "top level" processes in the Framework intended to provide a sequential and object set of process for senior management decision makers to prioritize maintenance, repair and renewal alternatives. The details for implementing the Framework (i.e. the "WHAT" and "HOW") can be found in Client Report B5123.14 (Vanier *et al.* 2006).

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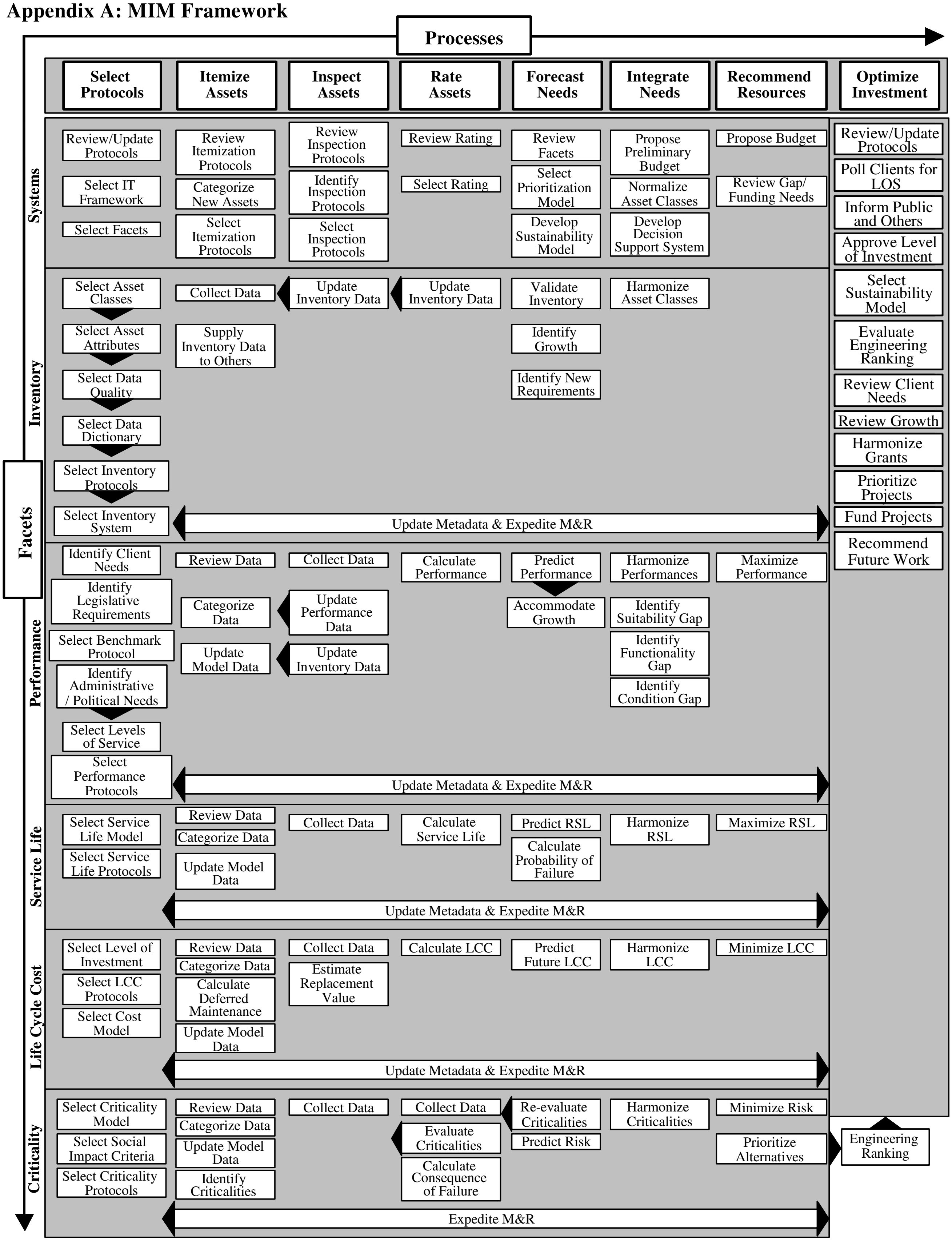
Appendix A: MIM Framework



Appendix B: Abbreviations

CRV	Current Replacement Value
DSS	Decision Support System
LCC	Life Cycle Cost
LOS	Level of Service
M&R	Maintenance and Repair
MIIP	Municipal Infrastructure Investment Planning
MIM	Municipal Infrastructure Management
NRCC	National Research Council of Canada
RSL	Remaining Service Life