Transportation Association of Canada

Highway Asset Management Systems

A Primer

1999

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Introduction

Roads, streets and highways are major capital assets which are essential to achieving our social and economic goals. Canada's road system represents billions of dollars in replacement value alone, and the ongoing costs to build, maintain and operate the road network are considerable.

In recent years, government agencies have been looking for better ways of managing their roadway systems. Government resources are becoming more scarce, and opportunities for increased tax revenues are diminishing. At the same time, the public is demanding more transparency from governments, greater accountability for government decisions and greater value for tax contributions. Government auditors are demanding that transportation agencies report on the condition of their assets, using acceptable public accounting procedures, methods and formats.

Faced with these issues and the desire for an overall business process to optimize network performance and return on investment, government agencies the world over are re-evaluating their current practices to ensure that the right management decisions are made at the right time.

Optimizing the condition of the road network has important ancillary benefits, as well. Infrastructure investments create jobs and stimulate local, regional and national economies. Furthermore, keeping the road system in good condition greatly reduces the costs to users.

Asset management is the process that makes these business goals attainable. It provides a business framework for optimizing the roadway system and establishes a common language between infrastructure managers and financial managers.

This primer for Canadian highway agencies has been developed by the Transportation Association of Canada (TAC). It introduces the concepts of asset management, outlines its potential benefits, and describes how to successfully plan and implement an asset management system.

1

What is Asset Management?

Asset management has been defined as:

"... a systematic process of maintaining, upgrading and operating physical assets effectively, combining engineering principles with sound business practice and economic theory, providing tools to facilitate a more organized, logical approach to decision making."

(U.S. Federal Highway Administration, 1996)

Asset management is a comprehensive process that employs people, information and technology to allocate funds effectively and efficiently among competing asset needs. It is an ongoing process of decision-making about highway assets, including their construction, maintenance, operation and, sometimes, their disposal or transfer.

In the context of an organization's specific business needs and strategic directions, an asset management process establishes the rules for managing the condition and use of assets, based on defensible principles which are technically and economically sound. Funds are then allocated accordingly.

Managing highway assets is not a new concept. In fact, highway agencies have been using pavement, bridge and maintenance management systems for decades. What sets asset management systems apart today is the move to merge these disparate, single-asset management systems into an integrated whole. The merger of individual management systems provides highway agencies with consistent system-wide data, enabling them to allocate available funds across competing pavement, structure and other infrastructure needs.

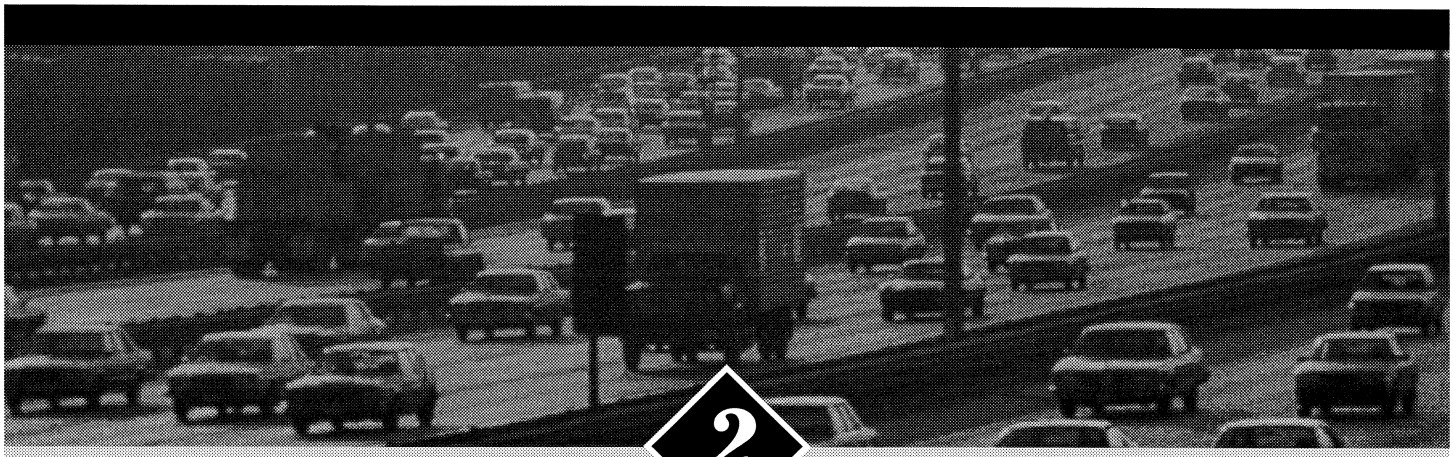
Highway Assets

Corporate assets can be grouped into a number of categories, such as physical, financial and human resources, and information. For the purposes of this primer, the major focus will be on physical highway infrastructure.

Publicly owned highway infrastructure includes a range of components with substantially different initial costs, maintenance costs and deterioration rates. For example, the infrastructure and other physical assets maintained by a provincial highway agency or a municipality might include the following:

Infrastructure assets:	Other physical assets:
pavements	right of way
bridges	gravel pits
culverts	salt sheds
traffic signals	properties
roadway lighting	vehicles and equipment
signs guardrails and	material stockpiles
fencing	communication equipment
drainage structures	buildings

Municipal agencies might have additional components, such as storm drainage structures, sewer, water, equipment and property, as part of their infrastructure assets. Airport authorities and railways have customized assets which would also benefit from an integrated, modular asset management plan.



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The Benefits of Asset Management

Asset management planning enables agencies to harmonize the technical, financial and political factors that affect their investment decisions. Generally implemented as an automated system, the asset management approach includes sophisticated analysis tools, makes use of timely, integrated and valid corporate data, and is capable of prioritizing investment options and assessing their impacts within the context of a defined set of objectives.

Asset management systems can be used to assess the potential impact of various improvement scenarios and provide the data needed for a range of management decisions including, for example:

- determining the funding levels required to maintain an infrastructure component at a known or desired level of service;
- prioritizing work requirements and funding allocations within individual components to achieve the organization's overall goals and objectives;
- optimizing expenditures among various components to get the best value for the overall asset; and
- enhancing reporting information for budget analysts and executives infrastructure condition is measured in terms of value and the effects of maintenance and rehabilitation treatments are evaluated in terms of how that value is affected).

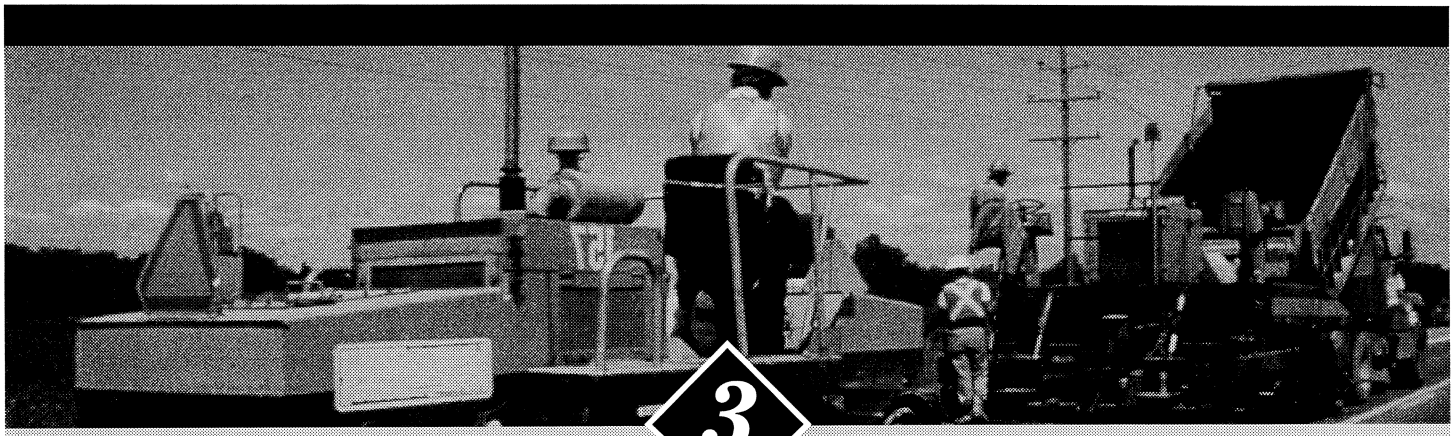
There are many other potential direct and indirect benefits of asset management. For example, asset management can:

- optimize maintenance and rehabilitation budgets;
- identify potential impacts on the physical infrastructure if budgets are reduced or performance standards are lowered;
- provide sound technical and economic criteria to justify intervention programs and budgets for maintenance and rehabilitation;

- assess the implications of specific network-level performance measures and recommend strategic changes in current practices;
- improve access to high-quality data and state-of-the-art information technology tools;
- instill confidence that maintenance and rehabilitation strategies are rational and represent the best expenditure of public funds;
- enhance the credibility of the public sector's decision-making process;
- introduce new, user-friendly technologies;
- put management tools into the hands of a broad range of front-line staff and involve them in decision-making processes;
- reduce fragmentation of information within organizations; and
- provide opportunities for staff to upgrade their technical skills and business knowledge.

It must be emphasized, however, that these benefits will only accrue to an organization if the asset management strategy is implemented fully, practiced, and evaluated regularly for fine-tuning and improvement.

Moreover, organizations must align their business management practices and performance measurement with the asset management process. One of the difficulties in predicting benefits is that some cannot be easily measured or quantified. For this reason, it is best to select a set of direct and indirect benefits that can be measured and compared on a common basis. For more information on benefits and costs, see Appendix A: *Benefit-Cost Analysis Procedure*.



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Components of an Asset Management System

While an asset management system does not need to be fully computerized, it should be as comprehensive as possible, albeit to varying degrees of sophistication. Over time, however, it should have all of the basic qualities expected from such a system, namely: a logical framework that is sound, objective, comprehensive and justifiable, and processes that are transparent and repeatable.

Asset management systems generally include the following major components: asset inventory, performance prediction models, project specific analytical tools, and decision-aid tools. Each of these is described briefly below.

a) Asset Inventory

The asset inventory, usually a computer database, contains information about each asset, such as its type, location, use, value, condition, and maintenance history. Because effective asset management requires an in-depth knowledge of assets, the database must be updated periodically to reflect any changes in the condition of the asset or its value over time. Data collection techniques include visual observation, review of historical construction records, video data collection and automated data collection (i.e., use of detection and monitoring instruments with computerized data collection and storage capacity). The elements of a typical asset inventory are described below.

♦ *Type and Location*

Establishing asset location requires a convenient referencing system that recognizes such inventory characteristics as highway or street linearity, highway or street number/name and place name. The location system must be flexible so that the inventory can be modified as new structures are built or other changes occur. Some agencies use Geographic Information Systems to assist in establishing asset

location; others use a Linear Highway Referencing System or X-Y Coordinate Referencing System. Because the type of location system used is closely linked to the data collection process, it should be developed early on to ensure efficient data collection, filing and retrieval.

♦ *Condition*

The condition of an asset can have a direct impact on the overall performance of the system. This makes it essential to have a clear understanding of the present condition of road assets and the rate at which their condition changes over time. The condition of assets is evaluated according to engineering indices, for example, roughness index value, deflection values, or visual distress.

♦ *Use*

The condition of an asset is affected by traffic and the environment. Asset use is generally measured in terms of traffic levels (such as average annual daily traffic or typical axle loading levels).

♦ *Value*

A standardized approach using recognized accounting principles should be used to determine the value of an asset. Some agencies use various measures of value concurrently for different purposes. For example, financial reporting requires measurement and reporting of the capital value of assets in a manner that is understood and accepted by government financial auditors, while current standards from the Public Sector Accounting and Auditing Board recommend using historical cost for valuing assets.

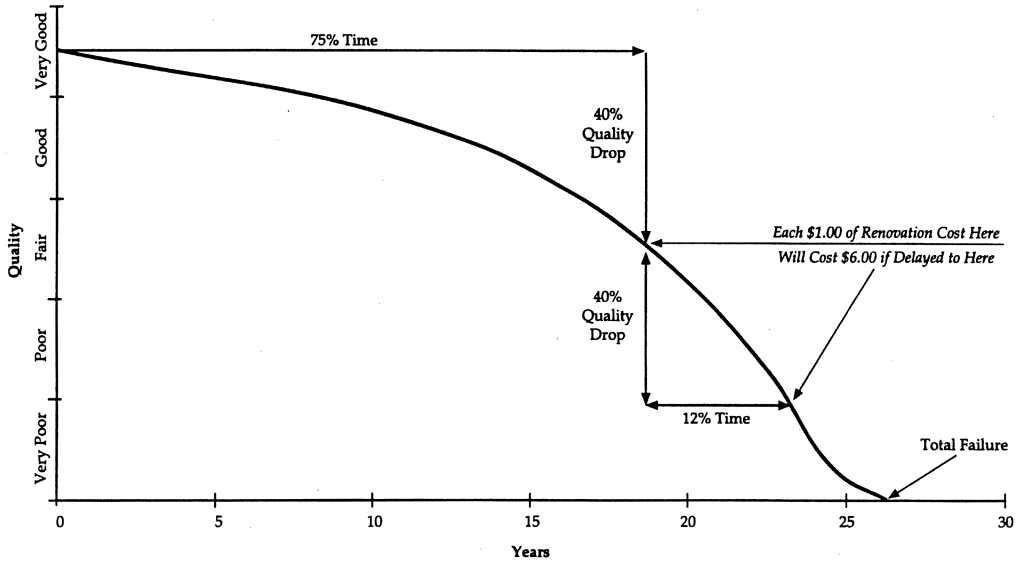
For the purposes of management accounting, however, highway agencies are generally more interested in measures which will help them determine how well they are managing their roadway assets. Some Canadian jurisdictions are using alternative methods such as written-down replacement cost to value their highway assets.

Changes in value over time can be measured using the condition inventory and other economic indicators, while future changes in value can be predicted using performance models coupled with maintenance and rehabilitation strategies. This permits calculation of the funding levels required to maintain an asset at a particular value, as well as the impact on value of deferred maintenance.

b) Performance Prediction Models

Each asset has associated deterioration rates or performance models which are used to predict its remaining useful life and condition each year. Pavement deterioration models vary according to pavement type and pavement maintenance strategy. There are varying deterioration rates for the component

parts of bridges, with bridge decks subject to deterioration at different rates than bridge structural members. The following chart demonstrates conceptually how the condition of pavement can deteriorate over time. Actual deterioration rates will vary depending on such factors as load levels, operating conditions, climate, pavement structural design and rehabilitation treatments.



Source: L.M. Richter, *Pavement management saves $3 million*, American Public Works Administration, 1988

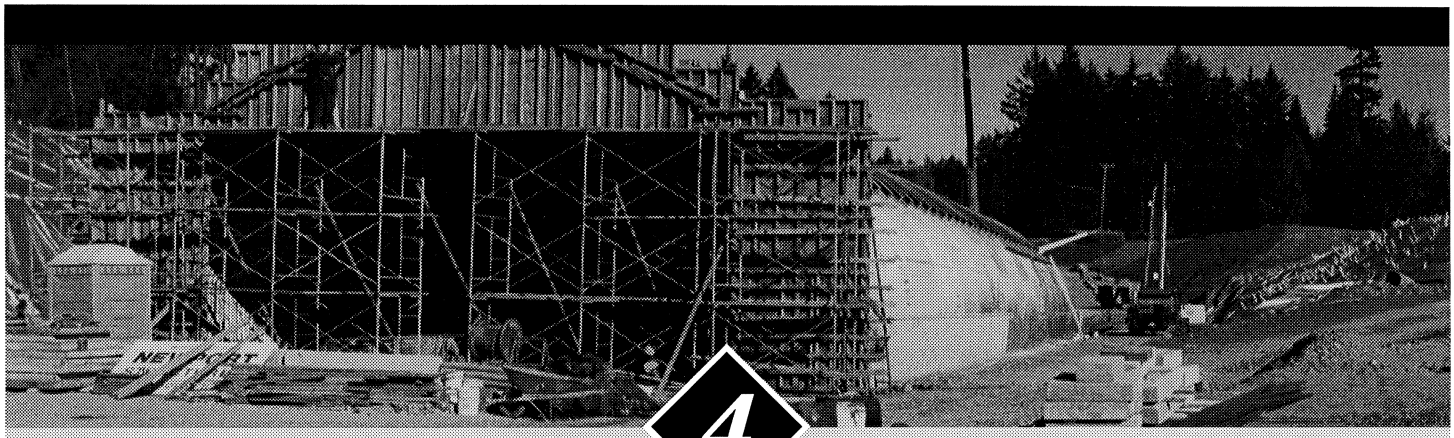
c) Project-Specific Analytical Tools

A set of project-specific analytical tools are used to develop and prioritize proposed maintenance treatments and schedules. These tools, which incorporate models of asset deterioration rates, life cycle analysis, performance prediction, risk assessment and benefit-cost analysis, determine the impact of various maintenance treatment scenarios on the asset itself and on the overall system.

Benefit-cost analysis tools are used to evaluate alternative treatments and combinations of treatments, related costs, applicability and likely effects on the life and performance of the infrastructure elements under study. Specific maintenance and rehabilitation options should be available for each asset based on knowledge of local conditions. The tools evaluate the cost-effectiveness of different treatment options to identify the option offering the best return on investment.

d) Decision-Aid Tools

These tools include trade-off analysis procedures for ranking projects or optimizing investments at the network level. They may be used to prioritize competing programs for highways, bridges and other assets based on the strategic objectives and corporate goals of the road owners. These strategic objectives can be expressed as measures, such as overall system value, condition or operational performance.



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Planning an Asset Management System

Proper planning of an asset management system is essential to delivering a quality product — one that has business value and is sustainable over the long term. A key element of the planning process involves identifying a vision and setting out a development approach for achieving that vision.

Vision

To sustain the necessary commitment of financial and human resources, an organization must have a clear, shared vision of why it wants an asset management system and what it expects the system to achieve. The vision can vary dramatically from organization to organization, depending on such factors as: current state of the assets; strategic direction from executive management; size of the organization and its asset portfolio; scarcity of available funding; current management practices; legacy technologies; culture and practice; and scope of the proposed asset management strategy.

Development Approach

Because of the complexity and the scope of the assets involved in asset management, it is advisable to adopt a modular but carefully integrated development approach. This approach often permits testing to be done prior to the system becoming fully operational, thereby aiding in risk management. Moreover, the modular approach contributes to improved product quality as it enables the development team to refine the system and processes at each stage. (NOTE: the use of a multi-disciplinary team in the development of the asset management system is recommended.)

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Critical Success Factors

The successful development, deployment and maintenance of an asset management system depends on a number of critical factors. These are outlined below:

❒ ***The organization is financially and strategically ready to embark on asset management.***

Set a realistic list of system applications and functions, and prepare a forecast of capital investment needs. Then, conduct a benefit-cost analysis to determine if the organization is ready to proceed.

❒ ***The organization has a strategic vision of where it wants to go with asset management.***

Provide dedicated resources, prepare a detailed project plan and manage the plan according to proper project management principles. If this is not done, cost over-runs and schedule slippage will inevitably occur and the quality of the final product will be compromised.

❒ ***There is an organization-wide commitment — from top management to front-line staff.***

Ensure that every employee understands what the asset management system is about and what they must do differently to contribute to the asset management vision.

❒ ***Development stays in the hands of the system users — the organization staff — and consultants and vendors are called on to provide expert advice and state-of-the-art products, as needed.***

Address specific, well-defined development needs, making sure that business needs and processes drive the information technology, not the other way around.

❒ ***All business areas of the organization are kept informed and involved through each phase of development and implementation.***

Demonstrate and report on project progress at regular intervals to maintain the confidence and support of executive management over the long term.

❒ ***The system is developed and deployed in a way that promotes a sense of ownership among staff.***

Don't reduce deployment to a simple training exercise late in the development cycle. For the system to operate efficiently, employees need to grasp the strategic importance of the system, be motivated to use it, and have a clear picture of how their own work fits into sustaining the business strategy.

❒ ***Changes in business standards, policy, data collection and other processes are communicated to all staff.***

Make sure that everyone knows what their roles and responsibilities are in the new asset management process and what workflows they support.

❒ ***Staff are surveyed through all phases of development to ensure that the benefits of the asset management initiative are being realized.***

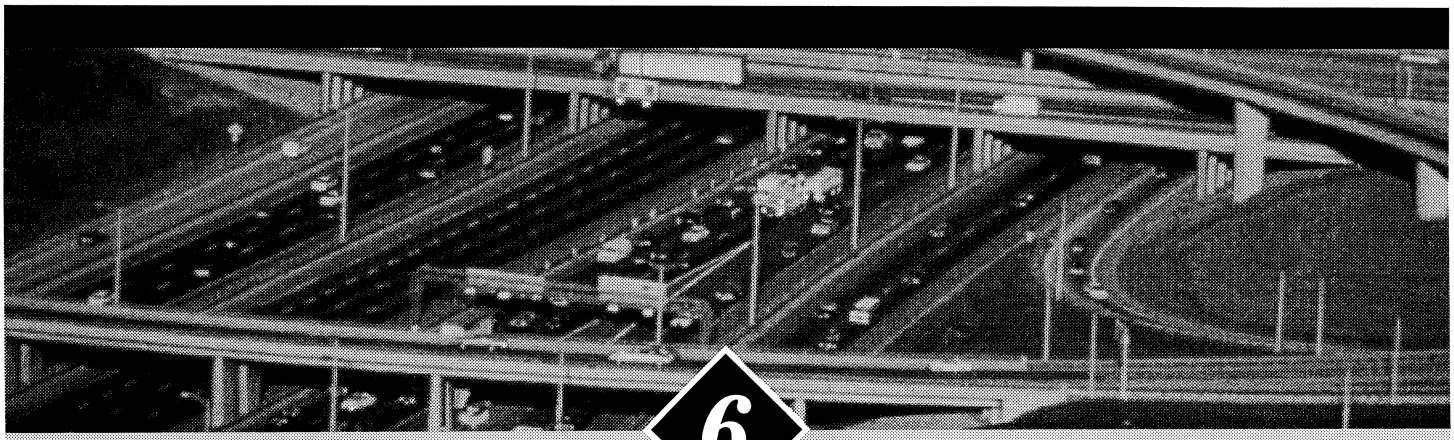
Feed back the results of the survey to respondents to let them know how their ideas are being put to use. This will help to maintain ongoing support for the project and improve the overall quality of the product.

❒ ***The organization develops and promotes a "learning" culture.***

This will improve the quality of the asset management process, promote good staff morale and help the organization achieve its strategic goals. Moreover, the organization will be a compelling place to work.

❒ ***Asset management is considered to be a process of continuous improvement.***

Lay the foundation for innovation, continuous improvement, enhanced business knowledge and corporate wisdom by systematically studying asset deterioration over time, as well as the relative effectiveness of various treatments.



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Implementing an Asset Management System

Following is a summary of the seven key steps involved in developing and implementing an asset management framework.

Step 1: *Identify Objectives*

In deciding which processes within the asset management framework are suitable for automating, an organization must first set clear objectives based on the organization's corporate goals and vision. These objectives should be established through consultation and communication with all stakeholders involved in the construction, operation, maintenance and administration of the road system.

Step 2: *Review the Current Decision-Making Process and Identify Gaps*

Next, review the organization's current business practices and identify the factors which may impede its ability to manage assets effectively. Once these gaps have been identified, a workplan can be developed to focus resources in the critical areas.

The roadblocks to implementing an asset management system may be categorized as technical, data-related, or process-related. Each of these is described briefly below.

- ***Technical Gaps***

Technical gaps refer to an agency's ability to predict the behavior of its assets given a specified investment level. To do so effectively, it must develop detailed models for estimating the anticipated service life of each asset. Analysis tools must be technically sound and capable of determining the best investment strategy for individual assets. Technical gaps may occur if suitable tools are not available to the agency or if the agency does not have the skill sets needed to develop and operate these models.

♦ *Data Gaps*

Data gaps refer to base information required about an asset or to aggregate information required to feed the decision-making process. It is important for an agency to determine what data must be collected to feed the framework, and the level of detail required. Agencies should avoid collecting detailed information that will not be used in the decision-making process.

♦ *Process Gaps*

The critical processes in asset management must have the proper controls to ensure data integrity and quality. Because asset management is data driven, the base data must be objective and repeatable. Quality system principles should be applied to ensure that reliable data is collected and analyzed in a timely fashion.

Processes must be in place to support optimal investment decisions. This applies both to individual assets at a specific location and to network-level trade-offs among assets. Processes related to individual assets — such as pavements and bridges — must be complementary, permitting both individual analysis and network-level analysis using the same database.

Step 3: *Determine the Appropriate Scope for the Asset Management Framework*

The scope of the asset management framework defines which processes will contribute to investment decisions. It determines how the agency's objectives — as well as costs and benefits — are defined and what supporting data will need to be collected.

An effective framework must be sufficiently broad to allow analysis of objectives, as well as evaluation of strategies designed to meet selected objectives. The framework must also create criteria for assessing how well the implemented strategy met the objectives.

An agency must be able to define its own costs and those of its users, as well as the benefits to be realized through any investment it makes in its assets. Benefits can range from enhancing international trade routes to improving service to a local community. Each section of the network is designed to achieve a number of different benefits. To formulate strategies related to its assets, an agency must therefore be capable of identifying the benefits for each section of its network.

Valuation of an asset is an important element of asset management, enabling trade-offs between investments in different asset types. An agency's approach to asset valuation is a critical step affecting both its long-term information requirements and the overall investment planning process.

It is important to note that the scope of the framework and the extent of existing gaps relative to the framework will drive the implementation timeline.

Step 4: Conduct a Benefit-Cost Analysis

Implementing an asset management system often represents a substantial investment — in data collection, development of analysis tools, technology and training. Both the costs and benefits are a function of how an agency currently makes its investment decisions. While the benefits of being able to optimize investments over the long term generally far outweigh the costs of implementing an asset management system, each agency should assess the anticipated costs and benefits of implementation. The results may limit the scope of the system, as defined in Step 3, above. A sample benefit-cost analysis for an asset management system is presented in Appendix A: *Benefit-Cost Analysis Procedure*.

Step 5: Assess Internal Expertise

Asset management uses sophisticated engineering and management analysis tools. The skill sets required for investment planning within an asset management framework may be different from those currently available within the agency. As part of the implementation process, the agency must determine if these skills are available internally or externally, and put in place suitable training programs.

For example, development of an asset management system requires that an agency know how to determine the impact of investment decisions on the service life of its infrastructure elements. Sophisticated management systems are available for pavements and bridges, generally a road agency's most significant assets. These may be integrated with models which estimate impacts on asset value as well as the costs and benefits of an investment plan. Personnel possessing the skills needed to develop these tools may not be available internally. In such cases, an agency may consider bringing in external expertise related to some of the key technical areas.

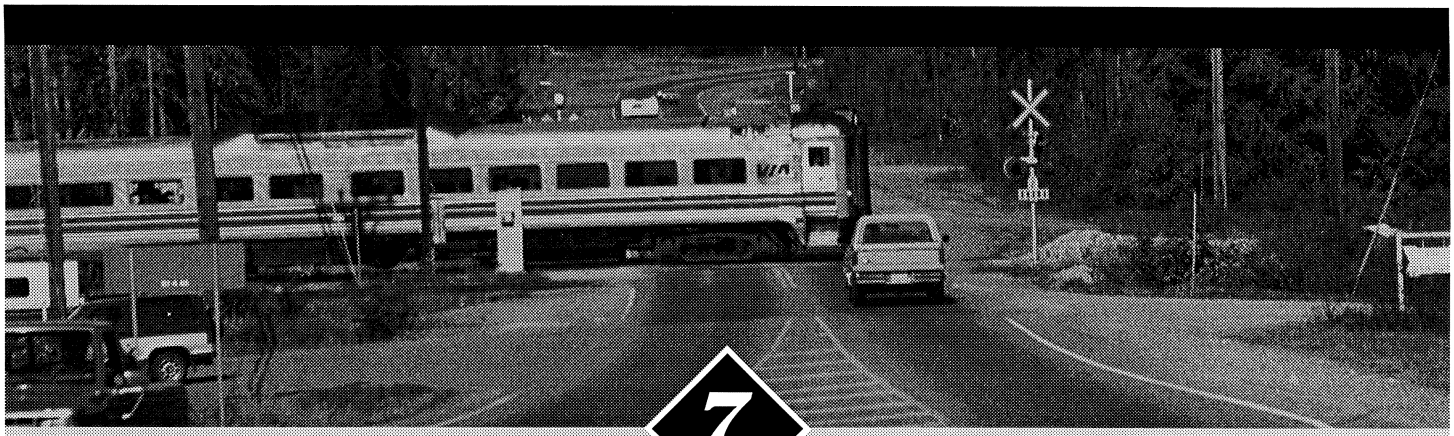
Step 6: Develop a Change Management Strategy

Asset management may represent a fundamental change in an agency's approach to the investment planning process. Therefore, it is essential that corporate objectives related to asset management be communicated clearly to the entire organization. For implementation to proceed smoothly, key internal stakeholders will need to be part of the development and change management process.

In addition to being technically sound, asset management analysis tools must be acceptable to outside funding agencies. A critical part of the implementation process will be to establish acceptance of the concept with key external stakeholders. One important tool for managing change is a communication plan aimed at both internal audiences as part of new business process implementation and at external stakeholders and funding agencies.

Step 7: *Develop Performance Measures*

Various levels of performance measures should be used to determine how well objectives have been met. Some relate to functional performance, others to performance of individual strategies or to corporate-level achievement of defined objectives. The information that is used for asset management should also be used to measure accomplishment and performance. Agencies must have the capability to quantify and assess performance of selected investment strategies and achievement of corporate objectives. An agency's ability to measure the impact of the investment on asset value and other tools within its asset management framework provides a simple and consistent means of measuring the effectiveness of asset investment decisions.



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Potential for Partnering

Given the complexity and cost of asset management systems, and the widespread need for them among transportation agencies, great potential exists for partnering in their development and implementation. One example of this type of partnering is an agreement involving the Manitoba and Saskatchewan Departments of Highways and Transportation and the City of Saskatoon.

The opportunity for this joint venture arose when the three agencies decided to investigate the implications and benefits of acquiring an asset management system at the same time. Further investigation demonstrated the potential benefits of collaboration, not only in reducing the demand on resources within each agency but also in creating ongoing opportunities by working with a common system.

Given the current fiscal constraints under which road agencies operate and the proven benefits of sharing expertise and resources, the Transportation Association of Canada (TAC) endorses and supports cooperative and collaborative efforts between agencies. If any jurisdiction wishes to explore partnering opportunities in system development, TAC can provide assistance in identifying potential partners or models.

Benefits

A range of benefits can be derived from partnering, depending on individual circumstances. Some of these benefits are outlined below.

♦ *Cost Savings*

The cost of developing a system is considerable, whether it is a unique customized system or an off-the-shelf package. Sharing development costs (and the risk of substantially escalating costs) can lessen individual liability significantly.

During the implementation phase of an asset management project, partnering also reduces the unit procurement costs for hardware and licenses. Systems support costs for each jurisdiction may also be reduced.

♦ *Benchmarking*

The term "benchmarking" refers to a process of creating performance or outcome-based measures by which an organization can gauge its progress and compare that progress with other agencies using similar measures. The ultimate goal of benchmarking is to identify and implement the best available practices.

The interaction of road agencies during the development of an asset management system provides an unparalleled opportunity for benchmarking every facet of each agency's operations. The need to benchmark has never been greater as governments reduce budgets and seek out the most economical means of doing business. A principal tool for measuring cost effectiveness is benchmarking with comparable jurisdictions.

Opportunities exist to benchmark a wide range of factors, such as unit costs and methodologies for individual maintenance and rehabilitation activities, work crew size, and equipment type and use.

♦ *Better Practices*

Benchmarking provides opportunities to make use of, or even improve on, practices in other jurisdictions that are more efficient and effective than current in-house practices. At the same time, closer working relationships among jurisdictional staff have made it easier to stay current with new innovations in technology. Keeping informed about technological advances in infrastructure maintenance and rehabilitation is easier if staff are part of a larger partnership than if they operate within individual jurisdictions.

♦ *A Different Viewpoint*

Staff interaction encourages "fresh eyes" and new viewpoints for analyzing departmental issues. For example, other jurisdictions may have found a solution to a problem that local staff have not yet resolved. Similarly, developing a new or revised maintenance management system as part of an asset management system gives maintenance staff the opportunity to review current practices and improve on them.

♦ *Reduced Workload*

Developing new systems, or upgrading existing ones, requires a great deal of research, analysis and creative activity. In a partnership arrangement, there are more resources and a larger knowledge base to draw from. The work can be shared, with the result that individual workloads are lessened, and ideas and practices exchanged.

The synergy of partnering can also be realized in the development and delivery of all types of staff training packages, including training during initial implementation, and periodic training once the system is in place.

♦ *Enhanced Credibility*

The credibility of an asset management system and the information it produces are often enhanced if the system is used by more than one jurisdiction. For example, an analysis showing a degradation in one jurisdiction's road network may be more credible if the same asset management system is in use elsewhere, thus adding force to requests for additional capital funding. The credibility of benchmarking activities is also enhanced when they are based on a common system.

Conditions for Partnering

If partnering venture is to succeed, a number of basic issues must be explored and agreed to by all parties. As with the potential benefits to be derived from partnering, the importance of these issues may vary according to circumstance:

- agreement on the type of system(s) to be included (e.g., maintenance, pavement or bridge management);
- agreement on the process for engaging consultants and parchasing technology;
- compatibility of timetables for system development;
- shared understanding of approval processes and the information required to obtain the necessary approvals;
- development of legal agreements addressing the goals and concerns of each party; and
- agreement on proprietary rights and access to source codes.

Appendix A:
Benefit-Cost Analysis Procedure

Introduction

This appendix is not intended to set out the details of a specific benefit-cost process. Rather, it provides a generic conceptual framework into which any benefit-cost analysis may be structured. The primary focus of the framework is on benefit-cost analysis of an asset management system for a highway network.

Objective

The objective of a benefit-cost analysis is to determine the relative economic advantages of alternative courses of action and to aid in the selection of the best alternative. In the context of highway asset management, the options are to continue managing infrastructure as it is currently done, or to do so in an alternative way.

While the framework stresses the economics of particular solutions, non-economic factors may also play a part in selecting an option. A benefit-cost analysis is a decision-support tool; it does not necessarily provide a comprehensive rationale for selecting one option over another.

Procedure

1. State the problem.

Briefly describe the business case that underlies the infrastructure management project under consideration.

2. Clearly define viable alternatives.

There are likely several options available to the organization, including: expanding manual operations; extending the current system; re-engineering a major business process; opting for an asset management approach (i.e., developing an integrated, modular, database-oriented asset management system); or developing some combination of the above.

It is important to define the alternatives as clearly and objectively as possible to remove any ambiguity or bias for an intuitively preferred option.

3. Outline all the factors in each option.

Even if certain costs are common to each option they should be listed so that all factors are considered and there is no room for doubt. The dollar value for common costs need not be specifically identified as long as it is noted that the class of cost is considered common to each alternative.

4. Assess the benefits and costs associated with each option.

Follow the basic accounting rule that "sunk costs" have no bearing on a future decision.

Some organizations may have a concern that their previous investments in a system will be wasted if they embark on a new information management approach. The accounting concept of "sunk costs" makes this concern a moot point.

- List all assumptions.
- Allow for discounting future costs and tax implications, if and when necessary.

Sample Costs

- analysis of data needs
- collection of additional data, if required
- re-formatting of existing data
- software acquisition
- additional hardware and communication
- consulting for customization, design, integration and implementation
- in-house staff and overhead costs for support of customization, design, integration and implementation
- ongoing maintenance costs, such as
  - costs to maintain/upgrade system software as required
  - annual package software license and support costs
  - software re-testing costs
  - annual training costs for new users and updating

Sample Benefits

- more efficient allocation of maintenance and rehabilitation costs
- more effective decision making
- increased productivity
- better information and improved access to information
- improved service to the customer at lower cost
- cost reductions from use of integrated data sets
- reduced support for older systems using outmoded languages

Summary

While a benefit-cost study will not necessarily be the deciding factor, it is an essential exercise that should be carried out before the organization becomes deeply involved in development of a new information system.

A benefit-cost study should be rigorous in that it should cover all bases; however, it is acceptable to use estimates rather than exact figures. If a positive return can only be achieved by shaving numbers, then it is too close to call. It is important for the business to manage the benefits identified in the benefit-cost analysis and to measure them through all phases of the project.