Leveraging Municipal Asset Master Data and Information for Maintenance and Reliability Readiness

BUSINESS CASE

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Business Case

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This project has been conducted by Toronto Metropolitan University and PEMAC Asset Management Association of Canada through an initiative that is offered through the Municipal Asset Management Program, which is delivered by the Federation of Canadian Municipalities and funded by the Government of Canada.

Funding for the partner organizations' grants is provided by Municipal Asset Management Program (MAMP), an eight-year, $110 million initiative funded by the Government of Canada and delivered by the Federation of Canadian Municipalities. The program provides asset management training, funding and information sharing to enable municipalities to access the data needed to plan effectively.

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EXECUTIVE SUMMARY

This business case is part of the project entitled *"Leveraging Municipal Asset Master Data and Information for Maintenance and Reliability Readiness."* Through a grant from the Federation of Canadian Municipalities, Toronto Metropolitan University, the PEMAC Asset Management Association of Canada, and municipal representatives from across Canada jointly conducted the project. The business case is a companion to a white paper that documents the complete details of the project (Easa and Lawlor, 2024) and a guide that presents a practical roadmap for organizations to implement the recommendations made (Lawlor et al. 2024).

The case presents a strategic approach to enhancing the capabilities of master data and resource readiness (MDRR) for maintenance and reliability in Canadian public sector organizations (PSOs). It consolidates information from various national data sources, such as:

- A survey of 27 organizations and 71 staff across Canada revealed achievements and areas for improvement in a wide range of practices.
- Statistics Canada's infrastructure condition data analysis reveals that 32.1% of assets are in fair, poor, or very poor condition, and 9.1% are in an unknown state.
- The Government of Canada study offers insights into processes that maintain value, such as repair, refurbishment, and repurposing, along with their economic and ecological advantages.

The business case suggests a comprehensive plan to leverage master data, information, and resource readiness to support optimum asset management.

- Developing comprehensive maintenance programs for various assets using structured maintenance frameworks like GFMAM.
- Utilizing reliability engineering methods such as root cause analysis and failure mode analysis to enhance asset uptime.
- Using predictive maintenance technologies driven by data analytics to facilitate proactive and optimized maintenance scheduling.
- Create uniform templates for asset master data systems at the enterprise level to enhance usability across various departments.
- Enhancing financial planning through the incorporation of dynamic forecasting models and thorough lifecycle costing.
- Highlighting sustainability aspects such as circular economy principles, climate resilience, and green infrastructure.
- Performing regulatory gap analysis and establishing collaborative working groups to guarantee compliance.

The conclusion predicts that enhanced MDRR will greatly influence the development of infrastructure that is more efficient and sustainable. The text delves into the substantial benefits of cost optimization, risk mitigation, performance enhancement, financial security, and improved asset management maturity. Overall, this comprehensive business case provides an integrated strategic roadmap to optimize infrastructure performance through amplified maintenance, reliability, and data capabilities. It makes a compelling case for investing in MDRR as part of a future-oriented asset management approach.

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The members of the PEMAC team, TMU team, and course instructors are listed below.

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SECTION 1 - INTRODUCTION

Efficient asset management is pivotal to the operational and financial sustainability of public sector organizations that own and manage essential infrastructure assets. Within this, Master Data and Resource Readiness (MDRR) has emerged as a strategic imperative to optimize infrastructure performance, longevity, and value realization. MDRR is defined as *"The provision of all resources, data, and information so that assets are moved toward a state of preparedness for maintenance and reliability work on the first day they are operational"*

This business case provides a thorough plan for organizations to revamp their maintenance, reliability, and data management practices to comply with ISO 55000 standards and international best practices. The report combines insights from reputable surveys, infrastructure data, and circular economy research, uncovering systemic problems such as overdependence on reactive maintenance and the absence of standardized data systems.

The document suggests implementing structured maintenance frameworks, reliability engineering techniques, predictive technologies utilizing data analytics, robust master data practices, and dynamic financial forecasting to tackle these challenges. The document offers an in-depth examination of the current situation, suggests ways to address areas of weakness, and showcases advantages using real-life case studies and theoretical financial models.

The business case also examines important factors like regulatory compliance, climate resilience, sustainability through circular economy principles, and comprehensive lifecycle costing. The conclusion discusses improved MDRR's significant strategic impact and transformative capacity in attaining more effective, sustainable, and resilient organizations.

This business case provides a comprehensive strategic plan to enhance infrastructure value by improving the timely provision of resources and data for maintenance and reliability engineering functions.

SECTION 2 - CURRENT STATE OF MASTER DATA AND RESOURCE READINESS

2.1 National MDRR Survey

2.1.1 Introduction to Survey Analysis

This section provides an in-depth analysis of the maintenance and reliability master data and information survey carried out by Toronto Metropolitan University and the PEMAC Asset Management Association of Canada in 2023. The survey was conducted among 27 municipalities, cities, and towns (organizations) across Canada, with populations totalling approximately 16,940,424. The survey contained over 180 questions that explored the current state of asset and maintenance management, master data, information, work practices and organizational configurations. The input from these organizations provides essential insights that are crucial for shaping the future of MDRR in Canada.

2.1.2 Key Aspects of Business Case Relating to Survey Findings

The results emphasize strong points and areas for enhancement, providing a factual basis for our strategic recommendations. This section combines these insights to strengthen the argument for improved maintenance management, reliability engineering, and asset master data use.

2.1.3 National Master Data Survey Highlights

Participant Profiles

- ***Data summary:*** 27 organizations, municipalities, cities, and towns participated across 13 provinces and 3 territories, representing combined populations greater than *16 million*. Ontario had the most participants, 55.71% of the total, representing 9,693,519 residents. Other leading provinces were Quebec, representing 1,854,442 people; Alberta, representing 2,349,675 people, and British Columbia, representing 1,180,135 people. The remaining provinces had organizations representing populations ranging from 20,636 to 749,607.
- ***Analysis:*** The participation data shows Ontario as the clear leader regarding the number of participating organizations and the total population represented. Based on the major urban centres involved, Quebec, Alberta, and British Columbia also feature prominently. The inclusion of all provinces and territories provides national representation and a broad perspective on asset management practices. However, participation remains limited outside of the leading regions. Targeted engagement efforts for underrepresented provinces could provide more balanced input on asset management across Canada.

Public Organization Size

- ***Data Summary:*** Data Summary: Out of 27 participating organizations:

- 33.3% serve populations over 400,000 people
- 17.4% are between 100,000 and 399,000
- 13.0% are between 30,000 and 99,999
- 21.7% are between 5,000 and 29,999
- 14.5% are under 5,000

Organizational Sections

- ***Data Summary****: Participants across various functions participated in the survey.*
  - *Asset Management: 51.4%*
  - *Maintenance Management: 17.7%*
  - *Other: 11.4%*
  - *Finance: 7.1%*
  - *Operations: 7.1%*
- ***Analysis:*** Five sections made up the bulk of respondents, with eleven different organizational sections participating in the survey. Asset management and maintenance management are the highest participating groups, indicating good alignment between the survey subject matter and the intended stakeholders.

Job Titles

- ***Data Summary:*** *Participants across various functions participated in the survey.*
  - *Manager: 41.2%*
  - *Other: 26.5%*
  - *Analyst/Specialist: 14.7%*
  - *Supervisor: 11.8%*
- ***Analysis:*** Three roles made up the bulk of respondents, with another 18 unique roles submitted in the “other” category, a total of 24 roles participated in the survey. The significance of managers and supervisors, with a combined percentage of 53%, indicates a strong desire from leadership positions to engage in continuous improvement. The diversity of participating roles indicates the breadth of maintenance and asset management throughout organizations.

Asset Classes

- ***Data Summary:*** Participant organizations shared that they were responsible for a diverse array of asset classes, with 20 identified. The highest proportion being, water and wastewater vertical infrastructure at 66.7%, followed by roads at 58.0%, stormwater, water and wastewater linear infrastructure, culverts all at 56.5%, public buildings at 55.1%, bridges at 53.6%, fleet services at 49.3%, solid waste at 43.5%, parks and recreational facilities at 46.4%, lands at 36.2%, other (please specify) at 10.1%, information technology at 30.5%, and public housing at 13%.
- ***Analysis:*** The data shows that many organizations are responsible for a diverse set of asset classes, emphasizing the complex nature of the required activities, data, and work. Looking at the whole survey in this context might explain why so many organizations rely on Excel to manage their data.

Master Data and Information Profiles

How Master data is collected

- ***Data Summary:*** Municipalities report a variety of methods for data collection across the lifecycle of their assets, including:
    - Scattered across documents: 36.5%
    - Tabularized with established connections: 29.0%
    - Tabularized with minimal connections: 25.6%
    - Standalone reports: 26.3%
    - Other methods: 12.7%
    - Data not collected: 10.0%
- ***Analysis:*** 21 separate questions about different types of master data and information sources reveal a mixed picture of data collection. The most common scenario is data being dispersed across different documents, which could signal challenges in data accessibility and consolidation. On the flip side, there's a clear effort towards structured and interconnected data systems, as seen in nearly 30% of participants. Some are not collecting data or being categorized as 'Other' indicates there are gaps to address in achieving optimal data management practices.

User Engagement and Application, Primary Data Users

- ***Data Summary:*** Primary users include Maintenance and Operations (75.4%), Finance (54.4%), Capital (43.9%), and procurement (15.8%)
- ***Analysis:*** The data suggests that maintenance and operations are the key users, with finance and other functions less involved, potentially indicating underutilization in their decision-making.

Work Practices

Master data, information, and storage locations

- ***Data Summary:*** Data storage is diverse; the system types used are CMMS (47.5%), GIS (45.8%), and Excel (35.6%), followed by ERP (37.3%). The count of unique systems across the system type is greater than 20.
- ***Analysis:*** The varied storage systems across Canada indicate a lack of standardization that points toward opportunities for more streamlined and integrated systems for a national-level asset management strategy, notably the use of Excel, which may point towards gaps in market system capability or CMMS, GIS, and ERP configurations to meet the needs of end users.

Asset Data Analysis and Utilization

- ***Data Summary:*** *49% engage in data analysis for asset conditions, but a similar proportion (51%) work with limited data for basic operations and maintenance, indicating a split in data utilization practices.*

- ***Analysis:*** *The data highlights a critical divide in asset management approaches, with significant room for improvement in leveraging data analysis for strategic decision-making across the board.*

Adoption of Asset Management Tools

- ***Data Summary:*** The majority reliance on Excel (75.5%) and GIS (73.5%) suggests a preference for general-purpose and specialized tools, with a considerable portion exploring other software (42.9%), 28 systems.
- ***Analysis:*** While foundational tools are widely used, the diversity in tool adoption points to fragmentation in asset management systems and a possible lack of optimization in leveraging specialized software, the dominance of Excel indicates a possible gap in the capabilities of existing systems versus the diverse portfolio of asset classes.

Formation of Asset Management Teams

- ***Data Summary:*** Established teams are prevalent (56.0%), indicating mature practices, yet 14.0% have only recently formed such teams, showing ongoing development efforts. 28% say they do not have an asset management team.
- ***Analysis:*** The presence of established teams underscores a foundational commitment to asset management, equally, the lack of AM teams also highlights ongoing challenges and the need for continuous evolution in organizational approaches.

Implementation of Asset Management Plans (AMP)

- ***Data Summary*:** A significant share has asset management plans (59.2%), with a smaller percentage (24.9%) indicating they do not and are not sure 10.2%.
- ***Analysis*:** While the presence of plans indicates progress, the difference between those with and without plans is significant, suggesting that more focus is required in developing plans nationally.

Monitoring the Implementation of Asset Management Plans

- ***Data Summary*:** A significant share (65.3%) say that AMPs are not monitored, a smaller percentage (16.3%) indicate they do monitor, and a further 16.3% say they are not sure if they are monitored.
- ***Analysis*:** While the presence of plans indicates progress, their limited monitoring indicates that they may not be integrated into business objectives or have a clear line of sight from a strategic deployment perspective.

Reliability Engineering Structures

- ***Data Summary:*** Only 14.3% have established reliability engineering structures, contrasting with 67.5% without, revealing a notable gap in proactive asset management focus.

- ***Analysis:*** The minimal adoption of reliability engineering points to a widespread oversight in prioritizing long-term asset reliability and performance, indicating a critical area for strategic improvement.

Dedicated Maintenance Management Structures

- ***Data Summary:*** Over half (53%) report having dedicated maintenance management, yet 32.7% do not, reflecting a divide in maintenance strategy integration.
- ***Analysis:*** The data shows a commitment to maintenance management in many organizations, but it also suggests that a significant portion of entities lack a structured approach to maintenance, which impacts asset longevity and performance.

Inclusion of Maintenance Management in Asset Management Policies

- ***Data Summary:*** Only 42.6% incorporate maintenance management into their policies, suggesting a strategic gap in fully integrating maintenance considerations into asset management planning.
- ***Analysis:*** The underrepresentation of maintenance management in asset policies indicates missed opportunities for aligning maintenance strategies with overall asset management objectives, pointing towards a need for more holistic policy development.

Lifecycle Costs in Procurement Decisions

- ***Data Summary:*** Only a minority (27.0%) consider future lifecycle costs in procurement, highlighting a prevalent issue of overlooking long-term financial implications.
- ***Analysis:*** The lack of comprehensive lifecycle cost consideration underscores a critical area for enhancing financial sustainability and efficiency in asset management practices.

Maintenance Budgeting in Capital Planning

- ***Data Summary:*** Similar to lifecycle costing, only 27.0% include maintenance budgets in capital planning, indicating a widespread gap in accounting for the total cost of asset management.
- ***Analysis:*** This gap in integrating maintenance and repair costs into initial planning phases suggests a broader challenge in achieving sustainable asset management through forward-looking financial planning.

Formal Maintenance Planning Processes

- ***Data Summary:*** While 33.3% have formalized maintenance planning, a significant 54.2% do not, revealing a substantial area for improvement in maintenance strategy execution.
- ***Analysis:*** The absence of formal maintenance planning in over half of the organizations highlights inefficiencies and the potential for enhanced asset management through more disciplined and structured maintenance practices.

Clarity of Municipal Regulations on Maintenance and Reliability

- ***Data Summary:*** The regulatory landscape is mostly unclear, with 54.4% finding regulations "not so clear" and 32.6% stating they are "not at all clear," emphasizing a significant lack of guidance.

- ***Analysis:*** The data starkly illustrates the challenges posed by the ambiguity in regulations, hindering the adoption of best practices in maintenance management and reliability engineering. This suggests a pressing need for more precise regulatory standards and guidance to support excellence in these critical areas.

Data Insights and Recommendations

Progress Made

- 59.2% have established asset management plans showing organizational commitment.
- 56% have formed dedicated asset management teams indicating maturing practices.
- 53% have formal maintenance management structures in place.
- 45.8% utilize GIS, and 47.5% use CMMS, adopting essential asset management systems.

Areas for Improvement

Data Management

- 36.5% have data scattered across documents, creating accessibility challenges.
- 20+ unique systems are used for storage, lacking standardization.
- 75.5% rely on Excel to manage their assets and data, suggesting capability gaps or access to a fit-for-purpose platform solution required for effective management and decision-making processes.

Strategic Planning

- 65.3% do not monitor asset management plan implementation, limiting integration.
- Only 14.3% have reliability engineering structures, limiting maintenance tactics selections and the benefits of more reliable infrastructure.

Financial Sustainability

- Just 27% consider lifecycle costs in procurement, overlooking long-term implications.
- Only 27% include maintenance budgets when planning new development acquisitions, missing the provision of the maintenance function to maintain assets in a state of good repair.

Maintenance Integration

- 32.7% lack dedicated maintenance management, revealing divided strategies.
- Only 42.6% incorporate maintenance into asset management policies, lacking alignment.

Regulatory Guidance

- 54.4% find regulations unclear on maintenance and reliability.
- 32.6% say regulations are unclear, hindering the adoption of best practices.

In summary, while progress has been made, opportunities remain to improve data management, strategic planning, financial sustainability, maintenance integration, and regulatory guidance. A coordinated national strategy can leverage its strengths while addressing these gaps to advance asset management across Canada.

2.2 Technology Systems Landscape Analysis

2.2.1 Insights from the 2023 Municipal Survey

The survey provides critical insights into Canadian PSOs' technological approaches to asset and maintenance management. To identify the systems used, we posed two separate questions.

1. Master data: “Where is the primary data/information storage location?”
2. What tools are used by your organization to manage assets and data?

For question one, the survey reveals various technologies used to manage asset master data. This question was asked 20 times for different types of master data, highlighting the diverse systems used. In total, 42 unique systems were mentioned, with the most common being:

- CMMS (Computerised Maintenance Management System): 40.2%
- Excel: 31.0%
- Asset Management System: 29.4%
- Other: 27.0%
- GIS (Geographic Information System): 24.8%
- Financial Fixed Registry: 16.6%
- ERP (Enterprise Resource Planning): 12.7%

The array of technologies for question two was again large, but Excel was the most prominent. Considering the nature of the work, monitoring asset conditions, maintenance schedules, and financial data. Excel likely provides flexibility lacking in other systems. The top responses were:

- Excel: 75.5%
- GIS: 73.5%
- Infor Hansen: 16.3%
- IBM Maximo: 14.3%
- Microsoft Access: 12.2%
- SAP PM: 10.0%
- Cityworks: 8.2%
- PSD City Wide: 8.2%
- I am not sure. 6.1%
- Riva/PowerPlan: 2.0%
- Oracle Enterprise Asset Management: 2.0%

2.2.2 The Challenge of Diverse Systems

The survey highlights a significant challenge in the current landscape: the diversity of systems employed. This diversity, while showing adaptability, leads to several critical issues:

- ***Data Fragmentation:*** The survey indicates that 49.0% of data is scattered across different documents, causing fragmented and inconsistent data pools, which obstruct a unified asset perspective.
- ***Inefficiency and Inaccuracy:*** Despite its limitations for complex asset management, using essential tools like Excel raises concerns about operational inefficiencies and data accuracy.
- ***Lack of Standardisation:*** The absence of standardized systems complicates data comparison, aggregation, and benchmarking across different municipalities.
- ***Challenges to Advanced Analytics:*** The diverse and inconsistent technological environment hinders the implementation of advanced data analytics, which is essential for proactive maintenance plans and well-informed decision-making.

2.2.3 Addressing System Fragmentation

Significant difficulties may arise due to this if the landscape of technological systems is highly fragmented. With data often siloed within different systems and teams, this can lead to operational inefficiencies and hamper coherent decision-making processes. Reliance on outdated or non-standardized systems increases the risk of data inaccuracies and limits the potential for comprehensive data analysis. To overcome these challenges, organizations need to break down data silos, consolidate systems where possible, and invest in technologies that enable data integration and standardization. This allows for a more unified platform that connects disparate systems, provides a single source of truth, and allows organization-wide visibility and optimized processes. Increasing system integration enables stakeholders to make data-driven decisions using precise and comprehensive insights. Having the correct technology strategy and seamless systems integration is essential for utilizing data effectively and realizing the complete potential of an organization.

2.2.4 The Advantages of Standardised Systems

Transitioning to standardized, enterprise-level systems can substantially enhance asset management's effectiveness and efficiency. Such systems facilitate centralized data storage, improved data accuracy, and more efficient inter-departmental collaboration. Moreover, they enable the deployment of sophisticated data analytics, which is critical for optimizing maintenance schedules and enhancing long-term asset management strategies. Integrating GIS with asset management software further augments this capability, providing a more detailed and spatially aware view of infrastructure requirements.

- ***Data Integrity and Consistency:*** Standardised systems provide a robust foundation for data integrity and consistency, essential for reliable decision-making.
- ***Operational Efficiency:*** A shift from essential tools like Excel to specialized asset management software will likely yield operational efficiencies and reduce data-related errors.
- ***Facilitating Collaborative Data Practices:*** Standardised systems ease the sharing and benchmarking of data, fostering a culture of collaboration and sharing best practices.

- ***Foundation for Advanced Analytics:*** Standardised systems are critical for implementing advanced analytics, which is instrumental in predictive maintenance and strategic asset management.

2.3 Canada's Core Public Infrastructure Report:

2.3.1 Canada's Core Public Infrastructure Results

The Statistics Canada 2020 Infrastructure Condition Scorecard presents a mixed picture of Canada's infrastructure. With replacement asset values at $2.1 trillion (excluding housing), about 32.1% of this infrastructure is in fair, poor, or very poor condition, conditions that represent significant risk exposure from deterioration levels. This situation underscores the urgent need for substantial efforts to maintain asset conditions in good and very good categories. Conversely, 58.8% of the infrastructure is in good or very good condition, reflecting the successes of existing strategies and ongoing maintenance and capital replacement programs. However, approximately 9.1% of the infrastructure falls into an unknown condition status, emphasizing the need for enhanced data collection and assessment practices.

"The following data was obtained from Statistics Canada: 'The replacement values of publicly owned infrastructure in Canada were composed of $1,267.3 billion of assets rated in good or very good condition (58.8% of the total), $425.9 billion of assets in fair condition (19.8% of the total), and $264.7 billion of assets in poor or very poor condition (12.3% of the total). Another $195.7 billion (9.1%) in replacement values were for assets of unknown physical condition' (Statistics Canada, 2023)."

2.3.2 Addressing Uncertainties in Asset Data

The unknown condition status of a sizable portion of assets highlights the urgency of enhancing asset evaluation methodologies for better-informed decision-making. Improving data practices is crucial for resolving uncertainties and ensuring sustainable and resilient infrastructure for the future.

2.3.3 Importance of Maintenance, Reliability, and Master Data

Maintenance management, reliability engineering, and asset master data are integral to a robust asset management system. Maintenance management focuses on planning, scheduling, and executing activities to maintain asset conditions and extend lifespan. Reliability engineering optimizes asset reliability through proactive strategies and performance monitoring. Asset master data, encompassing comprehensive information about assets, is essential for informed decision-making and optimizing asset performance. Leveraging these components is vital to maintaining asset conditions in good or very good states, avoiding reactive maintenance costs, and effective risk management, forming the foundation for proactive and data-driven asset management practices.

2.3.4 Condition Grades

Understanding and standardizing the use of condition grades across the spectrum, from 'Very Poor' to 'Very Good,' is vital in asset management, particularly for entities responsible for maintaining essential infrastructure. While the grades 'Very Poor', 'Poor', and 'Fair' indicate significant deterioration and an urgent need for intervention, the 'Good' and 'Very Good' conditions highlight the positive impact of proactive maintenance strategies.

A 'Very Poor' condition indicates critical deterioration necessitating immediate replacement or significant repair. It suggests a failure in previous maintenance efforts or a lack of timely intervention, emphasizing the urgent need to address safety risks and functional deficiencies.
In 'poor' condition, assets are close to failure, requiring substantial attention soon. This grade is a warning signal for imminent issues, underscoring the importance of timely maintenance to prevent further degradation and more significant problems.

Assets in 'fair' condition indicate significant deterioration is evident and require minor repairs or replacements. This stage is crucial for implementing proactive maintenance to prevent the asset from slipping into a poorer condition, extending its lifespan and maintaining its functionality.

Conversely, assets in 'good' and 'very good' conditions reflect a low risk of failure. 'Good' condition signifies minimal short-term failure risk, needing only minor work. Regular maintenance activities that find and fix problems before they get worse help to achieve this state.

'Very Good' condition indicates that the asset is in excellent health and likely to continue performing. Maintaining this grade involves consistent monitoring, routine maintenance, and strategic planning to ensure the asset remains in peak condition. This will maximize its service life and reduce the need for extensive repairs or replacements.

Proactive maintenance is critical in keeping assets in 'Good' or 'Very Good' condition. This approach involves regular inspections, timely repairs, and predictive maintenance strategies that anticipate and prevent problems before they occur. By embracing proactive maintenance, organizations can significantly reduce the number of assets that deteriorate to 'Fair,' 'Poor,' or 'Very Poor' conditions, thereby optimizing asset performance, extending lifespans, and ensuring safety and reliability. Standardized condition grading, coupled with proactive maintenance, forms the backbone of effective asset management, enabling organizations to allocate resources wisely, minimize downtime, and make informed decisions for long-term asset sustainability.

2.3.5 Condition Grades Explained

Very poor: There is an immediate need to replace most or all assets. Health and safety hazards present a possible risk to public safety, or the asset cannot be serviced or operated without risk to personnel. Major work or replacement is urgently required. The operating asset has less than 10% of its expected service life remaining.

• **Poor:** failure likely and substantial work required in the short term. The asset is barely serviceable. There is no immediate risk to health or safety. The operating asset has less than 40% of its expected service life remaining.

• **Fair:** Significant deterioration is evident; minor components or isolated sections of the asset need replacement or repair now, but the asset is still serviceable and functions safely at an adequate level of service. The operating asset has at least 40% of its expected service life remaining.

• **Good:** acceptable physical condition; minimal short-term failure risk, but potential for deterioration in the long term. Only minor work is required. The operating asset has at least 80% of its expected service life remaining.

• **Very good:** Sound physical condition. The asset is likely to perform adequately. The operating asset has at least 95% of its expected service life remaining.

2.4 Summary

The current state of readiness (MDRR) in Canada, as detailed in the preceding sections, sets the stage for a deeper exploration of the multifaceted challenges and opportunities. The insights gathered from the National Maintenance and Reliability Readiness Survey, along with the technological landscape analysis, underscore a critical need for standardized approaches in asset management systems. This standardization, particularly in technology systems, emerges as a pivotal factor for overcoming data management and system fragmentation barriers. Furthermore, the prevalent reliance on basic tools like Excel, as highlighted in the surveys, prompts further investigation into its impact on the efficiency and effectiveness of current asset management practices. Understanding the limitations and exploring alternatives to such basic tools will be crucial in shaping more robust and resilient asset management strategies.

Moving forward, the subsequent sections will delve into specific areas such as maintenance management frameworks, reliability engineering, and asset data strategies. These explorations aim to provide a comprehensive guide for enhancing asset management practices, ensuring a future of sustainable and resilient infrastructure.

3.1 Maintenance Management Frameworks and Best Practices

3.1.1 The Maintenance Framework, Second Edition

The GFMAM Maintenance Framework, 2nd Edition, serves as a pivotal guideline in the realm of maintenance management, especially for public sector organizations. It offers a holistic and structured approach, integrating sustainable practices and continuous improvement in asset management. This framework is crucial in establishing a comprehensive, standardized approach to maintenance management, thereby enhancing consistency and effectiveness across various asset types. The framework encompasses various elements, such as business requirements, asset acquisition, maintenance tactics, strategy development, resource management, work management, asset performance, data management, and program management. Each element is designed to align maintenance activities with business objectives and organizational needs, ensuring maintenance programs' effectiveness and operational excellence.

This framework outlines essential principles and subject groups:

GFMAM Principles:

- *Life Cycle Value:* Ensure decisions support maximum total life cycle value, balancing costs, revenues, and non-financial benefits like risk and reputation.
- *Risk-Based & Reliability-Focused:* Align maintenance strategies with risk and reliability requirements.
- *Execution:* Focus on disciplined and quality execution of maintenance tasks.
- *Supportive Culture:* Cultivate a leadership and workplace culture supporting maintenance objectives.
- *Continual Improvement:* Develop approaches for continuous maintenance efficiency and effectivenessimprovement.

Maintenance Framework Components:

- *Business Requirements & Organizational Context:* Incorporate business requirements into the strategic asset management plan.

- *Asset Creation & Acquisition:* Include maintenance considerations in the design, procurement, and installation stages.
- *Maintenance Tactics & Task Types:* Focus on both preventive and corrective maintenance, including condition monitoring and functional testing tasks.
- *Asset Maintenance Strategy Development:* Develop strategies based on asset criticality, failure modes, and proactive maintenance interventions.
- *Human & Material Resource Management:* Ensure effective management of human and material resources essential for maintenance.

3.1.2 Setting Up Maintenance Management Structures

Establishing robust maintenance management structures is vital to taking advantage of MDRR. This involves creating dedicated teams or departments responsible for maintenance planning, execution, and monitoring. These teams should have the necessary tools and resources to perform their functions effectively. It also includes developing clear maintenance policies and procedures that align with the municipality's broader asset management strategy and compliance requirements.

3.1.3 Maintenance Planning, Scheduling and Execution

Effective maintenance planning, scheduling, and work execution are crucial for optimizing asset performance and extending its lifespan. This process involves identifying maintenance needs, prioritizing tasks based on risk and impact, and allocating resources efficiently. Maintenance management software and following work order lifecycle processes can streamline efforts while enabling predictive maintenance strategies that can minimize reactive maintenance, which is more costly and less effective.

3.1.4 Enhancing Maintenance Tracking and Optimization

Continuous tracking and optimization of maintenance activities are essential for understanding their effectiveness and identifying areas for improvement. Key performance indicators measuring maintenance costs, downtime, and response times can achieve this. Regular reviews of these metrics can lead to adjustments in maintenance strategies, ensuring they remain aligned with the organization's objectives and changes in asset conditions.

3.2 Reliability Engineering & Predictive Maintenance

3.2.1 Reliability Engineering Principles

Reliability engineering is a critical discipline in asset management, focusing on the probability that an asset will perform its required functions without failure over its intended lifespan. It systematically analyzes asset failures, understands their causes, and implements mitigation strategies. Reliability engineering principles encompass reliability modelling, failure mode and effects analysis, and root cause analysis. By applying these principles, organizations can enhance the reliability and performance of their assets, leading to reduced maintenance costs and improved service levels.

3.2.2 Role of Reliability Engineering in Maintenance Optimization

Integrating reliability engineering into maintenance practices enables the transition from reactive to proactive maintenance strategies. This shift is crucial for optimizing maintenance schedules, reducing unplanned downtime, and extending the lifespan of assets. Reliability engineering provides the analytical foundation to predict when maintenance should be performed based on the likelihood of asset failure. This approach ensures that maintenance activities are more targeted and effective, leading to overall improvements in asset management.

3.2.3 Overview of Predictive Maintenance Techniques

Predictive maintenance, a key component of reliability engineering, involves using data-driven insights to anticipate and prevent asset failures before they occur. Techniques include condition monitoring, using sensors and Internet of Things (IoT) devices, statistical analysis, and machine learning algorithms. These techniques enable the continuous monitoring of asset performance and health, facilitating timely interventions that prevent failures and minimize maintenance costs.

3.2.4 Recommendations for Adoption

To effectively implement reliability engineering and predictive maintenance, organizations should:

- Invest in training for staff in reliability engineering principles and techniques.
- Acquire or upgrade technology systems to support data collection and analysis for predictive maintenance.
- Develop a systematic approach to failure analysis and documentation, integrating findings into maintenance planning.
- Collaborate with industry experts and technology providers to stay updated on best practices and innovations in the field.

3.2.5 Budgeting Considerations for Maintenance Activities

Adopting reliability engineering and predictive maintenance may require upfront investment in training, technology, and process adjustments. However, the long-term savings realized through decreased maintenance costs, increased asset lifespans, and improved service reliability typically outweigh these investments. organizations should consider these practices as strategic investments contributing to the financial and operational sustainability of their asset management programs.

3.3 Asset Data Strategies Across Lifecycle

3.3.1 Significance of Accurate Asset Master Data

Accurate and comprehensive asset master data is the cornerstone of effective asset management. It provides a centralized repository of detailed information about each asset, including its location, condition, maintenance history, and performance metrics. This data is critical for informed decision-making, as it allows for a clear understanding of the asset portfolio and its needs. Accurate master data ensures that maintenance and capital investment decisions are based on reliable information, leading to more effective resource allocation and asset optimization.

3.3.2 Enabling Seamless Sharing of Asset Information

Seamless sharing of asset information across different departments and systems is essential for cohesive asset management. This requires standardized data formats and interoperable systems to communicate and exchange data effectively. Facilitating easy access to and sharing of asset data can improve collaboration, reduce data redundancies, and ensure consistency in decision-making processes.

3.3.3 Recommended Data Management Strategies

Effective data management strategies are vital to maintaining the integrity and utility of asset master data.

- Implement data governance policies to ensure data accuracy, consistency, and security.
- Regularly update and validate asset data to reflect changes in asset conditions and maintenance activities.
- Utilize data management software for standardization and integration across different platforms.
- Train staff in data management best practices to ensure proper handling and utilization of asset data.

3.3.4 Technology Solutions to Enhance Data Utilization

Adopting advanced technology solutions can significantly enhance asset data utilization and analysis. Solutions such as GIS, building information modelling, and asset management information systems provide powerful tools for data visualization, spatial analysis, and lifecycle management. These technologies can help organizations gain deeper insights into their asset portfolios, enabling more strategic and data-driven decision-making.

3.3.5 Recommendations for System Improvements

To address these challenges::

- Conduct a comprehensive review of existing technology systems to identify gaps and opportunities for integration.
- Adopt standardized, enterprise-level asset management software that can be scaled to meet the municipality's needs.
- Invest in training and capacity-building for staff to effectively utilize new technologies.
- Establish a cross-departmental committee to oversee the implementation and maintenance of the new system.
- Pursue opportunities for inter-municipal collaborations to share knowledge, resources, and best practices.

3.4 Asset Performance Management

3.4.1 Importance of Specifying Performance Metrics

Specifying clear and relevant performance metrics is a crucial aspect of asset performance management. These metrics should be aligned with the municipality's service delivery goals and asset management objectives. Performance metrics might include measures of reliability, availability, maintenance responsiveness, and cost-effectiveness. By establishing these metrics, organizations can quantitatively assess how well their assets meet the intended service levels and identify areas for improvement.

3.4.2 Integration with Asset Management Objectives

Asset performance management should be closely integrated with the overall asset management objectives of the municipality. This integration ensures that the performance of assets is not only measured against their operational capabilities but also against how well they contribute to broader strategic goals such as sustainability, community well-being, and economic efficiency. This holistic approach helps balance short-term operational needs with long-term strategic objectives.

3.4.3 Role of Asset Health Monitoring

Asset health monitoring is vital for proactive asset management. This involves regular inspections, condition assessments, and sensor technologies to gather real-time data on asset performance. Monitoring asset health enables organizations to identify potential issues early, reducing the likelihood of unexpected failures and extending the assets' useful life. This proactive approach is more cost-effective than reactive maintenance strategies.

3.4.4 Continuous Improvement Powered by Analytics

Data analytics is what drives continuous improvement in asset performance management. By analyzing performance data, we gain insights into trends, identify potential areas of inefficiency, and identify opportunities for optimization. Advanced analytics, including predictive modelling and machine learning, can further enhance decision-making, allowing for more precise maintenance scheduling, resource allocation, and investment planning.

3.5 Financial Planning for Optimized Maintenance

3.5.1 Adopting Dynamic Forecasting Models

Dynamic forecasting models are essential for effective financial planning to enable timely MDRR. Forecast future maintenance costs during the initial planning stage based on benchmark maintenance costs as a percentage of replacement asset value (MC%RAV). Refine this forecast during the design, acquisition, construction, and commissioning stage with the original equipment manufacturer's proactive resource demands. Dynamic models allow for more precise and adaptable budget forecasting for capital expenditures (CapEx) and operational expenditures (OpEx) by considering variables like inflation rates, fluctuating technology costs, and evolving regulatory requirements.

This method facilitates improved financial decision-making by guaranteeing adequate funds for maintenance tasks while maintaining service quality. Both CapEx and OpEx financial teams must collaborate closely with asset management to explore new possibilities in maintenance budgeting. This includes considering adding MaintEx as a third budget category alongside CapEx and OpEx and consolidating them all under TotEx.

3.5.2 Incorporating Lifecycle Maintenance Costs Early On

It is critical to incorporate lifecycle maintenance costs at the initial stages of asset planning and acquisition. This approach ensures that the financial planning process considers the long-term costs of maintaining, repairing, and eventually replacing assets. By understanding these costs upfront, organizations can make more informed decisions about asset purchases and avoid unexpected future financial burdens. This practice also promotes the selection of assets with a lower total cost of ownership, contributing to overall economic sustainability.

3.5.3 Linking Financial Planning to Policy Objectives

Financial planning for asset maintenance should be closely linked to organizational policy objectives. This alignment ensures that budget allocations for asset maintenance support broader goals such as community development, environmental sustainability, and service quality enhancement. It also helps prioritize maintenance activities based on their impact on these objectives, facilitating a more strategic approach to budgeting.

3.6 Asset and Data Interoperability Improvements

3.6.1 Assessment of Existing Interoperability Challenges

Organizations often face challenges with asset and data interoperability due to the use of disparate systems and varied data formats. These challenges include data sharing between departments, inconsistencies in data quality, and obstacles in integrating new technologies with existing systems. This lack of interoperability can lead to inefficiencies in asset management processes, data duplication, and decision-making.

3.6.2 Improving Data Harmonization

Organizations should focus on data harmonization to address interoperability issues. This involves standardizing data formats, protocols, and terminologies across different systems and departments. Data harmonization facilitates seamless data exchange and integration, enhancing the data's overall quality and usability. It also simplifies the process of adopting new technologies and integrating them into the existing asset management framework.

3.6.3 Recommended Interoperability Strategies

Implementing effective interoperability strategies requires a multi-faceted approach.

- Adopting common data standards and protocols across all municipal departments.
- Investing in middleware solutions that facilitate data integration between disparate systems.
- Establishing cross-departmental teams to oversee data harmonization and integration efforts.
- Engaging with technology providers to ensure new systems are compatible with existing infrastructure.

3.6.4 Technology Enablers

Leveraging technology enablers is key to improving interoperability. Cloud computing, application programming interfaces, and IoT platforms can significantly enhance data and system integration. These technologies facilitate enhanced data sharing, instantaneous data access, and increased scalability of asset management systems.

3.7 Sustainability Considerations

3.7.1 Factoring in Exposure to Climate Change Events

In the context of asset management, it is increasingly important to consider the impact of climate change. Public sector assets are often directly exposed to climate-related events such as flooding, extreme temperatures, and severe storms. These events can significantly affect the performance and lifespan of assets. Therefore, organizations must factor in the potential risks posed by climate change in their asset management planning. This includes assessing the vulnerability of assets to climate events and incorporating resilience-building measures into maintenance and replacement strategies.

3.7.2 Risk Mitigation Strategies

Developing effective risk mitigation strategies for climate change impacts involves several key steps:

- Conducting vulnerability assessments to identify which assets are most at risk.
- Prioritising maintenance and upgrades for these high-risk assets.
- Implementing adaptation measures, such as reinforcing infrastructure or altering designs to withstand extreme weather conditions.
- Regularly reviewing and updating risk assessments to reflect changing climate patterns and emerging best practices.

3.7.3 Evaluating Green Infrastructure Solutions

Green infrastructure solutions represent an innovative approach to enhancing asset sustainability and resilience. These solutions involve using natural or semi-natural systems to deliver infrastructure services, such as stormwater management through green roofs or rain gardens. Green infrastructure can offer multiple benefits, including increased resilience to climate change, enhanced ecological value, and improved community well-being. organizations should evaluate the feasibility and benefits of integrating green infrastructure solutions into their asset management practices.

3.7.4 Circular Economy and Value Retention Processes

Value retention processes refer to activities that aim to extend the service life of products and retain their value within the economic system for longer. This increases economic and environmental sustainability. Government of Canada (2022) Towards a circular economy: value-retention processes describe categories of value retention as follows.

3.7.5 Categories of Value Retention Processes

- *Remanufacturing:* A standardized industrial process that takes place within industrial or factory settings, in which cores are restored to original as-new condition and performance, or better. The remanufacturing process aligns with specific technical specifications, including engineering, quality and testing standards, and typically yields fully warranted products. Firms that provide remanufacturing services to restore used goods to their original working condition are considered producers of remanufactured goods.
- *Comprehensive refurbishment:* Refurbishment within industrial or factory settings, with a high standard and level of refurbishment.

- *Refurbishment:* Modification of an object that is waste or a product to increase or restore its performance and/or functionality or to meet applicable technical standards or regulatory requirements, with the result of making a fully functional product to be used for a purpose that is at least the one that was originally intended.
- *Repair:* Fixing a specified fault in an object that is a waste or a product and/or replacing defective components to make the waste or product a fully functional product to be used for its originally intended purpose.
- *Arranging direct reuse:* The collection, inspection and testing, cleaning and redistribution of a product back into the market under controlled conditions (e.g. a formal business undertaking).

Implementing appropriate value retention processes (VRP) allows asset management leaders to derive more value from infrastructure assets, retain embedded energy and resources, reduce waste, and progress towards circular economy principles. This ties in closely with sustainable asset management practices.

3.8 Review of Regulatory Requirements

3.8.1 Analysis of Alignments and Gaps

Organizations must navigate a complex landscape of regulatory requirements related to asset management. This involves ensuring compliance with local, provincial, and federal regulations that dictate infrastructure maintenance, safety, environmental protection, and financial reporting standards. An in-depth analysis of these regulations is crucial to identify alignments and gaps between current practices and regulatory expectations and to ensure staff are both aware and provisioned to meet their compliance obligations. This analysis would help adjust asset management strategies to not only comply with legal requirements but also adopt best practices in asset management.

3.8.2 Recommendations for Enhancements

Based on the analysis, several recommendations can be made:

- Develop a compliance framework that aligns asset management practices with regulatory requirements.
- Train staff to understand and adhere to relevant regulations.
- Implement regular audits to ensure ongoing compliance and to identify areas for improvement.
- Engage with regulatory bodies to stay informed about upcoming changes and to advocate for regulations that support effective asset management.
- Provide resources to enable staff to meet their compliance obligations.

3.8.3 Forming Collaborative Working Groups for Continuous Improvement "Partnerships for Reliability"

Collaborative working groups involving various municipal departments and stakeholders can be instrumental in addressing compliance obligations, reliability and good practice implementation challenges. These groups could focus on sharing good practices, developing unified responses to regulatory changes, and fostering a culture of continuous improvement in compliance. Collaboration can also extend to national bodies that advocate for regulatory frameworks conducive to efficient and sustainable asset management.

3.9 Summary

The following is a summary of the main aspects of the future state of MDRR:

1. This structured maintenance management framework and best practices are essential for enhancing the longevity and performance of municipal assets. By adopting frameworks like GFMAM, setting up dedicated structures, and leveraging technology for planning and optimization, organizations can significantly improve their maintenance management capabilities. This leads to more effective resource use, reduced costs, and better service delivery to the community.
2. Reliability engineering and predictive maintenance are essential in modern asset management. Implementing these practices can greatly improve asset portfolios' dependability, efficiency, and cost efficiency.
3. Shifting to data-driven, predictive maintenance strategies is a crucial move toward enhancing the resilience and sustainability of municipal infrastructure systems.
4. Asset performance management requires a systematic approach to effectively managing assets by defining performance metrics, aligning them with asset management goals, monitoring asset conditions, and using data analytics for ongoing enhancement. This results in improved service delivery, efficient resource utilization, and increased asset sustainability.
5. Timely financial planning and "right-sizing" the OpEx budget with asset maintenance demands are essential for maintaining assets at their best and can ensure that asset maintenance strategies are financially sustainable by utilizing dynamic forecasting models, addressing lifecycle maintenance costs early, and integrating financial planning with policy objectives. This method enhances maintenance tasks and improves the economic sustainability and operational effectiveness of the municipality in the long run.
6. Enhancing asset and data interoperability is crucial for optimizing asset management; by addressing the existing challenges, focusing on data harmonization, adopting interoperability strategies, and leveraging technology enablers, organizations can enhance their asset management capabilities. This leads to better data-driven decision-making, improved asset utilization, and, ultimately, more effective service delivery to the community.
7. Sustainability considerations, particularly in the face of climate change, are crucial for future-proofing municipal assets. By acknowledging assets' exposure to climate change,

implementing risk mitigation strategies, and evaluating green infrastructure solutions, organizations can enhance their infrastructure's resilience and sustainability.

8. This approach addresses immediate asset management challenges and contributes to the long-term well-being and sustainability of the community.
9. Navigating compliance obligations is a critical aspect of effective asset management for organizations. Conducting thorough analyses of regulatory alignments and gaps, enhancing compliance frameworks, and fostering collaborative working groups can ensure that their asset management practices not only meet legal requirements but also contribute to the overall effectiveness and sustainability of their asset management programs. This approach helps safeguard infrastructure integrity, promote public safety, and ensure responsible stewardship of public assets.

SECTION 4 - BENEFITS OF MASTER DATA AND RESOURCE READINESS

4.1 Value Proposition of MDRR

In an era where asset management is pivotal to organizations' operational success and sustainability, particularly in the public sector, the strategic importance of MDRR cannot be overstated. As infrastructure ages and technological advancements pave the way for more efficient management practices, the shift from traditional reactive maintenance to proactive MDRR becomes increasingly critical.

The core of MDRR. At its heart, MDRR is about anticipating and preparing for maintenance needs in parallel to assets becoming operational, ensuring that they are both operationally and maintenance-ready at the same time. This approach is a departure from the conventional reactive maintenance strategy, where actions are taken post-failure, often leading to escalated costs, service level disruption, and risk exposure.

Broader Implications. Adopting MDRR has implications beyond mere cost savings. It encompasses enhanced asset reliability, operational continuity, risk mitigation, and alignment with broader organizational goals such as environmental sustainability and efficient natural resource utilization. These benefits are crucial not only for individual asset management but also at a national infrastructure level, where the scale of assets and investments significantly amplifies the impact of maintenance strategies.

Objective. Using straightforward financial models, we illustrate the theoretical cost efficiencies of MDRR at different scales and complexity—from individual assets to large-scale public sector infrastructure. These models serve as a logical argument for adopting MDRR practices and highlight their strategic dollar value in long-term asset management.

Through this exploration, we aim to provide a comprehensive understanding of MDRR and its role in modern asset management. We emphasize its potential to transform the way assets are maintained and managed, thereby contributing to the overall efficiency, sustainability, and resilience of organizations that rely on those assets to work, live, and prosper.

Assumptions:

- **Condition Ratings**: This assumes that Statistics Canada's 2022 score card accurately reports condition grades, replacement asset values (RAV), and counts.
- **Proactive maintenance cost**: assumes a 1.0% annual saving over reactive maintenance costs.
- **Asset Lifespan**: Lifespan extension varies based on asset type and usage.
- **Savings Calculation**: Actual results may differ in actual scenarios.
- **Reactive Maintenance**: Assumes Assets are being repaired and not neglected
- **Maintenance Function:** Assumes a certain level of maturity in the Maintenance function to execute proactive and reactive work efficiently and effectively

- **Refurbishment**: Refurbishment is 10% - 20% that of decommissioning and replacement costs.

4.2 Examples of MDRR Benefits

4.2.1 Understanding Reactive Maintenance: A Small-Scale Explanation - Scenario A

What We're Dealing With: We follow a reactive maintenance approach in Scenario A. This means we wait until something fails, causing the asset to stop functioning, before fixing it.
How It Works: Think of this like only taking your car to the mechanic after it breaks down. The car is already out of commission, and now you have to deal with uncertain repair work and costs.

Costs Involved

- **Annual Spend**: Each year, we spend 2.0% of the asset's value (which is $100,000) on repairs after breakdowns. This comes to $2,000 per year.
- **Over 10 Years**: We spend $20,000 on maintenance in a decade. But there's more to it.

What Happens Often

- **Replacements Needed**: Since we don't maintain the asset regularly, it breaks down and has a shorter lifespan than normal. We must replace it twice in 10 years.
- **Extra Costs**: The cost of Disposal, $20,000, plus replacement, adds up to $220,000 over 10 years.

The Bottom Line: When we add up the reactive maintenance, early disposal and replacement costs, we spend a total of $240,000 over 10 years. That's a lot more than proactive maintenance costs!

Why It Matters to You: As a user or stakeholder, this approach can lead to more disruptions. Assets might be unavailable when you need them due to breakdowns or replacements. It also means a larger portion of your budget goes towards fixing and replacing equipment rather than improving or expanding services.

4.2.2 Understanding Proactive Maintenance: A Small-Scale Explanation - Scenario B

What We're Doing: In Scenario B, we adopt a Proactive MDRR approach for managing our assets, such as machinery or equipment.

How It Works: Imagine your asset is worth $100,000. Instead of waiting for it to break down (which happens in reactive maintenance), we regularly check and maintain it. This proactive approach is like taking your car for regular servicing to prevent unexpected breakdowns.

Costs Involved

- **Annual Spend**: Each year, we spend 1.0% of the asset value on maintenance, which amounts to $1,000.
- **Over 10 Years**: Over a decade, our total spending on maintenance adds up to $10,000.

What We Avoid

- **No Replacements Needed**: Unlike the reactive approach, where you might have to replace the machinery entirely when it breaks down, proactive maintenance helps you keep the same machinery running smoothly for at least 10 years. This means you don't have to spend money on decommissioning, disposal and replacement.
- **Lower Costs**: By spending a little each year on maintenance, you avoid the bigger costs of fixing major breakdowns or buying new equipment. It's a bit like how regular oil changes in a car can prevent more expensive engine problems later.

The Bottom Line: Over 10 years, we only spent $10,000 on maintenance without needing to replace the asset. This saves a lot of money and keeps operations running without unexpected interruptions.

Why It's Great for You: As a user of your services or a stakeholder in your organization, this approach means more reliability and less downtime. We ensure that the equipment you rely on is always in top shape, ensuring consistent and efficient service. Plus, it's a smarter way to use our budget, which is good news for everyone involved!

4.2.3 Proactive Maintenance for 'Good' and 'Very Good' Condition Assets: A National Perspective, Scenario C

Overview: When we examine Canada's public infrastructure, we focus on preventing deterioration of assets in 'Good' and 'Very Good' condition. These assets form a significant part of our national infrastructure, and proactive maintenance is key to preserving their state.

Scenario Analysis Based on Statistics Canada 2020 Data

Overview: By targeting Canada's public infrastructure currently in 'Good' and 'Very Good' condition, we aim to preserve these assets, valued at approximately $1.2348 Billion, from declining into less optimal conditions, which lead to reactive maintenance and early replacements.

Proactive Maintenance Strategy

- **Approach**: Implementing regular, preventative maintenance on assets like well-maintained roads and reliable utilities to sustain their high condition ratings.
- **Objective**: Prevent these assets from deteriorating early in their life into 'Fair', 'Poor', or 'Very Poor' conditions, avoiding the increased costs associated with more intensive reactive maintenance and early disposal and replacement.

Financial Implications

- **Investment**: Proactive maintenance involves investing 1.0% of the total value of these assets annually, which is approximately $12.348 billion.
    - **Savings**: Compared to reactive maintenance, which costs 2.0%, proactive maintenance represents a 1.0% reduction in maintenance costs.
    - **Annual Savings**: This 1.0% saving on the total value of 'Good' and 'Very Good' condition assets amounts to $12.348 billion.

Conservative but Essential Logic

- **Why Conservative**: This calculation is intentionally conservative. It assumes only a 1.0% annual saving compared to reactive maintenance.
- This approach is essential for readers who wish to apply this logic with their own numbers, as actual savings could vary based on specific circumstances and asset types.
- **Encouraging Practical Application**: By presenting a conservative estimate, we encourage readers to consider their unique scenarios and calculate potential savings based on their specific infrastructure values and maintenance costs.

Public Benefits

- **Reliable Infrastructure**: Ongoing maintenance ensures uninterrupted public services and reliable infrastructure.
- **Budget Efficiency**: The conservative savings estimate from proactive maintenance allows for a more effective allocation of public funds.
- **Enhanced Safety and Comfort**: Regular upkeep of infrastructure in good condition means safer and more pleasant environments for communities.

Explanatory View

In practical terms, Canada can save significantly on future costs by investing in proactive maintenance for the infrastructure that's already in “very good” and “good” condition ($1.2348 billion worth). This substantial investment is designed to keep these assets functioning optimally and extend their lifespan, avoiding the much larger expenses that would be required if they were allowed to deteriorate.

On the other hand, there's a pressing need to validate the condition and address any deterioration for the $674.1 billion worth of infrastructure that's not in very good or good condition. This might involve more immediate repairs, refurbishment, or even replacement. The key is to manage these assets effectively and early in their lifecycle journey to prevent deterioration at their source while they're less costly to maintain.

This approach underscores the importance of a strategic, data-driven asset management plan that balances proactive MDRR with necessary interventions for assets in poorer condition. It’s a holistic view of maintaining and improving Canada's infrastructure for long-term sustainability and efficiency.

4.3 Environmental Sustainability - Value Retention Processes - Scenario D

Incorporating VRP in public sector asset management is crucial for achieving both environmental sustainability and economic efficiency. This section applies VRP principles to public sector assets, reflecting the findings of the Canadian VRP study and illustrating the dual benefits of cost savings and environmental stewardship.

4.3.1 VRP: Economic and Environmental Imperatives

Value retention processes, including remanufacturing and comprehensive refurbishment, significantly extend the lifecycle of public assets. This approach aligns with circular economy principles and offers notable cost savings while contributing to environmental conservation. VRPs are a vital strategy in sustainable asset management by reducing waste and minimizing new material consumption.

Estimated Financial Data Examples

- Small Scale (Individual Public Asset):
    - **Asset**: Water Plant Pump
        - Costs:
            - Decommissioning and Disposal: $50,000
            - New Pump: $100,000
                - Total Replacement: $150,000
            - VRP Costs:
                - Refurbishment: $15,000 - $30,000 (10.0-20.0% of replacement cost)
    - **Savings**: $120,000 - $135,000
    - **Environmental Benefit**: Resource Conservation and Waste reduction.
- Large Scale (Public Infrastructure):
    - **Asset**: Bridges
        - Costs:
            - Decommissioning and Rebuilding: $5 million
            - New Construction: $10 million
                - Total Replacement: $15 million
            - VRP Costs:
                - Comprehensive Refurbishment: $1.5 million - $3 million (10.0-20.0% of replacement cost)
    - **Savings**: $12 million - $13.5 million
    - **Environmental Benefit**: Lower carbon emissions and preservation of materials and resources.

4.3.2 Applying VRP in Public Sector Asset Management

- **Strategic Assessment**: Identifying which assets are suitable for VRP applications based on their condition and potential for lifecycle extension.
- **Policy Integration**: Aligning VRP initiatives with broader sustainability policies and goals, ensuring that asset management practices contribute to environmental objectives.
- **Training and Education**: Developing and implementing VRP training programs for public sector employees to enhance their skills and understanding of sustainable asset management practices.

4.3.3 Summary

The examples and logic presented in this chapter demonstrate the value of VRP at different scales, from individual assets to large-scale infrastructure. The small-scale example provides a tangible, relatable scenario, while the large-scale example projects this logic nationally, showcasing the potential for significant impact on substantial asset portfolios.

The Canadian Government, Department of Environment and Natural Resources, states "*VRPs offer significant benefits for businesses, Canadians and the environment. According to an Environment and Climate Change Canada study based on 2019 data, VRPs are approximately worth CAD$56 billion annually and support more than 371,000 direct jobs in Canada. According to the same study, each year, VRPs prevent approximately 1.6 million tonnes of carbon dioxide equivalent (CO2e) from entering the atmosphere, and avoid the use of 470 kilotons (kt) of virgin materials - including 74 kt of plastics.*"

Value retention processes represent a strategic approach for public sector organizations to balance operational efficiency with environmental responsibility. The financial examples, based on general principles and typical costs, illustrate the potential for substantial cost savings and environmental benefits. This highlights the importance of VRP in sustainable public sector asset management by combining economic efficiency with environmental stewardship.

4.4 Case Studies Demonstrating Best Practices

Twenty-one case study assignments titled "Maintenance Readiness Process Optimization" were submitted for the course "Leveraging Municipal Asset Master Data and Information for Maintenance and Reliability Readiness". We will provide a broad overview of everything and offer more detailed insights on a few specific topics.

Objectives of the Case Study Assignment:

• Show proficiency in analyzing and optimizing maintenance readiness for an asset.
• Apply risk-based analysis to inform maintenance priorities and strategies.
• Develop targeted data-driven improvements across the asset lifecycle stages.

• Protect confidential municipal information while conveying insights.

4.4.1 General Case Study Overview

The general overview of the 21 case studies captures the main ideas from the course participants' submissions, highlighting a move towards strategic, data-driven, and sustainable asset management practices in different asset classes. Challenges such as data management, resource allocation, technological adaptation, and environmental compliance are identified as key areas for improvement.

Transition to Proactive Maintenance: Submissions strongly emphasize moving from reactive to proactive and predictive maintenance strategies. This shift aims to enhance asset reliability, reduce downtime, and optimize maintenance costs.

*Technological Integration and Data Management***:** Many submissions stress the importance of integrating technology, such as IoT devices and advanced data analytics, to improve maintenance strategies. Efficient data management is seen as crucial for informed decision-making and enhancing the longevity of assets.

Sustainability and Environmental Compliance: A recurring theme is the focus on sustainability practices and ensuring environmental compliance in asset management. This includes considering the environmental impact of maintenance activities and adopting green technologies.

Asset Classes

The submissions cover a wide range of asset classes, including heavy machinery (e.g., bulldozers, motor graders), infrastructure (e.g., roads, bridges, water treatment facilities), community facilities (e.g., HVAC systems in community centres), and marine facilities (e.g., docks). This diversity underscores the broad applicability of maintenance management principles across different sectors.

Problems Solved or Encountered

*Data Management Challenges***:** A common issue identified is the struggle with data management, including the collection, analysis, and use of data for maintenance decision-making.

*Resource Allocation and Training***:** Adequate resource allocation and training for maintenance personnel are highlighted as significant challenges. Proposals include more targeted training programs and strategic resource distribution to ensure maintenance activities are carried out efficiently.

Adapting to New Technologies: The need to adapt to and embrace new technologies for better asset management is emphasized, with some submissions noting the challenge of integrating these technologies into existing systems.

Environmental Risks and Compliance: Addressing environmental risks and ensuring compliance with regulations emerge as critical concerns, especially in light of sustainability goals.

4.4.2 Specific Case Study Overview

The overview of the specific case studies investigates the relationship between organizational obstacles, preventative actions, and asset management results in businesses of varying sizes. This underscores the significance of early adoption of Master Data and Resource Readiness (MDRR) strategies throughout the asset's lifecycle to avert or reduce the occurrence of reactive events. Instances ranging from small communities in Nunavut experiencing crucial water pump system failures to large wastewater treatment facilities in Ontario encountering catastrophic equipment breakdowns underscore the negative consequences of reactive maintenance and the advantages of proactive, data-informed strategies. These specific cases from different organizations highlight particular failures, preventive measures, and consequences, and by doing so, strengthen the case for timely Maintenance resourcing and Readiness.

4.4.2.1 Smaller Organizations

- A small remote community in Nunavut faced challenges maintaining a critical raw water pump system that unexpectedly failed after 10 years of operation. With only one pump remaining, the risk of complete service disruption was high. The failure analysis revealed opportunities to enhance maintenance tactics, asset data, and master data. Key recommendations included implementing a PM program for pump inspection and overhaul, failure mode analysis, and condition monitoring. Despite resource constraints, small investments in maintenance fundamentals can significantly improve outcomes.

4.4.2.2 Mid-sized Organizations

- The failure of a critical sluice gate valve (SGV), leading to the contamination of the Fort McMurray water distribution system, resulted in consequential costs of $8.8 million for decontamination and distribution, highlighting the financial and operational impacts of inadequate maintenance strategies. Before the flood, there were no proactive maintenance tactics for the SGV, and its failure was not anticipated due to a lack of historical data and condition monitoring.

- A second case further underscores the significance of robust maintenance practices. A county in Ontario experienced the premature failure of a road culvert, causing an unexpected long-term closure and $700,000 in emergency repairs. The inspection data was inadequate to predict the rapid deterioration. To prevent such failures, they plan to implement a CMMS system to track detailed asset data like condition history and maintenance records. This will enable data-driven maintenance decisions and the proactive identification of high-risk assets. The case shows that midsized organizations can leverage technology investments to boost infrastructure management capabilities.

The post-event improvements implemented serve as a guide. These include implementing preventative maintenance strategies and ensuring that maintenance activities are properly documented and followed up in their CMMS system. Additionally, this organization conducted risk assessments for asset failure and enhanced maintenance readiness through better data management, resourcing, and training.

By adopting similar strategies earlier and as standard practice through MDRR, organizations can mitigate known and unknown risks and enhance their asset management capabilities, moving towards a more proactive and data-driven maintenance approach.

4.4.4.3 Larger Organizations

- A large wastewater treatment facility in Ontario experienced the failure of a 53-year-old anaerobic digester tank. The catastrophic roof collapse caused over $800,000 in damages and multi-year permit violations. The reactive maintenance approach missed critical monitoring upgrades needed to predict the failure. To advance their maintenance program, they plan to adopt global frameworks like GFMAM, enhance PM tactics, integrate predictive maintenance technologies, and improve asset data practices. The case demonstrates that even large organizations have opportunities to implement strategic asset management improvements.

4.4.5 Summary

These asset failure cases reveal premature and catastrophic breakdowns due to a lack of critical monitoring data and over-reliance on reactive maintenance. Implementing MDRR strategies like robust equipment registries, condition monitoring sensors, predictive maintenance analytics, and even basic work planning and control practices, leading to optimized maintenance tactics, could have helped predict and even prevent these failures.

In this context, it's essential to understand the connection between maintaining conditions established during the design, acquisition, building, and commissioning phases and sustaining proactive maintenance costs, a primary goal of MDRR. In the absence of an efficient MDRR, assets tend to degrade more rapidly into condition grades that entail greater expenses. This phenomenon can be measured by the proportion of increasing MC%RAV.

This correlation illustrates that when asset conditions deteriorate, the corresponding expenses will increase, regardless of whether they are classified as corrective, restorative, or reactive. Proactive costs throughout the asset's lifecycle are classified as standard ownership expenses, whether known or unknown. For various reasons, labour, material, and failure consequence costs will gradually rise as the asset deteriorates.

When the asset condition deteriorates, the extra repair expenses will be added to the proactive costs, leading to a rise in maintenance costs as a percentage of asset value. Figure 4.1 illustrates this concept. The goal is to keep the time between the initial design, acquisition, construction, and commissioning stage and the final decommissioning and disposal stage at an optimal duration, or benchmarked MC%RAV level.

The following graph helps visualize several key perspectives, Lifecycle stages, condition grades, MC%RAV and time while also illustrating the economic principle that investing in regular maintenance during the early stages of an asset's life can mitigate the steeper costs associated with the later stages of its lifecycle.

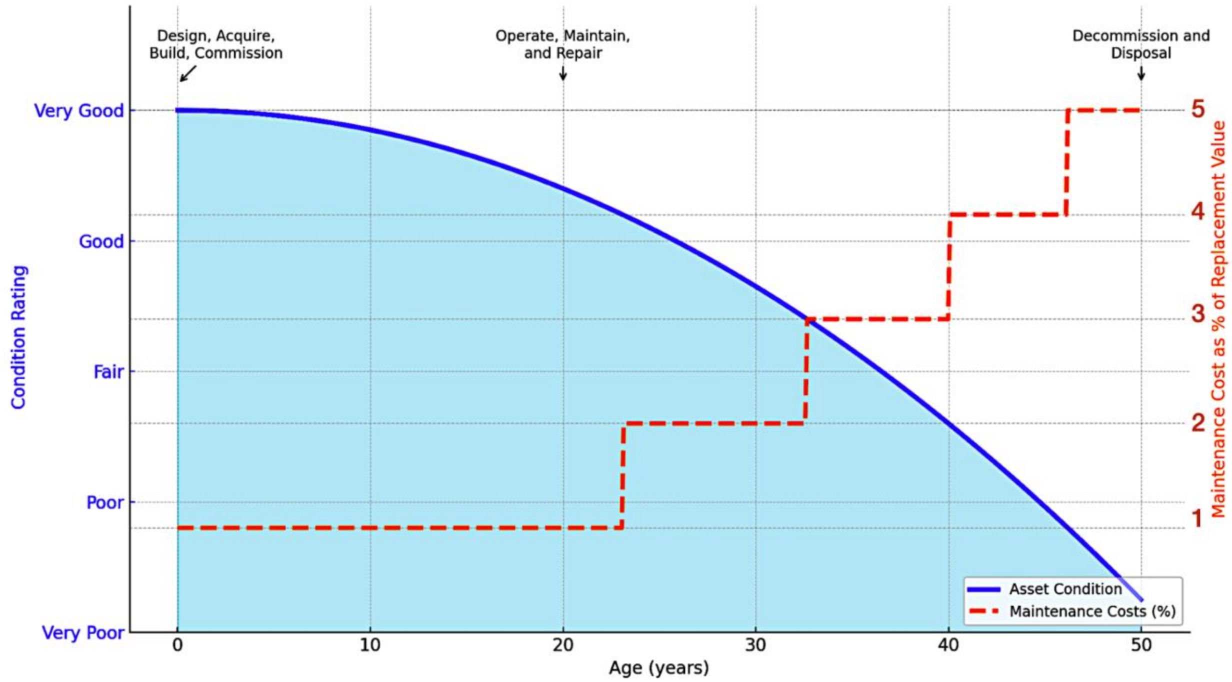

Figure 4.1 Asset lifecycle, condition, maintenance cost relationships

5.1 The Journey to Enhanced MDRR

The journey towards enhanced maintenance and reliability is marked by a critical analysis of current asset management practices within public sector organizations. The National Maintenance and Reliability Survey, along with Infrastructure Condition Statistics, has laid a solid foundation for understanding the gaps in maintenance, reliability engineering, and asset data management. The intended future state aspires to change the public asset management landscape under the guidance of global maintenance management frameworks and improved reliability engineering. A notable shift towards integrating robust asset data strategies and a well-structured financial plan is essential for a sustainable and effective overhaul of the current maintenance management component of the overall asset management system.

5.2 Strategic Implications of Enhanced MDRR

The strategic implications of enhanced MDRR are multifaceted. Adopting innovative strategies will significantly elevate operational efficiency and service quality, with predictive maintenance and sophisticated asset data management playing pivotal roles. Financial sustainability is expected to benefit substantially from these strategies, mainly through a focus on lifecycle costing and optimized long and short-term maintenance budgeting. The holistic approach suggested not only promises considerable cost savings but also ensures that maintenance and replacement costs are managed efficiently throughout the asset's lifecycle. Moreover, the alignment with global best practices and responsiveness to future challenges and regulatory changes mark a significant advancement in the maturity of asset management within Canada.

5.3 The Road Ahead

The path to realizing the full potential of enhanced MDRR is a journey of continuous improvement and adaptation. The dynamic nature of technological advancements necessitates responsive strategies to maintain momentum and realize the initiatives' full potential. Collaboration and knowledge sharing can play a crucial role in maximizing the benefits of these strategies. Collective efforts are expected to drive further innovations and efficiency gains in public asset management. The concluding thoughts emphasize that this business case presents not just a plan for improvement but a comprehensive roadmap to achieve sustainable, efficient, and effective public asset management. The successful implementation of these strategies promises not only to elevate the current state of public infrastructure but also to ensure its resilience and environmental sustainability for future generations.

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To access the accompanying White Paper and Guide, visit:

Easa, S. and Lawlor, P. (2024). *Leveraging municipal asset master data and information for maintenance and reliability readiness: White paper*. PEMAC Asset Management Association of Canada, Mississauga, Ontario, Canada.

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