Practitioner's Guide

LEVERAGING ASSET MASTER DATA ON ACQUISITIONS

(CAPITAL PROJECTS & MAINTENANCE)

A project conducted by
Toronto Metropolitan University and the PEMAC Asset Management Association of Canada

LEVERAGING ASSET MASTER DATA ON ACQUISITIONS

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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 Municipal grants is provided by the 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 practitioner's guide is based on the results of the project entitled *"Leveraging Municipal Asset Master Data and Information for Maintenance and Reliability Readiness."* The project was conducted jointly by Toronto Metropolitan University, the PEMAC Asset Management Association of Canada, and municipal representatives across Canada.

The project aims to influence the acquisition of timely and effective asset master data and information and provisioning of resources for Canadian municipalities to improve their maintenance management programs and readiness. The project involved conducting a national survey of Canadian municipalities, surveying municipalities with success stories, developing/delivering a training course, and developing a white paper, business case, and practitioner's guide. The white paper and business case are presented separately (Easa and Lawlor, 2024; Lawlor and Easa, 2024).

The guide will help municipalities effectively address deteriorated infrastructure and state-of-good repair objectives. According to Statistics Canada (2023), the total replacement values of publicly owned infrastructure in Canada were composed of **$1,267.3B** of assets rated in good or very good condition (58.8%), $425.9B of assets in fair condition (19.8%), $264.7B of assets in poor or very poor condition (12.3%), and $195.7B of assets of unknown physical condition (9.1%). Thus, by investing in proactive maintenance for the infrastructure already in good/very good condition, Canada can significantly save on future costs. On the other hand, for the other infrastructure in fair/poor/very poor condition (**$690.9B**), there is a pressing need to validate the condition and address any deterioration. Specifically, the guide will help municipalities transition from less reactive to more proactive maintenance practices, leverage Master Data and Resource Readiness (MDRR) planning during the asset lifecycle's initial stages, and help municipalities, cities, and towns save high costs in the short, medium, and long term.

The guide reflects the insights gained from a national survey of municipal organizations, their real-world case studies, and several developed sources, including the Federation of Canadian Municipalities (FCM) projects. Thus, it elevates maintenance management (MM) and reliability engineering toward a more integrated asset management (AM) system within public-sector organizations across Canada.

27 organizations across Canada, with populations of about **16.9M,** participated in a **national survey** conducted by the PEMAC Asset Management Association of Canada and Toronto Metropolitan University (TMU). The participants contributed to a body of knowledge that includes a white paper, a business case, and this guide. Additionally, 21 organizations attended two cohorts and six lessons. The course enabled the exchange of ideas, discussions, and

collaboration, ultimately leading to the enhancement of learning, the development of case studies, and a defined learning curriculum.

21 **Case Studies** reveal critical insights into shifting from reactive to proactive maintenance strategies across various asset classes, focusing on data-driven and sustainable practices. Data management, technological adaptation, and environmental compliance are common challenges. Four specific case studies identified costs due to failures exceeding **$9.3M**. Best practices include implementing preventive maintenance, advanced technology and data analytics integration, sustainability considerations, and targeted training.

The guide comprises six chapters, including Introduction (Chapter 1) and Closing Remarks (Chapter 6). Integrating the guide with the FCM's asset management resource library is presented in Appendix 1.

Chapter 2 describes the master data and information types required and made ready for use for effective maintenance and reliability management. These data can vary depending on the asset classes, software system options, and tools an organization utilizes. However, this chapter presents the necessary asset data and information for MDRR in the public sector, serving as the backbone for informed decision-making. MDRR enables organizations to optimize asset performance, minimize downtime, and extend asset lifecycle.

Chapter 3 proposes a system-ready data model for translating multiple data and information sources delivered from the market into a standard that aligns with the organizational system used for AM and MM functions. This chapter discusses several aspects to achieve MDRR, ensuring *"the right data, information, and resources are delivered at the right time."* The data and information ready for use on the asset's first operational day underpin the fundamental capability to record, report, analyze, and manage assets to realize their intended value.

Chapter 4 outlines specific steps toward establishing MDRR capabilities. By following these steps, municipalities can ensure their infrastructure assets are maintained efficiently, reliably, sustainably, and aligned with the best AM practices. These steps are crafted to guide practitioners through a comprehensive self-assessment, AM policy development, financial planning, acquisition criteria definition, post-commissioning handover to maintenance, and growing the capability of maintenance and reliability functions.

Chapter 5 describes the cost and benefits of implementing MDRR. The transition to MDRR entails both initial investments and ongoing operational costs, including costs associated with labour, materials, technology adoption, training, and the integration of new systems into existing infrastructure. However, the long-term benefits regarding operational efficiency, cost savings, and improved service delivery are substantial. The guide outlines several significant advantages of implementing MDRR, including circular economy and proactive maintenance as financial levers, initial investments, long-term benefits, and strategic benefits.

ACKNOWLEDGEMENTS

This initiative is offered through the Municipal Asset Management Program, delivered by the Federation of Canadian Municipalities, and funded by the Government of Canada. The project received valuable input from the subject-matter experts and staff of the PEMAC Asset Management Association of Canada and Toronto Metropolitan University (TMU). Several professionals taught the training course, doing an excellent job of developing and delivering the course material. The authors express their most profound appreciation and gratitude to all.

We are also grateful to Dr. Elsayed Elbeshbishy (Co-I) for his timely and tremendous project support. In addition, his TMU research associates (Mohamed Abdelsaei and Abir Hamzeh) provided significant technical help for the online survey and the training course. Special thanks to Nicolle Guillen, PEMAC Education and Professional Development Manager, for her time and commitment to all aspects of the project. We greatly appreciate her diligence and remarkable support. We are also incredibly grateful to Cindy Snedden, PEMAC Executive Director, for her thoughtful and insightful comments on the guide draft.

Finally, the authors would like to recognize the efforts of the 71 municipal professionals who participated in the online survey, providing invaluable data and insights on their current asset management practices. We also extend our deepest gratitude to all the municipalities and their representatives who generously shared their time, experiences, and insights for the targeted success stories survey. Their stories and expertise have not only enriched this guide but also stand to benefit other organizations striving for excellence in maintenance and reliability readiness. Further, the authors recognize the 47 participants in the training course (representing 21 municipalities) who took the training course, participated in the lively discussion, and provided valuable input in the course's case studies and assignments.

GLOSSARY OF ABBREVIATIONS

AM	Asset Management
AMO	Association of Municipalities of Ontario
BOM	Bill of Material
CapEx	Capital Expenditure
CMMS	Computerised Maintenance Management System
CO2e	Carbon Dioxide Equivalent
DABC	Design, Acquire, Build and Commission
FCM	Federation of Canadian Municipalities
GIS	Geographic Information System
IoT	Internet of Things
kt	Kiloton
MAMP	Municipal Asset Management Program
MC%RAV	Maintenance Costs as a Percentage of Replacement Asset Value
MDRR	Master Data and Resource Readiness (data refers to both data and information)
MTBF	Mean Time Between Failure
MTBWAR	Mean Time Between Whole Asset Replacement
MTTR	Mean Time to Repair
OEM	Original Equipment Manufacturer
OpEx	Operating Expenditure
PEMAC	PEMAC Asset Management Association of Canada
RFP	Request for Proposal
TMU	Toronto Metropolitan University
VRP	Value Retention Process

1. INTRODUCTION

MASTER DATA AND RESOURCE READINESS

"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."

The project journey, depicted in Figure 1.1, from the national survey stage toward the educate, collaborate, and grow stage took the team 15 months. This effort resulted in the development of a training curriculum, white paper, business case, and guide, defining the "what," "why," and "how" Master Data and Resource Readiness (MDRR) can support public sector asset management and long-range infrastructure objectives. MDRR strengthens and enables asset value realization at the lowest cost and risk ratio in an asset's lifecycle. It considers the essential information and resources required to support all phases of an asset's life cycle, focusing on the maintenance function within the 'operate & maintain' lifecycle stage, inputs and outputs thereof. Information and data, attributes, and the discrete data fields that support practical analysis and reporting, while resources consider maintenance labour, material, systems, training, and the timely provision of budgets that "rightsize" the maintenance capability relative to the maintainable infrastructure.

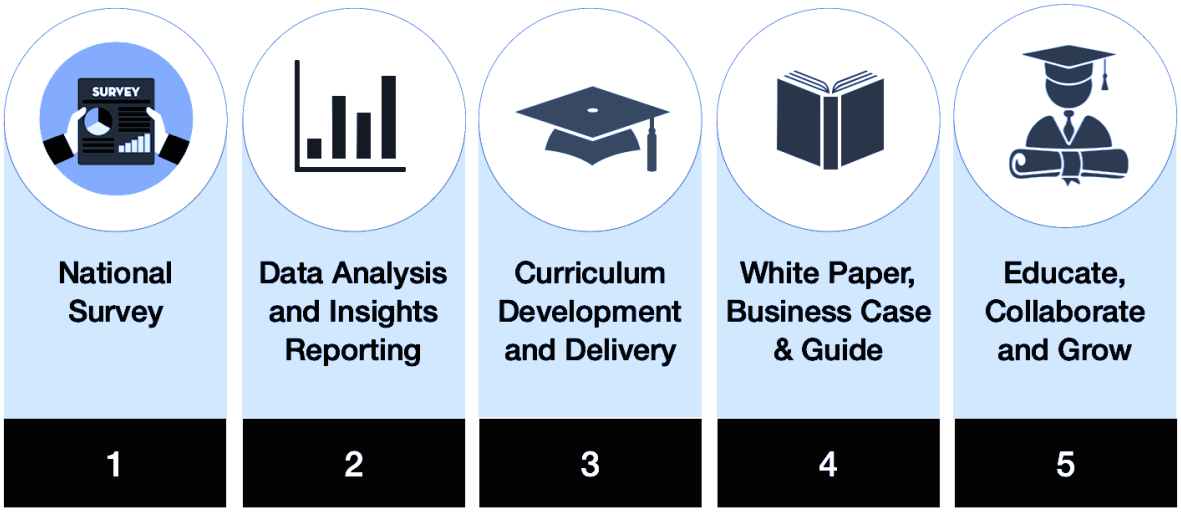

FIGURE 1.1. PROJECT STAGES

This *Practitioner's Guide: Leveraging Asset Master Data on Acquisitions (Capital Projects, Maintenance)* represents the culmination of a multipart set of documents designed to transform the approach toward utilizing maintenance management practices within Canadian public sector organizations. As the third and final instalment, referencing business case and white paper

findings, this guide applies the insights from the research, discussions, surveys, analysis, and SME insights that place a capstone on the final project deliverables.

The guide builds upon the insights of the white paper, which details the current state of practices, and the business case, which outlines the economic and strategic rationale for adopting master data and resource readiness for maintenance management and reliability engineering. Both sources offer extensive knowledge for organizations to confidently execute the recommendations, with a focus on established practices, financial allocation, and the precise definition of asset master data and information requirements.

The core principle of this work effort is to promote that assets are made both operational and maintenance ready simultaneously, thereby preventing accelerated deterioration at the most opportune moment. Organizations that aim to establish master data and resource readiness for maintenance management and reliability engineering can expect several positive outcomes. These include achieving value deliverables as described in the GFMAM Maintenance Framework (second edition), improving the Meantime Between Whole Asset Replacement (MTBWAR) and Circular economy outcomes.

The lifecycle stages for public sector organizations (Fig. 1.2) were adapted from the Maintenance Framework Second Edition (2021), which describes the Major Asset Life Cycle Stages in Physical Asset Management. MTBWAR (Mean Time Between Whole Asset Replacement) is a metric to measure the effectiveness of an organization's overall asset management strategy, specifically for state-of-good-repair programs. The core idea is that by implementing effective asset management practices, including maintenance, reliability engineering, and proactive strategies, organizations can extend the time between instances where an entire asset needs to be replaced due to deterioration. Measuring MTBWAR allows organizations to track how well their asset management approach is performing in terms of prolonging the useful life of assets and avoiding premature replacements.

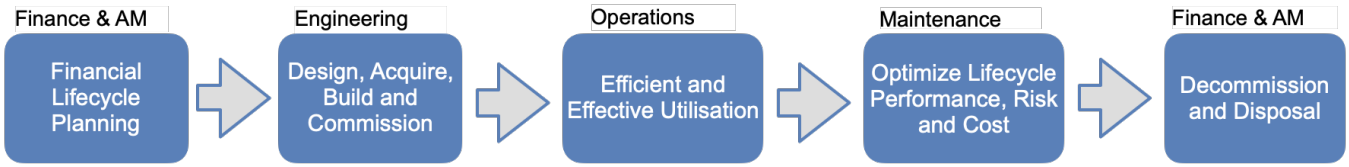

FIGURE 1.2. PUBLIC SECTOR ASSET LIFECYCLE STAGES – MODIFIED FROM GFMAM (2021)

"The guide includes contextual summaries of the white paper and business case in addition to the cost and benefits, technical criteria for the request for proposals (RFP) and recommended steps toward establishing Master Data and Resource Readiness (MDRR)."

2. TYPES OF DATA AND INFORMATION

The types of master data and information collected and made ready for use for effective maintenance and reliability management can vary depending on the asset classes, software system options, and tools an organization uses. However, specific fundamental categories of asset data serve as the backbone for informed decision-making, enabling public sector organizations to optimize asset performance, minimize downtime, and extend the asset lifecycle.

The following summary outlines a sample of the essential types of master data and information designed to support these core functions in public infrastructure management. While specific data fields and formats may differ across platforms, this overview provides a baseline understanding of the critical data and information. We recommend ISO 8000 for a detailed view of master data quality.

"ISO 8000 is the global standard for Data Quality and Enterprise Master Data. It describes the features and defines the requirements for standard exchange of Master Data among business partners. It establishes the concept of Portability as a requirement for Enterprise Master Data, and the concept that true Enterprise Master Data is unique to each organization." Also, *"ISO 8000-8 identifies that data have syntactic (format), semantic (meaning) and pragmatic (usefulness) characteristics."*

2.1 MASTER DATA - REQUIRED BEFORE 'OPERATE & MAINTAIN' LIFECYCLE STAGE BEGINS

This sample of comprehensive setup data is crucial for initial entry and planning in maintenance management systems:

- ***As-Built and Other Drawings:*** Detailed construction drawings that serve as a precise reference for the design, configuration, and modifications made to the asset over time. These drawings include schematics, layouts, and as-built documentation.
- ***Geographic Locations:*** The utilization of GIS technology aids in the precise location of assets, which is essential for strategic placement, effective deployment, and prompt response to emergencies or maintenance needs.
- ***Asset and Material Attributes and Specifications:*** Detailed descriptions of assets and materials, including type, size, capacity, brand, model, unique identifiers, and counts, are essential for precision in maintenance planning and management.

- ***Asset Criticality:*** Data on the relative criticality of assets, based on factors such as the consequence of failure, enables risk-based prioritization of maintenance activities to effectively manage the likelihood of failure.
- ***Financial Information:*** Detailed cost centre and cost element settlement rules so that work on assets and their costs settle correctly for reporting purposes, in addition to records of initial acquisition costs and depreciation configurations.
- ***OEM Maintenance Specifications:*** Tactics, task details, instructions, and planning information in a system-ready format to enable proactive work to be scheduled on day one.
- ***Inspection and Test Protocols:*** Initial inspection requirements and routine testing protocols are necessary to establish effective maintenance schedules.
- ***Compliance and Warranty Information:*** Documentation of compliance with regulatory standards and warranty coverage details, crucial for risk management and ensuring assets meet all legal and operational requirements.
- ***Initial Parts and Inventory Details:*** A catalogue of the initial parts and materials required for maintenance, including bills of materials and inventory and initial inventory levels.
- ***Vendor and Contract Details:*** Information on manufacturers, service providers, warranty agreements, and initial maintenance contracts, facilitating efficient management of external resources and compliance with service level agreements.
- **Labour Skills and Certifications Required:** Identification of the technical skills, certifications, or qualifications required to maintain and repair the asset. This ensures the right personnel are assigned or trained at the right time.

2.2 Data and Information - Captured during 'Operate & Maintain' Lifecycle Stage

This sample of dynamic data and information are collected throughout the asset's operation and maintenance lifecycle for ongoing management and optimization:

- **Maintenance Labour Records:** Detailed records of the labour hours spent on maintenance activities, repairs, and inspections. This includes personnel identification, roles, and specific tasks performed.
- **Cost of Labour:** Tracking the direct labour costs of maintaining each asset, including hourly rates, overtime, and contractor expenses. This data is crucial for budgeting and financial analysis.
- **Workforce Planning and Scheduling:** Dynamic scheduling of maintenance activities based on labour availability, skill requirements, and asset criticality. This includes planning for shifts, rotations, and emergency response teams.

- **Safety and Compliance Records:** Documentation of safety training, adherence to occupational health and safety standards, and any incidents or near-misses involving maintenance personnel. Ensuring worker safety is a critical component of labour management.
- **Labour Feedback and Insights:** Collection of feedback from maintenance personnel regarding asset conditions, potential improvements, and challenges faced during maintenance tasks. This firsthand information can be invaluable for continuous improvement and reliability engineering efforts.
- **Operational Conditions:** Monitoring the current state and performance levels of assets to prioritize maintenance tasks and predict potential failures, thereby preventing costly downtime.
- ***Maintenance and Historical Records:*** A chronological record of all maintenance activities, repairs, and inspections stored in CMMS, providing a comprehensive history that aids in predictive maintenance and lifecycle management strategies.
- ***Asset Condition Assessments:*** Periodic evaluations of asset condition, including defect data and remaining useful life estimates, inform maintenance planning and capital renewal decisions.
- ***Asset Connectivity and IoT Data:*** For assets with embedded sensors or IoT capabilities, real-time data on performance parameters enables condition-based monitoring and predictive maintenance strategies.
- ***Updated Financial Information:*** Continuous tracking of ongoing maintenance expenses and adjustments to depreciation rates based on asset performance and condition.
- ***Material - Parts and Inventory:*** Dynamic tracking of parts usage, reorder points, and inventory levels to ensure maintenance readiness, minimize downtime, and optimize stock levels.

3. MDRR - System Ready Data Model

System-ready data modelling is a process of translating multiple data and information sources delivered from the market into a standard that aligns with the organizational system used for AM and MM functions. Fundamental to this, is the need to achieve data and information readiness before assets are operational, so multiple factors must be considered when seeking to achieve Master Data and Resource Readiness (MDRR); they are “the right data, information, and resources, delivered at the right time.”

The requirement for data and information ready for use on the first day that assets are operational underpins the fundamental capability to record, report, analyze, and manage assets to realize their intended value.

3.1 System Readiness Considerations

Data and information readiness, on its own, can be considered challenging for public sector organizations, the WP and BC provide insights into the scale of variation of systems used across a large sample set. Additional interpretation of the survey data reveals there is no national effort to influence the choices organizations make toward harmonizing AM and MM data and information requirements. The following business case data summaries help us tell a story about the scale of variation found, explicitly focusing on the current state of management tools, master data collection, and storage.

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 listed in total.

How Master data is collected

- ***Data Summary:*** Organizations 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%

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.

3.2 Proposed Data Funnelling Model

National survey findings necessitate the development of innovative approaches that will enable data and information readiness, and approaches will differ from organization to organization. This guide introduces the core concept of *"data funnelling"* as a means of developing the optimum approach based on the organization's unique circumstances. The variety of vendors, products, and media available impedes the effective utilization of OEM data and information that is directly received. However, as data and Information become recognized as critical "data as an asset," the reduction of variation through federal and market harmonization can be anticipated. Until then, alternative methods should be explored, developed, shared, and adopted.

"Data funnelling translates market data and information into a system-ready state."

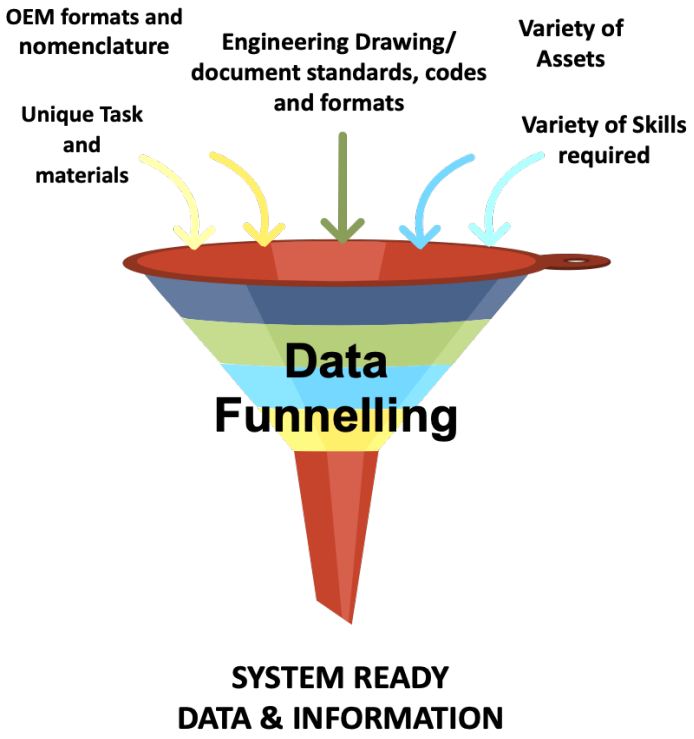

Figure 3.1 Data funnelling model

3.3 Opportunities for Improvement

This section suggests multiple paths toward overcoming the challenges posed by system diversity. It aims to unify asset data and information management practices, configuration, and improved decision-making. By navigating these proposed strategies, organizations can find unique opportunities to contribute to more standardized and efficient national standards.

Understanding the Basics of Data Funnelling

- *Objective:* standardize asset data and information delivery to end users.
- *Key Stakeholders:* Public sector organizations and staff, regulators, consultants, system engineers, and market partners.

Provincial/National Level

- *Standardization Efforts:* Encourage regulators or collective PS organizations to influence the market for standard data and information delivery.
- *Software Systems:* Adopt standard software systems and/or common data fields to utilize standard asset data and information.
- *Maintenance and Reliability Practices:* Embrace standard maintenance management and reliability engineering practices.

Single/Group organizational Level

- *Market Influence:* Persuade the market to provide standard data and information aligning with common system architectures.
- *Middleware utilization:* Employ consultants/systems to collate market data and translate it into the architecture used by specific PS organizations.
- *Commissioning as a Resource:* utilize PS staff and middleware for data translation and integration into specific PS organizational architectures.
- *Collaboration and Trials:* Work with organizational partners to research and trial optimal approaches.

Bridging the Gap

- *Collaborative Partnerships:* Build maintenance capability through grassroots collaboration and partnerships.
- *Community of Practice:* Form partnerships across public sector organizations to support learning and development in maintenance management and reliability engineering.
- *Regulatory Lobbying:* Advocate for asset management regulation changes encompassing maintenance and reliability readiness.

4. Steps Toward Establishing MDRR

Embarking on the journey toward establishing Master Data and Resource Readiness (MDRR) is pivotal for organizations aiming to optimize their asset management practices. This chapter outlines steps toward establishing MDRR capabilities. By following these guidelines, organizations can ensure their infrastructure assets are maintained efficiently, reliably, and sustainably, aligning with good practices in maintenance management. These steps are crafted to guide practitioners through a comprehensive self-assessment, policy development, financial planning, and leveraging technology to achieve a state of preparedness for maintaining and enhancing the reliability of assets.

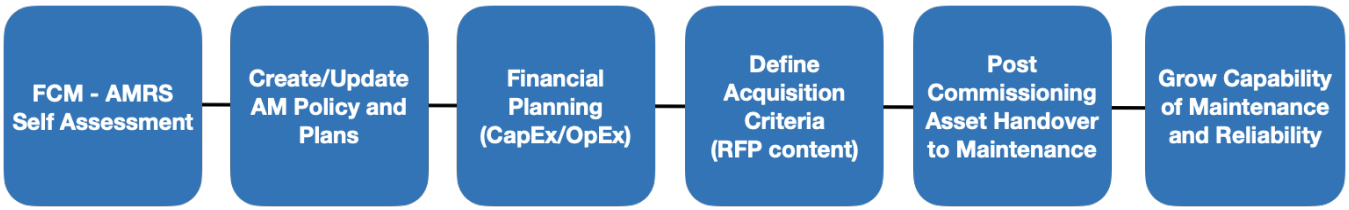

Figure 4.1 Stages of MDRR establishment

4.1 FCM - Asset Management Readiness Scale (AMRS) Self-assessment

The Readiness Scale is a comprehensive tool designed to benchmark your current maturity and enhance the management of assets within your public sector organization. It offers a multifaceted approach by enabling you to:

- Evaluate Existing Practices: Conduct a thorough assessment of your current asset management strategies, establish a benchmark, and understand areas of improvement.
- Opportunities for Enhancement: Identify potential for adopting innovative practices or integrating informal activities into formal, documented business processes.
- Track and Measure Progress: utilize the scale as a benchmark to monitor and measure the evolution of your asset management practices over time.

Crafted with the needs of staff and elected officials in mind, the readiness scale caters to municipalities and local government organizations across Canada. It provides a structured

framework to guide your efforts toward refining asset management practices, ensuring more efficient and effective utilization of assets within your organization.

For detailed guidance and to incorporate this tool into your municipal operations, access the Readiness Scale through the following link: [Tool: Asset management readiness scale | Federation of Canadian Municipalities (fcm.ca)].

This resource promises to be invaluable in optimizing asset management practices. It offers a clear path for continuous improvement and strategic development.

4.2 CREATE/UPDATE AM POLICY, PLANS, AND MATURITY

The Infrastructure for Jobs and Prosperity Act of 2015 establishes the requirement for asset management planning for municipal infrastructure under Ontario Regulation 588/17. This regulation, the only such regulation in Canada in the Province of Ontario, requires municipalities to prepare an asset management policy and a plan that includes their current and future lifecycle strategies to maintain service levels for municipalities. It is imperative to ensure that lifecycle considerations for maintenance management are included in both the asset management plan and that the direction of the maintenance function is aligned with maintenance management best practices.

Establishing a clear line of sight between the policy's maintenance and asset management plans ensures a coherent and integrated approach to managing infrastructure assets. Every maintenance decision aligns with broader organizational goals and strategies. This alignment ensures that resources are allocated efficiently, and maintenance activities contribute directly to asset longevity and performance. Ultimately, the organizations infrastructure effectively supports its service delivery objectives throughout the entire lifecycle.

Across all other provinces in Canada, asset management maturity has advanced to various levels, not through regulations as in Ontario but through the application of best practices that municipalities have been learning, developing, and implementing through ongoing efforts with internal champions and support from service providers. These include consultants, many not-for-profit organizations across Canada beyond FCM, and AM training partners too numerous to mention; see **Asset Management Training Partners | Federation of Canadian Municipalities (fcm.ca)**. In addition, advancement in AM maturity has been enabled through many infrastructure grants at both the Federal and Provincial levels.

4.3 Financial Planning (CapEx & OpEx)

There's a call for the inclusion of multi-stage life cycle costing and maintenance budgeting so that long-range forecasts for new assets include projected maintenance costs, and later, when assets are known, the actual costs for budget allocation are confirmed. This multi-stage approach ensures that both the CapEx and OpEx financial teams are in communication and can provision the resources necessary for MDRR.

- **CapEx Investments**: These are pivotal at the inception of acquiring new assets, covering up-front costs such as purchasing, installing, and ensuring that new infrastructure is accompanied by comprehensive maintenance readiness. This proactive approach not only facilitates the seamless integration of assets into municipal operations but also sets the stage for optimal maintenance and reliability from day one. The timing of Capex planning is typically years ahead of actual procurements. Therefore, it necessitates using benchmarked maintenance costs as a percentage of replacement asset value (MC%RAV) as a forecasting approach. The exact percentage benchmarked will differ by asset class and type. A recommendation is to set the initial target between .5% - 1% initially and refine over time based on actual expenditure.
- **OpEx Budgeting**: Conversely, OpEx is essential for the ongoing execution of maintenance activities. It encompasses regular and predictive maintenance tasks that ensure assets remain operational and efficient over their lifespan. Strategic OpEx planning enables effective resource allocation, ensuring maintenance tasks are well-planned, scheduled, and executed, thus minimizing downtime and extending asset longevity.

Rationale: This early-stage estimation is crucial for initiating long-range financial planning, mainly when detailed specifics of the assets are yet to be determined. It serves as a preliminary financial projection that aids in preparing for the costs associated with maintaining new and existing assets.

Benefits: Until Asset Management practices are ingrained in the organization, operational Expenditure (OPEX) finance teams may not always be fully informed about the impending costs stemming from new capital developments. By projecting potential cost increases early, the OPEX budgeting process can be adjusted proactively to accommodate the needs of the assets. This anticipatory approach helps mitigate negative financial variances. It supports the overarching Maintenance, Repair, and Overhaul (MRO) objectives by ensuring sufficient funding

is allocated to maintain asset health and functionality. Figure 4.2 shows the forecasting and discovery of actual costs relative to the lifecycle stages of the asset.

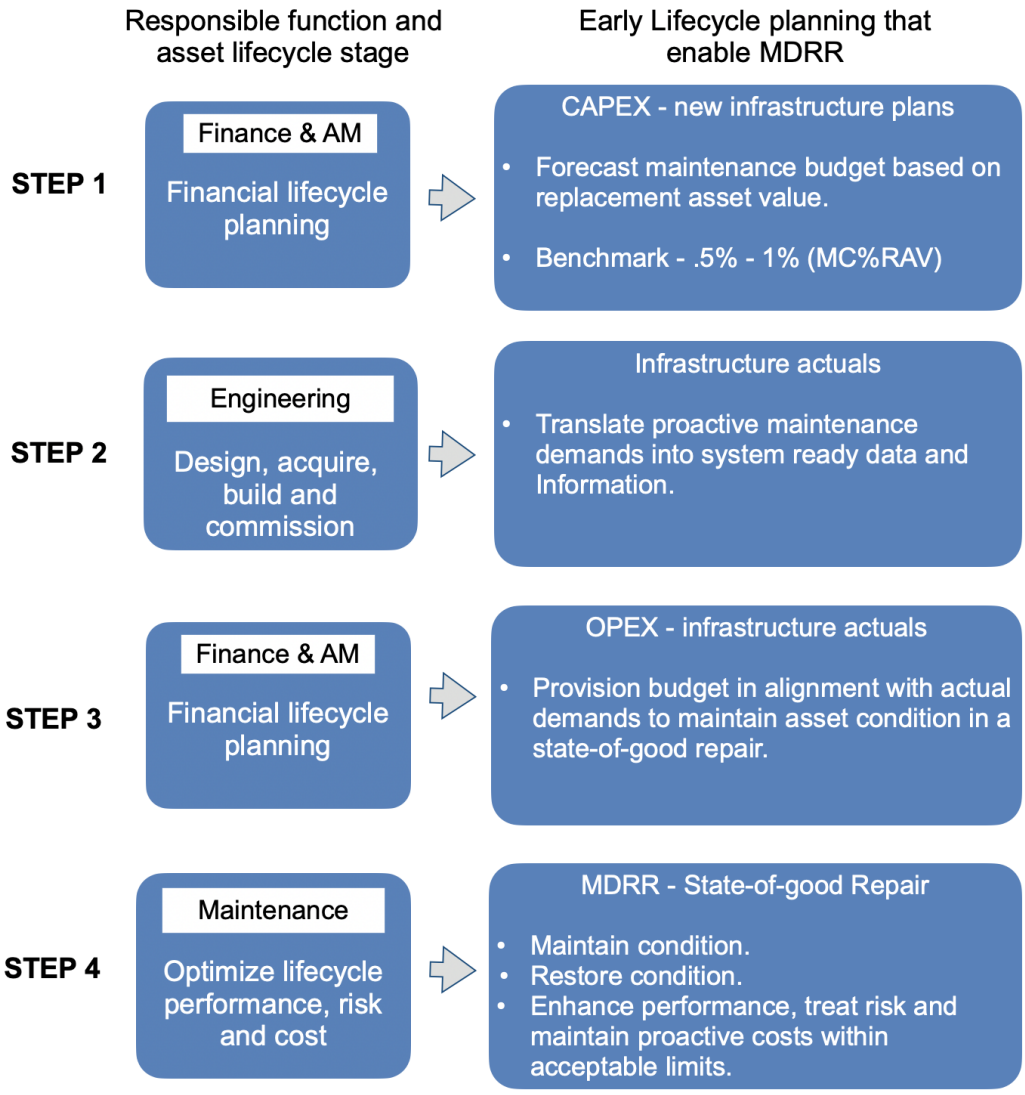

FIGURE 4.2. MULTI-STAGE FINANCIAL ENABLING OF MDRR

4.4 DEFINE ACQUISITION CRITERIA (RFP CONTENT)

Incorporating detailed OEM master data (asset and material) deliverables into RFPs and work agreements for new infrastructure and equipment is crucial for ensuring the maintenance function is adequately provisioned from the design, acquisition, build, and commission stages. This section outlines a structured approach to drafting RFPs and agreements, focusing on precise data specifications, adherence to standards, and ensuring data is system-ready and

resources are defined for maintenance and reliability functions. This is a complex area of business and requires innovative solutions that match the systems, process and capability of recipient organizations.

There is no one size fits all approach to the challenge of “data funnelling” and system readiness of maintenance deliverables. However, we recommend the following staged approach, successfully progressing toward a final outcome, MDRR:

1. *Design and Drawings:* Design drawings that include equipment data enable assets to be created in management systems at the design stage (e.g., type of equipment) and parent/child relationship will enable the creation of the asset hierarchy. This will enable work orders and warranty tracking to begin without delay, laying the foundation for stage 2 and 3.
2. *Asset Selection:* When actual equipment make/models are selected, transfer static master data directly into the system for each asset type setup in stage 1, this will enable sorting of assets and prioritisation for care plan implementations.
3. *Data funnelling:* Adapt, adopt, or copy original equipment manufacturer labour and material requirements for proactive maintenance (care plans), and configure the system to begin scheduling proactive PM or PdM work. This stage will enable financial accuracy for opex financial planning and ensure maintenance activities required to ensure warranty and MDRR.

Public Services and Procurement Canada provides good oversight on the many areas of an RFP that are critical to a quality procurement process, this guide will highlight some of the technical criteria that should be considered.

4.4.1 Specifying OEM Master Data Requirements

- *Drawings:* Drawing nomenclature and design specifications provide the foundational master data for identifying asset hierarchy and asset type. Establishing a robust format for drawings that supports the configuration of systems used by maintenance is critically important. Without the ability to build essential asset hierarchies during the design, acquire, build, and commission lifecycle stage, maintenance work, planning, and monitoring activities cannot be started.

- *Asset and Material:* Each asset class has the optimum master data requirements that will be unique, Chapter 2. The types of master data and information provide insights into a range of master data types that may be applicable. To ensure the accuracy of master data, an intake process and systems should be developed to ensure the master data required for the specific asset class is provided to bidders, consultants, and constructors as it applies. The intake system should mirror your system application so that the transfer can

be automated, it is anticipated that the public sector organization will not allow direct access to their systems, necessitating middleware solutions or services to translate equipment data into the system-ready format required.

- *Technical Specifications and Equipment Manuals:* Essential documents, including operation manuals, equipment manuals, instructions, and service schedules, should be specified to understand the asset's operational parameters.

- *Parts Lists (Bills of Material) and Material Specifications:* Detailed listings of all parts and consumables, ensuring procurement and inventory management align with maintenance needs. Known as the bill of material (BOM), these are all the items that “can be procured” versus the inventory, which are the items from the BOM that “should be purchased.” BOM data is critical to enable the purchase of both inventory (stock items) and non-inventory (non-stock).

- *Warranty Information*: Detailed warranty terms for both projects and equipment, and procedures are vital for effectively managing maintenance within the warranty period. It is to be expected that the likelihood of asset failure is highest after initial startup. Therefore, it is important to have equipment warranty rules in place to deal with anticipated failures during this time. Warranty master data also enables maintenance teams to allocate costs and communicate effectively with vendors during this time.

- *Inspection and Test Protocols:* Initial inspection requirements and routine testing protocols are necessary to establish effective maintenance schedules.

- *OEM Maintenance Specifications:* Tactics, Task details, instructions, and planning information in a system-ready format to enable proactive work to be scheduled on day one.

4.4.2 RFP AND CONTRACT DRAFTING GUIDANCE

- *Explicit Data Requirements:* Clearly outline the expected OEM master data in RFPs, using language that specifies the scope and detail of information required.

- *Delivery Milestones and Staged Payments:* Develop language and staged payment plans for the release of deliverables at specific times in the project, this is to ensure the timely delivery of key data and information, without which MDRR will not be possible.

- *Adherence to Standards:* Specify the need for compliance with recognized data and management standards, such as ISO 55000 for asset management and ISO 8000 for data quality, ensuring consistency and interoperability of data across systems. Additional Standards that may apply are ISO 14224 (Development of asset hierarchies), ISO 31000

(Risk Management), ISO 9001 (Quality Management), SAE JA1011 Standard (Reliability-Centred Maintenance (RCM)), and, ISO 13374 (Condition Monitoring & Machine Diagrams)

- *Delivery Schedule and Format:* Define a timeline for data delivery that matches project milestones.
- *Quality Assurance Measures:* Establish criteria for data accuracy and completeness, including provisions for corrections or additional information if initial submissions do not meet the specified standards.
- *Integration Testing:* Require testing to confirm that the provided data integrates with the organization's asset management system and supports maintenance planning and execution processes.

4.4.3 Utilizing External Resources

- *RFP Writing Resources:* Incorporate guidelines from authoritative sources on RFP development, such as the Government of Canada's Advice on RFP Development, to ensure comprehensive and practical procurement documents.
- *Training and Capacity Building:* Encourage training for staff on the latest best practices in RFP drafting and contract management, emphasising the incorporation of asset data requirements. This may involve workshops, webinars, or collaboration with organizations like FCM to enhance skills and knowledge.
- *Utilizing FCM Resources and Survey Insights for RFP Development:* This section integrates the comprehensive resources provided by the FCM and the actionable insights garnered from national surveys. It outlines methodologies for leveraging these assets in RFP development. It emphasizes the application of standardized frameworks and checklists to articulate precise, measurable data transfer requirements. By aligning procurement processes with established best practices and data standards, municipalities can significantly enhance the quality and utility of asset master data received, underpinning robust asset management practices.

4.5 Post-Commissioning Handover to Maintenance

The successful handover and validation of maintenance-ready infrastructure requires a systematic approach to ensure all assets are ready for maintenance work to be planned, scheduled, and executed from day one. This section outlines the key steps and considerations

when validating the provision of equipment and material master data and information. In addition, financial and resource considerations are also considered.

4.5.1 Validation and Maintenance Readiness

- *Master Data and Information Validation:* Review and validate critical asset data, information, and maintenance plans from the beginning.
- *Maintenance Readiness:* Ensure preparedness to execute commissioned requirements effectively.

4.5.2 Key Asset Data and Maintenance Plans for Validation

- *Asset Register:* Establish a comprehensive asset register that reflects the parent-child hierarchy of assets for cost roll-up and effective maintenance management. This register should be validated for accuracy and completeness during the handover process.
- *Asset Master Data:* Validate asset master data, including but not limited to make, model, serial number, and installation date. Ensuring the accuracy of this data is foundational for effective maintenance and operational efficiency.
- *Maintenance Plans:* Review and validate preventive maintenance plans, including tasks, frequencies, and procedures. This ensures a proactive maintenance strategy, reducing the likelihood of unplanned downtime and extending the asset's life.
- *Spare Parts:* Confirm the availability and recommended inventory quantities of spare parts, along with storage requirements. This preparation prevents maintenance activities from being delayed due to a lack of necessary parts.
- *Warranties:* Understand and document warranty terms, including defect coverage, exclusions, and the claims process. This knowledge helps in managing maintenance costs and responsibilities during the warranty period.
- *Staff Training Records:* Verify that all relevant staff have completed the necessary training on the assets they will manage or maintain. This verification is essential to ensure maintenance activities are performed safely and effectively.

4.6 Grow the Capability of Maintenance and Reliability

Based on current approaches, methods and processes generally resulting in lost opportunities in infrastructure service delivery and substantial financial savings, maintenance, and reliability, including Asset Management best practices will need to be better understood and applied across organizations. The following are some recommended references for consideration.

The Global Forum on Maintenance and Asset Management (GFMAM) website contains numerous resources and a broad array of resources worldwide. Members are non-profit organizations and the GFMAM vision to promote and develop the maintenance and asset management professions by collaborating on knowledge, standards and practices is intended to help advance maintenance and asset management. Two such non-profit associations that are considered global leaders in the Maintenance, Reliability and Asset Management space are SMRP and PEMAC, PEMAC Asset Management Association of Canada (smrp.org).

Many other organizations exist in Canada and contain excellent Asset Management material and training programs. They can also be found at the FCM Library Asset Management Resource Library | Federation of Canadian Municipalities (fcm.ca).

Three specific learning programs recommended for assisting with the advancement of capability for MDRR are:

(1) The Maintenance Management Professional (MMP) program consists of eight modules and is delivered live online by a variety of teaching institutions. This program focuses on the tools, techniques, strategies, and skills necessary to manage an organization's assets effectively. Graduates have the knowledge and skills to drive improvements in uptime, production capacity, equipment reliability, safety, environmental compliance, the economic life of assets, return on investment, and effective communication between departments. Completion of the program leads to the MMP certification.

(2) The Asset Management Professional Program consists of six courses delivered asynchronously online by Northern Lakes College. This program is designed for mid-career professionals from a variety of backgrounds who have responsibility for managing decisions concerning the core life cycle functions such as design, selection, operation, and maintenance of an organization’s assets. It introduces the participants to the latest in strategic asset management thinking, develops the capacity to engage others and build their knowledge and skill in key subject areas such as risk management and knowledge management and introduces tools for strategic decision-making at each stage of the asset lifecycle. Completion of the program leads to the CAMP certification.

5. Cost and Benefits of MDRR

The transition to advanced acquisition of data, information, and maintenance management resources entails both initial investments and ongoing operational costs. These include costs associated with labour, materials, technology adoption, training, and the integration of new systems into existing infrastructure. The business case highlights that while these upfront costs can be significant, the long-term benefits in terms of operational efficiency, cost savings, and improved service delivery are substantial. In addition, when assets are effectively provisioned for and the maintenance management function is mature, the ability of the organization to use maintenance data captured, including condition grades, reactive costs, and frequency, enables enhanced replacement decision-making and a step change toward data-driven replacement decisions.

5.1 Proactive Maintenance as Financial Lever 1

Proactive maintenance, requiring an annual investment of just 1% of the total replacement asset value, contrasts with an estimated 2%-5% reactive repairs and 100% replacement cost. Proactive maintenance not only diminishes annual reactive maintenance costs but also prolongs the lifespan of infrastructure, enabling substantial future cost savings while maintaining assets in “very good” and “good condition.”

5.2 Circular Economy as Financial Lever 2

When asset condition grades change from very good, good to fair, poor, and finally very poor, the next stage in the asset lifecycle is decommissioning and disposal. To eliminate cost and risk, maintenance functions can provide alternate options that can restore conditions to good or very good and, in the process, eliminate the need to decommission and dispose of assets and re-acquire new assets. Estimated cost savings of 10:1, meaning for every $1 you spend on maintenance, you save $10 on disposal and acquisition costs and 100% on replacement.

The diagram in Figure 6.1 illustrates the connection between the main stages of an asset's life cycle and the ability of the 'operate & maintain' stage to postpone disposals and enhance the Meantime Between Whole Asset Replacement (MTBWAR). MTBWAR, or Mean Time Between Whole Asset Replacement, is a crucial concept at the organizational level. The efficiency of the asset management function can be evaluated by quantifying the frequency of whole asset replacements caused by poor and very poor conditions.

The premise is that through the application of value retention processes (VRPs) (e.g., *remanufacturing, comprehensive refurbishment, refurbishment, and repair*), the life of an asset can be extended. Therefore, delaying disposals and slowing down the rate at which natural resources are consumed and waste management processes are engaged. The model anticipates that waste disposal will occur, but at a reduced rate.

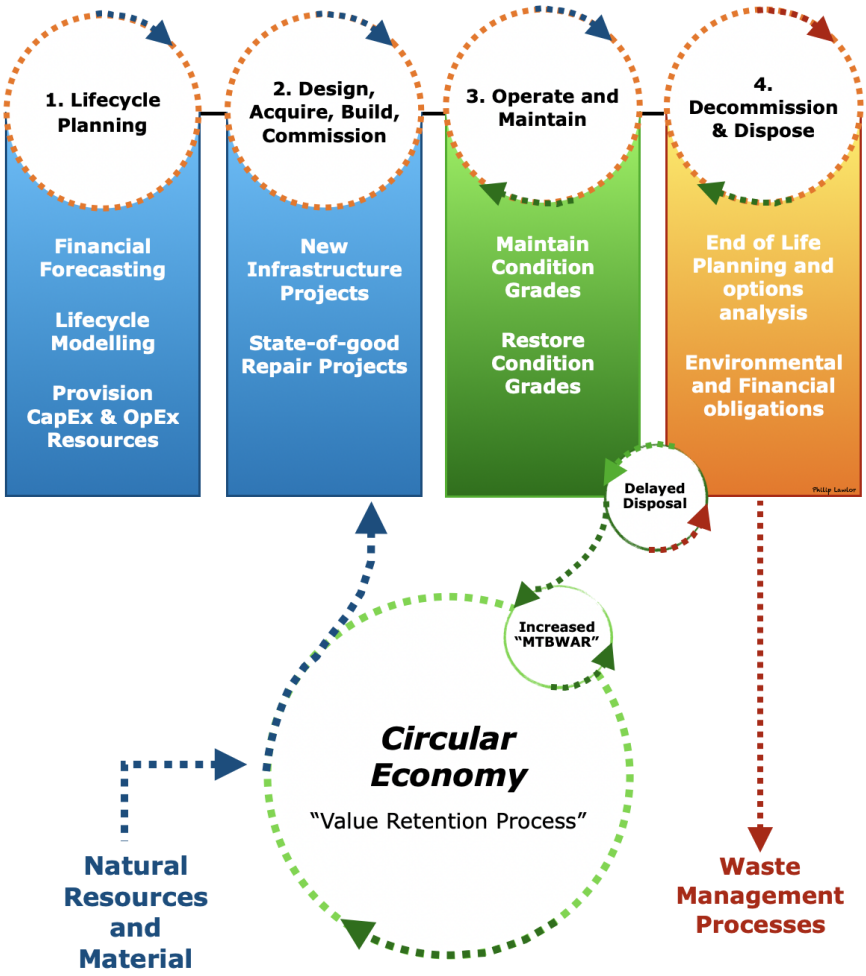

FIGURE 5.1. VRP AND MTBWAR RELATIONSHIP

5.3 INITIAL INVESTMENTS

To enhance data acquisition and maintenance practices, organizations will need to make strategic investments upfront. These initial investments lay the foundation for realizing long-term benefits. The key areas requiring investment include:

- *Technology Acquisition:* Costs associated with purchasing new asset management software or upgrading existing systems to accommodate enhanced data collection and analytics capabilities.
- *Staff Training:* investment in training for municipal employees to ensure they are equipped to utilize new technologies and follow updated data management protocols effectively.
- *Data Collection and System Integration:* Expenses related to collection and integrating new data management systems with existing infrastructure to ensure seamless data flow and accessibility.
- *Rightsizing Maintenance Function:* Connecting maintenance budget with the inherent Proactive demand for installed assets is an essential step in lifecycle planning and processes. It has been observed that budget allocation for maintenance is primarily linked to inflation, and as a result, the gap between asset demands and available recourse is disconnected. Benchmarking maintenance costs as a percentage of replacement asset value (MC%RAV) will enable budget forecasting and long-term benefits.

5.4 Long-term Benefits

While the initial investments in enhancing data management practices and provisioning for maintenance may seem substantial, the long-term benefits of these efforts are significant and far-reaching. By embracing data-driven asset management, organizations can expect to realize. The areas of effective decision-making include:

- Realizing asset value and finding alternate approaches other than decommissioning and disposal poses many benefits, including reduced cost, risk, service disruptions, and environmental deterioration. Ensuring installed assets continue to deliver value over a long time, even beyond projected lifecycle models.
- Determining the optimum maintenance tactics and investments into preventive maintenance to avoid costly reactive maintenance is most effective when information about “availability” is known. Availability considers both MTBF and MTTR to identify where investment is best allocated.
- *Operational Efficiency:* Improved data management practices lead to more informed decision-making, optimized asset utilization, and reduced downtime.
- *Cost Savings:* Enhanced predictive maintenance capabilities can significantly reduce the need for reactive maintenance, resulting in substantial cost savings over time.

- *Service Delivery Improvements:* Accurate and readily available asset data supports better planning and execution of maintenance activities, leading to improved service delivery and community satisfaction.

5.5 Strategic Benefits

Beyond the operational and financial benefits, enhanced data acquisition and management practices also offer strategic advantages that can position municipalities for long-term success and resilience. These strategic benefits include:

- *Risk Mitigation:* Better data insights contribute to more effective risk management strategies, reducing the likelihood of asset failure and associated costs.
- *Sustainability:* Advanced data practices support more sustainable asset management by enabling municipalities to make informed decisions that consider long-term environmental impacts.
- *Regulatory Compliance:* Enhanced data collection and management practices ensure municipalities can more easily comply with evolving regulatory requirements, avoiding potential fines and penalties.

The white paper and business case provide additional evidence that, despite the difficulties of initial investments and the requirement for organizational change management, the strategic implementation of improved data acquisition and maintenance management practices is essential for organizations seeking to attain financial sustainability.

6. CLOSING REMARKS

The purpose of this *Practitioner's Guide: Leveraging Asset Master Data on Acquisitions* is to equip and empower public sector municipalities, Cities and Towns across Canada with the knowledge and strategies necessary to improve their asset management capabilities. We have presented a comprehensive roadmap toward achieving excellence in maintenance, reliability, and asset management due to the collaborative efforts of Toronto Metropolitan University, the PEMAC Asset Management Association of Canada, and the generous support from FCM and the Government of Canada. This guide, white paper, business case and curriculum of learning, was developed to achieve excellence in these areas.

The Path Forward to improved maintenance and reliability begins with thoroughly evaluating existing whole-lifecycle AM approaches, explicitly focusing on MDRR deliverables. Insights from the National Maintenance and Reliability Survey and Infrastructure Condition Statistics have provided a clear basis for identifying shortcomings in maintenance, reliability engineering, and the management of asset data. The goal moving forward is to transform how public assets are managed, drawing on international MM standards and enhanced reliability engineering practices. A significant move toward adopting robust asset data strategies and a comprehensive financial strategy is crucial for a sustainable and prosperous update to the current system of managing maintenance within the broader AM framework.

This guide is intended to help guide, inform, and inspire municipalities of various sizes and different maturity levels of AM systems. For example, the self-assessment of AM readiness will help municipalities determine if they are ready to implement.

We encourage organizations to embrace the insights, methodologies, and good practices detailed within this guide, to not only improve their operational efficiencies and cost-effectiveness but also to contribute toward a more sustainable and resilient public infrastructure system in Canada. Our collective journey toward optimized asset management is ongoing, and it is through our continued collaboration, innovation, and dedication that we will achieve the highest standards of service delivery and community well-being.

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APPENDIX 1. ASSET MANAGEMENT RESOURCE LIBRARY

The application of Master Data and Resource Readiness draws upon a wide variety of Asset Management and Maintenance Management topics. As such, several elements of the Master Data and Resource Readiness (MDRR) described previously align and relate to existing Asset and Maintenance Management resources within the FCM Library Asset Management Resource Library | Federation of Canadian Municipalities (fcm.ca). This chapter demonstrates some of this alignment and resources that might benefit organizations as they consider the MDRR approach.

A1. ASSET DATA

The National Master Data Survey revealed that there is a "clear effort toward structured and interconnected data systems" for asset data. Static asset data in the form of the asset inventory and asset hierarchy represent the scaffold that other Asset Management data will be layered onto. Initiatives that focus on data harmonization, governance and interoperability will lead to improved data accuracy as well as utilization of the data for effective, consistent decision-making. These decisions will improve overall asset utilization, leading to the goal of effective service to the community.

Municipalities should consider standardizing and providing templates for the collection of asset data both internally by staff and externally as part of capital project delivery. These templates would capture asset data such as location, nameplate data and condition in addition to asset hierarchy and maintenance data. The use of templates as part of capital projects has the potential to vastly improve the speed at which asset data can be updated when assets are assumed by the organization - leading to faster decision-making ability.

FCM's report "*Asset Management Insights: Data and Information*" provides an overview of municipalities' progress on asset data and information competencies. In particular, it demonstrates that the majority of surveyed municipalities are actively developing their data and information capabilities as related to asset management. The report highlights aspects of the value proposition presented in the business case as well as high-level steps that align with the strategies defined in the BC, strengthening the case for MDRR.

The presentation **"***Establishing Asset Hierarchy & Conducting Data Gap Analysis***"** available from AMONTario and the *"AM Inventory Template"* represent excellent starting points for municipalities to determine their data gaps and develop templates that can be used internally and included as part of their capital project RFPs and other purchasing documents.

A2. Development of Proactive Maintenance Strategies

Asset master data for MDRR is a prerequisite for any functional and effective proactive maintenance program. Accurate data on the make-up, construction, or model of the asset, as well as its condition, maintenance history, and lifecycle costs, are required to plan and execute proactive strategies that are meant to effectively optimize asset performance and realize/extend their lifespan. The goal is to perform the right work at the right time so that proactive maintenance planning results in effective results.

Proactive maintenance best practices include the development of a mix of preventive (PM) and predictive maintenance (PdM) tactics, reactive maintenance tactics, and asset condition monitoring methodologies including, the use of sensor technologies for both condition and performance; and the development of maintenance strategies for proactive maintenance programs that manage asset performance, risk and cost by asset class.

Organizations should review the data requirements for these programs and create or enhance their templates to close any data gaps that may exist.

Another key component that is critical to any maintenance program is the development of assessment strategies for monitoring the overall effectiveness of the program. Maintenance and operations KPIs must be developed and aligned with maintenance and operational objectives in such a way that deficiencies are detectable and corrective action can be identified.

"*Timely Preventive Maintenance for Municipal Roads — A Primer***"** as part of the National Guide to Sustainable Municipal Infrastructure by FCM and National Research Council provides a detailed and technical approach to the development of Preventive Maintenance strategies for roads. The approach details steps to "establish management aspects of the program; establish technical aspects of the program; determine maintenance needs; provide a framework for treatment selection; set priorities for needs; and provide ongoing support, monitoring and assessment." Such an approach can be adapted to other forms of infrastructure (including vertical infrastructure) with the thoughtful application of failure modes, risks to objectives, intervention strategies and economic analysis based on the information and data available.

The Northwest Territories Association of Communities (NWTAC) has developed a series of *inspection forms (daily and monthly) and videos* for a municipal vehicle fleet. These inspection sheets can act as a starting template for municipalities looking to implement preventive and proactive maintenance on their fleet assets. Inspection sheets are a simple but useful tool for front-line staff to assess the condition and performance of fleet vehicles and relay this information

back to maintenance teams so that deficiencies can be inspected and corrected promptly. The videos provide an approach for standardizing the use and reducing errors in the inspections, leading to consistent outcomes across the different staff. The customization of these sheets and videos for an organization would ideally leverage master data provided at the purchase or delivery of the equipment as described under MDRR.

A3. Asset Information and Condition Ratings

The Nova Scotia Federation of Municipalities' "*Asset Management Data Collection Pilot Project Data Collection Standard Operating Procedure*" provides a templated approach to the collection of asset information consistent with the strategies outlined in 5.1. Templates such as these can act as a starting point for each organization to develop a customized approach for asset data collection in the service of MDRR.

"*Appendix A: Condition Assessment Guide*" to the Standard Operating Procedure demonstrates a detailed approach for assessing asset condition that covers tens of asset types. The assessment methodology allows front-line or engineering staff to perform assessments of conditions. The assigned ratings are not meant to replace engineering assessments but allow an organization to identify any observable deterioration (through condition changes) regularly, allowing the organization to highlight and follow up with specific assets through more formal assessments. Condition assessments are but one input that enables long-range capital planning. Actual budget allocation will be driven by needs assessments and augmenting condition assessments with maintenance work order data.

A4. The Importance of Proactive Maintenance for Asset Management

As described in the business case, the shift from reactive to proactive maintenance yields many proven benefits including improved service delivery, reduced maintenance costs, operational efficiency, and asset life extension. The implementation of proactive maintenance is predicated on accurate asset data and standardized data processes as described by MDRR; maintenance and reliability-oriented organizational structures and sufficient financial and technical resources.

The benefits of proactive maintenance are fundamental to asset management as the operation and maintenance (O&M) of assets typically represents most costs related to the asset lifecycle. A vast amount of data is also generated during the O&M stage of an asset's life cycle because

of operation and maintenance activities that, if leveraged by an asset management program, can improve the organization's decision-making abilities across the lifecycle of the asset.

The primer titled "*The Role of Operations and Maintenance in Asset Management*" developed by the Union of BC Municipalities, Asset Management BC, and the BC Ministry of Municipal Affairs and Housing provides a similar explanation of the benefits of proactive maintenance and its relationship to effective asset management. In particular, the primer provides a framework for integrating proactive maintenance into an asset management program through the inclusion and alignment of maintenance objectives with asset management objectives to raise the profile and awareness of O&M objectives to senior management and municipal leaders.

A5. Change Management for Organizations Moving Toward Asset Management

A significant step in the implementation of MDRR, proactive maintenance and asset management programs is organizational change management. To achieve the objectives and realize the values described by the business case and all other resources described in this section it is imperative to build a culture of change and adoption of the reviewed strategies and approaches across the entire organization.

The presentation "*Operationalizing Asset Management*" by the Union of British Columbia Municipalities identifies typical barriers that are faced when implementing new programs and bringing about organizational change; namely insufficient staffing, constrained budgets, organization structures, the existing culture, staff training etc. The business case and this guide highlight similar obstacles and make the similar case that such obstacles must be removed to implement and realize the goals of MDRR and asset management.

REVISION HISTORY

v.1.00 – March 19, 2024 – Release of the initial versions of the white paper and accompanying business case and guide documents.

ORGANIZATIONAL INFORMATION

PEMAC Asset Management Association of Canada
Canadian Leaders in Asset Management

PEMAC is a Canadian not-for-profit association enabling excellence in maintenance, reliability, and asset management through collaboration, applied learning, and leadership.

www.pemac.org

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www.torontomu.ca

To access the accompanying Business Case and White Paper, visit:

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

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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