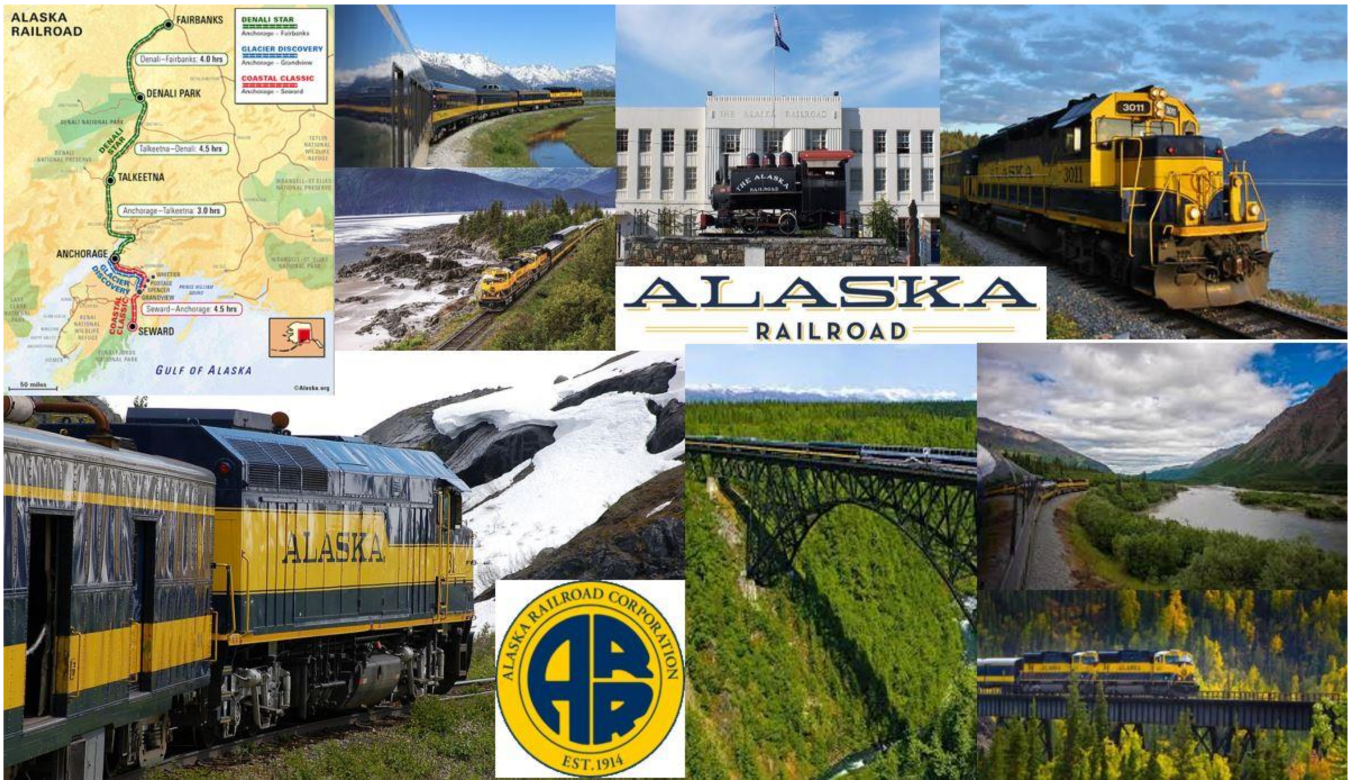
Alaska Railroad Corporation



Enterprise Asset Management Functional Requirements Analysis

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INTUEOR
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Executive Summary

The Alaska Railroad Corporation (ARRC) Transit Asset Management program identified the inability to leverage maintenance data in a consistent and efficient manner as a major gap in its maturity. As a result, ARRC hired the team of Kimley-Horn and Associates and Intueor Consulting, Inc. to carry out this asset management assessment in Spring 2019. The Needs Analysis Report (the first of two reports) provides an overall assessment of asset management maturity at ARRC. This second report is the system Functional Requirements Report. The two reports go hand-in-hand. The Needs Analysis delves into two key areas: day-to-day maintenance activities and capital planning. This Functional Requirements Report documents the baseline current practices at ARRC regarding Asset Management systems, identifies ARRC's high-level functional requirements for automated support for Asset Management policies and procedures, and assesses viable options to meet the requirements. The high-level functional requirements are based on interviews with ARRC staff for all asset classes, industry best practices, and industry accepted standards for asset management, such as ISO 55000.

The team documented the current systems support for asset management for each asset class. ARRC uses mostly manual tools and stand-alone business applications to manage their assets. In some instances, there are no tools or systems being used to manage specific asset management functions within asset classes. The only business application tool being used regularly throughout ARRC is JD Edwards (JDE), which is mostly being used to manage materials inventory and purchasing, and basic work order functions for some asset classes. There is a lack of integration and data sharing amongst systems, departments, functions, and asset classes. This lack of integration, and the over reliance on manual tools, results in missing or incomplete business functions, poor adoption and oversight of asset management standards, and inefficient entry, storage, and retrieval of asset data. It also exposes the agency to risks associated with lost data, incomplete records, multiple sources of the truth, and provides a sub-optimal view of true asset conditions across the enterprise. JDE, which is not a comprehensive asset management system, cannot adequately perform the functions and processes required for ARRC to manage ARRC assets. As it currently exists, ARRC's technology landscape of systems, spreadsheets, and manual processes is not capable of supporting full lifecycle asset management for the agency. In addition, compared to the transit peers reviewed in this study, ARRC is the only transit agency that does not utilize an industry proven asset management system or decision support tool to manage their assets.

ARRC should replace its current asset management systems with a new asset management solution that provides comprehensive support for its current asset management needs and that has the flexibility to be configured for future direction and growth as ARRC's asset management practices mature. The team identified and assessed options for implementing this recommendation, from specialized and focused software to a comprehensive Enterprise Asset Management (EAM) system, and concluded that a formal evaluation process based on detailed functional and technical specifications is needed to identify the best solution for ARRC.

The roadmap for successfully rolling out an asset management solution includes: (1) developing ARRC's detailed functional and technical requirements for asset management support; (2) evaluating the options for improvement against the requirements to identify the best option; (3) justifying the selected option through a business case and Return on Investment (ROI) analysis; and (4) developing an RFP to acquire and implement the selected solution.

2. Document Overview

2.1 Document Purpose

The project team has prepared this document on behalf of the Alaska Railroad Corporation (ARRC) for the following purposes. To:

1. Document the baseline current practices at ARRC with regard to Asset Management systems.
2. Document the high-level functional requirements derived from the interview process conducted at ARRC with regard to automated support for Asset Management policies and procedures.
3. Provide recommendations for improving systems support and meeting the functional requirements and outline the next steps for pursuing asset management system improvements at ARRC.
4. Document asset management systems state of the art and best practices.
5. Identify and assess viable asset management system options for ARRC.

2.2 Process Used

In conducting this Requirements Analysis, the consultant and the ARRC project team jointly interviewed key members of the following departments (in alphabetical order):

- Automated Train Control Systems (ATCS);
- Bridge Structures;
- Facilities;
- Fleet Vehicles/Heavy Equipment;
- IT;
- Marine Structures (Docks/Slips);
- Rolling Stock (Freight and Passenger)/Motive Power;
- Signals;
- Telecommunications; and
- Track/Avalanche.

In general, the process used to conduct the interviews was to first document and map out the existing systems and processes from each participant's perspective, identify major resource drains and process bottlenecks, and then to brainstorm and examine potential process and technology improvements through standardization and automation.

The focus was on current Asset Management practices and the current means of managing Asset Registries, Work Activities, Inventory and Stores and reporting. However, the project team also considered future direction as outlined in the ARRC Transit Asset Management Plan (TAM Plan).

The project team then developed *high-level* requirements for improvement opportunities identified through the interview process. In all areas, each need was considered from ARRC corporate asset management goals, end user perspective, and enterprise system best practices for the purpose of process optimization, automation and data sharing.

2.3 Organization of Document

This document is organized to include the following sections:

1. **Executive Summary** – a high-level summary of the major findings and themes present within the report.

2. **Document Overview** – a description of the project team's approach to generating the report. This includes a description of the document's purpose and the process used to generate the content within the report.
3. **ARRC Current State Asset Management Analysis** – analysis of information discovered related to ARRC's current practices for managing assets. This section includes analysis on how ARRC is leveraging technology to support asset management functions within the enterprise as well as a summary of our findings related to the current use, functional needs required, and the improvement opportunities found within each of the following asset management categories:
    a. Asset Hierarchy, Registry and Information;
    b. Asset Availability and Status;
    c. Configuration Management;
    d. Fault/Problem Detection;
    e. Planned Maintenance Programs;
    f. Work Order and Work Order Management;
    g. Component Tracking and Rebuild;
    h. Warranty Management;
    i. Capital Projects, Campaigns; and
    j. Timekeeping.
4. **Asset Management Systems and Peer Agency Comparison** – this section provides a description of the development and utilization of asset management systems historically present within the industry. In addition, this section also provides a high-level summary of how ARRC and its peers are using systems related to Asset Management, Enterprise Resource Planning, and support tools/systems.
5. **Asset Management Technology Options and Recommendation** – this section contains a review of multiple options that ARRC could consider to improve asset management for the organization, and our recommendation as to how ARRC should pursue an improved asset management solution.
6. **Next Steps for Improving Asset Management Technology and Operations** – this section expands on the recommendation for improving asset management technologies that was provided in the previous section. It outlines the suggested steps that ARRC consider for identifying and selecting an asset management solution that best fits their needs.
7. **Appendix A** – this appendix provides an overview of current state of the art in Enterprise Asset Management (EAM) and Maintenance Management systems.

3. ARRC – Current State Asset Management Analysis

3.1 Present Technology Used to Manage Assets at ARRC

The table below visually depicts the systems and tools AARC currently utilizes to manage their assets and perform maintenance management activities.

The areas highlighted in ***orange*** indicate that Asset Management is supported via stand-alone tools mainly in MS Excel, manual or paper-based processes.

Areas highlighted in ***green*** indicate that either JD Edwards (JDE) or another Commercial Off the Shelf (COTS) solution has been configured and implemented in some fashion. JDE is ARRC's Enterprise Resource Planning (ERP) system of record. It manages all of ARRC's business and financial processes, purchasing, human resources, and payroll. It has also been extended to provide some work management and inventory management tools to a number of departments. Other COTS tools include LanDesk, WebHelpDesk, Flagstop, RailDocs, ArcGIS, and Survey123. These tools are summarized in the sections below.

Areas in ***red*** indicate that there are no tools currently in use to manage asset management processes, and the *non-highlighted* areas indicate that the management functions for that particular process are not applicable.

As illustrated by the table, ARRC uses mostly manual tools and stand-alone business applications to manage their assets. In some instances, there are no tools or systems being used to manage specific asset management functions within asset classes; such as Asset Inventory and Information for Docks and Slips.

The only business application tool being used regularly throughout ARRC is JDE, which is mostly being used to manage Materials Inventory, Purchasing and Receiving; leaving other major asset management functions to be managed manually or via disparate systems. Because of this, there is a lack of integration and data sharing amongst systems, departments, functions, and asset classes. This lack of integration, and the over reliance on manual tools, results in missing or incomplete business functions, poor adoption and oversight of asset management standards, and inefficient entry, storage, and retrieval of asset data. It also exposes the agency to risks associated with lost data, incomplete records, multiple sources of the truth, and provides a sub-optimal view of true asset conditions across the enterprise.

The siloed or manual tools in place at ARRC have limited or no integration with other asset management applications and with non-asset management applications, such as JDE. The inability to effectively share information across applications limits the capability to analyze a function, activity, asset class, or other areas across applications. This also can lead to double data entry, duplicate data, missing data, and inefficient processing or loss of staff time.

Existing systems have varying levels of sophistication, different or inconsistent user interfaces, different technical platforms, and different capabilities, which present challenges in providing training and support, designing and deploying enhancements, controlling security, and other administrative and management functions.

JDE is not a true maintenance management or asset management system, meaning that it cannot adequately perform all of the functions and processes required for ARRC to manage all, or a majority, of ARRC assets. Because of this, ARRC has had to utilize satellite implementations of asset management tools to provide functionality and support that would be inherent within a more capable and fit for purpose asset management system. As it currently exists, ARRC's technology landscape of systems is not capable of supporting full lifecycle asset management for the agency.

	Guideway Assets			Vehicle and equipment Assets					Facilities	Systems Assets		
	Track & Avalanche	Bridges	Docks/Slips	Locos	Pass. Railcars	Freight Railcars	Vehicles	Heavy Equipment	Facilities	T/C Comms	Signals	IT Equip.
Asset Inventory & Information	Excel, Paper Track charts, GIS	Excel	None	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel, GIS	LanDesk
Asset Configuration/ Modifications	N/A (+ 3rd party and ArcGIS, Survey123)	N/A	N/A	Excel	Excel	Excel	Excel	Excel	N/A	N/A	N/A	LanDesk
Asset Condition & Performance	Manual/ Excel	Manual	Reports	Excel	Excel	Excel	Excel. ARI standard reports	Excel	Excel	None	None	LanDesk
Incident/ Defect Management	Manual	Manual	Reports	Manual	Manual	Data Report - JDE source TRMS ad hoc	Excel ARI standard reports	Excel	Flagstop	WebHelpDesk	RailDocs/ Manual	Flagstop
Work Management/ Work Orders	Manual	Manual	Manual - Bridge work JDE - Facilities	JDE	JDE	JDE	JDE- hyrails only	JDE	JDE	WebHelpDesk	RailDocs/ Manual	Flagstop
Materials/ Inventory Management	JDE	JDE	JDE	JDE	JDE	JDE	JDE - hyrails only	JDE	JDE	JDE	JDE	LanDesk
Purchasing & Receiving	JDE	JDE	JDE	JDE	JDE	JDE	JDE - hyrails only	JDE	JDE	JDE	JDE	JDE

Capital Program/ Projects	Manual/ Excel	Manual /Excel	Manual/ Excel	Manual /Excel	Manual/ Excel	Manual/Excel	Manual/ Excel	Manual/ Excel	Manual/ Excel	Manual/Excel	Manual/Excel	Flagstop to manage, Manual/ Excel to request
Reporting & Analysis/Internal	Manual	Excel	None	Manual	Manual	Manual	Manual	Manual	JDE/Excel	Manual	Manual	LandDesk, Flagstop
Reporting & Analysis/FTA	Manual	Excel	None	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual	N/A
Reporting & Analysis/FRA	Manual	Excel	None	Manual	Manual	Manual	Manual	None	None	N/A	Manual/ RailDocs	N/A

Table 1 - ARRC Asset Management Systems and Tools

3.2 Functional Requirement Categories

The following areas were reviewed at ARRC in the initial requirements gathering interviews:

- Asset Hierarchy, Registry and Information;
- Asset Availability and Status;
- Configuration Management;
- Fault/Problem Detection;
- Planned Maintenance Programs;
- Work Order and Work Order Management;
- Component Tracking and Rebuild;
- Warranty Management;
- Capital Projects, Campaigns; and
- Timekeeping.

3.2.1 Asset Hierarchy, Registry and Information

Description

An asset registry defines, describes, and categorizes an organization's assets, and provides accurate and consistent information to support asset management functions. The asset registry itself is the fundamental building block for asset management. In the registry, every asset is recorded according to a unique identification string ("number") against which certain asset attributes are recorded. Implementing a well thought out and well-constructed asset registry is one of the most important steps in building an effective asset management program. Constructing a hierarchy defining the parent-child relationships between assets provides both context and organization to the asset registry.

How ARRC Does This Now

Today, ARRC's assets are all managed within individual lists by each department, mostly in Excel. Some asset inventory also exists within JDE, but it is not complete. This management technique is a typical outgrowth of developing in-house solutions. The issue is that this technique can result in inconsistent data, potential duplication and double entry. The asset inventories are maintained by each department and are used for various functions such as:

- Tracking asset lists, hierarchies and classes;
- Tracking configuration;
- Tracking condition and performance;
- Tracking capital programs and projects;
- Recording life expectancy;
- Providing regulatory agency reporting and monitoring compliance; and
- Supporting other functions requiring asset reference information.

Functional Needs for ARRC

ARRC can benefit from one central registry of its assets with comprehensive, flexible, and consistent classification and reference information for all asset classes and types. The registry must be able to include components and sub-components, assemblies, systems, and other similar entities and be able to model and enforce the hierarchical relationship between assets. However, the registry must also be flexible enough to address the disparate needs of all asset classes and to accommodate information required to target specific results defined by ARRC.

ARRC's responsibility for assets represent various combinations of ownership, maintenance, operations, and replacement authority. The registry must also be able to accommodate linear assets, such as track (primarily), with future potential for pavement, fencing, cabling and others.

Full asset lifecycle tracking including expected life and useful life benchmarks (ULB) are needed, as well as the ability to track assets that require regulatory agency reporting and inclusion in a Transit Asset Management Plan.

Some departments at ARRC specifically indicate they require that asset management data include, at a minimum:

- Maintenance plan data associated with assets;
- Date asset was put in service;
- Purchase method (e.g., internal, FTA);
- Effective life span; and

- Forecasted end of life (year).

ARRC's asset registry should be a single source of asset information that forms a basis for supporting all asset management decisions and functions, and for accumulating lifecycle costs. Asset values, such as estimated current value, replacement cost, and potential salvage value must also be included.

Expected Benefits and Improvement Opportunities

The benefits of a centralized repository for ARRC's assets that links to all associated asset activities include:

- A single source of truth for all ARRC assets, organization-wide;
- Consistent asset information throughout the organization;
- Reduction and/or elimination of redundant processes;
- Improved asset data management;
- More efficient data administration derived from all the above; and
- More efficient governmental compliance reporting (FRA, FTA, NTD).

3.2.2 Asset Availability and Status

Description

Tracking the real-time status of assets and their availability for service is a key tool for managing assets, especially revenue vehicles that must be available to meet peak demand requirements for transportation service. Sample statuses could include: Active, Under Repair, Due for PM, etc. Tracking availability and status includes detailed information on asset condition, reliability and performance as well. Availability for service is typically an inherent attribute of asset status and contributes to the performance metrics an Asset Management system can provide based on asset history.

How ARRC Does This Now

As with ARRC's Asset Hierarchy and Registry, ARRC's asset information is managed within individual lists by each department, mostly in Excel. The activities performed on these assets (which drive the dates and durations of status changes, availability, and other attribute data in Asset Management solutions) are currently tracked in other, non-integrated tools. This process necessarily creates a break in the informational linkage between assets, their status, and the transactional data such as work performed, maintenance due, condition assessments, measurements and other information that determines availability and status. Therefore, availability status must be tracked and updated manually.

Functional Needs for ARRC

ARRC must be able to track the real-time and historical status of its assets and their availability for service, especially revenue vehicles. Any asset management implementation must collect operating information, statistics and costs, and be able to capture and trend inspection data, meter readings, measurements, and reliability associated with each asset.

A key requirement is the ability to assess and track asset condition or "State of Good Repair" (SGR) based on standard rating scales and consistent processes. In addition, the ability to set performance targets and measure performance will be required by the regulatory agencies and is consistent with good asset management practice.

The asset management system must also be able to support risk-based decision making by allowing ARRC to determine and store the criticality of its assets and provide the information necessary to assess risk.

Expected Benefits and Improvement Opportunities

The implementation of a solution that integrate asset attribute availability and status management tools within same asset registry would add a dimension to the modeling capabilities of ARRC's current asset management practices.

Representative benefits include:

- Knowing the condition of an asset in real-time via a centralized repository allows organizations to place maintenance resources on the assets that most need it.
- Ad hoc retrieval of an asset's (or group of assets) entire work history, availability, and performance within a specified date range.

- Knowing in real-time whether assets can be used or not is essential in managing asset assignments and meeting service and functional requirements. (Example: knowing whether you can meet peak vehicle requirements and mediating shortages via activities such as deferring work or conversely speeding it up is a benefit of asset availability and status tracking).

3.2.3 Configuration Management

Description

Configuration management refers to managing the replaceable components and parts for an asset to be sure that the right part gets installed in the right position as defined by an asset "model". This, for example, is applicable to ARRC's rail cars and locomotives, and potentially some non-revenue vehicles (NRVs), but can also apply to any asset class with the need to strictly enforce model structure and configuration rules for complex assets.

Asset configuration management tools provide visibility and control over asset design, and the positions for installing components and controlled parts. It verifies that an asset is compliant with the correct model and that components and parts are installed consistent with pre-defined rules. It maintains a history of configuration changes, part number replacements and of component exchanges.

How ARRC Does This Now

ARRC's vehicle departments do not currently have sufficient support to track and enforce asset configuration compliance.

The Vehicle and Equipment departments (Locomotive, Passenger Railcar, Freight Railcar, Vehicles and Heavy Equipment) manage their asset configurations within the asset registry Excel spreadsheets.

Facilities and System Asset departments (Facilities, Telecommunications and Signals) do not currently manage configurations while IT uses LanDesk to track IT assets individual configurations.

Today, ARRC is heavily reliant on the institutional knowledge of its people to manage, track, and enforce asset configuration information as well as the minimum-on-hand/lead-time characteristics of the required replacement parts discussed below in the Materials Management section.

Functional Needs for ARRC

The implementation of an enterprise tool that integrates asset configuration management within the same enterprise wide asset registry and enforces compliance with asset models would add a higher dimension of formal control to ARRC's current asset management practices thus reducing its reliance on institutional knowledge.

Expected Benefits and Improvement Opportunities

The benefits of an integrated Configuration Management tool within an Asset Management solution include:

1. Improved traceability of components due to a centralized repository of asset configuration data.
2. More detailed history of configuration changes performed on an asset as well as serialized component installation and removal history.
3. Better information to ensure safety sensitive components are in place and that assets are correctly configured.
4. More detailed information to determine root cause when failures occur.
5. Fewer in-service failures due to better management tools including ensuring correct configurations are placed in service.

3.2.4 Fault/Problem Detection

Description

Railway system faults/problems can arise and be detected via many means. These can be based on asset failures which present themselves directly to an operator all the way to Communications-Based Train Control (CBTC) systems which can automate the detection and notification of a problem for the organization.

The above can be represented in many departments within a transit organization including IT, Facilities, and many infrastructure, vehicle and equipment assets.

In general, the overall process of managing the complete lifecycle of a fault generally consists of the following steps:

- Problem detection;
- Problem diagnosis (isolation);
- Predicting the impact of the detected and diagnosed problem;
- Event correlation - filtering alarms and grouping correlated messages;
- Mitigation actions (steps taken while awaiting repairs, to minimize the impact of the problem);
- Corrective action (action to repair the problem);
- Return to normal operations after repairs are completed; and
- Postmortem analysis and corrective actions to prevent recurrence or optimize maintenance policy.

Problem/fault detection and mitigation is an important part of many organizations and crucial to the core operation of any transit organization.

How ARRC Does This Now

The Signal Department uses PRTG to monitor current signal status. The monitoring function can identify some component problems. Defects or non-compliance conditions identified by crews or encountered during preventive maintenance and/or inspections are addressed per the established priority hierarchy. Defects that cannot be immediately repaired are treated with appropriate priority, parts are ordered, and installation occurs as soon as replacement parts arrive.

Defects and corresponding repairs are noted within RailDocs as a “Maintenance Request” (or ticket) and the Signal Maintenance Manager is notified via email of the found-and-resolved issue.

On the Telecommunications side, service requests (I.e. customer needs a new phone), incident (outage), problems, etc., are currently managed within WebHelpDesk (which is operational but reportedly does not meet all the needs of ARRC). WebHelpDesk allows users to request work, which results in tickets assigned to technicians based on priority, set due dates, etc. There is an option to put in labor hours, notes, photo attachments and other information. It also emails the client with status updates. While it is generally considered a fair tool at ARRC, it is not considered to be a tool that meets all of Telecommunications asset management needs.

IT uses Ivanti for work management and asset management needs. This system is optimized for information technology and will continue to support the IT infrastructure.

For many assets (such as revenue vehicles and track), ARRC relies on the inspection process to identify problems and faults. Various methods are used to manage and monitor a problem through resolution, including Excel, JDE, and paper forms.

The use of different tracking systems requires separate asset reference information and lists which exacerbates the difficulty in analyzing asset information across systems.

Functional Needs for ARRC

ARRC would greatly benefit from a standardized method of capturing, identifying, classifying, and tracking problems, defects, and work requests associated with its assets. This includes integration of asset monitoring systems, and defect and fault recording with an asset management system to selectively create work orders against the asset (or system), link the work order to the defect or work request, and route the work to the appropriate party. This integration should be considered a trigger to the asset management system that creates work orders, captures costs, and maintains defect and failure history for the asset.

Expected Benefits and Improvement Opportunities

With an integration of ARRC's fault detection and monitoring systems into a centralized asset management system to trigger asset-based work orders, ARRC can expect benefits derived from:

- Single-source maintenance tracking in an integrated repository of all work against ARRC assets;
- More complete asset defect and failure history, work history, and costs leading to improved analysis and mitigation;
- Centralized reporting of asset work history and problems; and
- Elimination of technicians' use of multiple systems based on activities performed.

3.2.5 Planned Maintenance and Inspection Programs

Description

The primary objective of planned maintenance is to maximize equipment performance while controlling costs by keeping equipment running safely and effectively for as long as possible, without that equipment's performance deteriorating or having unplanned outages.

Planned maintenance work orders define resource requirements, instructions, checklists, and notes for each task to be performed. The type of work to be done and the frequency varies based on the equipment being maintained or inspected, and the environment in which it is operating.

Inspection programs are also scheduled activities designed to ensure that an organization has a solid awareness of the state of its assets. These inspection programs are typically mandated by regulatory agencies and are regularly audited by these agencies, but many organizations also increase or add additional inspection routines based on their own unique environments and needs.

Planned maintenance and inspection work can also provide tracking against items such as capital projects and programs and warranty tracking.

How ARRC Does This Now

Many preventive maintenance activities at ARRC occur within its Locomotive, Passenger Railcar, Freight Railcar, Vehicle and Heavy Equipment organizations. For the most part, JDE maintains the frequencies of preventive maintenance work and generates the work orders. The work performed as a result of these work orders is driven by paper-based steps and procedures, but time and materials are then entered into JD Edwards separately.

The Track and Signals organizations perform significant inspection activities at ARRC. Tracks has begun to utilize tools developed internally within the Survey 123 product (an adjunct to ARRC's ArcGIS system) to record data regarding activities such as any needed tie replacements, rail additions, rail repair and more.

Signals utilizes RailDocs to manage its inspection activities along with some manual processes.

In all cases, the detailed work performed and inspection data that is accumulated as a result of preventive maintenance and inspection activities at ARRC are managed independently, typically on paper, and without reconciliation back to the specific assets being worked on or inspected for historical purposes.

Functional Needs for ARRC

All work and inspection related activities, readings and labor/materials utilized should be generated through an integrated asset management solution and tied to asset or location based preventive maintenance or inspection-work orders.

ARRC needs comprehensive capabilities to support and report on the inspection, maintenance, and repair of its assets within an integrated repository of asset data. This would include the functionality to establish planned inspection and maintenance programs for all asset classes and types using a variety of factors based on calendar time, elapsed time, condition, meter readings and/or measurements. Planned maintenance capabilities must include preventive, predictive, reliability centered, and condition-based inspections and maintenance jobs, and must allow ARRC the option to specify the resources (instructions labor, material, tools and equipment, outside services, etc.) needed to perform each planned maintenance task and step.

Some departments also indicated other specific requirements:

- FRA Inspection Scheduling, Tracking and Reporting;
- Must be able to input all required inspections based on asset, location and inspection frequency;
- Meet all FRA requirements for data tracked and data retention (RailDocs in use today);
- Planned maintenance and FRA Inspection forecasting capabilities;
- On demand reports meeting FRA data requirements; and
- Synchronize completed inspection data with trouble calls (post repair inspections).

Predictive Maintenance (PdM) and Reliability Centered Maintenance (RCM) functionality should also be carefully considered as medium to long term goals for the future.

Expected Benefits and Improvement Opportunities

One key benefit of planned maintenance and inspection activities managed within an integrated asset management system is that it affords an organization with an enterprise view of the historic, current *and* future preventive maintenance in an on demand, ad-hoc manner, as well as inspection related activities instantaneously. This includes the cost, reliability, and performance data required to effectively manage, adjust, and optimize planned maintenance programs.

Because an asset management system provides this view into an organization on demand, it also allows for easier facilitation of scheduling work in such ways to effectively use resources without interfering with overall operation.

Improved planned maintenance capabilities can lead to fewer in-service failures thus providing for less inconvenience for customers. The adage still stands true that “fixing it before it breaks is usually cheaper than waiting for it to break and then fixing it”.

With safety being a priority in any transit organization, all safety benefits brought about via fewer failures should be compelling to any organization, with the added benefit of longer asset life as a return on ARRC’s investment in its infrastructure.

3.2.6 Work Orders and Work Order Management

Description

The work order is the primary tool used to track maintenance, inspection, and other activity for an asset. Work orders are used to define work, manage its completion and record results. Managers use work orders to assign and monitor work, and to accumulate history of activity for an asset. The work can be classified or categorized and can provide the basis for analyzing work cause/remedy, efficiency, and effectiveness. It is also a vehicle for accumulating costs and resource consumption detail by maintenance activity and asset.

How ARRC Does This Now

ARRC uses numerous tools, some commercial, such as: JD Edwards, Flagstop, RailDocs, WebHelpDesk and some in-house developed manual processes for its work management. These processes can generally be described as the electronic opening and closing of work orders along with some notes, labor reporting and materials used against this work.

JD Edwards is a tier-one ERP tool in use at ARRC for financial management purposes. It has a module that ARRC has fashioned to function as its maintenance management tool for some departments. Due to JD Edwards' limitations in the arena of asset management, it leaves ARRC lacking in the ability to implement and manage any true asset management strategies and maintenance regimes that require more detailed work order capabilities, other than the basic opening and closing work orders and summary level data.

During the lifecycle of an ARRC work order today, the bulk of the details such as steps taken to perform the work, (i.e. repairs made, replacements made, readings, problem, cause, resolution (PCR), technician notes, etc.), are typically annotated separately on paper and filed for auditing purposes.

While Mobile Technology has been attempted at a small scale at ARRC, no organization-sized approach has been undertaken. With the geographic diversity of ARRC assets this would be a beneficial technology improvement.

Functional Needs for ARRC

ARRC requires the ability to track and manage all maintenance activity (inspections, preventive, corrective, campaigns, overhauls, projects) from beginning to end for each individual asset. This includes defining and classifying the work to be done, planning the resource requirements (labor, material, services, tools, etc.), scheduling the work, assigning staff, performing the work and recording the results and associated costs.

ARRC needs the capability to define improved failure coding, system and component references, maintenance action and repair codes, and other coding required to review trends, identify repeat problems, isolate root causes, and develop changes to asset configuration or maintenance policy, programs, processes, and activities that will improve asset performance, reliability, and state of good repair.

The asset management system should provide the tools for ARRC to plan and schedule maintenance so that the availability of assets meets demand, while ensuring the most effective use of resources. ARRC requires the ability to monitor the real-time status of work in-process, and to capture detailed inspection and maintenance history, including quantities and costs of labor, materials, outside services, and other resources, as well as complete identification and coding of maintenance tasks.

Additional system requirements indicated by specific departments include:

- Ability to open work orders that are linked to assets, sites, buildings, vehicle, locomotive, freight or passenger railcar, equipment, waysides, crossings or defect detectors, etc.
- Ability to generate work order hierarchies to include multiple levels of Parent/Child work orders;
- Proper field length flexibility – Example: current JDE work order description field does not provide enough space to enter sufficient detail
- Ability to forward trouble tickets and work orders between technicians and departments
- Ability to annotate work performed, time-types (covered vs. non-covered e.g. regarding Hours of Service - HOS) and time towards tickets
- Allow multiple technicians to record time against a single ticket/work order
- Asset based work orders should flag Return Merchandise Authorization (RMA) or other replacement mechanisms
- Web based allowing customers a self-service interface to open tickets/work orders
- Easy creation and assignment of asset-based work orders to create a traceable work history
- Assignment of work orders to a specific asset, multiple assets (campaigns i.e.), or locations
- Automatically route work orders to the appropriate owners
- Dispatch calls for work orders via text message or e-mail
- Receive instant acknowledgment of work order acceptance
- Quickly turn service requests into work orders
- Access work order database over mobile devices
- Create and assign work orders for any future date
- Receive instant acknowledgment of work order completion
- Track labor hours and supplies used for work orders
- Collect technician feedback on completed work orders
- Generate work order specific instructions for employees
- Search for specific work orders and review or change details
- Analyze work order history and evaluate maintenance operations
- Run reports specific to work orders and review staff performance.

Expected Benefits and Improvement Opportunities

Asset management systems are integrated productivity tools and databases that help organizations manage the work associated with all asset types on a single software platform. They provide a comprehensive view of all assets, their conditions and locations, and the work processes that support them. Robust work order functionality and comprehensive work order management in a centralized asset management system will provide ARRC with numerous benefits, including

- More effective and efficient utilization of maintenance resources;
- Improved ability to analyze maintenance history and develop fact-based maintenance strategies and programs;
- Improved control of maintenance costs and of maintenance activity;
- Ability to analyze individual asset history and life-costs;
- Improved control of capital maintenance, programs, and projects;
- Improved assessment and tracking of asset condition; and
- Improved ability to design and implement asset modifications for improved performance and reliability.

3.2.7 Materials Management

Description

Materials management covers inventory and supply chain management for the parts, components, and maintenance materials and supplies required to maintain ARRC's assets. This includes:

- Inventory item and catalog management – determining what items to stock, how many, and where, and serving as a central depository for inventory item information, including item value;
- Warehouse/storeroom management – managing the physical storage of inventory material;
- Inventory transactions – recording the movement, consumption, and cost of material through issue, receipt, transfer, and return transactions, and maintaining perpetual inventory balances (quantity on-hand);
- Material replenishment – reordering inventory material to maintain target stocking levels and meet demand for items, while managing inventory cost and investment;
- Cycle counting/physical inventory – ensuring that inventory data is accurate and reliable;
- Serialization & Tracking – tracking and controlling individual serialized items such as major components; and
- Capital material & Lot Tracking – managing material purchased with capital funds for specific projects.

Materials management includes managing information on parts and components that are in asset hierarchies, bills of material, and configuration models, and also includes applying costs for non-inventory material ordered for specific work orders.

How ARRC Does This Now

ARRC maintains a number of centralized, main warehouse storerooms with which to locate and stock its inventory items for use in planned, corrective, and emergency work. There are also a number of stockpiles of materials kept along the right of way (RoW). The items maintained at the main storerooms tend to be managed more formally than the inventory along the RoW within JD Edwards.

In the case of RoW inventories, which tend to consist of more bulk related items such as railroad ties and rail itself, ARRC relies on institutional knowledge to understand what stockpiles may or may not have been purchased for (and therefore only to be used on) specific projects or campaigns.

Replenishment of inventory for general stores, project work, as well as long lead time and electronics, are all managed in independent, and mostly manual processes.

In the case of project work, many times a technician or supervisor will simply take a company credit card (PCard) and purchase the required materials from local retailers in a case by case approach.

Tied closely to the arenas of component tracking, rebuild management, and asset configuration management, ARRC must continue to stock high use as well as high-value parts at its stores locations. The parts may be critical to ARRC's infrastructure or are part of configurations that allow ARRC to maintain multiple assets from the same part or machine. There exists a number of essential parts that are no longer produced by the manufacturer and have no adequate replacement available.

Functional Needs for ARRC

ARRC needs comprehensive capabilities to cover a full range of materials management activity, including item management, inventory control across multiple locations, warehousing and storeroom management, inventory costing and transaction capture, serialized item tracking, material replenishment, etc. Materials management must be integrated with work management to support material resource planning and to charge material to a work order and asset. Materials management must also be integrated with finance to pass cost related information and record material expense in the general ledger.

In particular, ARRC departments identified some specific requirements:

- Reduction of institutional knowledge required in managing ARRC's replacement part inventories;
- Specific flagging of long lead time part replenishment;
- All parts and inventory consumed in maintenance activities (project, preventive, emergency, corrective or otherwise) on a specific asset (or location) be tracked and easily reported on;
- Tracking parts in the sites where they were installed (or if in a warehouse);
- Tracking inventory returns through a Return Merchandise Authorization (RMA) process;
- Track inventory as subcomponents of assets (such as cards and modules);
- Track signal and crossing software and firmware as inventory (or assets); and
- Maintenance plan data associated with assets.

Expected Benefits and Improvement Opportunities

Some of the benefits derived from implementing an asset management system with integrated materials management capabilities include:

- A single-source repository for materials management data improves accuracy and data management;
- Materials usage and expense are tied to work activities and to specific ARRC assets;
- Improved Materials Management performance leading to higher parts availability while reducing inventory investment;
- Demand based parts fulfilment reduces material shortages;
- Supply chain efficiency and improved timing of parts purchases;
- More effective ordering and replenishment processes;
- Tighter control of physical inventory leading to Increased availability of parts and lower inventory;
- Savings in inventory cost and carrying cost;
- Less shrinkage and obsolescence;
- Less time spent locating and expediting parts;
- Shorter ordering cycles; and
- Fewer stockouts.

3.2.8 Component Tracking and Rebuild

Description

Components are repairable items that are installed in parent assets. These items are repaired and re-installed, rather than being disposed of like other replaceable parts. Many ARRC assets contain repairable components that are assets themselves, such as engines, traction motors, trucks (bogeys), etc. These components rotate through a repair cycle:

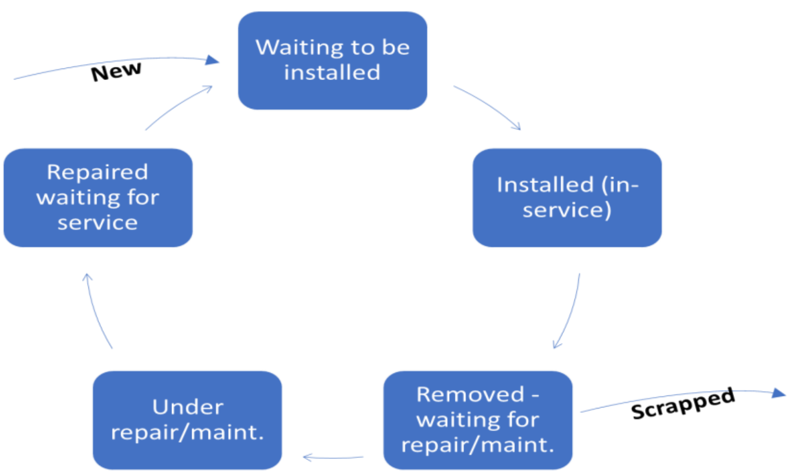


Figure 1 - Component Lifecycle

Components have their own repair history, inspection and maintenance programs, and lifecycle costs.

How ARRC Does This Now

As with ARRC's current usage of manual and Excel-based management tools for their assets, component tracking and rebuild data is managed using the same tools.

Functional Needs for ARRC

ARRC requires the ability to identify and track repairable components throughout their life, including:

- A history of their installation;
- Their current status in the repair cycle, including their parent (if installed) or their location (if waiting for repair or installation;
- Maintenance, inspection, and repair history;
- Lifecycle Costs; and
- Failure history.

Expected Benefits and Improvement Opportunities

Asset management systems provide functionality to track the usage, generate rebuild work orders, capture costs, and track inventory as well as failure rates and causes.

Effective component tracking and rebuild/repair information can lead to more informed and fact-based decisions, such as:

- Whether to repair or replace a component;
- Whether to repair internally or externally;
- When to optimally switch out a component;
- How many spares are required in the component pool; and
- When to purchase new components, and when to scrap existing components.

In addition, the ability to identify the status and location of all components results in more efficient implementation of modifications, improved on-time maintenance and inspections, easier fixed asset inventories, more efficient recall or disposal of specific component types, and more effective failure analysis for both the component and the parent assets.

3.2.9 Warranty Management

Description

Warranty management refers to maintaining information and terms for active warranty agreements, monitoring activity to highlight potential warranty situations, managing warranty claims, and tracking warranty dollars recovered. Warranties are applied at several levels, including assets, components, parts, and systems (e.g. electrical system or HVAC system).

How ARRC Does This Now

Although ARRC's step-by-step guidance for warranty related maintenance in the Mechanical Department includes use of JD Edwards enterprise resource planning (ERP) software, which integrates finance, accounting, supply management with a light-function maintenance tool, the maintenance processes and triggers are not automated and require manual and redundant processes.

ARRC's warranty process pertains to all assets maintained by the Mechanical department, including locomotives, passenger and freight railcars and heavy equipment. During any repair procedure, mechanical personnel must follow an established and manual warranty claim procedure.

The first step of the process is to determine if a warranty is applicable, and if so, confirm whether or not the warranty period has expired. Warranty research is manual and often coordinated with the supply management department's procurement section.

This process can be greatly reduced if an asset management system's inherent tools were utilized.

Currently, if a warranty is in effect, mechanical personnel must notify the supervisor to begin the warranty claim process rather than allowing for an asset management system to flag warranty work in an automated fashion.

Functional Needs for ARRC

In the arena of warranty management, ARRC indicates the following requirements:

- Track warranty contracts and terms against specific assets, components and certain stocked items in inventory;
- Identify potential warranty situation; and
- Support filing and tracking claims.

Expected Benefits and Improvement Opportunities

The benefits that can be expected in implementing an asset management system with integrated warranty tracking functionality are as follows:

- Automated flagging of maintenance activities where a warranty situation is present;
- Single source management of warranty contracts and terms;
- Efficiency improvements and reduction in labor resources required for activities on warrantied items, such as identifying, managing, tracking, and filing warranty claims;
- Automatic notification on warranties about to expire thus triggering warranty renewals; and
- Increase in dollars recovered from warranties.

3.2.10 Capital Projects and Campaigns

Description

Capital projects and campaigns are significant maintenance interventions that are beyond regular ongoing preventive and corrective maintenance. Projects may include major overhauls, major repairs, refurbishment, repurposing, and similar work either planned or unplanned (e.g. due to accidents). Campaigns refer to applying the same work or maintenance activity to a group of assets, such as to implement configuration modifications for a vehicle fleet, or to upgrade fare collection equipment to accommodate new fare media.

How ARRC Does This Now

ARRC currently stores and applies condition data and capital priorities manually or using Excel. Some assets classes utilize JD Edwards to some extent and some use Excel, but there is no comprehensive tool to create or track capital projects and campaigns.

Functional Needs for ARRC

ARRC requires support for identifying, planning, funding, and tracking the major maintenance interventions required to realize and potentially extend the useful life of its assets, and to ensure their fitness for purpose.

An asset management system must provide the capability to track all project and campaign activities and associate them to the appropriate individual assets in a manner and level of detail similar to regular on-going maintenance work. As with regular maintenance, ARRC requires complete and detailed tracking of the actual work performed, costs, and resources consumed for each action performed on each asset.

The asset management system must also support all regulatory information and reporting requirements.

Expected Benefits and Improvement Opportunities

Capturing capital project and campaign work provides a vital link in accumulating asset history and lifecycle costs. More detailed project data on condition, resources consumed, work performed, and costs leads to:

- More effective replacement analysis and asset retirement decisions;
- Increased utilization of assets during their life, and in some cases an extension of an asset's useful life;
- Improved performance and reliability;
- More efficient implementation of asset modifications and upgrades; and
- Improvement in project scheduling and on-time execution of major work, such as mid-life overhauls.

3.2.11 Timekeeping

Description

Comprehensive labor timekeeping beyond actual "wrench time", includes the capture of all time categorized into pre-defined work or pay codes. Non-work order time, such as preparation and cleanup, breaks, training, drug testing, etc. can be captured. In addition, absences, both planned and unplanned, are required to provide complete timekeeping data for individual asset management and maintenance personnel. Work order time can be further categorized, for example to capture travel time and to apply different labor rates based on personnel and category.

How ARRC Does This Now

ARRC's current timekeeping practices are not currently related to maintenance activities and in some cases can be described as manual, paper-based and occasionally redundant.

MOW field staff typically complete their work in the field for the day, return to their shops (or trucks in remote cases) and fill out their paper-based timesheet. The paper timesheets are then faxed or periodically physically transported to a centralized facility (or facilities) for review and input to JD Edwards.

All other staff complete JD Edwards time input, and this is sometimes updated with time and material data against work orders. Some departments also use RailDocs.

Hours of Service (HOS) rules exist that regulate the number of hours certain technicians can be in the field performing work-related activities, but only the Signal Department has a tool whereby HOS regulations can be enforced automatically.

As emergencies arise and a technician is required to go in the field and inspect, fix or mitigate an issue, Supervisors must manually reconcile their technician's availability to be called in without violating regulations.

Functional Needs for ARRC

The requirements uncovered in the interview process regarding timekeeping at ARRC include:

- The option to utilize labor time capture for payroll purposes. ARRC needs to develop and define its actual timesheet or interface goals during the detailed, specification-level requirements definition process;
- The ability to capture and classify both work order and non-work order labor time for all individuals so as to account for complete time coverage;
- An Interface with existing JD Edwards employee time entry functions (export asset management system time data such as cost codes, hours spent, and vehicle used) may be required;
- Ensuring a method to track between the covered and non-covered work in relation to HOS rules may be required;
    -

Expected Benefits and Improvement Opportunities

With the detailed definition of timekeeping requirements and the surrounding process improvements associated with those requirements, ARRC can expect benefits in the realm of:

- Paperless timesheet reporting provides increased efficiency and potentially fewer input errors;
- Greatly reduced "screen time" daily via the introduction of mobile technology;

4. Asset Management Systems and Peer Agency Comparison

4.1 Overview of Asset Management Systems in Public Transit

In the public transit industry, Asset Management systems originated as maintenance systems, primarily to store maintenance history on revenue vehicles and to track the availability of vehicles for the AM and PM peak service periods. The systems were largely custom developed and mainframe platform. For example, the Chicago Transit Authority's VMS (Vehicle Maintenance System) first developed in the late 70's was eventually ported to Los Angeles Metro (SCRTD at the time); and Tenera, which was developed for bus inspections and maintenance in the late 80's.

Early transit specific packages, such as Jakware for the IBM AS 400, and Fleetnet and Multisystems for the PC DOS environment, were targeted for smaller agencies. As more packages became available, many transit agencies added the capability to support facilities maintenance, usually with a separate software package. This mixture of custom developed systems and early packages formed the first wave of automated asset management support in public transit.

As the software industry has progressed, larger and more comprehensive Computerized Maintenance Management Systems (CMMS) either grew out of the early packages (for example Tenera became Spear) or were developed specifically for maintenance management, such as The System Works (TSW, now Indus), M4, Ultramain, Datastream, and others.

Many agencies implemented CMMS software to expand work order processing and inventory management capabilities, and to improve reporting and access based on new technology such as relational databases and advances in communication infrastructure.

In addition, ERP software became an option for transit maintenance, such as SAP, Oracle Applications, Lawson, JD Edwards, or Mincom Ellipse. However, ERP systems which were originally developed for manufacturing and distribution companies are often a difficult fit for public transit, and agencies experienced mixed results in utilizing this software for maintenance and materials management.

Appendix A documents the evolution of "work focus" CMMS to "asset focus" Enterprise Asset Management (EAM) systems. The asset focus provides much greater functionality with respect to hierarchy (parent-child relationship), asset inventory and reference, condition data, life cycle costing, reliability and performance, and reporting, among others.

The current trends in EAM systems in transit are driven by the increasing recognition of asset management as a focal activity in achieving transit organizational objectives, the emergence of international standards for asset management practices (such as PAS 55 and ISO 55000), the enactment of MAP-21 legislation and FTA's Final Rule requirements in asset management, and the ever-continuing advancement of technology. Traditional CMMS are evolving to provide the features and functions necessary to support full lifecycle asset management. The next section provides a snapshot of how selected peer transit agencies are addressing these changes.

4.2 Peer Agency Comparison for Asset Management

The following chart displays ARRC's current usage of tools to manage assets within the organization:

Agency	EAM/CMMS	ERP	Supporting Software	Decision Support
ARRC	N/A	JD Edwards	Signals: RailDocs Facilities, IT Equipment: Flagstop, LanDesk Communications: WebHelpDesk Culvert Inspections / Equipment Outages: Survey 123, Excel, Paper GIS: ESRI	Excel

Table 2 - ARRC Agency Profile

ARRC does not currently manage assets through the utilization of an EAM software solution. JD Edwards, the Enterprise Resource Planning software, is currently being used as a CMMS; which is providing basic, high-level, work order functionality. A majority of work order and project tracking, reporting, analysis and decision-making is being conducted using Excel or other manual based tools.

In comparison, the table below describes how other peer agencies compare in relation to utilizing asset management and ancillary support systems.

Agency	EAM/CMMS	ERP	Supporting Software	Decision Support
BART	MAXIMO (IBM)	PeopleSoft (Oracle)	Track: Track Conditioning Index TCI tool Linear Assets: Optram (Bentley)	TERM Lite
Maryland MTA	MAXIMO	PeopleSoft (Oracle)	Linear Assets: Optram Structural: InspectTech (Bentley) Fixed Assets: FMIS	TERM Lite
METRA	MAXIMO	Microsoft AX	Signal Assets: ServiceMAX (converting from RailDocs) Materials Management/Usage/Procurement: ERP + ServiceMAX Labor Tracking: METRA WO system, Kronos Document Storage: Project Wise GIS: ESRI	COST (TERM Lite), SGR database
SEPTA	Trapeze Asset Works – FA Suite	GEAC (Infor)		SGR Database

Agency	EAM/CMMS	ERP	Supporting Software	Decision Support
LA Metro	Spear v4i M3, MP2	EBS (Oracle)	Facilities, Stations, Vehicles: M3 Systems: Partially in M3 Rail Linear Asset Module of M3 not implemented. ITS assets not in M3 Structural: InspectTech (Bentley) Fixed Assets: FMIS	TERM Lite
Sound Transit	Trapeze (EAM)	JDE	Track: Conditioning Index TCI tool Facilities: Facilities PM	TERM Lite
MBTA	EAM	PeopleSoft	Optram, Excel, GIS: ESRI, Paper	Excel
SCCRA	EAM	Oracle	Bridges, Signals, Systems: Rail Asset Management Systems (RAMS) Facilities: Net Facilities PTC: Rational Suite, IBM, Jazz Manual for Track, some signals and structures	
MARTA	EAM	Oracle	Linear Assets: Optram Reporting: Oracle Business Intelligence	
Hampton Roads	EAM	Microsoft Dynamics	Fuel: FleetWatch	TERM Lite SGR Database (condition only)
Florida East Coast Railway			Invoices, Asset Tracking: TMS (AS400) Load status/Location: OASIS Work: SAS/Excel:	
Aurizon	FMMS	SAP	Reliability Centered Maintenance: FMECA Inspection/Health Monitoring: ATS/LINESUM/RMS/AMS Track Recording Car/Tie Inspect, Other: TEAR, Remedy and Link One	

Table 3 - ARRC Peer Agency Profiles

Compared to its listed transit peers, ARRC is the only agency represented that does not utilize an industry proven asset management system or decision support tool to manage their assets. All agencies listed, including ARRC, do utilize an advanced ERP system; however, it is believed that ARRC is the only agency listed that relies on their ERP system to support core financial functions as well as also attempt to serve core asset management functions. In this regard, ARRC trails their peers in adopting a true asset management system that works in conjunction with their ERP system to provide more advanced asset management capabilities, data workflow and reporting, and system integration.

It should also be noted that all peer agencies listed utilize a modern EAM product or suite of fit for purpose products, and do not rely on less advanced maintenance management or work order systems to manage their assets.

5. Asset Management Technology Options and Recommendation

5.1 Asset Management Technology Options

This section describes potential options/paths forward to leverage technology and improve Asset Management activities within AARC. The options presented below detail multiple paths forward, all of which have unique characteristics that need to be analyzed before identifying the option that best fits the needs and characteristics of ARRC:

Option	Description	Pros	Cons	Implementation Attributes
A	Status Quo: Continue using current processes and tools.	No upfront costs No disruption to organization No project implementation risk	Will not support full lifecycle asset management JDE, as an ERP system provides limited work and asset management benefits to ARRC Unrealized long-term cost benefits Unrealized efficiency gains Difficult to adhere to Federal standards Limited ability to support maturing asset management practices	Upfront Cost: None Effort: None Return On Investment (ROI): N/A
B	Continue using JDE, but invest in additional configuration modification to utilize JDE more efficiently	Leverage current technology in place Some improvement in asset management functionality	Modifications will not provide adequate asset management functionality to support ARRC asset management Only marginal gains in efficiency and cost	Upfront Cost: Low Effort: Low ROI: Low
C	Hybrid Model: Implementing multiple fit-for-purpose solutions by department	Potentially lower implementation complexity for some functions Can be implemented modularly based on individual department Solution will potentially provide	Ensures/promotes fractured management and reporting of asset management data for the foreseeable future Siloed systems with little or no integration Introduces the need for the procurement and maintenance of middleware to integrate asset management systems	Upfront Cost: Medium - High Effort: Medium - High ROI: Medium

Option	Description	Pros	Cons	Implementation Attributes
		adequate functionality for each department Allows ARRC to select the “Best of Breed” for each function Modest realization of system benefits within in shortened timeline	More IT resources required with a complex mix of skills to support multiple software packages Separate contracts, licenses, and terms to manage and enforce with potentially higher cost	
D	Implement a robust CMMS tool	Allows for realizing a central repository for asset management data May be able to realize a significant portion of ARRC’s asset management goals Provides an integrated central solution Slightly easier implementation with potentially less risk than a full EAM	System functionality limitations, such as linear asset and other management tools, likely not available Does not provide true enterprise wide-tools/capabilities Does not provide visibility into business related practices, such as capital planning, project management, whole-life costing, trend analysis, etc. Will require supplemental manual/Excel systems to “fill in the blanks” in functionality Potentially implementing an older generation system.	<u>Upfront Cost:</u> Medium - High <u>Effort:</u> Medium - High <u>ROI:</u> High
E	Implement EAM solution	True, comprehensive solution in the asset management arena Highest ROI over time Potentially the highest level of ARRC requirements met	Potential for underutilization Highest up-front cost option More complex undertaking and highest implementation risk	<u>Upfront Cost:</u> High <u>Effort:</u> High <u>ROI:</u> High

Option	Description	Pros	Cons	Implementation Attributes
		Viable, long-term solution (20+ years) Integration of EAM tools allows for efficient reporting to Federal agencies Exploits the utilization of the most advanced asset management tools and technology		

Table 4 - Asset Management Technology Options

5.2 Recommendation

ARRC should replace its current asset management systems with a new asset management solution that provides comprehensive support for its current asset management needs and that has the flexibility to be configured for future direction and growth as ARRC's asset management practices mature.

Existing systems present at ARRC do not have the capability of adequately supporting ARRC in asset management, and attempts to upgrade, supplement, or reconfigure an architecture with JD Edwards as the primary EAM system will only have limited benefits that will most probably be insufficient. In order to determine the ultimate technology tool(s) and asset management solution that best fits its organizational needs, ARRC should conduct a systematic and strategic approach based on the development of detailed functional and technical requirements.

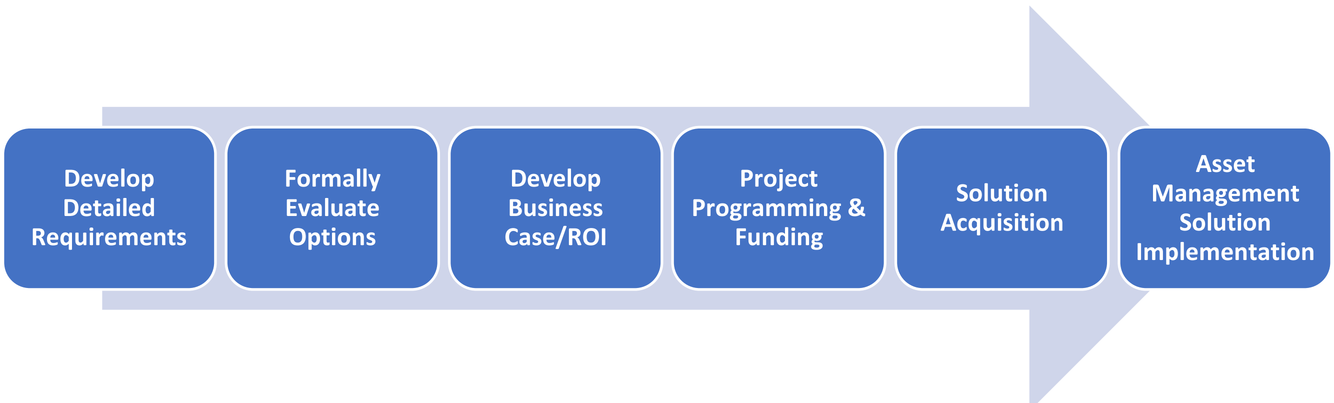
The requirements should be complete and thorough, covering all departments within the organization, and clearly articulate at a line item level the specific needs and requirements that ARRC has for asset management support from an operational, business process, and regulatory compliance perspective. Technical considerations include security, performance, reporting, user interface, integration, work flow, and data storage requirements.

The capabilities of the potential asset management system solutions identified in the previous section can be compared to the detailed requirements and the specific gaps can be identified. This exercise will highlight the requirements that can and cannot be met by each solution and will give ARRC a fact-based assessment of the best fit for the organization. Other factors such as integration, flexibility, scalability, risk, and cost can also be assessed more accurately based on detailed requirements. ARRC will be able to select the best option and build a business case justification using projected benefits, cost, and risk.

6. Next Steps for Improving Asset Management Technology and Operations

It is the recommendation of the Project Team that ARRC follows the roadmap identified below in order to determine their true asset management system needs so that ARRC can appropriately evaluate options available to them based on functional and technical requirements. This roadmap provides a path forward for ARRC to best select and implement an option for improving their asset management systems and technologies and to improve their asset management operations across the agency.

The roadmap for successfully rolling out asset management solutions includes developing ARRC's detailed requirements for asset management support, evaluating the options for improvement against the requirements to identify the best option, justifying the selected option through a business case and Return on Investment (ROI) analysis, developing an RFP to acquire and implement the selected solution, as illustrated in the following phases:



The following sub-sections provide a general overview of each phase of this system delivery model. It is recommended that ARRC follow this general approach in order to identify a technology solution that provides the best form, fit, and function for the agency.

6.1 Phase 1 - Requirements Development

The first task is for ARRC to formally document, in detail, what features, functions, and information the agency requires from an asset management system. These requirements should be based on business, operational, and regulatory need and should be independent of any specific asset management solution. Requirements should specify how the system must support existing practices, as well as the capabilities needed to implement ARRC's future direction and plans. Requirements should not be constrained by how the agency currently conducts business.

Requirements are generally organized by major asset management and materials management function similar to those in section 3.2 of this document. In addition to functional requirements, technical requirements should also be defined. These are general requirements that impact the entire system, such as security, reporting, dataflow, interfaces and integration, technical performance, user interface, data storage and retrieval, etc. Finally, all requirements should be assigned a priority, such as essential (high priority), desired (medium priority) or optional (low priority).

6.2 Phase 2 – Options Evaluation

In the options analysis phase, ARRC should formalize the scope of each solution option presented in Section 5 of this document, and perform a gap analysis examining how each option can meet the functional and technical requirements. Each option is evaluated requirement-by-requirement to identify the requirements met by the option and those that the option will not meet. Further, an evaluation of "how well" the requirement is met considers the user interface and the effort needed to meet the requirement. The ability to meet a requirement well results in a higher score than just meeting a requirement or not meeting it at all. Other evaluation factors, such as complexity, risk, cost, use of modern technology, cost, etc. should be identified, weighted and applied to each option. The result will identify the asset management solution that best meets ARRC's requirements. The gap analysis also includes comparing the functionality currently present in ARRC asset management systems and technologies against the requirements. The outcome of this exercise would provide ARRC with an accurate understanding of how their current asset management systems and technologies compare against the true needs of the agency, and how well ARRC's core asset management activities are being conducted, monitored, and supported by technology.

6.3 Phase 3 – Business Case Analysis/ROI

The purpose of this phase is to establish the business case and justification for the selected asset management system solution. ARRC should identify potential costs and quantified benefits of the selected asset solution, and estimate the long-term Return on Investment (ROI) to the agency. Qualitative costs, benefits, and risks will also be considered. Cost estimates should be based on the scope of the selected solution, and include full lifecycle costs of ownership, such as procurement of hardware and software, implementation, support, and maintenance of the selected option. This provides ARRC with a general understanding of the full costs associated with their selected option so that they can plan funding for the project appropriately, and plan for operating budget impacts after implementation.

During this phase ROI analysis would be conducted, identifying how the selected option will benefit ARRC long-term from a financial perspective; identifying the anticipated benefits of the system and sources of financial savings.

6.4 Phase 4 – Project Programming & Funding

In this phase, ARRC establishes the acquisition and implementation of the selected asset management system solution as a formal funded project. This phase involves finalizing the scope and procurement strategy for the solution, finalizing the estimated cost and budget, and gaining the appropriate approvals. Deployment strategies, such as on-premises, hosted, SaaS, etc., are evaluated and finalized, leading to a finalized cost and budget. Project evaluation gates are cleared, and approvals gained based on ARRC's capital programming procedures. At the end of this phase, ARRC is ready to move forward to procure and implement the selected solution.

6.5 Phase 5 – Solution Acquisition

This phase is ARRC's solicitation and procurement process to acquire the software, hardware, professional services, and any other equipment and services required to fully implement the selected asset management system solution. This include finalizing procurement methods and strategies, developing RFP(s), conducting the solicitation, and selecting and awarding the contract(s).

6.6 Phase 6 – System Implementation

Phase 6 is the implementation of the new system based on the procured products and services, and is the last project phase. At the end of this phase, the new solution is in production, ARRC staff trained in its operation, and contracts are in place for on-going maintenance and support.

Appendix A – State of the Art – EAMs

From Work-Focus to Asset-Focus Systems

EAM software has continued to expand and add features beneficial to transit agencies. EAMs have evolved from simple maintenance work order processing systems to full featured systems capable of planning, scheduling, managing, monitoring and recording all work activity and resources (labor, material, tools, shop equipment, budgets, etc.) related to asset operations and maintenance.

This activity covers inspections, preventive maintenance, breakdown maintenance, overhauls/rehabs, campaigns, and other projects, as well as monitoring selected operating activity.

In addition, these systems provide the information needed to identify, analyze, and address equipment failures, maintenance efficiency, maintenance history, materials management and supply chain, cost and budget control, and labor time reporting.

The systems store the basic asset information needed to support other functions, including component tracking, rebuild management, and asset configuration management. Generally, the EAM systems have expanded interfaces to include not only ERP and financial/HR systems, but GIS, SCADA, transit operations and dispatch, fuel dispensing, and similar systems that provide or use asset status, defect/failure, and operating information.

Figure 2 - Work Management Functions

Increasingly, mature transit asset management programs are requiring more sophisticated support for asset management activity. As a result, EAM systems which have traditionally been focused on "managing work" are evolving into systems capable of focusing on "managing assets".

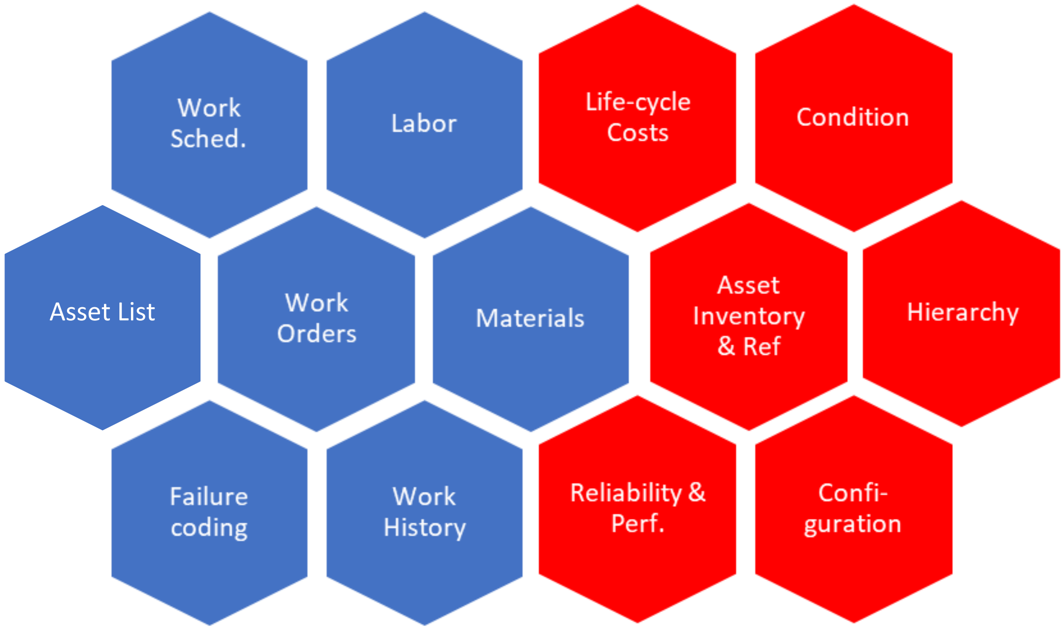


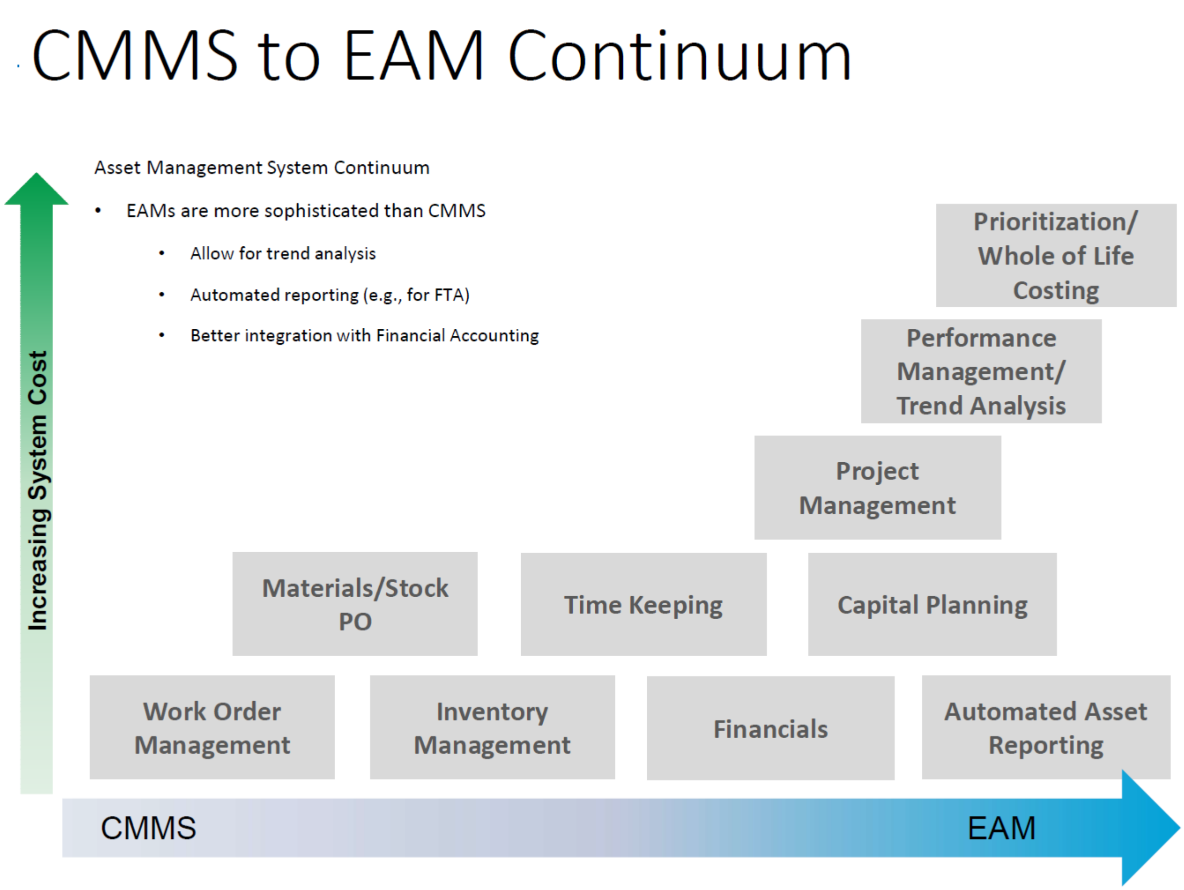
Figure 3 - Advanced Asset Management Functions (EAM)

Although EAMs continue to expand and improve work management capabilities, these systems are also adding capabilities to support industry standards in transit asset management, for example:

- **Expanded Asset Inventory & Information.** Although EAMs have long been the system of record for physical assets and equipment (not to be confused with financial fixed assets), most systems historically only stored the basic identification and descriptive characteristics for assets needed to support work management. EAMs are expanding the ability to store comprehensive asset information for each stage of the asset lifecycle, including allowing the flexibility for users to define information requirements based on the asset class and type. Moreover, EAMs support users in maintaining accurate asset inventories, including the ability to add assets and modify asset data remotely or on-site during asset inspections and maintenance;
- **Complex Asset and Location Hierarchies.** The capability to define complex asset parent and child relationships to multiple levels, including handling several types of sub-assets such as assemblies, sub-assemblies, serialized and non-serialized components, etc. "Network" type hierarchies are also possible where a child asset may belong to multiple parents depending on the user context (for example, a train control circuit may be a child of a control room of the train control system and at the same time be a child for a station infrastructure location). In a similar manner, complex asset location hierarchies allow users to define asset location using multiple methods to support different user needs, and to allow flexibility when tying assets to locations;
- **Asset Configuration Management.** The capability to (1) define acceptable asset configurations specifying the components and parts (including software versions) that make up an asset and the rules that govern the configuration; (2) allow multiple models, revisions, and variations to the base configuration; (3) track the specific components, sub-assets, and parts that are currently installed on any asset at a specified point in time; and (4) enforce the configuration rules and identify assets that are not in compliance;

- **Condition Assessment/Condition History/Asset Degradation.** The capability to record condition ratings and maintain condition history for each asset using several methods, e.g., asset age or remaining life, asset measurements or meter readings, automated diagnostics, visual inspection and entry, performance measures, etc. ; to allow users to review and analyse asset degradation related to condition measures and to implement condition based maintenance; and to monitor asset condition and automatically trigger defects, work orders, or inspections based on breached tolerances;
- **Reliability & Performance.** The capability to define, track, and report on quantitative reliability and performance measures for asset types and classes, and to monitor and analyse reliability and performance of individual assets;
- **Lifecycle Costs.** The capability to capture individual asset costs at all stages of the asset lifecycle, including design and acquisition costs, operations and maintenance, overhaul/rehab, engineering modifications, and disposal costs;
- **Rehab/Refurbish/Overhaul Programs (Major Capital Maintenance).** The capability to identify, plan, and prioritize major asset capital maintenance based on condition, reliability and performance, age, asset criticality, cost, and other factors. Extending work order processing to cover major capital maintenance on assets, including work on individual assets, as well as projects and campaigns that target large numbers of assets (such as mid-life overhauls for vehicles); and
- **Asset Transitioning.** The capability to accommodate the import of data for new assets from contractors and other systems, and to manage and control the asset commissioning process and the asset decommissioning and disposal processes.

The following chart illustrates the evolution from CMMS to EAM:



Leading EAM Software

There are a handful of software packages that are leading the software industry (Tier 1) in the development of comprehensive EAMs. In particular, the following software packages have emerged as leaders in asset management support for public transit:

- Trapeze EAM (formerly Asset Works);
- IBM Maximo; and
- Infor EAM (formerly Spear).

There are other alternatives; however, these leading software packages are currently being selected most often by transit agencies. Some alternatives, mostly Tier 2 solutions, include:

- SAP;
- Oracle eAM;
- Ellipse EAM;
- AgileAssets;
- RouteMatch;
- ThingTech; and
- Loc8.

Specialty and Supporting Systems in Transit Asset Management

In addition to the advancement of major EAM Systems, there are several specialty systems that supplement or expand the state of the art in automated EAM support. EAM Systems are integrated with these systems to automatically exchange information based on pre-defined conditions and triggers. Examples of these systems include:

- Geographic Information Systems (GIS) – provide the capability to view and analyse data (such as asset condition, failures and defects, and work orders) geographically using maps and other spacial representations.
- SCADA – automated monitoring and telemetry systems capable of detecting and reporting condition, measurements, faults, and other asset operations and status information.
- Automated data collection systems – to electronically capture specific types of asset data that can be imported into EAMs, such as condition and fault data, measurements, operating meter readings, failures, or asset characteristics. Examples include rail geometry cars, remote monitoring systems for fare collection equipment and escalators, on-board vehicle diagnostic systems for buses and rail cars, rail truing and wheel press software, etc.
- Asset Degradation Modelling and Analysis – to model the rate of deterioration and degradation of assets and project asset condition in the future based on time and operating data, for example to project rail wear, pavement deterioration, structural fatigue, etc.
- Decision Support Systems – to support the analysis of alternatives based on user defined criteria and priorities, for example prioritization of projects for capital spending.
- Asset Specific Inspection Programs – provide more detailed information, measurement points, built-in tolerance checks and other guidance for supporting the inspection of a specific asset type. For example, building inspections and measurements based on Building Information Modelling (BIM), bridge inspection programs based on industry tolerances, or rail turnout and switch-point inspections based on railroad safety standards.

- Yard Map/Lot Map and AVL – automatically locate and track assets (primarily vehicles) in yard and lot storage locations, as well as in maintenance shops. Graphically display asset location and status. Some EAMs are developing this capability internally.
- Scheduling and forecasting – various software to assist in forecasting resources (material, labor, etc.) and scheduling work. EAMs are also developing this capability internally.
- Inventory Optimization – to analyze inventory usage and demand and develop the optimum stocking levels and replenishment parameters (such as safety stock, min/max levels, order quantities, etc.).
- Product Lifecycle/Product Data Management (PLM/PDM) – to track the engineering design, specification, modification, and enhancement of assets throughout the asset life.
- Automated Time Capture/Time Clock – includes various devices to capture labor time, for example clock-in/clock-out to a work site and job-on/job-off to work orders.
- Data Warehousing, Analysis, and Reporting – independent software to extract, translate, and load data for the purposes of complex analysis, query, and reporting.

Summary of Best Practices in Transit EAMs

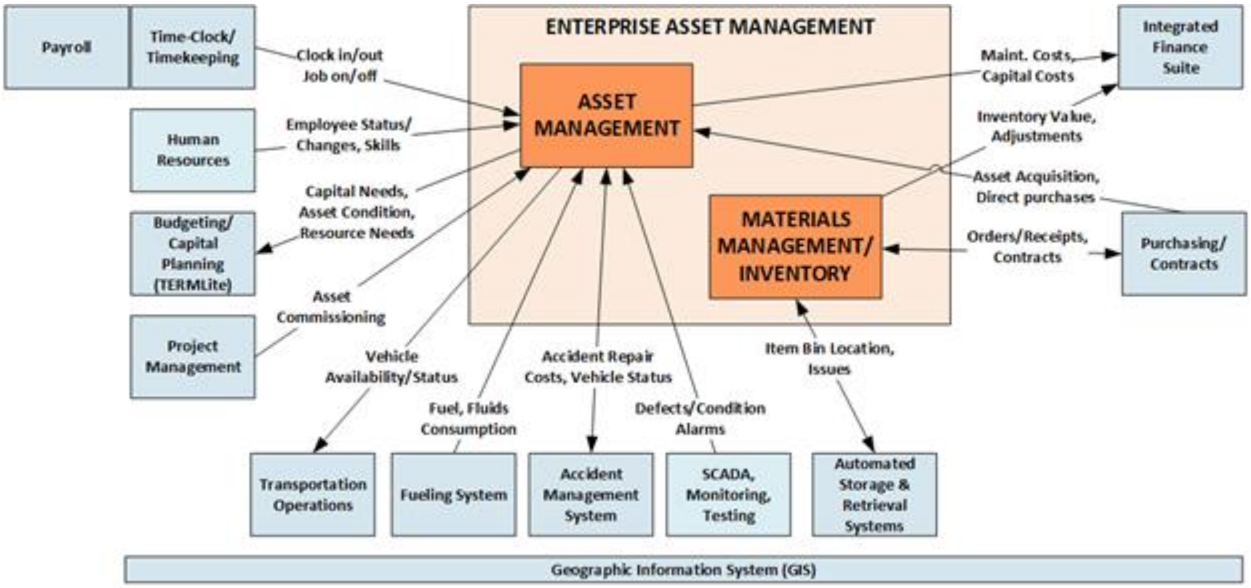
As public transit agencies move toward the state of the art in asset management systems, several trends and patterns emerge in practices that significantly impact the successful deployment and utilization of EAMs and supporting systems and enhance the benefits realized by the agency's stakeholders. These represent the industry's "best" practices. Although no particular agency adheres to all best practices, the following characteristics have been identified based on the body of experience in public transit:

- Automated EAM system support consists primarily of one central fully integrated EAM software package that supports full asset management capabilities for all asset classes and types: rolling stock, facilities, right of way infrastructure, bridges and structures, fare equipment, escalators/elevators, communications systems, train control systems, etc.
- The EAM contains separate modules, configured instances, or integrated products that are designed to meet the requirements of specific asset classes. This allows the EAM to provide standard organization-wide asset management functionality while meeting the unique needs of each asset class. Typical asset classes with special needs are rolling stock (revenue and non-revenue vehicles), linear assets (in particular rail, power distribution and other right of way assets), repairable serialized components, facilities/buildings, bridges and structures.
- The primary EAM software package is supplemented by a small number of specialty programs targeted toward specific functions or asset groups, such GIS, SCADA and built-in equipment monitoring and diagnostics systems, Rail Geometry Car systems, specialized analytical programs, and decision support software. In some cases, EAM functions such as inspections or work scheduling are extended through specialized front-end systems that feed the results into the EAM.
- The EAM is the system of record for material inventory and includes comprehensive materials management and supply chain management capabilities. There is seamless integration between all systems involved with the supply chain and procure-to-pay cycle (requisitioning, ordering, receiving, and paying).
- Automated interfaces are in place between the EAM, supporting systems, and other major agency software. EAMs automatically (transparent to users) exchange information with the agency's finance/purchasing, human resources, transportation operations (Scheduling/AVL/Dispatch), document management, and project management systems.
- Mobile technology is used to support both field and shop activity and to improve efficiency and effectiveness of asset management functions. Data is captured at the source and information is provided at the point of use. Electronically readable media (bar code, RFID) is used where appropriate to speed data entry and reduce errors. Mobile computing makes full use of modern devices (tablets, hand-held

scanners, smartphones, etc.) and effectively matches the most appropriate device to the function being performed. Typical functions supported by mobile technology include inventory functions (stock transactions and receiving, cycle counting), work order processing (asset/location ID, time and data capture), component tracking (asset ID and install/remove transactions), and asset inventory (asset/location ID).

- EAMs, along with supporting systems like GIS and yard/lot maps, make liberal use of visual graphics to support asset management functions, such as maintaining track charts, displaying asset hierarchies, drag and drop jobs to adjust visual work schedules, manage vehicle movement through maintenance shops, locate assets geometrically and manage access (e.g. to right-of-way or to buildings or tunnels, etc.).
- Major EAM implementations, upgrades, replacements and/or modifications are accompanied by business transformation and re-engineering activity that re-designs business processes to most effectively utilize new system capabilities to perform asset management functions. Business process changes are validated and documented, and re-training is provided based on the organizational impact of the changes. Periodic ongoing evaluations of EAM business processes helps mitigate changes in staffing, and ensure that EAM systems continue to be utilized to their full effect.
- Dedicated system support is provided in IT and in user departments for the EAM and all related software. IT support consists of help desk type technical and functional assistance. Departments utilize "super-users" to provide the first line of support for departmental users.
- External user query, analysis, and reporting tools are provided to allow users to access, manipulate, and report on data independent of IT.
- Although not an absolute requirement, the majority of EAM software is hosted by the transit agency and exploits the latest database, communications, and operating system technology, including mobile systems like Android and iOS. Hosting provides the maximum control for the agency over the computing environment reliability and performance.

The following chart shows the full context of an EAM in a typical public transit environment:


ENTERPRISE ASSET MANAGEMENT
ASSET MANAGEMENT
MATERIALS MANAGEMENT/ INVENTORY
Payroll
Time-Clock/ Timekeeping
Clock in/out Job on/off
Human Resources
Employee Status/ Changes, Skills
Budgeting/ Capital Planning (TERMLite)
Capital Needs, Asset Condition, Resource Needs
Project Management
Asset Commissioning
Vehicle Availability/Status
Fuel, Fluids Consumption
Accident Repair Costs, Vehicle Status
Defects/Condition Alarms
Item Bin Location, Issues
Transportation Operations
Fueling System
Accident Management System
SCADA, Monitoring, Testing
Automated Storage & Retrieval Systems
Integrated Finance Suite
Maint. Costs, Capital Costs
Inventory Value, Adjustments
Asset Acquisition, Direct purchases
Orders/Receipts, Contracts
Purchasing/ Contracts
Geographic Information System (GIS)