



2016 Metro Lifecycle Management Plan



Providing safe, efficient and reliable transit across Maryland with world-class customer service.

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1 Document Control

1.1 Table of Revisions

Rev. #	Date	Page #	Section	Description

1.2 Guidance Office & Distribution List

1.2.1 Guidance Office

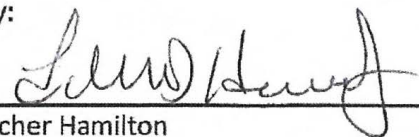
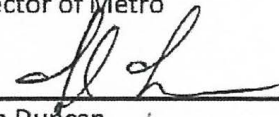
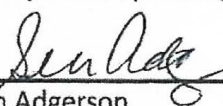
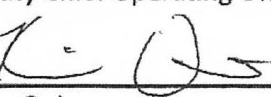
Office of Planning & Capital Programming

1.2.2 Distribution List

Name	Position
Paul Comfort	Administrator & CEO, MTA
John Duncan	Senior Deputy Administrator & Chief Operating Officer
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Steve Silva	Deputy Chief/ Chief Engineer, Office of Engineering
Bernadette Bridges	Chief Safety Officer, Office of Safety Quality Assurance & Risk Management
Heidi Tarleton	Deputy Director, Office of Finance
Anna Lansaw	Director, Office of Procurement
Fletcher Hamilton	Director of Metro
MTA ProjectWise	Global Electronic Distribution: <u>pw:\\mtapwint2:MTA PW Data\Documents\07 - Core Operations & Modes\Metro Operations\100 - Metro Shared\Metro Life Cycle Management Plan (LMP)\</u>

1.3 Signature for Authorization

Approved By:

x  Fletcher Hamilton Director of Metro	4/26/16 Date
x  John Duncan Deputy Chief Operating Officer – Core Operations	3-15-16 Date
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2 Introduction

2.1 Scope and Purpose of this Lifecycle Management Plan

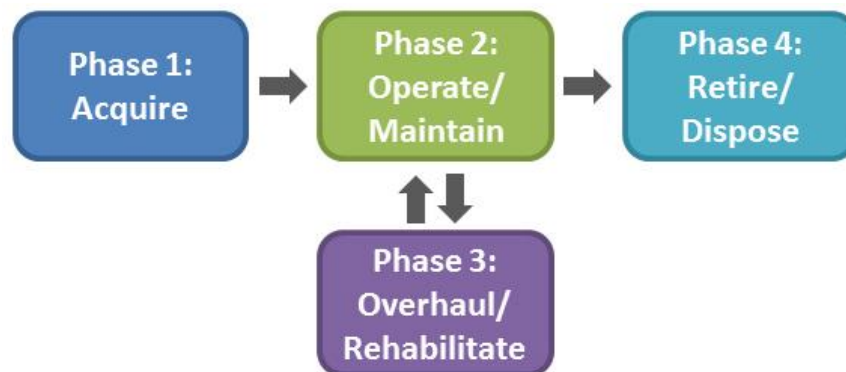
This Lifecycle Management Plan (LMP) has been created for MTA's Metro mode to document existing business processes, and to strategically plan for enhancements to those processes. This LMP outlines how Transit Assets are managed by each Metro across all lifecycle phases. This document has also been created to help attain broader asset management objectives set by the Maryland Transit Administration in its Transit Asset Management Plan (TAMP), and fulfill a variety of grant management, performance management, and reporting requirements established under the *Moving Ahead for Progress in the 21st Century (MAP-21) Act*.

Lifecycle Management Plans provide a number of key benefits, among them:

- Preserving institutional knowledge by documenting current practices;
- Providing mode-specific asset management best practices;
- Helping to better-informed investment decisions; and
- Improving cross-department coordination.

This LMP documents all management practices surrounding Transit Assets in the Metro system, but does not currently detail those assets managed by other departments, such as guideway elements and elevators which are currently managed by the *Office of Engineering* and *Office of Operations Support*, respectively. Furthermore, this document focuses on all business processes surrounding the four lifecycle phases of a Transit Asset:

Figure 2.1 - An asset's lifecycle, or the four phases over an asset's life.



This LMP does not describe administrative and human resource-related processes unless they directly impact cost, risk, or performance of Metro's Transit Assets.

2.2 Document Structure

The structure of this document follows the LMP standard outline found in *Appendix E* of MTA's Transit Asset Management Plan (TAMP), and based on the structure proposed in FTA's Asset Management Guide (Report No. 0027, dated October 2012). In general, information is presented for the Metro mode as a whole, but where appropriate, information is broken down by asset categories and classes, as described in Section 3.5.

Hyperlinks are embedded throughout this document for related policies, plans, and procedures that are stored on MTA's ProjectWise document management system. The ability to access these documents will be limited by individual user rights, but supervisors may request authorization for anyone with limited access.

2.3 Relationship of this Document to Other Plans

The *Office of Planning and Programming* and the *Office of Safety Quality and Risk Management* (OSQARM) facilitates the development of MTA's TAMP and the System Safety Program Plan (SSPP), respectively. LMPs were drafted to help meet the broad objectives outlined in MTA's TAMP and SSPP, while aligning with other policies, plans, and procedures at Metro and does not supersede those documents.

2.4 Key Definitions

Asset (Definition used by MTA Office of Finance: 2015)

Land, land improvements, buildings, building improvements, and capital equipment typically greater than \$250 in value. Any high theft item or easily concealable item having a value under \$250 may also be capitalized for their sensitive nature or issues. The term does not include materials, supplies, and non-capital equipment. *See definitions of Land Asset, Transit Asset, and Critical Asset below for disambiguation.*

Land Asset

A subset of the term "Asset." A developed or undeveloped plat owned or leased by the MTA. *See definitions of Asset, Transit Asset, and Critical Asset for disambiguation.*

Transit Asset

A subset of the term "Asset." A depreciable physical Asset required to support transit service either directly or indirectly, including vehicles, stations, facilities, guideway and systems Assets, whether mobile or fixed. Transit Assets may be tracked down to the sub-system level except for guideway assets, which should be tracked at the component level. Transit Assets do not include land, spare parts, or office furniture. *See definitions of Asset, Land Asset, and Critical Asset for disambiguation.*

Critical Asset

A subset of the term "Transit Asset." A Transit Asset having the potential to substantially impact safety or reliability of the transit system upon failure. Criticality will be calculated using the capital investment prioritization scores used by TERM Lite by Transit Asset type. TERM Lite prioritization scores are calculated on a 1-5 scale across four categories: asset condition, reliability, safety and O&M cost impact. To calculate asset criticality, the reliability and safety scores will be multiplied; if the product of this calculation is greater than or equal to 12, the asset will be considered critical. Critical Assets will be identified by asset type within each LMP and the MTA Transit Asset inventory alike. *See definitions of Asset, Land Asset, and Transit Asset for disambiguation.*

Asset Owner

Generally refers to the agency staff or department responsible for the inspection and/or maintenance phase of a Transit Asset's or Land Asset's lifecycle. For non-revenue vehicles allocated to a mode, the Asset Owner will be the agency staff or department dependent upon these Transit Assets.

Environmental Sustainability

Minimizing the impacts of MTA operations on air, land, water, and human health such that needs of the present are met without compromising the ability of future generations to meet their own needs.

Lifecycle

The time interval that begins with identifying the need for a Transit Asset or Land Asset, and ends with the disposal of the Transit Asset or Land Asset. Lifecycle phases may include planning, design, procurement, construction, operations, maintenance, rehabilitation, and asset replacement/disposal.

Lifecycle Management Plan (LMP)

A department/mode-specific TAM plan. An LMP describes performance measures and targets aligned with the commitments established in the TAMP, strategies for delivering these performance targets, and other mode/department-specific approaches to continually improve management of its Transit Assets and Land Assets over their lifecycle.

Maintenance (disambiguation):

Scheduled Maintenance – A form of preventive maintenance, regularly Scheduled Maintenance improve an asset's condition, avoid future failures/breakdowns, and assure that it reaches its design life.

Corrective Maintenance – Unscheduled Corrective Maintenance conducted in response to asset failure or detected fault so that the asset can be restored to an operable condition.

Maximo

Maintenance and inventory management software developed by IBM and purchased by MDOT for use among all modal administrations. While the use of Maximo varies mode-by-mode, MTA generally uses this software for scheduling inspection and maintenance activities, and spare parts inventory ordering.

State of Good Repair (SGR)

When the physical condition of a Transit Asset is at or above 2.5 according to the Federal Transit Administration's (FTA) numerically based system for evaluating Transit Asset conditions: 5 (excellent), 4 (good), 3 (adequate), 2 (marginal), 1 (poor). Obsolescence of a Transit Asset may constitute a "poor" condition rating. *Subject to change based on forthcoming FTA definition.*

State of Good Repair (SGR) Backlog

The cumulative dollar value of deferred Transit Asset maintenance and replacement needs.

TERM Lite

An MS Access-based decision tool provided by the FTA for estimating SGR Backlog, annual capital investment needs, current and future asset conditions, and capital investment priorities over a 20 to 30 year time horizon. TERM Lite produces these analyses for the MTA based on complete and comprehensive Transit Asset inventory data.

Transit Asset Management (TAM)

A total business approach through which an organization acquires, operates/maintains, rehabilitates, and disposes of Transit Assets and Land Assets to manage their performance, risks, and costs over their lifecycle to achieve the commitments made in the TAMP.

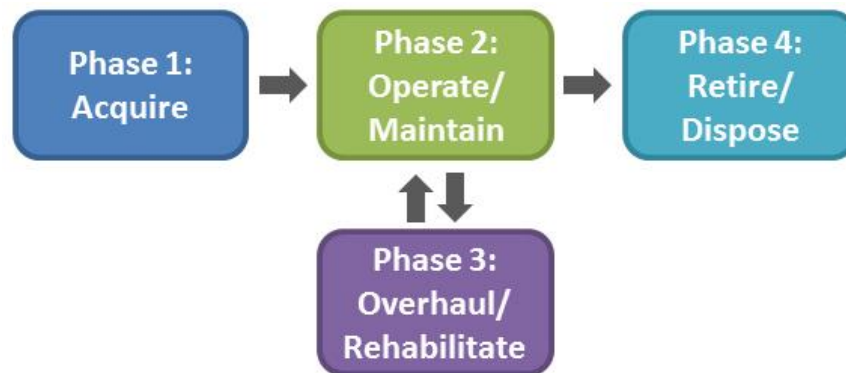
Transit Asset Management Plan (TAMP)

This document describes agency-wide TAM objectives, performance measures, and targets; strategies for delivering these performance targets, and other agency-wide approaches to continually improve TAM practices. While this TAMP exists as a standalone document, LMPs may be considered an extension of the TAMP by reference.

2.5 Overview of Lifecycle Management Phases

FTA's Asset Management Guide¹ describes a number of basic lifecycle activities, which are summarized in Figure 2.2 below. Most Transit Assets at Metro progress through each of these four lifecycle phases, but some will never be overhauled. Poor decisions in any of these lifecycle phases can result in higher costs, lower performance, or even safety impacts throughout the Metro system. Of particular note, the decisions made in the Plan/Design/Procure Phase have the greatest potential to impact system-wide cost, risk, and performance at Metro. For this reason, this LMP seeks to eliminate barriers between decision makers in any one phase and to consider assets comprehensively across their whole life.

Figure 2.2 - An asset's lifecycle, or the four phases over an asset's life.



For a given asset, different MTA departments or offices will serve as major stakeholders in each phase of the asset's lifecycle. A summary of these phases with corresponding major stakeholders are as follows:

¹ Federal Transit Administration. *Asset Management Guide*. Prepared by Parsons Brinckerhoff, Inc. Washington, DC., 2012. < <http://www.fta.dot.gov/13248.html> >

Table 2.1 - Major stakeholders involved with each phase of an asset's lifecycle.

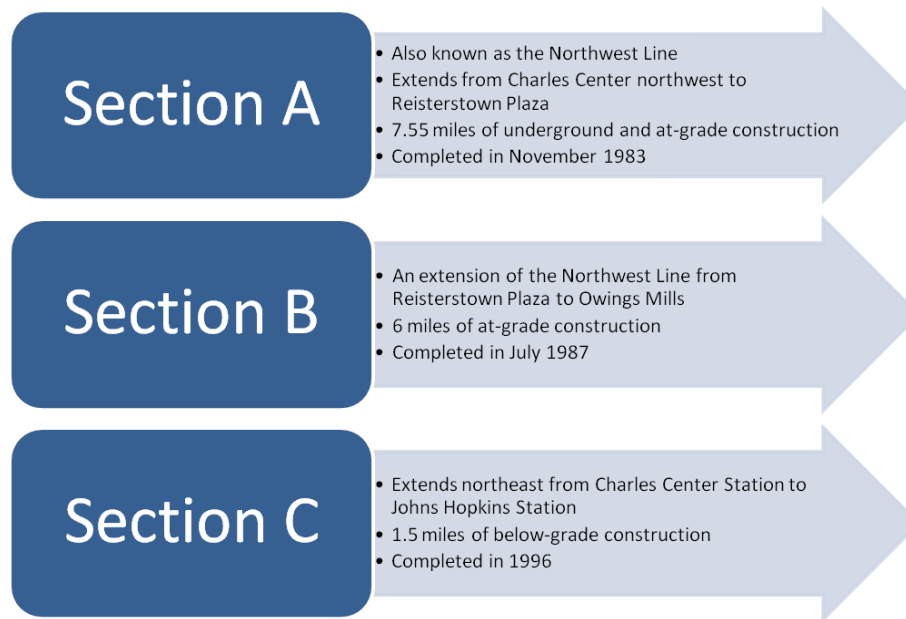
PHASE	PHASE NAME	PRIMARY STAKEHOLDERS
1	Acquire	Offices of: <i>Planning and Programming, Engineering, and Procurement</i>
2	Operate & Maintain	Metro Mode, <i>Office of Engineering</i> , outside contractors
3	Overhaul & Rehabilitate	<i>Office of Engineering</i> and outside contractors
4	Retire & Dispose	<i>Department of General Services</i>

3 Mode Overview

3.1 Mode Background

Constructed in three phases (Figure 3.1), MTA's Metro system operates a 98 car fleet on a 15.5 mile subway system extending from Owings Mills in Baltimore County to Johns Hopkins Hospital in the eastern portion of Baltimore City. The mode has a staff of approximately 301 employees and in FY 2014 had a capital budget of \$19,241,000 and an operating budget of \$37,129,000.

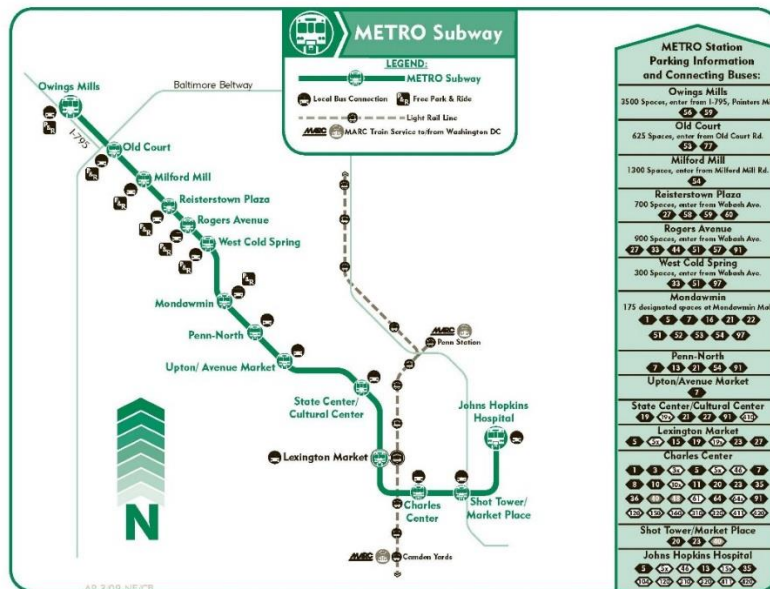
Figure 3.1 – Description and characterization of each Metro section.



3.2 System Map

The Metro system is directly connected to MTA Bus at all stations, and indirect connections also exists to Light Rail at Lexington Market and State Center; Metro and Light Rail services are adjacent at these locations, however this is not made obvious to riders though visible wayfinding and signage. Metro also connects to transit service outside of MTA's network, including the Johns Hopkins Shuttle, and the Baltimore City Charm City Circulator.

Figure 3.2 - Metro system map.



3.3 Ridership & Schedules

In FY 2015, Metro provided a monthly average of 13,900,813 unlinked passenger trips, accounting for 12.0 percent of MTA's total ridership. As of FY 2015, weekday service hours are between 5:00 a.m. and midnight, while weekend service is between 6:00 a.m. and midnight. Trains run every 8-10 minutes during the morning and evening peak periods; every 11 minutes during weekday evenings; and every 15 minutes on Saturdays, Sundays and holidays. One-way running time between the system's two terminus stations is approximately 29 minutes. Current schedules and approximate travel times are available at: <http://mta.maryland.gov/quick-schedule-links#metro>.

3.4 Fares

Maryland's Transportation Infrastructure Investment Act of 2013 requires MTA on a biennial basis to increase its base fare prices and the cost of multiuse passes to the nearest 10 cents for local service (local bus, metro-subway, light rail, and mobility) based on the percentage increase in the Consumer Price Index for All Urban Consumers as determined from January 1, 2012 to December 31, 2013 and each subsequent 2-year period. The bill also requires MTA to increase the base fare and the cost of multiuse passes to the nearest dollar for premium service (MARC & Commute Bus) every five years based on the percentage increase in the CPI from January 1, 2009 to December 31, 2013 and each subsequent 5-year period. MTA may take other commuter costs into consideration such as monthly parking fees, gas prices, the amount of any Federal Commuting Subsidy, and other factors when setting fares for premium service.

Fare increases are scheduled for the following fiscal years:

- *Local service* – 2017, 2019, 2021
- *Premium service* – 2020, 2025

If fare increases are based upon this law, then no public hearing process would be required. However, public hearings would be required if the MTA decides to increase its fare to account for additional service or other factors.

Table 3.1 - Metro's current fare structure.

Fares & Passes	Full Fare	Senior/Disability
Single Trip	1.70	.70
Round Trip (Light Rail & Metro only)	3.40	1.40
Day Pass	4.00	2.00
CharmCard 1 -Day Pass	4.00	2.00
Weekly Pass	22.00	---
CharmCard 7 - Day Pass	22.00	---
Monthly Pass	68.00	20.00
CharmCard 30 - Day Pass	68.00	20.00

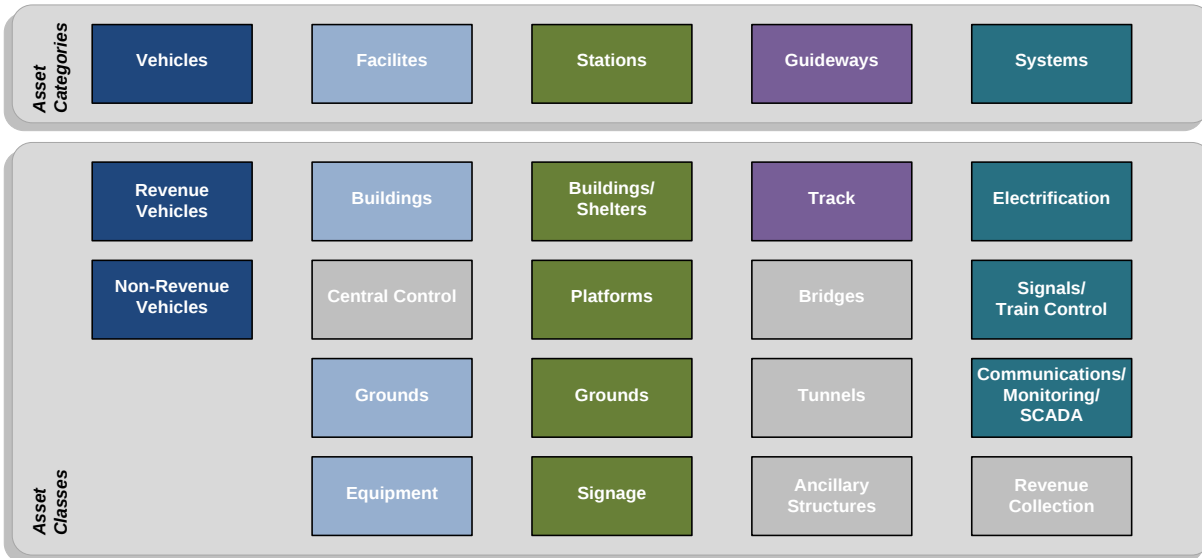
3.5 Snapshot of Metro Transit Assets

Every MTA mode provides service through the use of vehicles, facilities, and other infrastructure Transit Assets (assets). In an effort to better manage these assets, a common hierarchy must be established in order to standardize the way these assets are discussed and reported on – both internally and externally. The MTA Transit Asset hierarchy (Figure 3.3) is based on FTA guidance and shows Metro assets organized into five broad asset **categories** that are divided into sub-groups known as asset **classes**. While all of these categories and classes compose the Metro system, not all of them are directly managed by the Metro mode on a day-to-day basis:

- Metro manages Central Control facility, but each mode manages their respective assets therein
- *Office of Engineering* maintains bridge, tunnel, and ancillary structure assets
- *Office of Treasury* manages revenue collection assets.

These respective offices hold responsibility for major maintenance and inspection decisions regarding these assets. These third party assets currently fall outside the scope of this document and may be detailed in later versions of this LMP.

Figure 3.3 - MTA's Transit Asset breakdown hierarchy organizes Transit Assets into a broad **category** followed by separation into a more descriptive sub-group, or **class**. Asset classes managed by another MTA department or office are depicted in gray.



3.5.1 Vehicles

The Metro fleet is composed of 100 vehicles and procured in three batches. All of these vehicles are approaching their end-of-life and 90 vehicles will undergo replacement starting in 2019 through 2021. At the end of the procurement, the remaining 10 vehicles will be retired, leaving Metro with a 90 vehicle fleet. This procurement presents MTA with certain challenges to ensure compatibility between all on-vehicle equipment and all wayside equipment.

3.5.2 Facilities

Metro conducts or coordinates maintenance on all their Transit Assets out of two major facilities located at 5801 Wabash Avenue and 4380 Old Court Road. These facilities are referred to as “**Wabash**” and “**Old Court**,” respectfully. Wabash contains the main administrative offices and focuses on railcar and system maintenance, whereas Old Court focuses on maintenance-of-way and facility maintenance.

In addition, Metro is considered the Asset Owner for the MTA **Operations Control Center (OCC)**, located at 301 N. Eutaw Street, Baltimore, MD, 21202. While Metro is responsible for the maintenance of the building, it is not responsible for the maintenance of all building contents; Bus and Light Rail are responsible for the maintenance of various equipment that serve their modes respectively.

3.5.3 Stations

The Metro system is composed of 14 stations, of either an aerial or tunnel design. Note that each station contains a traction power substation (TPSS).

3.5.4 Guideway

The double-tracked mainline provides a service corridor totaling 34 waymiles. Along this corridor, the system depends on a series of tunnels and elevated structures. Since the system was built in three phases, the ages of these guideway assets generally differ accordingly.

3.5.5 Systems

Similar to the guideway assets above, the age of various systems assets (train control/signaling and electrification/traction power) correlates to the three phases of system construction. At the time of publication, a new train control/signaling was being procured as the old system reached its useful life. Due to compatibility issues between the new train control/signaling system and the existing revenue fleet, the legacy train control/signaling system is planned to be maintained in parallel until the entire revenue fleet is replaced accordingly.

3.6 Contracted Lifecycle Management Activities

Metro conducts the majority of its own operations and maintenance activities. However, the mode relies upon contracted services for a variety of needs:

- Railcar midlife overhauls;
- Specialty non-revenue vehicle overhauls (hi-rail vehicles, track tampers, skid loaders, front-end loader, prime mover, ballast regulator, and various snow removal equipment);
- Tunnel dewatering pump overhauls;
- Specialty shop equipment overhauls;
- Other asset overhauls and rehabilitations that exceed departmental capabilities;
- Elevator and escalator maintenance; and
- Annual track maintenance work (tamping, surfacing, grinding, etc.)

While Metro's day-to-day asset management responsibilities revolve around the operation and maintenance of its assets, other parties directly influence major decisions in the remaining lifecycle phases. These lifecycle considerations are discussed in Section 9 of this LMP.

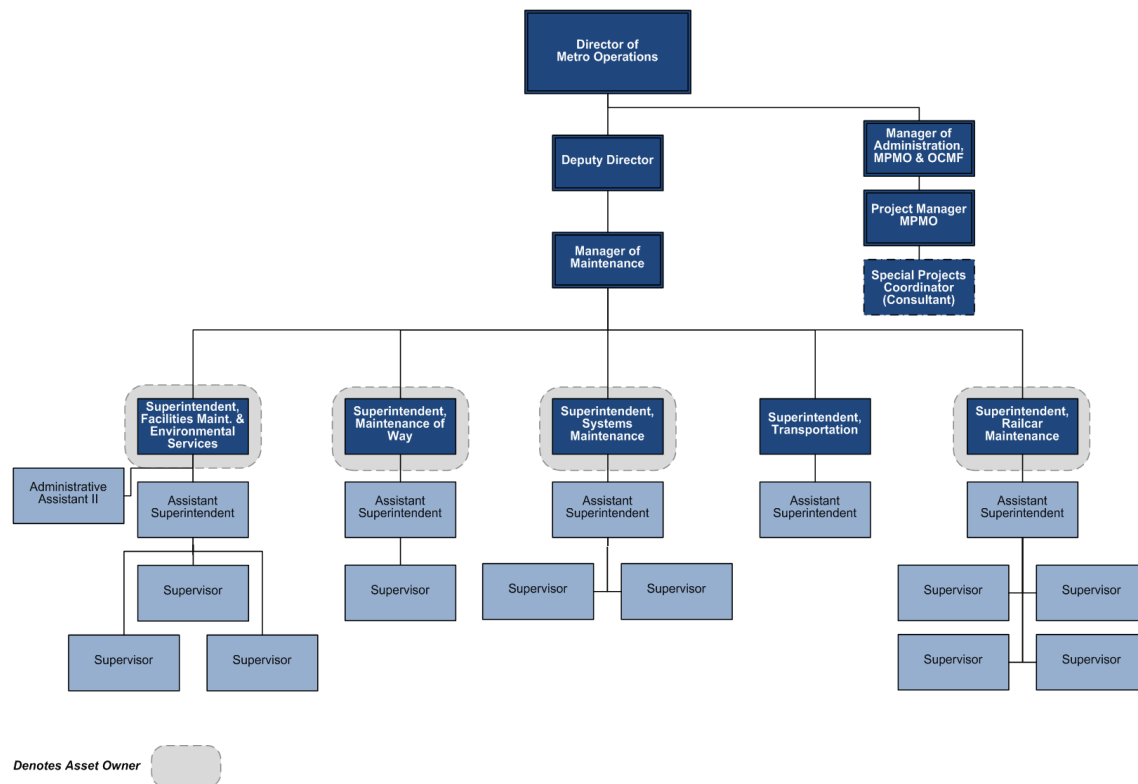
4 Roles & Responsibilities

Metro depends on both State employees and consultant support alike for daily asset management responsibilities. While the Metro mode allocates 301 total Personnel Identification Numbers (PINs), 120 PINs are allocated to the Transportation division, while the remaining 181 PINs are available for managing State of Good Repair (SGR) needs. This section of the LMP focuses on the human resources allocated to manage those SGR needs.

4.1 Metro Organizational Structure and Staffing Levels

Figure 4.1 below presents the current organizational structure and relationships between Metro management and its workforce. This organizational structure is divided among positions and departments geared toward either administration or operations management.

Figure 4.1 - Metro's organizational chart.



Administrative staff at Metro oversees and supports five Metro departments: Railcar Maintenance, Maintenance of Way, Systems Maintenance, Facilities Maintenance and Environmental Services, and Transportation. Of these, only the first four have responsibility for the ongoing management of physical Transit Assets included in the scope of this Lifecycle Management Plan. The fifth, Transportation Department, consists primarily of train operators, station attendants, and dispatchers. The main physical assets which they maintain are radio transponder units, which were not deemed substantial enough to include the Transportation Department in the scope of this document.

Table 4.1 shows the breakdown of **181** Metro Personnel Identification Numbers (PINs) by department, as reported through AdminStat as of August 2015. Note that the only PINs shown below are related to the

positions that directly correlate with SGR responsibilities, which means that the “Transportation Division” which has **120** additional PINs has been excluded from this analysis.

Table 4.1 - Breakdown of Metro personnel Identification Numbers (PINs) by department, via August 2015 AdminStat data.

METRO DIVISION RESPONSIBLE FOR MANAGING SGR NEEDS	“RESPONSIBILITY CENTER” DESCRIPTION	MANAGEMENT PIN COUNT	UNION PIN COUNT	TOTAL PINS BY DEPARTMENT
ADMINISTRATION¹	<i>Operations Manager</i>	2	0	2
	<i>Maintenance Chief</i>	2	0	2
FACILITIES MAINTENANCE²	<i>Cleaning</i>	0	16	16
	<i>Plant Maintenance</i>	6	24	30
RAILCAR MAINTENANCE²	<i>Railcar Maintenance</i>	4	57	61
	<i>Service & Inspection</i>	2	0	2
SYSTEMS MAINTENANCE²	<i>Traction Power</i>	1	14	15
	<i>Railcar Systems</i>	0	7	7
	<i>Signals</i>	3	18	21
	<i>Supervisory</i>	0	4	4
MAINTENANCE OF WAY²	<i>MOW</i>	3	18	21
TOTAL PINS BY TYPE		3	158	181

¹ Those PINs associated with **Administration** include: Director, Deputy-Director, and other managers/personnel whose positions span multiple divisions within the Metro mode.

² These reflect the (4) four departments specializing in the operations and maintenance of specific asset classes.

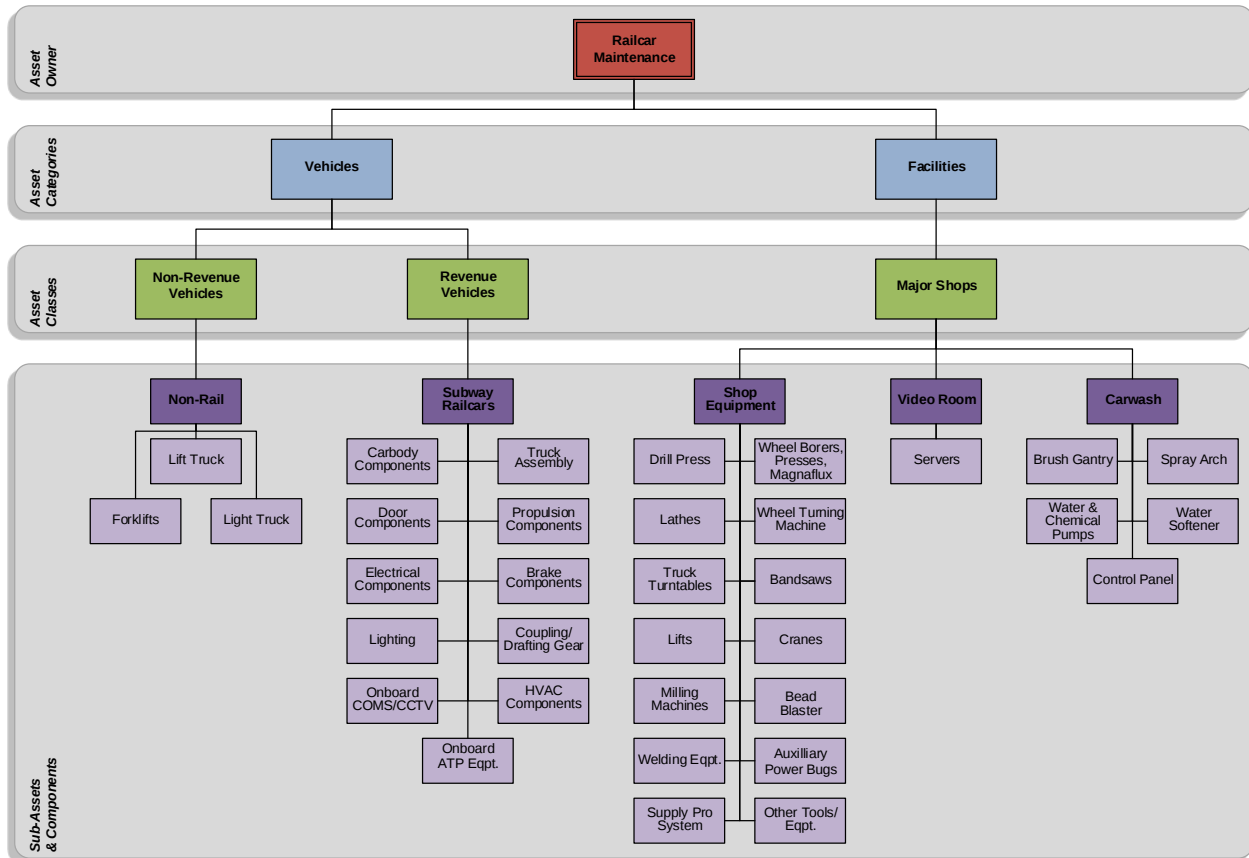
4.2 Transit Asset Owners

Despite the influence of other stakeholders on a Transit Asset’s lifecycle, each of the four Metro departments shown in Table 4.1 are considered an “Asset Owner,” because these departments are responsible for managing the largest portion of a Transit Asset’s lifecycle (See Section 2.4). The Asset Owner hierarchies below illustrate only those Transit Assets under the direct purview of each Metro department. A comparison of Metro’s Asset Owner hierarchies throughout this section will identify areas of overlap between Transit Asset classes that may indicate redundant management responsibilities.

4.2.1 Railcar Maintenance Department (RCM)

The Railcar Maintenance (RCM) department consists of a Superintendent, Assistant Superintendent, four supervisors, and 57 unionized lead men, technicians, and mechanics. RCM is responsible for daily inspections, preventive maintenance, and heavy repair of a 100 vehicle railcar fleet. This also includes management of non-revenue vehicles and major shop assets such as maintenance and video room equipment, as well as the carwash.

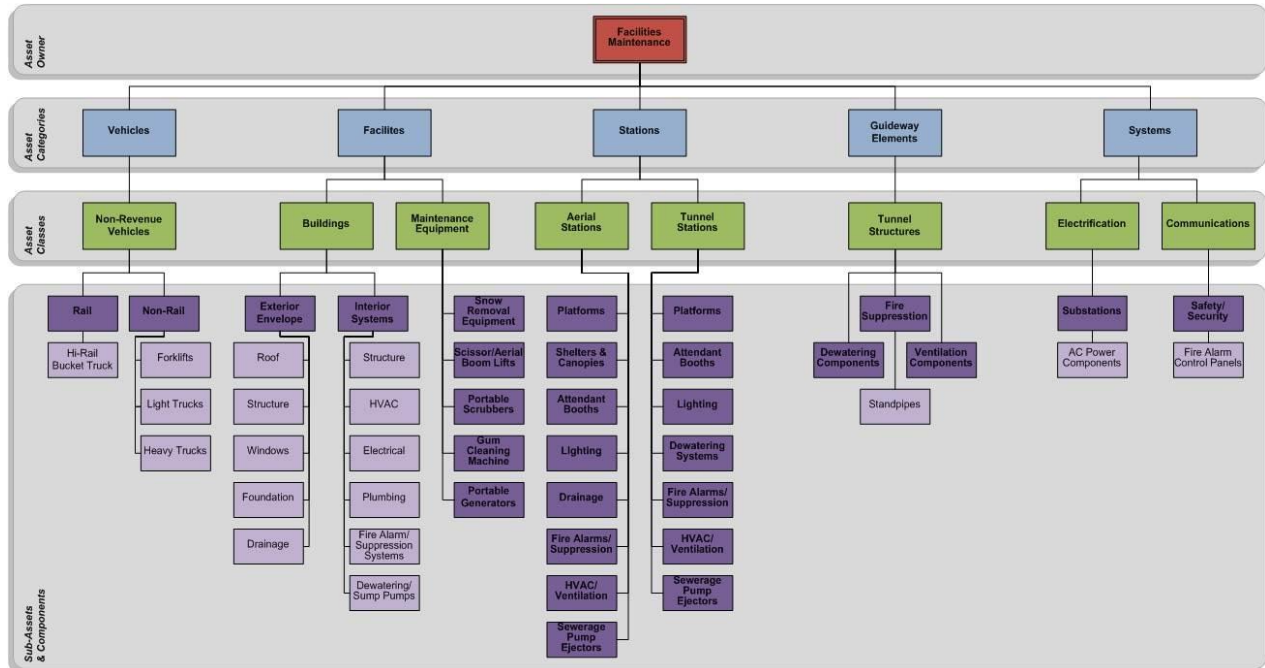
Figure 4.2 - Railcar Maintenance Department's Asset Owner hierarchy.



4.2.1 Facilities Maintenance & Environmental Services Department (FM)

The Facilities Maintenance and Environmental Services department consists of a Superintendent; Assistant Superintendent; three supervisors; an administrative assistant; and 40 unionized lead men, technicians, and repairmen. The Environmental Services group is responsible for the ongoing maintenance of Metro's stations and facility buildings. This also includes management of non-revenue vehicles, AC power components of substations, fire suppression systems, and ventilation and dewatering assets within tunnels.

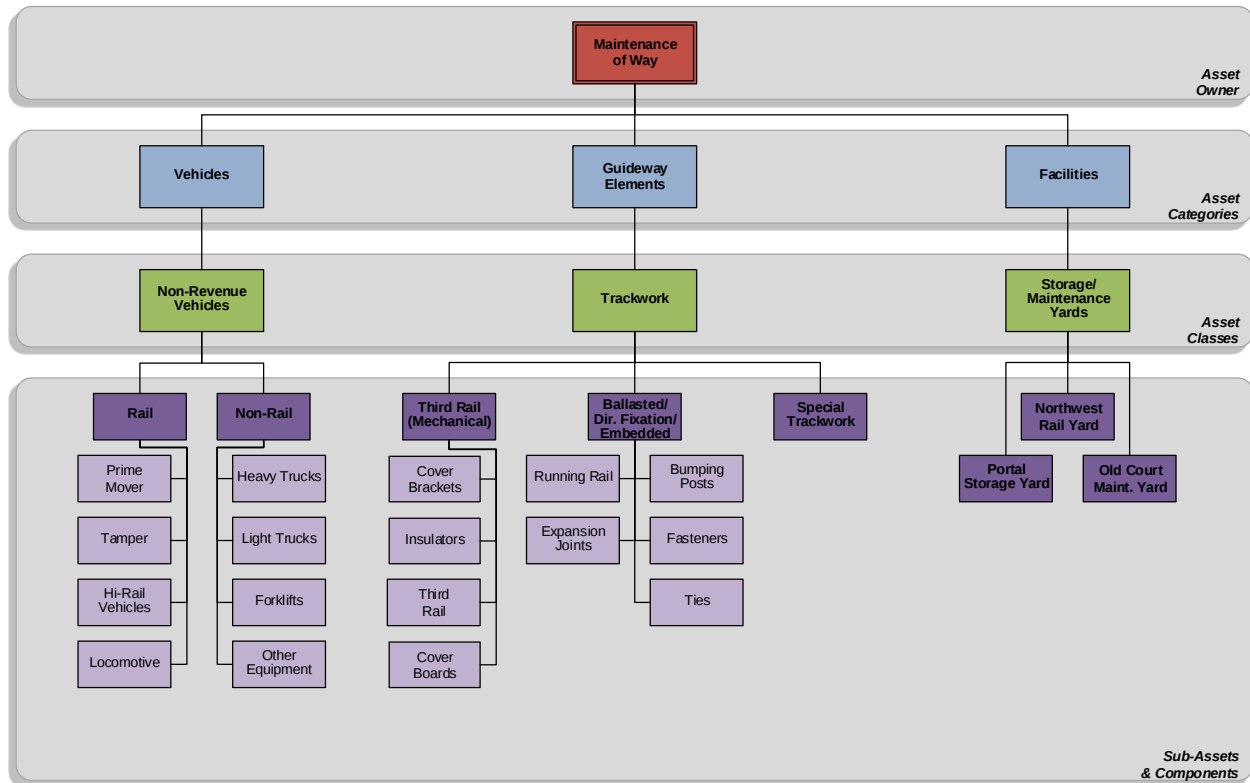
Figure 4.3 - Facilities Maintenance and Environmental Services Department's Asset Owner hierarchy.



4.2.2 Maintenance of Way Department (MOW)

The Maintenance of Way (MOW) department consists of a Superintendent, Assistant Superintendent, one supervisor, and 18 unionized lead men, technicians, and mechanics. MOW's responsibilities are to inspect and maintain mainline and yard trackwork. This also includes management of non-revenue vehicles and storage yards located along the mainline.

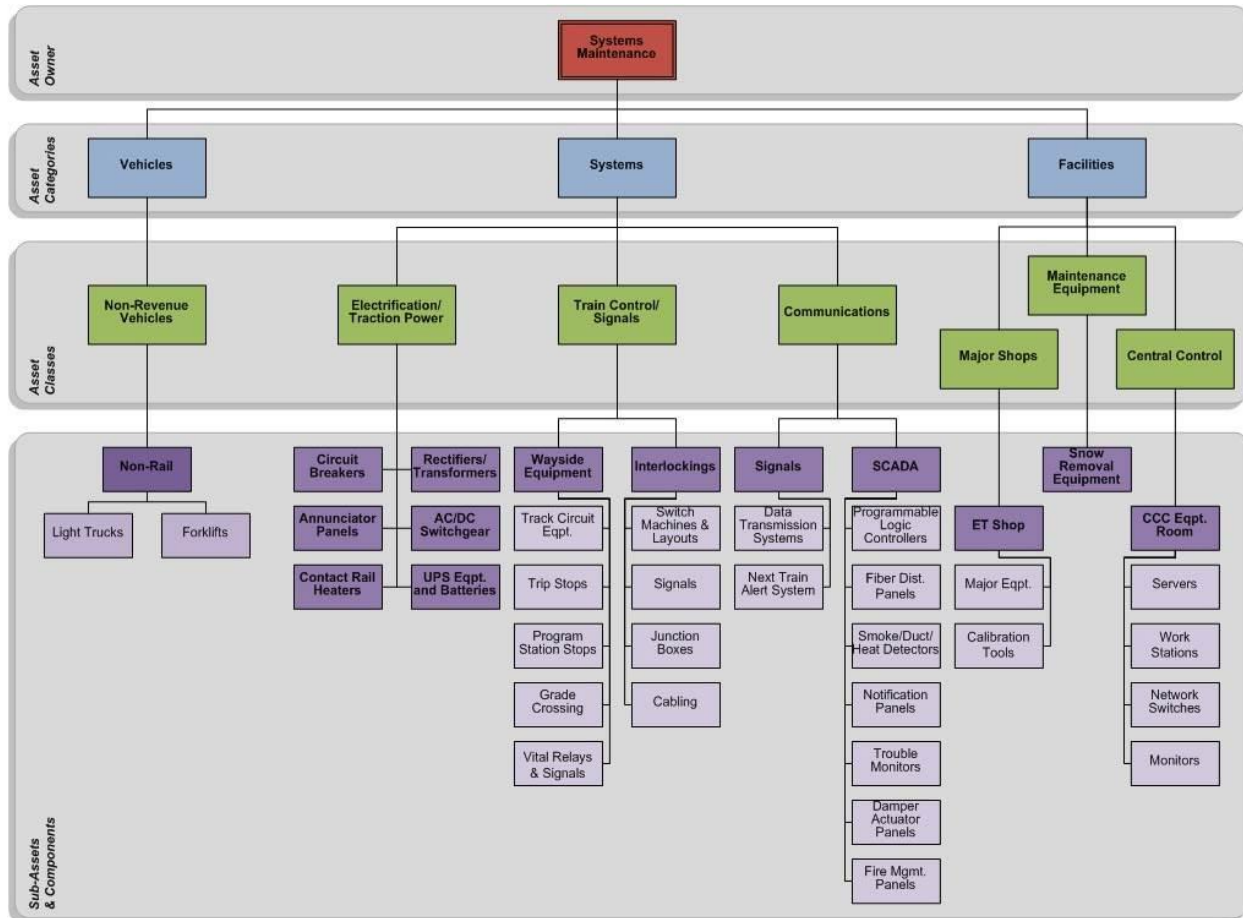
Figure 4.4 - Maintenance of Way Department's Asset Owner hierarchy.



4.2.3 Systems Maintenance Department (SM)

The Systems Maintenance department consists of a Superintendent, Assistant Superintendent, two supervisors, and 43 unionized lead men, technicians, and repairmen. SM has four teams to fulfill its responsibilities to maintain, inspect, test, and repair all of Metro's electronic systems. These teams include: Traction Power; Signals/Automatic Train Control (ATC); Supervisory Control and Data Acquisition (SCADA); and the Electronic Shop & Calibration Lab. This also includes management of non-revenue vehicles, snow removal equipment, and Central Control equipment.

Figure 4.5 - System Maintenance Department's asset hierarchy structure.



4.3 Overarching Metro Responsibilities

Together, these Metro departments play a role in the management of all lifecycle phases of the mode's Transit Assets, though they are most directly accountable for operations and maintenance activities. Metro's Asset Owner hierarchies show just how vast and complex its portfolio is. But while an asset hierarchy is a useful tool to summarize the broad spectrum of assets Metro owns, it is not useful for business analysis or data collection purposes. An asset inventory serves as the foundation for performing these functions.

5 Transit Asset Inventory

The MTA asset inventory details those assets owned by each mode/department, and associated data for each unique asset record. The inventory minimally includes an in-service (or construction) date, procurement cost, and estimated useful life for each record. Useful life values in MTA's initial asset inventory are based either on industry guidelines or values that reflect MTA's actual experience, if available. Additional details, such as serial number or asset location, are included where available.

*MTA's asset inventory includes an **in-service date**, **procurement cost**, and **useful life** (at a minimum) for each record.*

The MTA asset inventory also provides the ability to disaggregate high level asset groupings into a logical grouping of child assets. This is what is commonly referred to as the parent-child relationship. This is achieved by identifying each record's asset category, class, and type according to an accepted hierarchical structure, which has been summarized in Figure 3.3. Having this basic data enables MTA and Metro to perform deeper analyses and ultimately to make better asset management decisions.

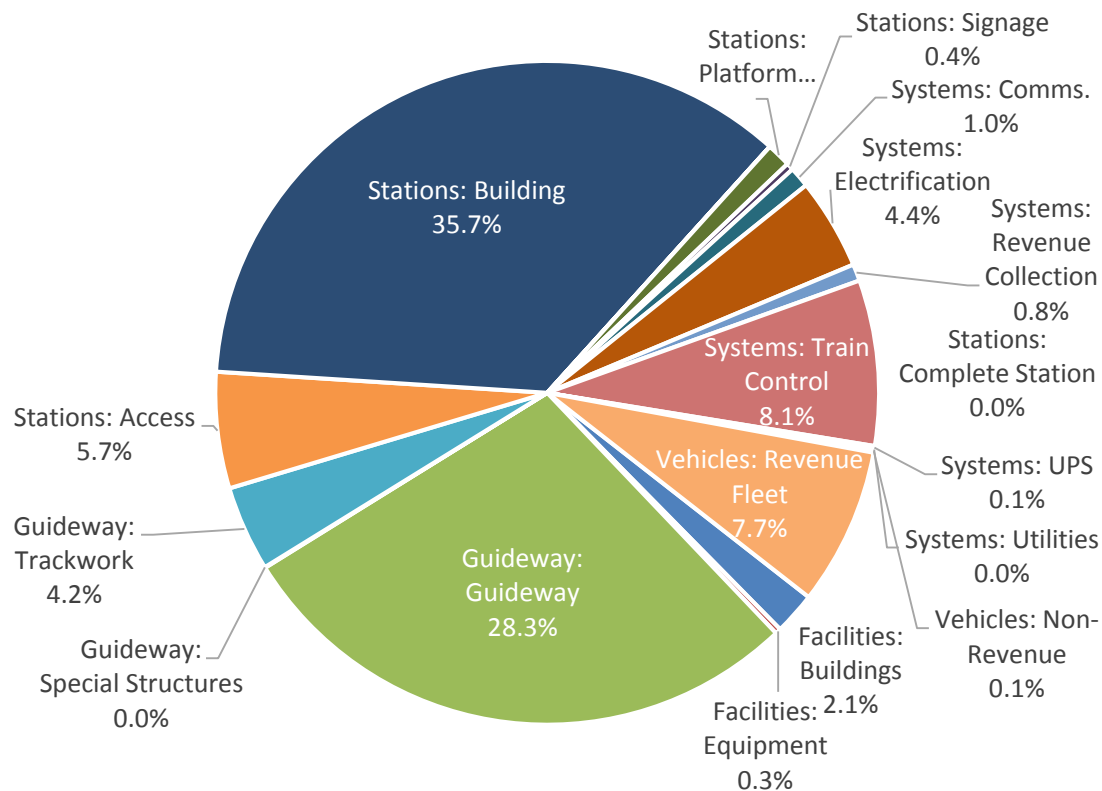
Metro's asset inventory is a subset of MTA's asset inventory and is reflective of Transit Assets that make up the Metro system across all five major categories. Figure 5.1 and Figure 5.2 below summarizes the Metro asset inventory. Note that some of these assets are not directly managed by Metro, such as fareboxes (managed by Treasury) and elevators and escalators (managed by Access Control). Based on a TERM-Lite analysis conducted on November 4, 2015, Metro's asset portfolio is valued at approximately \$3.8 billion (\$2014), with the biggest share of the asset base residing in *Stations* (43% of asset base) and *Guideways* (33% of asset base). Note that any of Metro's passenger stations

Figure 5.1 - Summary of Metro Transit Asset inventory by value.

Metro Asset Type	Replacement Cost (\$2014)	% of Agency Asset Base
Facilities: Buildings	\$ 78,505,566	2.1%
Facilities: Equipment	\$ 10,344,475	0.3%
Guideway: Guideway	\$ 1,075,021,895	28.3%
Guideway: Special Structures	\$ 1,214,026	0.0%
Guideway: Trackwork	\$ 158,029,380	4.2%
Stations: Access	\$ 215,331,705	5.7%
Stations: Building	\$ 1,356,757,759	35.7%
Stations: Complete Station	\$ 340,579	0.0%
Stations: Platform	\$ 44,829,869	1.2%
Stations: Signage	\$ 13,423,338	0.4%
Systems: Comms.	\$ 38,153,319	1.0%
Systems: Electrification	\$ 169,010,740	4.4%
Systems: Revenue Collection	\$ 31,159,533	0.8%
Systems: Train Control	\$ 306,505,738	8.1%
Systems: UPS	\$ 5,689,535	0.1%
Systems: Utilities	\$ 880,000	0.0%
Vehicles: Non-Revenue	\$ 5,611,771	0.1%
Vehicles: Revenue Fleet	\$ 291,581,299	7.7%
Total	\$ 3,802,390,527	100%

include rooms and equipment that serve both its *Train Control* and *Electrification* systems. While those equipment values are included under the appropriate *Systems* category, the structures and ancillary equipment (such as fans) are included in the *Stations* building values themselves.

Figure 5.2 – Summary of Metro Transit Asset inventory by value.



While the MTA has developed a consolidated inventory of its Transit Assets, Metro “owns” a number of linear assets, such as trackwork and electrified third rail, which are difficult to track and visualize in the absence of a more sophisticated inventory software system. Strategy #1 (*Maintain Transit Asset and Land Asset Inventories*) of the TAMP suggests that MTA and develop an improved strategy for visualizing and managing linear assets. The ability to visualize linear assets will allow Metro to better understand the condition and performance of these assets, consolidate inspection and maintenance activities in the same geographic area, and make better management decisions.

5.1 Inventory Maintenance Process

MTA believes the initial Metro inventory is substantially complete and accurate, however, some of the records are based upon assumptions and it is unknown if some assets might be still missing from the inventory. Over time, MTA will continue to replace its assets and acquire new ones.

Therefore, in accordance with Strategy #1 in the TAMP (*Maintain Transit Asset and Land Asset Inventories*), Metro will:

- Develop a process, in collaboration with other MTA Asset Owners, to keep the Metro inventory current and continually improve the quality of the data it contains;
- House the Metro inventory in the official inventory system(s) of record as designated through the MTA asset management program; and
- Contribute to the development of an improved strategy to visualize and manage linear assets.

5.2 Asset Criticality Assessment

Asset criticality plays a role in multiple decision making processes and strongly influences risk evaluation and capital investment considerations. In extreme circumstances, failure of Critical Assets may result in property damage, human injury, and possibly loss of life. But in most circumstances, failure of Critical Assets leads to service disruptions and loss of revenue. Having a formal process in place for identifying Critical Assets can help the MTA and Metro determine what level of intervention is appropriate for its assets and can help reduce costs.

Asset criticality was calculated using the TERM Lite capital investment prioritization scores by Transit Asset type. TERM Lite prioritization scores are calculated on a 1-5 scale across four categories: asset condition, reliability, safety and O&M cost impact. To calculate asset criticality, the reliability and safety scores are multiplied; for those assets where the product of this calculation is greater than or equal to 12, the asset is considered critical.

Table 5.1 - Metro's Critical Assets.

ASSET CATEGORY	ASSET CLASS	ASSET TYPE	DEPARTMENT RESPONSIBLE
SYSTEMS	Electrification/ Traction Power	Contact Rail	SMD
	Train Control/ Signaling	All	SMD
	Utilities	All Pumping Equipment	SMD
		SCADA	SMD
	Communications	Safety & Security	SMD
		Cable Transmission System (CTS)	SMD
FACILITIES	Central Control	OCC Equipment Room	FM
STATIONS	Building	All Building Components	FM
	Access	All Access	FM
VEHICLES	Revenue Vehicles	Subway Railcars	RCM
GUIDEWAY	Trackwork	All Trackwork	MOW
	Guideway	All Elevated Structures	Engineering
		All Tunnel Structures	Engineering
		All Retained Cut Structures	Engineering

5.3 Major Procurements

Metro manages a multitude of projects involving new asset acquisition, asset rehabilitation, and asset replacement. All large-scale projects are considered procurements, even if they are focused on existing system assets, such as is the case with overhauls or upgrades. This is because they rely on the procurement of *services*, such as engineering, design, testing, repair, installation, and construction, among others. A brief description of Metro's recent and current projects are provided in the sections below. For those interested in additional information, including cost and schedule details, the four digit project number has been provided to locate the project in MTA's Capital Programming Management System (CPMS). If you have trouble accessing CPMS, you may contact *Capital Programming* directly for assistance at 410-767-3770.

*Major procurements detailed below include the acquisition of new assets, overhauls, and replacements that involve **Critical Assets** and are over **\$2 million** in fully loaded costs.*

Metro has completed a number of key projects in recent years focused on system preservation and enhancement. System preservation, or SGR, projects are typically aimed at making necessary repairs, upgrades, and overhauls that are needed to realize the intended design life of a given Transit Asset; system enhancement projects add additional functionalities to the existing Metro system. Recent and current major projects are summarized in Table 5.2 and Table 5.3 below.

Table 5.2 - Recently completed preservation and enhancement projects on the Metro system.

Project Name		Details
Escalator/Elevator Upgrade (Enhancement)	Project Code:	0124
	Description:	- This project improved reliability of 81 escalators in the Metro system by rebuilding and improving safety features. - Provided for remote monitoring of operational status, protection from weather, snow melt, new security, two new entrance canopies, and modification of remaining exposed escalator canopies.
	Completion:	2011
Station Fire Management Systems (Enhancement)	Project Code:	0457
	Description:	- This project covered the design, acquisition, and installation of new Supervisory Control and Data Acquisition (SCADA) equipment for the Metro system. - Included were central computer interface equipment and software, smoke detectors, and fire/security systems.
	Completion:	2013
Electrical Substation Improvements (Enhancement)	Project Code:	0474
	Description:	- This project provided for the overhaul of 14 Traction Power Sub Stations (TPSS) in Sections A & B. - Included station equipment compartments, switch gear controls, flooring, power panels, and electrical connections.
	Completion:	2015
Yard Renovation (Preservation)	Project Code:	0520
	Description:	- The project involved study, design, and construction of track and systems rehabilitation work at the Wabash Metro Yard. - Project was required in order to reduce stray electrical currents and to restore track stability.
	Completion:	2009

Table 5.3 - Current preservation and enhancement projects to the Metro system.

Project Name	Details	
Fleet & Train Control Replacement Program (Preservation)	<i>Project Code:</i>	1415
	<i>Description:</i>	• Project involves the replacement of Metro’s railcar fleet that is past their 30-year design life. • Based on a previous service demand analysis, the new fleet will consist of 90 cars. • Replacement of the signaling system is being pursued in conjunction with Metro’s new railcar procurement and will enhance passenger comfort, while ensuring improved safety and reliability.
	<i>Estimated Completion:</i>	First car: 2019; Last car: 2021
Railcar Vehicle Subsystems Overhaul (Preservation)	<i>Project Code:</i>	1281
	<i>Description:</i>	• This is a 5-year truck overhaul as specified in the Metro Fleet Management Plan and vehicle maintenance manuals. • Project involves the dismantling of truck assemblies and overhauling critical equipment, such as traction motors, gearboxes, axles, and wheels.
	<i>Estimated Completion:</i>	2019
Owings Mills Platform Rehab (Preservation)	<i>Project Code:</i>	1413
	<i>Description:</i>	• Rehabilitation of the Owings Mills Metro Station platform includes construction of a new transparent sound barrier, automatic platform snow melt system, new concrete platform finish, new tactile platform edge, and the replacement of 6 platform passenger shelters.
	<i>Estimated Completion:</i>	TBD
Interlocking Renewals (Preservation)	<i>Project Code:</i>	1223
	<i>Description:</i>	• Five interlocking renewals are covered under the scope of this project: Reisterstown Plaza West and East, Portal, State Center, and Old Court • Also included is a complete evaluation of the systems to determine future renewal priorities. • Project includes replacement of turnouts, ballast, ties, rail, and electrical components as required, as well as complete system evaluation to determine future renewal priorities.
	<i>Estimated Completion:</i>	2016

6 Condition Assessment

6.1 Condition Assessment Philosophies

On Feb. 14, 2013, the FTA's [State of Good Repair White Paper](#) explores the various approaches to assessing Transit Asset conditions:

- Age-based
- Inspection-based
- Performance-based
- Comprehensive (combined)

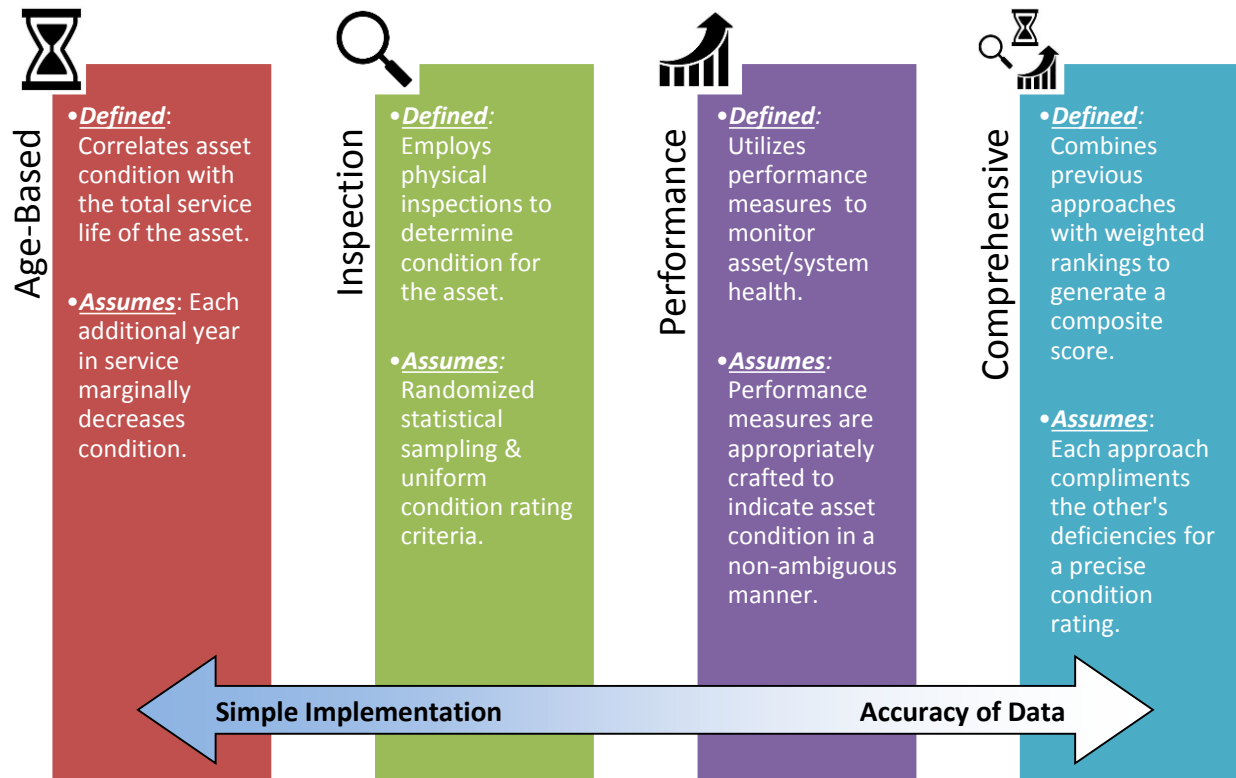
The **age-based approach** to assessing condition assumes that most assets have a useful life, measured in years. Once that useful life is met, it is assumed the asset will exhibit decreased performance, higher risk of failure, and higher maintenance costs. Using this method, the condition of assets can be estimated based on the asset's age in relation to its expected useful life. This approach usually relies on the use of empirically derived asset decay curves unique to each asset type, and each curve provides a point estimate of asset condition given the asset's age. A benefit of this approach is that it is cost effective, as it does not require on-site inspection of the asset. However, it only provides an approximation of condition and therefore is not appropriate if a more detailed understanding of actual condition is required. Finally, as asset age is only one of several determinants of asset performance, age-based condition measures can only provide a rough proxy measure of performance.

The **inspection-based approach** to assessing condition employs standardized inspection procedures and criteria. The frequency for these inspections will vary depending on type, criticality and the expected useful life of each asset. Because inspection of each and every asset can be unrealistic from a manpower standpoint, many assets may be assessed via a statistical representative sampling, and an average condition value can be calculated and assumed for all assets of the same type.

The **performance-based approach** to assessing condition employs diagnostic information and performance metrics to monitor the overall health of a transit system. This method assumes that performance metrics are sufficiently crafted in a way that allows management to quickly diagnose which assets are associated with a drop in performance. Using this method, the condition of assets can be estimated based on the overall performance of the transit system.

The **comprehensive approach** combines age-based, inspection-based, and performance-based metrics with weighted rankings into a composite condition score for each asset.

Figure 6.1 - A description of the age, inspection, performance, and comprehensive-based approaches to quantifying asset condition.



Of all four approaches outlined above, the age-based approach to condition assessment is the easiest to employ; by comparison inspection-based and comprehensive approaches require substantial manpower commitments, and performance-based approaches require substantial data systems to be in place. Furthermore, an age-based approach to estimating asset condition can be easily automated with a tool like TERM Lite.

TERM Lite is a Microsoft Access-based decision tool provided by the FTA, which allows transit agencies to estimate the current and potential future condition of their Transit Assets using agency inventory data and a series of asset-specific, age-based decay curves embedded in the tool. TERM Lite's decay curves were developed by the FTA using statistical analysis of condition assessment data from thousands of on-site inspections across a broad range of asset types and US transit operators. Each curve predicts how condition is expected to decline (on average) based on asset type and age. While TERM Lite's decay curves may not always attain the accuracy of actual on-site inspections, they are significantly more cost effective and provide the advantage of being able to look forward in time. That is, TERM Lite can estimate asset conditions today and what they may be tomorrow given differing levels of capital investment.

While the TERM Lite model is built on industry average data, it can also be customized to reflect asset decay scenarios specific to MTA. These condition estimates produced by TERM Lite serve as a supplement to existing inspection-based condition assessments employed by Metro, and serve as a proxy where Metro does not currently have any inspection-based condition assessment regimes.

6.2 Condition Estimates & “State of Good Repair” (SGR) Backlog

TERM Lite calculates condition estimates on a 5-point numerical scale (Table 6.1). By standardizing the use of this 1-5 scale for a condition rating, the MTA can begin to understand the condition of its assets across all modes and asset types, providing a common language for prioritizing SGR needs.

Table 6.1- FTA's TERM Lite condition rating scale.

Condition	Ratings	Description
Excellent	4.51 to 5.00	New asset; No visible defects
Good	3.51 to 4.50	Asset showing minimal signs of wear; Some (slightly) defective or deteriorated component(s)
Adequate	2.76 to 3.50	Asset has reached its mid-life (condition 3.5); Some moderately defective or deteriorated component(s)
Marginal	2.00 to 2.75	Asset reaching or just past the end of its useful life (reached between condition 2.75 and 2.5); Increasing number of defective or deteriorated component(s) and increasing maintenance needs
Poor	1.00 to 1.99	Asset is past its useful life and is in need of immediate repair or replacement; May have critically damaged component(s)

On November 4th, 2015, a TERM Lite analysis of Metro assets yielded the following summary of condition estimates (Table 6.2); a more detailed summary may be found in **Appendix D**. TERM Lite considers assets with a condition estimate of 2.50 and above to be in a **State of Good Repair** (SGR), while those assets with less than a 2.50 are considered to *not* be in a SGR and therefore considered to be in the **backlog** of assets that need replacement (SGR Backlog). All ratings are weighted by asset replacement value, while omitting expansion assets and those replaced in late CY 2014 and CY 2015. Subsequent changes to the Metro asset inventory will be reflected in future TERM Lite analyses which will be conducted on an annual basis, in accordance with Strategy #3 in the TAMP (*Monitor Transit Asset Condition*).

Metro's current estimated SGR Backlog is \$792 million (in 2014 dollars), which does include some already programmed procurements, such as train control, revenue fleet, and contact rail heaters. Therefore, some of the \$792 million backlog is already funded for replacement.

The current backlog accounts for approximately 21% of Metro's asset base. The largest portion of the current

Table 6.2 - Outline of condition ratings generated by TERM Lite output conducted on November 4th 2015.

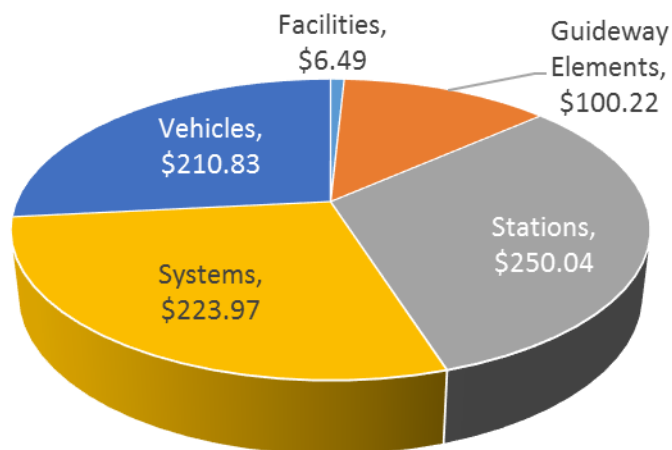
Category & Sub-Category	Avg. Condition
Facilities	3.48
Equipment	2.74
Buildings	3.57
Systems	2.60
Communications	2.78
Electrification	2.66
Train Control	2.51
UPS	4.37
Utilities	3.01
Vehicles	2.43
Revenue Vehicles	2.43
Non-Revenue Vehicles	2.29
Stations	3.16
Complete Station	3.02
Access	2.76
Building	3.24
Signage & Graphics	2.41
Platform	2.82
Guideway Elements	3.58
Guideway	3.75
Trackwork	2.46
Special Structures	2.86
Grand Total	3.18

backlog is in Stations, with many components beyond the useful lives provided by the Metro Facilities Maintenance division, including pedestrian access, parking lots, platforms, roofs, and some doors. With constrained funding, the SGR backlog remains relatively constant over the 20 year period of analysis; this is further discussed in Section 10.3.1 below.

Metro's current backlog is \$792 million, accounting for 21% of the total asset base

Even with unconstrained funding, delayed replacement age creates a backlog from 2015 through 2020 that averages \$255 million. This backlog is due to the known procurement schedules for revenue fleet, train control system, and contact rail heaters, which occur after their respective useful lives (Figure 6.2). 90 of the current 100 revenue vehicles will be replaced under the planned procurement scenario, with the oldest vehicles being replaced first by the TERM Lite model. The 10 vehicles not being replaced under current contract specifications have not been included in the analysis.

Figure 6.2 – Metro's SGR Backlog estimate (\$1,000s in 2014).



6.3 Current Condition Rating Methodologies

Metro engages in routine condition assessments for many of its assets via scheduled inspections. Note, that condition assessment for bridges and ancillary structures is performed by the *Office of Engineering, Track and Structures Division*. Each inspection provides the opportunity to supplement the TERM Lite (age-based) condition values described above and in **Appendix D** with more accurate data.

While Metro routinely inspects many assets, it does so by employing a number of different condition rating scales that can vary by department. The Table 6.4 below outlines the current condition rating scales currently employed at Metro, as well as related data sheets from work orders and corresponding storage locations.

Inspection regimes are often documented in Maximo, MTA's maintenance management system, detailing the inspection activities for each location/ Transit Asset, and the frequency for which each inspection will occur. Maximo uses associated terminology that may be confusing to new employees or those that work outside of the Metro mode. Inspections are initially programmed in the Maximo system via a master

scheduling file called a “Master PM,” which in turn generates a work order on the prescribed interval, called a “PM.”

New employees and those that work outside the Metro mode may benefit by simply considering the following definitions for these terms, and avoid associating them with the common acronym “preventative maintenance”:

Table 6.3 - Maintenance related terminology and disambiguation of “preventative maintenance.”

TERM	DEFINITION
MASTER PM	A schedule programmed into Maximo for any work that takes place on a recurring interval at a particular location, or for particular Transit Assets.
PM	A work order generated via a Master PM that details the scope of activities to be performed at the particular location, or for the particular Transit Assets.
DATA SHEET	Generated along with the PM (work order) to be completed with notes and data associated with the work performed. Completed Data Sheets, also known as “check-off” or “inspection sheets,” may be stored in a number of locations, via physical copy or electronic copy.

As discussed in Table 6.3 above, a “Master PM” refers to all scheduled activities, whether centered inspection or maintenance. Since all scheduled activities are process-based, “Master PM” and associated Data Sheet and PM titles rarely include the name of the asset, but often include the scheduled frequency and a short description (1-3 words). Generally, this description will either interchangeably utilize “PM” and/or “inspection,” or a very specific inspection-based action (e.g. traffic locking test, ground readings).

Along with inconsistent naming convention, each Metro department employs two different condition rating methodologies that lack easy comparison between asset classes:

- **Diagnostic Test:** Results in a pass/fail, employed when the PM calls for a testing procedure;
- **Inspection:** Results in a three color stop-light scale that varies depending upon Metro department, employed when a PM utilizes inspection-based activities.

Table 6.4 - Existing datasheets Data sheets outline either inspection or a diagnostic test condition assessment methodologies with corresponding rating scales, in addition to maintenance related fields. Note, this table excludes any condition assessment methodology and rating scales used by the *Office of Engineering* for bridge and ancillary structure inspection.

Asset Category	Asset Class	Asset Type	Department Responsible	Data Sheet Name	Methodology	Rating Scale	Data Sheet Storage Location
Facilities	Equipment	Calibrated Tools	SM	PM	Inspection	None	Maximo; ProjectWise
Facilities	Equipment	Torque Wrench	SM	PM (2)	Inspection	None	Maximo; ProjectWise
Facilities	Equipment	Substation Fan	SM	PM	Inspection	None	Maximo; ProjectWise
Systems	Traction Power/ Electrification	UPS System	SM	PM (2)	Inspection	None	Maximo; ProjectWise
Systems	Communications	SCADA System	SM	PM	Inspection	None	Maximo; ProjectWise
Facilities	Equipment	HV Gloves/ Hot Stick	SM	Inspection	Inspection	None	Maximo; ProjectWise
Systems	Train Control/ Signals	Track Circuits	SM	PM	Inspection	None	Maximo; ProjectWise
Systems	Traction Power/ Electrification	Substation	SM	PM (8) ¹	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Trip Stop	SM	PM (3) ²	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Interlocking	SM	Locking Test; Inspection	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Switch Machines	SM	Maintenance; Obstruction Test	Inspection; Diagnostic Test	Good/Fair/ Poor; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Switch Machines	MOW	PM (4)	Inspection; Diagnostic Test	Satisfactory/ Yellow/Red; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Switch Heaters	SM	PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Snow Melting System	SM	PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Traction Power/ Electrification	Calibrated Tools	SM	Cab Code Validation	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Grade Crossing Gate	SM	Semi-Annual PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Train Control/ Signals	Contact Rail Heater	SM	PM (2) ³	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise

Vehicles	Revenue Vehicles	Metro Rail Vehicle	RCM	45 Day & Annual PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Vehicles	Revenue Vehicles	Warning Horn	RCM	Semi-Annual PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Facilities	Building Components	Facility Components	FM	PM (24) ⁴	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Stations	Station Components	Station Components	FM	PM (25) ⁵	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Systems	Communications	Fire Alarm Panel	FM	PM	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Guideway	Track	Track	MOW	Inspection (2)	Inspection; Diagnostic Test	Satisfactory/ Yellow/Red; Pass/Fail	Maximo; ProjectWise
Vehicles	Non-Revenue Vehicles	Non-Revenue Vehicles	SMD	Mileage Log	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise
Guideway	Ancillary Structure	Turnback Sign	MOW	Inspection	Inspection; Diagnostic Test	None; Pass/Fail	Maximo; ProjectWise

¹ Substation PMs include: Power System Annual, Safety Inspection (2), Inspection (3), Quarterly Ground Detector, and Eyewash Maintenance.

² Trip Stops include: Program station stop, and emergency monthly & annual.

³ Mainline & Yard Annual PMs.

⁴ Nineteen (19) facility building components PMs and

⁵ Twenty (20) station building components PMs. 15 of these PMs are applied to both facilities and stations.

6.4 Recommended Condition Rating Methodologies

While Metro currently employs a number of different condition assessment methodologies that vary between each asset class and department, Strategy #3 in the TAMP (*Monitor Transit Asset Condition*) requires that physical condition assessment:

- ✓ Specifications be developed for Critical Assets;
- ✓ Methodologies be mapped to FTA's universal 1-5 rating scale; and
- ✓ Be performed by Metro accordingly.

7 Performance Monitoring

Performance monitoring enables Metro management to continually assess the efficacy of their management decisions. TAMP Strategy #11 (*Enhance Enterprise Performance Management*) requires that performance measures and targets be established at both the agency-wide and modal/department level. While Metro currently employs a number of asset-specific performance measures, better performance measures need to be developed in alignment with the agency-wide performance measures in the TAMP, and TAMP Strategy #11, alike. Some initial recommendations for future performance measures are made below.

Key Terms

Input KPI- Measures the amount of resources and efficacy of their use for producing a service

Output KPI- Measures the impact of the service

7.1 Current Performance Measures

Metro currently reports performance data through StateStat, an agency-wide dashboard, and other internal needs. Additionally each method of reporting employs a different set of Key Performance Indicators (KPIs):

- **StateStat** – Utilized by the Governor’s Office to provide transparency and oversight within 19 individual State agencies on a monthly basis.
- **Dashboard** – The newest initiative provides the public with quarterly KPI data based upon MTA’s core mission to provide safe, efficient, reliable transit services with world class customer service. This reporting tool will be operational by October 1st, 2015.
- **Internal** – Pertains to MTA’s asset management initiative, including this LMP, with KPIs that directly characterize a Transit Asset and are not reported outside of the MTA.

Metro currently collects and reports data for nine asset-related KPIs. **Error! Reference source not found.** describes these KPIs, while also establishing internal targets. While not discussed within the current version of this LMP, future versions may not only provide KPI data, but also outline methodologies for establishing and reporting these KPIs.

Table 7.1 - Current KPIs used by Metro and corresponding types of measure, data source, type of assets involved, report type, and applicable targets.

KPI	Type of Measure	Data Source	Asset Types	Report Type	Target
Completed Trips (%)	Output	Trapeze	RCM, MOW, Systems	State Stat	95%
On-Time Performance (%)	Output	Trapeze	RCM, MOW, Systems	State Stat	95%
PM On-Time Completion (%)	Input	Maximo	Systems (Traction Power, Signals), Facilities Equipment	State Stat	80%
Calibration Equipment within Acceptable Tolerance (%)	Output	Maximo	RCM	Internal	85%
Fleet Availability	Output	Maximo	RCM	Internal	70%

Station Lighting Inspections Completed (%)	Input	Maximo	Facilities	Internal	90%
Station Cleaning Inspections Completed (%)	Input	Maximo	Facilities	Internal	90%
Smoke Detectors Tested Completed (%)	Input	Maximo	Facilities	Internal	100%
Switch Inspections Completed (%)	Input	Maximo	MOW	Internal	100%

7.2 Recommended Performance Measures

Several additional KPIs have been proposed for the Metro mode, in accordance with TAMP Strategy #11. These proposed KPIs are focused on asset-level performance management, designed to support the agency-wide KPIs identified in the TAMP where possible, and support continued reporting for other internal MTA needs, such as StateStat (Table 7.2).

Table 7.2 - Proposed KPIs for Metro and corresponding types of measure, data source, type of assets involved, type of report, and rationale for inclusion.

MISSION ELEMENT	VISION ELEMENT	KPI	TYPE OF MEASURE	DATA SOURCE	ASSET TYPES
SAFETY	Safety	Asset-related preventable accidents per 100,000 miles	Output	--	Vehicles
		% of rail slow zone mileage	Output	--	Guideway
EFFICIENCY	Fiscal Responsibility	Farebox recovery ratio	Output	--	Treasury
		Cost of service outages	Output	--	All
		Value of SGR Backlog	Output	--	All
RELIABILITY	Operational Performance	PM to CM Cost Ratio	Output	Maximo (with additional data)	Systems, Facilities, MOW
		Mean Distance Between Failure (MDBF)	Output	Maximo (with additional data)	RCM
		Percent of fleet beyond MTA replacement standard	Input	Excel	Non-Rev Vehicles
CUSTOMER SERVICE	Customer Service	Count of asset related customer complaints	Output	--	All
		Count of asset related customer satisfaction results	Output	--	All

Data sources stated above are currently employed and available, but they may change as business processes or systems improve. For example, MTBF can be reported entirely out of Maximo if business processes change to enter data and run reports out of that system. Metro will also need to modify some of its daily activities to support the calculation of these recommended KPIs. For example, the PM to CM cost ratio cannot be properly calculated unless Metro employees consistently log their labor hours against PM and CM activities accordingly.

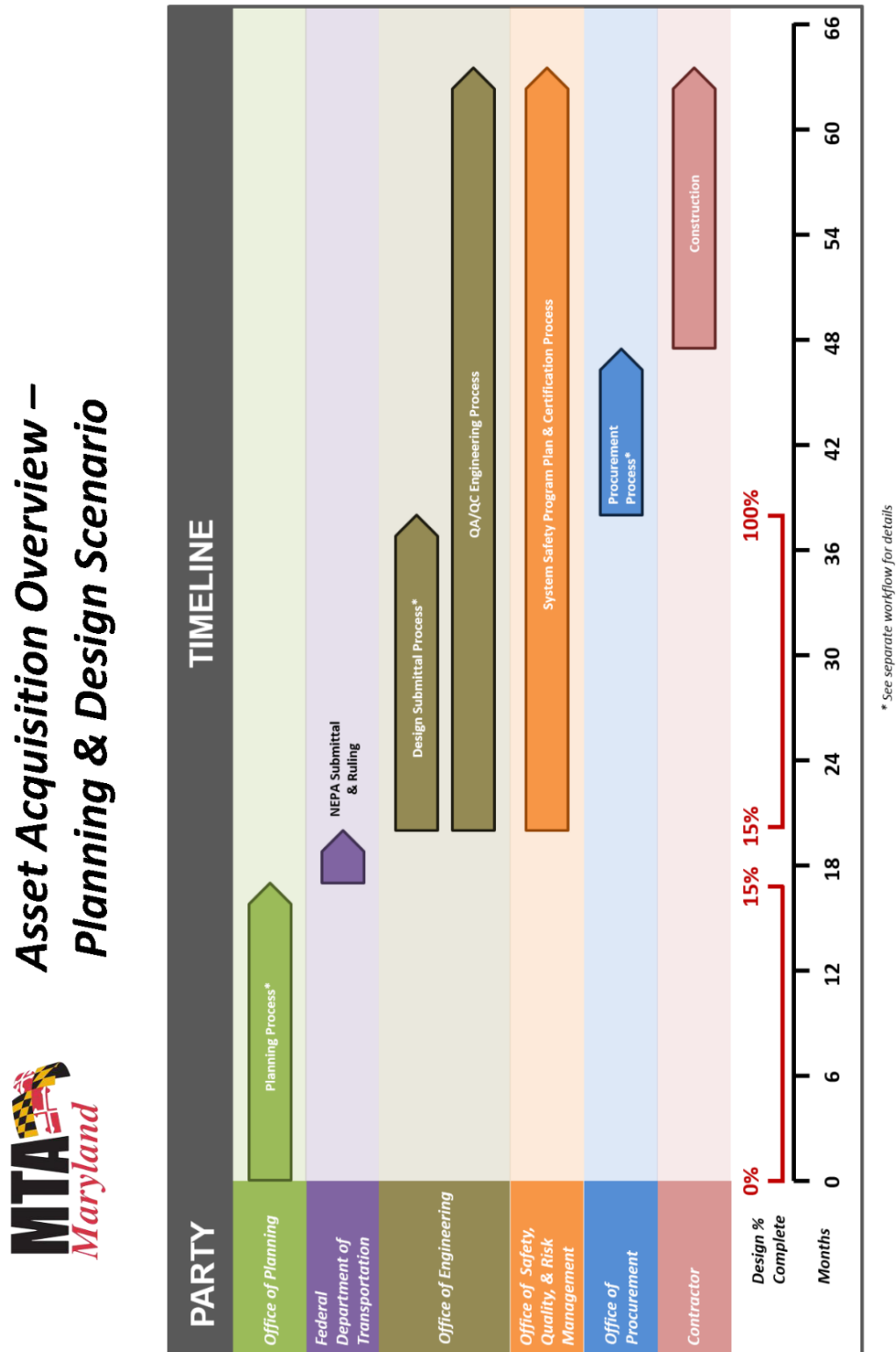
While previous chapters discuss Metro responsibilities and the management of its entire asset inventory as a whole, the subsequent four chapters focus on each phase of an asset's lifecycle. Specifically, each chapter describes Metro's current management practices from the perspective of each asset category.

8 Lifecycle Phase 1 – Acquisition

The asset acquisition phase requires coordination of numerous MTA offices to facilitate the procurement of a new Transit Asset. With major procurements the acquisition phase may include: planning, design, and/or construction processes. Smaller procurements may sometimes be accomplished through a purchase order or a credit card. Figure 8.1 illustrates the interrelationship between these asset acquisition processes, durations, and designation of responsibility to associated MTA offices or departments. The following subsections discuss these processes in greater depth.

Note, Figure 8.1 is only applicable to the acquisition of larger assets, such as facilities, signaling systems, revenue vehicles, or guideway. Smaller scale procurements, such as equipment, commodities, small storage facilities, or non-specialty non-revenue vehicles, will *not* undergo planning or National Environmental Protection Act (NEPA) documentation submittal.

Figure 8.1 - Overview of an asset's acquisition. Only applies to larger assets, such as facilities, signaling systems, revenue vehicles, or guideway. Demonstrates key player for each major process and related duration.



In addition, Figure 8.1 also assumes ideal conditions when correlating timeframes to each asset acquisition process. In other words, this timeline represents the best case scenario for all stakeholder involvement and capital funding availability to ensure an acquisition process without interruption. However, circumstances often arise that would increase the amount of time required to complete an acquisition (Table 8.1). Examples of these circumstances may include:

Table 8.1 – Possible delays in the asset acquisition process. The concepts and vocabulary contained in this table are discussed in greater detail throughout the remainder of this document. Please refer to the corresponding Section for each acquisition process.

ACQUISITION PROCESS	PROCESS TOPIC	CIRCUMSTANCE
PLANNING	NEPA documentation	When projects receive federal funding and require level of environmental documentation beyond a Categorical Exclusion.
	Site alternative analysis	Late stage discovery of a fatal flaw at the preferred site.
	Leadership priority	Executive or Legislative leaders change the priority of the organization.
	Hazardous Materials (HazMat) discovery	Discovery of HazMat at project site prompts participation into MDE's Voluntary Clean Up program.
	Negative public perception	Community stakeholders strongly oppose the project.
DESIGN SUBMITTAL	Right of Way (ROW) acquisition	Property seller does not agree with terms and legal action is required.
	Re-design	High bid projects must undergo value engineering to arrive at expected cost.
PROCUREMENT	Delegated authority surpassed	The value of the procurement surpasses agency's delegated authority. Would require control agency or Board of Public Works approval.
	Unexpectedly high bid	Bids come in higher than the Engineer's Estimate.
	Dispute, protest, & other conflict resolution	Bidders disagree with procurement process, either pre or post award.
CONSTRUCTION	Underperforming contractor	Contractor does not adhere to project schedule.
	Change order request	Construction findings requires modification to design.

The following subsections describe the interrelated acquisition processes in further detail, except for four because they are outside the scope of this LMP:

- NEPA Submittal & Ruling
- QA/QC Engineering Process

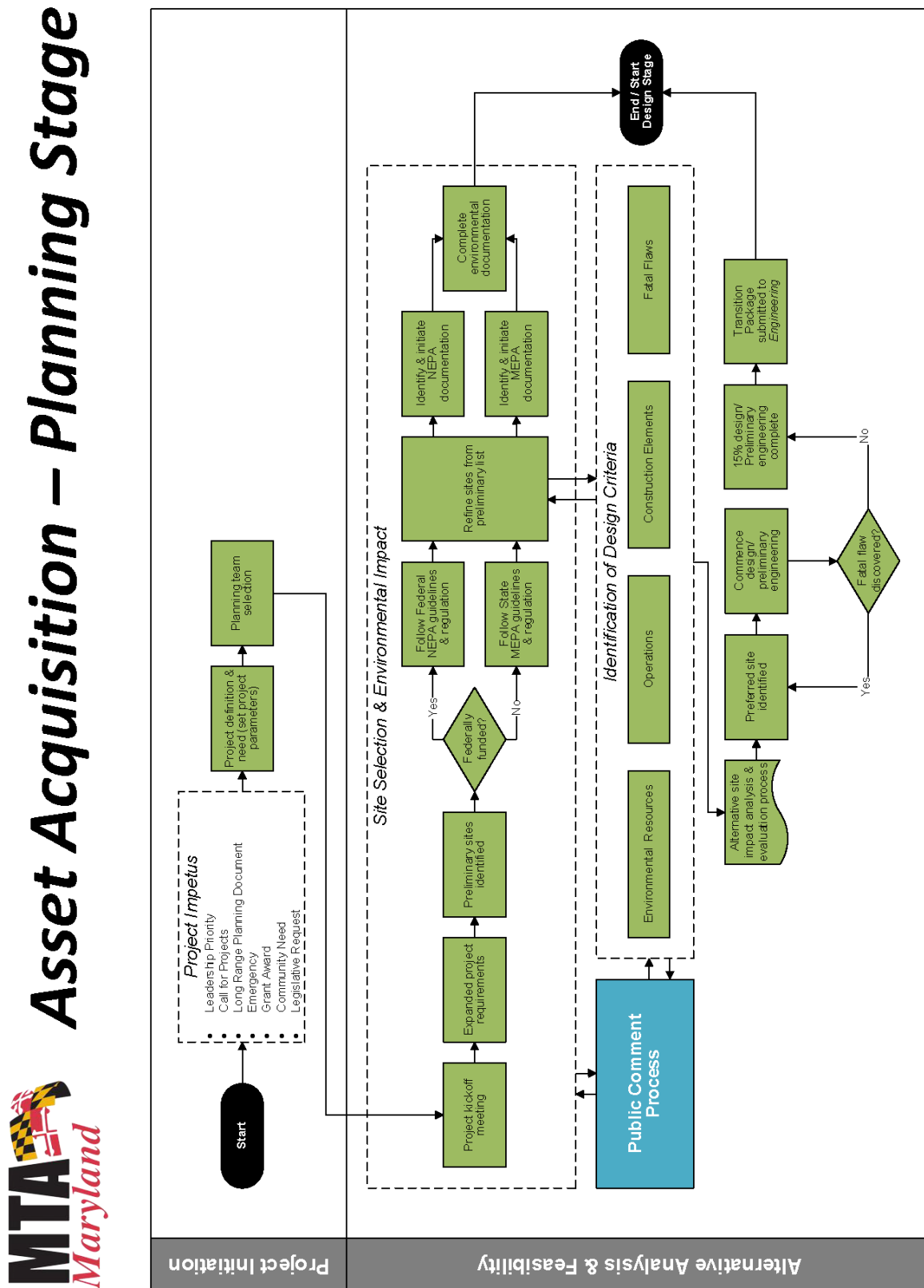
- [System Safety Program Plan](#) & Certification
- Construction

A detailed explanation of these four other processes can be found in other existing MTA documents; these have been hyperlinked above to the extent they have been available at the time of publishing.

8.1 Planning Process

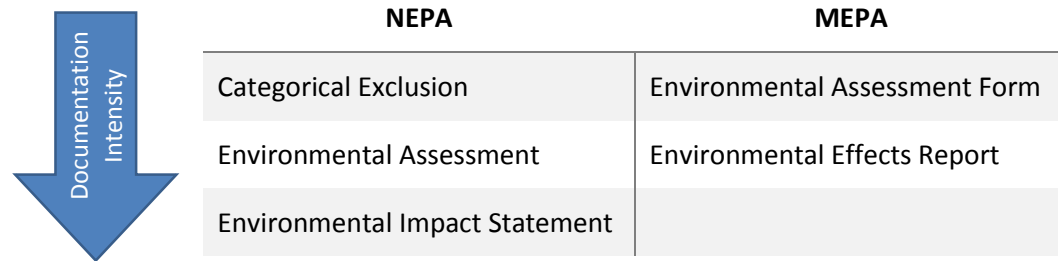
Planning is not always part of the asset acquisition phase. System expansion activities, including the construction of new fixed guideway/systems, facilities, stations, and other infrastructure, all undergo an intensive planning process at the outset of the asset acquisition phase. Acquisition of new vehicles, and replacement of existing assets typically do *not* involve planning activities. The MTA *Office of Planning* coordinates and conducts the Planning stage of an asset's acquisition, based upon the process below (Figure 8.2).

Figure 8.2 – Overview of the Planning Process. NEPA: National Environmental Protection Act; MEPA: Maryland Environmental Protection Act.



The *Planning Process* includes the development of NEPA/MEPA documentation and are only portrayed as one step in the diagram above for simplicity purposes. NEPA is required when a project utilizes Federal funding, whereas MEPA documentation occurs when a project receives *only* State funding. According to both NEPA and MEPA regulations, the project size (or impact) triggers more intensive levels of environmental documentation. Examples of this documentation include:

Figure 8.3 - Increasing intensity of NEPA/MEPA documentation.



Several other important distinctions are worth mentioning within Figure 8.2:

- This diagram focuses upon process and not assigning a chronological duration to each step.
- Environmental considerations unique to the project provide a basis for the simultaneous execution of site alternative analysis *and* NEPA/MEPA documentation.
- Each of the four *Design Criteria* become main elements of the alternative site impact analysis.
- The *Public Comment Process* box denotes that public comment is employed throughout the Planning stage at key junctures.

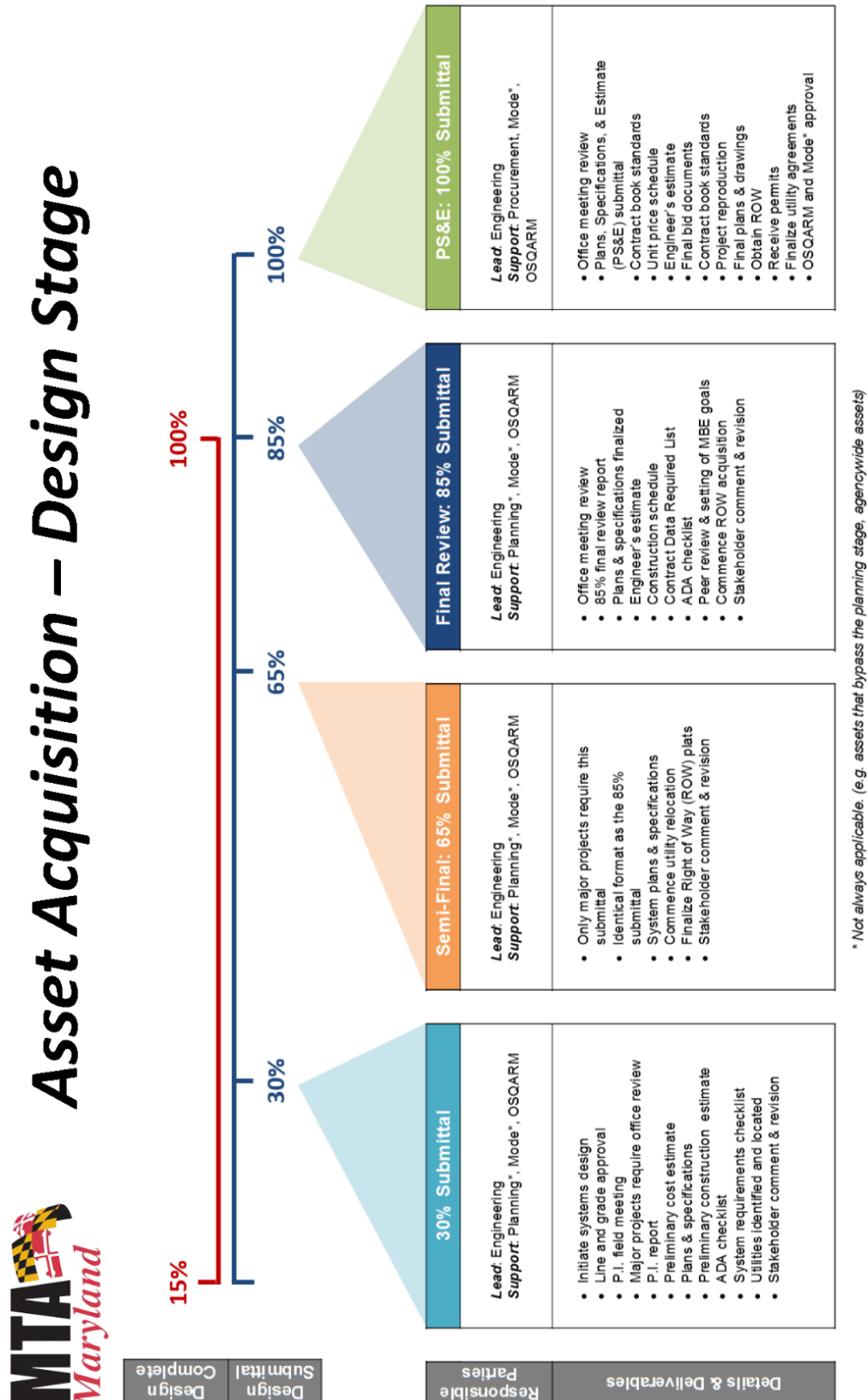
8.2 NEPA Submittal & Ruling Process

The *NEPA Submittal & Ruling Process* refers to the submittal of all NEPA documentation, prepared in the *Planning Process* above, to the Federal Department of Transportation (DOT). This three month duration allots time for DOT to obtain, review, and make final judgment on the NEPA package. This process may be fully detailed within a later version of this LMP.

8.3 Design Stage Process

MTA Office of Engineering coordinates the design stage of asset acquisition. Two diagrams are associated with this section, one embedded within this subsection describing the Design process (Figure 8.4) and another within the appendix describing applicable drawings and plans, categorized by engineering discipline (**Appendix C: Plan & Drawing Submittal Milestones**).

Figure 8.4 - Overview of the Design Process.



The Design Stage process above identifies which deliverables are required from each major submittal step of a project's design. Additionally, each submittal step maps to the total completion of the project design, as well as corresponding responsible parties. In the scenario where a project requires planning, the *Office of Planning* will carry project design through up to 15 percent design. Upon reaching 15 percent design completion, *Planning* prepares a transition package to transfer project design leadership to the *Office of Engineering*. If a project does not require planning, then the *Office of Engineering* assumes responsibility for the entirety of a project's design.

Furthermore, Figure 8.4 denotes that all right of way (ROW), or Land Assets, are procured within this stage *not* the procurement stage. While *Office of Procurement* purchases the service or Transit Asset (**Section 8.6**), the *Office of Engineering, Real Estate Division* manages all ROW acquisition. The details of the ROW acquisition process will be captured within a future version of the LMP.

8.4 QA/QC Engineering Process

Once a project enters the *Office of Engineering* for design, the *Office* employs a self-audit procedure via a formal QA/QC process. While QA/QC is documented within this LMP as part of the design process, it also provides *Engineering* oversight once the project enters the procurement and construction stages, as well. This process may be fully detailed within a later version of this LMP.

8.5 System Safety Program Plan (SSPP) and Certification Process

The MTA System Safety Program Plan (SSPP) requires that all major procurements undergo a regimented "certification process" to ensure the safety/security of MTA employees, customers, and the surrounding community throughout the lifecycle of the Transit Asset. The *Office of Safety, Quality, and Risk Management* (OSQARM) coordinates system safety/security certification parallel to Engineering's QA/QC. The SSPP and the safety/security certification process also ensure compliance with all federal and state regulation. A copy of the SSPP can be found here for further details ([Signed MTA 2016 SSPP.pdf](#)).

8.6 Procurement Stage

After the completion of the Design stage, *Office of Procurement* coordinates the procurement of the Transit Asset. Figure 8.5 indicates the procurement process will generally require nine months for completion.

Figure 8.5 - Overview of MTA's 11 step procurement process.

Step 1: Select a Contract Vehicle	Contract Vehicle	Purpose, when you...	Purchase Examples			
	Request for Proposal (RFP)	Know the evaluation criteria is defined, but you don't know how to reach the end result.	Professional Services			
	Competitive Sealed Bid (CSB)	Have finite, discrete, and concrete contract demands.	Buses or railcars			
	Multi-Step CSB	Two step process: 1) Qualifications are reviewed, possible questionnaire for construction, & applicants are approved; 2) CSB process.	Buses or railcars			
	Sole Source	Need a proprietary product, pilot project, or products that must be compatible with existing systems. Vendor cannot be a reseller.	New technologies; OEM materials			
	Emergency	Realize public safety is at risk.	Emergency response equipment			
Step 2: Select Procurement Type	Procurement Type	Definition				
	IT	Hardware, software, and other peripherals (i.e. monitors and modems)				
	Services	Professional services to be administered by a person (i.e. accounting & reconciliation)				
	Maintenance	Preventative and corrective maintenance activities.				
	Construction	Construction of a major large facility. Also includes <i>ancillary</i> , or minor construction projects implemented through a contract's task order.				
	Commodities	1 time supply of parts, or office supplies. Non-transit procurements managed through DGS. For Commodities that cost below \$25,000, see Inventory Invoice Process. Continue to Step (3) for purchases above \$25,000.				
	Preferred Provider	Socioeconomic policy that requires certain materials or services to be supplied by a pre-set list of providers, including: Public Safety & Correctional Services, Blind Industries & Services, or Maryland Works, Inc. Internal MTA process.				
Step 3: Funding Source?	State Funds Only		See Code of Maryland Regulations (COMAR) for Procurement Regulations			
	State and Federal Funds		See Code of Federal Regulations (CFR) for Procurement Regulations			
Step 4: Does the procurement require Control Agency Approval?	Contract Vehicle	Procurement Type				
		IT	Service	Maintenance	Construction	Commodity
	CSB/RFP	Y – Over \$25,000	Y – Over \$25,000	N	N	Y – \$25,000
	Single Bid/ Sole Source	Y – Over \$25,000	Y – Over \$50,000	N	N	Y – for Non Transit
	Approval Required for:	Control Agency Departments:			Y – Approval Needed	
	- Contract Modifications - Cooperative Purchasing	Budget Management for Services General Services for Commodities Information Technology for IT			N – No Approval Needed	
Step 5: Does the Procurement need to be posted on the eMaryland Marketplace?	eMaryland Marketplace (eMM) is the State's official online advertising engine. All agencies must utilize to solicit bidding and all vendors must have membership to submit their bids.					
	Contract Vehicle	Procurement Type				
		IT	Service	Maintenance	Construction	Commodity
	CSB/RFP	Y – Over \$15,000	Y – Over \$15,000	Y – Over \$15,000	Y – Over \$15,000	Y – Over \$15,000
	Single Bid/ Sole Source	Y	Y	Y	Y	Y
	Y – Post on eMM		N – Skip eMM Posting			

Procurement Process, Continued...

Step 6:
Bid Evaluation
Process

Step 7:
Does the Procurement require a Procurement
Officer Determination?

Step 8:
Does the Procurement need require
a Delegated Contract Action Record?

Step 9:
Does the Procurement require Board
of Public Works (BPW) approval?

Step 10:
BPW approval
process

Step 11:
Contract Award

*If CSB,
Then select the **lowest
responsive & responsible
bid.***

*If RFP,
Then select based upon
an **evaluation and
ranking** by a team of
experts.*

*If **Single Bid / Sole Source**,
Then select based upon
qualifying **justification**.*

A Procurement Officer Determination (POD) is a document that describes a procurement's background, scope, and the rationale for its award to the vendor.

	Procurement Type				
	 IT	 Service	 Maintenance	 Construction	 Commodity
Contract Vehicle					
<i>CSB/RFP</i>	Y	Y	Y	Y	Y – Over \$5,000
<i>Single Bid/ Sole Source</i>	Y	Y	Y	Y	Y

PODs also required for:

- ♦ Contract Modifications
- ♦ Cooperative Purchasing
- ♦ Emergency Orders
- ♦ Protests

Y – Issue POD

N – Skip POD

A Delegated Contract Action Record (DCAR) notifies the Board of Public Works (BPW) of a procurement worth less than \$200,000, when BPW's approval is not required.

	Procurement Type				
	 IT	 Service	 Maintenance	 Construction	 Commodity
Contract Vehicle					
<i>CSB/RFP</i>	Y – Under \$50,000	Y – Under \$100,000	Y – Under \$200,000	Y – Under \$200,000	N
<i>Single Bid/ Sole Source</i>	N – Under \$25,000	Y – Under \$50,000	N	N	N

DCAR also required for:

- ♦ Contract Modifications
- ♦ Cooperative Purchasing
- ♦ Emergency Orders

Y – Issue DCAR

N – Skip DCAR

	Procurement Type				
	 IT	 Service	 Maintenance	 Construction	 Commodity
Contract Vehicle					
<i>CSB/RFP</i>	Y – Over \$200,000	Y – Over \$200,000	Y – Over \$200,000	Y – Over \$200,000	N
<i>Single Bid/ Sole Source</i>	Y – Over \$50,000	Y – Over \$50,000	Y – Over \$50,000	Y – Over \$50,000	N

DCAR also required for:

- ♦ Contract Modifications

Y – BPW Approval Required

N – Skip Approval

Majority Vote from...

Governor
 Treasurer
 Comptroller

No – Procurement Denied or Repeat Step (9)

Yes – Proceed to (11)

Award Contract & Post Notice on eMaryland Marketplace

Procurement Concluded

Depending upon the type of contract vehicle used, and special circumstances that may exist, procurement durations may vary. Some examples of ideal procurement durations include:

Table 8.2 - Duration of specific contract vehicles and applicable special circumstances.

CONTRACT VEHICLE	STANDARD DURATION (MONTHS)	SPECIAL CIRCUMSTANCE	SPECIAL DURATION (MONTHS)
COMPETITIVE SEALED BID (CSB)	7	IT procurement	9
REQUEST FOR PROPOSAL (RFP)	7	Best and Final Offer (BAFO)	9
		IT procurement	9
PURCHASE ORDER (PO)	1.5	IT procurement	9
ANCILLARY TASK	1.5	IT procurement	9

8.7 Construction

For asset acquisitions that involve a discrete design phase, construction represents the final step in acquisition. For all major procurements, construction is generally performed by vendors/contractors on MTA property, and is coordinated by the *Office of Engineering, Construction Division*. However, offsite construction (e.g. revenue vehicles) and installation of on-vehicle systems is coordinated by the *Office of Engineering, Systems Division*. The main sequence of construction projects include:

1. **Notice to Proceed (NTP)** – Written authorization to initiate work, sent from the MTA to the vendor/contractor. A base contract NTP is authored by the *Office of Procurement*, whereas an ancillary task order NTP is authored by the appropriate division within the *Office of Engineering*.
2. **Mobilization** – A period in which the vendor/contractor coordinates construction materials, equipment, labor, site logistics, and any other permits not already obtained within the Design Phase.
3. **Work** – Physical construction activity.
4. **Substantial completion** – A period where the majority of physical construction activity is complete, and only punch-out items remain.
5. **Closeout** – Submittal and payout of final vendor/contractor invoice.

This process may be fully detailed within a later version of this LMP.

9 Lifecycle Phase 2 – Operations/Maintenance

Maintenance is often the first topic that comes to mind when one considers the broader discipline of asset management. This is because Lifecycle Phase 2 – Operations/Maintenance is the phase with the longest duration, and often reflects the majority of an asset’s Total Cost of Ownership (TCO). Generally, Metro currently employs corrective and/or Scheduled Maintenance regimes for its Transit Assets.

9.1 Current Maintenance Practices

While inspections are currently used throughout Metro for the purpose of condition assessment, they are often conducted simultaneously with scheduled preventive maintenance for time efficiency. As indicated in Table 9.1 below, not all Metro assets are scheduled for a recurring PM, in which case these inspections provide an opportunity to identify the need for a Corrective Maintenance work order.

Table 9.1 – Select asset **categories** undergo scheduled maintenance activities (left). All categories undergo inspection-based activities that trigger corrective maintenance actions.

SCHEDULED MAINTENANCE ACTIVITY PM	ASYNCHRONOUS MAINTENANCE ACTIVITY PM
Vehicles	Guideway
Facility Equipment	Stations
Electrification/ Traction Power	Facility Structure/ Grounds
Signaling/ Train Control	

Since maintenance is a broad topic, the description of Metro’s maintenance practices falls into two categories: operation and maintenance policy setting, and maintenance implementation. The former determines the scope and schedule of the maintenance work, while the latter describes *how* the work is operationalized through the Metro management structure.

As discussed in Chapter 6 above, Maximo uses associated terminology that may be confusing to new employees or those that work outside of the Metro mode. Both scheduled maintenance *and* inspection-based activities are initially programmed in the Maximo system via a master scheduling file called a “Master PM,” which in turn generates a work order on the prescribed interval, called a “PM.” In other words, a “PM” should not necessarily imply that a scheduled maintenance activity occurs, because some Metro Transit Assets are only subject to inspection-based “PM” work orders (to trigger corrective maintenance) (Table 9.1).

9.1.1 Operations and Maintenance Policy-Setting

Metro sets operations (Figure 9.1) and maintenance (Figure 9.2) policies for select asset types in its inventory, detailing the scope and schedule of the maintenance work to be performed. These policies are based upon Original Equipment Manufacturer (OEM) recommendations and regulatory requirements, and are captured in Standard Operating Procedures (SOPs) and/or “Master PM” documentation.

Figure 9.1 – Metro’s operations policy process.

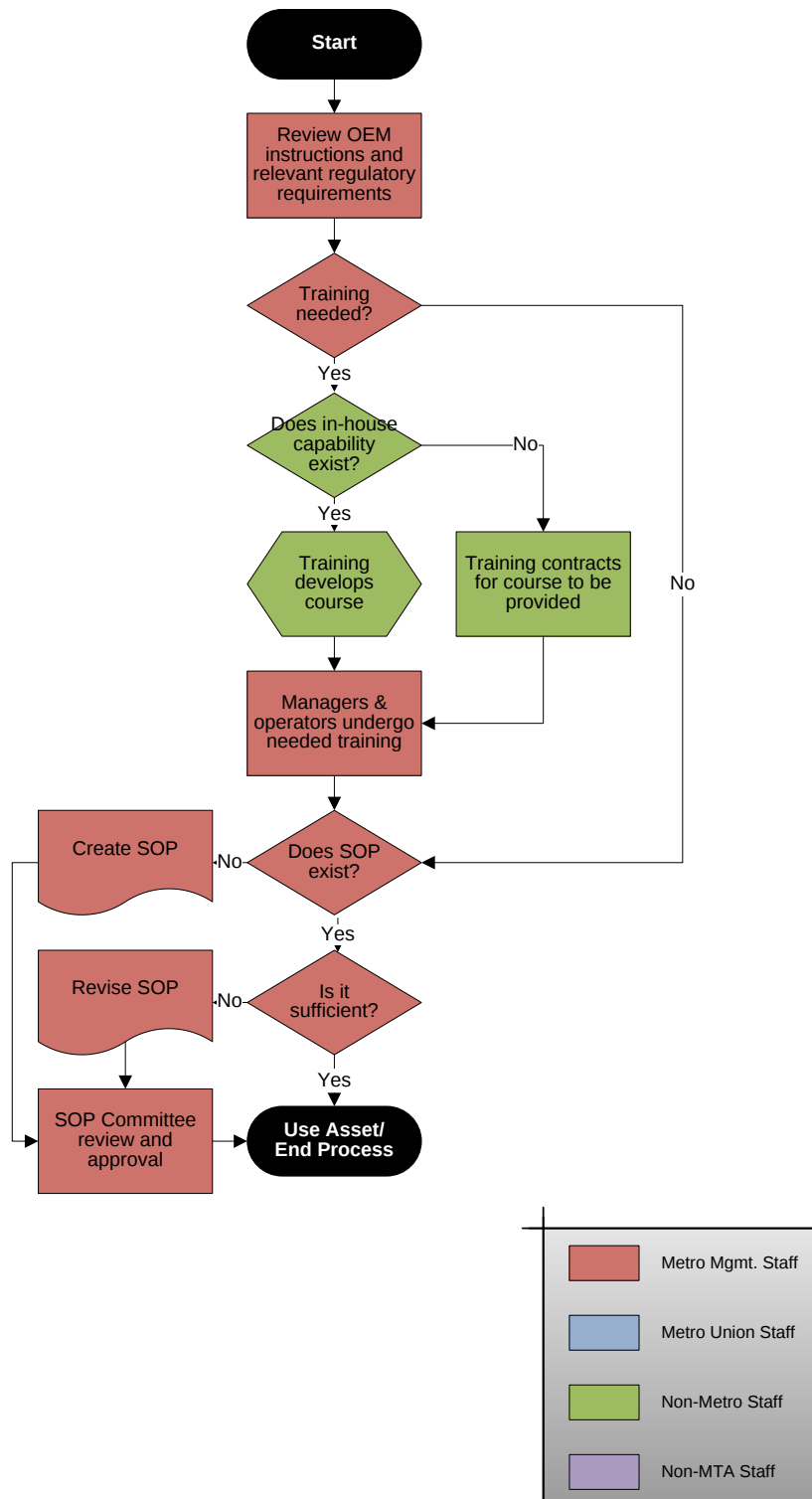
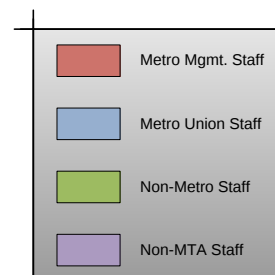


Figure 9.2- Metro's maintenance policy process.



All SOPs are finalized by executive management and undergo annual review. For the SOPs that require regularly executed maintenance and inspection actions, management schedules a Master PM in Maximo.

Note that as previously discussed in Section 6.3, both *inspection* and *maintenance* regimes are documented in Maximo using similar terminology. New employees and those that work outside the Metro mode may benefit by simply considering the following definitions for these terms, and avoid associating them with the common acronym “preventative maintenance”:

Table 9.2 - Maintenance related terminology and disambiguation of “preventative maintenance.”

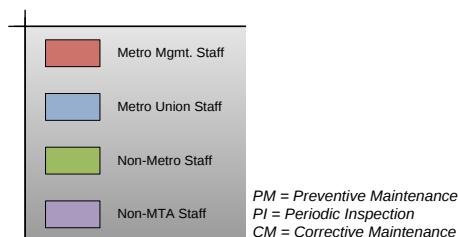
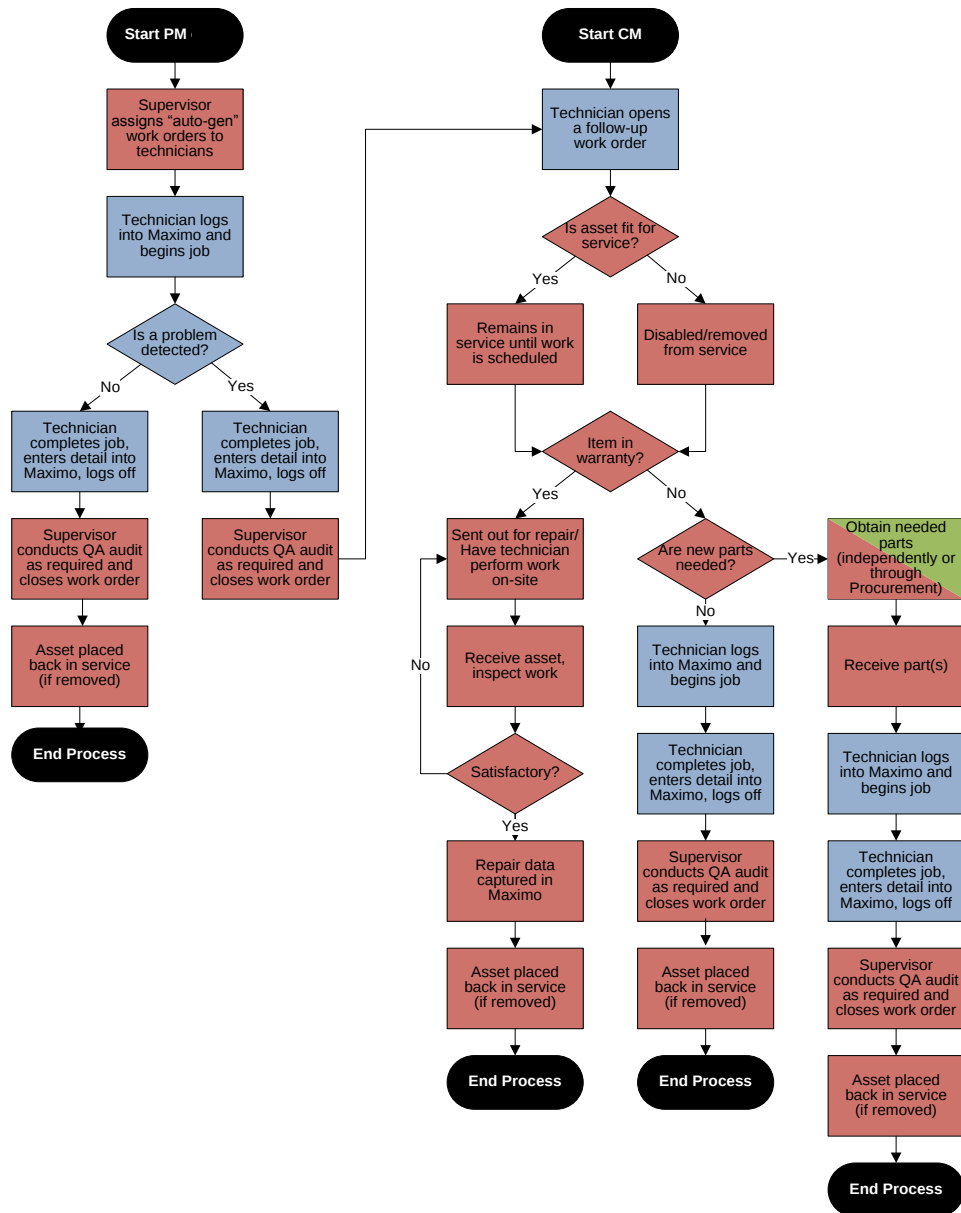
TERM	DEFINITION
MASTER PM	A schedule programmed into Maximo for any work that takes place on a recurring interval at a particular location, or for particular Transit Assets.
PM	A work order generated via a Master PM that details the scope of activities to be performed at the particular location, or for the particular Transit Assets.
DATA SHEET	Generated along with the PM (work order) to be completed with notes and data associated with the work performed. Completed Data Sheets, also known as “check-off” or “inspection sheets,” may be stored in a number of locations, via physical copy or electronic copy.

9.1.2 Maintenance Policy Implementation

Metro operationalizes its maintenance policy with either a Scheduled Maintenance or a Corrective Maintenance approach (Figure 9.3). Scheduled Maintenance PMs (work orders) require close-out within Maximo and submittal of the completed Data Sheet, and may also be subject to a quality assurance audit. If the asset was found to require a CM upon completion of the Scheduled Maintenance, the CM may be conducted immediately with paperwork filed post-completion, or scheduled for completion at a later date in time. CM activities involve warranty considerations that dictate whether the asset will be repaired on site, and whether asset repair requires procurement of additional spare parts or components.

Furthermore, Metro’s procedures dictate that maintenance work must undergo a monthly Quality Assurance/Quality Control (QA/QC) audit. However, ensuring compliance remains difficult, as QA/QC audits are not regularly scheduled through Maximo. Ultimately, once all maintenance work and QA/QC checks have been completed, the supervisor releases the asset back into service.

Figure 9.3 - Execution of Scheduled Maintenance or Corrective Maintenance work orders by all departments.



9.2 Current Maintenance Schedules

The following sections summarize inspection and maintenance activity based on MTA Metro **Standard Operating Procedures (SOPs)** and **Master PMs**. These maintenance schedules are summarized by asset category and further detailed by asset class in the sections below.

9.2.1 Vehicles

Metro is directly responsible for the daily operations and maintenance of its **revenue vehicles**, which are considered Critical Assets, and has established scheduled inspection and maintenance regimes for its railcars accordingly. Maintenance decisions for **non-revenue vehicles** are handled via a third-party contractor, by way of the Fleet Management Services Department; the associated maintenance regimes employed by this contractor are not well documented at the MTA.

Table 9.3 - Summary of maintenance documentation for revenue vehicles. The table does not include maintenance regimes for non-revenue vehicles because this documentation was not available at the time of publishing.

Asset Category	Asset Class	Asset Type	Department Responsible	SOP Name	Master PM Name
Vehicles	Revenue Vehicles	Railcar	RCM	• Daily Inspection • 45 Day Inspection • Annual Inspection • Daily Cleaning • Major Cleaning (--day) • Inspection Scheduling • Release to Revenue Service	• -- • Inspection (45 day) • -- • -- • -- • -- • --
Vehicles	Revenue Vehicles	Railcar Components	RCM	• Liquid Penetrant Testing (--day) • Magnetic Particle Testing (-- day)	• -- • --
Vehicles	Revenue Vehicles	Truck Assembly	RCM	• Torque Testing (--day) • Inspection and Maintenance (360 day)	• Annual Truck PM
Vehicles	Revenue Vehicles	Wheel & Axle Assembly	RCM	• Inspection (45, 360 day)	• --
Vehicles	Non-Revenue	Hi-Rail Vehicles	MOW	• Safe Operation (Light) • Safe Operation (Heavy)	• -- • --

The maintenance documentation gap analysis (Table 9.3) indicates that Metro has SOPs and Master PMs for their 45 Day and annual maintenance regimes. However, daily inspections, annual truck maintenance, railcar component inspection, and wheel and axle inspections all lack Master PMs while currently having a corresponding SOP. The five year railcar maintenance lack both maintenance SOPs and Master PMs. Conversely, the approach warning horn has a Master PM without a corresponding SOP.

9.2.1.1 Revenue Vehicles

Below is a more detailed discussion of the revenue vehicle maintenance documentation found in Table 9.3. Metro's [Fleet Management Plan](#) details the railcar fleet maintenance schedule, including staffing requirements and impacts to fleet availability. Table 9.4 below further summarizes maintenance and

inspection schedules for the Metro fleet in relation to the three available work shifts: **day**, **evening**, and **midnight**.

Copies of the SOPs listed in the table below may be found through the [SOP catalogue](#).

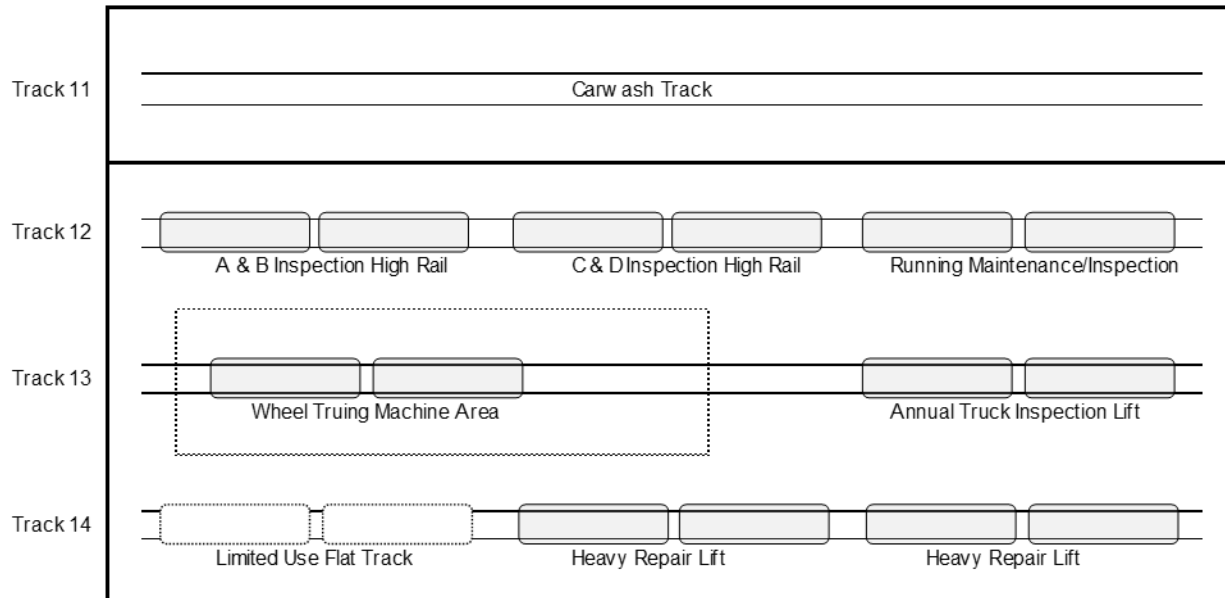
Table 9.4 – Revenue vehicle maintenance inspection schedules, modified from the Metro Fleet Management Plan.

Inspection Name	Cycle	Shift Responsible	Shifts Necessary	Hours per Inspection	Labor Hours	Inspections per Year, per Vehicle	Average Inspections per Day
Daily	Daily	Evening/ Midnight	--	4		312	85
<i>Inspection for cleanliness and interior defects; includes functional verification of the Propulsion, Brakes, ATP, HVAC, Doors, and Lighting; includes visual inspection of under-car equipment (trucks, couplers, actuators, brake pads, collector assemblies, covers, and air lines).</i>							
B	45 Days	Day/Evening	2	8	40	7	1.17
<i>Includes minor diagnostic inspection of all major systems, with adjustments made to ensure adequate functioning; equipment failures requiring more extensive repairs are recorded via Maximo, and the car is removed from service if necessary. Every fourth "B" inspection also includes a door inspection to lubricate the door track and gearbox, and to make any necessary adjustments to tension and timing calibration.</i>							
D	Annual	Day	1	32	144	1	1.00
<i>Includes a comprehensive inspection of equipment and sub-assemblies and major diagnostic inspection and adjustments. Recorded operation and change-out of critical systems are conducted and include brake components, brake rates, vital relays, and ATP.</i>							
E	5 years	All	--	--	--	--	0.05
<i>Involves an overhaul of the Truck subsystem and associated subsystem components.</i>							
Truck	Annual	Day	1	40	80	1	1
<i>Involves removal of trucks from the railcar and inspection, repair, and/or replacement of critical items such as liners, bearings, shocks, and radius rods; all components lubricated before reassembling.</i>							
Average Scheduled Maintenance Demand							3.22*

* Daily inspections have been excluded from this calculation of average schedule maintenance demand.

Most maintenance activities for railcars take place at Wabash, with specific track segments utilized for specialized maintenance purposes (Figure 9.4). Wabash has seven inspection and repair locations containing both fixed and mobile assets, each capable of accommodating one married pair of cars.

Figure 9.4 - Track layout at the Wabash facility and corresponding maintenance activities, as shown in the Metro Fleet Management Plan.



9.2.1.2 Non-Revenue Vehicles

Metro generally employs contractors on an as-needed basis to maintain its specialty vehicles, such as hi-rail vehicles, track tampers, skid loaders, front-end loader, prime mover, ballast regulator, and various snow removal equipment. Non-revenue vehicle maintenance, whether routine or non-routine, is performed through a number of avenues:

- The first recourse for maintenance is the **Fleet Services Department** within the MTA's Operations Support Division. Fleet Services conducts routine preventive maintenance and repairs at MTA's main Truck Shop located on the Bush Division property. Day-to-day activities are set in the State of Maryland's Department of Budget and Management's Policies and Procedures for Vehicle Fleet Management [[MTA LRT Fleet Management Plan - 06 11 14.pdf](#)].
- Fleet Services also contracts with **Element Fleet Management (formerly PH&H)** to provide vehicle maintenance needs. Whether maintenance is conducted at the Truck Shop or sent out to Element for servicing often comes down to the availability of MTA personnel and shop floor space to conduct the work.
- **Metro may make repairs themselves**, as a last resort, for expediency.

Since maintenance of non-revenue vehicles is conducted outside the Metro mode, associated SOPs and Master PMs are not available to Metro staff, and were not available for reference in this LMP at the time of publishing.

9.2.2 Facilities

Facilities Maintenance and Environmental Services Department (FM) inspects and maintains all asset classes. Note that a gap analysis between SOPs and Master PMs demonstrate inconsistent application of maintenance documentation, with few asset types having both documents (Table 9.5).

Copies of the SOPs listed in the table below may be found through the [SOP catalogue](#).

Table 9.5 – Summary of maintenance documentation for each facility asset.

Asset Category	Asset Class	Asset Type	Department Responsible	SOP Name	Master PM Name
Facilities	Access	Security Gate	FM	• -- • -- • --	• PM (30, 90, 180, 360 day) • PM (30, 90 day) • PM (90, 180, 360 day)
Facilities	Building Component	Air Compressor	FM	• -- • --	• Ventilator PM (30, 90, 360 day) • Sprinkler PM (30, 90, 360 day)
Facilities	Building Component	Air Conditioning Unit	FM	• --	• PM (30, 90, 360 day)
Facilities	Building Component	Air Handling Unit	FM	• --	• PM (90 day)
Facilities	Building Component	Electric Panel	FM	• Preventative Maintenance (180 day)	• PM (180 Day)
Facilities	Building Component	Heaters	FM	• -- • -- • -- • --	• Unit PM (360 day) • Wall PM (360 day) • Electric Duct PM (360 day) • Electric Water PM (180 day)
Facilities	Building Component	HVAC	FM	• Preventative Maintenance (Annual)	• PM (30, 90, 360 day)
Facilities	Building Component	Lighting, Non-Public	FM	• --	• PM (30 day)
Facilities	Building Component	Boiler	FM	• --	• PM (180 day)
Facilities	Building Components	Egress Hatch	FM	• --	• PM (180 day)
Facilities	Building Components	Fire Valve Pit	FM	• --	• PM (360 day)
Facilities	Building Components	Fire Suppression System	FM	• --	• PM (30 day)

Facilities	Building Components	Motor Control Center	FM	• --	• PM (180 day)
Facilities	Building Components	Sewage Ejector	FM	• --	• PM (30, 90 day)
Facilities	Building Components	Sprinkler System	FM	• --	• PM (30 day)
Facilities	Building Components	Water Fountain	FM	• --	• PM (180 day)
Facilities	Equipment	Bulk Fluid Storage Tank	FM	• Monitoring & Control (-- day)	• --
Facilities	Equipment	Vent Fans	FM	• Line PM (2) (30, 360 day) • Station PM (2) (30, 360 day) • Under Platform PM (2) (30, 360 day) • TPSS PM (2) (30, 360 day)	• Exhaust PM (360 day) • TPSS PM (30, 360 day)
Facilities	Equipment	Fire Extinguishers	FM	• --	• PM (30 day)
Facilities	Major Shops	Pit Lighting	FM	• Inspection & Maintenance (30 day)	• PM (30 day)
Facilities	Equipment	Auxiliary Power Bugs	RCM	• Operation	• --
Facilities	Equipment	Band Saw (2)	RCM	• Operation (2)	• --
Facilities	Equipment	Bead Blasting Machine	RCM	• Operation	• --
Facilities	Equipment	Belt Sander	RCM	• Operation	• --
Facilities	Equipment	Drill Press	RCM	• Operation	• --
Facilities	Equipment	Electric Jacks	RCM	• Operation	• --
Facilities	Equipment	Engine Lathe	RCM	• Operation	• --
Facilities	Equipment	Lift Truck	RCM	• Operation	• --
Facilities	Equipment	Magnaflux Machine	RCM	• Operation	• --
Facilities	Equipment	Overhead Cranes	RCM	• Operation	• --
Facilities	Equipment	Railcar Lift System	RCM	• Operation	• --
Facilities	Equipment	Stinger Clamp	RCM	• Operation	• --
Facilities	Equipment	Truck Hoist	RCM	• Operation	• --
Facilities	Equipment	Truck Turntable	RCM	• Inspection (180 day)	• --
Facilities	Equipment	Welding Equipment	RCM	• Operation	• --

Facilities	Equipment	Wheel Bore	RCM	• Operation	• --
Facilities	Equipment	Wheel Press	RCM	• Operation	• --
Facilities	Equipment	Wheel Lathe	RCM	• Operation	• --
Facilities	Major Shops	Maintenance Shop	RCM	• Safety Inspection (7 day)	• --
Facilities	Major Shops	Pit Track			
Facilities	Major Shops	Safety Chains	RCM	• Operation	• --
Facilities	Equipment	Battery Charger	SM	• Performance Analysis	• --
Facilities	Equipment	Calibration Equipment	SM	• Operation	• PM (360 day)
Facilities	Equipment	Drill Press	SM	• Operation	• --
Facilities	Equipment	HV			
Facilities	Equipment	Gloves/Hot Stick	SM	• --	• PM (150 day)
Facilities	Equipment	Insulating Gloves	SM	• Testing	• --
Facilities	Equipment	Torque Wrench	SM	• -- • --	• PM (60 day) • PM (360 day)
Facilities	Equipment	Ultrasonic Cleaner	SM	• Operation	• --
Facilities	Major Shops	Eyewash Units	SM	• Preventative Maintenance (180 day)	• --

9.2.3 Stations

According to the maintenance document gap analysis (Table 9.5), Metro departments do not distinguish between Facility and Station asset categories. As such, all existing maintenance practices apply to both these asset categories and most documentation does not clearly identify the location of where these practices occur. The exception to this statement is a Master PM titled “snow removal equipment” which indirectly refers to platform heaters (Table 9.6).

Table 9.6 - Summary of maintenance documentation for a clearly defined Station asset.

Asset Category	Asset Class	Asset Type	Department Responsible	SOP Name	Master PM Name
Stations	Station Component	Snow Melting System	FM	• --	• PM (180 Day)

9.2.4 Guideways

Maintenance of Way Department (MOW) inspects and maintains all guideway assets with the exception of major structures (e.g. bridges and tunnels), which are maintained by the *Office of Engineering, Track and Structures Division*. Nearly all guideway assets are considered to be Critical Assets by the MTA. A comparison between maintenance documentation, both SOPs and Master PMs, highlight gaps in activities (Table 9.7).

Copies of the SOPs listed in the table below may be found through the [SOP catalogue](#).

Table 9.7 - Catalogue detailing maintenance documentation for guideway assets. Note, this table excludes any SOPs and Master PMs used by the *Office of Engineering* for bridge and tunnel maintenance.

Asset Category	Asset Class	Asset Type	Department Responsible	SOP	Master PM
Guideway	Ancillary Structures	Turnback Sign	MOW	--	Inspection (180 day)
Guideway	Trackwork	Switch Machine	MOW	-- --	- Yard Inspection (90 day) - Mainline Inspection (30 day)
Guideway	Trackwork	Track	MOW	- Walking Inspection (-- day) - Access: Minor Repairs (2) - Access: Inspection Crew - Access: Lubricating Running Rail - Work Block Procedure: Revenue Hours (3) - Work Block Procedure: Non-Revenue Hours (2)	- Weekly Walking Inspection - Vehicle Weekly Inspection

9.2.4.1 Trackwork

MOW's SOPs and Master PMs require two redundant crews to inspect the mainline weekly. The track inspection Master PM presumably includes inspection of interlockings, because interlockings lack its own Master PM. MOW also contracts out a number of Federal Rail Administration (FRA) mandated tests:

- Geometry testing of track
- Ultrasonic testing
- Rail profile testing
- Heat watch testing

The Master PMs used by MOW are process-based, broadly applying to multiple asset types in a given location. In an effort to make targeted SGR improvements on these Critical Assets, Metro will consider

developing new SOPs and Master PMs centered upon the asset, at the component level. Metro will also consider other best practices in trackwork maintenance for the inclusion of future versions of its maintenance documentation.

9.2.4.2 Bridges and Tunnels

The *Office of Engineering, Track and Structures Division*, is responsible for all inspection and maintenance of bridges and tunnels in the Metro system. The *Office of Engineering* does not currently use Maximo in conjunction with maintenance activities and therefore Master PMs do not exist for these asset classes. Additional information on bridge and tunnel maintenance SOPs and related practices may be included in a future version of this LMP.

9.2.5 Systems

Many offices and departments across the MTA collaborate to maintain Metro systems assets:

- **Security and communications** systems assets are maintained by the *Office of Engineering, Systems Division*;
- **Revenue collection** assets are maintained by the *Office of Treasury*.
- **All other systems assets** are maintained by the Metro Systems Maintenance Department (SM).

A comparison between maintenance documentation, both SOPs and Master PMs, highlight gaps in activities (Table 9.8). Copies of the SOPs listed in the table below may be found through the [SOP catalogue](#).

Table 9.8 - Catalogue detailing maintenance documentation for systems assets. Note, this table excludes any SOPs and Master PMs used by the *Office of Engineering* for bridge and ancillary structure maintenance.

Asset Category	Asset Class	Asset Type	Department Responsible	SOP Name	Master PM Name
Systems	Communications	Data Transmission System ¹	SM	• Inspection & maintenance (7 day)	• --
Systems	Communications	Fire Alarm Panel	FM	• --	• PM (30 Day)
Systems	Communications	SCADA	SM	• PM (360 day)	• PM (360 Day)
Systems	Electrification/ Traction Power	15HK Circuit Breakers	SM	• PM Inspection (360 day)	• --
Systems	Electrification/ Traction Power	480/277 AC Circuit Breakers	SM	• PM Inspection (360 day)	• --
Systems	Electrification/ Traction Power	Cable Conductors	SM	• Testing	• --
Systems	Electrification/ Traction Power	Contact Rail Heater	SM	• -- • --	• Mainline PM (360 day) • Yard PM (360 day)
Systems	Electrification/ Traction Power	DC Rectifier Transformer	SM	• PM Inspection (360 day)	• --

Systems	Electrification/ Traction Power	FBK-H DC Circuit Breakers	SM	• PM Inspection (360 day)	• --
Systems	Electrification/ Traction Power	Substation	SM	• -- • PM Inspection (7 day) • PM Inspection (30 day) • PM (90 day) • --	• Power System (360 day) • Weekly (7, 90 day) • Annual (360 day) • Weekly (7 day) • Quarterly (90 day)
Systems	Electrification/ Traction Power	Switch Heaters	SM	• --	• PM (360 day)
Systems	Electrification/ Traction Power	Third Rail	SM	• Operation	• --
Systems	Electrification/ Traction Power	UPS	SM	• --	• Semi-annual (180 day)
Systems	Electrification/ Traction Power	UPS Batteries	SM	• Operation	• Battery (7, 90 day)
Systems	Electrification/ Traction Power	VU-9 AC Transformer	SM	• PM Inspection (360 day)	• --
Systems	Train Control/ Signals	AF 400 Track Circuit	SM	• Verification Test (90 day) • Maintenance (360 day)	• Quarterly (90, 360 day)
Systems	Train Control/ Signals	Trip Stop	SM	• PM & Testing (30 day)	• EM-1 (30 day)
Systems	Train Control/ Signals	Emergency Trip Station	SM	• PM (360 day)	• PM (360 day)
Systems	Train Control/ Signals	Genisys Non-Vital Logic Emulator	SM	• Test (180 day)	• --
Systems	Train Control/ Signals	Grade Crossing Gates	SM	• PM (180 day)	• PM (180 day)
Systems	Train Control/ Signals	Ground Detector Circuits	SM	• Test (90 day)	• Quarterly (90 day)
Systems	Train Control/ Signals	Interlocking	SM	• Locking Tests (8) (720 days)	• Locking Test (720 day) • Inspection (30 day)
Systems	Train Control/ Signals	Switch Machine	SM	• Inspection & Test (30 day) • PM (90 day)	• Maintenance & Obstruction Test (30, 90 day)

Systems	Train Control/ Signals	Switch Machine	MOW	• -- • --	• Inspection (180 day) • Inspection (360 day)
Systems	Train Control/ Signals	TCC	SM	• Inspection (7 day)	• --
Systems	Train Control/ Signals	Tunnels	SM	• Inspection (180 day)	• --
Systems	Train Control/ Signals	Vital Relay	SM	• Inspection & Test (1, 2, & 4 year)	• --
Systems	Train Control/ Signals	Approach Warning Horn	SM	• --	• Semi Annual Test

1 Corresponding Master PM is enfolded within an inspection Master PM of the TPSS

* This Master PM does not include power frequency track circuits.

9.2.5.1 Security & Communications Systems

The *Office of Engineering, Systems Division*, is responsible for all inspection and maintenance of major security and communications systems in the Metro mode. The Office of Engineering does not currently use Maximo in conjunction with maintenance activities and therefore Master PMs do not exist for this asset class. Additional information on SOPs and practices related to these systems may be included in a future version of this LMP.

9.2.5.2 Revenue Collection

The *Office of Treasury* is responsible for all inspection and maintenance of revenue collection systems in the Metro mode. Additional information on SOPs and practices related to these systems may be included in a future version of this LMP.

9.2.5.3 Traction Power/Electrification

SM maintains 12 traction power/electrification assets. The maintenance document gap analysis demonstrates that only substations have both a SOP and a Master PM. Those assets with only SOPs include: DC and AC circuit breakers, cable conductors, DC rectifier transformer, third rail, UPS batteries, and AC transformers. Additionally, SM has three assets that only have Master PMs and lack SOPs, such as contact rail heaters, switch heaters, and UPS equipment.

9.2.5.4 Train Control/ Signaling

Metro maintains 13 train control/signaling assets, of which the audio-frequency (AF) track circuit, trip stop, grade crossing gates, interlockings, and switch machines all have SOPs with corresponding Master PMs. Assets with only SOPs include: the Genisys non-vital logic emulator, ground detector circuits, program station stop, train control center, and vital relays.

9.2.5.5 Communications

SM retains the responsibility for both the data transmission system and SCADA equipment. The former only has a SOP, while the latter of which is subject to both a SOP and Master PM. Fire alarm panels fall under the jurisdiction of FM, which only have a Master PM.

9.3 Other Maintenance-Related Activities

9.3.1 Spare Parts

Metro has its own storeroom that serves all mode departments and which is located within the Wabash maintenance facility. Storeroom staff are not Metro employees, but rather are staff of MTA's Procurement office. Procurement oversees all MTA purchases of materials, goods, and services, and its Purchasing Department is responsible for spare parts inventory control processes. The guiding document for their day-to-day activities is the [MTA Procurement Policies and Procedures Manual \(rev. 2/19/14\)](#). In addition, the following Procurement SOPs are most relevant to the spare parts inventory control process and are available on MTA's intranet site:

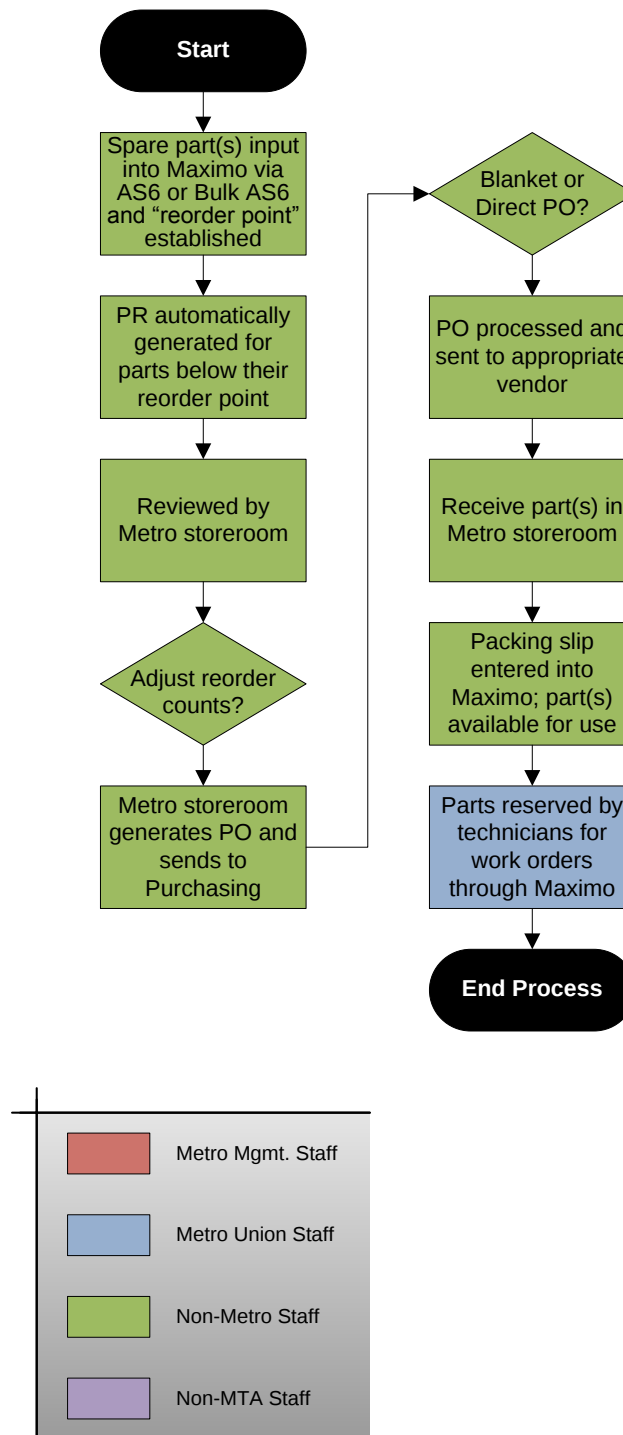
- [Inventory Disbursement Authorization \(SOP No. 09.03.05.00.01\)](#)
- [Maximum Percentage of Withdraw of Any One Inventory Item \(SOP No. 09.03.05.00.02\)](#)
- [Receiving Inventory Items \(SOP No. 09.03.05.00.03\)](#)
- [Inventory Withdraws \(SOP No. 09.03.05.00.05\)](#)
- [Request for New Inventory Stock \(SOP No. 09.03.05.00.08\)](#)

Purchases originating from Metro's storeroom are processed by Procurement before being sent to the appropriate vendor. When parts are received in fulfillment of those purchase orders (POs), they are received directly at Metro rather than being processed through a central storeroom first. There is an inventory storeroom located on Monroe Street that is known as the Main Storeroom but which should not be confused as the MTA's main storeroom. It serves the Bus mode exclusively and is a distribution point to storerooms located at each of the Bus division facilities.

Spare parts purchases are funded entirely by Metro's operating budget with one notable exception. Major procurements of new assets (such as the new signaling system) or overhauls (such as railcar mid-life overhauls) typically require that the vendor provide a full range of **contractual spares**. These contractual spares are included to meet early maintenance needs and are paid for out of Metro's capital budget, as they are a provision of the original procurement contract. Moreover, the contractual spares provided by the vendor are accompanied by suggested unit counts for each. These unit counts usually inform the **reorder point** that Metro establishes for each part once contractual spares are depleted, though this is ultimately at the discretion of Metro and storeroom personnel.

Once an inventory item is input into the Maximo system, its ordering is automated, and Purchase Requests (PRs) are generated weekly for all stock below the minimum threshold, or reorder point. Parts entered into inventory are immediately available to mechanics and technicians and are reserved through Maximo for specific work orders and withdrawn from inventory. Outside of Maximo, management personnel have the option to purchase infrequently used "one-off" type items on corporate credit cards with pre-defined per transaction spending limits, in accordance with the following Procurement policy memorandum (available on MTA's intranet site): [MTA Payment Procedures](#).

Figure 9.5 – Overview of Metro inventory supply management.



The existing process contains important limitations. First, Maximo reordering depends upon a **reorder point**, instead of a method that correlates needed parts for each Master PM and associated work orders. As a result, Maximo could simultaneously forecast inventory needs, ensure part availability, and shorten time needed to close out work orders.

Secondly, there is another value assigned automatically in Maximo for spare parts known as the **economic order quantity**. It is currently unclear to Metro personnel how this value is derived, but in cases where it dips below the reorder point, this can negatively impact parts availability. The reorder point is set jointly by Metro storeroom personnel and superintendents, supervisors, and others directly involved in asset maintenance, and overriding it has a deleterious effect on maintenance.

Lastly, there is a field known as **lead time in days** that has associated values for some but not all spare parts. Lead time refers to the amount of time between when a purchase order is sent to the vendor and that part is received back at Metro. This value assigned inconsistently (as it doesn't appear for all parts) and is often inaccurate as well. In cases when the actual lead time exceeds what has been recorded in Maximo, there may be shortages of required parts. In cases where the actual lead time is less than what has been recorded in Maximo, there may be an oversupply of parts with insufficient storage space.

9.3.2 Warranty Administration

Metro does not have a structured process for the tracking of warranties associated with its Transit Assets. While Metro utilizes contractors to perform QA/QC oversight on the work performed by other vendors, this does not reliably capture all opportunities to file a warranty claim with that vendor. Additionally, the stockroom does not have a system to monitor the age of each spare part in its inventory, preventing a warrantee from being utilized even if it is suitable for that part. As a result, Metro is not consistently compensated by vendors when a Transit Asset prematurely fails.

9.4 Recommended Scheduled Maintenance

Stations are public-facing and require higher standards to ensure a safe and comfortable environment for MTA customers. Therefore, the Facilities Maintenance and Environmental Services Department will consider how it can more effectively delineate scheduled inspection and maintenance activities for facilities versus stations, and conduct a further gap analysis on scheduled maintenance activities for its stations.

In general, Metro should ensure that all Critical Assets have SOPs with corresponding Master PMs and base this documentation on physical asset, not a process. Furthermore, Metro applies a corrective maintenance approach to many of its Transit Assets. A more proactive maintenance approach may be more effective at maximizing the life of a Transit Asset and minimizing risk of unexpected failure. These proactive maintenance philosophies are discussed in the subsection below.

9.4.1 Maintenance Philosophies

As Metro seeks to improve their Transit Asset maintenance regimes, it should consider the myriad maintenance philosophies that can be reasonably implemented with available resources. These maintenance philosophies exist along a continuum, running from the lowest intensity strategies (no maintenance, run-to-failure, then replace), and the highest intensity strategies on the other end (focused on predicting and preventing failures before they occur).

Table 9.9 - A summary of common maintenance strategies, from the simplest to most complex. Metro’s current maintenance interventions are, for the most part, either corrective or scheduled.

Maintenance Strategy	Description
No Maintenance/ Run-to Failure	No prescribed maintenance for the asset in question. Simply replace it when it fails. This approach should only be used when no cost-effective maintenance treatments exist for the asset, and the risks associated with failure are low compared to the cost of preventive maintenance.
Reactive/Corrective Maintenance	Corrects failures in response to a fault or functional failure, or when an issue has been identified through an inspection. This approach should be used when an asset is relatively reliable or when failures are infrequent and appear to occur randomly; when the time and effort to repair are minimal; or when the asset’s failure would not likely impact service delivery. Also known as “Fix it When it Fails” (FIWIF).
Scheduled Maintenance	A form of preventive maintenance in which the asset has a prescribed set of activities performed at standard intervals. These intervals can be either mileage or time-based and are usually prescribed by the Original Equipment Manufacturer (OEM) specifications manual(s). This type of approach is usually undertaken in addition to reactive maintenance and may be derived from regulatory requirements.
Predictive Maintenance	A form of preventive maintenance which is prescriptively adjusted based upon an asset’s level of use, condition, and/or performance. This approach uses historical condition and performance data for prognostics and better timing of preventive maintenance activity. It tends to be more costly from the standpoint of additional inspection, testing, and ongoing data analysis. Yet these costs may be fully offset by reduction in unnecessary maintenance and in-service failures.
Proactive Maintenance	A form of preventive maintenance that builds on predictive maintenance and emphasizes ongoing improvement with a particular focus on Quality Assurance and Quality Control (QA/QC) measures, as well as on modifications to maintenance procedures to mitigate conditions that lead to wear and tear. This type of approach is usually reserved for the most Critical Assets that consume maintenance resources disproportionately.
Self-Maintenance	Self-maintenance, also known as “e-maintenance”, is an engineering approach to give an asset the capability to actively manage its own performance via: monitoring capability (in real-time via electronic sensors); fault judging capability (to assess whether the asset is operating within normal parameters); diagnostic capability (to identify likely causes of abnormal performance); repair planning capability (to identify appropriate repair actions and to schedule them); adaptive control (adjusting operations to avoid failure); and self-learning and improvement (using past data to update control logic). This represents an aspirational, optimized approach to maintenance, where asset reliability is paramount.

9.4.2 Maintenance Implementation

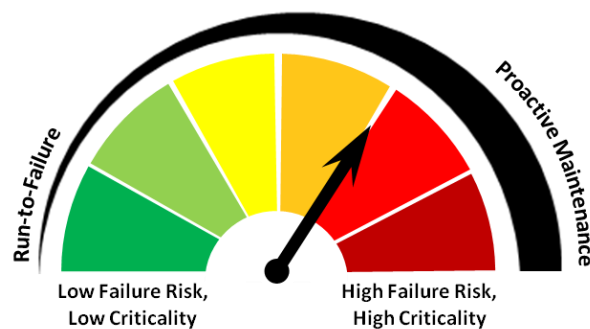
Metro may choose to adopt a particular maintenance philosophy for a given asset class. The transit industry has developed implementation frameworks to help guide the selection and application of appropriate maintenance philosophies:

- **Reliability Centered Maintenance (RCM)** – A 7-step engineering framework defined by a formal technical standard. The process begins by identifying what an asset is supposed to do, along with its associated performance standards. It is followed by a detailed failure mode and effects analysis. Then, RCM decision logic is applied to help operators develop and implement an appropriate preventive maintenance strategy. This may result in one or more of the strategies listed above being utilized, depending on the specific asset in question.
- **Total Productive Maintenance (TPM)** – A complement to RCM, as it is more focused on the quality and efficiency of maintenance processes than on the technical elements of maintenance. It is organized around four pillars: (1) Maintenance Prevention and Process Improvement, (2) Customer and Quality Focus, (3) Collaboration and Teamwork; and (4) Continuous Learning.

Best practice suggests the most intensive maintenance strategies to be assigned to Critical Assets (Figure 9.6). Therefore Metro will implement TAMP Strategy #4 (*Optimize the preventive maintenance of Critical Assets*) to prioritize the optimizations of preventative maintenance regimes by asset class, in addition to developing reliability availability, maintainability, and safety (RAMS) contract language for 3rd party maintenance services.

Metro will consider implementing more intensive maintenance philosophies as Transit Assets enter the acquisition phase (TAMP Strategy #9 - *Consider Total Cost of Ownership in Investment Decisions*). While recognizing maintenance costs go up as the level of intervention increases, this may not necessarily result in higher total cost to the agency. Preventive maintenance activity has the ability to offset risks that can be substantially greater, such as those incurred with accidents or system shutdowns.

Figure 9.6 – Intensive maintenance philosophies are often attributed to assets with a higher risk.



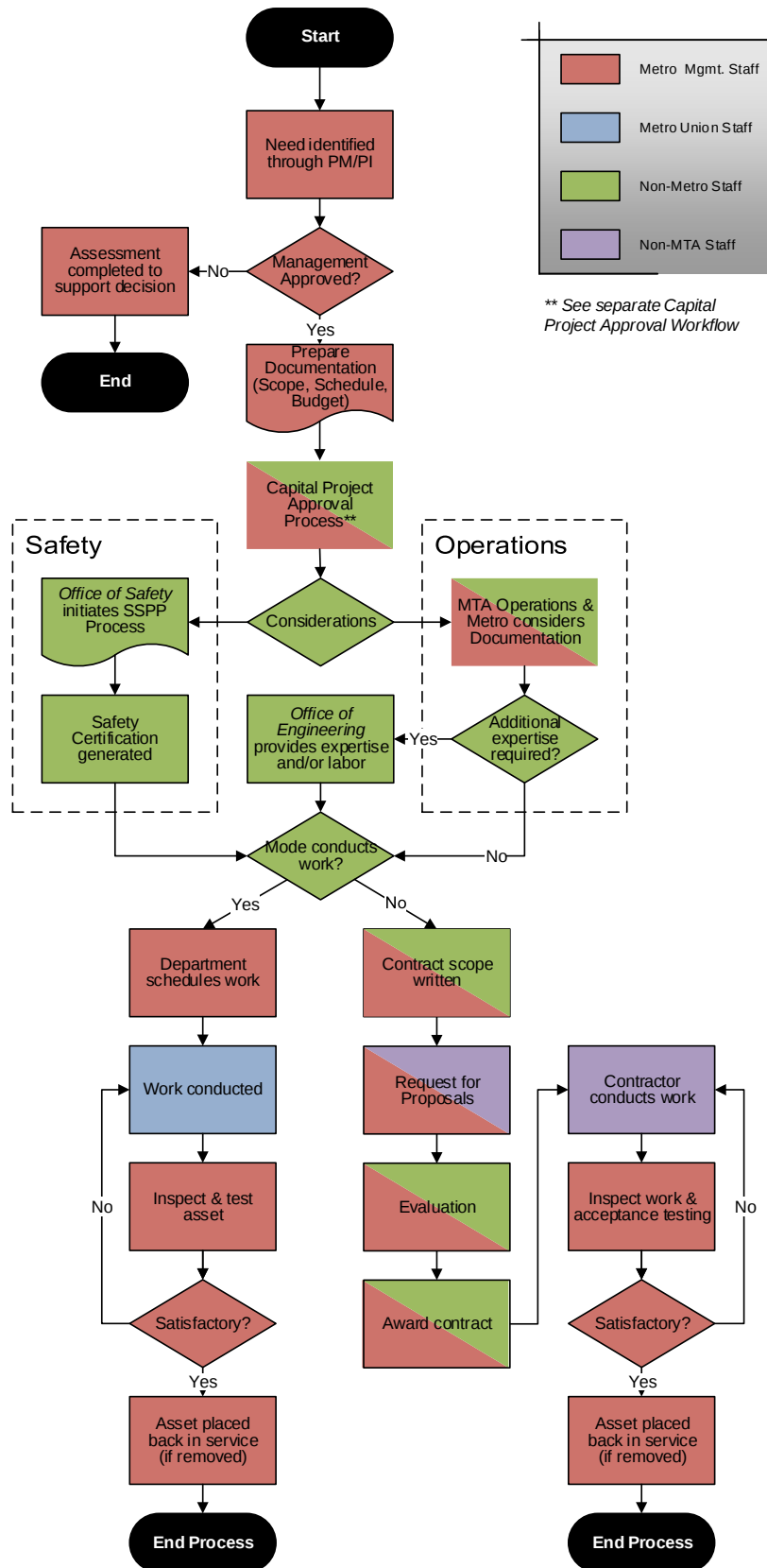
10 Lifecycle Phase 3 – Overhaul/Rehabilitation

10.1 Overhaul/Rehabilitation Implementation

Metro primarily outsources the overhaul/rehabilitation of their Transit Assets through a bottom-up approach. Specifically, crews and Superintendents identify potential projects and communicate that need to Metro management (Figure 10.1).

Unlike preservation projects, most of these Metro overhauls are managed by the *Office of Engineering* as the lead. As such, once the project need has been identified, coordination between the MTA offices of *Engineering*, *Safety*, and *Planning and Programming* produce the project scope, schedule, and budget. Additionally, these offices determine whether these overhauls and replacements are conducted through contracted or in-house services.

Figure 10.1 - General overhaul/ rehabilitation workflow of Metro Transit Assets.



10.2 Current Overhaul/Rehabilitation Schedules

All Metro asset classes undergo component upgrade/replacement on an as-needed basis. In lieu of a formal component replacement schedule for all asset classes, the MTA generally anticipates the need for component replacement based upon industry-average useful life data. The following sub-sections outline Metro overhaul/rehabilitation schedules by asset category. **Appendix A: Metro Asset Replacement Schedules** details industry-average useful life data for all Metro Transit Asset components.

10.2.1 Vehicles

Metro **revenue vehicles** undergo two overhauls on the following time-scales: 5 year and midlife. Since management decisions for **non-revenue vehicles** are handled via a third-party contractor, by way of the Fleet Management Services Department; the associated overhaul/rehabilitation regimes employed by this contractor are not well documented.

10.2.1.1 Revenue Vehicles

In addition to the 5-year railcar “mini overhaul” referenced in Section 9.2.1.1 above, which is scheduled on an as-needed basis, Metro conducted a midlife overhaul program of its entire fleet between 2000 and 2006. The program was designed to enable Metro railcars to reach their design life expectancy of 30 years. During the 6-year overhaul program, 12 to 14 cars were located offsite at any given time. The program included scope elements which can either be considered maintenance activities or enhancement activities:

- **Maintenance** activities included a complete teardown of the car, detailed cleaning, inspection and testing, selective equipment upgrades to the propulsion logic and traction motors, and replacement of the DC-DC converter.
- **Enhancement** activities (either aesthetic or safety) included an auto-announcement system, video surveillance system, new floor covering, and seat cushion upgrades.

The following Metro fleet overhaul costs in TERM Lite were estimated based on information provided by the Asset Owner:

- \$20 million budget for the next 5 year minor overhaul for the entire fleet and
- Major mid-life overhauls costing over \$900,000 per vehicle.

10.2.1.2 Non-Revenue Vehicles

Since maintenance of non-revenue vehicles (light trucks, specialized track maintenance vehicles, and other maintenance vehicles) is conducted outside of the Metro mode, associated details on overhaul/rehabilitation practices were not available for reference in this LMP at the time of publishing.

10.2.2 Facilities and Stations

Facilities and stations assets do not undergo proactive overhaul/rehabilitation, but components are upgraded/replaced on an as-needed basis. In lieu of a formal component replacement schedule, MTA can generally anticipate the need for facilities and stations component replacements based on industry-average useful life data. Anticipated useful life data for assets under the facilities and stations category can be found in **Appendix A**.

All facilities and stations overhaul/rehabilitations are managed through the *Office of Engineering, Facilities and ADA Division*. The execution of work can be managed through either Metro in-house staff or a third-party contractor.

10.2.3 Guideways

Guideway assets do not undergo proactive overhaul/rehabilitation, but components are upgraded/replaced on an as-needed basis. In lieu of a formal component replacement schedule, MTA generally anticipates the need for guideway component replacements based on industry-average useful life data for each method of track fixation (ballasted, embedded, or direct fixation) and type of trackwork (tangent, curve, or yard). Anticipated useful life data for assets under the guideway category can be found in **Appendix A**. Note that the current Metro asset inventory does not contain details on all guideway components, limiting MTA's ability to forecast the need to replace/upgrade individual components.

All guideway overhaul/rehabilitations are managed through the *Office of Engineering, Track and Structures Division*. The execution of work can be managed through either Metro in-house staff or a third-party contractor.

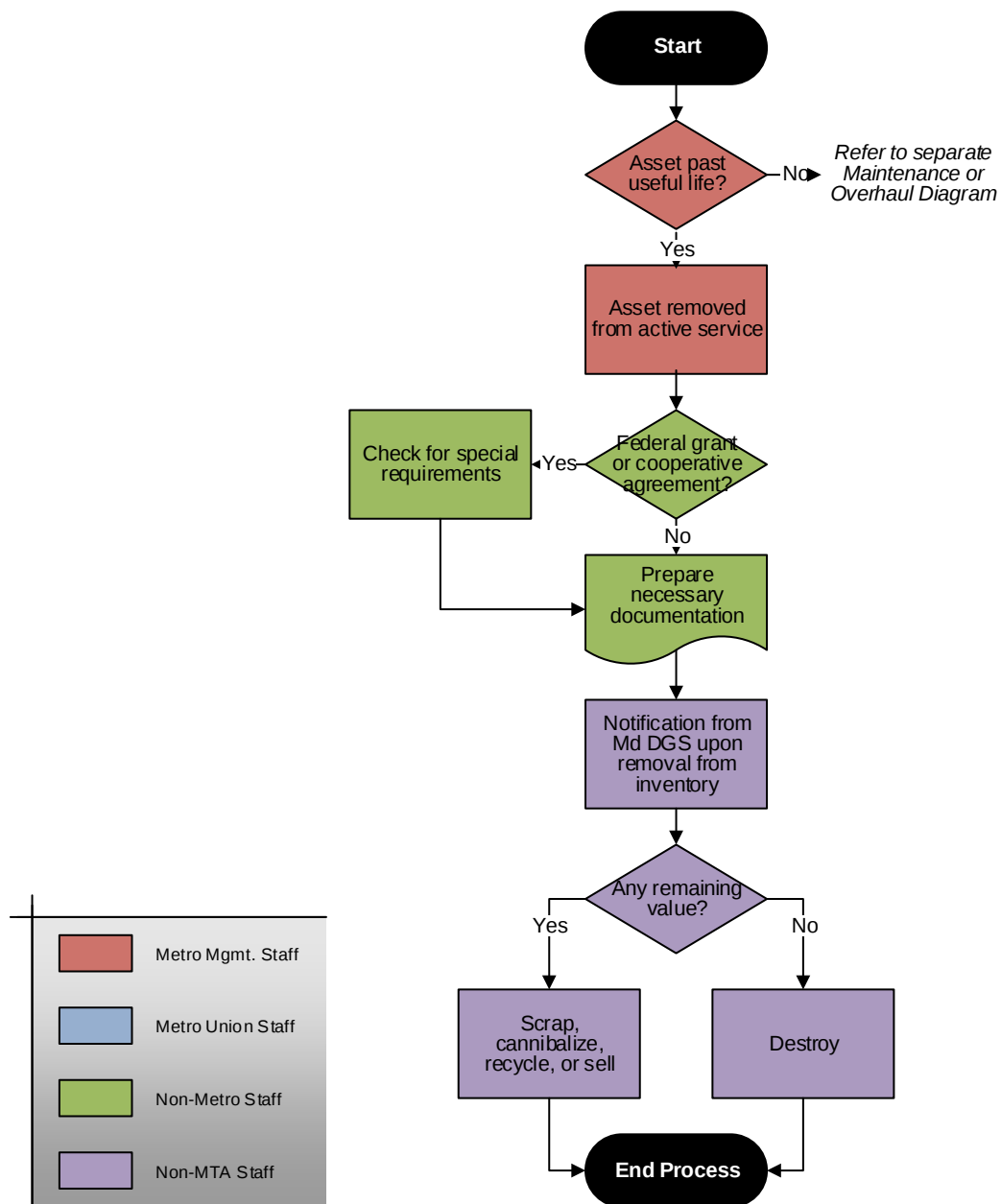
10.2.4 Systems

Systems assets do not undergo proactive overhaul/rehabilitation, but components are upgraded/replaced on an as-needed basis and managed by the *Office of Engineering, Systems Division*. In lieu of a formal component replacement schedule, MTA can generally anticipate the need for systems component replacements based on industry-average useful life data. Anticipated useful life data for assets under the systems category can be found in **Appendix A**.

11 Lifecycle Phase 4 – Disposal

Figure 11.1 provides a summary overview of Metro practices around asset retirement and disposal. Replacement is not considered on this workflow diagram, as it is one and the same as acquisition or procurement. Note that asset disposal is heavily dependent on people and policies outside of Metro, namely the Maryland Department of General Services (DGS). DGS has an Inventory Standards and Support Services Division responsible for the creation of its **Inventory Control Manual**, which governs this process and is available here: <http://www.dgs.maryland.gov/ISSSD/InventoryControlManual.pdf>

Figure 11.1 - Overview of asset disposal.



As a basic premise of system preservation, Metro replaces Transit Assets that are past their useful life. Meaning, Metro often initiates the acquisition of a new Transit Asset concurrent with the retirement/disposition of an in-kind Transit Asset. Rarely does Metro retire/dispose of a Transit Asset causing the inventory to shrink on a net basis.

Figure 11.2 - An asset's lifecycle, or the four phases over an asset's life. Return arrow between Phase 4 and Phase 1 indicates asset replacement.

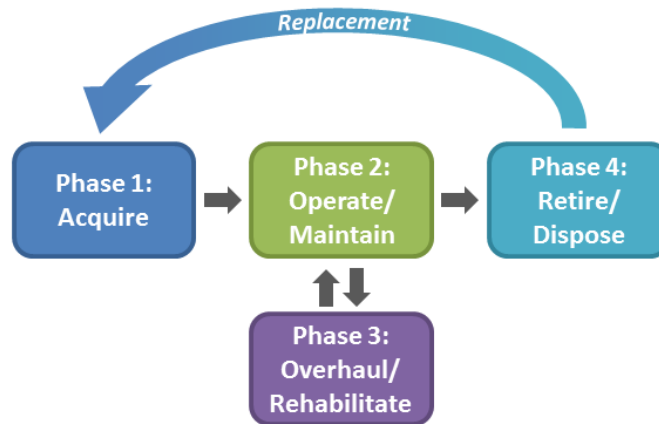


Figure 11.2 illustrates the cyclical nature of lifecycle management. Given Metro's current approach, many opportunities exist to increase the performance of the Metro system, decrease safety risks and risks of Transit Asset failure, and gain capture time/cost savings. These opportunities are discussed in further detail within the *Continuous Improvement* chapter below.

Funding will be required to capitalize on many of these opportunities to improve lifecycle management of the Metro system. The following chapter details the process of capital and operations budgeting. By making this process more transparent, Metro management can begin to contemplate how it may take a modified approach to prioritizing its budget requests, and strengthen its business justifications for those requests.

12 Financial Considerations

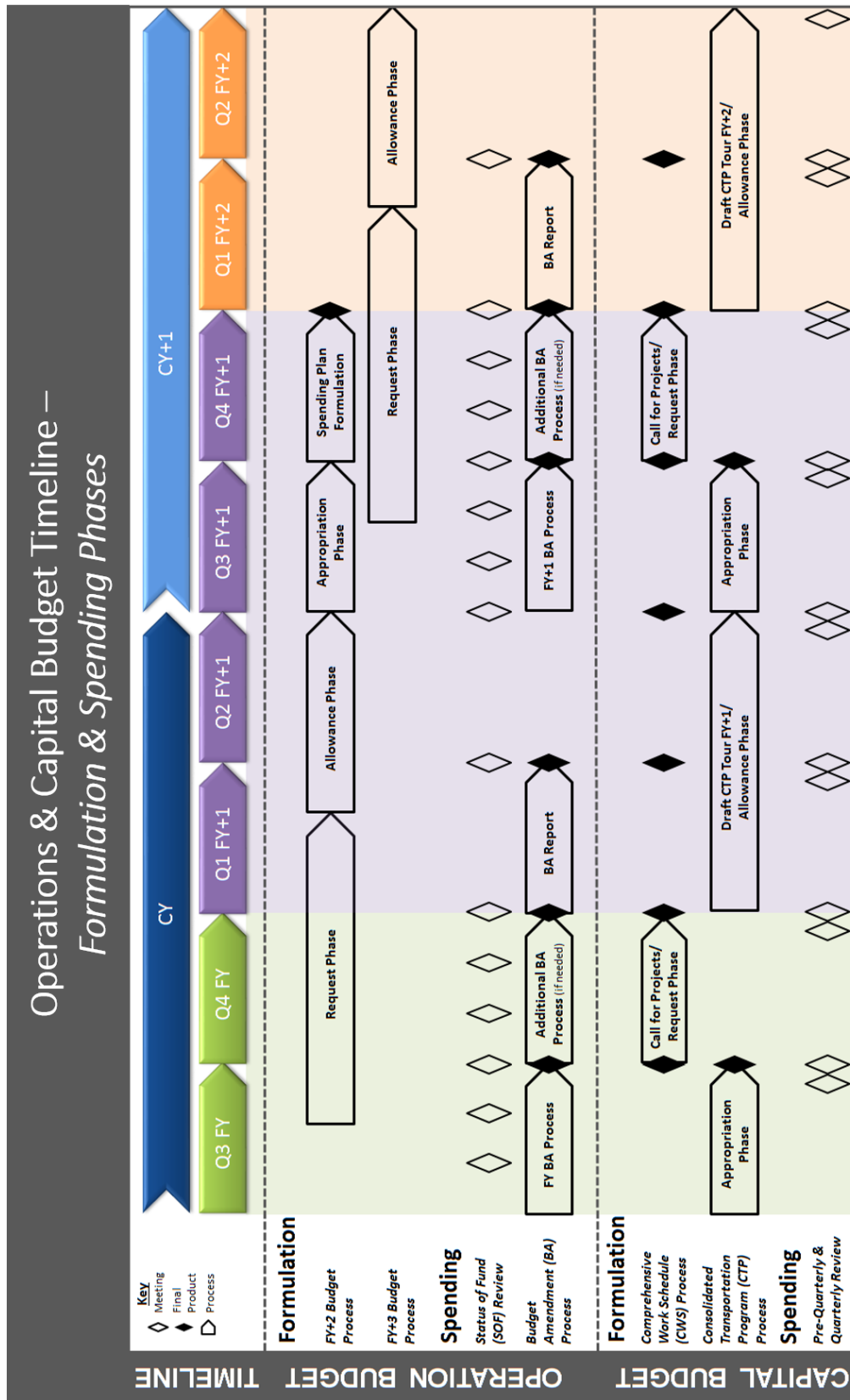
The MTA maintains separate Operating and Capital budgets, coordinated by the *Office of Finance* and the *Office of Planning and Programming*, respectively. Each of these budgets are maintained on an accrual basis, and have their own formulation and spending processes based upon the Maryland Fiscal Year (FY), which runs from July of a given calendar through June of the following calendar year. For the purposes of this LMP, **budget formulation** refers to the overarching process by which a budget is approved. Once a budget has been approved, all activities surrounding the ongoing management of that budget are collectively referred to the **spending process**.

Figure 12.1 below provides a high level, chronological overview of MTA's budget formulation and spending processes. Budget formulation is the same for both Operations and Capital, and includes three discrete phases: Request, Allowance, and Appropriation. The Operating and Capital budgets are each subject to their own unique spending process. The Operating spending process is managed via "Status of Fund" (SOF) meetings. The Capital spending process is managed via a series of meetings known as "Pre-Quarterlies" and "Quarterlies."

If a funding shortfall is discovered at any given point in the year, and all cost containment measures fail, discrete processes may be employed to request mid-year increases to the Operating and Capital budgets. Requests to increase the MTA Operating budget are facilitated by a stand-alone Budget Amendment process that may occur up to twice a year. Requests to increase the MTA Capital budget may be submitted as part of the Consolidated Work Schedule (CWS) process, which programmatically reviewed four times per year. If Metro experiences an accident, incident, or other emergency, and immediately requires additional funds as a result, they may work directly with the *Office of Finance* and/or *Office of Planning and Programming* on a case-by-case basis.

The details of these processes are discussed later in this chapter.

Figure 12.1 - Overview of the capital and operating budget processes and related durations.



12.1 Budget Formulation

Budget formulation is the same for both Operations and Capital, and includes three discrete phases: Request, Allowance, and Appropriation. Metro influences these budgets through the Request Phase. Like all modes and departments throughout the MTA, Metro makes its Budget Request based upon a prioritized list of needs; not all of these needs will be funded, due to State-wide budget constraints.

12.1.1 Operations Budget Formulation

The *Office of Finance* manages the formulation of MTA's Operations budget (Figure 12.2). The operations budget funds all scheduled preventative maintenance, minor corrective maintenance, regularly ordered inventory items under \$25,000.00, wages, and other personnel benefits; and is managed year-to-year.

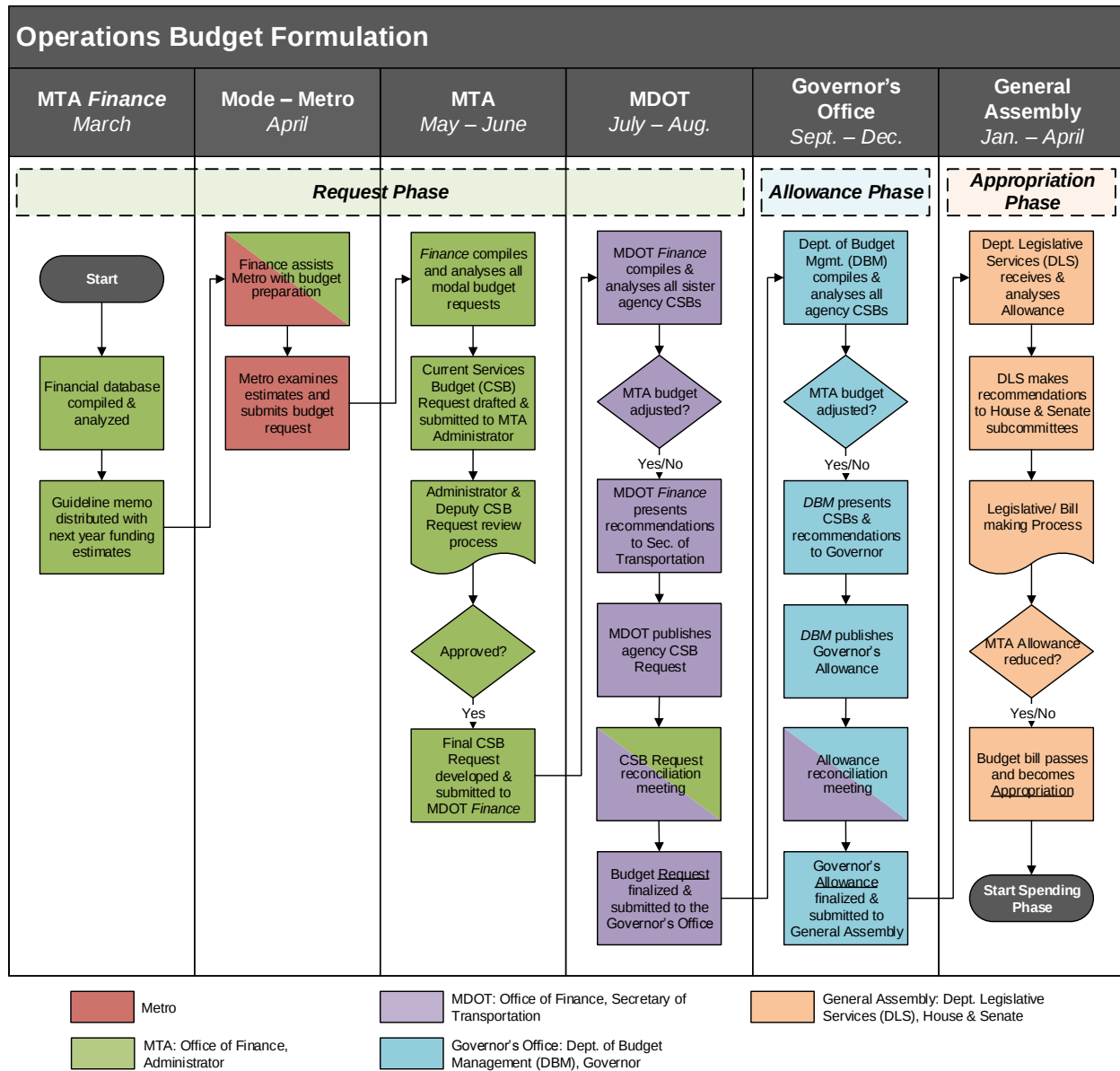
The Operations Budget is generally based on an annual analysis of historic expenditures – this analysis yields a trendline that can be used to forecast the approximate level of funds needed for this upcoming year. This budget forecast, called the Current Services Budget (CSB), is provided to Metro for review in the third Fiscal Quarter of every year (March). Metro first conducts an independent review of its portion of the CSB based upon a set of guidelines provided by the *Office of Finance*. This is followed by subsequent joint meetings between Metro and the *Office of Finance* to produce justifications for any additional operational needs and ultimately formulate Metro's annual CSB request.

The *Office of Finance* concurrently works with all other modes/departments to complete their annual Operating Budget requests respectively, and compile a complete draft CSB for the whole agency. MTA executive leadership then reviews, approves, and submits the agency-wide CSB to MDOT. In turn, MDOT compiles and analyzes all sister agency CSBs in advance of a final review by the Secretary of Transportation.

Should MDOT have any questions, comments, or concerns with MTA's CSB, a series of reconciliation meetings would then occur, allowing the MTA to advocate for additional needs. Upon a final revision, MDOT's CSB becomes the formal **Budget Request** and submitted to the Department of Budget Management (DBM) in the Governor's Office.

DBM then initiates a similar process, with compilation, DBM review, Governor review, and reconciliation between MDOT and DBM before publishing the final draft, or **Governor's Allowance**. The MTA Operating Budget now requires final review by the Maryland State Legislature. Once approved by both the House of Delegates and the Senate, and signature by the Governor, then the **Appropriation** is formally adopted as the operations budget for the upcoming Fiscal Year.

Figure 12.2 - Formulation of the Operations Budget.



Throughout this LMP, Metro has identified a number of gaps in its documented procedures, and opportunities for its improvement to its lifecycle management approach. Efforts to improve TAM may require an increase in the Metro Operating Budget. Metro intends to use analysis of its Transit Assets and their lifecycle needs to better guide the development of its future Operating Budget requests accordingly.

12.1.2 Capital Budget Formulation

Capital Programming, a division of the *Office of Planning and Programming*, manages the formulation and of MTA's Capital Budget (Figure 12.3). The Capital Budget, also known as the Capital Program, funds all activities associated with the acquisition of Transit and Land Assets. It may also fund other Capital costs not directly attributable to system preservation, such as software procurement, management studies, etc.

MTA's Capital Budget covers a six year period, and is approved once per year by the Maryland State Legislature, as part of a master Capital Budget for MDOT and its modal administrations. This master Capital Budget is referred to as the Consolidated Transportation Program (CTP). While the CTP is only approved once per year at the State level, MDOT revises the Capital Budgets of MTA and its sister agencies each fiscal quarter, within the budget limits set by the General Assembly.

While MTA can revise its Capital Budget four times per year, the first Fiscal Quarter of the year represents the only opportunity for Metro to submit new projects into the Capital Program. The process for Capital Programming's *Call for Projects* is detailed in Figure 12.4, and occurs in January of every year. The remaining quarterly revisions to the Capital Budget are reserved for balancing project over/under expenditures, and funding unforeseen emergency needs.

Each quarterly revision of MTA's Capital Budget is captured in a database known as the Comprehensive Work Schedule (CWS). The FY 1st quarter CWS represents the **Request Phase** in the formulation of MTA's Capital Budget, and captures the *Call for Projects* accordingly. The submittal of FY 3rd quarter CWS to the Maryland State Legislature constitutes the **Allowance Phase** in the formulation of MTA's Capital Budget. The **Appropriations Phase** entails the review and approval of the 3rd Quarter CWS, or the Allowance, by the Maryland State Legislature, which is ultimately published in the CTP.

Figure 12.3 - MTA's capital budget formulation. The capital spending processes is grayed out. Budget formation involves the creation and editing of the CWS and CTP documents, whereas spending remains a standalone process that informs the CWS.

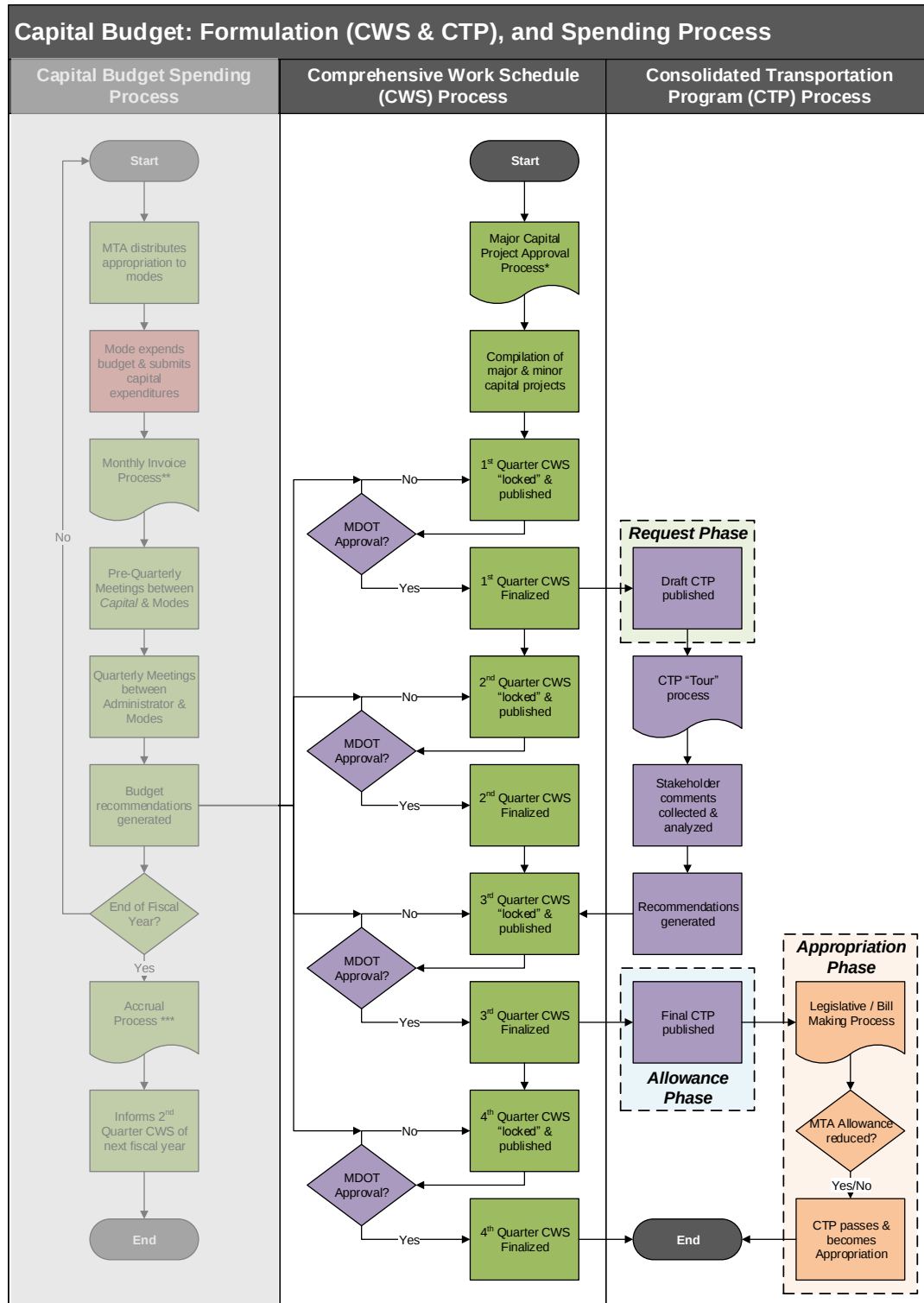
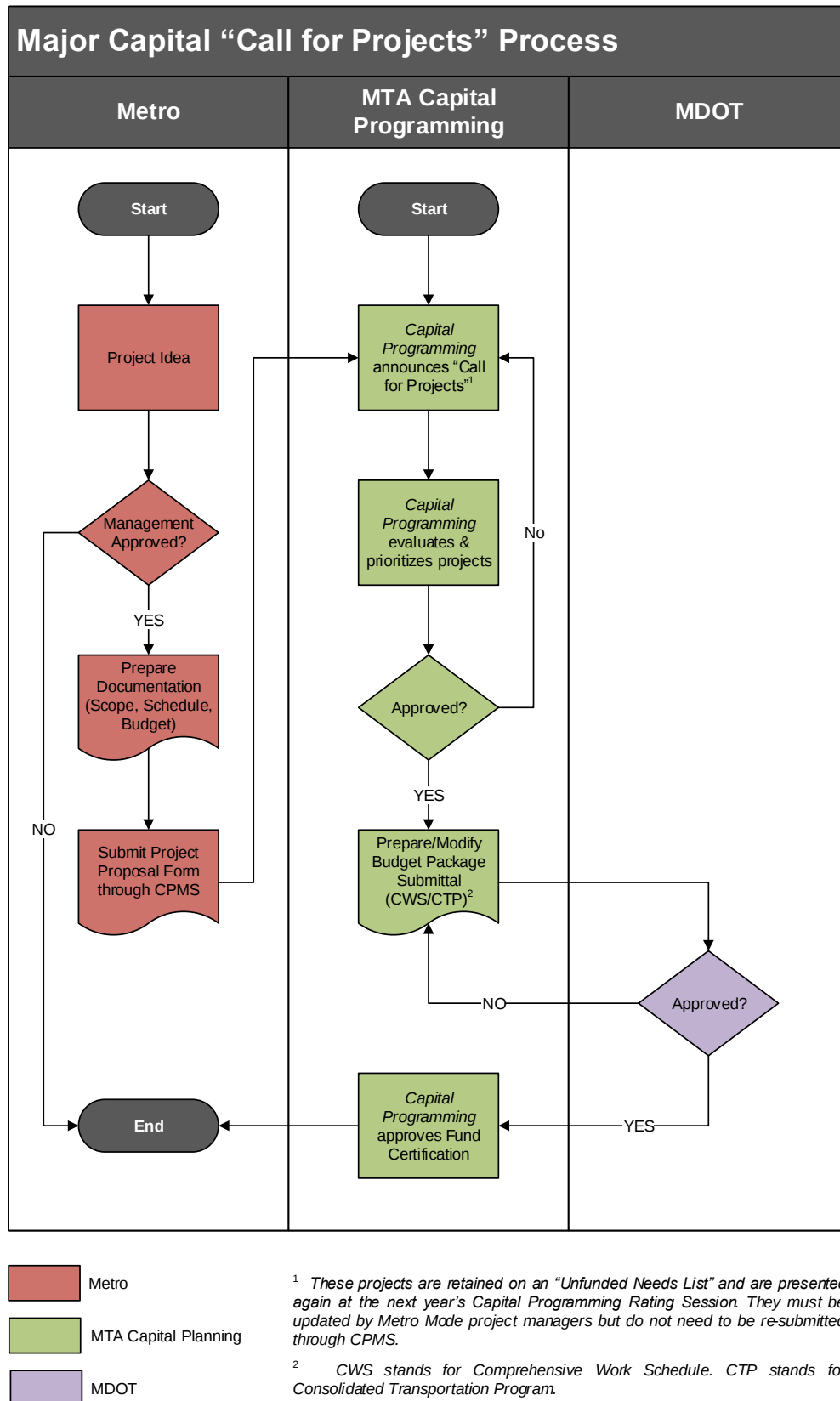


Figure 12.4 - Capital Programming's major capital "Call for Projects" Process.



Traditionally, Metro has defined its Capital projects with a focus on minimizing acquisition costs. However, the MTA may save money in the long-term by considering Total Cost of Ownership in its Capital investment decisions. Therefore, Metro will apply the principles defined in TAMP Strategy #9 (*Consider the Total Cost of Ownership in Investment Decisions*), to the extent practicable.

Throughout this LMP, Metro has identified a number of Transit Assets in its SGR Backlog, and other capital needs to improve its lifecycle management approach. Efforts to improve TAM may require an increase in the Metro Capital Budget. Metro intends to use analysis of its Transit Assets and their lifecycle needs to better guide the development of its future Capital Budget requests accordingly.

12.2 Spending Process

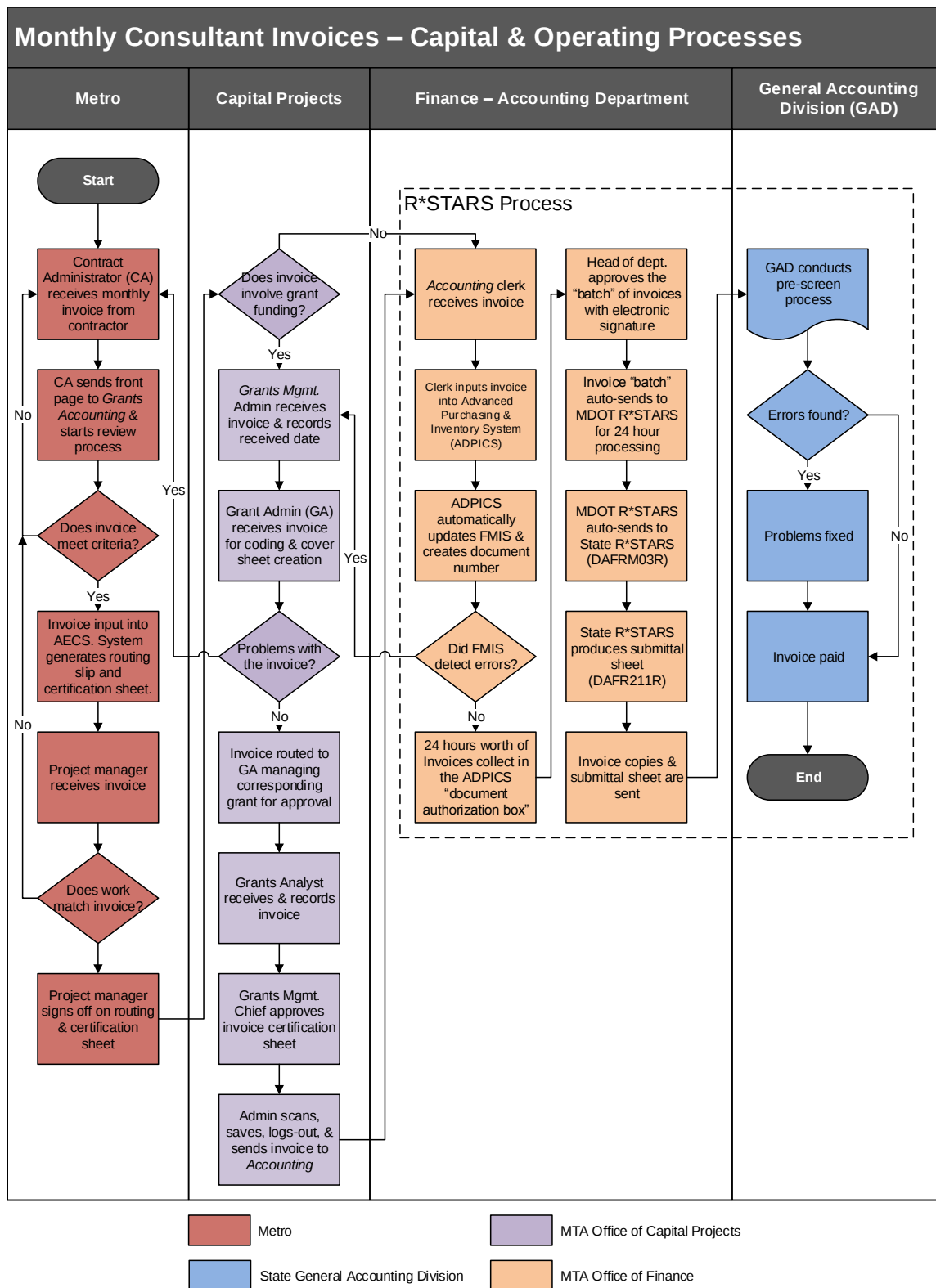
Once the Operating and Capital Budgets have been set, the Spending Process begins with the expenditure of funds, but extends to all processes associated with the ongoing management of those budgets. Expenditure of funds occurs after work has been performed by MTA staff and reported on their timecards accordingly. For vendors/contractors expenditure of funds occurs following their submittal of an invoice, which is paid by MTA.

The processes for ongoing management of the Operating and Capital Budgets are respectively different. Each budget is managed via different meetings, and usage of different software, cost containment, and accrual processes. These different processes are detailed in the subsections below.

12.2.1 Operations and Capital Shared Spending Processes

While spending process for both the Operating and Capital Budgets are respectively different, they generally share the same invoicing process for vendors/contractors (Figure 12.5).

Figure 12.5 - Overview of the invoicing process, applicable for both capital and operating budgets.



12.2.2 Operations Spending Process

The *Office of Finance* coordinates the Spending Process of the Operations Budget, and uses a series of Status of Funds (SOF) meetings to contain costs, and identify the potential need for a budget amendment request (Figure 12.6). While vendor/contractor invoicing was detailed in the subsection above, a separate invoicing process exists for inventory invoicing (Figure 12.7). The *Office of Finance* also uses a distinct process for accruals, which is detailed in Figure 12.8. Note, Metro shares responsibility for the Operations Spending Process with various other MTA offices/departments, as illustrated in the aforementioned figures.

Figure 12.6 – Operations budget spending process.

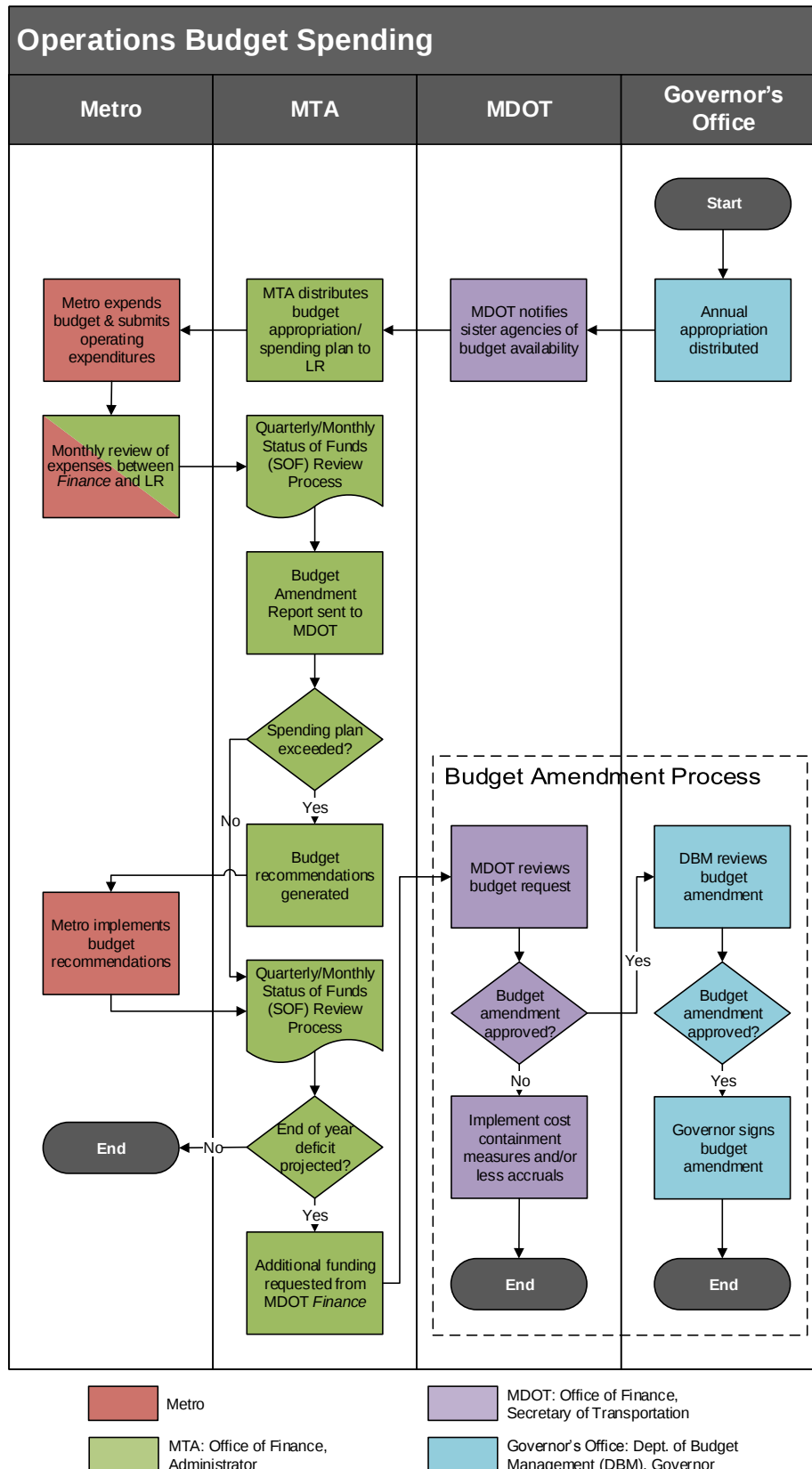
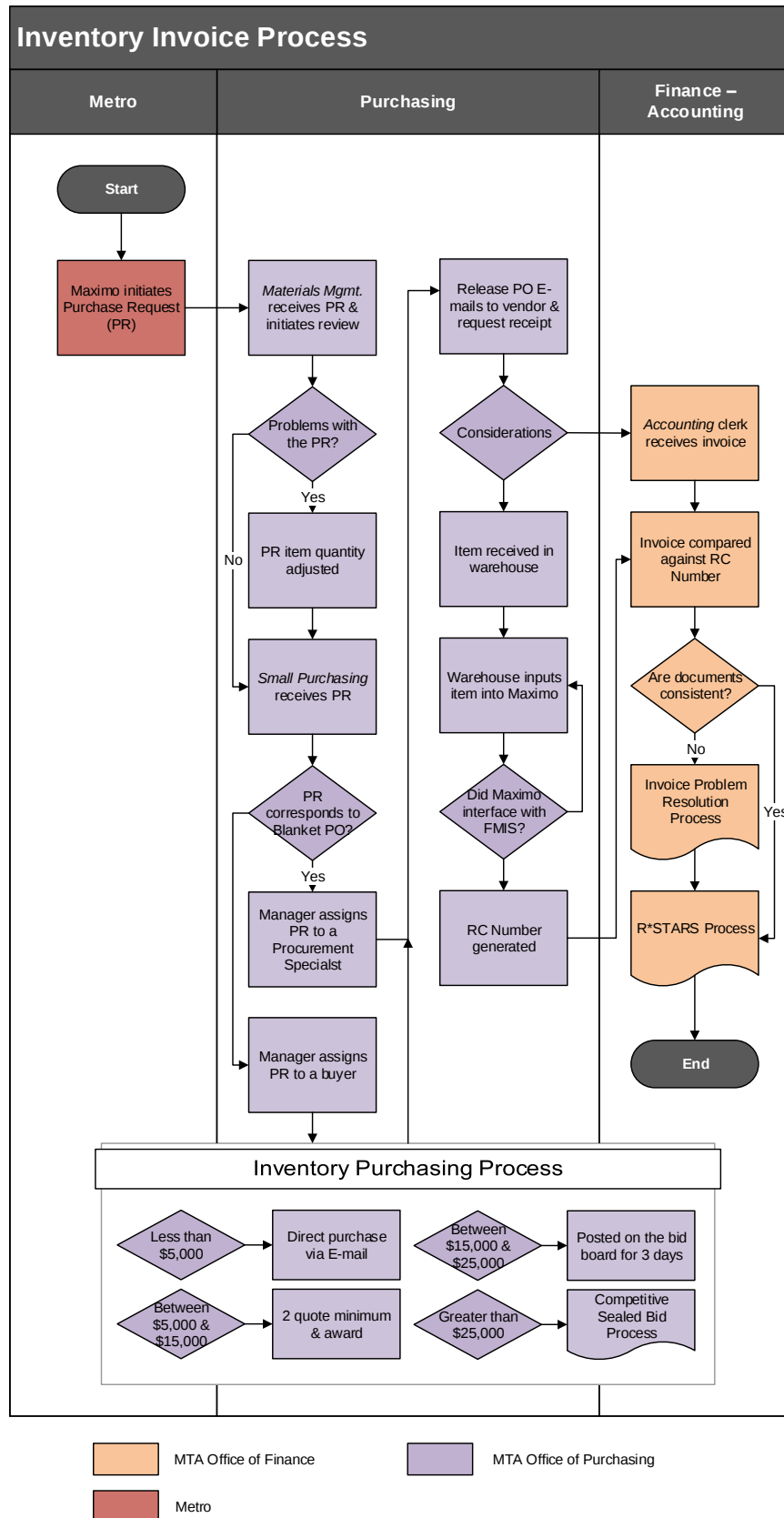


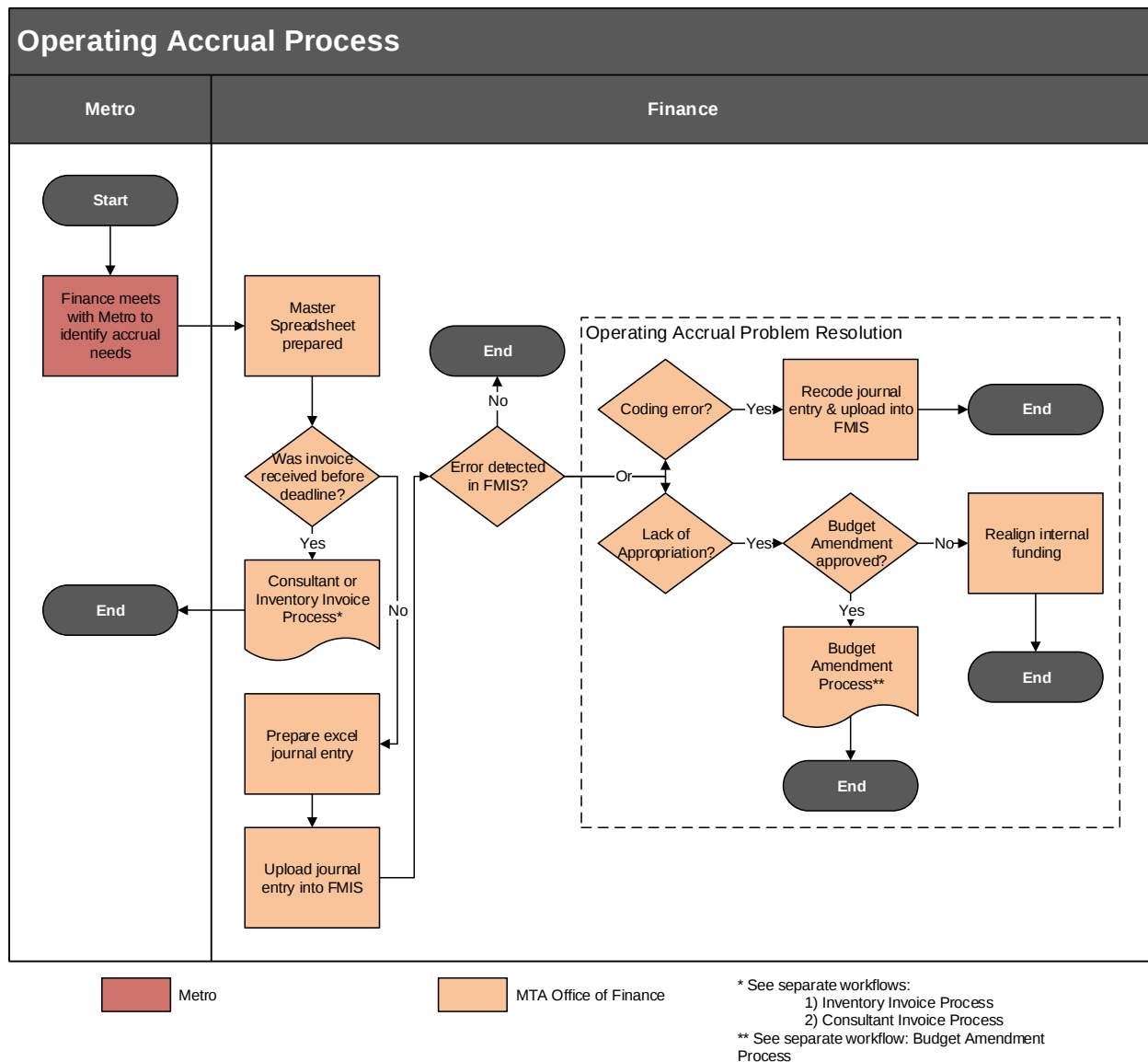
Figure 12.7 – Inventory invoice process.



The MTA Operating Budget is managed on an *accrual* basis per FTA regulations, meaning that MTA is required to account for the cost of work *performed* in a given month, not when that work was paid for. For example, if a vendor performed a service for \$1,000.00 in August, and MTA received an invoice in late September, and paid the invoice in early October, MTA is required to show the \$1,000.00 expense in August.

Throughout most of the year the *Office of Finance* records these expenses on an accrual basis based on of the information contained in an invoice. However, in the last few months of the Fiscal Year work is still being performed by MTA's vendors/contractors, but the *Office of Finance* may not receive an invoice in time to guide how the accrued expenses should be recorded. Therefore, in the last Fiscal Quarter of each year, the *Office of Finance* will reach out to Metro for assistance in estimating year-end accruals. This process is detailed in Figure 12.8 below. This year-end accrual process is time sensitive as all accrual based activities must be completed by a deadline set by the Maryland Legislature for subsequent review.

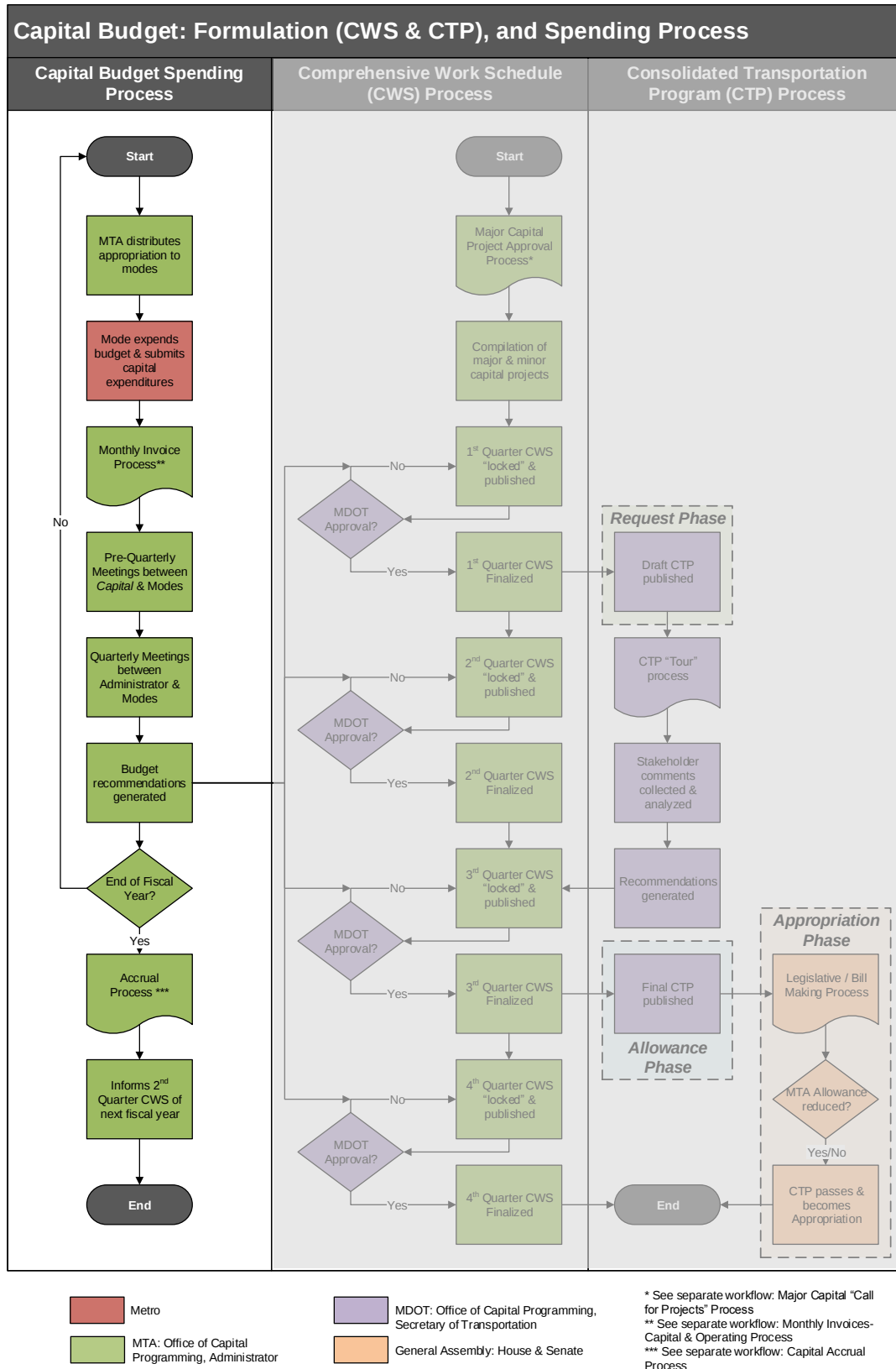
Figure 12.8 – Accrual process for the operating budget.



12.2.3 Capital Spending Process

The Division of Capital Programming coordinates the Spending Process of the Capital Budget, and uses a series of Pre-Quarterly and Quarterly meetings to help ensure projects stay on-budget and on-schedule. Should a funding discrepancy arise through any of these meetings, they may inform the next quarterly revision of the Capital Budget. The process for all invoicing in the Capital Spending Process was detailed in Figure 12.5. A detailed illustration of the ongoing management processes for the Capital Spending Process can be found in Figure 12.9 below. Capital Programming also uses a distinct process for accruals, which is detailed in Figure 12.10. Note, Metro shares responsibility for the Capital Spending Process with various other MTA offices/departments, as illustrated in the aforementioned figures.

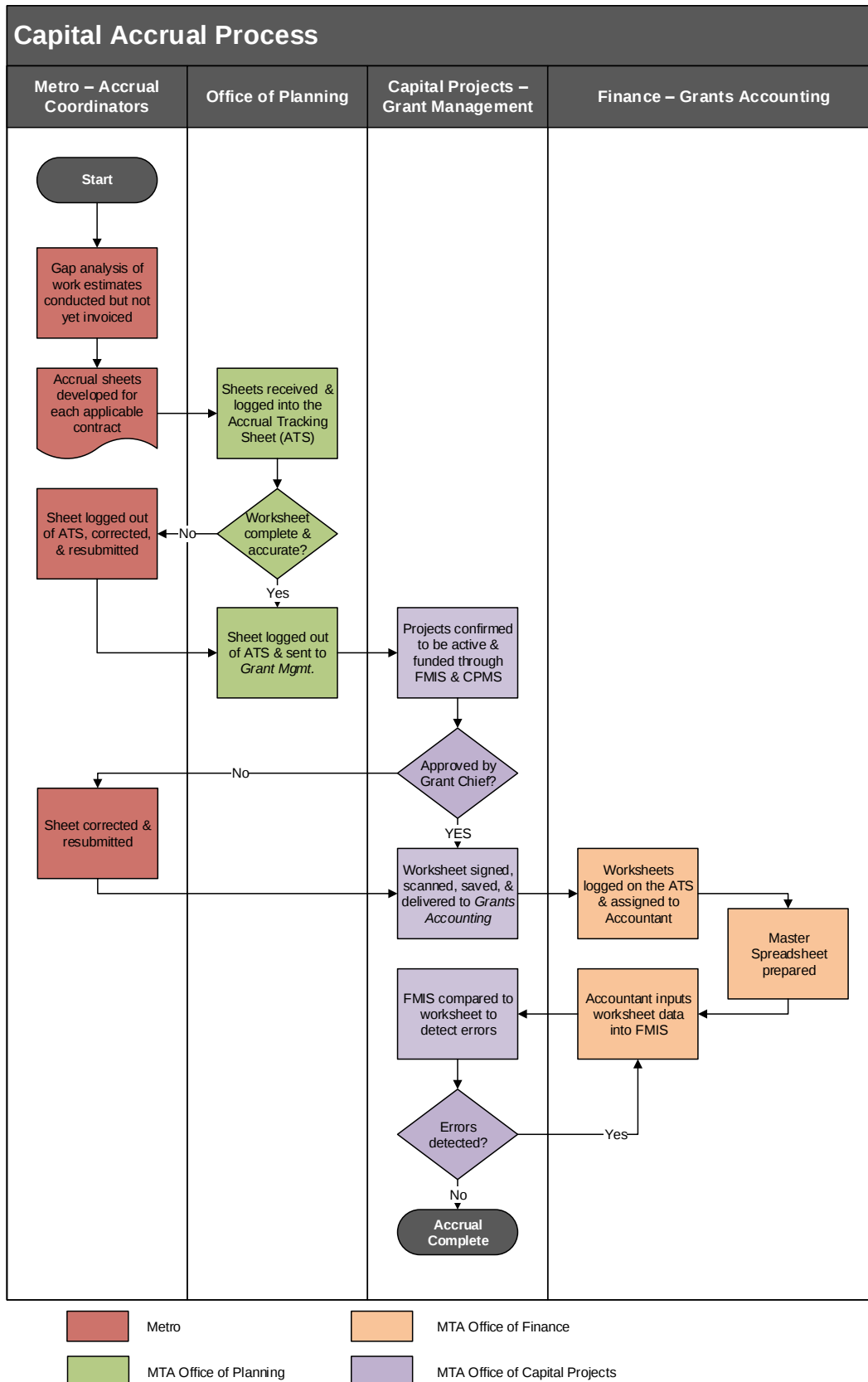
Figure 12.9 – MTA’s capital budget formulation and spending processes. Budget formation involves the creation and editing of the CWS and CTP documents, whereas spending remains a standalone process that informs the CWS.



The MTA Capital Budget is managed on an *accrual* basis per FTA regulations, meaning that MTA is required to account for the cost of work *performed* in a given month, not when that work was paid for. For example, if a vendor performed a service for \$1,000.00 in August, and MTA received an invoice in late September, and paid the invoice in early October, MTA is required to show the \$1,000.00 expense in August.

Throughout most of the year Capital Programming records these expenses on an accrual basis based on of the information contained in an invoice. However, in the last few months of the Fiscal Year work is still being performed by MTA's vendors/contractors, but Capital Programming may not receive an invoice in time to guide how the accrued expenses should be recorded. Therefore, in the last Fiscal Quarter of each year, Capital Programming will reach out to Metro for assistance in estimating year-end accruals. This process is detailed in Figure 12.10 below. This year-end accrual process is time sensitive as all accrual based activities must be completed by a deadline set by the Maryland Legislature for subsequent review.

Figure 12.10 - Capital Programming's accrual process.



13 Summary of Performance and Funding Impacts

13.1 Anticipated Transit Asset Replacement Needs

With rare exception, Transit Assets will need to be replaced as they reach the end of their useful lives. These replacement needs and necessary funding can be forecasted. For the analysis below, replacement policies are driven by the useful lives of assets, determined by Metro staff during interviews. In lieu of specific useful life data, default values contained within TERM Lite were utilized.

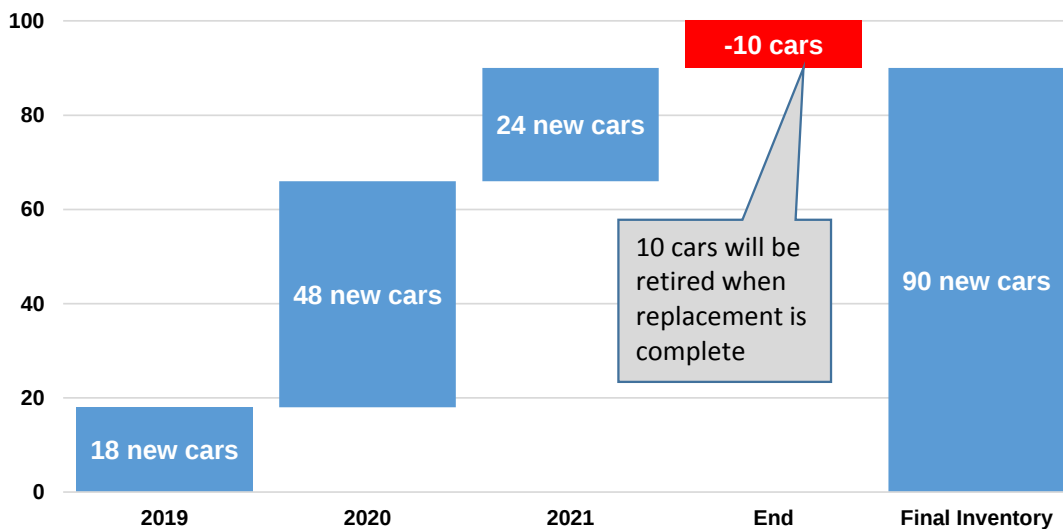
Current costs for train control and signaling for Sections A through C are derived from the estimated total procurement costs of \$325 million. The total costs were prorated for each section based on section length, with Section A making up the largest cost, then Section B followed by Section C. Similar to current revenue vehicle costs, current train control costs were deflated based on their year of procurement, which can be seen below. Useful lives are 30 years for train control, as provided by Metro Systems.

- Section A: 2016 (Original Date Built: 1983)
- Section B: 2017 (Original Date Built: 1987)
- Section C: 2018 (Original Date Built: 1995)

Current revenue vehicle costs are derived from the estimated procurement costs divided by the number of replacements, or \$3.19 million per vehicle. Procurement costs are deflated using a 2.82% inflation rate in the TERM Lite model to calculate the current revenue vehicle costs. Total deflation and, hence, current revenue vehicle costs depend on the year of procurement for each record, either 2019, 2020 or 2021.

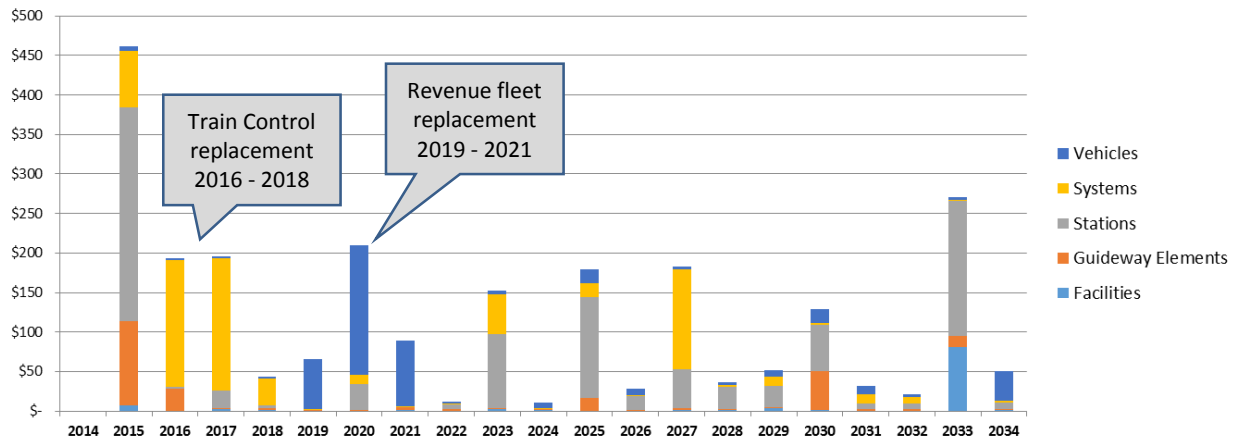
The replacement schedule for Metro's revenue vehicles is shown in Figure 13.1 below. Note that the TERM Lite model is set to replace oldest vehicles first. Total procurement costs are projected at \$287.1 million, along with the schedule shown in Figure 13.1 below.

Figure 13.1 - Metro revenue fleet procurement 2019-2021.



A TERM Lite analysis was employed to project asset replacement needs over the next 20 years. The sum of all replacement and rehabilitation activities yield the total *capital* expenditures identified by TERM Lite (Figure 13.2), based upon the existing Metro asset inventory, and set of general assumptions (Table 13.1).

Figure 13.2 - TERM Lite procurement schedule (\$mil). Revenue vehicles and train control replacement is highlighted.



Over the 20 year analysis, Metro requires \$2.4 Billion to replace all Transit Assets when they reach the end of their useful life. This averages to \$120.65 million in needs per year.

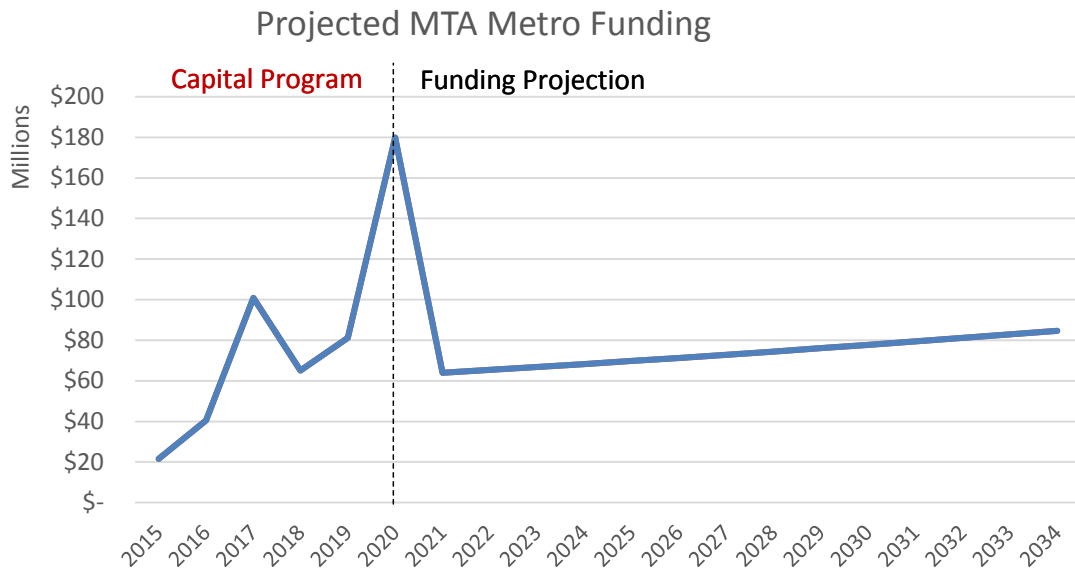
Table 13.1 - Assumptions for the TERM Lite analysis.

Assumptions	
•	All costs in Fixed Asset Ledger (FA) are in "In Service" year dollars
•	Unless otherwise given, all Priority Status is "Normal"
•	Unless otherwise noted, TERM default useful lives are applied
•	Revenue collection assets taken from FMIS and confirmed with MTA's <i>Office of Treasury</i>
•	Where linear assets with differing useful lives were identified, cost was subtracted from the total FMIS record based upon segment length.
•	Needs are inflated at 2.82% (based on direction from <i>MDOT Office of Finance</i>)

13.2 Anticipated Metro SGR Funding

Not all of Metro's capital budget is used for SGR needs; other portions of the budget are used for system enhancements and management studies. The analysis below projects Metro SGR funding based on historic trends. Funding projections are based on historic expenditures from 1996 through the current capital program, which goes to 2020. At the conclusion of the current capital program in 2021, Metro's average funding level was adjusted down to account for the major capital projects (revenue fleet, train control replacements) in the current capital program. An annual growth rate of 2.18% was applied to the adjusted average funding level post-2020. Accordingly, the analysis below forecasts an annual average of \$76 million in funding over 20 years.

Figure 13.3 – Metro’s projected capital funding through 2034 (\$mil).

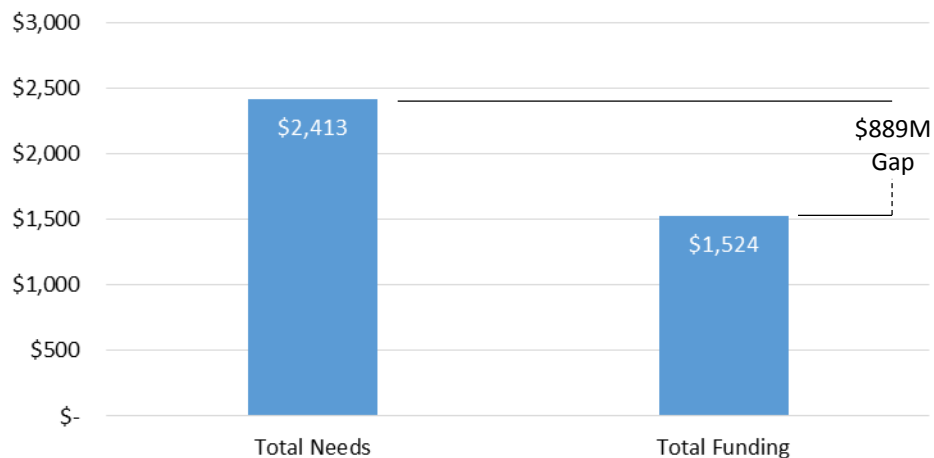


13.3 Funding Impact Analysis

As discussed above, Metro’s total 20 Year asset replacement needs are \$2,413 million in year of expenditure dollars; however, Metro is anticipated to have only \$1,524 million (year of expenditure dollars) in SGR funding available over the same period. The result is a total funding gap of approximately \$889 million over the 20-year period.

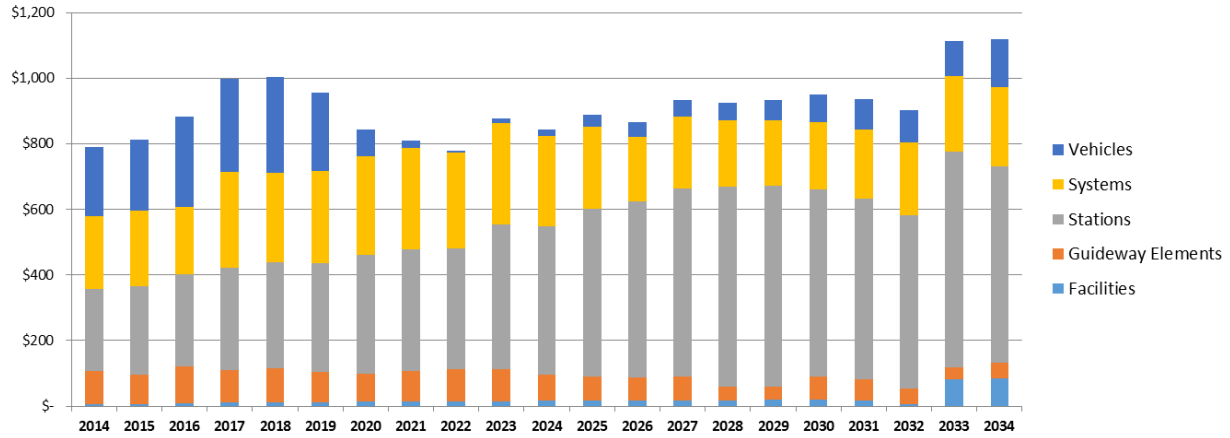
On annual basis, Metro’s average annual reinvestment needs over the same 20-year period are \$120.65 million. Metro’s average annual funding, over 20 years, is constrained to \$76.2 million. The result is an average annual funding gap of \$44.45 million.

Figure 13.4 – Metro 20 year capital needs and expected funding (\$mil).



Due to this funding gap, Metro’s SGR Backlog is expected to grow over the 20-years from \$791 million to over \$1.1 Billion. Specifically, the backlog is anticipated to grow in *Stations* based on TERM Lite prioritization.

Figure 13.5 – Anticipated growth of Metro SGR Backlog due to annual funding gap.



14 Continuous Improvement

In relation to this LMP, continuous improvement refers to not only improving asset management activities within Metro, but also ensuring continual update of this LMP to document these improvements. This section captures recommendations to improve asset management activities and mitigate risk, and instituting an annual LMP update and approval process.

14.1 Risk & Review

An Enterprise Risk Management system currently doesn't exist at the MTA. However, risk management is a critical component of any asset management system. The MTA has committed in its TAMP to employ an Enterprise Risk Management (ERM) approach to identify and quantify all risks, then select the highest risks for mitigation. TAMP Strategy #2 (*Employ an Enterprise Risk Management Approach*) aimed to formulate the mechanics of the ERM, including responsibilities, process, and milestones. Metro intends to incorporate the ERM approach into its future TAM activities and this LMP alike.

14.2 Performance Modeling

TAMP Strategy #11 (*Enhance Enterprise Performance Management*) specifies the need to develop performance models. Performance modeling is an advanced technique used to inform managerial decision making, and ultimately guide the improvement of TAM practices. Essentially, performance modeling is an exercise of data analysis enabling the structured comparison of various operational scenarios. Performance modeling can be as simple as a spreadsheet-based analysis, and as complex as a full software tool.

In many cases, performance modeling is used to forecast asset condition, asset failure, or asset replacement costs; many of these functions are currently provided through the TERM Lite model used for the various analyses in this LMP. Ultimately, performance modeling at Metro should evolve to forecast lifecycle costs of an asset or system, and optimize the value of Metro's entire asset portfolio.

In the future, available performance models will be listed and hyperlinked in this LMP to provide Metro management with easy access to these tools.

14.2.1 Performance Modeling Uses

Initially, Metro may benefit from smaller discrete studies to determine the optimal time to rehab/replace an asset, the optimal maintenance interval for a given asset, the optimal number of spares to hold in inventory, etc. The intent is to focus performance modeling on activities that will result in cost savings, system performance increases, and risk reductions.

While TERM Lite is currently used for estimating SGR Backlog, annual capital investment needs, current and future asset conditions, and long-term capital investment priorities, its application is limited. TERM forecasts major capital needs, but it cannot predict operating and maintenance costs associated with Transit Assets.

The ideal approach to lifecycle costing (TAMP Strategy #9) considers all costs and ownership implications for an asset or system of assets over its entire lifecycle. Through a lifecycle cost analysis, Metro can consider the "Total Cost of Ownership" (TCO) associated with various investment scenarios, ensuring that asset performance requirements are met at the lowest TCO.

Value optimization is a further evolution of the lifecycle cost model; it goes beyond performance and cost implications, and considers the other elements of the MTA's TAM Vision to deliver the best value-for-

money of the entire modal asset portfolio. Value optimization represents the pinnacle of performance modeling, and is currently beyond industry capabilities.

14.2.2 Current Data Deficiencies

Metro is currently limited in its ability to employ performance modeling techniques due to a lack of quality data inputs. Each type of performance analysis referenced in Section 11.1 above is listed with required data inputs and a generalized reference to Metro's data deficiencies:

Table 14.1 - Gap analysis of required data to build/run performance models.

Performance Model	Level of Analysis	Required Data Currently Available within Metro	Required Data Currently <u>Not</u> Available within Metro
Rehab/Replacement Schedule Optimization	Intermediate	✓ Asset replacement cost ✓ Asset overhaul cost estimate ✓ Asset-level corrective maintenance action history	✗ Asset-level maintenance cost history ✗ Asset condition history (performance and/or physical condition)
Maintenance Interval Optimization	Intermediate	✓ Asset useful life policy/history ✓ Asset-level corrective maintenance action history	✗ Asset-level maintenance cost history
Spares Analysis	Intermediate	✓ Spare part cost history	✗ Inventory depletion history ✗ Time history for fulfillment of spares needs
Lifecycle Cost Model	Advanced	✓ Asset replacement cost ✓ Asset useful life policy/history ✓ Asset-level corrective maintenance action history ✓ Anticipated decommissioning/disposal costs/revenues	✗ Asset-level maintenance cost history ✗ History of direct consequences due to asset failure ✗ Performance valuation standards (for calculating lost opportunity asset failure costs) ✗ Asset-level socio-economic costs

			✗ Identification of post-disposal residual liabilities
Value Optimization	Aspirational	TBD	TBD

The list of performance models above is illustrative, and will be modified in future revisions of this LMP to guide desired investments in data capture and performance modeling improvements.

14.2.3 Data Capture Improvement Plan

The ability to capture quality input data is prerequisite to any valuable performance modeling. Once Metro has identified the performance models it wishes to invest in, Metro will initiate development of corresponding data capture improvement plans which will detail:

- Scope of asset to be used in the desired performance model
- Applicability to other modes/departments
- Process map for performance model
- Data input requirements
- Inventory and gap analysis of existing input data
 - Relevant MTA technology policies
 - Data system(s) of record (and associated data owners)
 - Schedules for data updates
- Strategies to fill data gaps
- Projects to implement data capture improvement plan

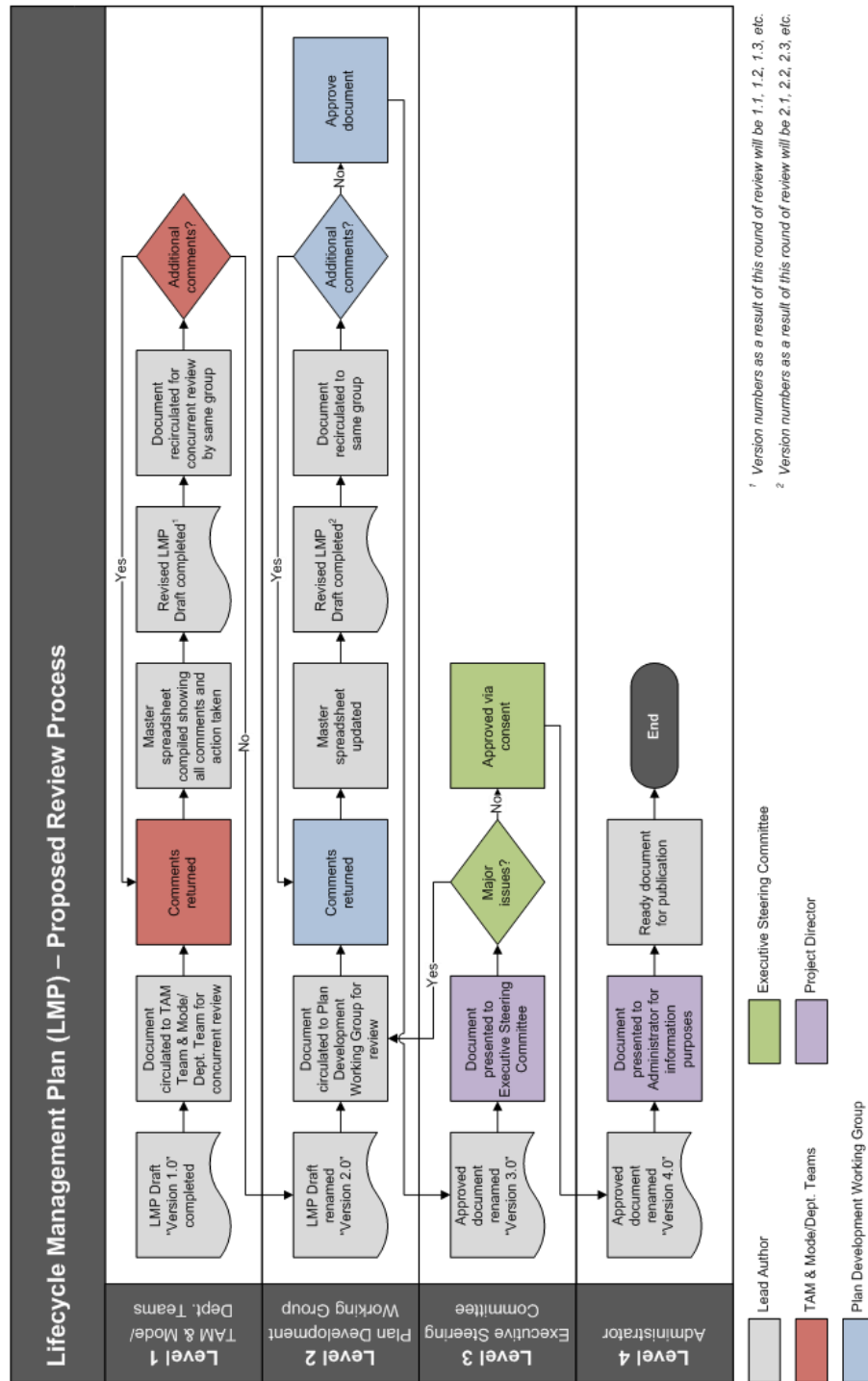
14.3 Other Recommendations

Several key recommendations are detailed in the preceding chapters. However, additional recommendations were identified through staff interviews and the development of this LMP at large. A complete summary of all recommendations can be found in **Appendix D**. Metro recognizes that it cannot take action on all recommendations with existing resources, and therefore will take a strategic approach to the prioritization of these improvements, forming a basis for the next version of this LMP.

14.4 LMP Maintenance Process & Timeline

This LMP will be updated **annually** since Transit Asset Management is founded on a continuous business process. The LMP update will also coincide with an annual update of the TAMP and SSPP, since changes in either document may warrant corresponding changes in this LMP. The annual maintenance process (Figure 14.1) outlines steps for LMP approval and comment.

Figure 14.1 - LMP maintenance process and timeline.



15 Appendices

15.1 Appendix A: Metro Asset Replacement Schedules

Category	Sub-Category	Element	Sub-Element	Average Agency Useful Life	Number of Rehabs
Facilities					
	Buildings			40	1
		Building Components			
			Drainage	40	0
			Fencing	15	0
			HVAC	40	0
			Major HVAC	40	0
			Minor HVAC	40	0
			Other	15	0
			Roof	40	0
		Maintenance			
			Misc.	50	1
			Rail Heavy Rail	50	1
			Utilities	50	1
	Equipment			15	0
		Furniture		12	0
		Maintenance			
			Air Compressor	25	0
			Cart	25	0
			Fuel Tank	25	0
			Hoist	25	0
			Lifts Misc. Portable	7	0
			Misc Equip	25	0
			Rail Heavy Rail	10	0
			Scrubber, Sprayer	25	0
			Train Washer	40	0
			Turntables, Truck	25	0
			Wheel Presses	25	0
			Wheel truing machines	25	0
		MIS/IT/Network Systems			
			Computers/Hardware	6	0

Guideway Elements					
	Guideway				
		At Grade Ballast	Heavy Rail	80	0
		At Grade/In-Street	Grade Crossing Heavy Rail	20	0
		Elevated Structure	Bridge Heavy Rail	80	0
		Retained Cut	Box Culvert	80	0
		Underground			
			Cut & Cover Heavy Rail	80	0
			Tunnel Heavy Rail	80	0
	Special Structures	Retaining Walls		40	0
	Trackwork				
		Ballasted			
			Curve	16	0
			Tangent	30	0
		Direct Fixation			
			Curve	19	0
			Tangent	29	0
		Special			
			Misc.	30	0
			Diamond Crossover	15	0
			Single Crossover	15	0
		Ties	Concrete	35	0
		Yard		70	0
Stations					
	Access			25	0
		Elevators		25	0
		Escalators		25	0
		Parking	Lot	20	1
		Pedestrian Walkway		30	0
	Building				
		Building Components			
			Misc.	20	0
			Building Electrical	60	0
			Drainage	40	0
			Exterior	53	0
			Fire Alarm	23	0
			HVAC	32	0
			Lighting	50	1

			Other	26	0
			Plumbing	50	0
			Roof	20	0
			Shelter	20	0
	Complete Station	Bus Stop Shelters		40	1
	Platform	Platform		31	1
	Signage & Graphics			20	0
Systems					
	Communications				
		Cable Transmission System (CTS)	MIS/IT/Network Systems	15	0
		Passenger Communications Systems	Public Address (PA)	10	0
		Phone System	Phone System	12	0
		Radio	Mobile Radios	10	0
		Safety and Security			
			Misc.	20	0
			CCTV	20	0
		SCADA		10	0
	Electrification				
		Contact Rail			
			Contact Rail, Chairs, Anchor and Incline Heavy Rail	25	0
			Heaters	12	0
			Protection Boards	25	0
		Power Cable			
			Contact Rail	40	0
			Substations	40	0
		Substations			
			Misc.	40	0
			AC Switchgear	45	0
			DC Switchgear	45	0
			Exterior	40	0
			Transformer	40	0
	Revenue Collection				
		Central Revenue Collection		20	0
		In-Station			

			Faregates	20	0
			TVMs	20	0
	Train Control				
		Centralized Train Control	Control Room (central)	40	0
		Wayside Train Control			
			Heavy Rail	28	0
			Train Control Cable	30	0
	UPS			30	0
Vehicles					
	Non-Revenue Vehicles			6	0
		Car		6	0
		Locomotive, Switch		40	0
		Special		15	0
		Truck		10	0
	Revenue Vehicles	Heavy Rail	Heavy Rail	30	5

15.2 Appendix B: [SOP & Master PM Catalogues](#)

15.3 Appendix C: Plan & Drawing Submittal Milestones



Asset Acquisition – Design Stage Plan Requirements

ALL SECTIONS • Cover Sheet • Index of Drawings • General Notes • Abbreviations, Symbols, & Legends • General & Special Provisions • SGPs • Design Criteria • Detailed Drawings • Sequence of Construction	CIVIL PLANS • Typical Sections • Geometrics • Demolition • Site • Profiles • Utility • Grading • Stormwater Drainage & Management • Erosion & Sediment • Control • Maintenance of Traffic • Soil & Geological • Right-of-Way • Cross Sections • ADA Accessibility
LANDSCAPE PLANS • Planting Details • Site Details	TRACKWORK PLANS • Track Chart • Special Trackwork
SYSTEM PLANS • Architecture (Block Diagrams) • Systems Specifications • Communication Room Design • Electrical Design • Power Load Calculations • Heat Loads • Risers • Conduit Layouts & Schedules • Network Layout • Device Layout & Locations • Rack Elevations	
ARCHITECTURAL & STRUCTURAL PLANS • Floor Plans • Sections • Elevations • Roof Plans^A • Reflected Ceiling Plan^A • Beam Tables^S	MECHANICAL & ELECTRICAL PLANS • Equipment Location • Equipment Schedule^M • Panel Schedule^E • Lighting Fixture Schedule^E • Control Sequence

A: Architectural only
S: Structural only

M: Mechanical only
E: Electrical only

15.4 Appendix D: Detailed Summary of Transit Asset Conditions

Category, Sub-Category & Element	Avg. Condition
Vehicles	2.43
<i>Revenue Vehicles</i>	2.43
Heavy Rail	2.43
<i>Non-Revenue Vehicles</i>	2.29
Misc.	2.48
Car	1.61
Locomotive, Switch	2.81
Special	2.33
Truck	2.05
Facilities	3.48
<i>Equipment</i>	2.74
Misc.	4.14
Furniture	3.63
Maintenance	2.48
MIS/IT/Network Systems	3.28
<i>Buildings</i>	3.57
Misc.	4.26
Building Components	3.60
Maintenance	3.12
Systems	2.60
<i>Communications</i>	2.78
Cable Transmission System (CTS)	4.19
Passenger Communications Systems	1.17
Phone System	1.45
Radio	3.79
Safety and Security	3.97
SCADA	2.95
<i>Electrification</i>	2.66
Contact Rail	2.21
Substations	3.01
<i>Train Control</i>	2.51
Centralized Train Control	3.00
Wayside Train Control	2.50
<i>UPS</i>	4.37
<i>Utilities</i>	3.01
Drainage	3.01
Stations	3.16
<i>Complete Station</i>	3.02
Bus Stop Shelters	3.02
<i>Access</i>	2.76
Misc.	2.33
Elevators	3.58
Escalators	3.57
Parking	2.15
Pedestrian Walkway	2.52
<i>Building</i>	3.24
Building Components	3.24
<i>Signage & Graphics</i>	2.41
<i>Platform</i>	2.82

Category, Sub-Category & Element	Avg. Condition
Guideway Elements	3.58
<i>Guideway</i>	3.75
At Grade Ballast	3.74
At Grade-In-Street	2.01
Elevated Structure	3.71
Retained Cut	3.78
Underground	2.46
<i>Trackwork</i>	2.33
Ballasted	1.60
Direct Fixation	2.70
Special	4.56
<i>Special Structures</i>	2.86
Retaining Walls	2.86
Grand Total	3.18

15.5 Appendix E: Prioritized Summary of Recommendations

NO.	TOPIC	CORRESPONDING TAMP STRATEGY	RECOMMENDATION
1	Maintain Transit and Land Asset Inventories	1	Metro should maintain its Transit Asset and Land Asset inventories. This includes implementing policies and procedures that adds or removes records with the asset's acquisition or disposal, respectively. Additionally, Metro needs to maintain a high level of data quality that ensures Transit Asset records have accurate: names, quantities, acquisition costs, and in-service dates. <i>The Data Working Group will provide more refined recommendations on policies, procedures, and roles of personnel.</i>
2	Employ an Enterprise Risk Management (ERM) Approach	2	Metro should employ an ERM approach to identify and quantify all risks, then select the highest risks for mitigation. <i>MTA will provide a standardized methodology and milestones.</i>
3	Asset Condition: Implement FTA Rating Scale	3	Each Metro department, coordinated by management, should implement FTA's standardized 1-5 point rating scale for evaluating Transit Asset physical conditions. <i>MTA will provide standards for replicating unique Transit Asset class scales across all modes and departments.</i>
4	Asset Condition: Train Staff	3	Metro should train all maintenance personnel how to utilize FTA's 1-5 point scale for their respective Transit Asset classes. <i>See Recommendation #3.</i>
5	Develop Capability for Visualization of Linear Assets	NA	Metro should participate in the development of an agency-wide strategy for managing and visualizing linear assets. <i>MTA to provide guidance.</i>
6	Asset Condition: Make Data Sheets Compatible with FTA Condition Rating Scale	3	Metro departments should update all post work order sheets, data sheets, or check-off sheets with fields to accommodate FTA's 1-5 point condition rating scale. <i>See Recommendation #3.</i>
7	Asset Condition: Perform Physical Inspection	4	Metro should compare all TERM Lite condition estimate data against perceived physical condition. For those Transit Assets where Metro is producing an inaccurate estimate of condition, Metro will perform a structured and comprehensive physical condition assessment of those assets. <i>MTA will provide standards on physical inspection methodology.</i>

8	Critical Assets: Maintenance Regimes	4	Metro should reassess maintenance procedures for all Critical Assets and supplement these regimes when necessary. Metro will give priority consideration to its trackwork maintenance regimes. <i>MTA will provide guidance on appropriate maintenance regimes for Critical Assets.</i>
9	Critical Assets: Infill SOP and Master PM Gaps	4	Metro should develop SOPs and Master PMs as necessary, to ensure that all Critical Assets are documented with a corresponding set of SOPs and Master PMs accordingly. These maintenance documents should be centered upon the physical asset, or component (when applicable), not an activity. Each SOP should contain sections that outline: operations, inspection procedures, and maintenance procedures.
10	Critical Assets: Improve Third-Party Contract Language	4	Metro should reassess all contracts concerning Critical Assets and insert Reliability, Availability, Maintainability, and Safety (RAMS) specifications into the contract language as each 3 rd part contract is renewed. <i>MTA will provide guidance on appropriate RAMS specification language.</i>
11	Perform Third-Party Contractor Cost-Benefit Analyses	NA	Metro and MTA should implement a comprehensive cost-benefit evaluation of conducting maintenance either in-houses versus through a contractor.
12	Performance Monitoring: Ensure Consistent Documentation of Labor Hours	11	Metro should ensure that all maintenance personnel are correctly logging their labor hours for PM and CM activities accordingly, allowing for accurate calculation of recommended KPIs. <i>MTA will provide additional guidance on the methodology for calculating these KPIs.</i>
13	Performance Monitoring: Correctly Use Corrective Maintenance (CM) Work Orders	11	Metro should ensure that all maintenance personnel are closing out Preventive Maintenance (PM) work orders upon their completion, and opening a separate CM work order for all corrective activities. Metro should also standardize these procedures across all departments. This will ensure accurate calculation of associated KPIs. <i>MTA will provide additional guidance on the methodology for calculating these KPIs.</i>
14	Data Management: Improve Work Order QA/QC	10	Metro should explore the feasibility of customizing Maximo so that the completion QA/QC on a work order by a supervisor can be electronically recorded; Metro will also explore

			the feasibility of a corresponding report of the number of work orders audited by supervisor. <i>MTA will provide additional guidance on the feasibility of these customizations.</i>
15	Condition: Identify Obsolete Transit Assets	3	Metro should identify obsolete Transit Assets, such as wayside electronic equipment and evaluate the need to manually assign a “poor” condition rating to these assets accordingly. Such changes to the designation of a Transit Asset’s condition must be coordinated with <i>Office of Planning and Programming</i> to ensure a commensurate revision of the MTA Transit Asset inventory and may influence how Metro structures its funding requests thereafter. <i>MTA to provide additional guidance on making these determinations with obsolete Transit Assets.</i>
16	Improve Succession Planning	NA	While this LMP captures institutional knowledge and improves training for the position’s successor, the MTA should explore how it can more proactively identify candidates for succeeding a position and increase the duration of shared time between the outgoing employee and the successor.
17	Data Management: Develop Warranty Program	10	Metro should develop methods and tools for efficiently tracking warrantees associated with Transit Assets and spare parts. <i>MTA may provide programmatic guidance.</i>
18	Data Management: Allow Contractors the Use of Maximo	10	Metro should explore the feasibility of allowing contractors direct access to work orders in the Maximo system as appropriate, so they may directly record details on the work they performed, and appropriately indicate work order closeout. Contractor use of Maximo may be audited in accordance with the recommendation #15 above. <i>MTA and MDOT will provide additional guidance.</i>
19	Reinstitute Dedicated Maintenance Training Staff and Program	NA	In the past, Metro had a staff person dedicated to training union labor on safe and proper maintenance procedures, use of equipment, and techniques. Metro should explore its ability to reestablish this position and expand the scope of this individual’s role to identifying to identifying maintenance efficiencies on an ongoing basis.
20	Establish Universal Transit Asset Specifications	NA	The Metro system is currently composed of numerous incompatible subsystems and Transit Assets, requiring MTA to hold large inventories of spare parts, and conduct separate staff

			trainings for each of these incompatible subsystems and Transit Assets. Metro should seek to establish universal specifications that can guide future Transit Asset procurements, such that they may share a common pool of spare parts, and allow the consolidation of training programs.
21	Adopt Recommended Key Performance Indicators (KPIs)	11	Metro and MTA should adopt recommended asset related KPIs as outlined in Section 7.2.
22	Document Existing Data Systems and Needs	10	Metro depends on numerous disparate spreadsheets and databases to track TAM-related information. Metro should document the existence of each respective data system, its purpose, the employee who manages the data system, and any obvious needs to improve these data systems. This will support the agency-wide initiative to develop a data catalogue and ultimately enhance enterprise data management. <i>MTA to provide guidance.</i>
23	Make SOPs directly available on Maximo	NA	Metro should make SOPs available within Maximo, so that maintenance staff may view SOPs directly from maintenance terminals. This can be accomplished in a number of ways, including installing ProjectWise on maintenance terminals and providing SOP hyperlinks from within Maximo.
24	Develop Performance Modeling Data Capture Plans	11	Metro will identify the performance models it wishes to invest in, and initiate development of corresponding data capture improvement plans, as described in Section 13.2.3.
25	Data Management: Optimize Maximo Automated Parts Reordering	10	Currently, Maximo automatically initiates a reorder of spare parts based on numeric reorder points, economic order quantities, and lead time values. In certain cases, however, these values lead to parts inventory being depleted while mechanics are awaiting arrival of the new parts, thereby causing a delay in maintenance activities. To avoid this delay, Metro should assess new threshold values for automatic parts ordering based on cyclic scheduled maintenance needs, as detailed in Section 9.3.1 above.
26	Provide Supervisor Training on Part Ordering and Capital Project Submission	12	Initial capability assessments performed at the outset of the TAM project highlighted that supervisors were unsure about how to efficiently order spare parts and develop/submit capital projects. Accordingly, Supervisors should be trained on: 1) part ordering, including using

			Maximo and creating technical specifications; 2) <i>Capital Programming's</i> Call for Projects and how to develop/submit SGR projects.
27	Standardize Maintenance Terminology	NA	Metro should standardize maintenance terminology to create a common, easily understood language throughout the MTA. This terminology would clearly distinguish between: scheduled maintenance, scheduled inspections, and work orders.