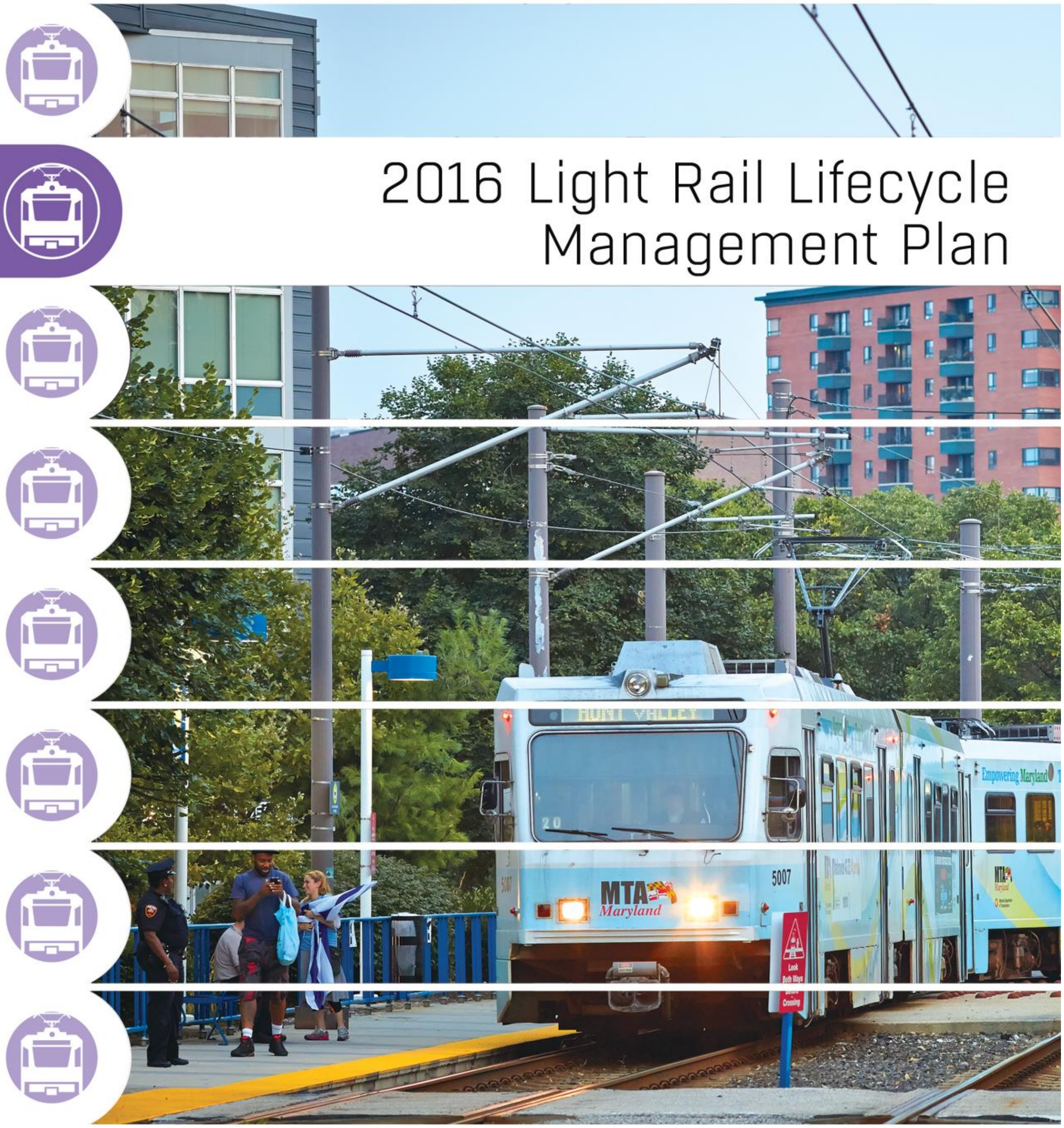
2016 Light Rail Lifecycle Management Plan



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

1.1.1 Guidance Office

Office of Planning & Programming

1.1.2 Distribution List

Name	Position
Paul Comfort	Administrator & CEO, MTA
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MTA ProjectWise	Global Electronic Distribution: pw:\\mtapwint2:MTA_PW_Data\Documents\07 - Core Operations & Modes\Light Rail Operations\100 - Light Rail Shared\Light Rail Life Cycle Management Plan (LMP)\

1.3 Signature for Authorization

Approved By:

x 4-26-16

for Gary Hinton Date
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2 Introduction

2.1 MTA Transit Asset Management Background

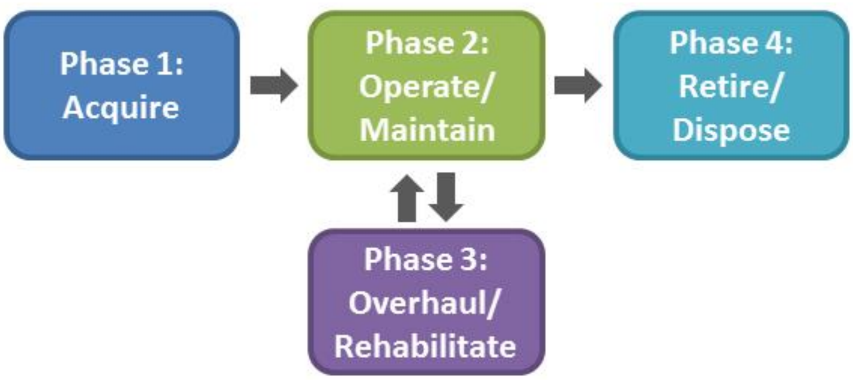
This Lifecycle Management Plan (LMP) has been created for MTA's Light Rail mode to document existing business processes, and to strategically plan for enhancements to those processes. This LMP outlines how Transit Assets are managed by Light Rail across all lifecycle phases. This document has also been 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-inform investment decisions; and
- Improving cross-department coordination.

This LMP documents all management practices surrounding Transit Assets in the Light Rail 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 Light Rail'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 Light Rail 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 Light Rail 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 <u>Land Asset</u>, <u>Transit Asset</u>, and <u>Critical Asset</u> 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 <u>Asset</u>, <u>Transit Asset</u>, and <u>Critical Asset</u> 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 <u>Asset</u>, <u>Land Asset</u>, and <u>Critical Asset</u> 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 <u>Asset</u>, <u>Land Asset</u>, and <u>Transit Asset</u> 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 (disambiguagion):

> **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.

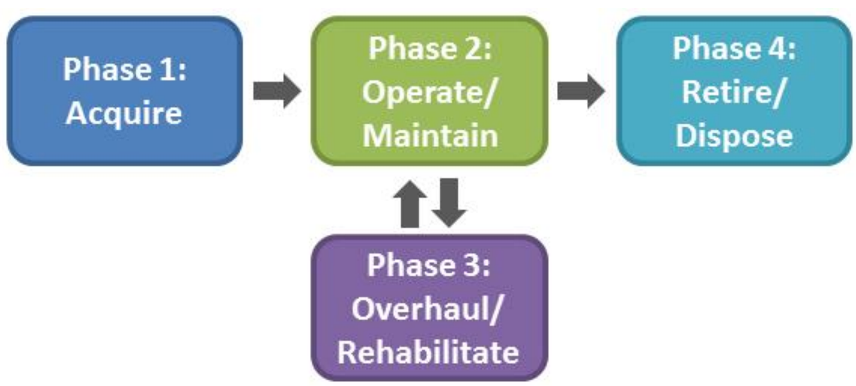
Transit Asset Management Plan (TAMP)

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 Guide[1] describes a number of basic lifecycle activities (Figure 2.2). Many Transit Assets at Light Rail 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 Light Rail 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 Light Rail. 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.

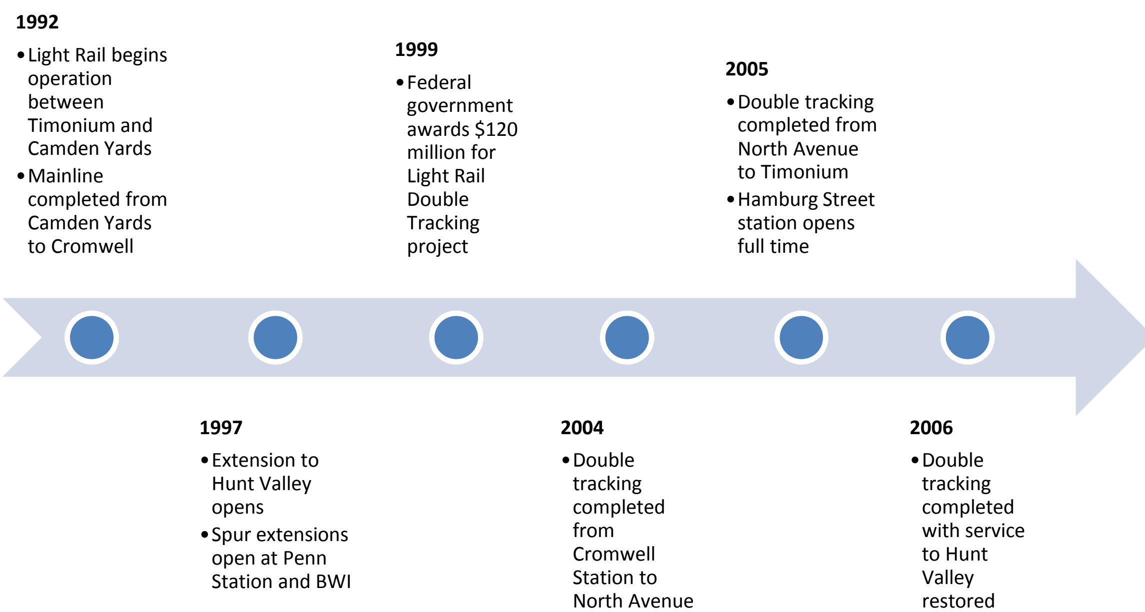
PHASE	PHASE NAME	PRIMARY STAKEHOLDERS
1	Acquire	Offices of: *Planning and Programming*, *Engineering*, and *Procurement*
2	Operate & Maintain	Light Rail Mode, *Office of Engineering*, outside contractors
3	Overhaul & Rehabilitate	*Office of Engineering* and outside contractors
4	Retire & Dispose	*Department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

3 Mode Overview

3.1 Mode Background

MTA's 53 car Light Rail fleet runs on a 58 mile double track system that services Baltimore City, Baltimore County, and Anne Arundel County. The main line provides service to 31 out of 33 stations, extending north from Hunt Valley in Baltimore County, south to Cromwell in the town of Glen Burnie. The remaining two stations, each accessed through spur tracks, provide access to the major transportation centers of Baltimore Washington International Thurgood Marshall Airport (BWI) and Pennsylvania (Penn) Station via Linthicum and University of Baltimore/Mount Royal stations, respectively. In FY 2014 Light Rail had capital budget of $31.8 million and operating budget of $29.3 million, which supports the employment of 212 employees.

Figure 3.1- Timeline of major construction and improvements to the Light Rail System.



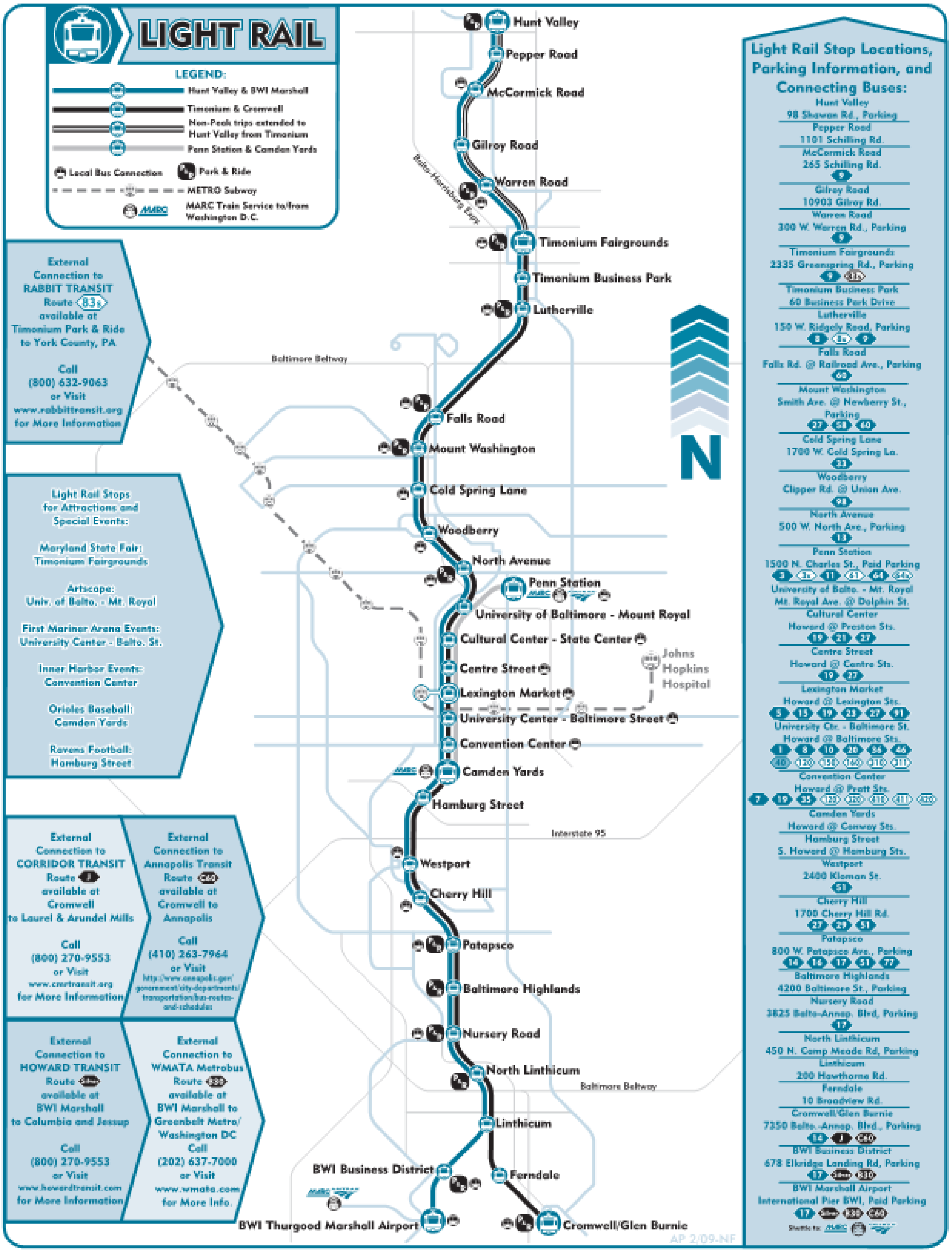
3.2 System Map

The Light Rail system map (Figure 3.2), operates three different routes: Hunt Valley to BWI, Hunt Valley to Cromwell, and Penn Station to Camden Yards, each with running times of 80, 80, and 16 minutes, respectively. A passenger cannot continuously travel between two spurs, such as between Penn Station and BWI; in order to do so, they must transfer at any station between University of Baltimore and Camden Yards.

Light Rail's system map also illustrates connections between MTA's services. For example, MTA provides connectivity to different bus routes at 22 out of 33 stops along the Light Rail system. Additionally, indirect connections exist between Light Rail and Metro service at Lexington Market and State Center, however this is not made obvious to riders though visible wayfinding and signage. Furthermore, riders may transfer between Light Rail and MTA's Maryland Area Regional Commuter (MARC) train: directly at Penn Station and Camden Yards, and indirectly via shuttle bus at BWI airport.

The Light Rail system also provides connectivity between many non-MTA provided transportation options, but lacks sufficient delineation to inform riders that these connections exist, such as signage, sheltered walkways, or increasing the detail of system maps. Riders may transfer from Light Rail to Amtrak services directly through Penn Station, or indirectly via shuttle at BWI airport. Additionally, Light Rail provides linkages with the city owned and Veolia operated Charm City Circulator at Penn station, and either at Baltimore Street or Convention Center. Furthermore, the Penn Station Light Rail stop provides transfer opportunities for the Bolt Bus and the following free shuttle services: Johns Hopkins University, Collegetown, University of Baltimore, and the University of Maryland. The last two college shuttle services, for the universities of Baltimore and Maryland, also connect to the University of Baltimore and State Center stations, and all stations between and including State Center and the Convention Center, respectively.

Figure 3.2 - Light Rail system map.



3.3 Ridership & Schedules

In FY 2015, Light Rail provided a monthly average of 7,657,256 unlinked passenger trips, accounting for 6.6 percent of MTA's total ridership. As of FY 2015, Light Rail system operates weekday service hours between 5:00 a.m. and midnight, and operates Saturday service runs between 6:00 a.m. and midnight, while Sunday runs between 11 a.m. and 7 p.m. Trains run approximately every 10 minutes during the morning and evening peak periods; every 15 minutes during weekday evenings; and every 15 minutes on Saturdays, Sundays, and holidays. Current schedules and approximate travel times are available here at: http://mta.maryland.gov/light-rail

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.

Figure 3.3 - Light Rail'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

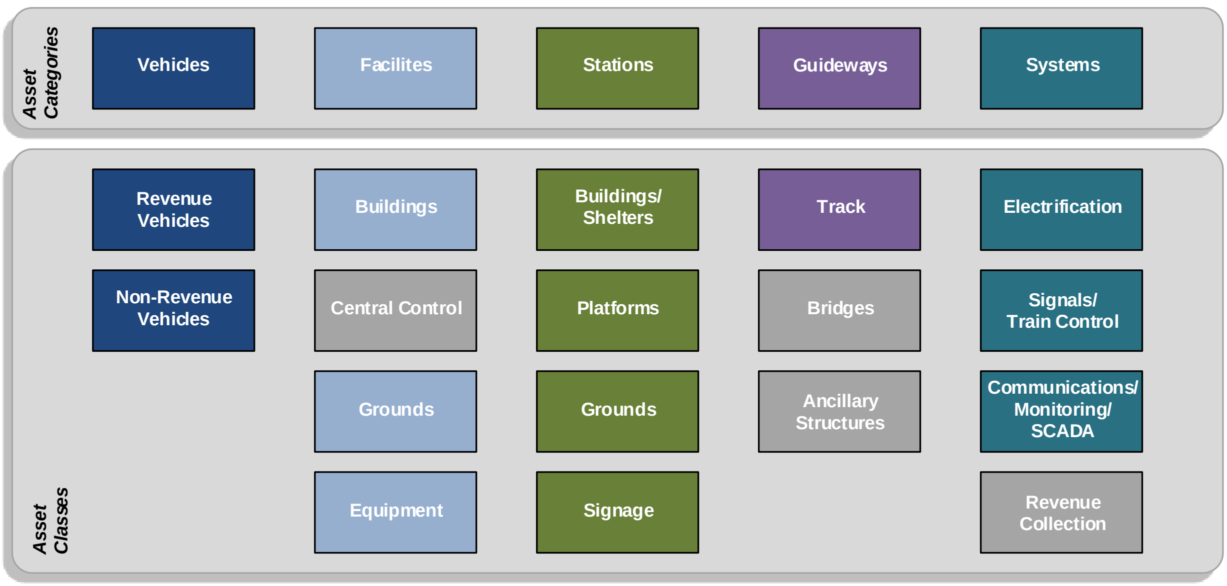
3.5 Snapshot of Light Rail Transit Assets

Every MTA mode provides transit 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 Transit Assets are discussed and reported on – both internally and externally. The MTA Transit Asset hierarchy (Figure 3.4) is based on FTA guidance and shows Light Rail 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 Light Rail system, not all of them are directly managed by the Light Rail 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 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 3.4 - 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 Light Rail fleet is composed of 53 vehicles, all from the same manufacturer, ABB Inc. All of these vehicles are past their mid-life and are currently undergoing an overhaul accordingly. This overhaul presents MTA with certain challenges to ensure compatibility between all on-vehicle equipment and all wayside equipment.

3.5.2 Facilities

Light Rail conducts or coordinates maintenance on all their Transit Assets out of two major facilities located at 344 West North Avenue, Baltimore and 7390 Baltimore Annapolis Boulevard, Glen Burnie. These facilities are referred to as "**North Ave**" and "**Cromwell**," respectively. North Avenue serves as the main location for administration and heavy maintenance, whereas Cromwell serves mainly as an inspection-based facility. Both facilities each have a storage yard for train sets.

3.5.3 Stations

The Light Rail system is composed of 33 at-grade passenger stations that are each very simple in design, each featuring: high-block, platform, shelter, lighting, and passenger information systems.

3.5.4 Guideway

The double-tracked mainline and two spurs provide service corridors totaling 58 waymiles. Along these corridors the system depends on 19 bridges and elevated structures. Despite the installation of culverts and other ancillary structures along the corridor, several segments of the Light Rail system exist within the flood plain and are subject to periodic track washouts.

3.5.5 Systems

When originally constructed, the Light Rail system utilized Transit Signal Prioritization (TSP) equipment to give trains priority over surrounding vehicle traffic in the CBD. On-dash vehicle TSP equipment was maintained by MTA and the corresponding wayside equipment way maintained by Baltimore City. At some juncture in time, maintenance of wayside TSP was stopped, and the TSP system no longer functions as a result.

Also when originally constructed, the Light Rail system utilized a relay logic-based Power Frequency (PF) track circuit throughout the mainline, with the exception of the CBD, where operators relied on visual markings to safely navigate through mixed traffic. However, through the process of double tracking in the new millennium, the Light Rail system adopted a new Audio Frequency (AF) track circuit, which enabled the use of automated train protection (ATP) capabilities.

The AF track circuit did not completely replace the legacy PF track circuit. Accordingly, MTA still relies on the PF track circuit just to the North and South of the CBD, despite this equipment being obsolete. This poses a variety of risks to the Light Rail system. A diagram of PF and AF track circuit locations, and further discussion of associated operational risks can be found in **Appendix A**.

The Light Rail system also employs Overhead Catenary System (OCS) equipment from two manufacturers throughout the mainline. The original OCS manufacturer equipment, ABB, services the mainline from Fairground to Cromwell stations. To save on equipment costs, Light Rail decided to switch to Impulse equipment for both spurs, Cromwell Yard, and the entire length of doubletrack. Hamburg and Patapsco stations utilize both Impulse and ABB OCS equipment.

While Metro is responsible for the ongoing maintenance of the Operations Control Center (OCC), located at 301 N. Eutaw Street, Baltimore, MD, 21202, Light Rail is responsible for the ongoing maintenance and replacement of *Systems* equipment used by the OCC for the Light Rail mode.

3.6 Contracted Lifecycle Management Activities

Light Rail conducts the majority of its own operations and maintenance activities utilizing MTA personnel. However, the mode relies upon contracted services for a variety of needs:

- All maintenance needs for the Facilities Maintenance department;
- Railcar midlife overhauls;
- Cleaning of Light Rail Vehicles;
- Elevator maintenance;
- Vegetation control along right of way; and
- Other Transit Asset repairs, overhauls and rehabilitations that exceed departmental capabilities.

While Light Rail's day-to-day Transit Asset management responsibilities revolve around the operations and maintenance of its Transit Assets, other parties directly influence major decisions in the remaining lifecycle phases. These lifecycle considerations are discussed in Section 9 of this document.

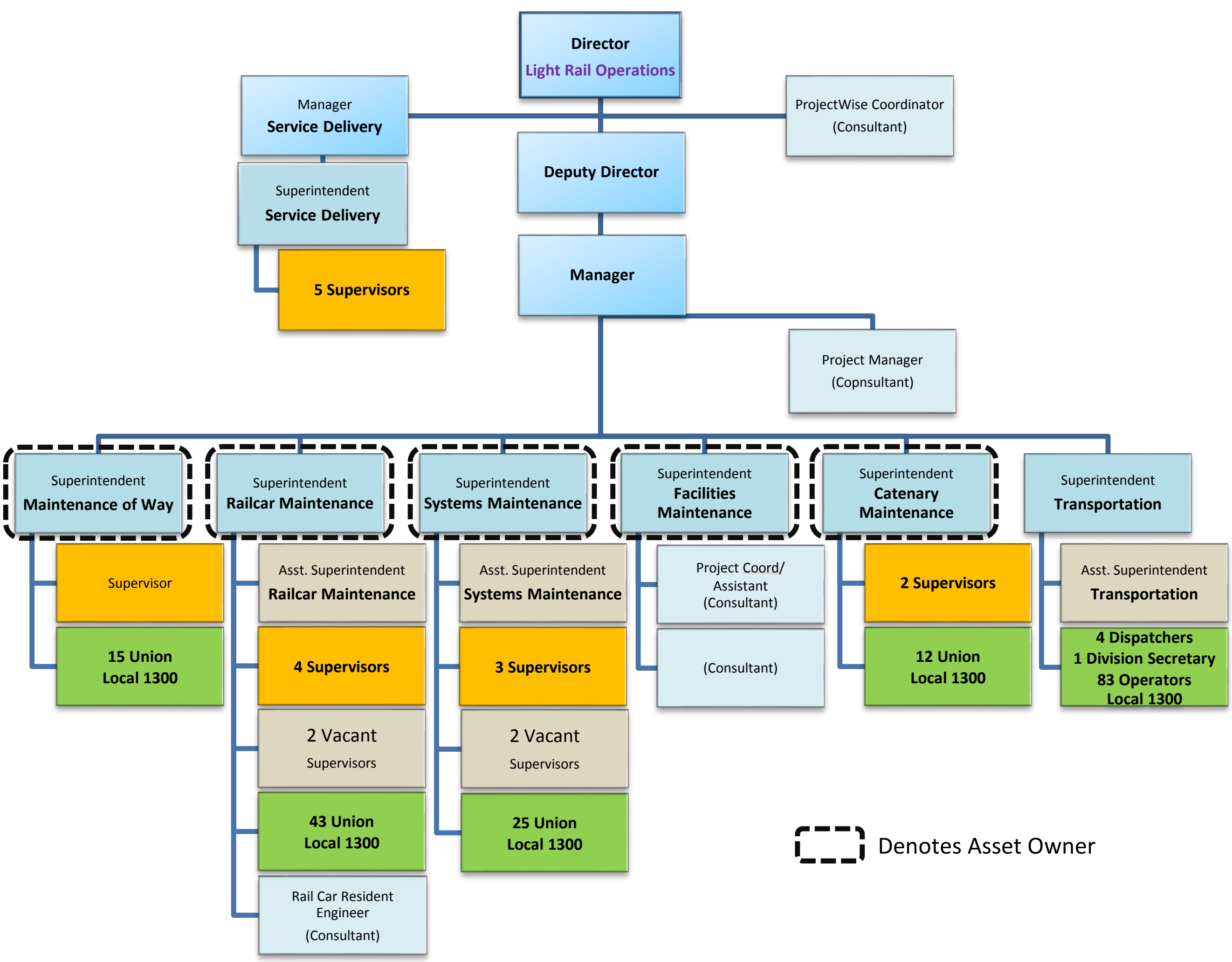
Roles & Responsibilities

Light Rail depends on both State employees and consultant support alike for daily asset management responsibilities. While the Light Rail mode allocates 212 total Personnel Identification Numbers (PINs), 97 PINs are allocated to the Transportation division, while the remaining 115 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.

3.7 Light Rail Organizational Structure and Staffing Levels

Figure 3.5 presents the current organizational structure and relationships between Light Rail management and its workforce. This organizational structure is divided among positions and departments geared toward either administration or operations management.

Figure 3.5 - Light Rail's organizational chart.



The administrative staff at Light Rail oversees and supports six Light Rail departments: Railcar Maintenance, Maintenance of Way, Systems Maintenance, Facilities Maintenance, Catenary Maintenance, and Transportation. The first five have responsibility for the ongoing management of physical Transit Assets included in the scope of this Lifecycle Management Plan. The sixth, Transportation Department, consists primarily of train operators and dispatchers. The main physical Transit Assets which they maintain are radio transponder units, which were not deemed substantial enough to include Transportation Department in the scope of this document.

Table 3.1 shows the breakdown of **115** Light Rail Personnel Identification Numbers (PINs) by department, as reported through AdminStat on August 2015. Note that the only PINs shown below are related to positions that directly correlate with SGR responsibilities, which means that the “Transportation Division,” with **97** additional PINs, has been excluded from this analysis.

Table 3.1 - Breakdown of Light Rail personnel Identification Numbers (PINs) by department, via August 2015 AdminStat data.

LIGHT RAIL DIVISION RESPONSIBLE FOR MANAGING SGR NEEDS	“RESPONSIBILITY CENTER” DESCRIPTION	MANAGEMENT PIN COUNT	UNION PIN COUNT	TOTAL PINS BY DEPARTMENT
ADMINISTRATION[1]	*Operations Manager*	3	0	**3**
FACILITIES MAINETNANCE[2]	*Maintenance Chief*	1	0	**1**
RAILCAR MAINTENANCE[2]	*Heavy Repair*	1	6	**7**
	Service & Inspection	5	37	**42**
SYSTEMS MAINTENANCE[2]	*Traction Power*	2	6	**8**
	Systems Maintenance	1	0	**1**
	Railcar System	0	9	**9**
	Signals	2	10	**12**
CATENARY MAINTENANCE[2]	*Catenary*	3	12	**15**
MAINTENANCE OF WAY[2]	*MOW*	2	15	**17**
TOTAL PINS BY TYPE		**20**	**95**	**115**

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

2 These represent the five departments specializing in the operations and maintenance of specific asset classes.

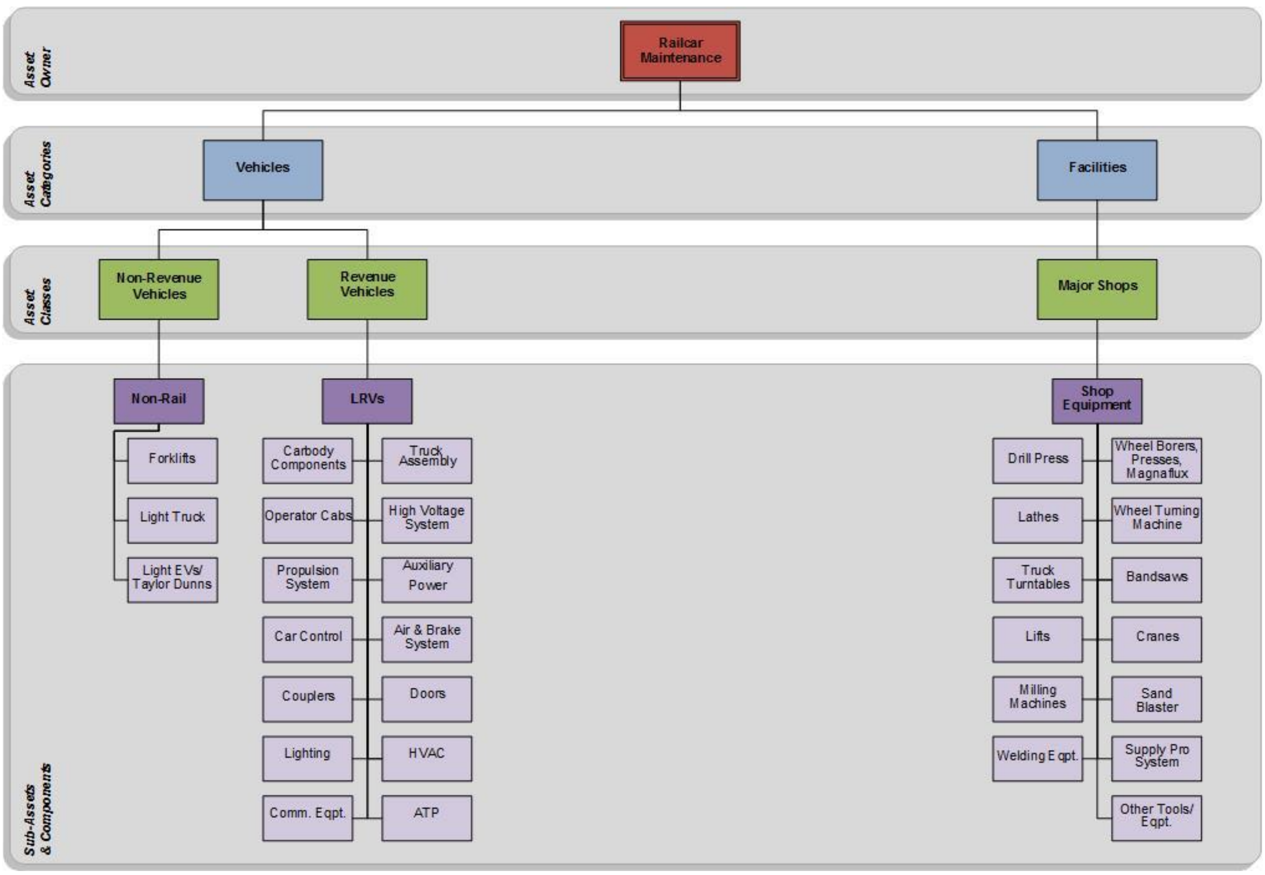
3.8 Transit Asset Owners

Despite the influence of other stakeholders on a Transit Asset’s lifecycle, each of the five Light Rail departments shown in Table 3.1 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 Light Rail department. A comparison of Light Rail’s Asset Owner hierarchies throughout this section will identify areas of overlap between Transit Asset classes that may indicate redundant management responsibilities.

3.8.1. Railcar Maintenance Department (RCMD)

The Railcar Maintenance Department (RCMD) consists of a Superintendent, Assistant Superintendent, 6 supervisors, and 43 unionized lead men, technicians, and mechanics. RCMD is responsible for daily inspections, preventive maintenance, and heavy repair of a fleet of 53 railcar vehicles, originally procured from ABB, Ltd. This also includes management of certain shop equipment and non-revenue vehicles.

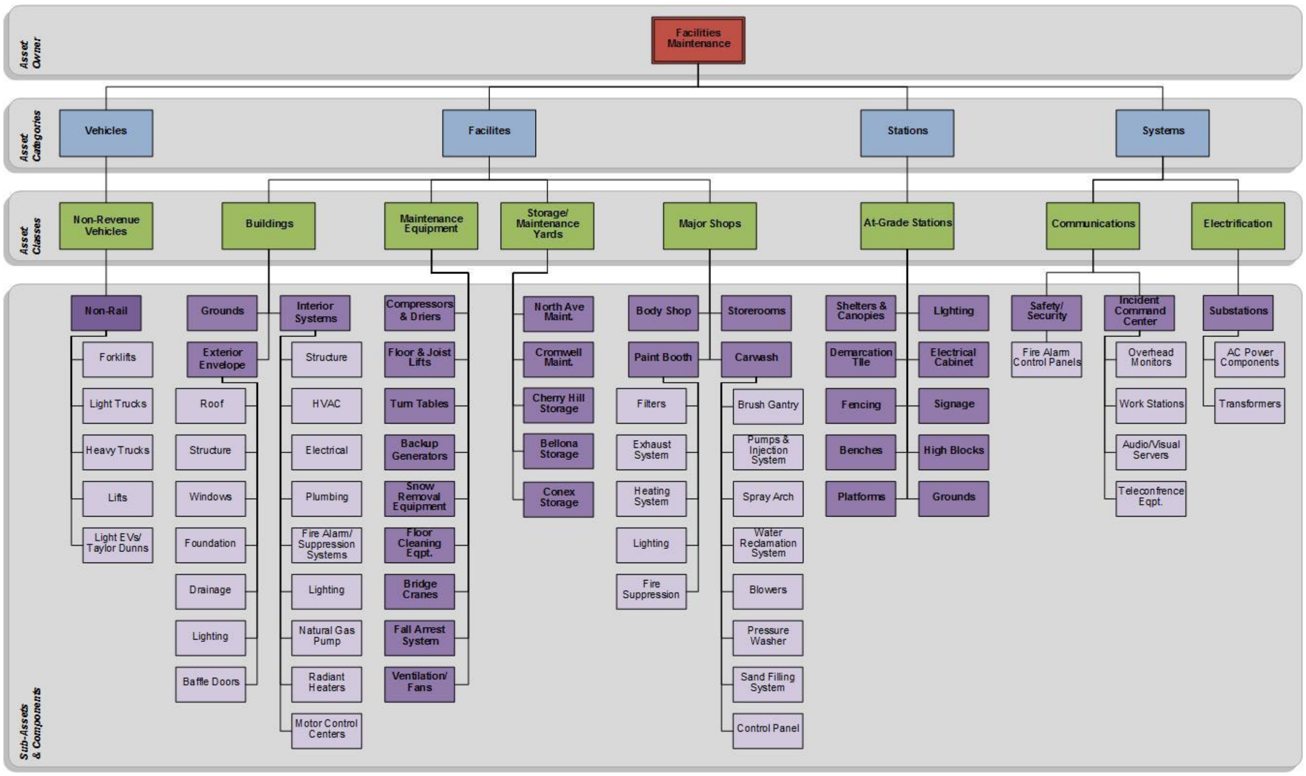
Figure 3.6 - Railcar Maintenance Department's Asset Owner hierarchy.



3.8.2. Facilities Maintenance Department (FMD)

The Facilities Maintenance Department (FMD) consists of a Superintendent, a Project Coordinator/ Assistant, and Project Manager, with the last two of which are consultants. FMD manages contracts related to the maintenance of all Light Rail stations, storage areas, maintenance shops, substations, facility grounds, some communications equipment, and administration offices.

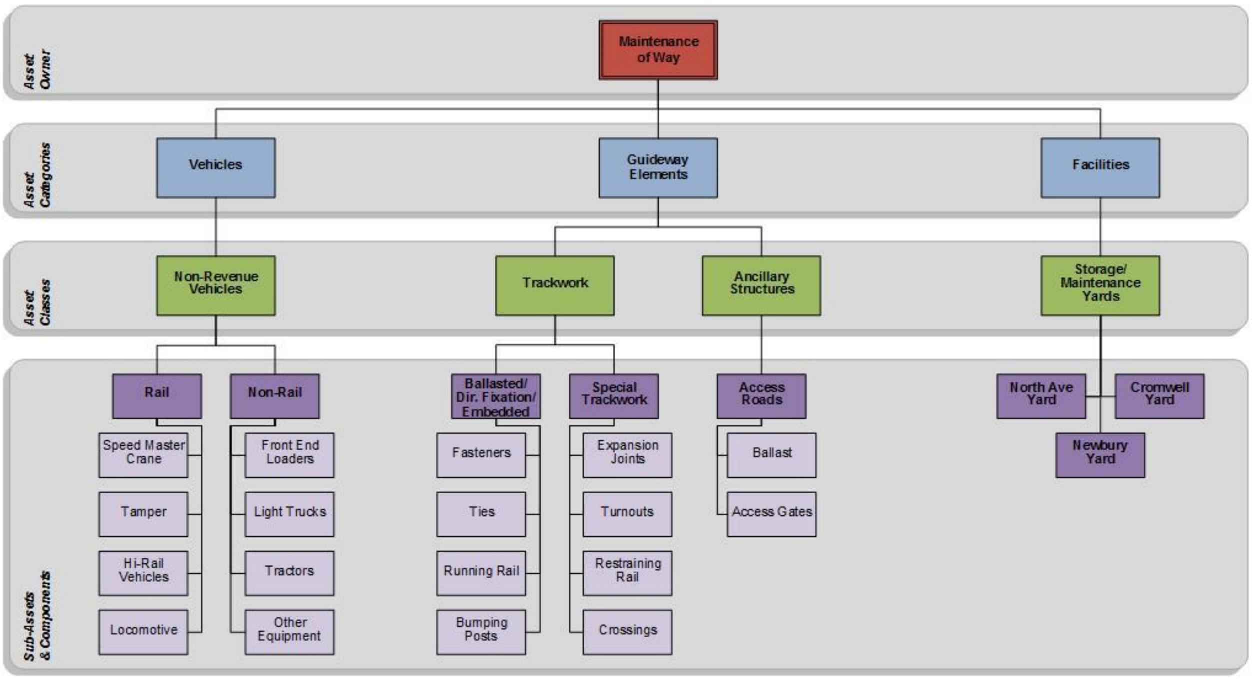
Figure 3.7 - Facility Maintenance Department's Asset Owner hierarchy.



3.8.3. Maintenance of Way Department (MOWD)

The Maintenance of Way Department (MOWD) consists of the Superintendent, supervisor, and 15 unionized lead men, technicians, and mechanics. MOWD's responsibilities include maintenance of all ballasted, direct fixation, and embedded trackwork. This also includes management of access roads and non-revenue vehicles.

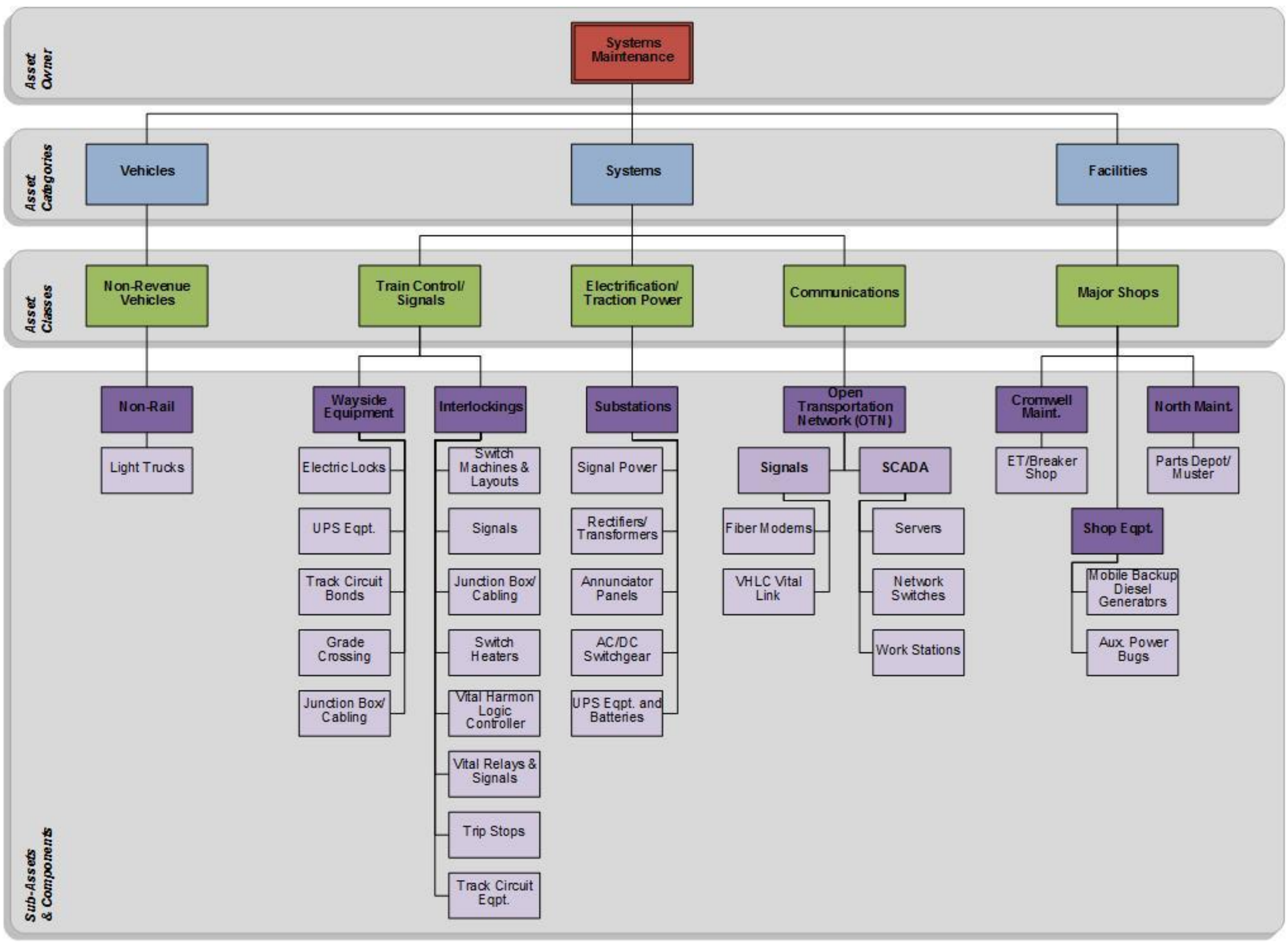
Figure 3.8 - Maintenance of Way Department's Asset Owner hierarchy.



3.8.4. Systems Maintenance Department (SMD)

The Systems Maintenance Department (SMD) consists of a Superintendent, Assistant Superintendent, five supervisors, and 25 unionized lead men, technicians, and repairmen. SMD maintains, inspects, tests, and repairs most electronic systems including Traction Power, Signals & Train Control, and Communications. This also includes management of certain shop equipment and non-revenue vehicles.

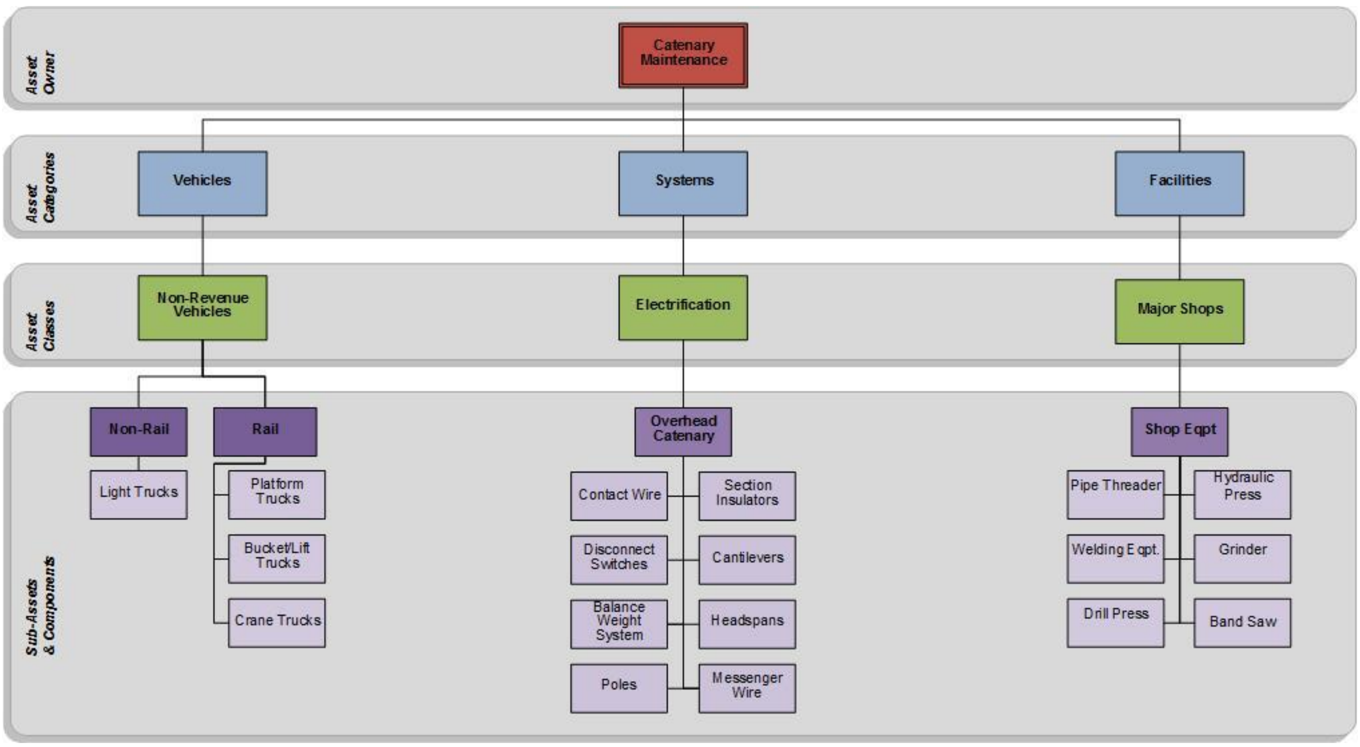
Figure 3.9 - Systems Maintenance Department's Asset Owner hierarchy.



3.8.5. Catenary Maintenance Department (CMD)

The Catenary Maintenance Department (CMD) consists of a Superintendent, two supervisors, and 12 unionized lead men, technicians, and repairmen. Like Systems Maintenance, Catenary has responsibility for some electrification and traction power assets. The physical jurisdictional boundary between these two departments lies roughly at the base of the catenary pole, with CMD mostly taking responsibility for the poles and messenger wire contained within, as well as all overhead catenary system (OCS) assets. CMD also manages shop equipment and non-revenue vehicles.

Figure 3.10 - Catenary Maintenance Department's Asset Owner hierarchy.



3.9 Overarching Light Rail Responsibilities

Together, these Light Rail 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. Light Rail'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 Transit Assets Light Rail owns, it is not useful for business analysis or data collection purposes. A Transit Asset inventory serves as the foundation for performing these functions.

4 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 **in-service date, cost**, and **useful life** (at a minimum) for each record.*

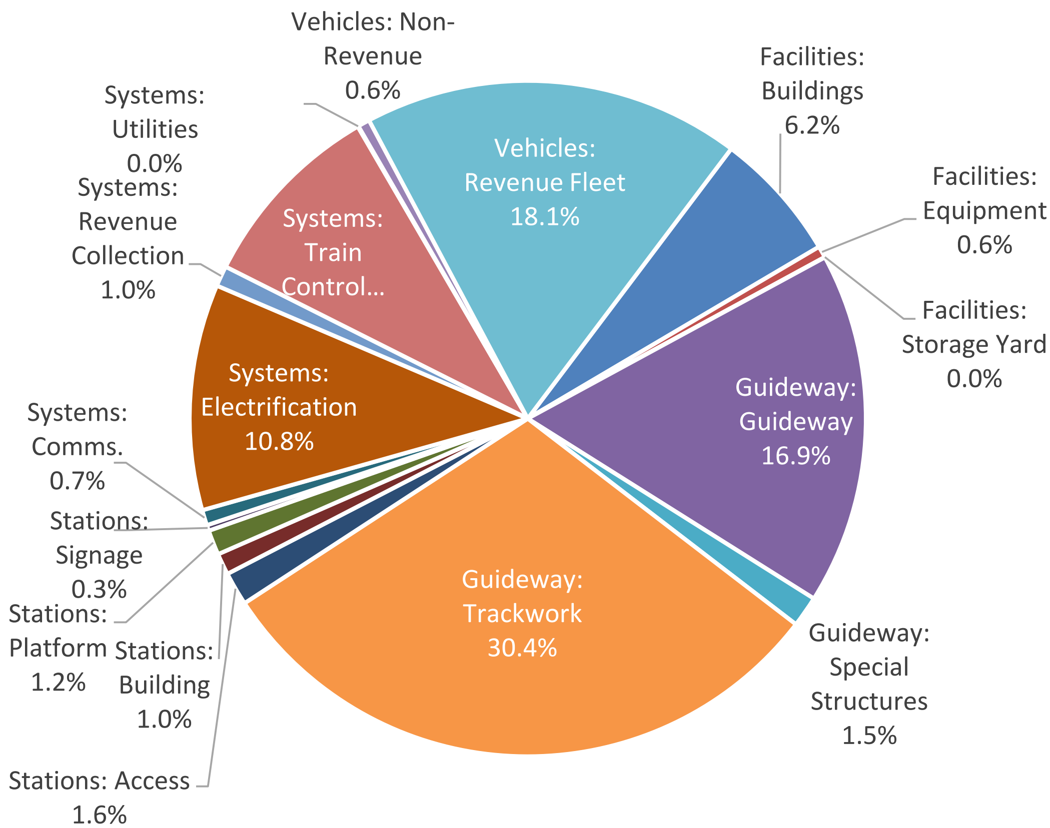
The MTA asset inventory also provides the ability to disaggregate high level asset groupings into a logical grouping of child assets. This is what is commonly referred to as the parent-child relationship. This is achieved by identifying each record's asset category, class, and type according to an accepted hierarchical structure, which has been summarized in Figure 3.4. Having this basic data enables MTA and Light Rail to perform deeper analyses and ultimately to make better asset management decisions.

Light Rail's asset inventory is a subset of MTA's asset inventory and is reflective of Transit Assets that make up the Light Rail system across all five major categories. Table 4.1 and Figure 4.1 below summarizes the Light Rail asset inventory. Note that some of these assets are not directly managed by Light Rail, 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, Light Rail's asset portfolio is valued at approximately $1.4 billion ($2014), with the biggest share of the asset base residing in *Guideways* (at 49% of asset base) and *Vehicles* (at 19% of asset base).

Table 4.1 - Summary of Light Rail Transit Asset inventory by value.

Light Rail by Asset Type	Replacement Cost ($2014)	% of Agency Asset Base
Facilities: Buildings	$ 90,580,934	6.2%
Facilities: Equipment	$ 8,036,342	0.6%
Facilities: Storage Yard	$ 237,600	0.0%
Guideway: Guideway	$ 245,079,130	16.9%
Guideway: Special Structures	$ 21,477,312	1.5%
Guideway: Trackwork	$ 441,341,631	30.4%
Stations: Access	$ 23,246,117	1.6%
Stations: Building	$ 14,909,151	1.0%
Stations: Platform	$ 17,289,572	1.2%
Stations: Signage	$ 3,997,923	0.3%
Systems: Comms.	$ 10,754,548	0.7%
Systems: Electrification	$ 157,086,745	10.8%
Systems: Revenue Collection	$ 14,320,204	1.0%
Systems: Train Control	$ 133,595,091	9.2%
Systems: Utilities	$ 519,349	0.0%
Vehicles: Non-Revenue	$ 8,286,656	0.6%
Vehicles: Revenue Fleet	$ 262,350,000	18.1%
Total	**$ 1,453,108,303**	**100%**

Figure 4.1 - Summary of Light Rail Transit Asset inventory by value.



While the MTA has developed a consolidated inventory of its Transit Assets, Light Rail "owns" a number of linear assets, such as trackwork and Overhead Catenary Systems (OCS), 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 Light Rail 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.

4.1 Inventory Maintenance Process

MTA believes the initial Light Rail 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*), Light Rail will:

- Develop a process, in collaboration with other MTA Asset Owners, to keep the Light Rail inventory current and continually improve the quality of the data it contains;
- House the Light Rail 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.

4.2 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 Light Rail determine what level of intervention is appropriate for its Transit 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 4.2 - Light Rail's Critical Assets.

ASSET CATEGORY	ASSET CLASS	ASSET TYPE	DEPARTMENT RESPONSIBLE
SYSTEMS	Train Control/ Signaling	All	SMD
	Traction Power/ Electrification	Overhead Catenary System (OCS)[1]	CMD
	Communications	Safety & Security	SMD
		Cable Transmission System (CTS)	SMD
FACILITIES	Central Control	OCC Equipment Room	SMD
STATIONS	Building	All Building Components	FMD
	Access	All Access	FMD
VEHICLES	Revenue Vehicles	Light Railcar Vehicles	RCMD
GUIDEWAY	Trackwork	All Trackwork	MOWD
	Guideway	All Elevated Structures	*Engineering*
		All Retained Cut Structures	*Engineering*

[1] Except: Catenary poles, pulleys, feed spans, poles & foundation, manhole, ductbank

4.3 Major Procurements

Light Rail 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 Light Rail'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 no or only limited access to CPMS, you may contact the Capital Programming division of MTA's Office of Planning directly for assistance at 410-767-3770.

Light Rail 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 Light Rail system. Recent and current major projects are summarized in Table 4.3 and Table 4.4 below.

***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.*

Table 4.3 - Recently completed enhancement projects on the Light Rail system.

Project Name	Details	
Traction Power Substations (*Enhancement*)	*Project Code:*	0341
	Description:	• Constructed two (2) additional one-megawatt traction power substations in Baltimore County. • Located at Industry Lane and Gilroy Road.
	Completion:	November, 2014
LED Signage & PA System (*Enhancement*)	*Project Code:*	1294
	Description:	• Includes: ○ Audible signals for ADA compliance; ○ Next train arrival capabilities; and ○ LED signage. • Transmits PA safety messages and general announcements.
	Completion:	2015

Table 4.4 - Current preservation and enhancement projects on the Light Rail system.

Project Name	Details	
Yard Switch Automation (*Enhancement*)	*Project Code:*	0451
	Description:	• Replacing North Ave yard switches from logic-based circuitry to electromechanical circuitry. • Installing a yard switch control system. • Contains full function entrance/ exit capabilities. • Located at North Ave Maintenance Shop.
	Estimated Completion:	June 2016
Midlife Vehicle Overhaul (*Preservation*)	*Project Code:*	1346
	Description:	• Alstom contracted to conduct Mid-Life Overhaul on 53 LRVs. • Includes selective replacement or overhaul of components • Goal of increasing LRV fleet life by an additional 10-15 years.
	Estimated Completion:	2019

5 Condition Assessment & Performance Monitoring

5.1 Condition Assessment Philosophies

On Feb. 14, 2013, the FTA's State of Good Repair White Paper explores the following four approaches to assessing Transit Asset conditions:

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

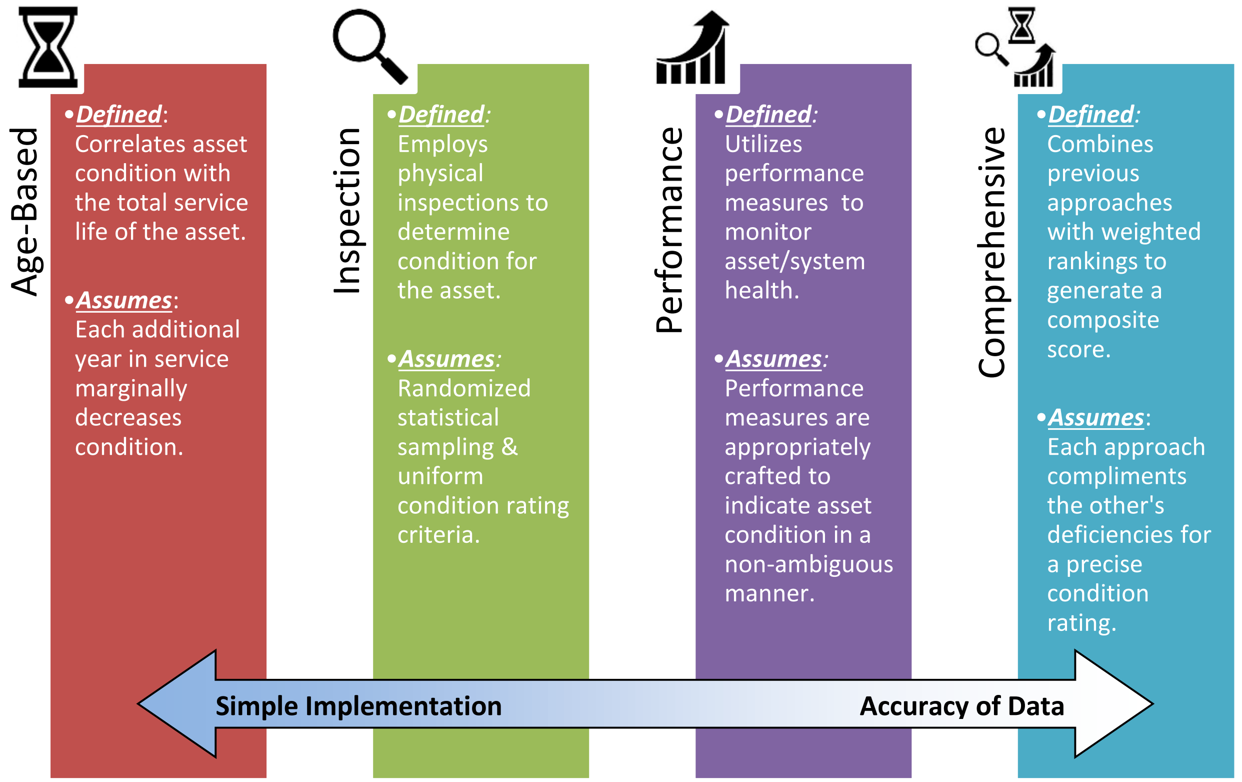
The **age-based approach** to assessing condition assumes that most assets have a useful life, measured in years. Once that useful life is met, it is assumed the asset will exhibit decreased performance, higher risk of failure, and higher maintenance costs. Using this method, the condition of assets 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 in 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 5.1 - 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 commissioned 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 Light Rail, and serve as a proxy where Light Rail does not currently have any inspection-based condition assessment regimes.

5.2 Condition Estimates & "State of Good Repair" (SGR) Backlog

TERM Lite calculates condition estimates on a 5-point numerical scale (Table 5.1). 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 5.1 - 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 4, 2015, a TERM Lite analysis of Light Rail assets yielded the following summary of condition estimates (Table 6.2); a more detailed summary may be found in **Appendix E**. 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 Light Rail 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*).

Light Rail's current SGR Backlog stands at $52 million (in 2014 dollars) and accounts for four percent of the mode's asset base. $26.40 million of the SGR Backlog, or 51 percent, belongs to guideway elements and particularly ballasted trackwork. $14.16 million of the backlog, or 27 percent, can be attributed to station components, such as shelters, platforms, highblocks, pedestrian access, lighting, and electrical panels. Additionally, all non-revenue vehicles

Table 5.2 - Outline of condition ratings generated by TERM Lite output conducted on November 4, 2015.

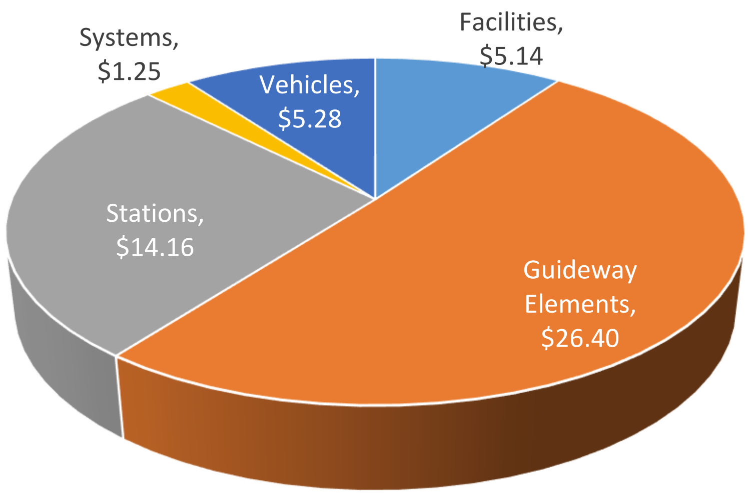
Category & Sub-Category	Avg. Condition
Facilities	**3.92**
Equipment	**2.66**
Buildings	**4.04**
Storage Yard	**3.68**
Systems	**3.65**
Communications	**3.58**
Electrification	**3.60**
Train Control	**3.71**
Utilities	**4.84**
Vehicles	**3.32**
Revenue Vehicles	**3.35**
Non-Revenue Vehicles	**2.21**
Stations	**3.07**
Access	**3.03**
Building	**2.96**
Signage & Graphics	**3.01**
Platform	**3.21**
Guideway Elements	**3.77**
Guideway	**4.16**
Trackwork	**3.58**
Special Structures	**3.37**
Grand Total	**3.64**

are found in the SGR Backlog, while none of the revenue vehicles are there due to their 35 to 40 year useful lives.

> *Light Rail's current backlog is **$52 million**, accounting for **4%** of the total asset base.*

Given the current capital program, the Light Rail SGR Backlog would persist until 2023; however, a massive backlog is expected in years 2032 – 2034 as major systems and revenue fleet reach the end of their useful lives. These major systems include the majority of the mainline catenary system, estimated to cost $34 million in the Year of Expenditure (YOE), 12 of 30 substations ($42 million YOE), and 8 of 33 central instrument houses ($23 million YOE).

Figure 5.2 - Light Rail's current SGR backlog estimate ($1,000s).



5.3 Current Condition Rating Methodologies

Light Rail engages in routine condition assessments for many of its assets via scheduled inspection. 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 E** with more accurate data.

While Light Rail routinely inspects many assets, it does so by employing a number of different condition rating scales that can vary by department. Table 5.4 outlines the current condition rating scales currently employed at Light Rail, 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 Light Rail 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 Light Rail mode may benefit by simply considering the following definitions for these terms, and avoid associating them with the common acronym “preventative maintenance”:

Table 5.3 - 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 5.3 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 Light Rail 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 Light Rail department, employed when a PM utilizes inspection-based activities.

Table 5.4 - 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.

Department Responsible	Asset Category	Asset Class	Asset Type	Name of Inspection Activity	Methodology	Rating Scale	Data Sheet Storage Location
CMD	Systems	Traction Power/ Electrification	Balance Weight Assembly	Inspection	Inspection	Red, Yellow, Satisfactory	Hard Copy
CMD	Systems	Traction Power/ Electrification	Disconnect Switches	Inspection	Inspection	Red, Yellow, Satisfactory	Hard Copy
CMD	Systems	Traction Power/ Electrification	Overhead Catenary System	Inspection (5)[3]	Inspection	Red, Yellow, Satisfactory	Maximo
CMD	Systems	Traction Power/ Electrification	Section Insulators	Inspection	Inspection	Red, Yellow, Satisfactory	Hard Copy
FMD	Facilities	Buildings	Maintenance Yard	Occupational Health Safety	Inspection	Red, Purple, Green	ProjectWise

FMD	Facilities	Equipment	Backflow Preventer	Inspection	Inspection	Red, Purple, Green	ProjectWise
FMD	Facilities	Equipment	Fire Extinguishers	Inspection	Inspection	Red, Purple, Green	ProjectWise
FMD	Station	Station Components	Lighting	Inspection	Inspection	Red, Purple, Green	ProjectWise
FMD[1]	Facilities	Equipment	Air Compressor	Inspection	Inspection	Red, Purple, Green	ProjectWise
MOWD	Guideway	Trackwork	Track	Track Inspection	Inspection	Red, Yellow, Green	Hard Copy
RCMD	Vehicles	Revenue Vehicles	Light Rail Vehicle	PM (4)[2]	Inspection; Diagnostic Test	None; Pass/Fail	Maximo
SMD	Systems	Traction Power/ Electrification	Relays	Exchange Tracking	Inspection	None	ProjectWise
SMD	Systems	Traction Power/ Electrification	TPSS	Monthly Substation PM	Inspection	None	ProjectWise
SMD	Systems	Traction Power/ Electrification	TPSS Battery	Quarterly PM	Inspection	None	ProjectWise
SMD	Systems	Train Control/ Signals	AF Track Circuit	Quarterly Ground Readings	Diagnostic Test	Pass/Fail	ProjectWise
SMD	Systems	Train Control/ Signals	Magnetic Trip Stops	Semi Annual PM	Inspection	None	ProjectWise
SMD	Systems	Train Control/ Signals	Electric Locks	Biannual Test	Diagnostic Test	Pass/Fail	ProjectWise
SMD	Systems	Train Control/ Signals	Grade Crossing	Monthly PM; Annual PM	Inspection	None	ProjectWise
SMD	Systems	Train Control/ Signals	PF Track Circuit	Quarterly PM; Annual PM	Inspection	None	ProjectWise
SMD	Systems	Train Control/ Signals	Switch Machines	Monthly Obstruction Test (2)[4]	Diagnostic Test	None	ProjectWise
SMD	Systems	Train Control/ Signals	U5 Switch Circuit Controller	Quarterly PM	Inspection	None	ProjectWise
SMD	Systems	Train Control/ Signals	UPS	Monthly PM	Inspection	None	ProjectWise
SMD	Vehicles	Non-Revenue Vehicles	Non-Revenue Vehicles	Mileage Log	Inspection	None	ProjectWise

[1] All FMD maintenance activities are conducted by outside contractors and as such data for FMD may be incomplete.
[2] Maximo outputs from four (4) Master PMs combine both inspection and diagnostic tests depending upon the work order, see Section 8.1.2.
[3] Ten (10) Inspection findings are documented weekly for OCS inspection, see Section 8.2.5.5.
[4] Two (2) documents are generated for Monthly Switch Obstruction Tests, one for the mainline and the other for the North Avenue Yard.

5.4 Recommended Condition Rating Methodologies

While Light Rail 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 Light Rail accordingly.

6 Performance Monitoring

Performance monitoring enables Light Rail 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 Light Rail 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.

6.1 Current Performance Measures

Light Rail 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** – MTA's 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.

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*

Light Rail currently collects and reports data for two asset-related KPIs. Table 6.1 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 6.1 - Current KPIs used by Light Rail and corresponding types of measure, data source, type of assets involved, type of reporting, and targets.

Description	Type of KPI	Data Source	Asset Types	Report Type	Target
PM On-Time Completion (%)	Input	Maximo	All	State Stat	95%
Fleet Availability (%)	Output	ProjectWise / Maximo	LRV	Internal	75%

6.2 Recommended Performance Measures

Several additional KPIs have been proposed for the Light Rail 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 6.2).

Table 6.2 - Proposed KPIs for Light Rail and corresponding types of measure, data source, type of assets involved, type of report, and rationale for inclusion.

MTA MISSION ELEMENT	TAM 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 Time b/t Failure (MTBF)	Output	Maximo, Excel	LRV
		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. Light Rail 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 Light Rail employees consistently log their labor hours against PM and CM activities accordingly.

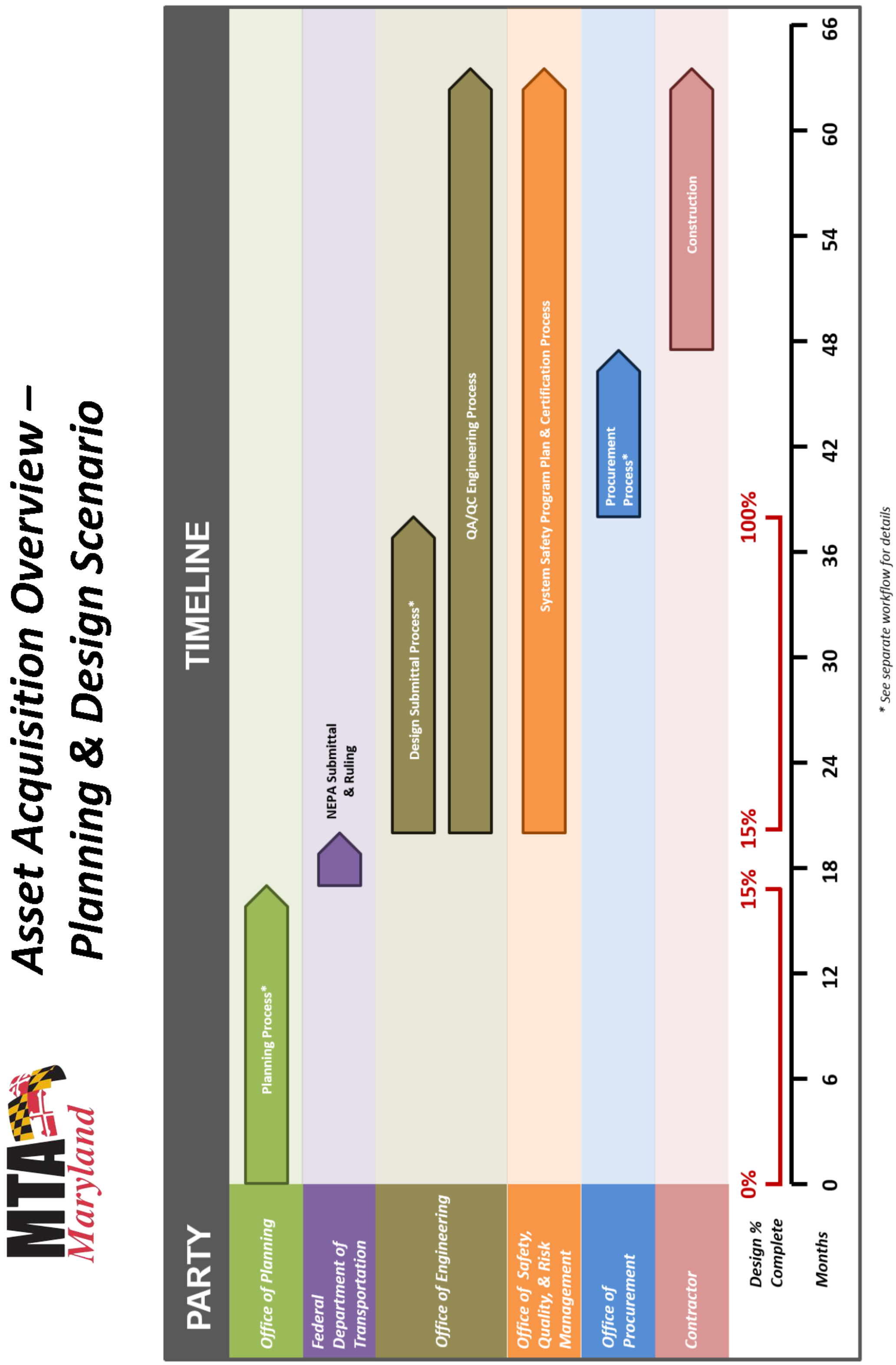
While previous chapters discuss Light Rail responsibilities and the management of its entire asset inventory as a whole, the subsequent four chapters focus on each phase of an asset's lifecycle. Specifically, each chapter describes Light Rail's current management practices from the perspective of each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

7 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 7.1 – 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 7.1). Examples of these circumstances may include:

Table 7.1 – 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:

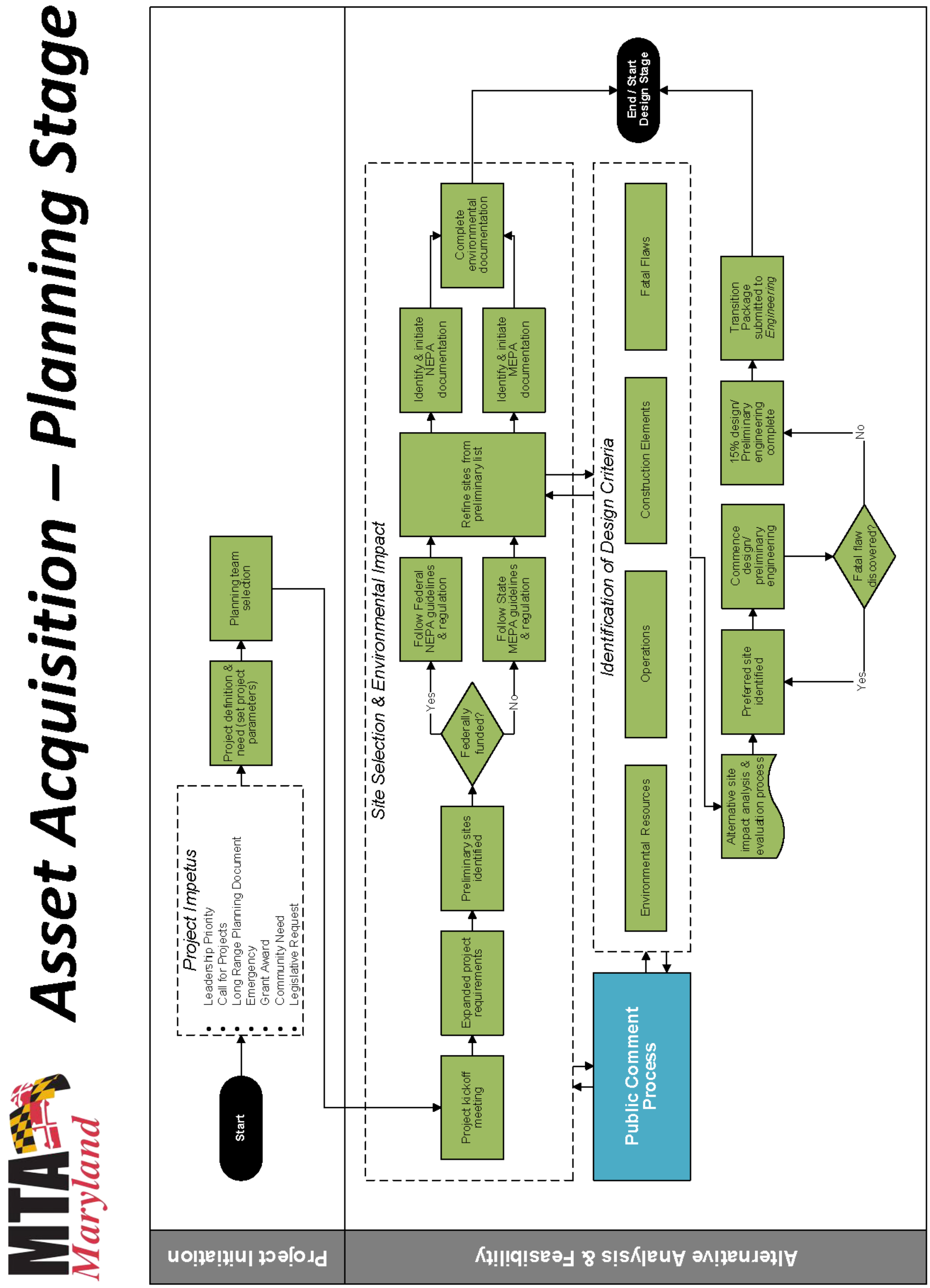
- NEPA Submittal & Ruling
- QA/QC Engineering Process
- System Safety Program Plan & Certification
- Construction

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.

7.1 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 7.2).

Figure 7.2 - 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 7.3 - Increasing intensity of NEPA/MEPA documentation.

NEPA	MEPA
Categorical Exclusion	Environmental Assessment Form
Environmental Assessment	Environmental Effects Report
Environmental Impact Statement	

Several other important distinctions are worth mentioning within Figure 7.2:

- This diagram focuses upon process and not assigning a chronological duration to each step.
- Environmental considerations 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.

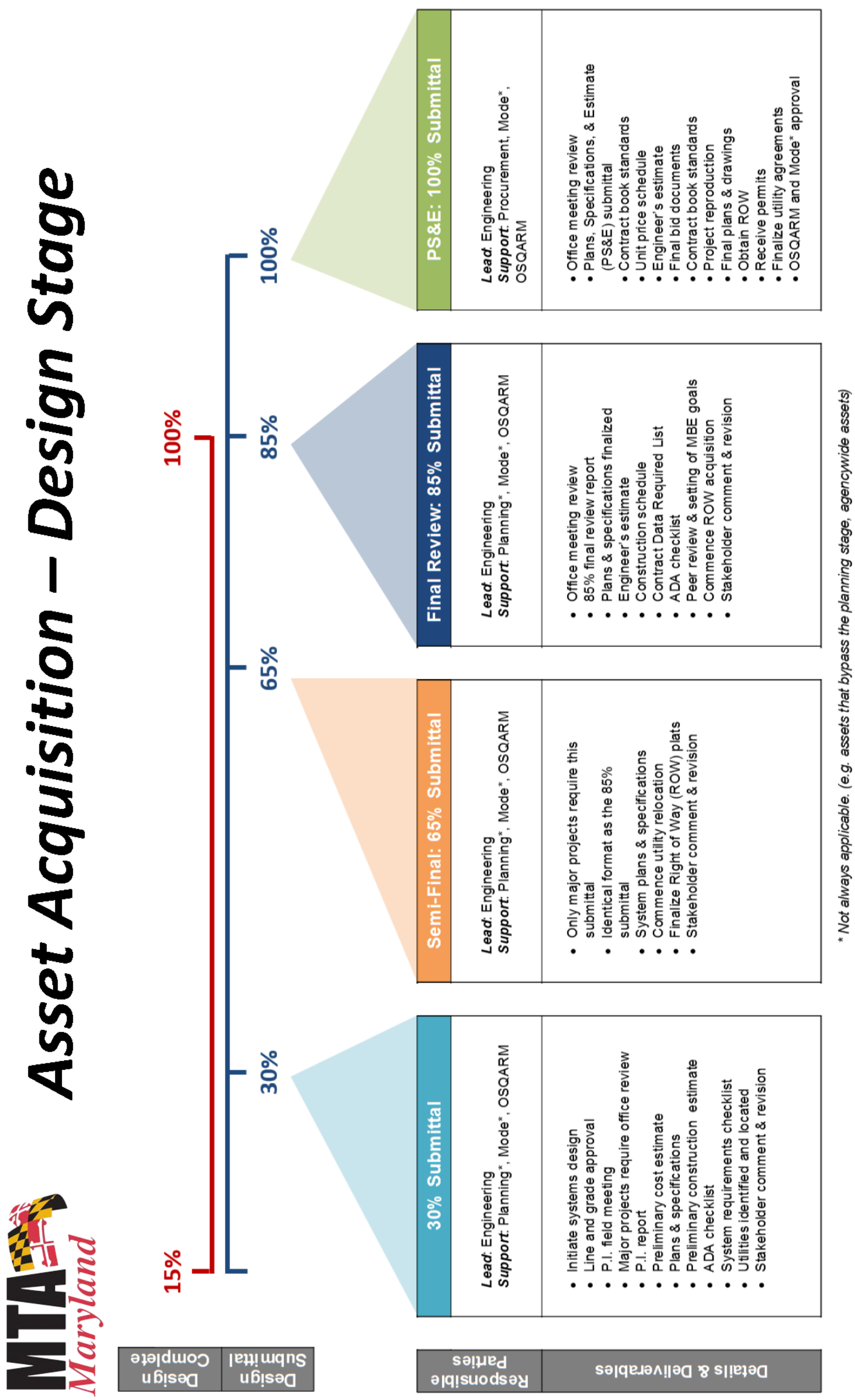
7.2 NEPA Submittal & Ruling Process

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.

7.3 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 7.4) and another within the appendix describing applicable drawings and plans, categorized by engineering discipline (**Appendix D**).

Figure 7.4 - 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 7.4 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 9.1.6**), 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.

7.4 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.

7.5 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).

7.6 Procurement Stage

After the completion of the Design stage, *Office of Procurement* coordinates the procurement of the Transit Asset (Figure 7.5). Figure 7.5 indicates the procurement process will generally require nine months for completion.

Figure 7.5 - 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 *ancillary*, 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	*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:

- Contract Modifications
- Cooperative Purchasing

Control Agency Departments:

- Budget Management for Services
- General Services for Commodities
- Information Technology for IT

Y – *Approval Needed*

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	*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*

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***.

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

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

Contract Vehicle	Procurement Type: *IT*	*Service*	*Maintenance*	*Construction*	*Commodity*
CSB/RFP	Y	Y	Y	Y	Y – Over $5,000
Single Bid/ Sole Source	Y	Y	Y	Y	Y

PODs also required for:
- Contract Modifications
- Emergency Orders
- Cooperative Purchasing
- Protests

Y – *Issue POD* | **N** – *Skip POD*

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

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.

Contract Vehicle	Procurement Type: *IT*	*Service*	*Maintenance*	*Construction*	*Commodity*
CSB/RFP	Y – Under $50,000	Y – Under $100,000	Y – Under $200,000	Y – Under $200,000	N
Single Bid/ Sole Source	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*

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

Contract Vehicle	Procurement Type: *IT*	*Service*	*Maintenance*	*Construction*	*Commodity*
CSB/RFP	Y – Over $200,000	Y – Over $200,000	Y – Over $200,000	Y – Over $200,000	N
Single Bid/ Sole Source	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*

Step 10: *BPW approval process*

Majority Vote from…
- Governor
- Treasurer
- Comptroller

No – Procurement Denied or Repeat Step (9)

Yes – Proceed to (11)

Step 11: Contract Award

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 7.2- 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

7.7 Construction Phase

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.

8 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, Light Rail currently employs corrective and/or Scheduled Maintenance regimes for its Transit Assets.

8.1 Current Maintenance Practices

While inspections are currently used throughout Light Rail for the purpose of condition assessment, they are often conducted simultaneously with scheduled preventive maintenance for time efficiency. As indicated in Table 8.1 below, not all Light Rail 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 8.1 - 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	Overhead Catenary System
Electrification/ Traction Power	Stations
Signaling/ Train Control	Facility Structure/ Grounds

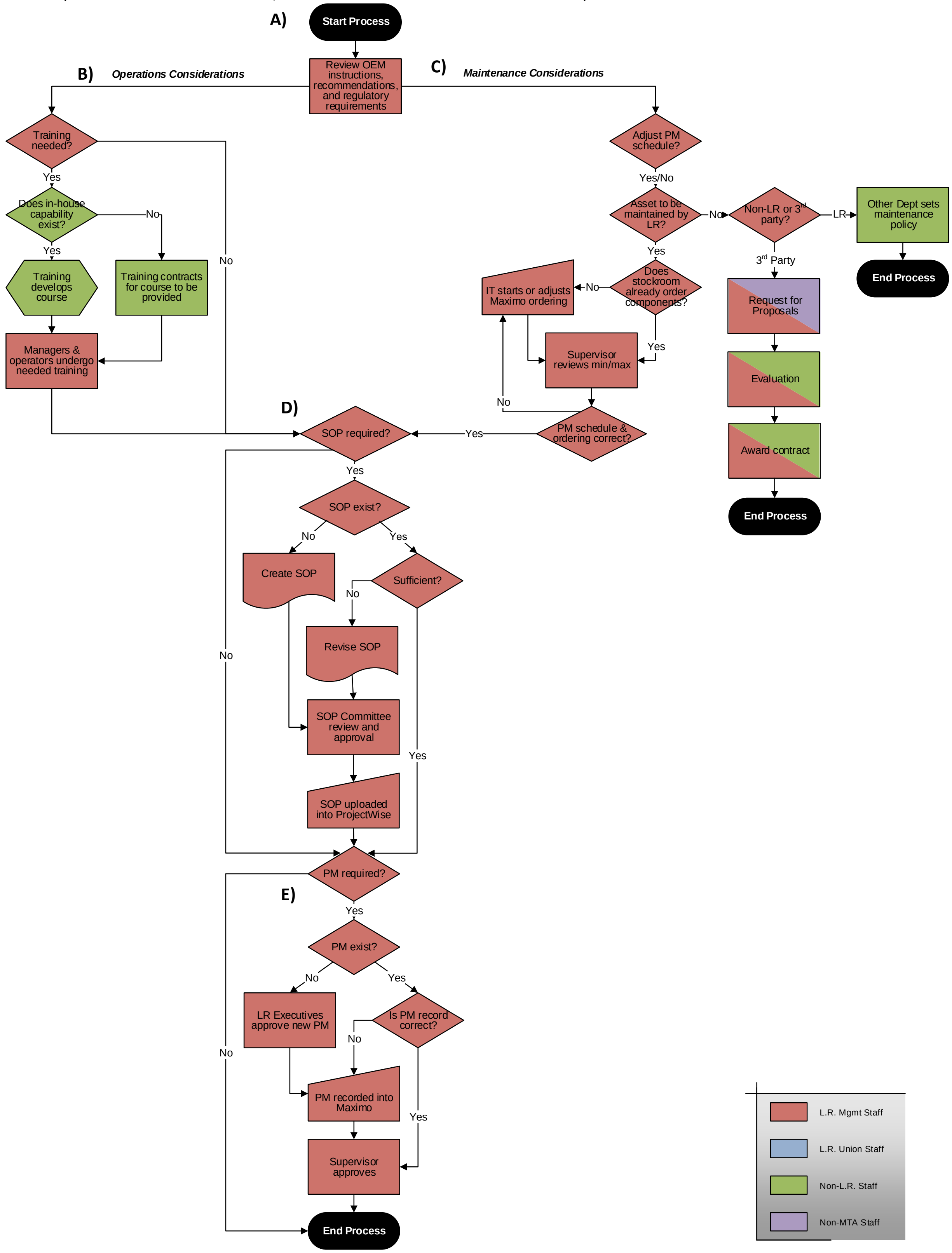
Since maintenance is a broad topic, the description of Light Rail's maintenance practices falls into two categories: operation and maintenance policy setting, and maintenance implementation. The former determines the scope and schedule of the maintenance work, while the latter describes *how* the work is operationalized through the Light Rail 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 Light Rail 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 Light Rail Transit Assets are only subject to inspection-based "PM" work orders (to trigger corrective maintenance) (Table 8.1).

8.1.1. Operation and Maintenance Policy-Setting

Light Rail sets operations and maintenance policies for select asset type 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 8.1).

Figure 8.1 - Light Rail's maintenance policy process. A) Commences with analysis of OEM recommendations and regulatory requirements and; incorporates B) Operations and C) Maintenance considerations; D) SOP developed based upon these considerations; E) Master PM activities scheduled based upon the SOP.



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 5.3, both *inspection* and *maintenance* regimes are documented in Maximo using similar terminology. New employees and those that work outside the Light Rail mode may benefit by simply considering the following definitions for these terms, and avoid associating them with the common acronym "preventative maintenance":

Table 8.2 - 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.

8.1.2. Maintenance Policy Implementation

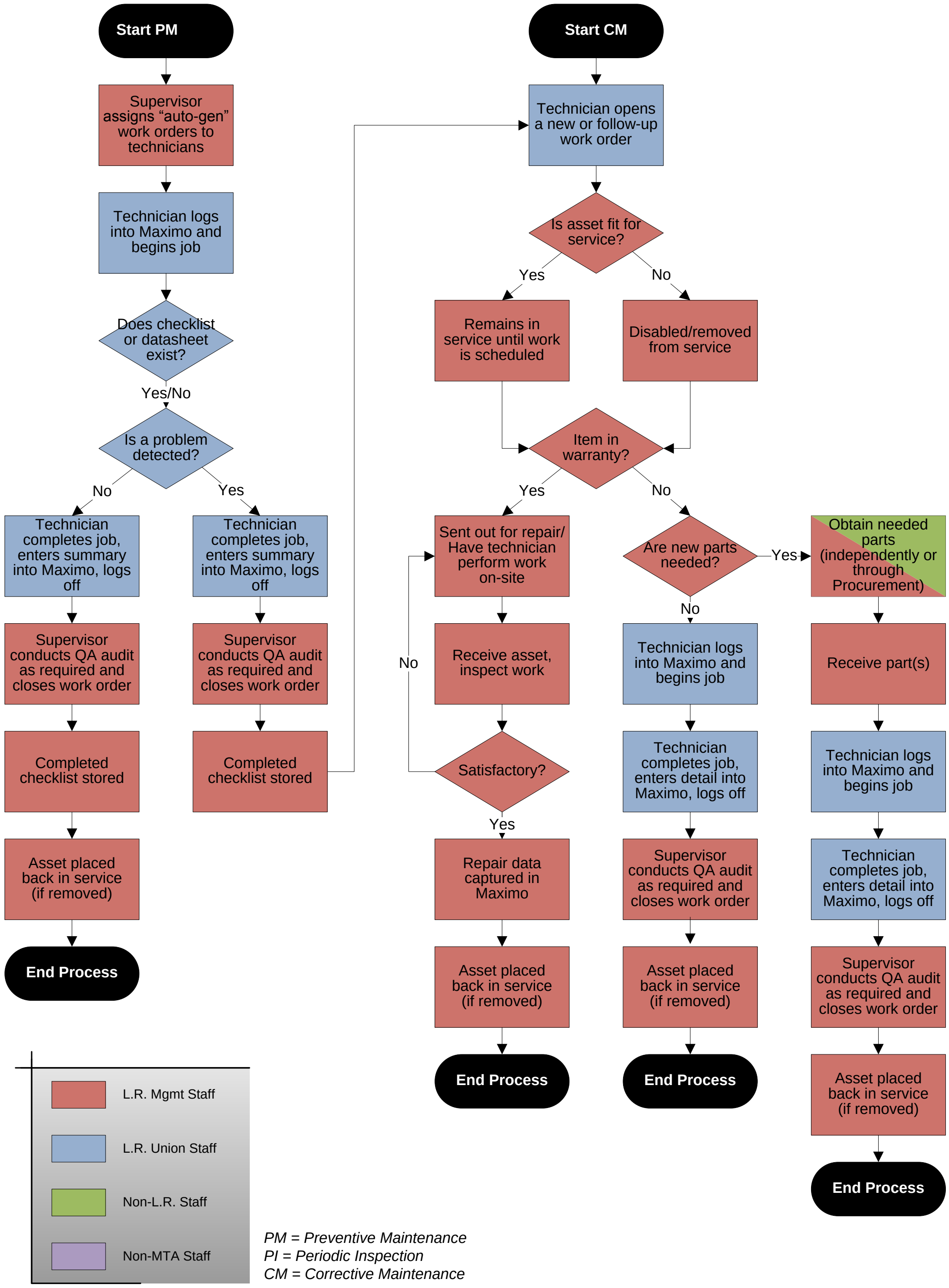
Light Rail operationalizes its maintenance policies via two independent business processes, each aimed at coordinating human resources for timely and effective work completion: Section 8.1.2.1 outlines the workflow processes when in-house staff performs maintenance; Section 8.1.2.2 delineates the process when Light Rail employs contracted services.

8.1.2.1. In-house Staff (Vehicles, Guideway, and Systems Assets)

In-house maintenance commences with either a Scheduled Maintenance or a Corrective Maintenance approach (Figure 8.2). 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, RCMD and SMD SOPs dictate that maintenance work must undergo a monthly Quality Assurance/Quality Control (QA/QC) audit. Once a month a supervisor needs to inspect two railcars or two signal and one traction power location, depending upon the department. In addition these supervisors must also audit the maintenance process itself by directly overseeing the repairs. 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.

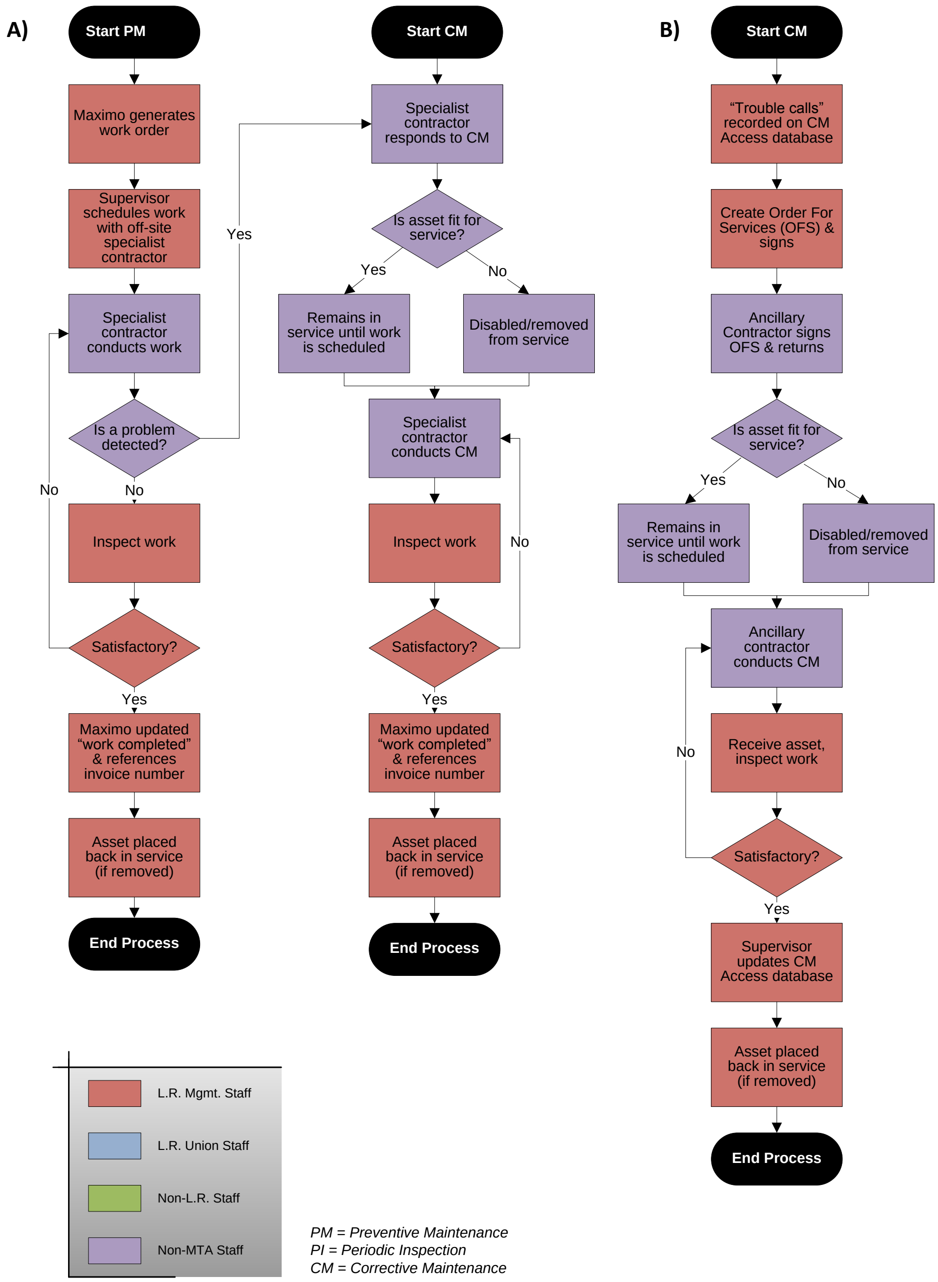
Figure 8.2 - Execution of Scheduled Maintenance or Corrective Maintenance work orders by all departments except for FMD, or instances where maintenance is contracted out by third party.



8.1.2.2. Contracted Services (Facilities and Stations Assets)

While the other Light Rail departments conduct maintenance work mainly with in-house staff, the Facility Maintenance Department (FMD) relies heavily upon contracted services for all maintenance needs (Figure 8.3). Process A resembles the previous workflow, where all Scheduled Maintenance activities are identified by Light Rail staff, but then carried out by one of many contractors specially qualified to conduct work on particular equipment (e.g. air compressors, cranes, and train lifts). Process B deals with general CM work, triggered by an Order for Services and carried out by an ancillary contractor on an annual basis.

Figure 8.3 - Execution of maintenance work conducted by contracted services. A) PM or CM services conducted by asset specific specialist contractors; B) CM services conducted by holders of the ancillary contract.



8.2 Current Maintenance Schedules

The following sections summarize inspection and maintenance activity based on MTA Light Rail **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.

8.2.1. Vehicles

Light Rail 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 Light Rail Vehicles 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 8.3 - Summary of current inspection processes outlined in Light Rail's Fleet Management Plan. The table does not include maintenance regimes for non-revenue vehicles because this documentation was not available at the time of publishing.

Type of inspection	Time Out of Service (Hrs)	Labor (Hrs)	Description
Daily	0.5	0.5	Interior inspection and cleaning process.
Biweekly	2	2	More thorough interior inspection and cleaning process.
Exterior Cleaning	5	5	Cleaning the exterior of the LRV vehicle; running the LRV through the carwash.
Weekly	4	3.5-4.0	All safety-sensitive systems are checked for defects (e.g. door operations, communications equipment, brakes, etc.).
45 Day	24	24-42	Detailed review of electrical, mechanical, and pneumatic systems. Critical items are adjusted, lubricated, repaired, and cleaned. Filters are replaced, and critical fluids are measured and refilled as necessary. The sensitivity and timing of various systems are recorded and adjusted.
Automatic Train Protection (ATP) 90 Day	24	12	Detailed review of electrical, mechanical, and includes calibration of the vital circuits of the ATP car borne equipment. Includes a visual inspection of components; ATP and BRR relay operation, speed sensor checks, calibration of the decelerometers and pick-up coils and successful completion of a departure test.
Annual	48	72	Examination of all mechanical, electrical, and pneumatic systems, with the exception of the ATP system. Inclusive of all procedures in the 45 Day inspection. Also includes: coupler height adjustments, oil analysis, and dynamic brake rate analysis.

Light Rail currently has six (6) SOPs and three (3) Master PMs in place for maintenance of their revenue vehicles (Table 8.4). Note, however, that Master PMs are not always set up in Maximo to guide the execution of these SOPs. Also note, that while Light Rail manages its revenue vehicle at the component level, SOPs and Master PMs do not exist for many of these components, as discussed in the next section. Copies of the SOPs listed in the table below may be found through the SOP catalogue.

Table 8.4 – 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	ATP System Component	Railcar Maintenance (RCMD)	• Departure Test (7 day) • Yard Loop Test (90 day)	• -- • --
Vehicles	Revenue Vehicles	LRV	Railcar Maintenance (RCMD)	• Yard Testing (-- day) • 45 Day Inspection • Annual Inspection	• 7 Day PM • 45/90 Day PM • Annual PM Inspection
Vehicles	Revenue Vehicles	Wheel Shunt	Railcar Maintenance (RCMD)	• Installation	• --

8.2.1.1. Revenue Vehicles

Below is a more detailed discussion of the revenue vehicle maintenance schedules found in Table 8.3 and Table 8.4. Railcar Maintenance Department (RCMD) inspects and maintains Light Rail Vehicles (LRV) that consist of fourteen vehicle components, including: carbody, truck, operator's cab, high voltage/ pantograph, propulsion, auxiliary power, car control, braking system, couplers, doors, lighting, HVAC, communications, and Automatic Train Protection (ATP). LRVs are maintained and inspected through seven different schedules: daily, biweekly, exterior cleaning, weekly, 45 day, ATP 90 day, and annually.

Both the **daily** and **biweekly** processes require the LRV to undergo a visual inspection and cleaning process, requiring 0.5 and 2 hours respectively. **Exterior cleaning** occurs weekly. All three of these processes are subcontracted; associated SOPs and Master PMs have not been developed by Light Rail.

The **45-day** maintenance process has been documented in both a SOP and through Master PM, requiring a crew of four.

The **weekly** and **90-day** processes require crews of two and four, respectively, and each have a SOP that requires maintenance of the LRV and testing of a LRV's ATP component. Note, the Master PMs for both these frequencies do not clearly distinguish between maintenance processes conducted on the entire LRV and the ATP system. The intent of these Master PMs is to focus on the entire LRV, not just the ATP system component.

The **annual** LRV maintenance process requires the most intensive work and necessitates 9 mechanics to complete. The name of the associated SOP (*Annual Inspection for Light Rail Vehicles*) suggests more of an inspection based process, whereas the Master PM implies a maintenance activity.

RCMD centers its maintenance activities of the LRVs at the component level. For example, in the case of a damaged wheel, RCMD will swap out an entire truck to bring the LRV back into service quickly, and will inspect/repair the damaged truck assembly offline. While RCMD has an SOP for the ATP LRV component, the department currently does not have SOPs or scheduled work orders solely identifying the other thirteen (13) LRV components. Therefore, Light Rail will consider developing new SOPs and Master PMs centered upon these Critical Assets, at the component level, to align with Light Rail's current maintenance practices.

Most maintenance activities for LRVs, including the 45 day, 90 day, and annual processes, take place at North Avenue. Each of the tracks in the North Avenue yard are used for designated maintenance purposes (Table 8.5).

Table 8.5 - Track layout at the North Avenue facility and corresponding maintenance activities.

Track	Function
1	Light repair; Weekly inspections, HVAC & pantograph
2	Light and heavy repair
3	Light repair; Wheel truing; Preventive maintenance; Weekly inspections
4	Light repair; Weekly inspections
5	Car wash

While Cromwell has the capability to perform minor maintenance, daily cleaning, and all inspections, the facility does not have the capability to perform substantive PM work. A 1995 study estimates that the North Avenue facility and yard can contain 40-44 LRVs, while Cromwell can hold 18 LRVs. Due to the limited capacity, on-time completion of scheduled maintenance can be affected by the additional time necessary to "shuffle" vehicles through the yards.

8.2.1.2. Non-Revenue Vehicles

Light Rail's non-revenue vehicles include light trucks, specialized track maintenance vehicles, and other maintenance vehicles that are able to be driven both on and off the rails. 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 on non-specialized vehicles 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.

- **Light Rail may make repairs themselves**, especially for specialized track vehicles as a last resort, for expediency.

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

8.2.2. Facilities

As previously discussed, the Facility Maintenance Department (FMD) relies solely upon contracted services to maintain and inspect all asset classes, which is why FMD has a disproportionately small number of SOPs and Masters PMs compared to the large number of asset classes it "owns." Note, that the existence of certain SOPs and Master PMs does not imply that these maintenance functions are performed by in-house personnel; these functions are all delegated to an ancillary or specialized contractor. Due to the fact that contractors cannot access Maximo, many of the maintenance activities performed on Light Rail facilities cannot be tracked and analyzed. Copies of the SOPs listed in the table below may be found through the SOP catalogue.

Table 8.6 – Summary of maintenance documentation for facility assets. Note that while FMD has several SOPs and Master PMs in place, these represent only a small proportion of the asset classes it "owns."

Asset Category	Asset Class	Group	Department Responsible	SOP Name	Master PM Name
Facilities	Building	Building/ Grounds	Facilities Maintenance (FMD)	• Occupational Health Safety (Annual)	• Environmental (30 day) • Environmental (30 day) • SPCC Inspection – North Ave (30 day) • SPCC Inspection – Cromwell (30 day) • Safety Inspection – North Ave (30 day) • Safety Inspection – Cromwell (30 day) • Weekly/Monthly Cleaning – North Ave • Weekly/Monthly Cleaning – Cromwell
Facilities	Major Shops	Car Wash	Facilities Maintenance (FMD)	• -- • --	• Inspection – Cromwell (14 day) • Inspection – North Ave (14 day)
Facilities	Major Shops	Car Wash	Railcar Maintenance (RCMD)	• Operation	• --
Facilities	Major Shops	Car Wash - Sanding System	Facilities Maintenance (FMD)	• --	• PM (-- day) • PM (-- day) • PM – Cromwell (14 day) • PM – North Ave (14 day)
Facilities	Major Shops	Car Wash - Sanding System - Dust Filter	Facilities Maintenance (FMD)	• -- • --	• PM (-- day) • PM (-- day)
Facilities	Building	Eye Wash	Facilities Maintenance (FMD)	• --	• Inspection – North Ave (30 day) • Inspection – Cromwell (30 day)
Facilities	Maint. Eqpt.	Fall Arrest System	Railcar Maintenance (RCMD)	• Operations	• --
Facilities	Maint. Eqpt.	Fire Extinguisher - Maint. Yard	Facilities Maintenance (FMD)	• Inspection (30 day)	• Inspection – North Ave (30 day) • Inspection – Cromwell (30 day)

Facilities	Major Shops	Generator	Facilities Maintenance (FMD)	• --	• Inspection – North Ave (7 day) • Inspection – Cromwell (7 day)
Facilities	Building	HVAC System	Facilities Maintenance (FMD)	• Inspection & Maintenance (30, 90, 180, 360)	• Inspection & PM – North Ave (90 day) • Inspection & PM – Cromwell (90 day) • PM at 1/3/12 months • PM at 1/3/12 months • Seasonal Summer/Winter PM • Seasonal Summer/Winter PM
Facilities	Building	Ice Machine/ Water Fountain	Facilities Maintenance (FMD)	• -- • --	• PM (-- day) • PM (-- day)
Facilities	Buildings	Lighting - Facilities & Stations	Facilities Maintenance (FMD)	• Inspection & Maintenance (14 day)	• --
Facilities	Major Shops	Paint Booth	Facilities Maintenance (FMD)	• Operation	• --
Facilities	Major Shops	Pit Lighting	Facilities Maintenance (FMD)	• --	• PM (-- day)
Facilities	Major Shops	Roof Access Key Interlock System	Railcar Maintenance (RCMD)	• Operation – North Ave • Operation – Cromwell	• --
Facilities	Major Shops	Shop Bug	Railcar Maintenance (RCMD)	• Inspection (-- day)	• --
Facilities	Major Shops	Tool Kit	Railcar Maintenance (RCMD)	• Inspection (annual)	• --
Facilities	Major Shops	Wheel Truer	Railcar Maintenance (RCMD)	• Operation	• --

In general, facilities maintenance management decisions are made on an ad-hoc basis, largely due to constrained resources. Documentation of facility maintenance practices within FMD is sparse. FMD does not have any in-house staff available to perform maintenance functions, and even with embedded consultant support, constrained resources cause the management of contractors to be challenging. It is unknown whether the outsourcing of all FMD functions is cost effective, and warrants further analysis.

8.2.3. Stations

FMD relies upon contracted services to maintain all Light Rail stations as well. Similar to Facilities, FMD has a disproportionately small number of SOPs and Masters PMs compared to the large number of asset classes it “owns.” Due to the fact that contractors cannot access Maximo, many of the maintenance activities performed on Light Rail stations cannot be tracked and analyzed.

The Light Rail system has only at-grade stations and the following tables summarize pertinent maintenance documentation.

Table 8.7 – Summary of facility asset maintenance documentation. Note that while FMD has several SOPs and Master PMs in place, these represent only a small proportion of the asset classes it “owns.”

Asset Category	Asset Class	Asset Type	Department Responsible	SOP Name	Master PM Name
Stations	At-Grade Stations	Stations	Facilities Maintenance (FMD)	• --	• Inspection Weekly/Monthly
Stations	At-Grade Stations	Stations - Electrical Panels	Facilities Maintenance (FMD)	• --	• Inspection (90 day)
Stations	At-Grade Stations	Stations - Lighting	Facilities Maintenance (FMD)	• --	• Inspection (30 day)

Similar to facilities, FMD maintenance management decisions are made on an ad-hoc basis, largely due to constrained resources. Documentation of station maintenance practices within FMD is sparse. FMD does not have any in-house staff available to perform maintenance functions, and even with embedded consultant support, constrained resources cause the management of contractors to be challenging. It is unknown whether the outsourcing of all FMD functions is cost effective, and warrants further analysis.

8.2.4. Guideways

Maintenance of Way Department (MOWD) inspects and maintains all guideway assets with the exception of major structures (e.g. bridges), which are managed by the *Office of Engineering*. Nearly all guideway assets are considered to be Critical Assets by the MTA. MOWD does not employ any SOPs for its maintenance activities, accordingly Table 8.8 outlines existing Master PMs only. Unlike most other Asset Owners in the Light Rail system, MOWD keeps hard copies of its data sheets, and does not store them electronically.

Table 8.8 – Summary of maintenance documentation for guideway 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
Guideways	Trackwork	Switch Machines	Maintenance of Way (MOWD)	• --	• Annual Inspection • Semi-Annual Inspection
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 1 – SECT 1: CM 902N - 586N (7 day) • Team 2 – SECT 1: CM 902N - 586N (7 day)
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 1 – SECT 2: CM 586N - 235N (7 day) • Team 2 – SECT 2: CM 586N - 235N (7 day)
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 1 – SECT 3: CM 235N - 16S (7 day)
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 1 – SECT 4: CM 16S - 355S (7 day) Team 2 – SECT 4: CM 16S - 355S (7 day)
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 1 – SECT 5: CM 355S/488S & Cromwell Yard (7 day)

Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 2 – SECT 3: CM 235N/16S & North Ave Yard (7 day)
Guideways	Trackwork	Track	Maintenance of Way (MOWD)	• --	• Team 2 – SECT 5: CM 355S - 488S (7 day)

8.2.4.1. Trackwork

MOWD bases all trackwork maintenance on the 2006 *Field Guide for Track Inspectors* in lieu of documented SOPs. The *Field Guide for Track Inspectors* is pocket-sized and easily transportable and made available to all MOWD employees. A Master PM requires individual inspection of switch machines on a semi-annual basis. Ten (10) additional Master PMs require two redundant crews to inspect the mainline weekly. Other MOWD maintenance processes that are both undertaken and detailed within the *Field Track Guide* but lack maintenance documentation include:

- Geometry Testing of Track with Ultrasound – Contracted process occurring annually.
- Grinding & Surfacing – Contracted process occurring every three years unless otherwise noted.
- Tamping of Ballast – Conducted by MOWD and occurring once a year from April through October.

The Master PMs used by MOWD 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, Light Rail will consider developing new SOPs and Master PMs centered upon the asset, at the component level. Light Rail will also consider other best practices in trackwork maintenance, such as temperature adjusting of rail for the inclusion of future versions of its maintenance documentation.

8.2.4.2. Bridges

The *Office of Engineering*, *Track and Structures Division*, is responsible for all inspection and maintenance of bridges in the Light Rail system. 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 bridge maintenance SOPs and related practices may be included in a future version of this LMP.

8.2.4.3. Ancillary Structures

MOWD directly maintains ancillary structure assets, such as privately owned roads and gates used to access Light Rail's mainline. These ancillary structures are inspected when work orders are generated for mainline track inspection in the same vicinity. Corrective maintenance work orders are generated for these ancillary structures only when problems are discovered during inspection.

The *Office of Engineering*, *Track and Structures Division*, is responsible for all inspection and maintenance of culverts and other ancillary structures in the Light Rail system. The maintenance practices used by this department may be included in a future version of this LMP.

8.2.5. Systems

Many offices and departments across the MTA collaborate to maintain Light Rail 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 Light Rail mode.

Currently, the Light Rail System Maintenance Department (SMD) maintains all systems assets, with the exception of those assets located on and including the catenary pole, which are maintained by Catenary Maintenance Department (CMD). The following sub-sections outline the differences between SMD and CMD departments when conducting maintenance activities.

8.2.5.1. System Maintenance Department

For the SMD, Maximo produces 42 PM work orders on a weekly basis for various inspection and maintenance activities to be performed throughout the Light Rail system. The superintendent assigns each work order to one of three shifts, morning or afternoon, with work located on the most heavily traveled mainline sections delegated to the night shift. Additionally, SMD conducts PM work orders with two crews, North and South, that alternate daily. In the event that urgent CM work is needed, during any hours of operation, Light Rail Control has the authority to initiate same-day work, regardless of geographic location.

8.2.5.2. Catenary Maintenance Department

For CMD, Maximo produces 15 PM work orders on a weekly basis for various inspection and maintenance activities, geographically clustered according to chain markers that start on the mainline's Northern terminus and work their way South. Similar to SMD, CMD schedules work orders amongst three shifts and assigns all physical maintenance on heavily trafficked sections to the night shift. In the event that urgent CM work is needed, during any hours of operation, Light Rail Control has the authority to initiate same-day work, regardless of geographic location. Unlike most other Asset Owners in the Light Rail system, CMD keeps hard copies of its data sheets, and does not store them electronically.

In lieu of SOPs, CMD bases all OCS maintenance on the recommendations detailed in large binders provided by the Original Equipment Manufacturers (*ABB* and *Impulse*). Due to few copies of these binders in circulation, and their large size, documentation of maintenance procedures is not easily sharable among CMD employees, and is also difficult to utilize in the field. Similar to MOWD, CMD completes ten (10) PMs requiring two redundant crews to inspect OCS along the mainline once a week.

Copies of the SOPs listed in the table below may be found through the SOP catalogue.

Table 8.9 – Summary of maintenance documentation for system assets. Overhead Catenary System (OCS) assets utilize OEM maintenance recommendations. Note, this table excludes any SOPs and Master PMs used by the *Office of Engineering* or *Office of Treasury.*

Asset Category	Asset Class	Group	Department Responsible	SOP Name	Master PM Name
Systems	Train Control/ Signals	AF Track Circuit	Systems Maintenance (SMD)	• Ground Readings (90 days) • Inspection & Maintenance (180 day) • Test (90 day) • CAB Test (-- day)	• PM (-- day) • Ground Readings PM (-- day) • Ground Readings Quarterly (90 day)
Systems	Train Control/ Signals	ATP Current Sensor	Systems Maintenance (SMD)	• Programming	• --

Systems	Train Control/ Signals	Automatic Trip Stops (ATP)	Systems Maintenance (SMD)	• Inspection & Maintenance (180 day)	• Semi-Annual (180 day)
Systems	Traction Power/ Electrification	Balance Weight Assembly	Catenary Maintenance (CMD)	• --	• PM Inspection (-- days)
Systems	Train Control/ Signals	CIH	Systems Maintenance (SMD)	• --	• Locking Test (-- day)
Systems	Traction Power/ Electrification	Disconnect Switches	Catenary Maintenance (CMD)	• --	• Inspection (Annual)
Systems	Train Control/ Signals	Electric Locks	Systems Maintenance (SMD)	• Test (180 day)	• Biennial EL (-- day) • Biennial EL (Odd/Even Year) (--day) • PM (-- day)
Systems	Traction Power/ Electrification	Fire Extinguisher - TPSS	Facilities Maintenance (FMD)	• --	• Inspection (30 day)
Systems	Train Control/ Signals	Grade Crossing	Systems Maintenance (SMD)	• Operation Maintenance (30 day)	• PM (-- day) • PM (30 day)
Systems	Train Control/ Signals	Interlockings	Systems Maintenance (SMD)	• --	• Locking & Traffic Locking Tests (-- day)
Systems	Train Control/ Signals	Switch Machine - M23E	Systems Maintenance (SMD)	• Inspection & Maintenance (30 day)	• --
Systems	Traction Power/ Electrification	Overhead Catenary System	Catenary Maintenance (CMD)	• --	• ***Fri (Group 1) & Wed (Group 2)*** SECT 5: CM 355S - 493 S (7 day)
Systems	Traction Power/ Electrification	Overhead Catenary System	Catenary Maintenance (CMD)	• --	• ***Tues (Group 1) & Fri (Group 2)*** SECT 2: CM 586N - 236 N (7 day)
Systems	Traction Power/ Electrification	Overhead Catenary System	Catenary Maintenance (CMD)	• --	• ***Mon (Group 1) & Thurs (Group 2)*** SECT 1: CM 906N - 586 N (7 day)
Systems	Traction Power/ Electrification	Overhead Catenary System	Catenary Maintenance (CMD)	• --	• ***Wed (Group 1) & Mon (Group 2)*** SECT 3: CM 236N - 22S (7 day)
Systems	Traction Power/ Electrification	Overhead Catenary System	Catenary Maintenance (CMD)	• --	• ***Thurs (Group 1) & Tues (Group 2)*** SECT 4: CM 22S - 355S (7 day)
Systems	Train Control/ Signals	PF Track Circuit	Systems Maintenance (SMD)	• Inspection & Maintenance (90 day) • Inspection & Maintenance (Annual)	• Quarterly/Annual (90, 360 day) • PM (-- day)

Systems	Traction Power/ Electrification	Section Insulator	Catenary Maintenance (CMD	• --	• PM Inspection (-- day)
Systems	Train Control/ Signals	Signal Lamps	Systems Maintenance (SMD)	• Installation	• --
Systems	Train Control/ Signals	Snow Melter	Systems Maintenance (SMD)	• Inspection & Maintenance (Annual)	• --
Systems	Train Control/ Signals	Switch Machines	Systems Maintenance (SMD)	• --	• Switch Obstruction (30 day) • Switch Obstruction Test / PM (-- day) • PM (-- day) • PM (30, 90 day)
Systems	Traction Power/ Electrification	TPSS	Systems Maintenance (SMD)	• Isolation Procedure • Maintenance (30 day)	• Monthly (30 day) PM (30 day)
Systems	Traction Power/ Electrification	TPSS Battery	Systems Maintenance (SMD)	• Inspection & Maintenance (90 day)	• PM (-- day) • Quarterly (90 day)
Systems	Train Control/ Signals	U5 Switch Circuit Controller	Systems Maintenance (SMD)	• Inspection & Maintenance (90 day)	• PM (-- day) • Quarterly (90 day)
Systems	Train Control/ Signals	UPS	Systems Maintenance (SMD)	• Inspection & Maintenance (30 day)	• Monthly (30 day) • Monthly PM (30 day)
Systems	Train Control/ Signals	VHLC	Systems Maintenance (SMD)	• Installation	• --
Systems	--	--	Systems Maintenance (SMD)	• --	• PM (90, 180 day)

8.2.5.3. Security & Communications Systems

The *Office of Engineering, Systems Division*, is responsible for all inspection and maintenance of major security and communications systems in the Light Rail 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.

8.2.5.4. Revenue Collection

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

8.2.5.5. Traction Power & Electrification

Traction power and electrification assets are divided into two sub-classes, substations and overhead catenary systems (OCS), maintained by SMD and CMD, respectively.

Substations Assets

Substation assets are located at each of the 30 traction power substation (TPSS) positioned equidistantly along the Light Rail mainline. SMD maintains both the TPSS battery and the substation itself with corresponding SOPs and Master PMs. Note that FMD inspects/maintains the TPSS facility shell and associated fire extinguishers through Master PM and no associated SOP.

Overhead Catenary Systems

CMD maintains all OCS assets through both inspection and maintenance activities, both of which follow OEM guidelines (not Light Rail specific SOPs). Master PMs issue work orders to inspect the mainline twice a week, by splitting the system into five equidistant sections to generate ten total work orders, completed by two different crews. Master PMs also generate work orders for three large OCS assemblies, including section insulators, balance weight assemblies, and disconnect switches. Limitations of the Maximo system configuration currently prevent the management of work orders at a more logical component level.

8.2.5.6. Train Control & Signaling

SMD conducts inspection and maintenance for all train control & signaling asset classes, including interlocking and wayside equipment assets.

Interlockings

Interlocking refers to those assets located throughout the mainline located at track junctions that control train movement, such as switch machines or the Vital Harmon Logic Controllers (VHLCs). SMD's nine interlocking assets include: ATP current sensors, automatic trip stops, the interlockings themselves, M23E switch machines, unspecified switch machines, signal lamps, snow melters, VHLCs, and U5 switch circuit controllers. As indicated in the Table 8.9 above, maintenance procedures are not consistently documented for all asset types with both SOPs and Master PMs.

Wayside Equipment

Wayside equipment assets refer to those assets located periodically throughout the mainline, such as grade crossings or assets found within one of the 33 central instrument houses (CIHs). CIH assets detect train position and velocity, calculates a safe route, and direct interlocking assets to establish a safe path for all LRVs. SMD has maintenance documentation for six wayside equipment assets: the entire CIH, electric locks, grade crossings, power frequency (PF) and audio frequency (AF) track circuits, and uninterruptable power sources (UPS). All wayside assets have both SOPs and Master PMs, except for CIHs. CIH assets only have a Master PM that requires scheduled locking tests and no SOP.

8.3 Other Maintenance-Related Activities

8.3.1. Spare Parts

Light Rail has its own storeroom that serves all modal departments, located within the North Avenue maintenance facility. Storeroom staff are not Light Rail 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 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 Light Rail'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 Light Rail rather than being processed through a central storeroom first.

Spare parts purchases are funded entirely by Light Rail'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 Light Rail'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 Light Rail establishes for each part once contractual spares are depleted, though this is ultimately at the discretion of Light Rail and storeroom personnel.

Once an inventory item is input into the Maximo system, its ordering can be 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.

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 Light Rail 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 Light Rail 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 Light Rail. 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.

8.3.2. Warranty Administration

Light Rail does not have a structured process for the tracking of warranties associated with its Transit Assets. While Light Rail 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, Light Rail is not consistently compensated by vendors when a Transit Asset prematurely fails.

8.4 Recommended Maintenance Approaches

FMD will evaluate its ability to conduct a cost-benefit analysis to compare the efficacy of utilizing contracted service versus in-house staff to complete maintenance duties. Additionally, stations are public-facing and require higher standards to ensure a safe and comfortable environment for MTA customers. Therefore, the Facilities Maintenance 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, Light Rail should ensure that all Critical Assets have SOPs with corresponding Master PMs and base this documentation on physical asset, not a process. Furthermore, Light Rail 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.

8.4.1. Maintenance Philosophies

As Light Rail 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 8.10 - A summary of common maintenance strategies, from the simplest to most complex. Light Rail'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.

8.4.2. Maintenance Implementation

Light Rail 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:

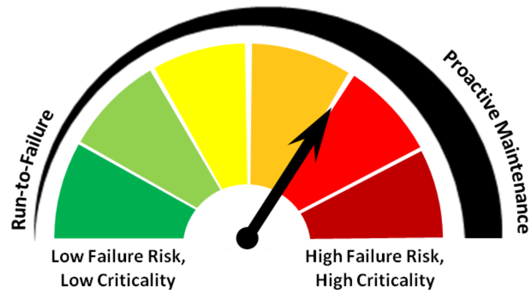
- **Reliability Centered Maintenance (RCM)** – A 7-step engineering framework defined by a formal technical standard. The process begins by identifying what an asset is supposed to do, along with its associated performance standards. It is followed by a detailed failure mode and effects analysis. Then, 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 8.4). Therefore Light Rail 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.

Light Rail 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 8.4 - Intensive maintenance philosophies are often attributed to assets with a higher risk.



9 Lifecycle Phase 3 – Overhaul/Rehabilitation

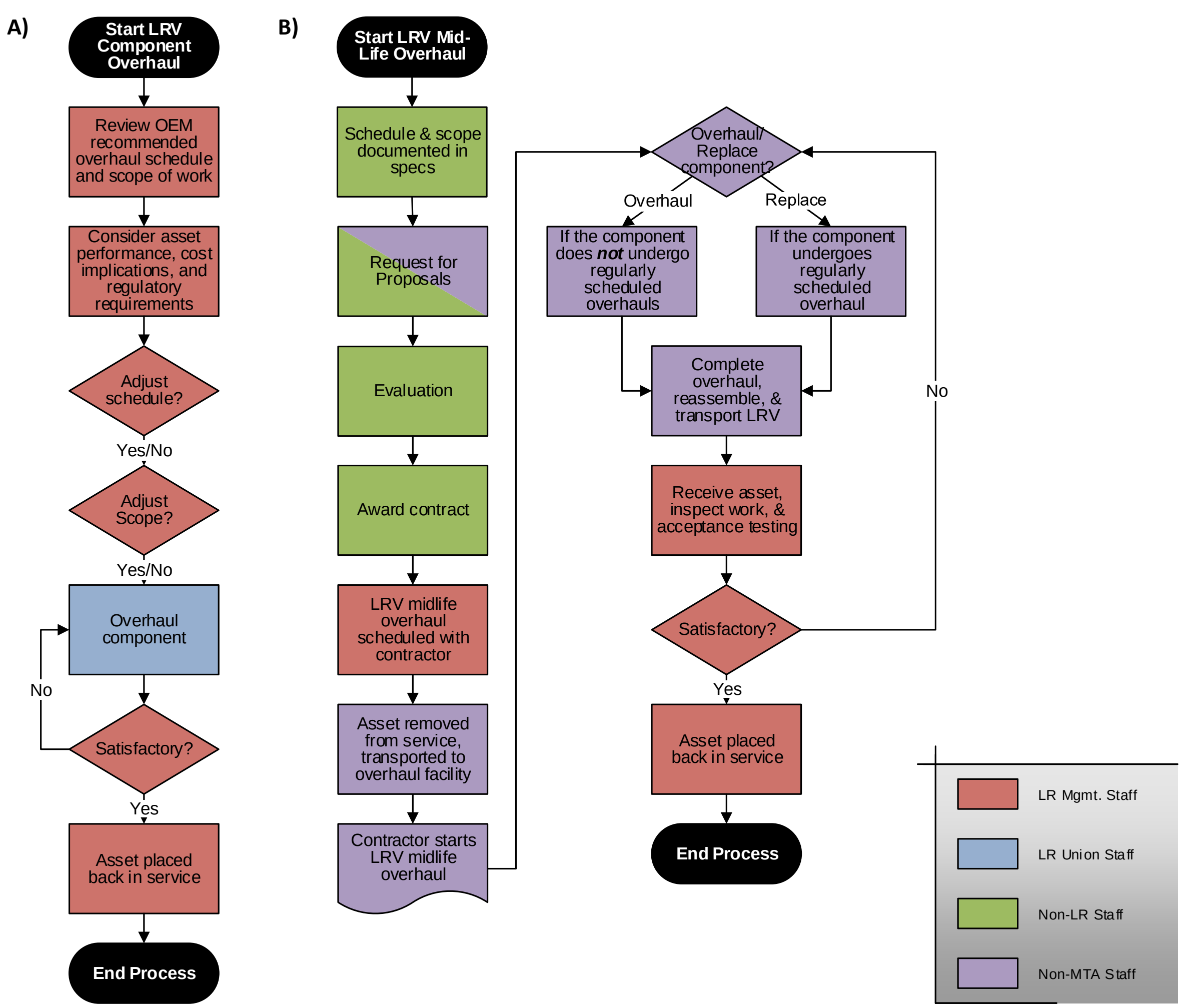
9.1 Overhaul/Rehabilitation Implementation

Light Rail conducts their overhaul/rehabilitation of assets based upon one of two workflow processes. Section 9.1.1 outlines an overhaul/rehabilitation process for vehicle assets, whereas Section 9.1.2 includes a general overhaul/rehabilitation process for all facilities, systems, stations, and guideway assets.

9.1.1. Revenue Vehicles

As previously established, RCMD maintains Light Rail Vehicles (LRVs) on a component level (See Section 8.2.1). RCMD manages ongoing overhaul/rehabilitation of vehicles by upgrading or replacing their associated components according to the following workflow (Figure 9.1). Component overhaul follows OEM recommendations and regulatory requirements, to be completed on a set schedule. MTA *Office of Engineering* sets the LRV mid-life overhaul scope and schedule that entails a consolidated series of off-site vehicle component overhauls and replacements. Once a contract has been awarded for the LRV mid-life overhaul, MTA Engineering then assumes management of the process.

Figure 9.1 - Overhaul/Rehabilitation programs and processes for A) LRV components and; B) entire LRVs.

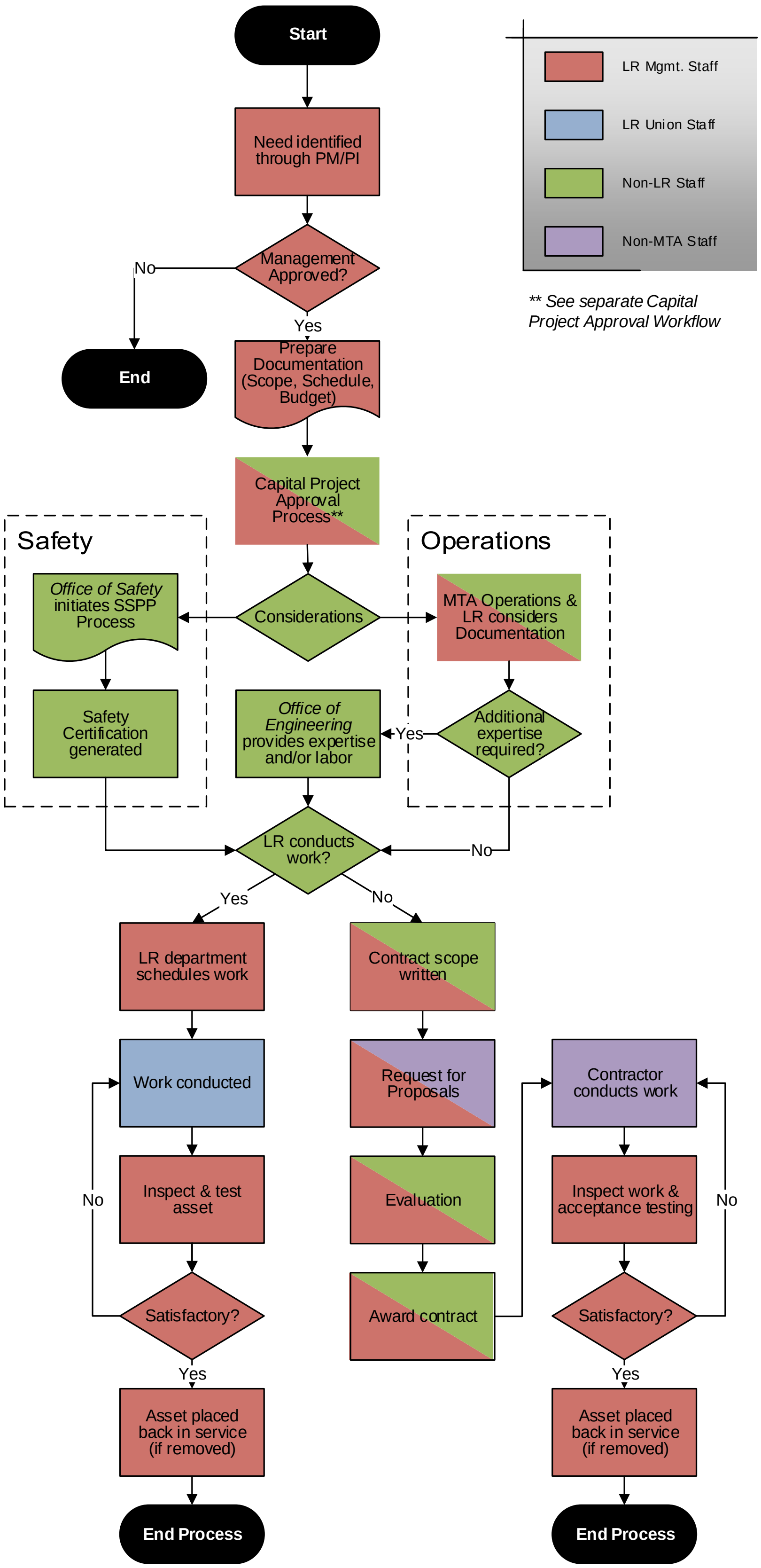


9.1.2. Non-Revenue Vehicles, Facilities, Stations, Guideway, and Systems

While Light Rail employs a proactive overhaul/rehabilitation process for its revenue vehicles, all other asset classes have their components replaced when inspection reveals that they are functionally defective. In general, Light Rail departments conduct asset overhaul/rehabilitation on all other asset classes through a bottom-up approach, where crews and Superintendents identify potential projects and communicate that need to Light Rail management (Figure 9.2).

Unlike preservation projects, most of these Light Rail overhauls are managed by *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 9.2 - General overhaul/ rehabilitation workflow of Light Rail assets.



9.2 Current Overhaul/Rehabilitation Schedules

As indicated in the section above, LRVs are overhauled according to a predetermined schedule, however all remaining asset classes undergo component upgrade/replacement on an as-needed basis. In lieu of a formal component replacement schedule for non-revenue vehicles, facilities, stations, and systems assets, the MTA can generally anticipate the need for component replacement based on industry-average useful life data. The following sub-sections outline current Light Rail overhaul/rehabilitation schedules by asset category. **Appendix B** details industry-average useful life data for all Light Rail Transit Asset components.

9.2.1. Vehicles

Light Rail **revenue vehicles** undergo four overhauls on the following time-scales: 5 year, 8 year, 10 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. The following tables outline the scope and schedule of these overhauls.

Table 9.1 - Outline of the 5, 8, and 10 year LRV overhaul; data on time out of service, labor, and associated costs were not available for the 8 and 10 year overhauls at the time of publishing. The table does not include overhaul/rehabilitation regimes for non-revenue vehicles because this documentation was not available at the time of publishing.

Overhaul Schedule	Time Out of Service (Hrs)	Labor (Hrs)	Cost ($/LRV)	Description
5 Year	100	820	$55,325.00	• Trucks: 12 axle bearings, Chevrons, dampers, and couplings • Brake System: 6 Brake Calipers, 2 Brake Control Units, 1 air compressor • 2 HVAC Compressors: Heating elements, valves, and software updates • Car Body: Floor repairs, & articulated ring repairs • 4 Traction Motors • 1 Pantograph: Shunts, bearings, & springs • Propulsion: 4 traction motors, Propulsion module capacitors, & GDU transformers
8 Year	-	-	$38,654.00	• 2 Couplers: Electrical head, buff gear, deformation unit
10 Year	-	-	$55,325.00	• Same actions included in 5 Year overhaul • More intensive truck assembly work, including: ○ Magnafluxing the axles ○ Wheel replacement ○ AC motor & gearbox assembly overhaul

The LRV midlife overhaul is expected to cost approximately $156 million over the course of three years. Each LRV is anticipated to be out of service for approximately six months over the course of the midlife overhaul. A more detailed scope of this midlife overhaul can be found in Table 9.2 below, and discussed in greater detail in Section 8.2.1.1 below.

Table 9.2 – Mid-life overhaul scope for LRVs.

LRV Component	Overhaul/ Upgrade	Replace/ New	Definition
Carbody	✓		Re-qualify carshell structure and add new paint/decal scheme; new composite floor covering; New passenger seats; Low location exit path marking system.
Truck	✓		Re-qualify truck structure and rebuild gearbox; all components are renewed.
Operator's Cab		✓	New ergonomic cab design, Operator's seat, Human Machine Interface display screen; Cab HVAC system; Cab privacy glass; Cab-to-cab communication system.
High Voltage	✓		New cables, redesigned circuitry.
Propulsion		✓	New insulated-gate bipolar transistor (IGBT) propulsion system; Overhaul and reuse existing traction motors.
Auxiliary Power		✓	New IGBT auxiliary system.
Car Control		✓	New Car Control system (enhanced operational redundancy); On-board monitoring and diagnostic system (touch screen display); Remote wireless fault downloads.
Friction Brake		✓	Improved brake control system with intelligent sanding and air supply systems.
Coupler	✓		Re-qualify coupler structure; Selected component upgrades.
Doors		✓	New composite door panels, Microprocessor controlled door system.
Lighting		✓	New energy efficient interior/exterior LED lighting system; Geo-fenced light bar system.
HVAC		✓	New energy efficient and eco-friendly HVAC units (Scroll technology).
Communications		✓	New auto announcement system; LED destination signs; Ethernet Train Information System; Intelligent CCTV system; Automatic passenger counter; 2-interior passenger infotainment displays.
ATP	✓		Improved integration with propulsion/braking, and enhanced monitoring and diagnostics.

9.2.1.1. Revenue Vehicles

As with maintenance, LRV overhaul/rehabilitation is centered on 14 asset components, including: carbody, truck, operator's cab, high voltage/ pantograph, propulsion, auxiliary power, car control, braking system, couplers, doors, lighting, HVAC, communications, and ATP. With the exception of truck assembly overhauls, all other component overhauls/rehabilitations are completed by an outside contractor. Once an overhaul/rehabilitation contract has been procured, Railcar Maintenance Department (RCMD) oversees all subsequent work.

Of the 100 out of service hours required for the 5 year LRV overhaul (Table 9.1), 60 non-consecutive hours are required for the removal and replacement of the overhauled components. The other 40 service hours are for the repair of the LRV floors and articulated area. Additional labor details for the 8 and 10 year LRV overhauls were not available at the time of publication.

While replacement of the entire 53 LRV fleet would cost approximately $238 million ($4.5 million per LRV), the LRV midlife overhaul project was awarded to Alstom for $156 million. The project scope (Table 9.2) was built around the following objectives:

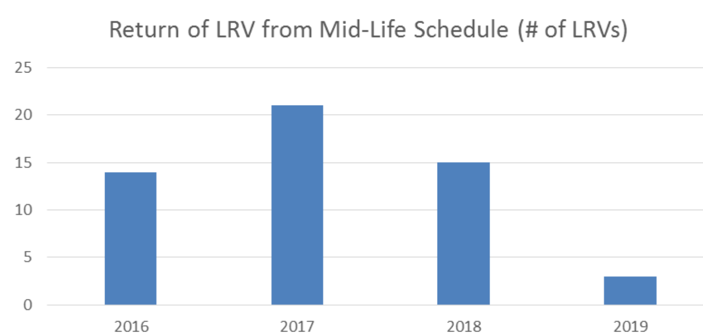
- Harmonize the original and extension fleet components;
- Address part obsolescence;
- Reduce equipment degradation and corrosion;
- Improve system reliability, maintainability, & safety; and
- Improve aesthetics and passenger amenity.

This overhaul schedule follows the original revenue vehicle delivery schedule, with the oldest vehicles overhauled first (Table 9.3). At the time of publication, Light Rail has five LRVs at Alstom's New York facility undergoing their overhauls with the first vehicle scheduled for delivery to Light Rail by spring of the 2016 calendar year. Overhauled LRVs will then be swapped 1 for 1 with uncompleted vehicles over the course of three years, until Alstom delivers the last overhauled LRV to MTA in 2019 (Figure 10.3). With a useful life of 30 years, LRVs were due to undergo a mid-life overhaul at 15 years of age. Unfortunately, budget realities forced Light Rail to delay this project until these vehicles were 22 years old, and expect the overhaul program to extend the vehicle life by 10 to 15 additional years.

Table 9.3 - Revenue vehicle procurement schedule.

Year Delivered	# of Cars
1991	2
1992	27
1993	6
1998	15
1999	3
Total	**53**

Figure 9.3 - Return of LRVs from midlife overhaul program.



9.2.1.2. Non-Revenue Vehicles

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

9.2.2. 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 B**.

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 Light Rail in-house staff or a third-party contractor.

9.2.3. 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 can generally anticipate 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) (Table 9.4). Specifically:

Table 9.4 - Trackwork type breakdown over the entire mainline according to MOWD interviews.

Track Section	Fixation Type
Hunt Valley – North Ave	100% Ballasted
North Ave – University Center / Baltimore Street	20% Ballasted, 80% Direct Fixation
University Center / Baltimore Street – Cultural Center	30% Ballasted, 70% Embedded
Cultural Center – Camden Yards	100% Embedded
Camden Yards – Hamburg	100% Direct Fixation
Hamburg – Westport	15% Ballast, 85% Direct Fixation
Westport – End of Line	100% Ballasted

Sections of curved track delineated by chainmarkers were provided by MOWD with a corresponding useful life of 20 years. Tangent track and restraining rail both have a useful life 30 years, while yard track has a 70 year useful life. Anticipated useful life data for other asset types under the guideway category can be found in **Appendix B**. Note that the current Light Rail 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 Light Rail in-house staff or a third-party contractor.

9.2.4. Systems

Systems 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 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 B**.

9.2.4.1. Traction Power & Electrification

While MTA estimates that majority of the Overhead Catenary System (OCS) will have an industry-average 40 year useful life, two mainline sections between Mount Royal and North Ave are anticipated to have 10 year useful lives, respectively. These shorter useful lives can be attributed to the dramatic gradient changes (uphill/downhill) associated with the existing Light Rail system alignment, resulting in premature wire wear. These sections include:

- Mainline #1:N76+22 thru N-71+70
- Mainline #2: N-76+70 thru N-72+02

Note that the current Light Rail asset inventory does not contain details on OCS components, limiting MTA's ability to forecast the need to replace/upgrade individual components.

Overhaul/rehabilitation of the 30 traction power substations is managed via the *Office of Engineering, Systems Division* and occur on an as-needed basis. Note that the current Light Rail asset inventory does not contain details on substation components, limiting MTA's ability to forecast the need to replace/upgrade individual components.

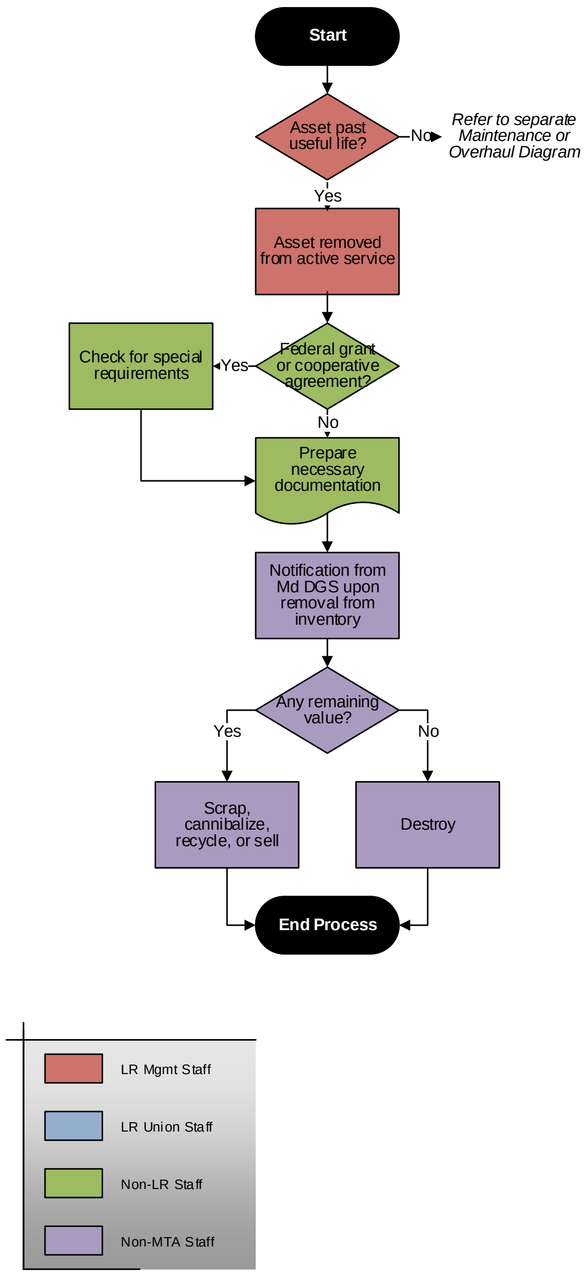
9.2.4.2. Train Control & Signaling

Overhaul/rehabilitation of interlockings (including switch machines, logic controllers, ATP sensors, snow melters, etc.) and wayside equipment (Central Instrument Houses, track circuits, etc.) are managed via the *Office of Engineering, Systems Division* and occur on an as-needed basis. Note that the current Light Rail asset inventory does not contain details on train control and signaling components, limiting MTA's ability to forecast the need to replace/upgrade individual components.

10 Lifecycle Phase 4 – Disposal

Figure 10.1 provides a summary overview of Light Rail practices around asset retirement and disposal. Note that asset disposal is heavily dependent on people and policies outside of Light Rail, 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 10.1 – Overview of asset disposal.



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

Figure 10.2 - An asset's lifecycle, or the four phases over an asset's life. Return arrow between Phase 4 and Phase 1 indicates asset replacement.

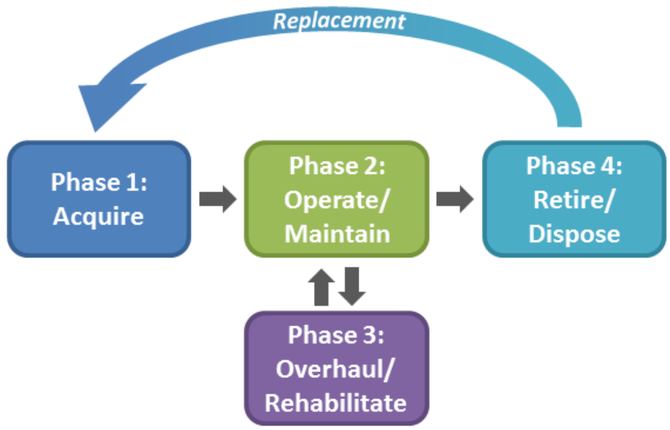


Figure 10.2 illustrates the cyclical nature of lifecycle management. Given Light Rail's current approach, many opportunities exist to increase the performance of the Light Rail system, decrease safety risks and risks of Transit Asset failure, and gain capture time/cost savings. These opportunities are 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 Light Rail system. The following chapter details the process of capital and operations budgeting. By making this process more transparent, Light Rail 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 Management

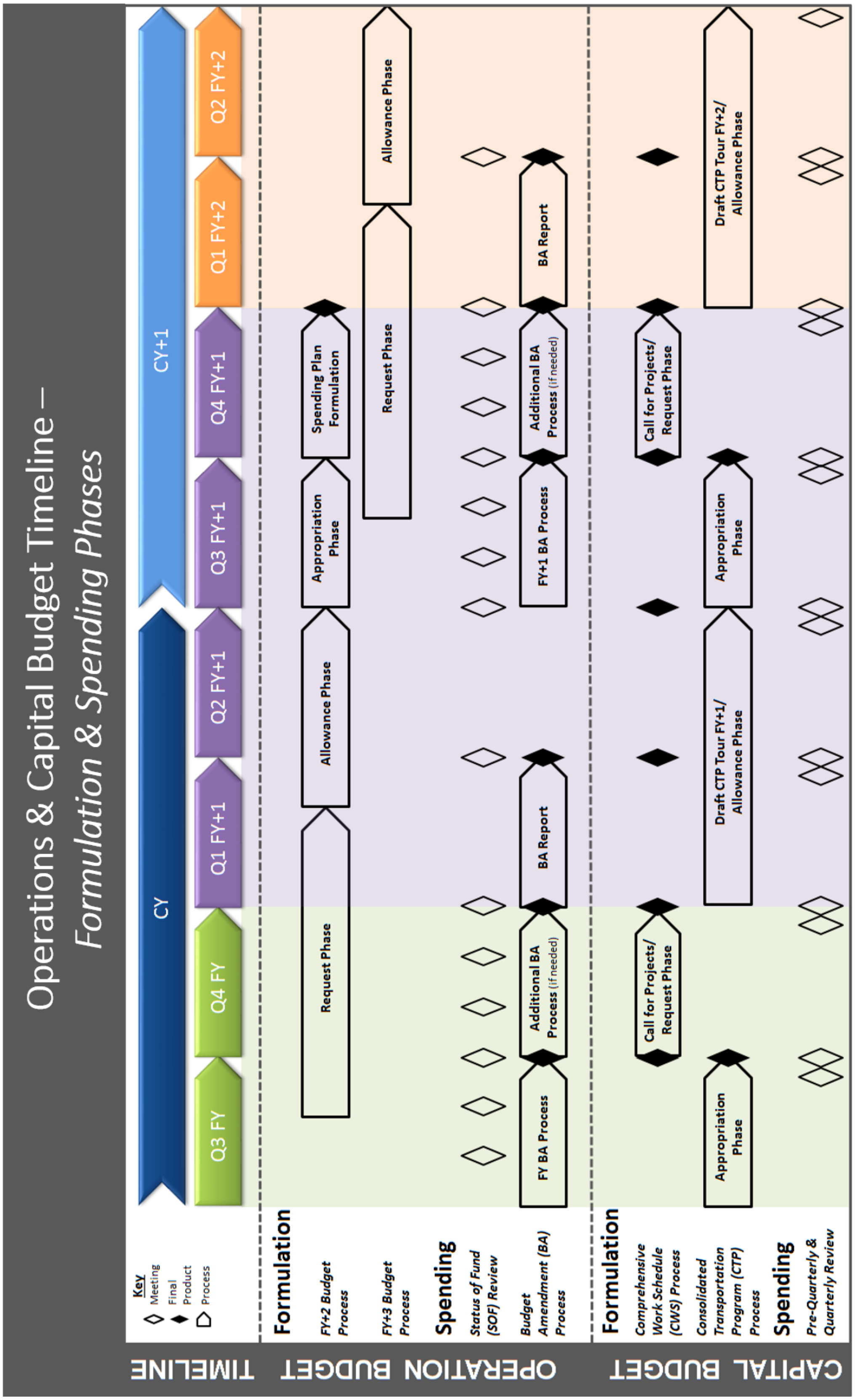
The MTA maintains separate Operating and Capital budgets, coordinated by the *Office of Finance* and the *Office of Planning and Programming*, respectively. Each of these budgets are maintained on an accrual basis, and have their own formulation and spending processes based upon the Maryland Fiscal Year (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 Light Rail 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. Light Rail influences these budgets through the Request Phase. Like all modes and departments throughout the MTA, Light Rail 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.

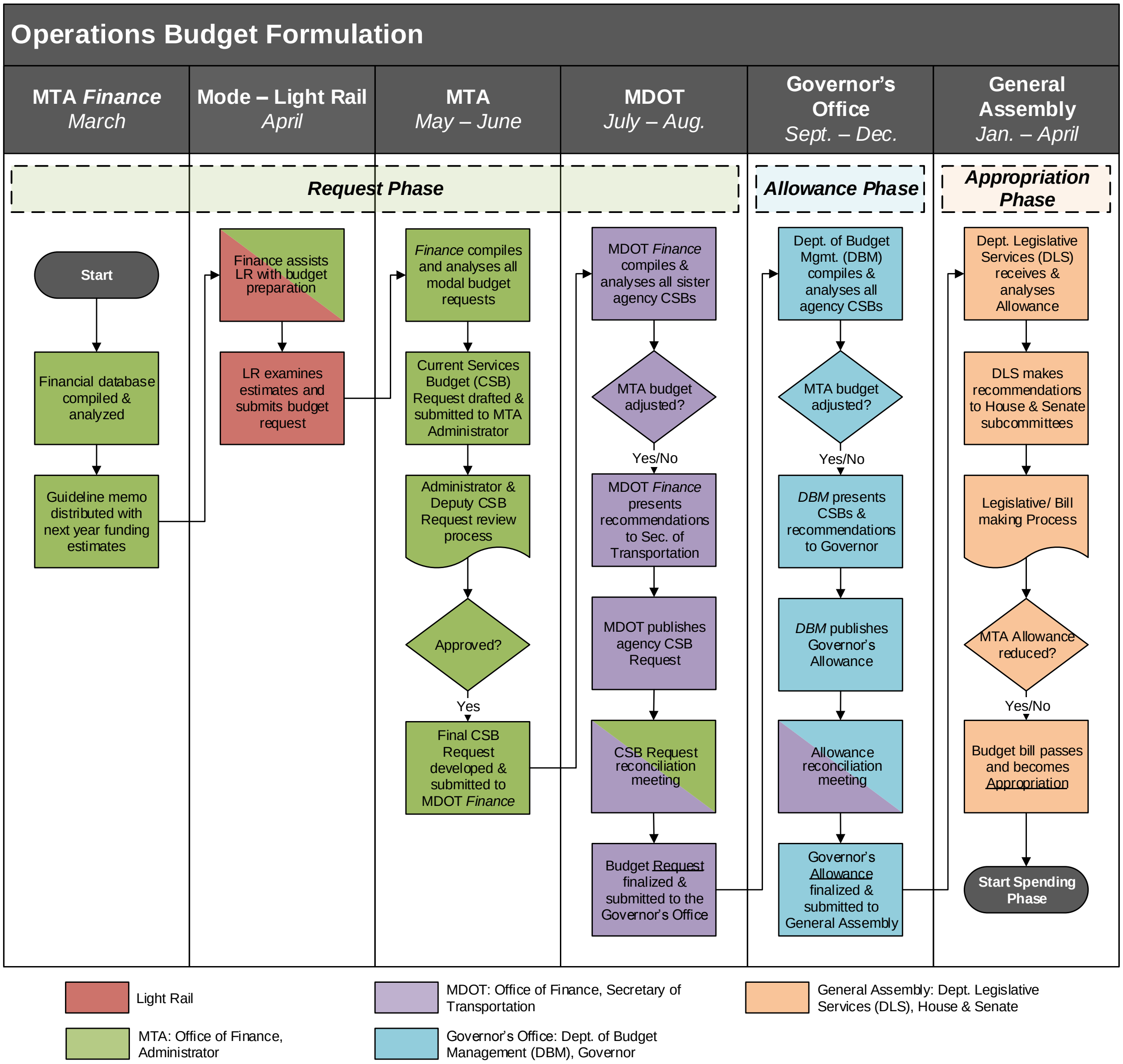
The Operations Budget is generally based on an annual analysis of historic expenditures – this analysis yields a trendline that can be used to forecast the approximate level of funds needed for this upcoming year. This budget forecast, called the Current Services Budget (CSB), is provided to Light Rail for review in the third Fiscal Quarter of every year (March). Light Rail 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 Light Rail and the *Office of Finance* to produce justifications for any additional operational needs and ultimately formulate Light Rail'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, Light Rail 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 Light Rail Operating Budget. Light Rail 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

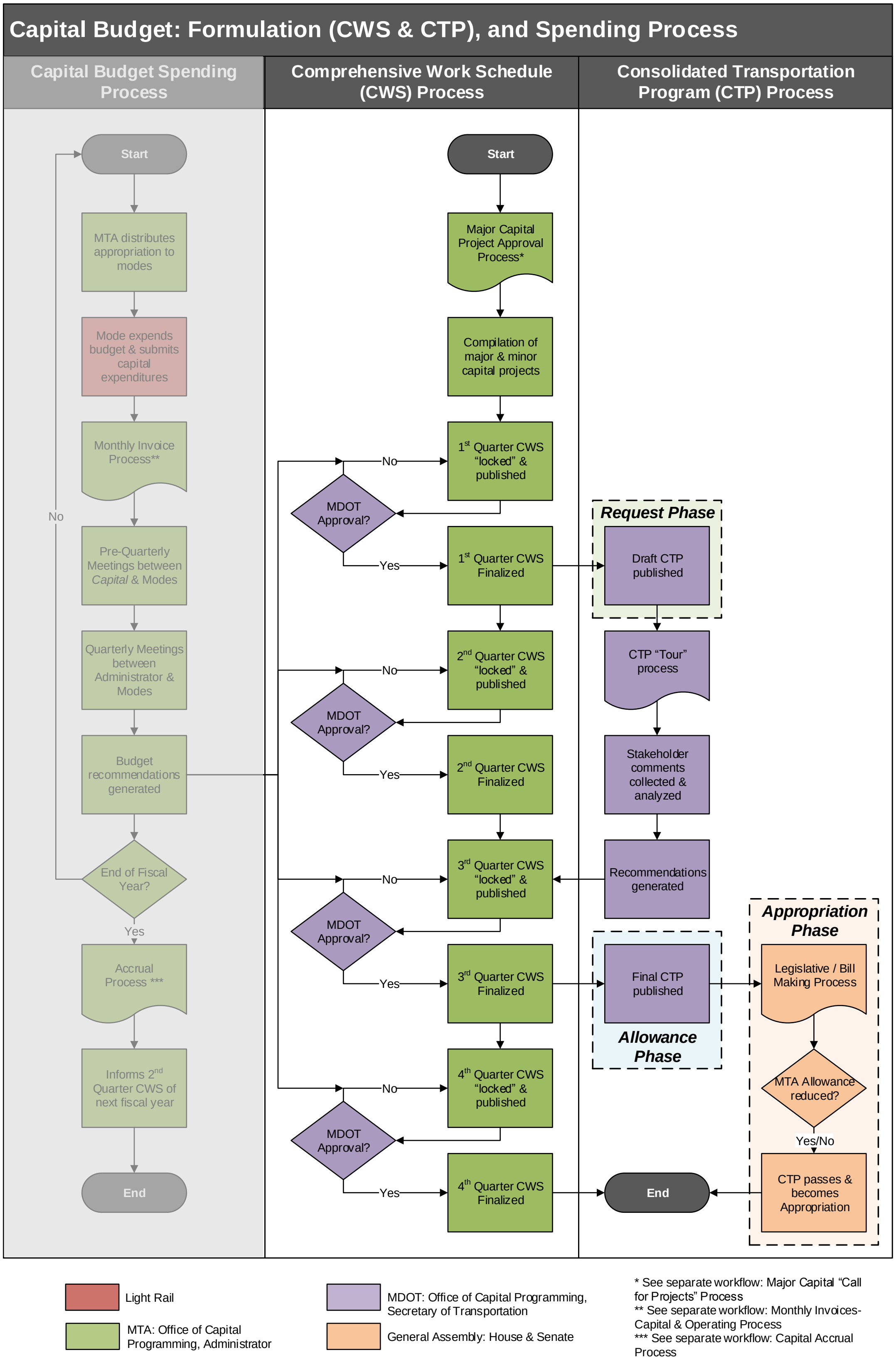
Capital Programming, a division of the *Office of Planning and Programming*, manages the formulation and of MTA's Capital Budget (Figure 12.3). The Capital Budget, also known as the Capital Program, funds all activities associated with the acquisition of Transit and Land Assets. It may also fund other 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 Light Rail 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.

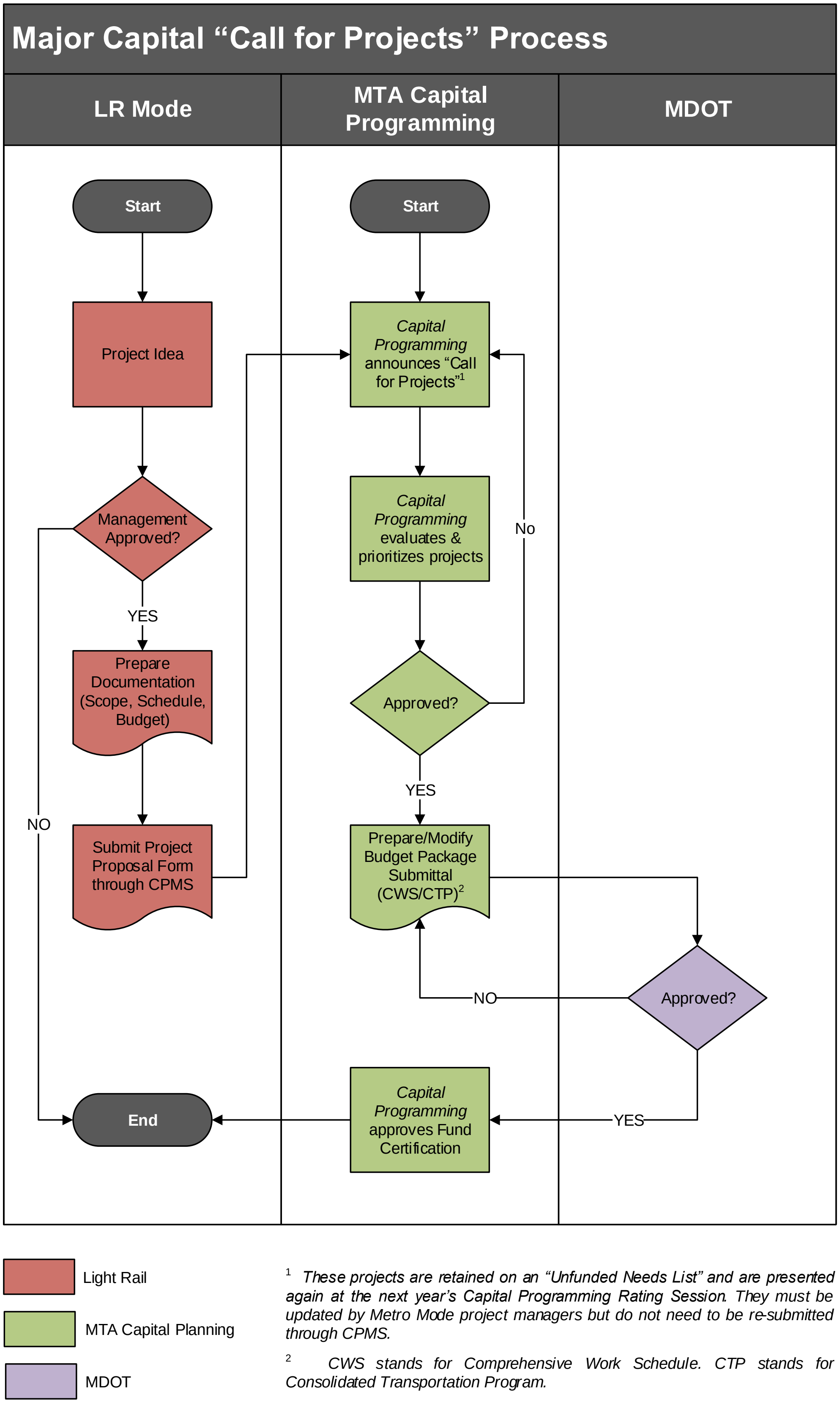
Each quarterly revision of MTA's Capital Budget is captured in a database known as the Comprehensive Work Schedule (CWS). The FY 1st quarter CWS represents the **Request Phase** in the formulation of MTA's Capital Budget, and captures the *Call for Projects* accordingly. The submittal of FY 3rd quarter 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.



* See separate workflow: Major Capital "Call for Projects" Process
** See separate workflow: Monthly Invoices-Capital & Operating Process
*** See separate workflow: Capital Accrual Process

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



[1] *These projects are retained on an "Unfunded Needs List" and are presented again at the next year's Capital Programming Rating Session. They must be updated by Metro Mode project managers but do not need to be re-submitted through CPMS.*

[2] *CWS stands for Comprehensive Work Schedule. CTP stands for Consolidated Transportation Program.*

Traditionally, Light Rail 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, Light Rail 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, Light Rail 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 Light Rail Capital Budget. Light Rail 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

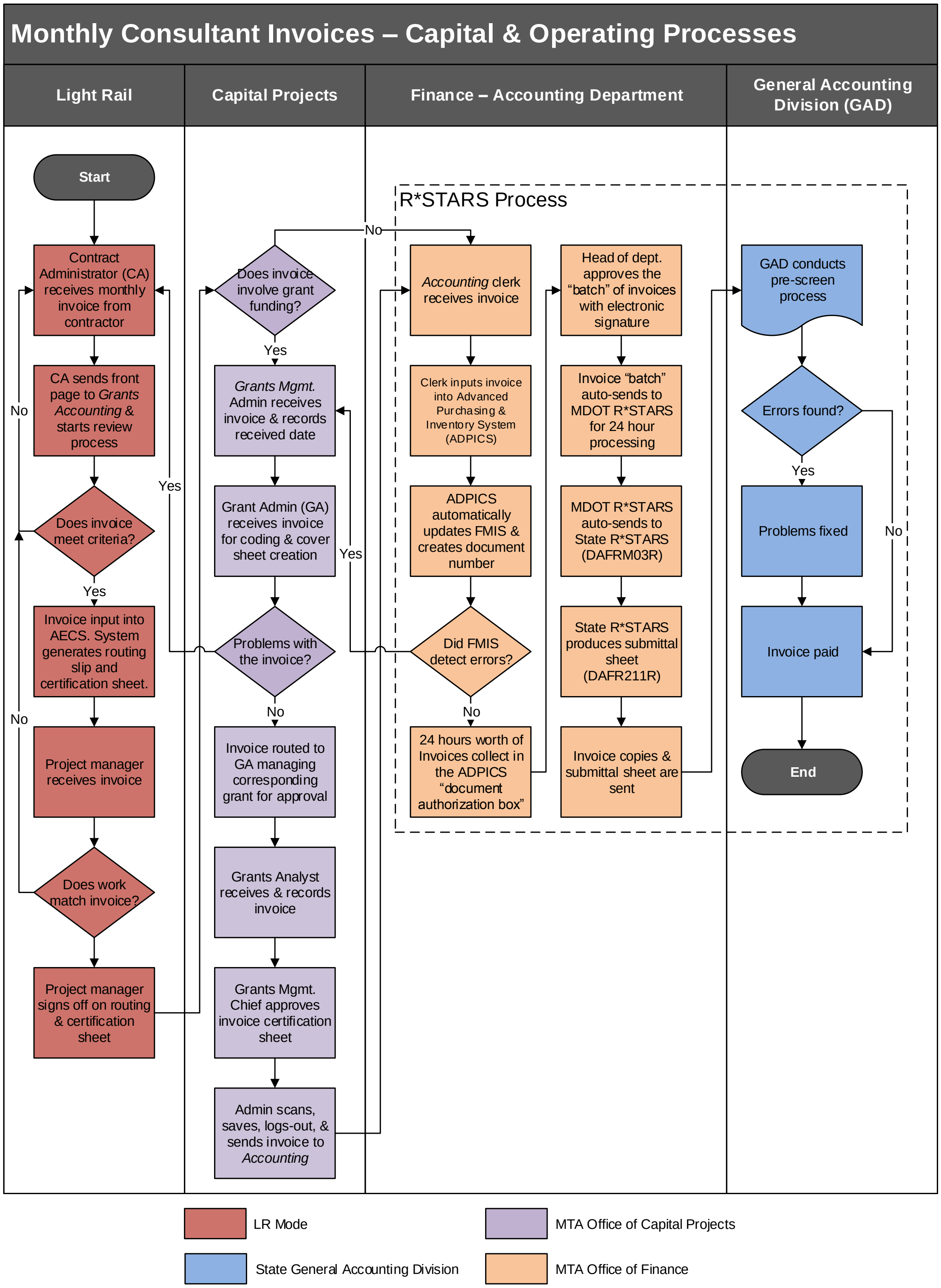
Once the Operating and Capital Budgets have been set, the Spending Process begins with the expenditure of funds, but extends to all processes associated with the ongoing management of those budgets. Expenditure of funds occurs after work has been performed by MTA staff and reported on their timecards 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 to 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, Light Rail 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.

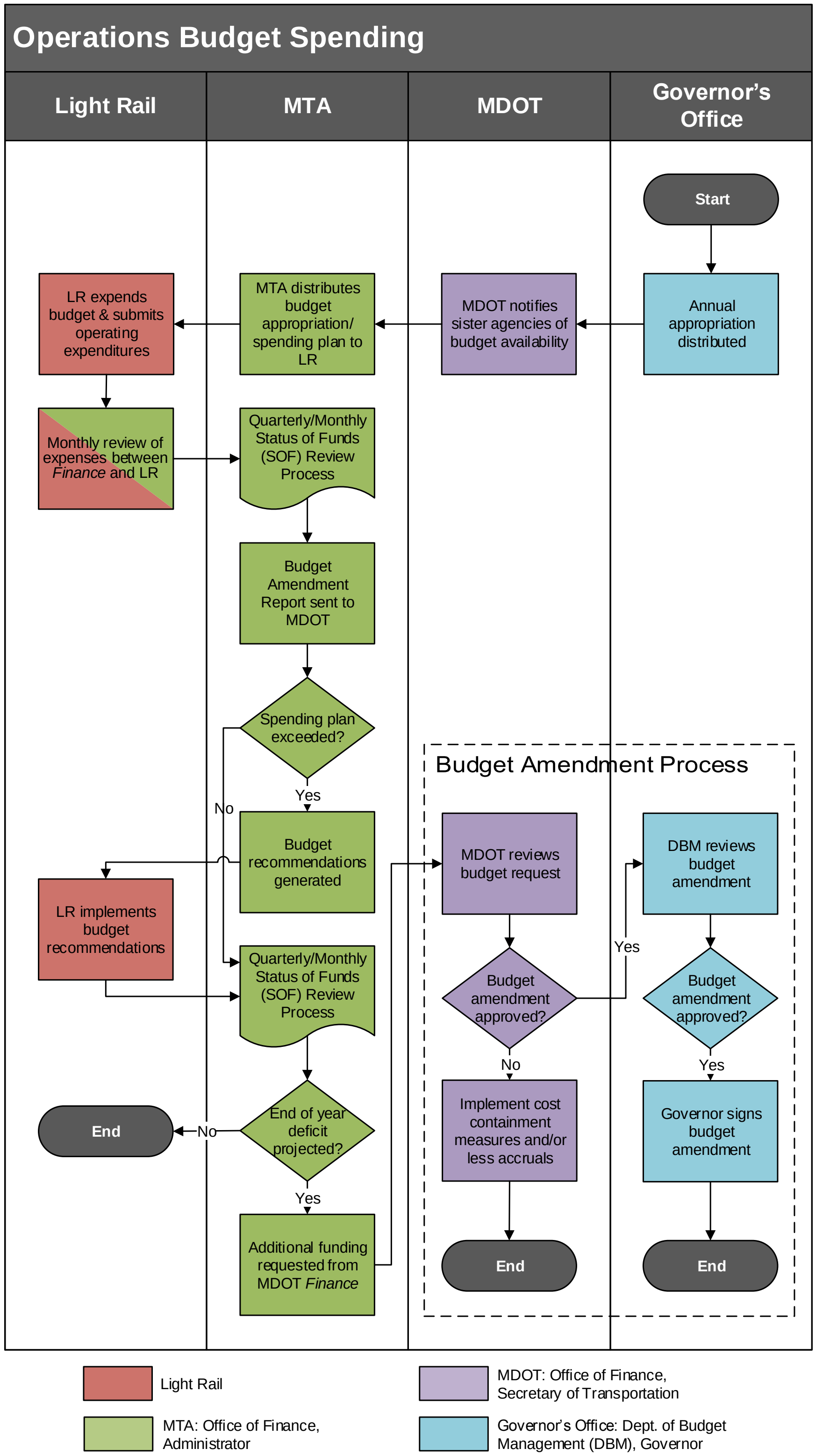
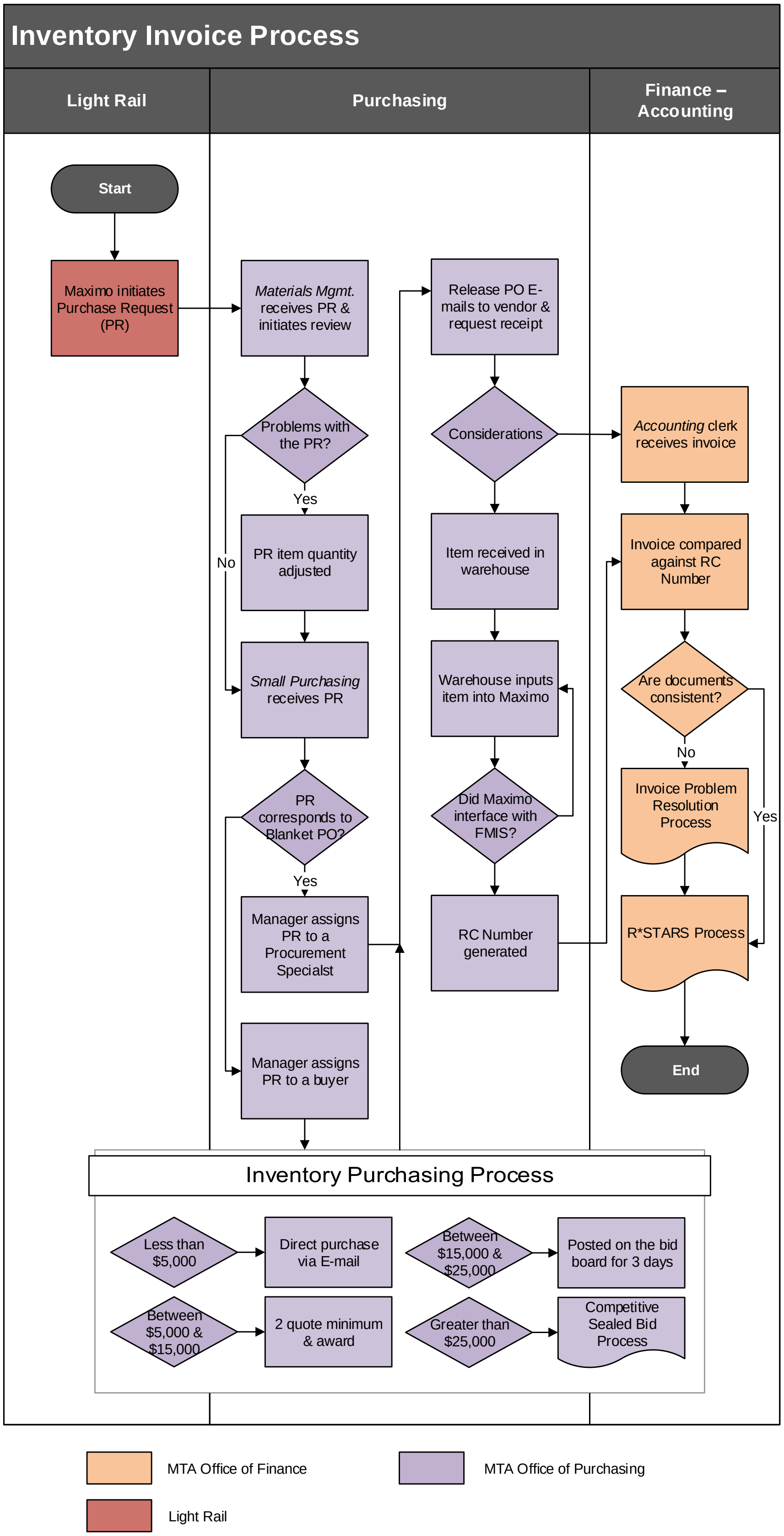


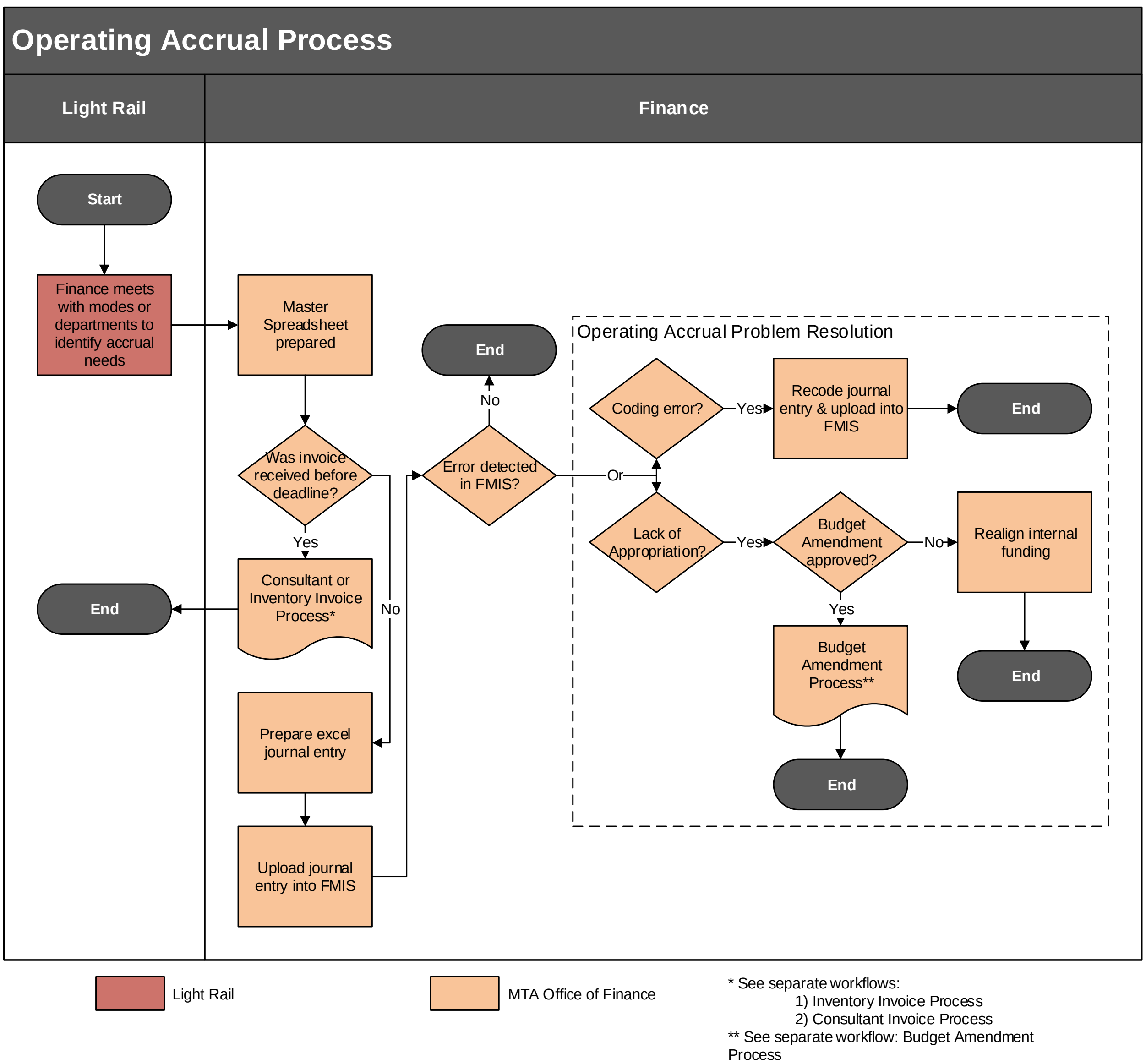
Figure 12.7 – Inventory invoice process.



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 Light Rail for assistance in estimating year-end accruals. This process is detailed in Figure 12.8. 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.



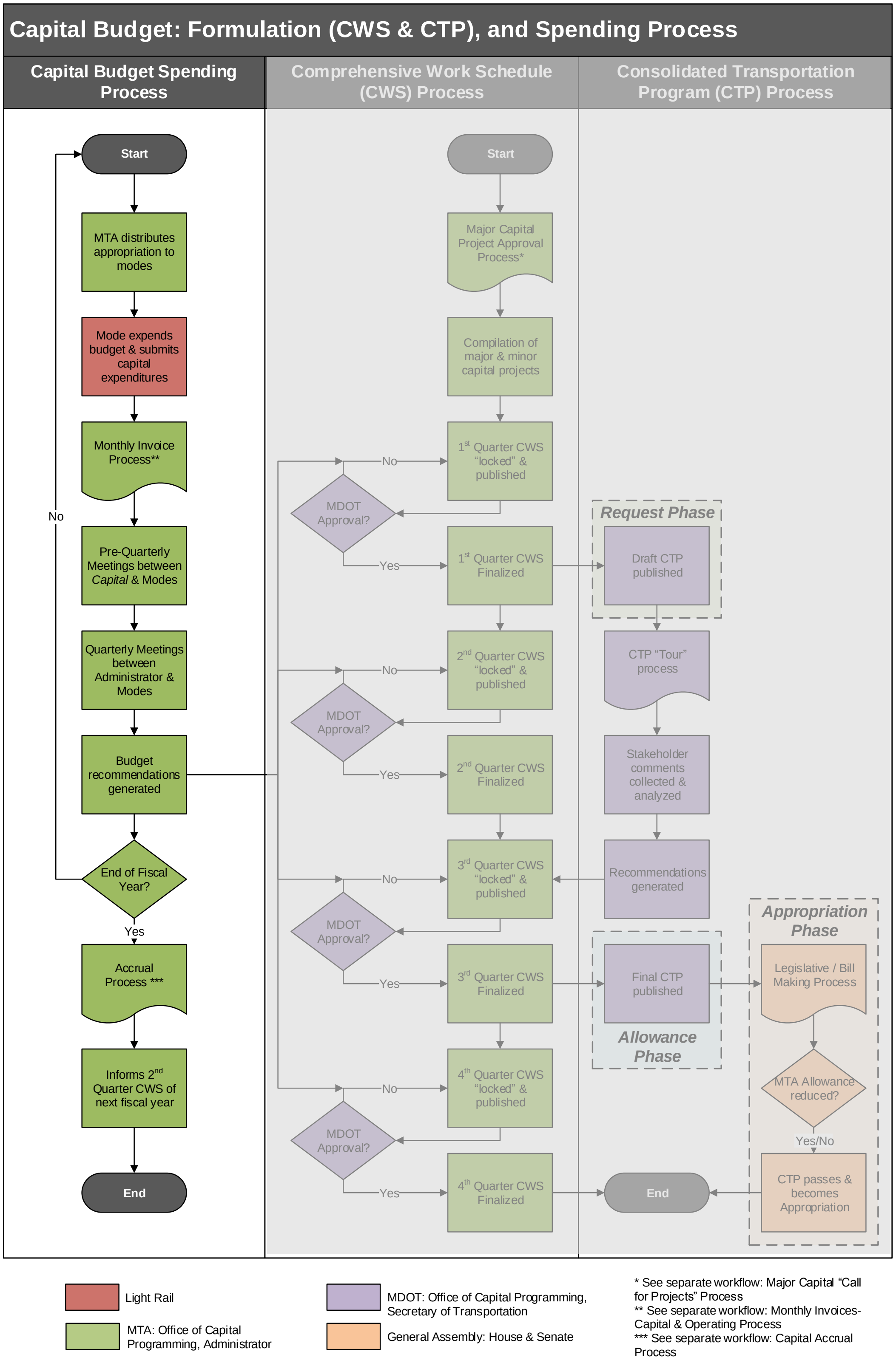
12.2.3 Capital Spending Process

**The Division of Capital Programming coordinates the Spending Process of the Capital Budget, and uses a series of Pre-
series of Pre-Quarterly and Quarterly meetings to help ensure projects stay on-budget and on-schedule. Should a funding
Should a funding discrepancy arise through any of these meetings, they may inform the next quarterly revision of the Capital
revision of the Capital Budget. The process for all invoicing in the Capital Spending Process was detailed in Section 4. A
in Section 4. A detailed illustration of the ongoing management processes for the Capital Spending Process can be found in**

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, Light Rail shares responsibility for the Capital Spending Process with various other MTA offices/departments, as illustrated in the aforementioned figures.

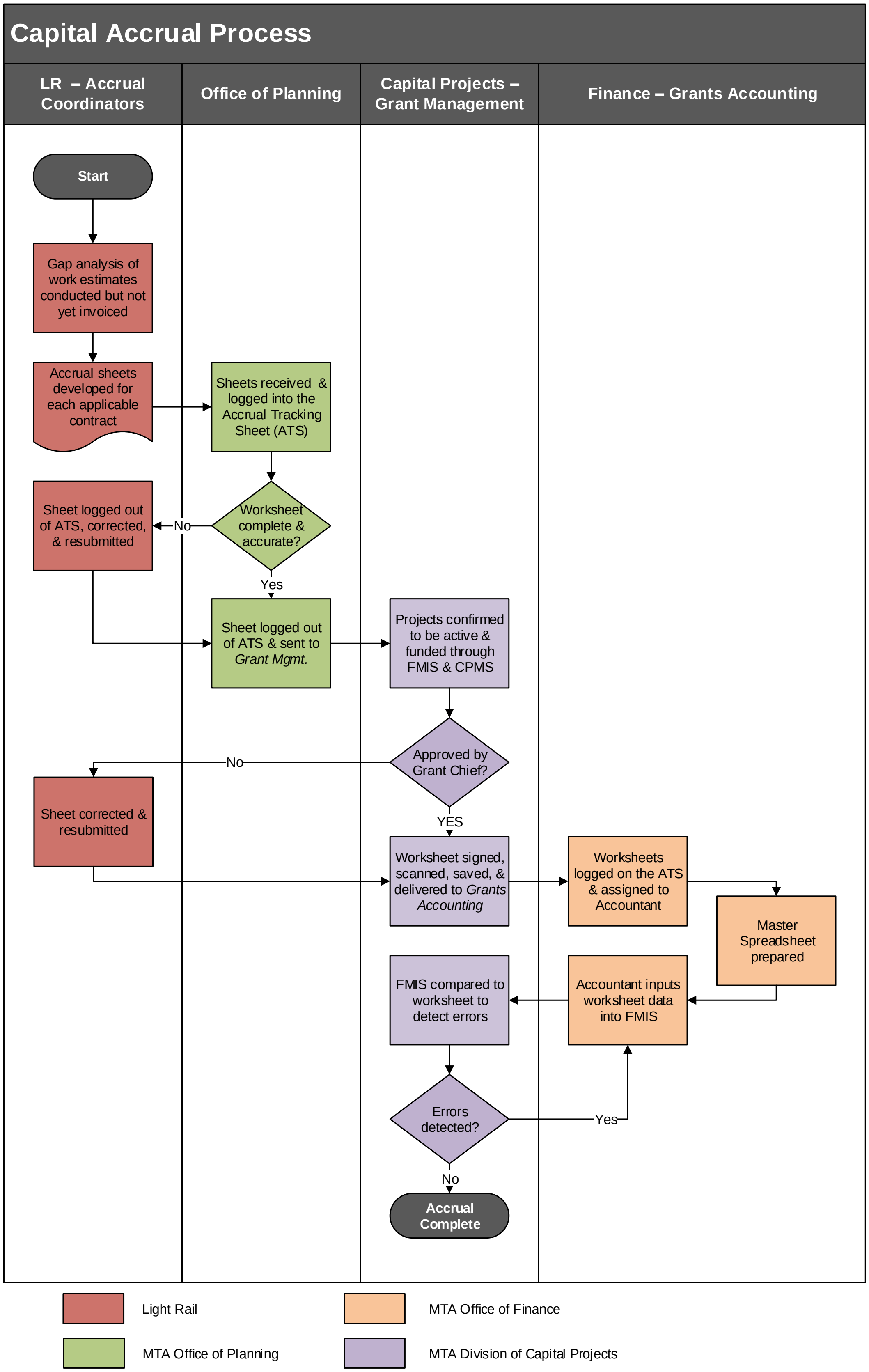
Figure 12.9 - MTA's capital spending process. The capital budget formulation is grayed out. Budget formation involves the creation and editing of the CWS and CTP documents, whereas spending remains a standalone process that informs the CWS.



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 Light Rail for assistance in estimating year-end accruals. This process is detailed in Figure 12.10. 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.

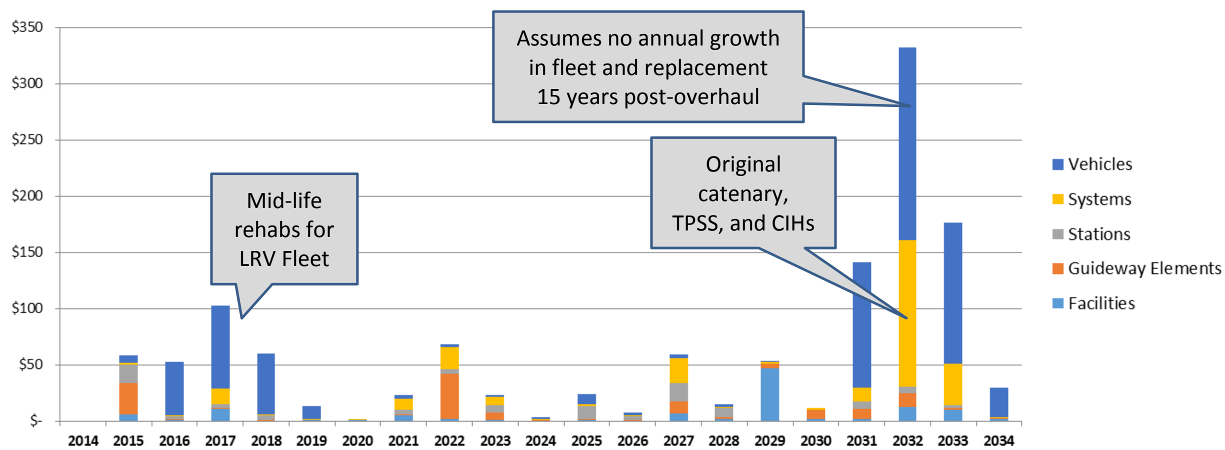


13 Summary of Performance and Funding Impacts

12.1 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 Light Rail staff during interviews. In lieu of specific useful life data, default values contained within TERM Lite were utilized. The sum of all replacement and rehabilitation activities yield the total *capital* expenditures identified by TERM Lite over a 20 year analysis (Figure 13.1), based on the Light Rail inventory at the time of publication. Table 13.1 itemizes all assumptions built into the analysis.

Figure 13.1 - TERM Lite analysis, Light Rail capital expenditures through 2034.



Over the 20 year analysis, Light Rail requires $1.26 Billion to replace all Transit Assets when they reach the end of their useful life. This averages to $62.75 million in needs per year.

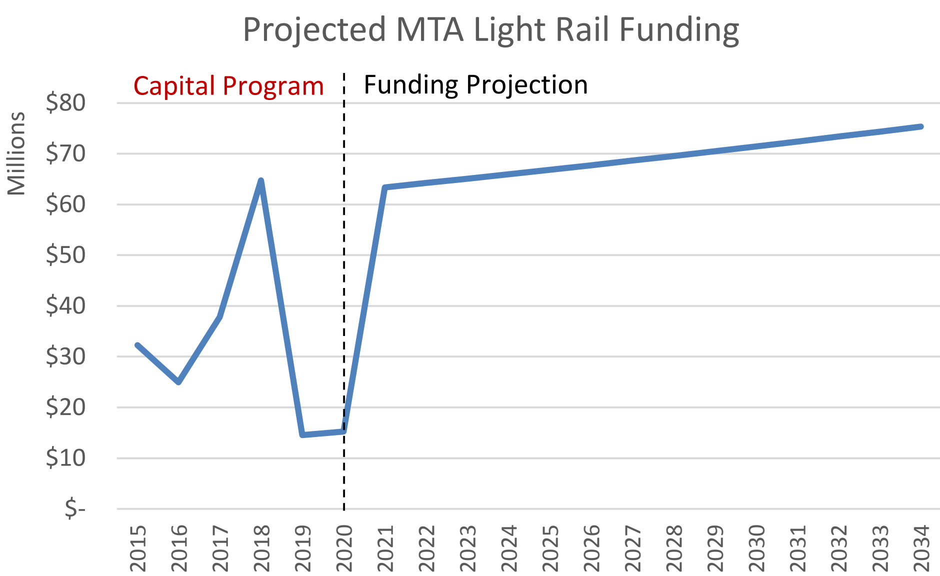
Table 13.1 - Assumptions for the TERM Lite analysis.

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 *Office of Treasury*
• 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 *MDOT Office of Finance)*

12.2 Anticipated Light Rail SGR Funding

Not all of Light Rail'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 Light Rail SGR funding based on historic trends. Funding projections are based on historic expenditures from 1996 through the current capital program, which goes to 2020. Upon the capital program's conclusion in 2021, Light Rail's average funding level increases to accommodate for the known 2030 replacement of revenue fleet. In addition to increasing the average funding level, an annual growth rate of 1.34% was also applied post-2020. Accordingly, the analysis below forecasts an annual average of $57.9 million in funding over 20 years.

Figure 13.2 – Light Rail's projected capital funding through 2034.

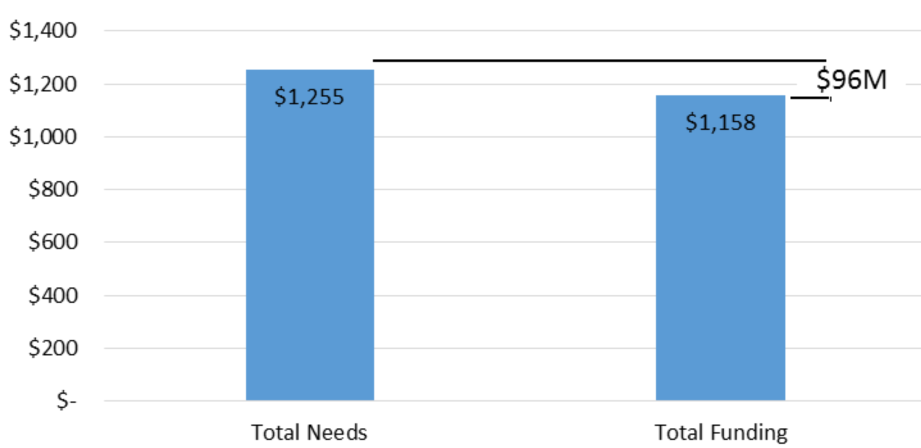


12.3 Funding Impact Analysis

As discussed above, Light Rail's total 20 Year asset replacement needs are $1,255 million in year of expenditure dollars; however, Light Rail is anticipated to have only $1,158 million (year of expenditure dollars) in SGR funding available over the same period. The result is a total funding gap of approximately $96 million over the 20-year period (Figure 13.3).

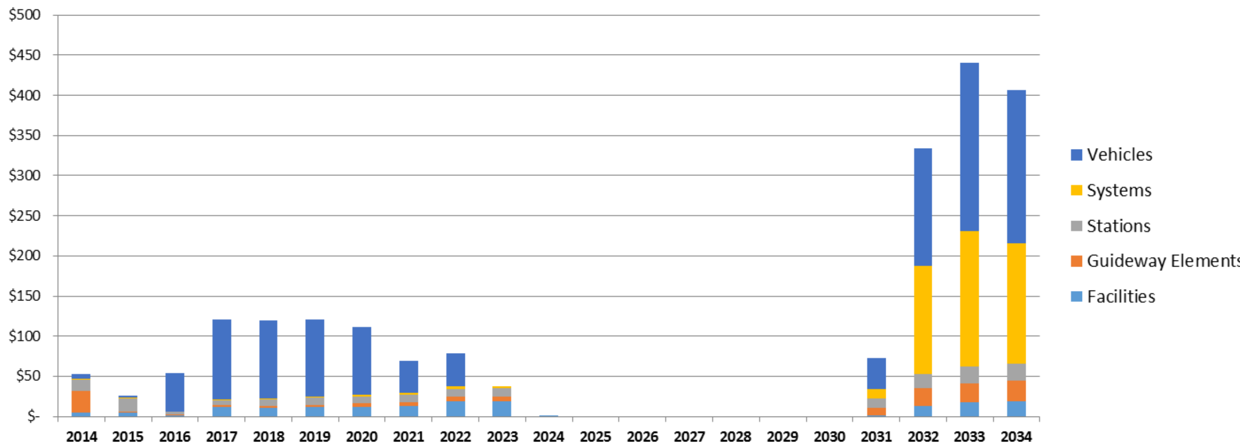
On annual basis, Light Rail's average annual reinvestment needs over the same 20-year period are $62.75 million. Light Rail's average annual funding, over 20 years, is constrained to $57.9 million. The result is an average annual funding gap of $4.8 million.

Figure 13.3 - Light Rail's SGR Backlog needs over 20 years.



Due to this funding gap, Light Rail's is expected to maintain an SGR Backlog through 2023. However, assuming consistent funding levels, Light Rail can expect a substantial backlog (approximately $334 million) to emerge in the year 2032 as the *Vehicles* (revenue fleet), and *Systems* (catenary, substations, and Central Instrument Houses) simultaneously reach their useful lives.

Figure 13.4 - Anticipated growth of Light Rail 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 Light Rail, but also ensuring continual update of this LMP to document these improvements. Specifically, 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. Light Rail 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 Light Rail should evolve to forecast lifecycle costs of an asset or system, and optimize the value of Light Rail's entire asset portfolio.

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

14.2.1 Performance Modeling Uses

Initially, Light Rail 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, Light Rail 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

Light Rail 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 Light Rail's data deficiencies:

Performance Model	Level of Analysis	Required Data Currently Available within Light Rail	Required Data Currently *Not* Available within Light Rail
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 Light Rail has identified the performance models it wishes to invest in, Light Rail 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

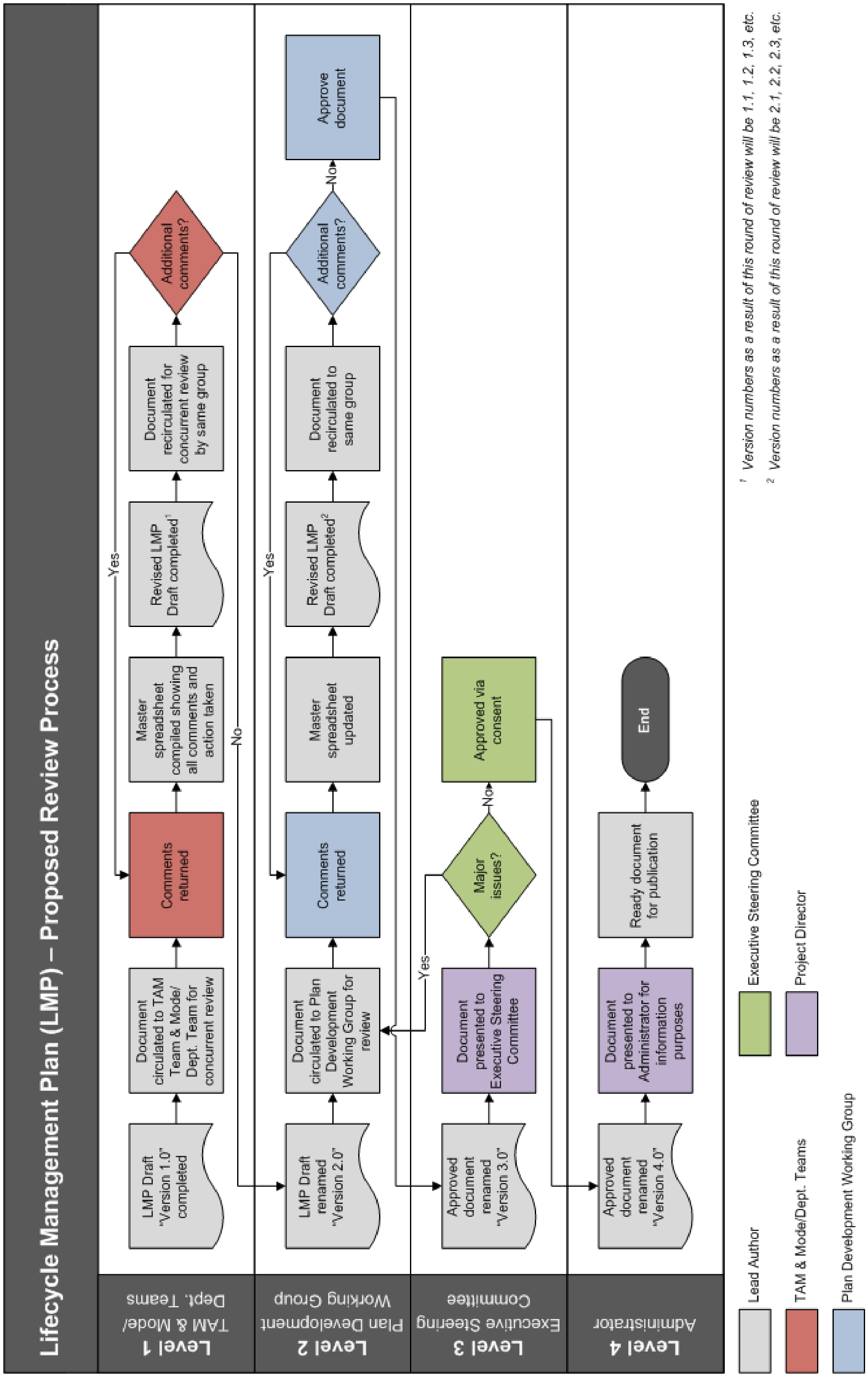
14.3 Other Recommendations

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 F**. Light Rail 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: Light Rail Track Circuit Locations and Associated Operational Risks

Light Rail employs track circuit technology across most of the Light Rail system. Track circuits allow the presence of a train to be detected along the track, enabling automated articulation of interlockings and other safety features.

When the Light Rail system was originally constructed in the 1990's, **Power Frequency** track circuit technology was employed everywhere on the system except for the Central Business District (CBD) where the trains operate in mixed traffic. Accordingly, trains in the CBD are operated manually.

When the Light Rail system was double-tracked in the 2000's, the track circuit system was upgraded to a modern **Audio Frequency** technology, except for two segments of the system to the north and south of the CBD respectively (see diagram to the right). This enabled the use of more advanced Automated Train Protection (ATP) throughout much of the system.

While the legacy Power Frequency track circuit system is still functional, it is obsolete; replacement parts for the Power Frequency system are unavailable. The possible failure of this legacy track circuit will pose some risks to the MTA:

- *Automated safety features will be lost, requiring staff to quickly and uniformly adjust manual operations in these segments.*
- *Interlockings will require manual articulation in these segments, causing service delays.*

15.2 Appendix B: Light Rail Transit Asset Replacement Schedules

Category	Sub-Category	Element	Sub-Element	Average Agency Useful Life	Number of Rehabs
Facilities					
	Buildings			40	1
		Misc.	Misc.	20	1
		Building Components			
			Electrical	40	0
			Elevators and Conveying	25	0
			Fencing	15	0
			Generators	15	0
			Major HVAC	40	0
			Minor HVAC	40	0
		Maintenance			
			Rail Light Rail	45	1
	Equipment			15	0
		Furniture		12	0
		Maintenance			
			Air Compressor	25	0
			Lifts – Fixed	20	0
			Lifts - Portable	7	0
			Misc Equip	25	0
			Rail Light Rail	10	0
			Vehicle Paintbooth	20	0
		MIS/IT/Network Systems			
			Computers/Hardware	6	0
	Storage Yard	Rail	Light Rail	20	1
Guideway Elements					
	Guideway				
		At Grade/In-Street			
			Grade Crossing Light Rail	20	0
			Ductbank	80	0
		Elevated Structure			
			Bridge Light Rail	80	0
			Footwalk	80	0
		Retained Cut	Box Culvert	80	0
	Special Structures	Retaining Walls		40	0

	Trackwork				
		Misc.	Misc.	50	0
		Ballasted			
			Curve	20	0
			Tangent	30	0
		Direct Fixation	Tangent	30	0
		Embedded	Tangent	30	0
		Yard		70	0
Stations					
	Access				
		Light Rail		30	0
		Parking	Lot	20	1
		Pedestrian Walkway		80	0
		Roadway Access		20	1
	Building				
		Building Components			
			Building Electrical	60	0
			Lighting	50	1
			Other	20	1
			Shelter	20	0
	Platform	At-Grade	Side Platform	35	1
	Signage & Graphics			20	0
Systems					
	Communications				
		Misc.		12	0
		Cable Transmission System (CTS)			
			Fiber Optic Cable Transmission System	20	0
			MIS/IT/Network Systems	15	0
		Passenger Communications Systems	Public Address (PA)	10	0
		Radio	Mobile Radios	10	0
		Safety and Security			
			Misc.	20	0
			CCTV	20	0
	Electrification				
		Misc.	Light Rail	40	0
		Catenary	Light Rail	40	0
		Overhead Catenary	Pole Grounding	50	0

		Power Cable		40	0
		Substations	Light Rail	40	0
	Revenue Collection				
		In-Station			
			Faregates	20	0
			TVMs	20	0
	Train Control				
		Interlockings		40	0
			Switch Heaters	40	0
			Switch Machines	20	0
		Roadway Crossings	Light Rail	25	0
		Wayside Train Control	Power Supplies – UPS	40	0
	Utilities	Lighting	Station	25	0
Vehicles					
	Non-Revenue Vehicles			6	0
		Special		20	0
		Truck		10	0
	Revenue Vehicles	Light Rail			
			LRV 1991-1992	40	4
			LRV 1992-1993	39	4
			LRV 1998-1999	35	4

15.3 Appendix C: SOP & Master PM Catalogs

pw:\\mtapwint2:MTA_PW_Data\Documents\20 - Agencywide\Asset Management\Lifecycle Management Plans\Light Rail\

15.4 Appendix D: Design Stage Plan Requirements

MTA Maryland

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*

15.5 Appendix E: Detailed Summary of Transit Asset Conditions

Category, Sub-Category & Element	Avg. Condition
Vehicles	3.32
Revenue Vehicles	3.35
Light Rail	3.35
Non-Revenue Vehicles	2.21
Special	2.97
Truck	2.06
Facilities	3.92
Equipment	2.66
Furniture	1.64
Maintenance	3.06
MIS/IT/Network Systems	2.48
Buildings	4.04
Misc.	3.49
Building Components	3.16
Maintenance	4.13
Storage Yard	3.68
Rail	3.68
Systems	3.65
Communications	3.58
MIsc.	1.65
Cable Transmission System (CTS)	4.40
Passenger Communications Systems	1.70
Radio	3.86
Safety and Security	3.41
Electrification	3.60
Misc.	3.60
Catenary	3.37
Power Cable	3.01
Substations	3.70
Train Control	3.71
Interlockings	4.01
Roadway Crossings	2.89
Wayside Train Control	4.61
Utilities	4.84
Lighting	4.84
Stations	3.07
Access	3.03
Light Rail	3.00
Parking	2.94
Pedestrian Walkway	4.33
Roadway Access	2.01
Building	2.96
Building Components	2.96
Signage & Graphics	3.01
Misc.	3.01
Platform	3.21
At-Grade	3.21

Category, Sub-Category & Element	Avg. Condition
Guideway Elements	3.77
Guideway	4.16
At Grade-In-Street	3.99
Elevated Structure	4.17
Retained Cut	4.07
Trackwork	3.58
Misc.	3.70
Ballasted	2.67
Direct Fixation	2.89
Embedded	2.89
Yard	4.15
Special Structures	3.37
Retaining Walls	3.37
Grand Total	3.64

15.6 Appendix F: Prioritized Summary of Recommendations

NO.	TOPIC	CORRESPONDING TAMP STRATEGY	RECOMMENDATION
1	Maintain Transit and Land Asset Inventories	1	Light Rail 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, Light Rail needs to maintain a high level of data quality that ensures Transit Asset records have accurate: names, quantities, acquisition costs, and in-service dates. *The Data Working Group will provide more refined recommendations on policies, procedures, and roles of personnel.*
2	Asset Condition: Perform Physical Inspection	3	Light Rail should compare all TERM Lite condition estimate data against perceived physical condition. For those Transit Assets where Light Rail is producing an inaccurate estimate of condition, Light Rail will perform a structured and comprehensive physical condition assessment of those assets. MTA will provide standards on physical inspection methodology.
3	Critical Assets: Maintenance Regimes	4	Light Rail should reassess maintenance procedures for all Critical Assets and supplement these regimes when necessary. Light Rail will give priority consideration to its trackwork maintenance regimes. MTA will provide guidance on appropriate maintenance regimes for Critical Assets.
4	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, Light Rail should assess new threshold values for automatic parts ordering based on cyclic scheduled maintenance needs, as detailed in Section 9.3.1 above.
5	Reinstitute Dedicated Maintenance Training Staff and Program	3	In the past, Light Rail had a staff person dedicated to training union labor on safe and proper maintenance procedures, use of equipment, and techniques. Light Rail 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.
6	Employ an Enterprise Risk Management (ERM) Approach	2	Light Rail should employ an ERM approach to identify and quantify all risks, then select the highest risks for mitigation. *MTA will provide a standardized methodology and milestones.*
7	Critical Assets: Infill SOP and Master PM Gaps	4	Light Rail 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.
8	Make SOPs directly available on Maximo	NA	Light Rail 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.
9	Performance Monitoring: Ensure Consistent Documentation of Labor Hours	11	Light Rail 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. *MTA will provide additional guidance on the methodology for calculating these KPIs.*
10	Performance Monitoring: Correctly Use Corrective Maintenance (CM) Work Orders	11	Light Rail 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. Light Rail should also standardize these procedures across all departments. This will ensure accurate calculation of associated KPIs. *MTA will provide additional guidance on the methodology for calculating these KPIs.*
11	Data Management: Improve Work Order QA/QC	10	Light Rail should explore the feasibility of customizing Maximo so that the completion QA/QC on a work order by a supervisor can be electronically recorded; Light Rail will also explore the feasibility of a corresponding report of the number of work orders audited by supervisor. *MTA will provide additional guidance on the feasibility of these customizations.*
12	Improve Succession Planning	3	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.
13	Asset Condition: Implement FTA Rating Scale	3	Each Light Rail department, coordinated by management, should implement FTA's standardized 1-5 point rating scale for evaluating Transit Asset physical conditions. *MTA will provide standards for replicating unique Transit Asset class scales across all modes and departments.*
14	Asset Condition: Train Staff	3	Light Rail should train all maintenance personnel how to utilize FTA's 1-5 point scale for their respective Transit Asset classes. *See Recommendation #3.*
15	Asset Condition: Make Data Sheets Compatible with FTA Condition Rating Scale	3	Light Rail 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. *See Recommendation #3.*
16	Data Management: Develop Warranty Program	10	Light Rail should develop methods and tools for efficiently tracking warrantees associated with Transit Assets and spare parts. *MTA may provide programmatic guidance.*
17	Provide Supervisor Training on Part Ordering and Capital Project Submission	4	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) *Capital Programming's* Call for Projects and how to develop/submit SGR projects.
18	Data Management: Allow Contractors the Use of Maximo	NA	Light Rail 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. *MTA and MDOT will provide additional guidance.*
19	Condition: Identify Obsolete Transit Assets	3	Light Rail 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 *Office of Planning and Programming* to ensure a commensurate revision of the MTA Transit Asset inventory and may influence how Light Rail structures its funding requests thereafter. *MTA to provide additional guidance on making these determinations with obsolete Transit Assets.*
20	Document Existing Data Systems and Needs	10	Light Rail depends on numerous disparate spreadsheets and databases to track TAM-related information. Light Rail 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. *MTA to provide guidance.*
21	Adopt Recommended Key Performance Indicators (KPIs)	11	Light Rail and MTA should adopt recommended asset related KPIs as outlined in Section 7.2.
22	Develop Performance Modeling Data Capture Plans	11	Light Rail 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.
23	Develop PF Track Circuit Contingency Plans	NA	The Power Frequency track circuits to the North and South of the Central Business District enable automated operations and safety systems. However, they are obsolete; no spare parts are available. Light Rail should worth with *Safety* and *Engineering* to develop a contingency plan for how to handle a possible failure of these Power Frequency track circuits.
24	Establish Universal Transit Asset Specifications	NA	The Light Rail 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. Light Rail 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.
25	Develop Capability for Visualization of Linear Assets	NA	Light Rail should participate in the development of an agency-wide strategy for managing and visualizing linear assets. *MTA to provide guidance.*
26			Currently Systems Maintenance Department conducts PMs throughout the mainline on a given

	Synchronize Systems Maintenance to a Geographic Methodology	NA	day. To improve efficiency SMD should group their maintenance based upon geography, working systematically along the mainline. See Catenary maintenance methodology.
27	Standardize Maintenance Terminology	NA	Light Rail 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.
28	Critical Assets: Improve Third-Party Contract Language	4	Light Rail should reassess all contracts concerning Critical Assets and insert Reliability, Availability, Maintainability, and Safety (RAMS) specifications into the contract language as each 3rd part contract is renewed. *MTA will provide guidance on appropriate RAMS specification language.*
29	Consistently Use of Mainline Demarcation	NA	Light Rail should standardize the use of chainmarker boundaries when denoting between track segments 1-5 across all departments.
30	Store Data Sheets Electronically	3	Light Rail should eliminate the practice of only archiving hard copy Data Sheets. Until MTA provides additional guidance, Light Rail should store electronic copies of Data Sheets on ProjectWise.
31	Perform Third-Party Contractor Cost-Benefit Analyses	NA	Light Rail and MTA should implement a comprehensive cost-benefit evaluation of conducting maintenance either in-houses versus through a contractor.