

DRAFT RAIL FLEET MANAGEMENT PLAN FY2013-FY2035

AUGUST 2, 2013
Version 6



Metro Rail lines and stations	
	Red Line
	Purple Line
	Blue Line
	Green Line
	Gold/Expo Line
	Crenshaw Line
	Alignment Options Under Study
	Transfer Station

CIRCA 2035 Subject to Change

Rail Fleet Management Plan

Revision History

Revision	Date	Changes	Notes
Initial	June 23, 1997	All	
1	February 25, 2004	All	
2	June 5, 2009	All	Final
3	October 8, 2010		
4	August 23, 2011	Update	Draft
5	November 1, 2012	Update	Draft
6	August 2, 2013	Heavy Rail Update/Excerpt	Draft

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Acronyms

AC	Alternating Current
AL	Subway Track Alignment Left (from Union Station Westbound)
AR	Subway Track Alignment Right (from Union Station Eastbound)
CPUC	California Public Utilities Commission
DC	Direct Current
Expo	Exposition Line
FTA	Federal Transit Administration
FY	Fiscal Year
HRV	Heavy Rail Vehicle
HVAC	Heating-Ventilation-Air Conditioning System
LACMTA	Los Angeles County Metropolitan Transportation Authority (AKA "Metro")
LAX	Los Angeles International Airport
LRTP	Log Range Transportation Plan
LRV	Light Rail Vehicle
MMBF	Mean Miles between Failures
OSR	Operating Spare Ratio
PMP	Preventive Maintenance Program
PVR	Peak Vehicle Requirement
RFMP (Plan)	Rail Fleet Management Plan
RFS	Rail Fleet Services
ROCC	Rail Operations Control Center
VDC	Voltage – Direct Current

1.0 Introduction

The Los Angeles County Metropolitan Transportation Authority (LACMTA or Metro) has determined the current and future rail vehicle fleet requirements, vehicle fleet spare percentage and maintenance practices, based on guidelines set forth by the Federal Transit Administration (FTA). This document has been developed according to the requirements of FTA Circular 5200.1A and in accordance with the March 2, 1999 FTA Guidance for Rail Fleet Management Plans.

The scope of this document, in this version, includes Metro's Heavy Rail services currently operating and those planned to begin operation before the conclusion of FY 2035. Metro's Light-Rail system will be provided in the next update to this Plan, which is anticipated prior to the end of the year. The purpose of providing a "Heavy Rail only" version at this time is to advance 'project readiness' in a fastidious manner and enable funding stakeholders to consider vehicle requirements. This update reflects the change that the Purple Line Extension project will be constructed and opened in three (3) segments over a 12-year period, FY2023 through FY2035, rather than as a single segment.

This Rail Fleet Management Plan (RFMP or Plan) is considered a living document to be reviewed annually and updated as necessary. The timeframe covered is FY 2013 through FY 2035, which satisfies the minimum 10-year coverage period required by the FTA Guidance.

This version continues Metro's approach to examine a broader time frame to coincide with the build-out year of many of the projects discussed in this plan. Unless otherwise stated, all information related to Fiscal Years (FY) noted on tables and appendices should be considered as ending June 30 of the year in reference.

Future events or occurrences that may require an update to the Plan include (but are not limited to):

1. New vehicle procurements
2. Retirement of existing vehicles
3. Rebuild, rehabilitation or overhaul programs
4. Fleet configuration changes or manufacturer modifications
5. System changes
6. Service delivery changes that impact peak vehicle requirements, vehicle mileage or passenger load factors
7. Changes to the spare ratio

The Plan has three primary purposes: 1) to describe and evaluate Metro's existing rail operations and maintenance facilities; 2) to identify and outline the current and future revenue vehicle fleet and facility requirements; and 3) to become a source for capital and operating budget preparation.

Presentation of future fleet size requirements and maintenance practices enables LACMTA to effectively and efficiently plan and budget for, and the Federal Transit Administration to clearly oversee, the mid and long term vehicle procurement needs necessary to support revenue service. Vehicle requirement projections allow associated procurement processes to be initiated in timely fashion to allow for adequate vehicle availability when service expansions or new projects are expected to be operational, in turn maintaining high quality rail transit service delivery.

2.0 System Overview

The purpose of Section 2 in this Plan is to provide an overview of the Metro Rail system, including both the existing system and the future planned system. As noted in Section 1, the Metro Rail system is composed of both light-rail and heavy rail lines. Initial lines commenced service in July 1990. Additional lines and expansion to services followed thereafter. Section 3 and Section 4 provide more detail concerning the light-rail and heavy rail systems respectively.

2.1 Existing Metro Rail System

Combined, there are more than 84 miles of revenue service track, with 83 stations. Average weekday boarding's surpass 350,000 and annual total boardings surpass 110 million.

FY2014 Metro Rail System



Note: Metro Rail existing rail system, including lines under construction.

2.2 Future Metro Rail System

The Los Angeles County Metropolitan Transportation Authority is currently active in numerous expansion efforts of the rail network and services. Currently, two rail line extensions are under construction, two projects are currently 'in procurement' for construction, one project will enter 'procurement by year end (2013)', three lines are in advanced planning phases, and two lines are undergoing Alternatives Analysis or refinement studies. Each of the projects is identified in Measure R and the LACMTA 30-Year LRTP.

Moreover, LACMTA is pursuing efforts to accelerate the delivery of the projects that are in advanced planning or Alternative Analysis phases whereas they would be completed within the next 10 years. Initially, this was called the "30-10 Initiative". This initiative was later rebranded as "America Fast Forward". This Plan is consistent with the 30-10 Initiative and America Fast Forward with respect to advancing proposed implementation dates of rail projects identified in Measure R and the LACMTA 30-Year LRTP; however, with one exception.

This Plan assumes the Purple Line Extension project will be delivered in three segments rather than one. This is a change from the previous Plan and represents the purpose of this update. As noted in Section 1 of this Plan, the purpose of this update is to provide essential information to support 'project readiness' in a fastidious manner and enable funding stakeholders to consider vehicle requirements.

Of note, the 30-10 Initiative identified two new projects, the West Santa Ana Branch Corridor and the I-405/Sepulveda Pass Corridor. However, at present neither is adequately defined for this Plan and is not included in future fleet requirements at this time. Additionally, the LRTP included another project, the East San Fernando Valley Transit Corridor; however, a mode has not been selected and is also not included in future fleet requirements at this time.

Anticipated rail projects within the life of this plan are identified in the following table and discussed in more detail in Section 4 for Light-Rail or Section 5 for Heavy Rail Subway.

Table 2.1: Metro Rail Projects

Project	Mode	Status	Anticipated Year of Delivery
Gold Line Foothill Extension; Phase 2A to Azusa	Light-Rail	Under Construction	FY2016
Exposition Line Extension, Phase 2 to Santa Monica	Light-Rail	Under Construction	FY2016
Crenshaw Line	Light-Rail	Notice to Proceed for Construction anticipated Summer 2013	FY2020
Regional Connector	Light-Rail	Notice to Proceed for Construction anticipated Late 2013	FY2020
South Bay Extension (Crenshaw Line)	Light-Rail	Draft EIR/EIS In Review; LPA Pending	FY2020
Gold Line Foothill Extension; Phase 2B to Claremont	Light-Rail	Final EIR Issued; Funding Pending	FY2022*
Gold Line East LA Extension; Phase 2	Light-Rail	Draft EIR/EIS In Review; LPA Pending	FY2022
Airport Metro Connector	Light-Rail	Alternatives Analysis Refinement Study	FY2023
Purple Line Extension; Segment 1 to La Cienega	Heavy Rail	Notice to Proceed for Construction anticipated 2014	FY2023
Purple Line Extension; Segment 2 to Century City	Heavy Rail	Final EIR/EIS Pending	FY2026
Purple Line Extension; Segment 3 to Westwood/VA	Heavy Rail	Final EIR/EIS Pending	FY2035 (Pre-Revenue)

Note: Dates subject to change depending on project readiness.

The following map depicts the FY2035 Metro Rail system assuming each of the above cited projects are delivered. Metro Rail maintenance and storage facilities are included. As noted above, Section 3 and Section 4 provide more detail concerning the light-rail and heavy rail systems respectively.

FY2035 Metro Rail System



Note: Respective of the east end of the Gold/Exposition Line, the line would have one end terminal and not two as shown. Although only one alignment option would be selected, each option is depicted.

4.0 Heavy Rail Subway System

The purpose of this section is to provide a plan about how Metro will manage the Heavy Rail fleet through FY2035. A similar plan for the Metro Light-Rail system is provided in Section 3. This Section has the following subsections and can be located per the following page references.

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4.1 Heavy Rail Lines in Revenue Service

Metro’s Heavy Rail system is composed of the Red and Purple lines. These lines share a trunk segment in Downtown Los Angeles consisting of 3.9 miles and serving six (6) stations. The FY2013 average daily boardings on the combined lines are over 157,000 riders and annual ridership is 49.6 million. Key characteristics of each line are described in the following table.

Table 4.1: FY2013 Heavy Rail System Select Characteristics

	Red Line	Purple Line
Terminal	Union Station to North Hollywood	Union Station to Wilshire/Western
Peak Period Service Level	10 min hdwy; 6-car	10 min hdwy; 4-car
Stations Served	14	8
Miles of Line Service	14.9	5.0
No. of Peak Trains	7+2	4
No. of Peak Vehicles*	54	16
Average Daily Ridership	117,427	39,762

Note: “No. of Peak Trains” includes Gap/Reserve trains. This table cites “2” Gap/Reserve trains assigned for the Red Line.

See **Appendix 7** for the heavy rail peak hour scheduled service and projected ridership by line for FY 2013-2035. See **Appendix 8** for the heavy rail travel time and peak schedule cycle time by line.

4.2 Heavy Rail Maintenance Facilities

Metro currently has one heavy rail maintenance facility serving the **Red and Purple Lines**. Vehicle storage, inspection, and repair occur at the Heavy Rail Maintenance Facility (Division 20), 1 mile south of Union Station in Downtown Los Angeles. All activities associated with the maintenance of the Heavy Rail Vehicle Fleet are supported at this facility. Total practical capacity at this facility is 200 vehicles with respect to current layout and configuration.

4.3 Heavy Rail Vehicle Fleet

There are 104 Breda A650 vehicles providing service for the **Red and Purple Lines**. The first 30 have an average age of 20 years (date of acceptance), with an average of more than 660,000 operating miles per car. The remaining 74 HRVs have an average age of 14 years (date of acceptance), with more than 996,000 operating miles per car. These vehicles are capable of operating up to 70 miles per hour.

Each vehicle is designed to accommodate a crush load of 175-200 passengers; however, are scheduled to reasonably accommodate up to 131 passengers (55 seated) during peak service hours.

The vehicles are designed for high-level platform boarding and are operated in two, four, or six car consists. Each vehicle is primarily built with a stainless steel shell, approximately 75 feet long, 10 feet – 4 inches wide and 12 feet – 7 inches tall, weighing 80,000 pounds empty. Power is collected from an energized third rail via a contact shoe on the truck, leading to DC propulsion equipment operating at a nominal voltage of 750 VDC. Two vehicles are combined into a permanent married pair, with shared vital systems. Each vehicle has one Train Operator cab, opposite to the end that is permanently connected with the other car.

Table 4.2: Heavy-Rail Vehicle Fleet

Manufacturer	Model	No. of Vehicles	Average Miles per Vehicle	Year Placed in Service
Breda	A650	30	660,000	1993
Breda	A650	74	996,000	1999

Note: Average Miles per Vehicle is current estimate provided through June 2013.

The first 30 vehicles acquired by LACMTA are DC powered. The remainders are AC powered. Due to inconsistent wear-and-tear and maintenance requirements between the set of vehicles,

Metro has increasingly not deployed vehicles among the first 30 for revenue service, and retained them for longer maintenance cycles. As typical, presently as many as 12 of 30 vehicles are undergoing maintenance cycles and are unavailable for revenue service. Therefore, vehicles among the first 30 have not accumulated as many miles in recent years. To alleviate maintenance matters and prolong the life of the fleet, LACMTA plans to begin a component overhaul program of this fleet in FY 2013 through FY 2016. Rebuild plans are discussed in more detail in Section 4.10.

4.4 Heavy Rail System Expansion

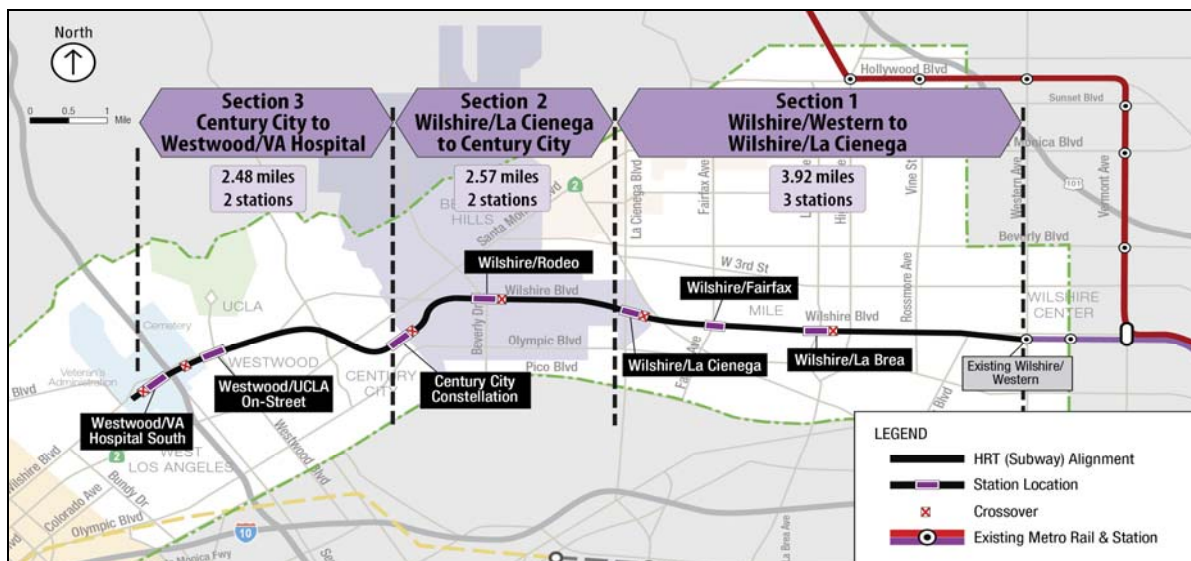
As cited in Section 2 of this Plan, LACMTA is active in numerous expansion efforts of the rail network and services, including an expansion of the heavy rail subway system. Expansion includes a singular project, the Purple Line Subway Extension. The Purple Line Subway Extension is summarized in the following sub-section. There are no other planned Heavy Rail expansion projects considered in this Plan.

Purple Line Subway Extension

The Purple Line Subway Extension, formerly known as the Westside Subway Extension, is a 9-mile heavy-rail subway project undertaken by Metro. It is located east of Downtown Los Angeles along the Wilshire corridor. Included is a 'Turnback Facility' at a new eastern terminus so-as to enable the planned project feature to operate a 4-minute headway.

This Plan reflects the recent change to deliver the project in three segments. Previous versions of this RFMP planned that the project would be delivered as one project. As currently planned, Segment 1 would be delivered in FY2023, Segment 2 in FY2026 and Segment 3 in FY2035. The map below shows the project location, including segments.

Purple Line Subway Extension; Segments 1-3



The Purple Line Subway Extension Segment 1 from Wilshire/Western to Wilshire/La Cienega is readying itself for construction. Early action items include utility relocations and an exploratory shaft, which commenced in early 2013. This first segment includes three new stations and is planned to open in FY2023. Additionally, certain functions that are currently in place for the Turnback Facility will be relocated. Construction of the Turnback Facility itself will occur immediately afterwards and this Plan targets use of the Turnback Facility in FY2020.

The Purple Line Subway Extension Segments 2 and 3 are planned to occur after Segment 1. The Final EIR/EIS for Segment 2 and 3 have been presented to the LACMTA Board of Directors.

Metro needs to expand its fleet in order to serve the subway system and the Purple Line Subway Extension. Service levels and accompanying vehicle requirements will be tied to service demand with the Red Line, though, noted is that a planned project feature of the Purple Line is to operate 4-minute headways is a driving factor. Provided current ridership forecasts, conceivably, the Red Line could provide sufficient capacity at a lesser headway. Table 4.3 provides key planned service characteristics for the subway network and aligned with the opening, or commencement of pre-revenue service of each segment.

Table 4.3 Heavy Rail Expansion; Planned Service Characteristics

	FY2016-FY2019 Existing Plan	FY2020-FY2022 Turnback	FY2023-FY2025 Segment 1	FY2026-FY2034 Segment 2	FY2035 Segment 3
Service Level					
<i>Purple Line</i>	6min hdwy; 4-car	6min hdwy; 4-car	4min hdwy; 4-car	4min hdwy; 4-car	4min hdwy; 6-car
<i>Red Line</i>	6min hdwy; 4-car	6min hdwy; 4-car	4min hdwy; 4-car	4min hdwy; 4-car	4min hdwy; 6-car
Stations					
<i>Purple Line</i>	8	8	11	13	15
<i>Red Line</i>	14	14	14	14	14
Route Miles					
<i>Purple Line</i>	5.0	5.7	9.6	12.2	14.7
<i>Red Line</i>	14.9	15.6	15.6	15.6	15.6
Travel Time (1-way)					
<i>Purple Line</i>	13 minutes	17 minutes	23 minutes	28 minutes	33 minutes
<i>Red Line</i>	29 minutes	33 minutes	33 minutes	33 minutes	33 minutes
Cycle Time					
<i>Purple Line</i>	36 minutes	42 minutes	52 minutes	64 minutes	72 minutes
<i>Red Line</i>	66 minutes	72 minutes	72 minutes	72 minutes	72 minutes
No. of Pk Trains					
<i>Purple Line</i>	6	7	13+1	16+1	18+1
<i>Red Line</i>	11+2	12+2	18+2	18+2	18+2
No. of Pk Veh.					
<i>Purple Line</i>	24	28	56	68	114
<i>Red Line</i>	<u>52</u>	<u>56</u>	<u>80</u>	<u>80</u>	<u>120</u>
<i>subtotal</i>	76	84	136	148	234
Veh. Fleet Total	104	104	162	178	280

Notes: The Turnback Facility will add 0.7 miles of Route Miles and 4 minutes one-way travel time (rounded) for each line. For "No. of Pk Trains", no interlining is presently assumed. Gap/Reserve trains are included in "No. of Pk Trains" as indicated by the "+" symbol. "Veh. Fleet Total" includes a 20% Spare Ratio. Planned Service Characteristics will be updated to reflect the latest project changes or ridership trends and forecasts.

Due to having a shared track alignment, each line will be required to operate compatible headways. Based on current understanding of extension, including the use the Turnback Facility and minimum capacity objectives, the total heavy rail fleet size will need to increase from 104 vehicles to 280 vehicles by the end of this Plan.

4.5 Heavy Rail Maintenance Facilities in Development

LACMTA has one maintenance yard for HRV's, Division 20. Under the current layout and configuration, Division 20 has capacity for 200 HRV's. At present, 104 HRV's are maintained at Division 20.

Additional HRV's will be added to the fleet and maintained at Division 20. The Purple Line Subway Extension will expand upon the length of the railway, increase the number of stations served, and, enable a 4-minute peak period headway. Assuming 4-car operations on each of the Red and Purple lines, the system total peak fleet requirement would be 182 vehicles. Assuming 6-car train operations on each of the Red and Purple lines, the system total peak fleet requirement would be 280 vehicles.

As currently portrayed in this Plan, 4-car train operations will be sufficient to provide the necessary capacity through approximately FY2034. However, commencing with the Purple Line Subway Extension, Segment 3, and Pre-Revenue Service in FY2035, this Plan portrays the need to operate 6-car consists. The need is based upon current ridership trends and ridership modeling conducted for the Purple Line Subway Extension project.

Although Division 20 does not require expansion for approximately 15-20 years, advanced preliminary engineering efforts have identified how Division 20 can be improved. The facility could be expanded to accommodate 284 HRV's. This assumes condemnation of property to the south. Additionally, the existing maintenance building shop areas could have the number of maintenance bays expanded from 36 to 52. Advanced preliminary engineering efforts revealed that sufficient room is available within the building for increased transportation and rail fleet services staff.

Adjacent to Division 20 are separate Metro facilities. Functions provided at the adjacent site are Maintenance-of-Way parts storage, Gold Line parts storage, and non-revenue vehicle maintenance. To support the Turnback Facility, these functions will be relocated to the south-end of Division 20. It is anticipated that the relocated facilities will be operationally in approximately FY2018.

As previously noted, this Plan is a living document. This Plan will revise operational forecasts as necessary to reflect the ridership trends and other available information.

As noted in this section, this plan forecasts a future need to expand Division 20. Given a forecast for multiple competing interests for space in the vicinity, Metro will initiate a Master Plan for the area to consider alternatives. Forecasted competing interests for space include a high-speed rail alignment, consideration of a new Red and Purple Line station south of Division 20, heavy-rail test track, and a revitalization of the Los Angeles River flood channel to convert to a recreational corridor.

4.6 Heavy Rail System Vehicle Requirements

Metro’s heavy rail fleet currently consists of 104 vehicles. As discussed in previous sections, the heavy rail system will be expanded and service levels will be increased. Table 4.4 depicts the Heavy Rail Fleet size over time, including necessary fleet expansion. Due to the lead time to acquire vehicles, and the numbers involved, it is necessary to initiate procurements efforts far in advance for project implementations. As a result, some vehicles are delivered many years in advance of the Westside Purple Line Extension project.

Table 4.4: Heavy-Rail Fleet Size over Time

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23 - FY29	FY30 - FY35
Heavy-Rail Fleet Size	104	104	104	104	104	104	104	104	104	104	104	104
<i>Unavailable/Rebuild</i>				-12	-12	-12						
<i>Fleet Expansion A</i>						+24	+48	+72	+74	+74	+74	+74
<i>Fleet Expansion B</i>												+102
<i>Available</i>	104	104	104	92	92	116	152	176	178	178	178	280

Note: Fleet Expansion A would support service adjustments consistent with operating the Purple Line Subway Extension through Segment 2 to Century City, including headway capacity adjustments. Fleet Expansion B would support service adjustments consistent with the Purple Line Subway Extension Segment 3 to Westwood/VA and transitioning from 4-car consists to 6-car consists. Vehicle replacements are not included in this table.

The approach used to determine the fleet size is outlined beginning in Section 4.7.

4.7 Demand for Revenue Vehicles

The demand for revenue vehicles has been estimated for the previously stated scope of this document. Using the process outlined by the FTA’s 1999 Guidance, the following eight-step methodology has been applied to the Metro’s rail system:

- Step 1: Determine peak-hour/peak direction ridership load.
- Step 2: Define service standards for vehicle loading.
- Step 3: Determine vehicle run times.
- Step 4: Determine the number of vehicles required to meet the service standards for vehicle loading and frequency at the peak hour/peak direction load point.

- Step 5: Determine peak vehicles required based on headway and consist size to meet vehicle loading criteria
- Step 6: Determine the requirements for reserve trains and add them to the vehicles required for revenue service to calculate the Peak Vehicle Requirement.
- Step 7: Define and determine the target maintenance fleet and calculate the spare vehicles required.
- Step 8: Determine the total fleet demand and operating spare ratio

This process has been specifically applied to meet the needs of Metro's rail system and relies on actual vehicle loading observations, boarding estimates derived from ride checks, boarding projections, maintenance data and estimates, actual and projected run times. This Plan will be revised as appropriate and will include additional operating and planning data as it becomes available.

Step 1: Peak Hour / Peak Loading

Ridership information is collected by the Service Performance Analysis Section of the Service Planning and Development Department. Schedule Checkers are assigned to count boardings and alightings at least once on every rail car and every revenue trip over the course of a year, using a random sampling method. The data is then entered into a rolling database that is updated monthly, reflecting the collected data from the previous month. Ticket Vending Machine receipts are then used to verify the most recent results of the data collection.

Projected line boardings are generated from current boarding estimates, historical trends, future system improvements and new project ridership modeling. The peak hour ridership percentage is then applied to projected line boardings to determine the projected number of passengers traveling during the peak hour in the peak direction.

The results of these actual counts and projections are shown for each line in the ridership tables in **Appendix 7**. The tables show, for each year, both the weekday average passenger load and the maximum Peak Hour / Peak Direction passenger count that is used for calculating maximum hourly vehicle need to meet the rail passenger loading standards that are described in the following step.

Respecting Purple Line Peak Hour Loading, **Appendix 7** relies on a ratio that can be produced from modeled projections for the Subway Extension project Segments 1, 2 and 3. The ratio, which is consistent with the model, is re-applied to a revised forecast for average daily ridership. This was determined necessary because recent ridership trends have surpassed the usefulness of the base model, which originates from FY2006 observations. Table 4.5 references the major milestone events for the Purple Line that effect the 1-hour Directional Load to Daily Ratio.

Table 4.5: Purple Line 1-Hour Directional Load Ratio

	FY 2013 Existing	FY 2020	Segment 1 Wil/La Cnga	Segment 2 Century City	Segment 3 Westwood/VA
Average Daily Ridership	40,145	38,487	60,000	79,500	114,000
Peak Hour Peak Direction Load	1,791	1,386	2,290	3,473	5,671
1Hr Directional Load to Daily Ratio	4.5%	3.6%	3.8%	4.4%	5.0%

Note: The Regional Connector becomes operational in FY 2020 and results in efficiencies whereas the Purple Line observes a decrease in patronage. Passengers begin using the Blue/Expo/Gold network in greater numbers.

Step 2: Peak Period Service Loading Standard

Passenger loading standards are used to determine scheduled service requirements respective to the number of people that can be expected to board each rail car and whereas station dwell times remain within expected parameters. Typically, the determined capacity includes a fully seated passenger load, along with a significant number of standing passengers. The number is expressed in terms of percentage in excess of a seated load or as a “Load Factor.” Standards have been established based on observation of peak period loading and an assessment involving the safe and efficient egress and ingress of passengers at door locations.

Table 4.6: Heavy Rail Peak Hour Load Factor and Passengers per Vehicle

Load Factor	Seated Passengers	Standees	Total Passengers
2.30	55	74	131

Metro is currently reviewing plans to reconfigure the seating arrangement aboard trains to accommodate disabled passengers and those with large items. Reconfiguration will include removal of up to five (5) seats; however, it is anticipated that there will be no adjustment to “Total Passengers” per vehicle. The Load Factor would be adjusted accordingly.

Peak Hour load factors are shown for each line in the ridership tables in **Appendix 7**, “Vehicles required –131 for heavy rail row. Load Factors are used to determine the vehicles required to meet peak period ridership.

Step 3: Cycle Times

Minimum train cycle time is calculated from terminal to terminal directional run times and the minimum required turn-around time at each terminal. System-wide travel times and peak period cycle times are affected by various system design characteristics involving train control, terminal crossover design and location, security, platform design issues, and the need for operators to relocate to the opposite ends of a train at terminals.

Track layouts at terminals provide an additional parameter in determining cycle times. These are highlighted below:

- **Red Line-Purple Line** Union Station – the terminal will be required to cycle trains (includes alighting, security sweep, logistical move from Platform AL to Platform AR via Yard Lead tail tracks, boarding) an average of every 3 minutes through the life of the RFMP.
- **Red Line-Purple Line** Division 20 Turnback – the terminal will be located in Division 20 Yard area via a set of non-revenue track leads on an existing alignment. The Turnback terminal will need to cycle trains every 2 minutes per estimated planned 2035 build-out year service levels.
- **Red Line** North Hollywood Station – the terminal will be required to cycle trains (includes alighting, security sweep, boarding), without support of complete tail track crossovers, an average of every 6 minutes through the life of the RFMP. The terminal will need to cycle trains operating on 4 and 6 minute headways per estimated planned 2035 build-out year service levels.
- **Purple Line** Wilshire/Western Station – the terminal will be required to cycle trains (includes alighting, security sweep, boarding), without tail tracks, an average of every 6 minutes.
- **Purple Line** Wilshire/La Cienega Station – the terminal will be required to cycle trains every 4 minutes using crossovers on the near side of the station. Or, on the approach side. No rear crossovers are provided; however, tail tracks will provide sufficient distance for safe braking distance for 4-car trains to enable arrivals at regular speed. Cycling trains includes passenger alighting, security sweep, and boarding.
- **Purple Line** Century City Station – the terminal will be required to cycle trains every 4 minutes using crossovers on the near side of the station. Or, on the approach side. No rear crossovers are provided.
- **Purple Line** Westwood – the terminal will be required to cycle trains operating every 4 minutes through the life of the RFMP. For the FY 2035 build-out year, the terminal will need to cycle trains operating on 4 minute headways per planned 2035 build-out year service levels.

The calculated run and terminal turnaround times, taking the above factors into account, are shown for each line in the Run Time Tables in **Appendix 8**. It should be noted that while the Northbound and Southbound run and terminal turn times shown in the tables will add up to the minimum needed cycle time, the actual cycle time shown for each line is that minimum time

rounded up to the nearest multiple of the headway. Lines not currently in service are subject to adjustment during the various project phases leading up to revenue service.

Step 4: Vehicles Required to Meet Peak Hour Demand

Using the peak hour/peak direction ridership from **Appendix 7** and the maximum passengers per car for the Load Factors, the number of vehicles required to pass the maximum load point in the peak hour is calculated. This calculated number is shown in the tables in **Appendix 7** in the “Vehicles Req’d. (131 Per Veh.)” row in the light rail tables and the “Red Veh. Req’d (131 Per Veh.)” row in the heavy rail table. These numbers represent the minimum vehicles required to meet demand for the provided load standard. As explained in Sub-Section 4.5, the actual number of vehicles operated is usually greater due to headway, interline logistics, and train length factors. Interline logistics may also affect service level and number of vehicles.

Step 5: Peak Vehicles Required for Scheduled Service

The peak vehicle requirement is the total number of trains needed to complete the operational cycle on a given line multiplied by the number of cars assigned to the trains.

The peak hour headways are not only determined by a combination of passenger volume through the peak load point, but also running time / travel time cycles, line junctions, trunk line, terminal crossover configuration and terminal capacity.

Heavy rail trains can be operated in two, four and six-car consists. All heavy rail station platforms allow for operation of six-car consists. Effective in FY 2014, Metro will operate the Red and Purple Line at 7/8-minute headways as 6-car consists during peak periods. Using the methodology described above for light rail, the calculated train requirement for the Red and Purple Line scheduled service in FY 2014 is 14 trains, resulting in a need for 56 vehicles for scheduled service. **Appendix 9** depicts this level of service through FY 2015.

Effective in FY 2016 through FY 2022, the Red and Purple Line will operate 6-minute headways, which will require more trains and cars. Lastly, the Red and Purple Line will require more trains effective with the Subway Extension in FY 2023 and the 4-minute headways planned for both lines. Each adjustment to rail service noted here is consistent with Table 4.3.

Step 6: Gap/Reserve Train Requirements

The vehicles required for scheduled service, calculated as described in Sub-Section 4.5, do not represent the full vehicle requirement for revenue service. As do most other transit systems, Metro stages Gap, or Reserve Trains at terminal stations, division yards, or sometimes both locations. The purpose of these staged trains is to quickly recover from the loss of a scheduled train or compensate for a delay in peak hour service. Location and the number of trains are based on operating experience.

The number of trains staged at terminals for each line for each year is shown in the “Reserve Trains- Terminal” rows in the tables in **Appendix 9**, and the number of trains staged at Division yards is shown in the “Reserve Trains-Division” rows. Similarly, the vehicle numbers for terminals and yards are shown in the “Reserve Vehicles-Terminal” and “Reserve Vehicles-Division” rows in the tables in **Appendix 9**.

Step 7: Spare Vehicle Requirements

In addition to vehicles needed for daily scheduled service and gap trains, vehicles are needed to replace those vehicles when they are required to undergo scheduled maintenance, repair (or unscheduled maintenance), overhaul, warranty work, or testing. These vehicles are usually referred to as operating spares and sometimes called the “maintenance fleet.” The operating spares are the total number of vehicles in the fleet above and beyond the peak vehicle requirement (scheduled plus gap), needed to maintain the peak vehicle requirement.

The number of operating spares required is determined by calculating those needed for scheduled maintenance procedures, overhaul programs, or other activities that can be scheduled, plus an estimate of those that will be needed to compensate for vehicles undergoing repair.

That said, as a product of FY 2012 service improvements during non-peak hours, whereas vehicles now operate more average daily miles and have less time allotted for maintenance staff access, Metro will undertake a study to determine best practices to manage each fleet. Possible outcomes could range from an adjustment to targeted spare ratios, physical improvements at maintenance facilities, or staffing. The study will additionally evaluate the implications for 24-hour service and Special Event services whereas vehicles will accumulate miles at greater rates and will increasingly be unavailable for maintenance purposes. The provisions for 24-hour service have not been determined; however, theoretically may be pursued within the next 2 to 8 years.

Step 8: Total Fleet Demand and Operating Spare Ratio

The combination of the peak vehicle requirement (PVR), which consists of the peak scheduled vehicle requirement and gap vehicle, and the operating spare (maintenance fleet) requirement results in the total vehicle requirement, or Total Fleet Demand. The Total Fleet Demand is the minimum number of vehicles required to meet service and maintenance needs. The Total Fleet is comprised of any all operational vehicles available and may be lower or higher than the Total Fleet Demand. The Operating Spare Ratio (OSR) is calculated by subtracting the PVR from the Total Fleet and then dividing by the PVR.

The addition of the vehicles for scheduled service and gap vehicle requirement to yield the PVR for each line for each year is shown in the “Total Vehicles-Revenue Service” rows in **Appendix 9**. The PVR is carried over as the top row in each table in **Appendix 10**, where it is added to the maintenance spares to obtain the Total Fleet Demand. This is shown in the “Vehicle

Demand – Revenue Service / Maintenance” row in each line table in **Appendix 10**. The Tables for each line also show the actual or projected Total Fleet size for each year in the row labeled, “Fleet Size (on property / ordered),” row in each table in **Appendix 10**. Finally, the OSR is calculated and shown in the bottom row of each table labeled, “Operating Spare Ratio (All Vehicles).

4.8 Supply of Revenue Vehicles

Metro’s heavy rail fleet size of 104 vehicles is sufficient to provide service levels planned in the near term and through FY 2022. However, as indicated in previous sub-sections, Metro will be required to expand the heavy rail fleet in order to support the Purple Line Subway Extension Segments 1 and 2, and, support 4-car consist lengths system-wide. Expanding the fleet to support Segment 3 will require procuring additionally vehicles, either 10 vehicles assuming 4-car consist lengths system-wide, or, 102 vehicles assuming 6-car consist lengths system-wide. Initial efforts to procure cars have already begun.

As part of the effort to procure additional cars, Metro is considering replacement of the two sub-fleets that compose the total Heavy Rail vehicle fleet. Metro’s sub-fleets consist of an original 30-vehicle ‘Base Buy’ set and a 74-vehicle ‘Option Buy’ set. If pursued, plans will also be advanced for dispersal of existing vehicles, which are typically sold to foreign transit operators for continued life, or, to local recyclers for repurposing materials.

Metro will also consider pursuing a 102-vehicle “Option Buy” to support Segment 3 and transitioning to a system-wide 6-car operational fleet. Table 4.7 summarizes the supply of vehicle and pending procurement.

Table 4.7: Heavy-Rail Vehicle Fleet & Pending Procurement

Manufacturer	Model	No. of Vehicles (purpose)	Year Placed in Service
Breda	A650	30	1993
Breda	A650	74	1999
Procurement			
<i>Base Buy</i> *	TBD	74 (Expansion)	FY 2018 – FY 2021
<i>Option Buy #1</i>	TBD	30 (Replacements)	TBD
<i>Option Buy #2</i>	TBD	74 (Replacements)	TBD
<i>Option Buy #3</i> *	TBD	102 (Expansion)	TBD

Note: The listed “Base Buy” and “Option Buy #3” figures are consistent with Table 4.3 and the row for “Veh. Fleet Total.” Figures are subject to change. “Option Buy #3” may be pursued as a new or separate procurement.

Of note, Metro is considering a mid-life rebuild project to continue the useful life of existing vehicles in Metro’s existing fleet. If pursued, the timing for the replacement of these vehicles will be reviewed. This scenario is discussed in more detail in Section 4.10.

A detail of the specific fleet assignment is shown in **Appendix 11**, on the “Total Vehicles Needed – System” row, heavy rail vehicle shortages do not occur. The vehicle requirement is driven by the Purple Line Subway Extension and a reduction in vehicles due to a Rebuild program. At this time, no service adjustments involving reserve trains, gap trains, and maintenance spare ratios are assumed respective of the need to accommodate the heavy-rail fleet Rebuild program.

Individual yard capacity, specific fleet assignments and number of vehicles are shown in **Appendix 12** – Projected Vehicle Distribution by Maintenance Facility.

4.9 Maintenance and Reliability

Heavy Rail maintenance activities are assigned to one location; Division 20 located in the Los Angeles Artist District.

The Preventive Maintenance Program (PMP) consists of regularly scheduled activities that are necessary to maintain the performance level of the vehicle and its components. Examples of typical activities include complete lubrication, calibration adjustments as required, and replacement of consumables such as air filters, brake pads/shoes, Pantograph Carbon Strips (Light Rail), and Third Rail Current Collector Shoes (Heavy Rail). Additionally, many items are subject to visual inspection and if necessary, repair and/or replacement. Table 4.8 shows the intervals between inspections for the heavy rail fleet.

Table 4.8 Heavy Rail Vehicle Service and Inspection Intervals (Miles)

Service/Inspection Interval	Breda HRVs
1	7,500
2	7,500
3	22,500
4	7,500
5	7,500
6	45,000
7	7,500
8	7,500
9	22,500
10	7,500
11	7,500
12	90,000

The specific activities for the various levels of PM inspections (i.e. 7,500; 15,000; 30,000 and 90,000 for Sumitomo/Siemens LRVs) are described in individual work order templates the M3 Maintenance Database, and are available as requested.

Fleet performance is measured by the Mean Miles Between Failures (MMBF) and on-time roll-out performance. Various categories, such as friction brake, propulsion, door, gearbox, circuit cards, Heat-Ventilation-Air Conditioning (HVAC) can be tracked in the M3 Data Management System, where trending can be monitored. Failure rates vary by vehicle type and line and are constantly monitored and addressed. Vehicle age, specific operating environment and systems technology each have impact on vehicle failure categories. The goal for RFS is to meet on-time roll-out for the Revenue Vehicle Service Requirement as indicated by line and shown in **Appendix 10**, on the "Revenue Vehicle Service Requirement" row.

Vehicle Requirement Compliance is monitored by the Rail Operations Control Center (ROCC) on a daily basis and reported to Rail Management on a daily basis, 99.99% is considered acceptable.

4.10 Heavy Rail Vehicle Rebuild Scenario

Metro is examining two separate efforts to rebuild or refurbish all heavy vehicles. Some flexibility with the fleet is available to allow multiple vehicles to be removed from service; however, Metro shall manage rebuilding efforts to always assure sufficient availability remains so that revenue service can continue without interruption.

The initial effort is a parts overhaul or replacement project to be applied to the first 30 heavy rail vehicles procured by Metro; however, will not affect the ongoing fleet availability. Instead, the parts overhaul and replacement effort will occur as part of the fleet made available for maintenance purposes.

The remainder 74 heavy-rail cars will undergo a more comprehensive refurbishment. Metro is considering a plan whereas two (2) vehicles per month enter structural rebuilding efforts, and, no more than 12 vehicles are unavailable at any one time. Each vehicle, or married pair of two vehicles, would be unavailable for approximately 6 months. Assuming these characteristics, the project would span approximately 43 months, and, the peak number of vehicles (12) being unavailable would be for approximately 31 months.

At this time, and given other heavy-rail fleet projects as well as planned service adjustments, the 74-Car HRV Refurbishment Project would begin in mid-2015 and conclude in late 2018. As many as 12 cars would be allocated to the refurbishment in FY 2016 through FY 2018. In order to meet these timelines Metro would need to develop specifications beginning in late 2012, initiate procurement by June 2013, and issue a Notice-to-Proceed by June 2014.

As this RFMP is updated, Metro will introduce additional mid-life refurbishment projects for future fleets. For example, heavy rail vehicles planned to be procured and delivered in FY 2018

through FY 2021 will reach their mid-life in FY 2033 through FY 2036. This would fall within the span of time covered by this RFMP. Mileage considerations may accelerate this timeline.

4.11 Revenue Vehicle Demand/Supply Balance

This section discusses the demand for vehicles and issues concerning their deployment. As discussed in previous sections of this Plan it is necessary to expand the light rail and heavy rail fleets in order to meet future service requirements.

Table 4.9 depicts the vehicle requirements and fleet size change over the life of this RFMP.

Table 4.9: Heavy Rail Baseline Vehicle Requirement

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23- FY25	FY26- FY34
Base Fleet	104	104	104	104	104	104	104	104	104	104	104	104
<i>Unavailable/Rebuild</i>				12	12	12						
<i>Procurement</i>	0	0	0	0	0	24	48	72	74	74	74	74
Total Available	104	104	104	92	92	116	152	176	178	178	178	178
Total Service Requirement	78	104	104	92	92	92	98	104	104	104	162	178
Excess / Shortage	+26	0	0	0	0	+24	+54	+72	+74	+74	+38	0

Note: "Total Service Requirement" includes the in-service vehicles and maintenance spares. For FY35, see Appendix 9 through 12.

As previously mentioned in Section 4.10, discussions are underway to develop a program to complete a structural remanufacture and component replacement of the Breda Heavy Rail vehicles. Timelines have not been finalized; however discussions involve work occurring in FY 2016 through FY 2018.

Table 4.10 presents the fleet requirements. Table 4.11 presents the Maintenance Facility capacity and the assigned number of vehicles.

Table 4.10: Red/Purple Lines Fleet Summary

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Total Fleet Available	104	104	104	92	92	116	152	176	178	178	178
Total Fleet Requirement	78	104	104	92	92	92	98	104	104	104	162
Excess / Shortage	+26	0	0	0	0	+24	+54	+72	+74	+74	+38

Note: See Appendices for more detail for FY24 through FY35.

Table 4.11: Red / Purple Lines Maintenance Facility Summary

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Total Fleet Available	104	104	104	92	92	116	152	176	178	178	178
L.A. Div. 20 (200)	104	104	104	92	92	116	152	176	178	178	178
Available Storage Capacity	96	96	96	108	108	84	48	24	22	22	22

Note: See Appendices for more detail for FY24 through FY35.

Appendix 11 presents the vehicle type assignment expected throughout the Plan and should be referenced to review specific fleet detail.

4.12 Heavy Rail Summary

The heavy-rail fleet will almost double within the next ten years and almost triple by the end of this RFMP; however, sufficient time currently exists to initiate and complete a vehicle procurement in order to support the Purple Line Subway Extension, including the opening of Segment 1 planned for FY 2023. The existing maintenance facility is also of sufficient size to receive the necessary cars through the majority life of this Plan; however, would require a major expansion of storage track and maintenance functions by FY 2035.

5.0 Glossary

Provided in this section is brief list of transportation terms and phrases used in this plan, and appropriate definitions.

30/10 Initiative – Is an initiative advanced to leverage future Measure R sales tax receipts to secure low-interest loans and build and operate each of the rail transit projects identified in the L RTP. Essentially, 30/10 Initiative proposes to build 30 years worth of projects in the next 10 years.

Active Fleet - That portion of the transit operator's total fleet which is operable for service, including the peak vehicle requirement, ready reserve and maintenance spares.

California Public Utilities Commission - Is a State department responsible for, among other regulatory responsibilities, regulating rail system safety.

Consist - In rail systems, the makeup or composition (number and specific identity) of individual units (or cars) of a train.

Cycle Time - The time the train needs during revenue service to make one cycle, including travel time in each direction of travel, and any necessary recovery time.

Dwell Time - The time required between the arrival and departure of a train at non-terminal station to allow for alighting and boarding of passengers.

Federal Transit Administration (FTA) - FTA is a part of the U.S. Department of Transportation (DOT). FTA administers the federal program of financial assistance for public transportation.

Gap Train / Ready Reserve Train - A train stationed at a terminal or maintenance facility that is ready to enter into revenue service to provide consistent delivery of service. LACMTA uses these trains to fill-in service when another train is delayed or incurs a mechanical problem.

Grade Crossing/Separation - A highway or railroad crossing separated from other traffic using an underpass or overpass.

Headway - The time interval between vehicles moving in the same direction on a particular route.

Heavy Maintenance Facility (Yard) - A support location for a system used for vehicle maintenance and large scale repair (including body work /painting), storage and staging.

Heavy Rail Vehicle (HRV) - Rail cars with motive capability, driven by electric power taken from overhead lines or third rails, configured for passenger traffic and are usually operated on exclusive right-of-way (ROW). LACMTA Heavy Rail Vehicles take power from a third rail.

Light Maintenance Facility (Yard) - A support location for a system used for vehicle maintenance and light repairs, storage and staging.

Light Rail Vehicle (LRV) - A type of vehicle used on a railway with a light volume traffic capacity compared to heavy rail (HR). It is characterized by passenger rail cars operating singly (or in short trains, usually up to three-cars) on fixed rails in shared or exclusive right-of-way (ROW), low or high platform loading, and vehicle power drawn from an overhead electric line via a trolley or a pantograph. LACMTA light rail vehicles utilize high platform boarding, operate with up to three cars in length and draw power from a overhead catenary system using a pantograph.

Load Factor - The ratio of passengers actually carried versus the total seating capacity of a vehicle.

Los Angeles County Metropolitan Transportation Authority (LACMTA) – Is the regional transportation planning agency and public transit operator for Los Angeles County. LACMTA operates light rail and heavy rail transit systems, as well as a full range of bus services.

Maximum Load Point - The location(s) along a route where the vehicle passenger load is the greatest. The maximum load point(s) generally differ by direction and may also be unique to each of the daily operating periods. Long or complex routes may have multiple maximum load points.

Measure R – Is a half-cent sales tax measure approved by Los Angeles County voters on November 2008 and took effect in July 2009. Measure R will provide funding for transportation improvements over the next 30 years. Among improvements are a host of rail extensions and new lines.

Overhead Catenary System - The overhead catenary system (OCS) is the electric traction power supply contact wires suspended over the track, for current collection by trains through their pantographs, and the support system for the contact wires.

Pantograph - Is the device used atop vehicles to draw power from an overhead catenary system. LACMTA uses pantographs on light rail vehicles.

Peak Direction - The direction of travel with the heaviest transit usage.

Peak Hour - A single hour during the morning or afternoon period when transit riding is heaviest.

Pocket Track – Storage track situated between two revenue tracks with access from either track, allowing a vehicle or train to be taken off the primary revenue tracks for staging or emergency maintenance. Can also be used as a crossover between the two revenue tracks.

Preventive Maintenance - Preventative Maintenance (PM) are programmed inspection and maintenance activities done on a fixed time or mileage basis, designed to improve vehicle, system, or equipment reliability and to minimize in-service failures.

Pre-Revenue Service - The period prior to the beginning of revenue service on a new line or line extension. LACMTA commonly refers to pre-revenue service as the time following construction, after successful systems testing, when non-revenue scheduled service is tested prior to the beginning of revenue service. Typically, the period of time for pre-revenue testing is approximately 8 weeks, however, could be longer depending on special or unusual circumstances.

Revenue Service - When a revenue vehicle is in operation over a route and is available to the public for transport.

Revenue Vehicle Service Hour - The measure of scheduled hours of service available to transport passengers. It is equivalent to one transit vehicle traveling one hour in revenue service. As such, a three-car train in revenue service for 1 hour equals a total of three Revenue Vehicle Service Hours. Recovery/layover time is included, and deadhead hours are excluded from the calculation.

Right-of-way (ROW) - The land over which a public road or rail line is built. An exclusive right-of-way is a road, lane, or other right-of-way designated exclusively for a specific purpose or for a particular group of users, such as light rail vehicles or buses.

Revenue Operations / Non-Revenue Operations - Revenue Operations includes the time when a vehicle is available to the general public and there is an expectation of carrying passengers. Revenue service includes layover / recovery time. Non-Revenue Operations include all other times, typically deadheading between the last revenue station and the maintenance yard.

Run Time, or Running Time - The time the vehicle travels on the route in passenger service, typically from the beginning to the end of a route. It includes all travel and station dwell time required to go from the point of the first passenger station to the last passenger station on a specific trip.

Siding Track – Storage track situated outside of two revenue tracks with access from the adjacent track (and the distant track via an additional set of crossovers), allowing a vehicle or train to be taken off the primary revenue tracks for staging or emergency maintenance.

Spare Ratio / Spare Vehicle Ratio - The proportion of the vehicle fleet maintained to meet routine and heavy maintenance requirements, meet unexpected vehicle breakdowns or accidents, and thereby preserve scheduled service operations. The spare ratio is the ratio between the portion of the fleet not required to meet the peak vehicle need, with the peak vehicle requirement.

Storage and Inspection Facility – A support location that is used only for vehicle cleaning, inspection and storage.

Tail Track – Non-revenue tracks at the end of a terminal station, allowing a vehicle or train to be taken off the primary revenue tracks for staging or emergency maintenance.

Third Rail - Is an electrically powered rail running parallel to standard rail tracks. The LACMTA subway system heavy rail vehicles draw power from the third rail.

Transitway - A transit-only guideway used by public transit vehicles. Transitways can be grade separated and provide prioritization over regular traffic when shared with other modes.

Travel Time – The time required to travel between two stations.