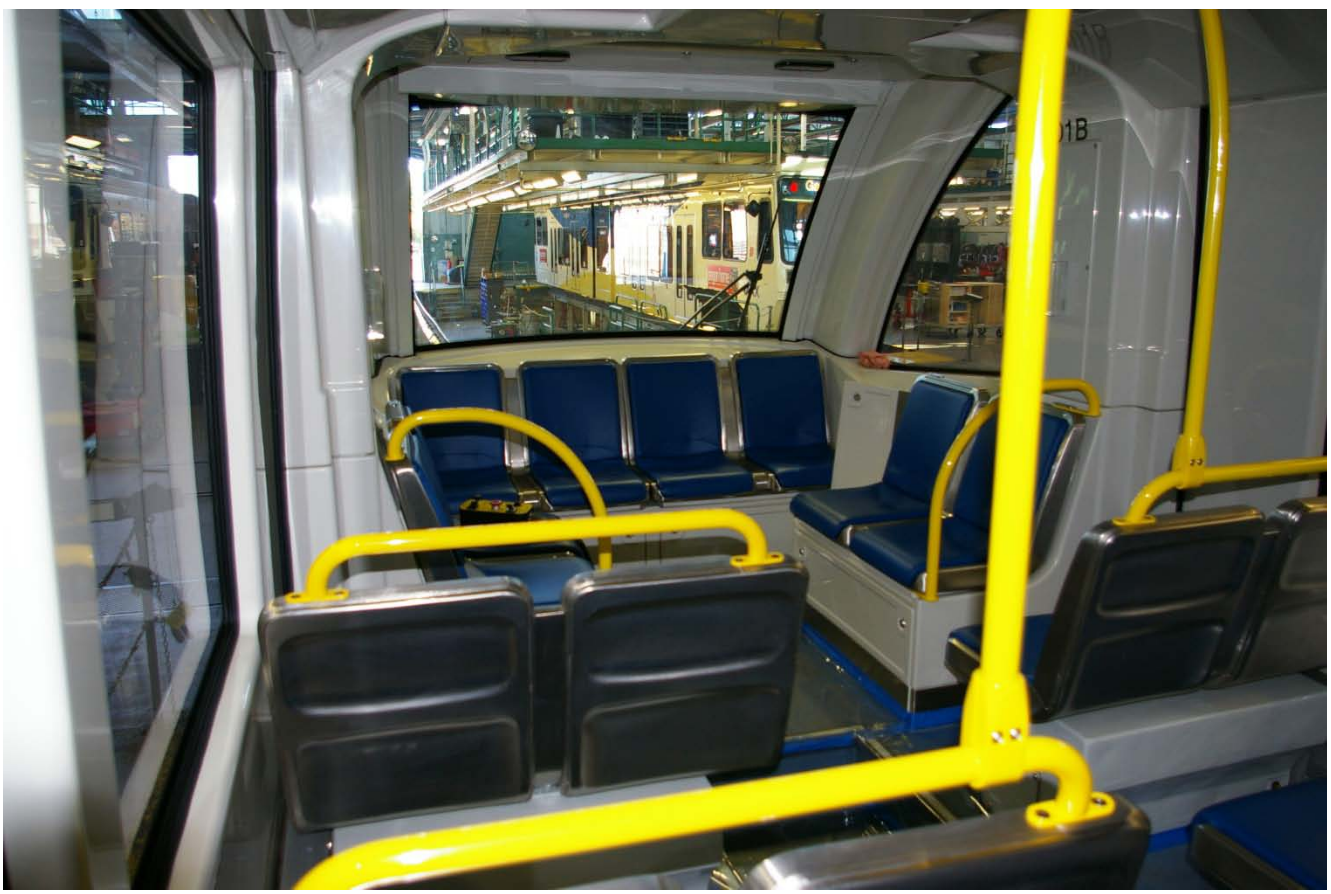
Tri-County Metropolitan Transportation District of Oregon

Light Rail Transit
Fleet Management Plan

2010 - 2030

June 21, 2011
Revision 15 Final



Revision History

Revision Number	Date	Approval	Comments
0	10/30/97	JG	Light Rail Fleet Analysis
1	4/1/98	JG	Original RFMP
2	6/1/99	JG	
3	10/15/99	JG	IMAX project
4	7/15/01	JG	
5	6/2/02	JG	
6	6/15/02	JG	Addendum
7	8/15/03	JG	
8	8/16/04	JG	
9	4/15/05	JG	
10	4/10/06	JG	I-205/Portland Mall Project
11	3/15/07	JG	Type 4 LRV details
12	7/30/08	JG	Milwaukie PE application revision
13	8/29/08	JG	CRC PE application revision
14	1/4/10	JG	Revision to address Milwaukie and CRC FEIS and PMOC comments
15	1/17/11	JG	Revision to address Milwaukie recalibration and PMOC comments
15 Final	6/21/11	JG	Additions for Preventive Maintenance Force Account Plan

Cover photo: Type 4 LRV interior non-cab end at Ruby shop.

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1) Introduction

This plan documents characteristics of the light rail fleet and maintenance facilities as well as the process of forecasting Tri-Met's future fleet requirements. Also, the report projects the fleet's spare ratio in the overall context of an operations and maintenance program that meets or exceeds rail transit industry best practices. Tri-Met has and will continue to update this document periodically to reflect emerging trends in such key areas as ridership, service policies, and system expansion.

This plan update also includes Tri-Met's two light rail system extension projects; Portland to Milwaukie (PMLR) with Preliminary Engineering (PE) completed, and Expo Center to Vancouver, Washington (CRC) with PE to be completed in the Summer of 2011.

- **Milwaukie.** The Milwaukie extension will run from the south terminus of the Green and Yellow Lines on the Portland Mall 6.2 miles to a Lake Road terminus in Milwaukie or 7.3 miles to a Park Ave. terminus south of Milwaukie (both figures based on the Tillamook alignment option). The line, currently designated as the Orange Line and proposed to open in the Fall of 2015 to Park Ave., will require 14 LRVs initially and 18 LRVs in 2030 for 8.6-minute peak hour and 15-minute mid-day headways.

- **Columbia River Crossing (CRC).** The CRC extension is planned to run 2.7 miles from the north terminus of the Yellow Line at Expo to Clark College in Vancouver, Washington. The extended Yellow Line, proposed to open in the Fall of 2018, initially requires 7 LRVs to provide 10-minute peak hour and 15-minute mid-day policy headways. The planning horizon peak load forecast indicates that 19 LRVs will be required to provide Yellow Line service in 2030 with 6-minute peak hour and 15-minute mid-day headways.

Currently, Tri-Met has a fleet of 127 vehicles for its MAX (Metropolitan Area Express) light rail system. The fleet consists of 101 low floor cars and 26 high floor cars. A vehicle chronology follows:

- In 1986, a 26-vehicle fleet began serving passengers on a 15-mile line between Portland and Gresham.

- During 1997 and 1998, an additional 46 vehicles entered service in conjunction with an 18-mile system expansion to the West. These were North America's first low floor light rail vehicles.

- Prior to 1998 there were too few vehicles to keep pace with growing ridership. In response to these ridership trends and in consideration of the rare opportunity to purchase a small number of cars, TriMet's Board exercised an option (in the Westside vehicle contract) to purchase 6 additional vehicles put in service in 2000 and 2001.

- In 2000, 17 vehicles were ordered for the Interstate MAX, Yellow Line, opening.
- In 2002, 10 option vehicles were ordered for system ridership growth, 7 of those for Interstate MAX through 2020 as stated in the North Corridor FEIS.
- In 2006, 21 vehicles were ordered for the I-205/Portland Mall, Green Line extension. An option for 1 more vehicle was exercised in 2008.

The light rail operating and maintenance program reflects industry best practices. Maintenance is conducted at two modern facilities, one, Ruby Junction, 13 miles east of Portland and the other, Elmonica, 10 miles to the west of Portland. Rather than conduct major vehicle overhauls at mid-life or periodically, Tri-Met follows the practice of progressive overhauls by subsystem as indicated by failure rate analysis for each subsystem.

This plan differs from the previous, January 2010, Plan in the following ways:

1. A definition of Loading Standard has been added to Section 2.

2. Table 3.3 was added to show existing Peak Vehicle Requirements (PVR) in Section 3.

3. Updated information about the proposed Operations and Maintenance facility expansion at Ruby Junction for the Milwaukie and CRC projects has been added in Sections 4.

4. In July 2010, TriMet received direction from the Federal Transit Administration to provide a financial plan for the Milwaukie Project that includes a limit of 50 percent New Starts funds and as a result, the Project with its local partners recalibrated the Project to fit with the available local financial resources. The recalibration process included reducing scope at park and ride lots at SE Tacoma and SE Park Avenue from 800 to 320 spaces and from 600 to 355 spaces respectively. Subsequent travel demand forecasting analysis resulted in slightly lower forecasts.

   The final demand model runs made in September of 2010 for the 2015/16 and 2030 forecasts have lower peak passenger loads than those known in December of 2009 that were used in Revision 14 of the RFMP. These lower loads will allow a longer peak hour peak direction headway of 8.6 minutes and the purchase of four fewer light rail vehicles for 2030, 17 instead of 21, as shown in the updated Table 5.6. Also three fewer vehicles will be needed at project opening in 2015, 14 instead of 17, as shown in the updated Table 5.8, in Section 5.

   Since these vehicles may be similar to the Type 4 vehicles with a cab at one end only, it will be desirable to purchase them as pairs since they can only run in revenue service as pairs. For this reason it would be preferable to purchase 18 vehicles even though only 17 are strictly required.

5. Sections 7, 8 and the Appendix have been updated with more recent data, including TriMet's Force Account Plan for Preventive Maintenance in Section 7a.

2) Definition of Terms

Capacity … achievable – The portion of design capacity that reflects uneven loading of cars in a train and uneven passenger arrivals at stations upstream of the peak load point during the peak hour. For MAX this is 80% of design capacity or an average of 133 passengers per vehicle (266 per 2-car train) during the peak hour with standees at a density of 2.7 per square meter. This capacity is equivalent to a load factor of 2.1. This is TriMet's adopted loading standard for the peak hour.

Capacity … design (AW2) – The total number of seated and standing people a vehicle is designed to accommodate with some comfort as opposed to no comfort (crush load). Design capacity equals 166 passengers per vehicle (332 per 2-car train) with standees at a density of 4 per square meter. This capacity is equivalent to a load factor of 2.6.

Capacity … crush (AW3) – The total number of seated and standing people a vehicle is designed to accommodate with no comfort (crush load). As so defined crush capacity would equal 217 passengers per vehicle (434 per 2-car train) with standees at a density of 6 per square meter. This capacity would be equivalent to a load factor of 3.4. Historical manual counts have never recorded a 2-car train passenger load above 370 passengers even when holding a train until it was full after a special event.

Capacity … structural design (AW4) – The maximum passenger capacity of a vehicle used for calculating maximum loaded vehicle weight for structural analysis, with standees at 8 per square meter. This capacity would be equivalent to a load factor of 4.2.

CIP – Capital Improvement Program

Cycle time – The round trip travel time (run time in both directions) plus the layover times at both ends of the transit line.

Daybase train – A train that provides service most of the day and is in service generally between 16 and 20 hours per day.

Dwell time – The time a train spends stopped in the station waiting for passengers to board and a clear signal to proceed.

FFGA – Full Funding Grant Agreement

Forecast – Future passenger demand based on a mathematical model.

Gap train – A train with an assigned operator that waits at a designated location to fill a gap between scheduled trains that are off schedule creating an unacceptable gap in service.

Headway – The time interval between the passing of the front ends of trains moving along the same track in the same direction, usually expressed in minutes.

Life cycle – The length of time that it is economic to operate a vehicle. For light rail vehicles this is usually between 25 and 36 years.

Loading Standard - The maximum acceptable passenger load set by TriMet policy. TriMet's loading standard for an individual train equals 166 passengers per vehicle (332 per 2-car train) with standees at a density of 4 per square meter. This standard is equivalent to a load factor of 2.6. To achieve this standard for individual trains the standard for the peak hour is set lower to an average of 266 passengers per 2-car train.

Load factor – The number of sitting and standing passengers divided by the number of seats in a transit vehicle. A full-seated load has a load factor of 1. Load factor comparisons between different vehicles or transit systems are not valid because the ratio of areas for sitting and standing varies from vehicle to vehicle. The density of standees is a valid comparison of vehicle crowding.

MDBF – Mean Distance Between Failures

OSR – Operating Spare Ratio that equals the total active fleet minus the PVR divided by the PVR, (fleet-PVR)/PVR. The OSR is usually shown as a percentage.

Overhaul – The disassembly, inspection, repair or replacement and reassembly of all vehicle systems. Mid-life overhauls usually occur half way through the vehicle's life cycle.

PVR - Peak Vehicle Requirement is the number of vehicles needed to meet the expected passenger demand at the peak load points during the peak hour in the peak direction during a typical weekday and provide at least daybase headways elsewhere in the MAX system.

Passenger demand – The number of passengers and the time of day they desire to travel.

Peak tripper – A train that runs only during the peak periods to supplement the daybase trains when peak passenger demand is such that daybase trains alone cannot carry the loads. Trippers generally run from two to five hours at a time.

Progressive overhaul – The disassembly, inspection, repair or replacement and reassembly of only those vehicle systems that analysis of failure rates indicate is economically desirable.

Spare vehicle – Vehicles in the active fleet that are not needed during the peak periods for service and are therefore available for maintenance. If not scheduled for maintenance a spare can be used to replace a vehicle that fails in service.

Spare ratio – The number of spare vehicles divided by the PVR.

TC – Transit Center or passenger transfer station

Runtime – The one-way travel time from one end of a transit line to the other end.

3) The Existing System

a) Tri-Met Overview

The Tri-County Metropolitan Transportation District of Oregon, Tri-Met, was established by the State Legislature in 1969 to provide mass transit service to the more populous parts of Multnomah, Washington, and Clackamas counties (the Portland metropolitan area). The governing body of Tri-Met is a seven member board of directors, who are unpaid citizen volunteers appointed to four year terms by the governor and confirmed by the Oregon Senate.

The Tri-Met district covers about 600 square miles containing approximately 1.2 million people. Tri-Met's services as of September 2009 consist of:

- 103 peak light rail vehicles operating on 4 routes with 52 miles of right-of-way and 75 stations,
- 4 peak commuter rail vehicles operating on one 14.7-mile route with 5 stations.
- 530 peak buses operating on 93 routes with over 8,000 stops and over 1,000 shelters,
- 18 bus / train interchange transit centers and 57 park and ride lots providing about 10,000 parking spaces.

The light rail system is referred to as MAX, for Metropolitan Area Express. The 33-mile long, east to west, Blue Line was opened in stages during 1986, 1997 and 1998. The 5.6-mile Airport Extension Project, the Red Line, opened for revenue service in September of 2001. The 5.8-mile Interstate Ave. Extension Project, the Yellow Line, opened for revenue service in May of 2004. The 6.7-mile I-201/Portland Mall Extension Project, the Green Line, opened for revenue service in September of 2009. Figure 3.1 is a map of the system from September 2009 on. Each line runs between the following terminals:

- Blue – Government Center and Cleveland Ave.
- Red – Portland International Airport (PDX) and Beaverton Transit Center (BTC)
- Yellow – Expo Center and South Terminal just south of Portland State (PSU)
- Green – Clackamas Town Center (CTC) and South Terminal / PSU

Current headways by line are as follows:

Blue – 15 minute daybase and 7 minute peak hour
Red – 15 minute daybase and peak hour
Yellow – 15 minute daybase and peak hour
Green – 15 minute daybase and peak hour

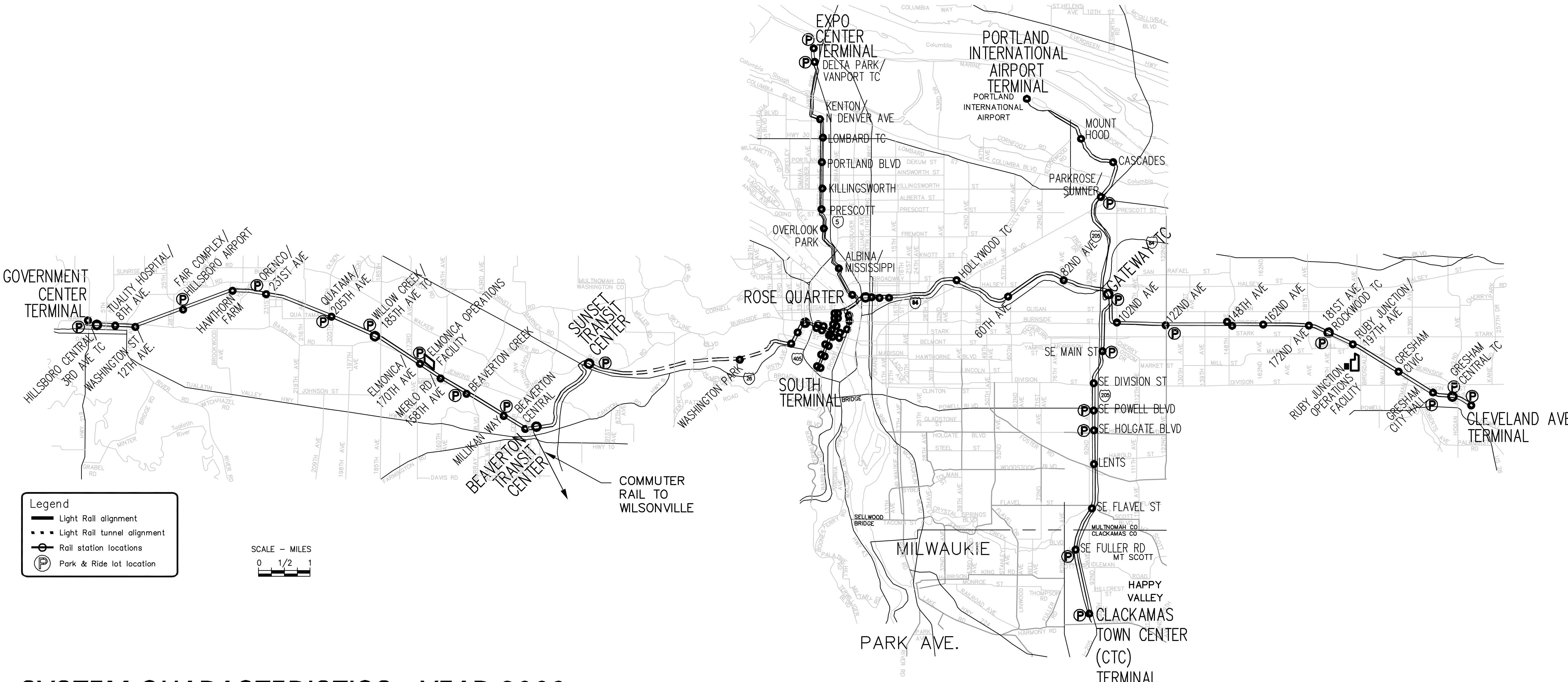
Blue Line headways include some Red Line trains that become Blue Line trains by running west to Hillsboro Government Center in the PM peak.

Combined or trunk headways along shared track are as follows:

Rose Quarter to Gateway - 5 minute daybase and 3 minute peak hour
Downtown east/west to BTC - 7.5 minute daybase and 5 minute peak hour
Downtown north/south – 7.5 minute daybase and peak hour

FIGURE 3.1

TRI-MET LIGHT RAIL SYSTEM



SYSTEM CHARACTERISTICS - YEAR 2009

- *52 ROUTE MILES, 4 LINES (BLUE, RED, YELLOW & GREEN)*
- *127 LRV'S (26 TYPE 1, 52 TYPE 2, 27 TYPE 3, 22 TYPE 4)*
- *75 PASSENGER STATIONS*
- *3-15 MINUTE HEADWAYS IN PEAK PERIODS (15 MIDDAY)*
- *51 TRAINS OPERATING IN PEAK PERIODS (42 MIDDAY)*
- *120,000 DAILY PASSENGERS*

Responsibility for the rail fleet is generally split between the Operations Division and the Capital Projects Division. Responsibility for design, procurement, and testing predominately rests with systems engineers within the Capital Projects Division. Operation and maintenance of the fleet is the responsibility of the Operations Division.

b) Light Rail Vehicles (LRV's)

The fleet consists of vehicles produced by two manufacturers: Bombardier and Siemens, referred to as Type 1 and Type 2, 3 & 4, respectively. At the end of 2001 the fleet included 26 Type 1 vehicles and 52 Type 2 vehicles. The Interstate MAX project contract for 17 Type 3 vehicles resulted in these cars being available for service in 2004. All 17 were part of the active fleet by March 2004. Ten additional option vehicles, acquired through the Interstate MAX contract were available for service by Spring of 2005. The I-205 / Portland Mall MAX project contract for 22 Type 4 vehicles resulted in these cars being available for service in 2009, see Table 3.1.

Table 3.1 Fleet Size Chronology

Ordered	Available	Increase	Fleet Size	Notes
1982	1986	26	26	Original Eastside Purchase, cars 101-126 all active
1993	1997	8	34	Piggy-back Eastside order with Westside contract, cars 201-208, all active
1993	1997	2	36	Favorable price allowed an increased order, cars 209 & 210, both active
1993	1998	29	65	Original Westside Order, cars 211-239, all active
1995	1998	7	72	Expansion to accommodate Hillsboro Extension, cars 240-246, all active
1997	2000	6	78	Option allowed increased order to meet system growth, cars 247-252, all active
2000	2003-4	17	95	Interstate (North) MAX Line Order, cars 301-317, delivery 2003
2002	2004-5	10	105	Option allowed increased order to meet 2020 fleet size of 24 for Interstate, cars 318-327, delivery 2004-5
2006	2009	22	127	I-205/Portland Mall MAX Line Order, cars 401-422, delivery 2008-9

With the introduction of the Type 2, 3 & 4, low floor vehicles, all two-car consists must include at least one Type 2 or 3 vehicle or two Type 4 vehicles to insure accessibility for mobility devices. Type 1 vehicles cannot operate alone as the train would not be accessible to passengers requiring the use of mobility devices. Also, the system is designed to operate with trains of no more than two cars. (A two car train is roughly the length of one city block, thus when stopped at a platform cross-traffic can proceed unimpeded.)

Type 1 – Bombardier

The Bombardier vehicles were placed into service in September 1986. BN of Belgium designed the cars. Bombardier, the principal shareholder of BN, assembled Tri-Met's vehicles in Barre, Vermont. The cars are electrically propelled (DC drive) to a maximum design speed of 55 miles per hour, are constructed of corten steel, and have bi-directional operating capability. The cars seat 76 with a design capacity of 166 passengers with standees at 4 per square meter.

Type 2 and Type 3 – Siemens Duewag SD 660

The Siemens' vehicles entered service at various times between August 1997 and September 1998. Siemens Duewag of Germany designed the cars, with final assembly in Sacramento, California. They are designed with operator cabs at both ends to allow bi-directional operation. There is seating for 64 people and a design capacity of 166 passengers with standees at 4 per square meter. The 92-foot long cars are air-conditioned.

These are the first low floor light rail vehicles placed into service in North America. The cars are constructed of high tensile steel and designed for a top speed of 55 miles per hour with electric propulsion (AC drive). The cars are double articulated and can be operated in train sets of up to four, but are limited to two due to the length of MAX stations. These cars can be used in any combination of Type 1, Type 2 or Type 3 vehicles. Along with passenger/operator-activated bridgeplates on the center four doors, the low floor design allows full wheelchair access. The low floor section encompasses 70% of the vehicle, which is supported by a non-powered truck in the center articulation section.

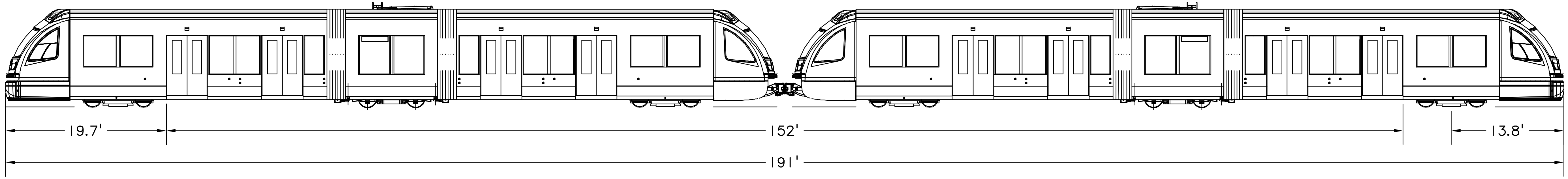
Type 3's are the same as Type 2's with the following additions:

- Automatic passenger counters, APC's, for collecting better passenger load data for scheduling purposes
- Thermoking instead of Sutrak HVAC equipment.

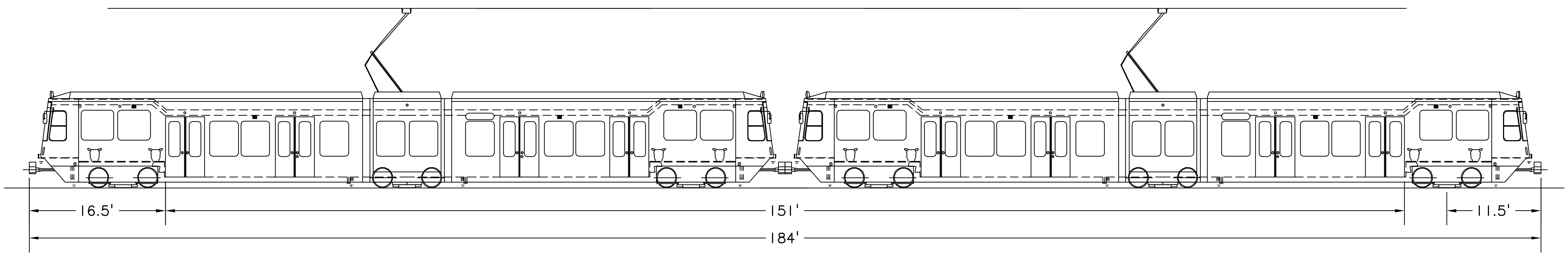
Type 4 – Siemens S70

Type 4 vehicles are not backward compatible with the previous fleet in terms of the ability to train-line electrically with Type 1, 2 and 3 vehicles. Therefore, they are not able to run coupled together as trains with the existing Type 1, 2 or 3 vehicles in revenue service, see Figure 3.2 for all 2-car train consist configurations. Type 4 vehicles are mechanically compatible so that they may tow or be towed by a previous fleet vehicle. Type 4 vehicles are single-ended (have a control cab only at one end) which means they will be run as two-car trains, since the ends of the existing and planned lines do not have loops. Single-ended cars were selected because they have 5% greater passenger capacity. All vehicles will be capable of operating anywhere in the MAX system, so that the single-ended vehicles can be used where passenger loads and train congestion are greatest.

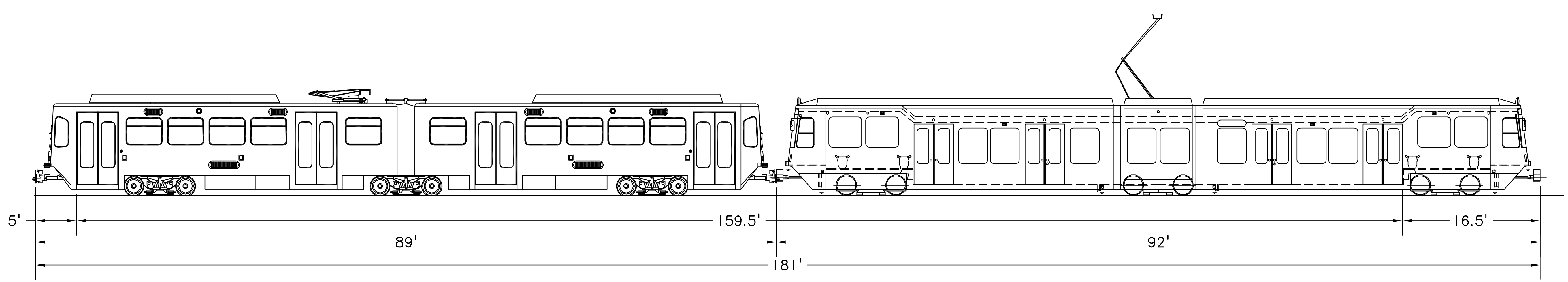
A schematic of the individual car types and lengths is shown in Figure 3.3.



TYPE 4 2-CAR TRAIN



TYPE 2 OR 3 2-CAR TRAIN



TYPE 1/TYPE 2 OR 3 2-CAR TRAIN

NO.	DATE	BY / CHK.	APPD.	REVISIONS

JG — DESIGNED — 01/07 DATE
JHM — DRAWN — 01/07 DATE
CHECKED — DATE
APPROVED — DATE

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON

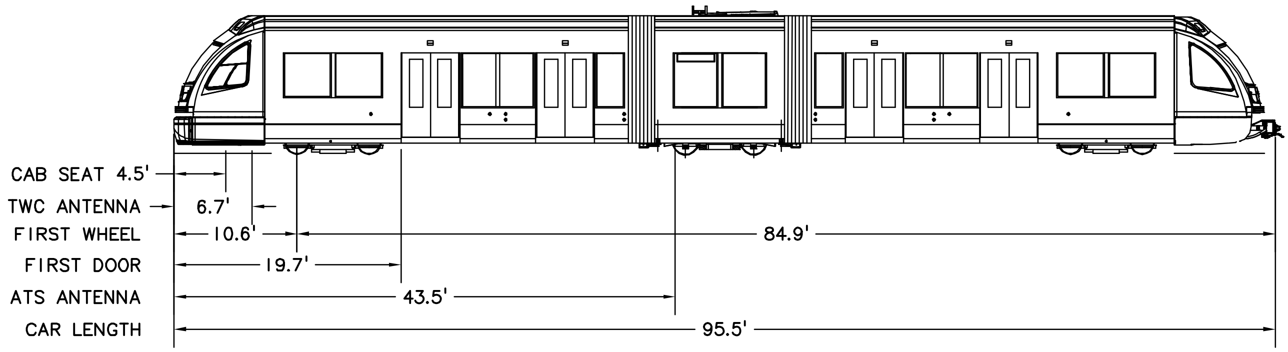
TRI MET

CAPITAL PROJECTS DIVISION
710 NE HOLLADAY STREET
PORTLAND, OREGON 97232

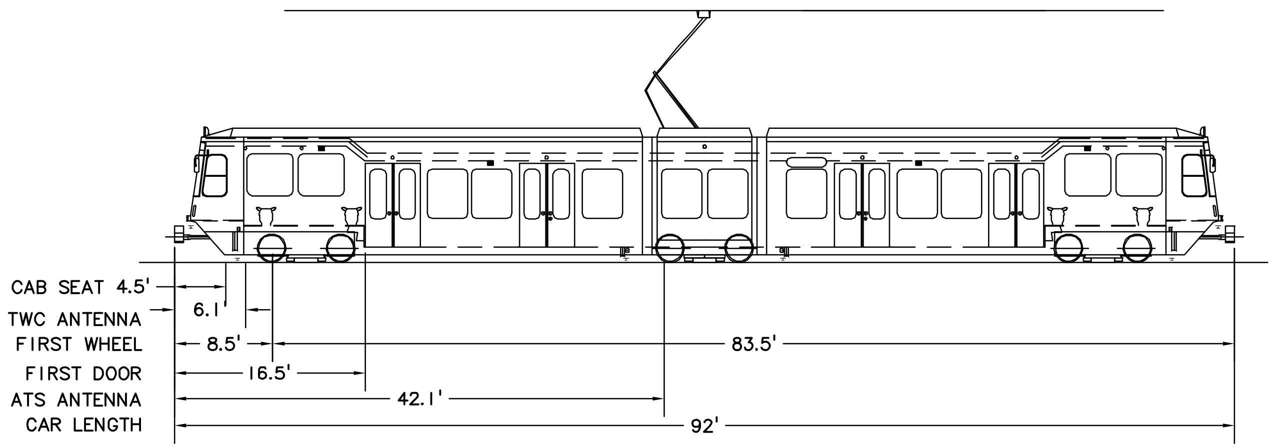
SUBMITTED: DATE: APPROVED: DATE:

FIGURE 3.2
REVENUE SERVICE 2-CAR CONFIGURATIONS

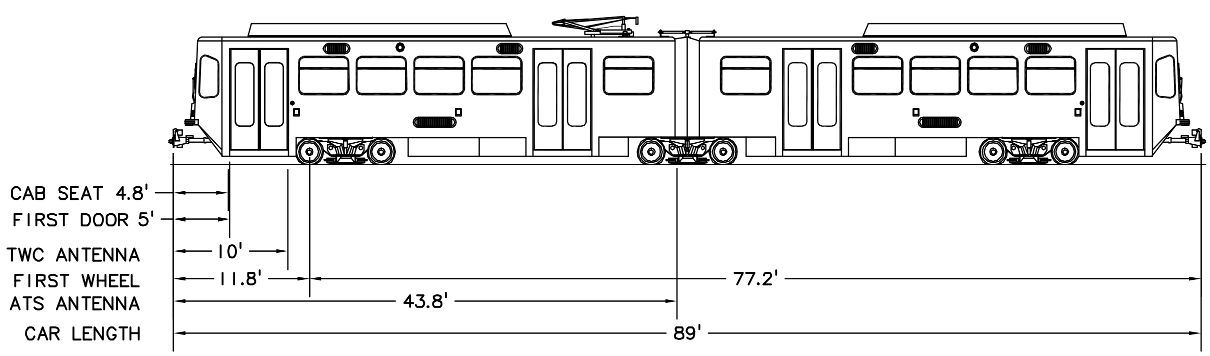
SCALE: NOT TO SCALE
DRAWING NO.: FIG 3.3 2-CAR CONFIG
CONTRACT NO.:
SHEET NO.:



TYPE 4



TYPE 2 OR 3



TYPE 1

TRIMET CAPITAL PROJECTS AND FACILITIES DIVISION 710 N.E. HOLLADAY STREET PORTLAND, OREGON 97232	FIGURE 3.3 LRV CONFIGURATIONS

DRAWN	DESIGN	CHECKED	APPROVED:	DATE:
JHM	JG	JG	JG	JANUARY 2008

SCALE:	FILE NAME:	CONTRACT NO:	SHEET NO:
NOT TO SCALE	FIG 3.4 LRV CONFIGS		1 OF 1

c) Maintenance Facilities

TriMet's Rail Operations Department has two operations and maintenance facilities. Ruby Junction is located two miles west of the eastern terminus in Gresham and Elmonica located in Beaverton seven miles east of the western terminus in Hillsboro. The two facilities operate as a unit with most specialized functions, such as central train control and heavy maintenance work, occurring at Ruby Junction.

Ruby Junction

This facility, opened in 1985, houses Tri-Met's light rail vehicle maintenance department, rail central control, bus dispatch and offices for rail operations staff. During 1995, remodeling prepared the facility to service the new low floor vehicles as well as house a new system-wide communication and control center, based on a fiber optic network (SONET) and supervisory control and data acquisition (SCADA) technology. For the Interstate MAX extension, Yellow Line, that opened in 2004 new storage tracks were added and a new building, Ruby South was built to house Maintenance of Way (MOW) and a new LRV body shop and paint booth.

The 17-acre facility (see Figure 3.4) includes the following:

- Storage track for 67 vehicles
- Ruby Main, a 112,000 square foot three story shop, operations and administrative building with 11 maintenance bays excluding the wash bay and the 2nd bay on the wheel truing track, a truck shop and two sets of in floor jacks
- Ruby West, a 9,500 square foot non-revenue vehicle (support vehicles) servicing shop and storage area
- Ruby South a satellite building with a 21,000 square foot footprint, containing paint and body bays, one flat track bay for interior car work, a metal fabrication area, some body parts storage, a Maintenance-of–Way (MOW) shop and offices, restrooms, lockers and a lunch room to accommodate 60 workers over 3 shifts.
- 180 parking spaces
- A 6,700 square foot MOW shop and covered/open MOW storage

Elmonica

This facility was constructed in conjunction with the Westside project. To allow for testing and storage of new vehicles, the construction contract for this facility was one of the first completed, opening in 1996. The design was based on existing facilities in Europe, where low floor cars are commonly used.

The 18-acre facility (see Figure 3.5) includes the following:

- Storage track for 48 vehicles

Figure 3.4 - Ruby Junction

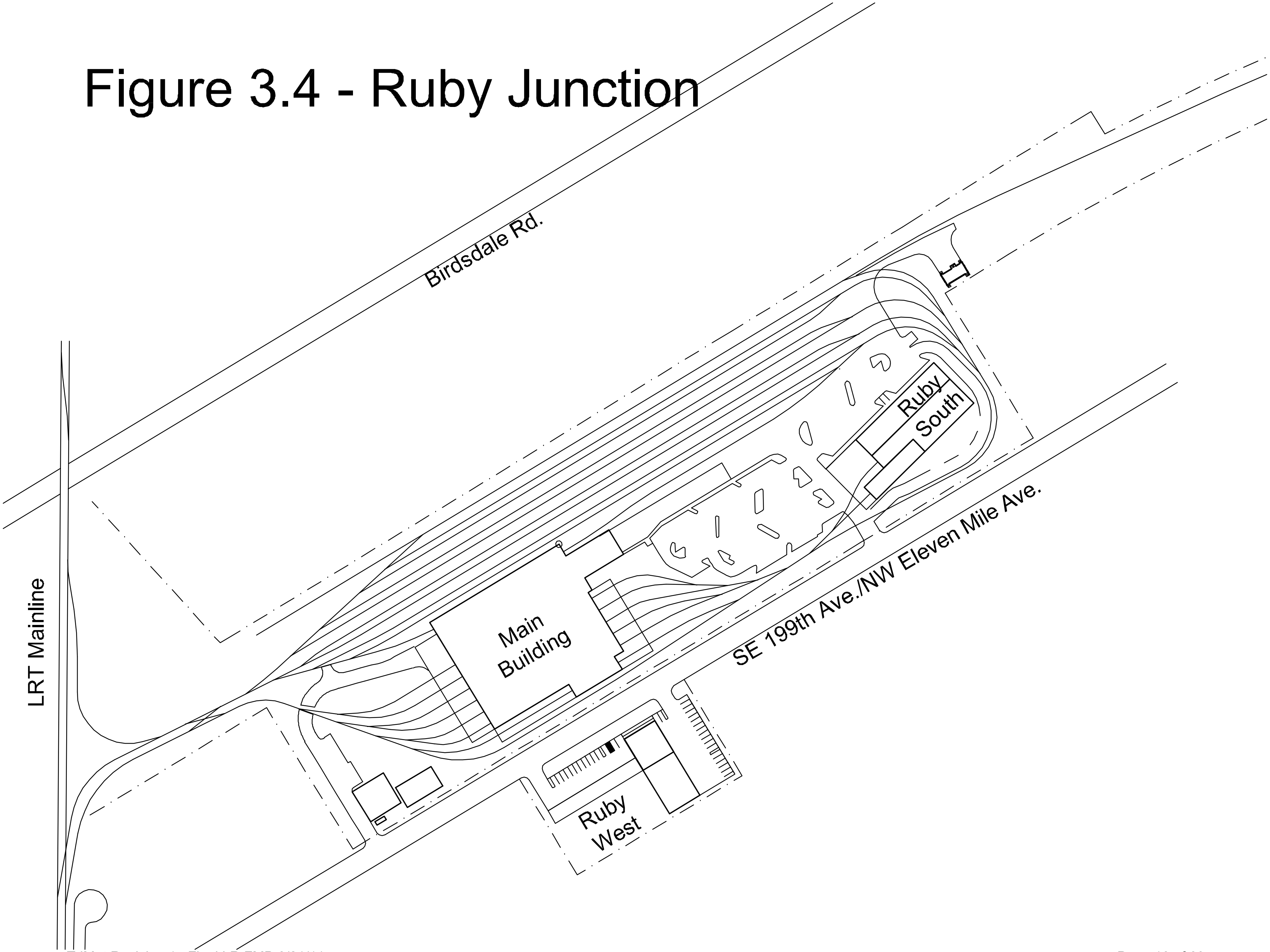
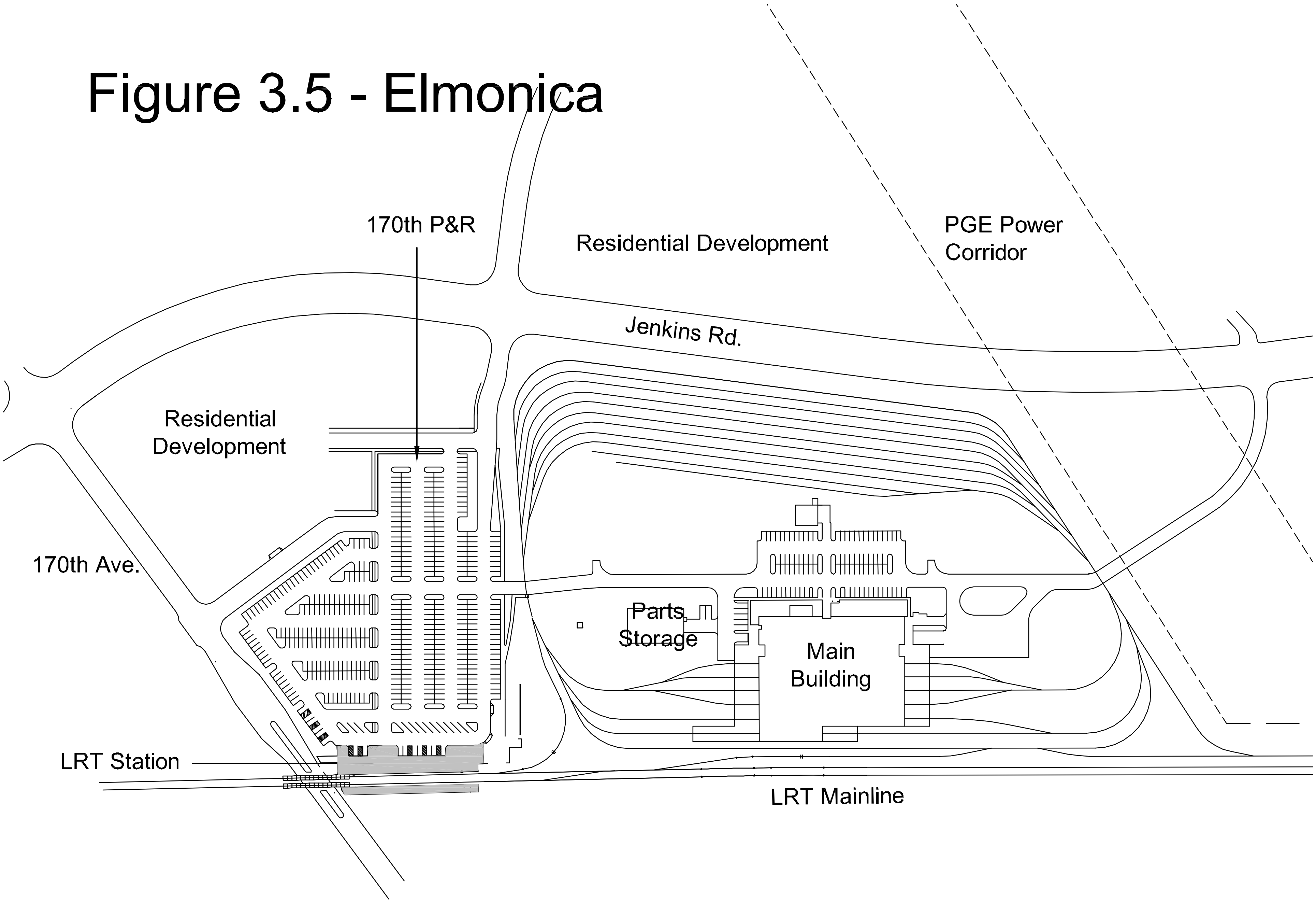


Figure 3.5 - Elmonica



- A 70,000 square foot two story shop and operations building and 1,500 square foot storage building
- 8 maintenance bays excluding the wash bay and the 2nd bay on the wheel truing track (five with access to the rooftops)
- A seven and a half ton overhead crane
- 97 parking spaces

Storage Yard Size vs. Fleet Size

Since 1986 Tri-Met has had a surplus of storage yard spaces to accommodate fleet size increases due to ridership growth. The I-205 / Portland Mall South Corridor MAX Green Line extension only added 5 spaces reducing the surplus to minus seven in 2009, see Table 3.2. The 2009 surplus of -7, although not ideal, is workable since 7 or more LRVs will be in some of the 26 available repair bays, not including wash bays.

Table 3.2

Storage Yard Size vs. Fleet Size

		2002	**2004**	**2007**	**2009**
LRV Yard storage spaces					
	Ruby Junction	48	48	67	67
	Elmonica	42	42	42	48
Yellow Line additions					
	at Ruby Junction		19		
	at Elmonica			6	
Green Line additions					
	at Elmonica				5
Total storage		**90**	**109**	**115**	**120**
	Yellow Line fleet additions		24		
	Green Line fleet additions				22
	System Growth fleet additions		3		
Total fleet		**78**	**105**	**105**	**127**
Surplus		12	4	10	-7

d) Service Design, Ridership and Fleet Size

In September of 2009 the MAX system evolved from a 3-route to a 4-route system. The four routes are identified by colors: the Green Line for the south corridor service to Clackamas Town Center, the Yellow Line for the north corridor service to Expo Center, the Red Line for Airport to Beaverton service via Downtown Portland and the Blue Line for Gresham to Hillsboro service via Downtown Portland. All four lines share the same right-of-way and tracks between Rose Quarter and the west end of the Steel Bridge, as shown in Figure 3.6 which is a time scaled diagram of the track plan and the MAX routes that use it. The north, east, south and west peak load points are also shown in Figure 3.6.

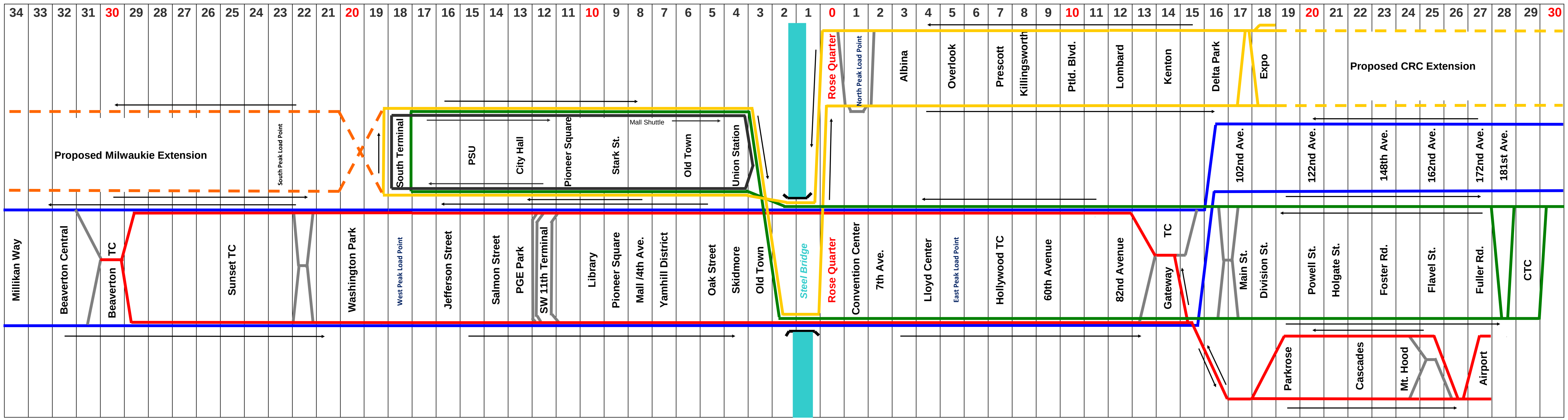
The MAX light rail system's service design is based on the use of daybase trains to provide the base service, 15-minute headways throughout the system. These 15-minute policy headways are provided for most of the service day until about 10:30 PM when there is a transition to 30-minute headways. As a supplement to the daybase trains, peak tripper trains are added during peak periods where peak passenger demand is such that daybase trains alone cannot carry the loads. Trains are mostly 2-car consists, but can be single cars if passenger demand permits. The downtown block length, tunnel station platform lengths and the station design criteria limit train length to a maximum of two cars.

Peak passenger demands are caused primarily by work trips and are greatest inbound, to downtown Portland, in the AM peak and outbound in the PM peak. As a result the Blue and Red lines have two peak load points, one east of downtown at Lloyd Center and one west of downtown at Goose Hollow. The Yellow Line's peak load point is north of Rose Quarter while the Green Line's peak load point is east of Lloyd Center. These are the points where most trains have their heaviest passenger loads and are used to apply TriMet's loading standards, detailed in Section 5.b, to estimate future peak vehicle requirements (PVR) and to monitor crowding that may require schedule or service adjustment.

The existing peak vehicle requirements (PVR) are shown in Table 3.3. Since April of 2004, TriMet has been receiving accurate passenger counts through the automatic passenger counters built into the newer light rail cars. TriMet continually monitors crowding on MAX and makes adjustments within our ability to shift capacity to alleviate it. A typical two-car (four section) MAX train can seat 128 people and carry 332, including standing passengers. When average daily peak passenger loads on a two-car train reach 266 passengers at the peak load point TriMet either adjusts that train's schedule or adjusts its leader's schedule or both. If schedule adjustments do not solve the problem another train may be added. TriMet makes these changes to accommodate and foster further ridership growth.

The light rail system's average weekday boardings (AWB) have been about 1,000 passengers per LRV since MAX opened in 1986, see the comparison of AWB vs. LRVs in Figure 3.7.

Figure 3.6
MAX Route Overlap on Time-Scaled Track Plan

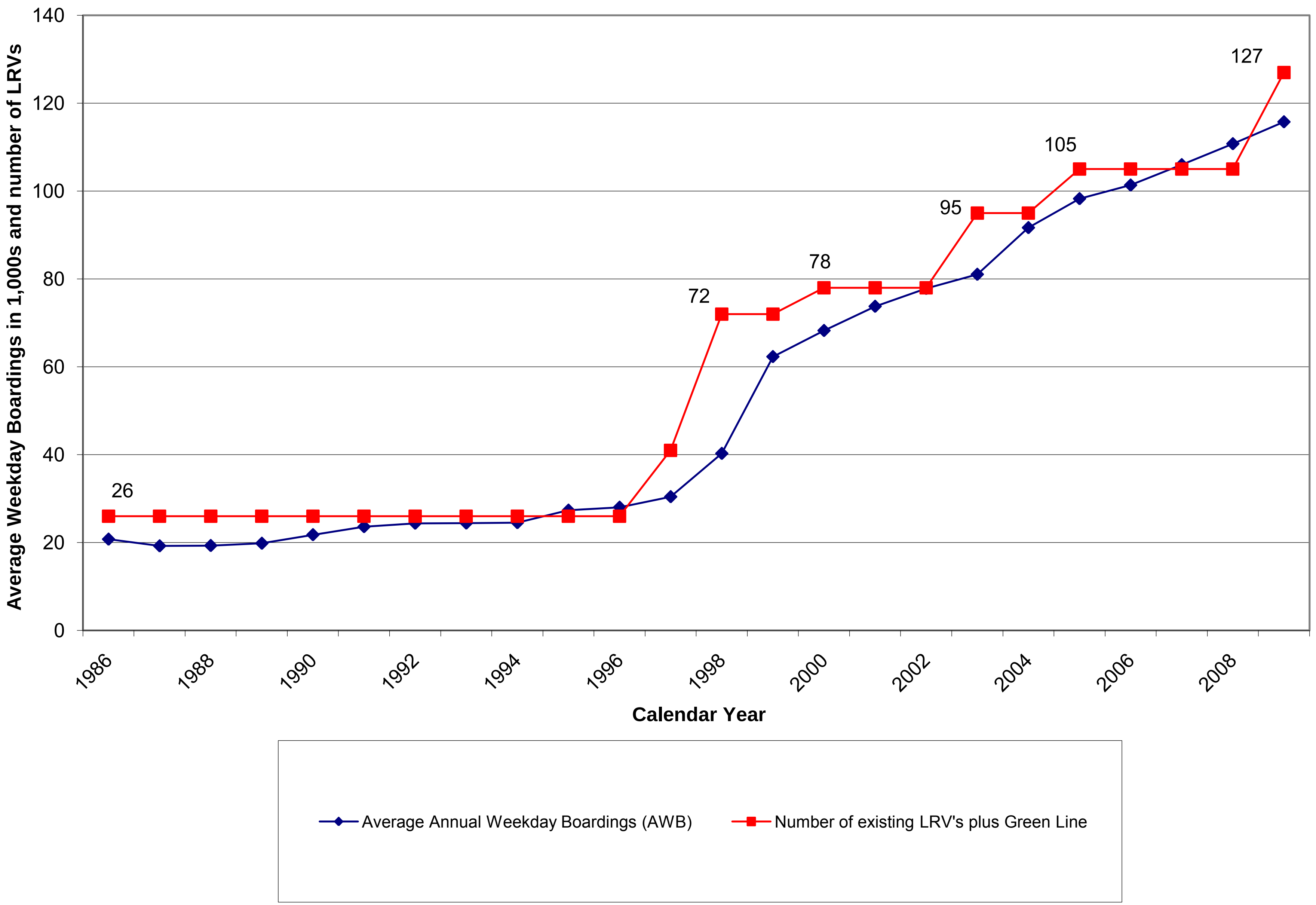


Blue Line opened in stages 1986, 1997 and 1998
Red Line opened in 2001
Yellow Line opened in 2004
Green Line opened in 2009
Mall Shuttle opened with Green Line
Auxiliary Tracks

Table 3.3
2010-11 MAX Light Rail Peak Vehicle Requirements
based on the evaluation of APC data for individual trains

Year 2010-11	**Loads from Automatic Passenger Counters**						
MAX Line	East-West Gresham to Hillsboro		AirMAX: through routed to Beaverton TC	Interstate MAX: Expo to PSU	I-205: CTC to PSU	Mall Shuttle	Total
Travel Times							
Adjusted Travel Time	96		58	34	46		
Round Trip Travel Time	192		116	68	91		
Daybase layover time: total for both ends (for operator break and schedule recovery)	38		34	22	29		
Travel time as a % of cycle time	83%		77%	76%	76%		
Daybase Cycle Time (round trip travel time + total layover time in minutes)	230		150	90	120		
Daybase							
Daybase Headway in minutes	15		15	15	15		
Number of trains required for daybase (Cycle time / headway) + 1 for Blue Line	**17**		**10**	**7**	**8**		**42**
Number of daybase trains passing the peak load point(s) in peak hour	4		4	4	4		
PM Peak Period: Peak Hour							
	East	West	East-West	North	East		
Peak Hour Volume from APCs	1,086	1,615	557	606	595		
Minimum number of 2-car trains required (forecast/266)	4.1	6.1	2.1	2.3	2.2		
Actual number of 2-car trains (2 Red Line trains continue to Gov. Ctr. In the PM peak)	6	6	6	4	4		
Achievable Capacity with standard average load, see Section 5.b	1,596	1,596	1,596	1,064	1,064		
Average Headway	10.0	10.0	10.0	10.0	15.0		
Number of peak hour trippers required past the peak load point(s)	**2**	**2**	**2**	**0**	**0**		**6**
PM Peak Period: Peak 2-Hours							
Peak 2-Hour Volume from APCs	1,848	2,545	1,101	1,053	1,091		
Minimum number of 2-car trains required (forecast/266)	6.9	9.6	4.1	4.0	4.1		
Actual number of 2-car trains in peak hour	6	6	6	4	4		
Actual number of 2-car trains in peak 2-hours	11	12	10	8	8		
Average Headway	10.9	10.0	12.0	15.0	15.0		
Number of transition trippers required past the peak load point(s)	**1**	**2**	**0**	**0**	**0**		**3**
Fleet Size							
Total peak trains (daybase trains + peak trippers)	**24**		**12**	**7**	**8**	**1**	**52**
Peak Vehicle Requirement (PVR) = total peak trains x 2, except shuttle	48		24	14	16	1	103
Spares = Total Fleet minus PVR minus 2 Type 1s undergoing body rebuild							22
Active Fleet including spares							125
Total Fleet including Spares							127
Spare Ratio							21.3%
Notes: Achievable peak hour peak direction capacity per 2-car train averages 266 passengers per train at the peak load point.							

Figure 3.7
Weekday Ridership Growth vs. LRV Fleet Size



4) System and Service Expansion

a) Milwaukie, Orange Line Opens 2015

This is the second phase of the South Corridor Project; the first phase was the Green Line. The Orange Line will extend light rail south from Downtown Portland to south of downtown Milwaukie at Park Ave., see Figure 4.1. The extension will either operate as a through route with the North Corridor's Yellow Line, Interstate Ave. MAX or terminate at Union Station at the north end of the Mall. Revenue service on the Milwaukie extension is planned to begin in 2015, initially with 14 LRVs (12 in service and 2 spares) to provide 10-minute peak hour and 15-minute mid-day policy headways. It is estimated that a fleet of 17 (14 in service and 3 spares) to 18, Type 5, vehicles will be needed to accommodate an average of about 27,000 weekday boardings on this extension in 2030, see Section 5 for calculations.

The demand modeling assumes through routing of daybase trains and some of the peak tripper trains. Other peak tripper trains will turn back at Union Station at the north end of the Mall. See Section 5 for headway calculations.

Type 5 vehicles will be compatible with Type 4 vehicles but not electrically compatible with Type 1, 2 and 3 vehicles. Therefore, they will not be able to run coupled together as trains with Type 1, 2 or 3 vehicles in revenue service. Type 5 vehicles may be single-ended like the Type 4 vehicles or they may be double ended for greater flexibility in service, depending on a review of the performance of Type 4 vehicles in the first few years of service.

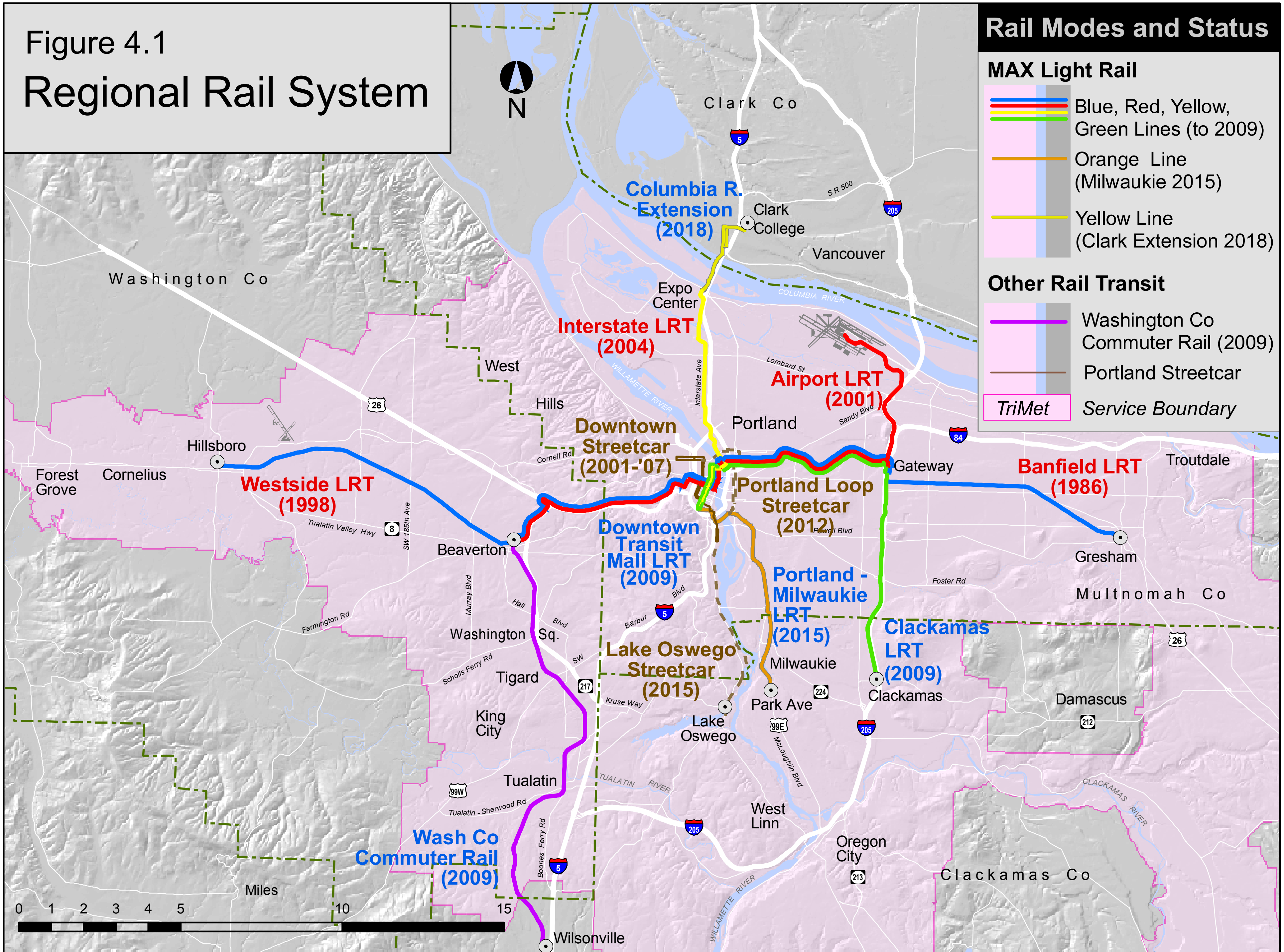
b) Columbia River Crossing (CRC) Opens 2018

The Columbia River Crossing (CRC) project will extend the Yellow Line north from the Exposition Center station in Portland to Clark College in Vancouver, Washington, see Figure 4.1. Revenue service on the CRC extension is planned to begin in 2018, initially with 7 (6 in service and 1 spare) LRVs to provide 10-minute peak hour and 15-minute mid-day policy headways. It was estimated that a fleet of 19 (16 in service and 3 spares), Type 5, vehicles will be needed to accommodate an average of about 19,000 weekday boardings on this extension in 2030. The large increase in trains is caused by the fact that trains added to the extension must also travel the length of the existing Yellow Line to shorten peak headways that provide the needed passenger capacity.

c) Green Line Service Improvements

Twenty-two LRVs were purchased for the Green Line within the FFGA. The 2025 demand forecast indicated that 30 LRVs will be needed in the planning horizon year of 2025. This means Tri-Met needs to acquire 8 more LRVs prior to about 2025. TriMet will monitor actual ridership growth to determine when these 8 LRVs need to be acquired.

Figure 4.1
Regional Rail System



Planned Facility Expansion

Facility expansion for LRV storage and maintenance will be done at Ruby Junction for both projects. The expansion is being planned in two phases: Phase 1 to be built with Milwaukie project funding and Phase 2 to be built with CRC project funding. Construction will be combined if the CRC project advances fast enough

Operation and Maintenance Facility additions for the Milwaukie fleet at Ruby Junction (Phase 1) on about 5.7 acres of land acquired with Milwaukie project funds will include:

- LRV Storage
  - Construct the first phase of Ruby's west storage yard to a capacity of 20 spaces on 5 tracks (4 LRVs on each track).

- Maintenance Bays
  - Relocate the wash bay to make room for added maintenance bays.
  - Add 2 pit & platform bays on the west side of the main shop.

- Rail Control Improvements
  - Build a new Operations Command Center (OCC) on a more central TriMet site, Center St., to accommodate control room expansion, redundant equipment for reliability in emergencies and an overview display of greater height for acceptable readability.
  - Retain space for a scaled down back-up OCC at Ruby Junction.

- Parking and Parts Storage
  - Add about 50 parking spaces for the increase in workers.
  - Prepare outdoor storage area site for equipment that can be stored outside.
  - Retain one of the acquired existing buildings for indoor covered parts storage.

- Unit Repair Area
  - Expand the unit repair area on the 1st floor of the main shop through the relocation of administrative functions and parts storage to other floors or buildings.

Operation and Maintenance Facility additions for the CRC fleet at Ruby Junction (Phase 2) on about 4.8 acres of land acquired with CRC project funds will include:

- LRV Storage; 22 new spaces
  - Complete Ruby's west storage yard for a total capacity of 42 spaces on 7 tracks (6 LRVs on each track)

- Maintenance Bays; Complete the shop expansion by
  - Adding 3 pit & platform bays.
  - Adding 1 bay for a second wheel truing machine.
  - Adding 1 flat bay with jacks for truck work.

- Rail Control Improvements
    - Finish the back up Operations Command Center (OCC) at Ruby.

- Parking and outdoor storage
    - Add about 55 parking spaces for the increase in workers.
    - Finish outdoor storage area for equipment that can be stored outside.

- Unit Repair Area
    - Retain an acquired existing shop building for MOW shop use.
    - Retain a few other acquired buildings for reuse.

A more detailed description and drawings of these improvements are contained in the “Operating and Maintenance Facilities Basis of Design Report for Entering Final Design” dated October 2010. Phase 1 construction is expected to begin in 2012 and be completed in 2014.

5) Demand for Revenue Vehicles

a) Passenger Demand Forecasts (Step 1)

Peak Passenger Loads. The Blue and Red Lines have two peak load points: Lloyd Center east of downtown and Goose Hollow (SE18th & Jefferson) west of downtown. The Green Line also passes Lloyd Center and serves that peak load point. The Yellow Line's peak load point is just north of Rose Quarter before it shares the right-of–way with the Blue, Red and Green Lines over the Steel Bridge and into downtown. The Milwaukie extension will have a new peak load point south of Tacoma while CRC is an extension of the Yellow Line and will share its peak load point, north of Rose Quarter.

2010 to 2030 actual and forecasted PM peak direction passenger loads are shown in Table 5.1. The forecasted volumes for 2015, 2018 and 2030 are outputs from the regional EMME2 travel demand model. These outputs are from more than one model run; 2015 and 2018 volumes for the Orange and Yellow Lines are from the opening year forecasts for the Milwaukie and CRC FEIS runs. For the Red, Green and Blue lines volumes are a linear interpolation between actual 2010 counts and the 2030 forecasts from the last Milwaukie model run made in September 2010. This is also true for the Yellow line volumes between 2010 and 2018. The 2030 volumes are from the horizon year forecasts from the Milwaukie and CRC FEIS runs. The only combined Milwaukie / CRC run was made for the Regional Transportation Plan (RTP) for 2035 which is not shown.

PM peak passenger loads are used for fleet size forecasting because they are higher than AM peak passenger loads.

Table 5.1

PM Peak Direction Passenger Loads past the peak load points

	Milwaukie Orange Line **south** of Tacoma		CRC Yellow Line **north** of Rose Quarter		Blue, Red and Green Lines **east** of Lloyd Center		Blue and Red Lines **west** of Goose Hollow	
	1-hour	2-hour	1-hour	2-hour	1-hour	2-hour	1-hour	2-hour
2010	0	0	606	1,175	2,238	4,039	1,835	3,262
2011	0	0	613	1,179	2,397	4,279	1,930	3,405
2012	0	0	620	1,183	2,556	4,519	2,025	3,548
2013	0	0	627	1,187	2,715	4,759	2,120	3,691
2014	0	0	634	1,191	2,874	4,999	2,215	3,834
2015	1,239	2,354	641	1,195	3,033	5,239	2,310	3,977
2016	1,264	2,372	648	1,199	3,192	5,479	2,405	4,120
2017	1,289	2,390	655	1,203	3,351	5,719	2,500	4,263
2018	1,314	2,408	1,802	2,924	3,510	5,959	2,595	4,406
2019	1,339	2,426	1,868	3,029	3,669	6,199	2,690	4,549
2020	1,364	2,444	1,934	3,134	3,828	6,439	2,785	4,692
2021	1,389	2,462	2,000	3,239	3,987	6,679	2,880	4,835
2022	1,414	2,480	2,066	3,344	4,146	6,919	2,975	4,978
2023	1,439	2,498	2,132	3,449	4,305	7,159	3,070	5,121
2024	1,464	2,516	2,198	3,554	4,464	7,399	3,165	5,264
2025	1,489	2,534	2,264	3,659	4,623	7,639	3,260	5,407
2026	1,514	2,552	2,330	3,764	4,782	7,879	3,355	5,550
2027	1,539	2,570	2,396	3,869	4,941	8,119	3,450	5,693
2028	1,564	2,588	2,462	3,974	5,100	8,359	3,545	5,836
2029	1,589	2,606	2,528	4,079	5,259	8,599	3,640	5,979
2030	1,620	2,624	2,590	4,179	5,427	8,843	3,732	6,130

b) MAX Service Standards for Train Loading (Step 2)

In 1989, The Tri-Met Board of Directors adopted Service Standards for the design, evaluation and adjustment of transit service. The Service Standards do not apply to individual train trips but to average vehicle loads during each time period. This Service Standards document established the operating policies for headways as well as passenger loads. Headway is the time interval between train arrivals at stations. The minimum policy headways for light rail are:

- 10 minutes in the peak (7-9AM & 4-6PM)
- 15 minutes in the daybase (6-7AM & 9-4PM)
- 15 minutes in the evening (6-9:30PM)
- 30 minutes at night (9:30 PM -12 midnight)

The peak policy headway does not apply to the Red Line that averages 15-minute headways nearly the entire service day, seven days a week. This near uniform headway is a result of the line's more even demand levels due to a lower percentage of commuters and the bi-directional nature of travel patterns on the line during peak periods.

Due to the recent downturn in the economy and the resulting budget pressures the Green Line and Yellow Line are operating on 15-minute peak headways with 2-car trains, however the loading standards described below are being met.

The first eighteen years of operating experience taught Tri-Met that, in Portland, rider's crowding threshold is an average of 266 people per 2-car train during the peak hour in the peak direction. While some trains do carry the standard maximum passenger load of 332 or more riders, the average during the peak hour is 266, see Figure 5.1. This average is comparable to achievable capacity as defined in TCRP Report 13, "Rail Transit Capacity".

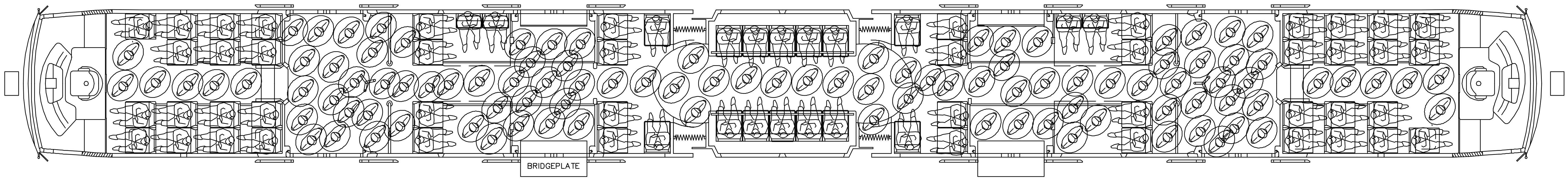
TriMet's loading standard is based on seated passengers plus standees at a peak hour average of 2.7 standees per square meter of standing floor area. This 2.7 average for the peak hour is very close to the 3.3 value suggested on page 5-27 and 28 of the TCRP Report 100 for the peak 15 minutes allowing for the peak hour factor, see Appendix A. Using load factors would result in a different standard for each LRV type.

Type 4 LRVs have a slightly higher capacity than the Type 1, 2 and 3 LRVs, see table 5.2. However, since Type 4 LRVs make up only 17% of the fleet and due to increases in the demand from passengers who bring bicycles with them Tri-Met has elected to continue using the peak hour loading standard of 266 passengers per 2-car train. Type 5 LRVs may have less capacity than Type 4 LRVs if it is decided to restore the second operator cab.

Table 5.2

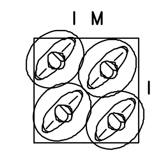
LRV Capacity

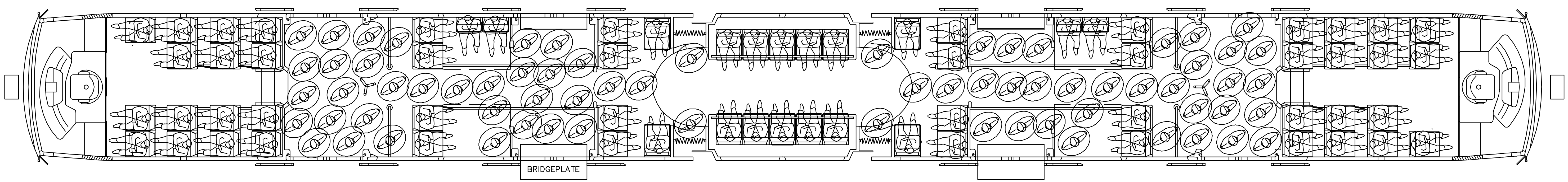
LRV Type	Design Capacity				Achievable Capacity	
	Seats per car	Standees per car	1-car train	2-car train	1-car Train	2-car Train
1	76	90	166	332	133	266
2 or 3	64	102	166	332	133	266
4	68	104	172	344	138	275



STANDARD MAXIMUM PASSENGER LOAD DURING PEAK HOUR (LOAD FACTOR OF 2.6)

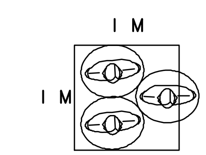
166 = 64 SEATED + 102 STANDING AT 4 PER SQ. M.

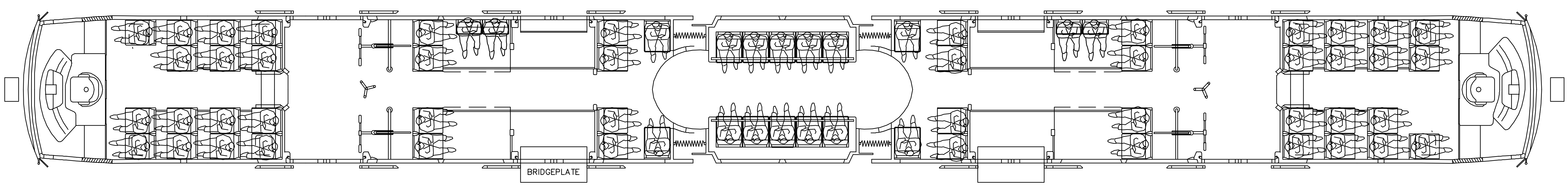




STANDARD AVERAGE PASSENGER LOAD DURING PEAK HOUR (LOAD FACTOR OF 2.1)

133 = 64 SEATED + 69 STANDING AT 2.7 PER SQ. M.





64 SEATED: LOAD FACTOR OF 1.0

NO.	DATE	BY / CHK.	APPD.	REVISIONS

DESIGNED: JHM DATE: 12/01
DRAWN DATE
CHECKED DATE
APPROVED DATE

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON

TRI MET CAPITAL PROJECTS DIVISION
710 NE HOLLADAY STREET
PORTLAND, OREGON 97232

SUBMITTED: DATE: APPROVED: DATE:

FIGURE 5.1

MAX PASSENGER LOADING STANDARD

SCALE: NONE | DRAWING NO.: FIG 5.1 LFLRVCAP | CONTRACT NO.: | SHEET NO.: 21

R:\CAD_Admin\Operations\Figures\FIG 5.1 LFLRVCAP.dwg, 1/12/2011 2:13:33 PM, mcbridej

c) Run and Cycle Times by Line (Step 3)

Cycle time is the round trip travel time for a train and its operator on a particular line that accounts for travel time variations during peak and non-peak periods of the day. Cycle time includes the run times from one end of the line and back as well as schedule recovery and operator break time. Schedule recovery time is 10% of run time and operator break time is five minutes per hour. There is also a labor contract requirement for meal breaks that results in one additional daybase train on the Blue Line. The run and cycle times for the MAX lines and the resulting daybase train requirements are shown in Table 5.3. TriMet's use of peak tripper trains results in a lower PVR than full cycle trains require, because a tripper train can serve the peak load point's passenger trips without making a full cycle. For Milwaukie without CRC in 2030 the difference for through routed Yellow/Orange trains is 18 full cycle trains vs. 10 daybase trains plus 5 peak trippers. That is a 6-car reduction in the PVR for 2-car trains.

Table 5.3

MAX Run and Cycle Times

MAX Line and Alignment	One-way Run Time	Round Trip Cycle Time	Daybase Headway in minutes	Number of Daybase Trains	Peak Hour Headway in minutes	Number of Full Cycle Peak Trains
Blue Gov. Ctr. To Clev. Ave.	96	230	15	16		
Red PDX to BTC	58	150	15	10		
Yellow/Orange Expo Ctr. To Park Ave.	57	150	15	10	8.6	18
Yellow Clark Col. To PSU	43	120	15	8	6	20
Green CTC to PSU	46	120	15	8		

d) Application of Loading Standards (Step 4)

Applying the 266 passenger 2-car train loading standard to the load data from Table 5.1 gives the minimum required number of trains that are needed in the peak direction past the peak load points. The minimum number of required trains in the peak hour is shown in Table 5.4. The minimum number of required trains in the peak two hours is shown in Table 5.5. Since many peak tripper trains do not make full cycles the 2-hour load must be examined to insure a smooth transition from the peak hour to the off-peak period.

The maximum headway can then be calculated by dividing the time period in minutes by the minimum number of trains required. Therefore for Milwaukie an average headway of 12 minutes is required in 2015 and 8.6 minutes in 2030 during the peak hour. During the 2-hour peak period an average headway of 13 minutes is required in 2015 and 12 minutes in 2030.

Table 5.4

Minimum Number of 2-car Trains required past the peak load points in the peak hour

Year	Milwaukie Orange Line **south** of Tacoma		CRC Yellow Line **north** of Rose Quarter		Blue, Red and Green Lines **east** of Lloyd Center		Blue and Red Lines **west** of Goose Hollow	
	1-hour load	Trains Required	1-hour load	Trains Required	1-hour load	Trains Required	1-hour load	Trains Required
2010	0	0	606	3	2,238	9	1,835	7
2011	0	0	613	3	2,397	10	1,930	8
2012	0	0	620	3	2,556	10	2,025	8
2013	0	0	627	3	2,715	11	2,120	8
2014	0	0	634	3	2,874	11	2,215	9
2015	1,239	5	641	3	3,033	12	2,310	9
2016	1,264	5	648	3	3,192	12	2,405	10
2017	1,289	5	655	3	3,351	13	2,500	10
2018	1,314	5	1,802	7	3,510	14	2,595	10
2019	1,339	6	1,868	8	3,669	14	2,690	11
2020	1,364	6	1,934	8	3,828	15	2,785	11
2021	1,389	6	2,000	8	3,987	15	2,880	11
2022	1,414	6	2,066	8	4,146	16	2,975	12
2023	1,439	6	2,132	9	4,305	17	3,070	12
2024	1,464	6	2,198	9	4,464	17	3,165	12
2025	1,489	6	2,264	9	4,623	18	3,260	13
2026	1,514	6	2,330	9	4,782	18	3,355	13
2027	1,539	6	2,396	10	4,941	19	3,450	13
2028	1,564	6	2,462	10	5,100	20	3,545	14
2029	1,589	6	2,528	10	5,259	20	3,640	14
2030	1,620	7	2,590	10	5,427	21	3,732	15

Note: See Section 3.d for an explanation of why 2-car trains are assumed.

Table 5.5
Minimum Number of 2-car Trains required past the peak load points in the peak 2-hours

Year	Milwaukie Orange Line **south** of Tacoma		CRC Yellow Line **north** of Rose Quarter		Blue, Red and Green Lines **east** of Lloyd Center		Blue and Red Lines **west** of Goose Hollow	
	2-hour load	Trains Required	2-hour load	Trains Required	2-hour load	Trains Required	2-hour load	Trains Required
2010	0	0	1,175	5	4,039	16	3,262	13
2011	0	0	1,179	5	4,279	17	3,405	13
2012	0	0	1,183	5	4,519	17	3,548	14
2013	0	0	1,187	5	4,759	18	3,691	14
2014	0	0	1,191	5	4,999	19	3,834	15
2015	2,354	9	1,195	5	5,239	20	3,977	15
2016	2,372	9	1,199	5	5,479	21	4,120	16
2017	2,390	9	1,203	5	5,719	22	4,263	17
2018	2,408	10	2,924	11	5,959	23	4,406	17
2019	2,426	10	3,029	12	6,199	24	4,549	18
2020	2,444	10	3,134	12	6,439	25	4,692	18
2021	2,462	10	3,239	13	6,679	26	4,835	19
2022	2,480	10	3,344	13	6,919	27	4,978	19
2023	2,498	10	3,449	13	7,159	27	5,121	20
2024	2,516	10	3,554	14	7,399	28	5,264	20
2025	2,534	10	3,659	14	7,639	29	5,407	21
2026	2,552	10	3,764	15	7,879	30	5,550	21
2027	2,570	10	3,869	15	8,119	31	5,693	22
2028	2,588	10	3,974	15	8,359	32	5,836	22
2029	2,606	10	4,079	16	8,599	33	5,979	23
2030	2,624	10	4,179	16	8,843	34	6,130	24

Note: See Section 3.d for an explanation of why 2-car trains are assumed.

For CRC an average headway of 8.6 minutes is required in 2018 and 6 minutes in 2030 during the peak hour. During the 2-hour peak period an average headway of 11 minutes is required in 2018 and 7.5 minutes in 2030.

The calculations for number of peak tripper trains needed during the peak hour and transition periods to the daybase for each line are described in the next subsection. The marginal difference from the no-build operation of the Yellow Line to operation of the Milwaukie and CRC extensions is also shown in the next subsection.

e) Peak Vehicle Requirements (Step 5)

Calculation of 2030 PVR

Table 5.6 Milwaukie and Table 5.7 CRC show the calculations of the PVRs for the planning horizon year 2030. The description of the PVR calculation that follows refers to the tables, which have the rows, numbered for reference.

The table begins with travel times, step 3 in the FTA Guidance; used to determine the daybase cycle time, line 6. The number of daybase trains, line 9, are then calculated based on these cycle times and the daybase headways, line 8. TriMet's longest average daybase headway allowed by policy is 15 minutes. Daybase trains provide frequent service to all passengers whether they are peak direction or reverse direction commuters or are traveling on the extremities of the system. Only some of the daybase trains pass the peak load points in the peak direction during the peak hour, line 10.

Next the peak hour, peak direction demand is considered, FTA step 4. Line 13 the forecast passenger load for 2030, FTA step 1, comes from Metro's demand model. The Blue and Red Lines have both an east and west peak load point. Line 14 divides the forecast by 266, the load standard for a 2-car train, FTA step 2. Line 15, the proposed number of trains, rounds up to a whole train or provides for the longest peak hour peak direction headway of 10 minutes allowed by policy, as is the case with the Yellow line North. The Red Line is an exception to the peak policy headway since the Blue Line provides parallel service through the peak load points. The number of peak hour trippers, line 18, is the proposed number of trains, line 15, minus the number of daybase trains passing the peak load point in the peak direction during the peak hour, line 10.

Next the peak period outside the peak hour is considered, lines 19-25. If peak period demand is great enough outside the peak hour trains may be added to smooth the transition between the daybase and the peak hour headways, as is the case with the Blue Line.

Next total peak trains, line 27, are calculated by adding up daybase trains, line 9, and peak trippers in the peak hour, line 18 and outside the peak hour, line 25. Then the PVR, line 28 and FTA step 5, is calculated by multiplying by 2 cars per train and accounting for any single car trains. Finally the Total Fleet with Spares, line 29, is calculated using TriMet's spare ratio target of 15% to 18%.

FTA step 6, TriMet does not currently use or plan to use gap trains.

The far right-hand column, Milwaukie or CRC Marginal, shows the difference between the baseline and the build alternative car requirements for a through-routed Yellow Line. The total car requirement is 17 LRVs for Milwaukie and 19 LRVs for CRC in 2030.

Table 5.6
2030 LRT Fleet Requirements for Milwaukie Build, based on Projected Travel Times and Proposed Headways

	Year 2030	**Milw FEIS LPA BLD Tsade 10.1 (9/09/10)**								
	MAX Line	East-West Gresham to Hillsboro	AirMAX: through routed to Beaverton TC	I-205: CTC to PSU	Blue, Red and Green		Interstate and Milwaukie through routed		Interstate MAX: Expo to PSU	Milwaukie Marginal
1	Travel Times									
2	Adjusted Travel Time	96	58	46			57		34	
3	Round Trip Travel Time	192	116	91			114		68	
4	Daybase layover time: total for both ends (for operator break and schedule recovery)	38	34	29			36		22	
5	Travel time as a % of cycle time	83%	77%	76%			76%		76%	
6	**Daybase Cycle Time (round trip travel time + total layover time in minutes)**	230	150	120			150		90	
7	Daybase									
8	Daybase Headway in minutes	15	15	15	5	7.5	15		15	
9	**Number of trains required for daybase (Cycle time / headway) +1 on Blue Line**	**16**	**10**	**8**	**34**		**10**		**6**	**4**
10	Number of daybase trains passing the peak load point(s) in peak hour	4	4	4	12	8	4		4	
11	Peak Period: Peak Hour									
12					East	West	North	South	North	
13	Forecasted Peak Hour Volume from EMME2 travel demand model				5,427	3,732	743	1,620	919	
14	Minimum number of 2-car trains required (forecast/266)				20.4	14.0	2.8	6.1	3.5	
15	Proposed number of 2-car trains				21	15	6	7	6	
16	Achievable Capacity at standard average load				5,586	3,990	1,596	1,862	1,596	
17	Proposed Average Headway				2.9	4.0	10.0	8.6	10.0	
18	**Number of peak hour trippers required past the peak load point(s)**				**9**	**7**	**2**	**3**	**2**	**3**
19	Peak Period: Peak 2-Hours									
20	Forecasted Peak 2-Hour Volume from EMME2 travel demand model				8,843	6,130	1,263	2,624	1,533	
21	Minimum number of 2-car trains required (forecast/266)				33.2	23.0	4.7	9.9	5.8	
22	Proposed number of 2-car trains in peak hour				21	15	6	7	6	
23	Proposed number of 2-car trains in peak 2-hours				34	23	10	11	10	
24	Proposed Average Headway				3.5	5.2	12.0	10.9	12.0	
25	**Number of transition trippers required past the peak load point(s)**				**1**	**0**	**0**	**0**	**0**	**0**
26	Milwaukie Fleet Size									
27	**Total peak trains (daybase trains + peak trippers)**				**51**		**15**		**8**	**7**
28	Peak Vehicle Requirement (PVR) = total peak trains x 2				102		30		16	14
29	**Total Fleet with Spares = (PVR x 1.165)**				**119**		**35.0**		**18.6**	**17**
	Notes: Achievable peak hour peak direction capacity per 2-car train averages 266 passengers per train at the peak load point.									

Table 5.7
2030 LRT Fleet Requirements for CRC Build,
Hours and Miles based on Projected Travel Times and Proposed Headways

	Year 2030	**Clark College July 2009**							
	MAX Line	East-West Gresham to Hillsboro		AirMAX: through routed to Beaverton TC	Interstate to Vancouver through routed		I-205: CTC to PSU	Interstate MAX: Expo to PSU	CRC Marginal
1	Travel Times								
2	Adjusted Travel Time	96		58	43		46	34	
3	Round Trip Travel Time	192		116	86		91	68	
4	Daybase layover time: total for both ends (for operator break and schedule recovery)	38		34	34		29	22	
5	Travel time as a % of cycle time	83%		77%	72%		76%	76%	
6	**Daybase Cycle Time (round trip travel time + total layover time in minutes)**	230		150	120		120	90	
7	Daybase								
8	Daybase Headway in minutes	15		15	15		15	15	
9	**Number of trains required for daybase (Cycle time / headway) +1 on Blue Line**	**16**		**10**	**8**		**8**	**6**	**2**
10	Number of daybase trains passing the peak load point(s) in peak hour	4		4	4		4	4	
11	Peak Period: Peak Hour								
12		East	West	East-West	North		South	North	
13	Forecasted Peak Hour Volume from EMME2 travel demand model	2,496	3,086	508-466	2,590		2,309	815	
14	Minimum number of 2-car trains required (forecast/266)	9.4	11.6	1.9	9.7		8.7	3.1	
15	Proposed number of 2-car trains	10	12	4	10		9	6	
16	Achievable Capacity	2,660	3,192	1,064	2,660		2,394	1,596	
17	Proposed Average Headway	6.0	5.0	15.0	6.0		6.7	10.0	
18	**Number of peak hour trippers required past the peak load point(s)**	**6**	**8**	**0**	**6**		**5**	**2**	**4**
19	Peak Period: Peak 2-Hours								
20	Forecasted Peak 2-Hour Volume from EMME2 travel demand model	4,031	5,061	887-775	4,179		3,758	1,375	
21	Minimum number of 2-car trains required (forecast/266)	15.2	19.0	3.3	15.7		14.1	5.2	
22	Proposed number of 2-car trains in peak hour	10	12	4	10		9	6	
23	Proposed number of 2-car trains in peak 2-hours	16	20	8	16		13	10	
24	Proposed Average Headway	7.5	6.0	15.0	7.5		9.2	12.0	
25	**Number of transition trippers required past the peak load point(s)**	**2**	**4**	**0**	**2**		**0**	**0**	**2**
26	CRC Fleet Size								
27	**Total peak trains (daybase trains + peak trippers)**				**16**			**8**	**8**
28	Peak Vehicle Requirement (PVR) = total peak trains x 2				32			16	16
29	**Total Fleet with Spares = (PVR x 1.165)**				**37.3**			**18.6**	**19**
	Notes: Achievable peak hour peak direction capacity per 2-car train averages 266 passengers per train at the peak load point.								

Opening Year PVRs

Table 5.8 Milwaukie and Table 5.9 CRC show the calculations of the PVRs for the opening years of the two projects.

f) Gap or Ready Reserve Train Usage (Step 6)

After the introduction of Type 2 vehicles in October of 1997, Tri-Met did operate gap trains, when available, to mitigate the impact of more frequent mechanical failures which resulted in cars from the new fleet being taken out of service. As the Type 2 vehicles became more reliable the need for gap trains ended.

Table 5.8
2015 LRT Fleet Requirements for Milwaukie Build, based on Projected Travel Times and Proposed Headways

Year 2015	**Milw FEIS LPA BLD Tsade 10.1 (9/09/10)**									
MAX Line	East-West Gresham to Hillsboro		AirMAX: through routed to Beaverton TC	I-205: CTC to PSU	Blue, Red and Green		Interstate and Milwaukie through routed		Interstate MAX: Expo to PSU	Milwaukie Marginal
Travel Times										
Adjusted Travel Time	96		58	46			57		34	
Round Trip Travel Time	192		116	91			114		68	
Daybase layover time: total for both ends (for operator break and schedule recovery)	38		34	29			36		22	
Travel time as a % of cycle time	83%		77%	76%			76%		76%	
Daybase Cycle Time (round trip travel time + total layover time in minutes)	230		150	120			150		90	
Daybase										
Daybase Headway in minutes	15		15	15	5	7.5	15		15	
Number of trains required for daybase (Cycle time / headway) +1 on Blue Line	**17**		**10**	**8**	**35**		**10**		**6**	**4**
Number of daybase trains passing the peak load point(s) in peak hour	4		4	4	12	8	4		4	
Peak Period: Peak Hour										
	East	West	East-West	Southeast	East	West	North	South	North	
Forecasted Peak Hour Volume from EMME2 travel demand model							641	1,239	570	
Minimum number of 2-car trains required (forecast/266)							2.4	4.7	2.1	
Proposed number of 2-car trains							6	6	6	
Achievable Capacity at the standard average load							1,596	1,596	1,596	
Proposed Average Headway							10.0	10.0	10.0	
Number of peak hour trippers required past the peak load point(s)							**2**	**2**	**2**	**2**
Peak Period: Peak 2-Hours										
Forecasted Peak 2-Hour Volume from EMME2 travel demand model							971	2,354	983	
Minimum number of 2-car trains required (forecast/266)							3.7	8.8	3.7	
Proposed number of 2-car trains in peak hour							6	6	6	
Proposed number of 2-car trains in peak 2-hours							10	10	10	
Proposed Average Headway							12.0	12.0	12.0	
Number of transition trippers required past the peak load point(s)							**0**	**0**	**0**	**0**
Milwaukie Fleet Size										
Total peak trains (daybase trains + peak trippers)							**14**		**8**	**6**
Peak Vehicle Requirement (PVR) = total peak trains x 2							28		16	12
Total Fleet with Spares = (PVR x 1.165)							**32.6**		**18.6**	**14**

Notes: Achievable peak hour peak direction capacity per 2-car train averages 266 passengers per train at the peak load point.

Table 5.9
2018 LRT Fleet Requirements for CRC Build,
Hours and Miles based on Projected Travel Times and Proposed Headways

Year 2018	Clark College July 2009							
MAX Line	East-West Gresham to Hillsboro		AirMAX: through routed to Beaverton TC	Interstate to Vancouver through routed		I-205: CTC to PSU	Interstate MAX: Expo to PSU	CRC Marginal
Travel Times								
Adjusted Travel Time	96		58	43		46	34	
Round Trip Travel Time	192		116	86		91	68	
Daybase layover time: total for both ends (for operator break and schedule recovery)	38		34	34		29	22	
Travel time as a % of cycle time	83%		77%	72%		76%	76%	
Daybase Cycle Time (round trip travel time + total layover time in minutes)	230		150	120		120	90	
Daybase								
Daybase Headway in minutes	15		15	15		15	15	
Number of trains required for daybase (Cycle time / headway) +1 on Blue Line	**16**		**10**	**8**		**8**	**6**	**2**
Number of daybase trains passing the peak load point(s) in peak hour	4		4	4		4	4	
Peak Period: Peak Hour								
	East	West	East-West	North		South	North	
Forecasted Peak Hour Volume from EMME2 travel demand model	1,988	2,842	402-378	1,802		1,750	725	
Minimum number of 2-car trains required (forecast/266)	7.5	10.7	2.6	6.8		6.6	2.7	
Proposed number of 2-car trains	8	11	4	7		7	6	
Achievable Capacity	2,128	2,926	1,064	1,862		1,862	1,596	
Proposed Average Headway	7.5	5.5	15.0	10.0		8.6	10.0	
Number of peak hour trippers required past the peak load point(s)	**4**	**7**	**0**	**3**		**3**	**2**	**1**
Peak Period: Peak 2-Hours								
Forecasted Peak 2-Hour Volume from EMME2 travel demand model	3,239	4,623	696-627	2,924		2,868	1,242	
Minimum number of 2-car trains required (forecast/266)	12.2	17.4	4.3	11.0		10.8	4.7	
Proposed number of 2-car trains in peak hour	8	11	4	7		7	6	
Proposed number of 2-car trains in peak 2-hours	13	18	8	11		11	10	
Proposed Average Headway	9.2	6.7	15.0	10.9		10.9	12.0	
Number of transition trippers required past the peak load point(s)	**1**	**3**	**0**	**0**		**0**	**0**	**0**
Fleet Size								
Total peak trains (daybase trains + peak trippers)				**11**			**8**	**3**
Peak Vehicle Requirement (PVR) = total peak trains x 2				22			16	6
Total Fleet with Spares = (PVR x 1.165)				**25.6**			**18.6**	**7**

Notes: Achievable peak hour peak direction capacity per 2-car train averages 266 passengers per train at the peak load point.

6) Supply of Revenue Vehicles

a) Financial Constraints

Tri-Met carefully studies the capital and operating (financial) implications of expanding the fleet. This is done in the context of the Agency's overall financial planning process. Every year Tri-Met updates its five-year capital and operating financial forecasts. While financially sound, agency resources are scarce. The purchase of vehicles requires either federal funding assistance, the issue of Tri-Met long-term debt, or both. Equally important, operating costs are forecast so that local, continuing-revenue, sources will adequately meet any new continuing-expenditures. Funding for the fleet expansions for service in 2015 and 2018 in this plan will come from the Milwaukie and CRC Light Rail Projects. Funding for fleet expansions after 2018 will come from either the next Light Rail Project or bonding, see Section 8 for an estimate of when these fleet expansions will be needed.

b) Vehicle Purchasing Constraints

Like most light rail systems in the United States, Tri-Met vehicle specifications are unique to Portland. Thus, there are several "logistical" constraints to purchasing vehicles. First, purchase orders require a long (several years) lead-time to allow adequate time for the manufacture and transport of thousands of precision components, as well as the fabrication, assembly, and testing of the vehicles. Second, due to the long lead times, purchase orders of fewer than ten vehicles are uneconomical. For these reasons it is not possible to quickly purchase a few vehicles in response to an unexpected surge in ridership. On the contrary, large orders are placed years in advance for any project or extension. This inability to purchase a few vehicles at a time leads to interim spare ratios that are often higher than the transit agency desires.

c) Fleet Life Cycle

TriMet's anticipated replacement cycle for LRVs is 41 years. The 26 Type 1 vehicles are due for replacement in 2027 prior to 2030; see Section 8, Vehicle Demand and Supply Balance, and the vehicle replacement schedule in Appendix B from TriMet's Capital Improvement Plan (CIP) for further details of timing. These LRVs are subject to a sale and leaseback arrangement that has penalties for early retirement. Type 1 vehicles are currently undergoing a full body rebuild after 18 to 20 years of service, this is the only body rebuild planned before retirement. To help maintain reliability these cars may be assigned to trains with shorter runs to reduce annual mileage. TriMet intends to maintain these vehicles via progressive overhauls until their retirement to assure a high level of in-service reliability and a reasonable resale value. If the possibility of resale looks doubtful during the last few years prior to retirement, then the deferral of some maintenance prior to sale for scrap will be considered.

7) Maintenance and Reliability

a) Maintenance Program Elements

Tri-Met's overall LRV maintenance program consists of seven distinct, but mutually supportive maintenance work programs: preventive maintenance, running repairs, component rebuild, progressive overhaul, scheduled maintenance, modifications (product improvements), and equipment engineering analysis and training. These seven work programs required about 115,000 labor hours per year for the 105-car fleet, or just less than 1,100 labor hours per year per vehicle, Type 4 LRVs were excluded from these calculations due to the brief time in operation. .

<u>Preventive Maintenance (35% of total labor hours)</u>

Preventive Maintenance (PM) inspections, including correction of defects found, are performed on a consistent schedule based on mileage. PM inspections are scheduled at intervals of 4,500, 9,000, 13,500, 27,000, 40,500, and 81,000 miles, each mileage grouping accrues mileage independently from the other and is scheduled based on the mileage accrued since the completion of the last PM, each mileage interval is based on the specific needs of that system's components. Any periodic, scheduled inspection and maintenance tasks with intervals greater than 81,000 miles are performed under the Progressive Overhaul program.

The PM program content and intervals are based on manufacturer recommendations, refined through continuous analysis by equipment engineering staff, maintenance supervisors and technicians. Physical inspections of components and systematic data tracking of failures and repairs are continually analyzed to maximize both effectiveness and efficiency of the PM program. See Appendix C for a description of PM Inspections and their respective mileage intervals by LRV type. Items with a 0 for the mileage interval are no longer covered by technicians during PMs instead they are performed as running repairs when reported by operators or cleaners.

TriMet's goal is to complete at least 80% of PM inspections on time.

TriMet Preventive Maintenance Force Account Plan. TriMet's rail and facilities maintenance program includes work performed by TriMet's labor force and by contractors. By far the great majority of preventive maintenance is performed by TriMet's own labor forces as negotiated by the Working and Wage Agreement between Amalgamated Transit Union Division 757 and TriMet. Under the labor agreement work that is contracted out must meet criteria specified in the labor agreement. Contracted maintenance must also be pre-approved by the ATU. The justification for using force account work for preventive maintenance is the TriMet ATU labor agreement. Budgets for this work are shown in Appendix D.

Running Repairs (21% of total labor hours)

Running Repairs diagnose and correct defects on vehicles identified during revenue service and reported to LRV Maintenance by Transportation personnel. Vandalism and accident repairs are also classified under the Running Repairs program.

Component Rebuild (4% of total labor hours)

The component (or unit) rebuild program refers to repairable equipment removed and replaced on the vehicle. Such equipment components or subsystems are rotated through the component rebuild section of LRV Maintenance in appropriate cycles so as to maintain availability of rebuilt or repaired components to meet running repair requirements for removal and replacement of such components. This allows much faster return of defective vehicles to service. Component rebuild production and quality is under dedicated supervision, and is also supported by equipment engineering analysis and product improvement modifications at the component/subsystem level.

Progressive Overhaul (22% of total labor hours)

Tri-Met's LRV maintenance program seeks to keep current with the entire scope of vehicle maintenance requirements, and therefore seeks to avoid requirements for mid-life remanufacturing for its LRVs. Accordingly, long-cycle tasks (beyond the 81,000 PM program cycle) are also scheduled based on continuing fleet condition assessment and design of overhaul campaigns. Each overhaul campaign bundles multiple overhaul tasks which are now due, for simultaneous performance on each vehicle cycled through the campaign, for efficient overhaul program production. This progressive overhaul approach was recognized by USDOT in a 1995 report as best-practice in the rail transit industry, preferable to mid-life vehicle remanufacturing in terms of keeping the fleet continuously in service at a higher spare ratio and in minimizing fleet life-cycle total cost.

Scheduled Maintenance (13% of total labor hours)

Other scheduled maintenance tasks that are outside of preventive maintenance or progressive overhaul and are scheduled from time of completion, from measured wear limit or by seasonal requirements are captured under scheduled maintenance. Maintenance tasks such as wheel truing, car floor height adjustment and brake disc truing are examples of scheduled maintenance.

Modifications (product improvements are 5% of total labor hours)

Modifications are product improvements made to (1) increase vehicle reliability by decreasing failure and wear rates, (2) increase maintainability by easing or decreasing maintenance tasks, and (3) increase customer service by improving vehicle amenities or comfort.

Vehicle reliability and maintainability modifications are an ever-present element of the LRV maintenance program, and arise out of continuous analysis by equipment engineering staff, maintenance supervisors and technicians. Introduction of a new-type vehicle fleet to operate in train consists with existing vehicle types can also require considerable modifications to existing vehicle types, as was required for Tri-Met's Type 1 LRVs when the Type 2 LRVs were introduced. The new curved platforms on the Portland Transit Mall resulted in the addition of side view CCTV on the entire LRV fleet. Customer service modifications have include retrofitting air conditioning to the Type 1 LRVs, retrofitting CCTV surveillance to Type 1 and 2 LRVs, and modifying interior stanchions of Type 2 LRVs to increase bicycle boarding accommodations.

<u>Equipment Engineering Analysis and Training (less than 1% of total labor hours)</u>

Equipment engineering analysis and training functions are provided through a 4-member staff unit working in a team effort with maintenance supervisors and technicians, continuously analyzing failure data among component subsystems, refining maintenance techniques (e.g., procedures and training, including PM program effectiveness), and developing product improvement modifications.

The equipment engineering staff is dual-function, by also serving as LRV maintenance trainers. Training program elements include (1) initial training of apprentices from Tri-Met's maintenance helper classification to become LRV maintenance technicians (30-month program of classroom and on-the-job training), (2) technician recurrent training, and (3) training of technicians and apprentices on modifications, new or revised maintenance procedures, and new types of LRVs or maintenance equipment.

b) Train Failure Definitions and Actions

Train failures can require the use of spare vehicles to maintain scheduled service. The term relevant failure has been used to define which failures are used to calculate the mean distance between failures (MDBF).

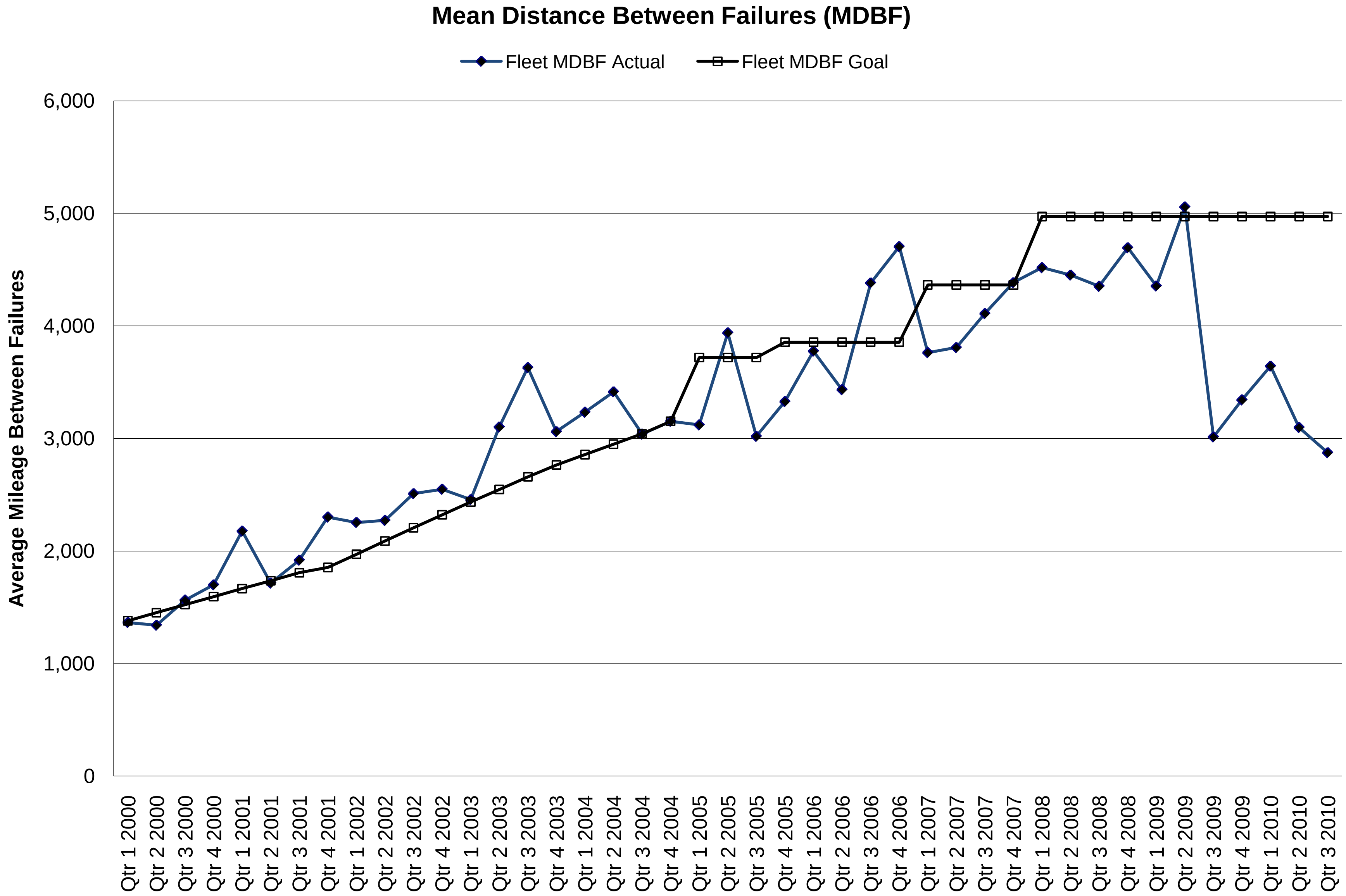
Relevant failures used in Tri-Met’s traditional calculation of the mean distance between failures (MDBF) include any independent failure of an item which results in any of the following:

1. A four-minute or longer delay of revenue service.
2. Failure to enter revenue service at the scheduled time.
3. Need to remove a vehicle from revenue service.
4. Failure of the ventilation system.
5. Door and bridgeplate system failure that requires two or more doors or bridgeplates per car to be cutout.

Relevant failures varied between 7,500 miles and 25,000 miles between 2000 and 2004. Problems with the software’s tracking of delays between 2004 and 2008 resulted in erratic data of little use for measuring trends in vehicle reliability.

In the year 2000, a new measure of vehicle reliability was developed, for more precision in measuring reliability, determining trends and meeting TriMet’s goal of continuous improvement in LRV reliability. This service related failures measure is based on the number of times any symptom code is used to log in a repair on the pending worklist, see Appendix E for examples. There has been much improvement in this measure of MDBF since 2001, from below 2,000 miles to above 4,000 miles. The MDBF for the past ten years is shown in Figure 7.1. When new LRVs enter the fleet they tend to bring down the MDBF for some period of time as can be seen from the 3rd quarter of 2009 on.

Figure 7.1
Service Related Failures



8) Vehicle Demand and Supply Balance (Steps 7 and 8)

a) Spare Vehicle Requirements

There are three purposes for vehicle spares:

- to allow for routinely scheduled, preventative maintenance work to be performed during day and swing shifts in service bays that would otherwise be vacant
- to replace vehicles that fail in peak revenue service
- to allow for progressive overhaul and vehicle modification campaigns that take more than 1 or 2 shifts per car to complete.

Prior to Green Line opening in September 2009 TriMet operated with an 18% spare ratio, 16 spare cars compared with 87 cars in PM peak service. Two Type 1 cars at a time were out of the active fleet of 103 undergoing mid-life body rebuilds. Since TriMet's fleet is fairly small a certain number of spares are not dedicated to a given category of work on a regular basis. With only 16 spares an entire car cannot be devoted to the smaller categories of work on a continuous basis. However on average: 5.6 cars were undergoing Preventive Maintenance, 3.36 cars were undergoing Running Repairs, 0.64 of a car was undergoing Component Rebuild, 3.52 cars were undergoing Progressive Overhaul, 2.08 cars were undergoing Scheduled Maintenance, 0.8 of a car was undergoing Modifications, and 0.16 of a car was involved in Equipment Engineering Analysis & Training.

TriMet's long term goal is to operate with a spare ratio between 15% and 18%. This range allows TriMet to meet its service objectives in a cost effective manner. However, because small LRV orders are not economical and service increases for passenger load growth on existing lines are limited to an additional train every few years many LRVs must be acquired before they are required. This situation results in a spare ratio that fluctuates over time, higher just after LRV acquisitions and gradually declining as more LRVs are put in service.

b) Fleet Demand and Spare Ratio

The fleet size, at any given time, is governed by:

- The Peak Vehicle Requirement (PVR) required to serve the current passenger demands based on data from automatic passenger counters
- The Peak Vehicle Requirement (PVR) required to serve future passenger demands based on transportation demand modeling with assumptions on future population and employment growth
- Financial constraints
- Vehicle procurement constraints including minimum economical size of order and delivery schedule
- The spare ratio target of 15% to 18% for the planning horizon year

The anticipated fleet size requirements for MAX between 2010 and 2030 with both the Milwaukie extension and the CRC extension are summarized in Table 8.1. Based on the passenger demand model forecasts for 2030 the fleet will total 175 cars. This includes new LRVs available for peak service and spares in:

- 2015 – 18 for Milwaukie
- 2018 – 19 for CRC
- 2025 – 11 for system growth (includes the 8 Green Line cars not delivered for 2009)
- 2027 – 26 replacement LRVs for Type 1 retirements

Financial constraints could delay the purchase of some of the 18 LRVs for Milwaukie or some of the 19 LRVs for CRC similar to the 8 cars deferred for Green Line growth.

The operating spare ratio (OSR) is the number of spares (active fleet - the PVR) divided by the PVR. The spare ratio forecast which varies from 17% to 30% is shown in Table 8.1. A 17% spare ratio would be fairly close to the lowest spare ratios in the rail transit industry. Achieving spare ratios below 15% would force uneconomical and inflexible operating and maintenance practices such as:

- concentrating the vast majority of maintenance during off-peak periods leaving maintenance bays idle several hours twice daily
- forcing more swing and graveyard shift work at higher wages and lower productivity while increasing the need for more maintenance bays.

The future service increases shown in Table 8.1 are estimates of when service would be added based on passenger demand models that are updated often. Actual service implementation will be based on updated model forecasts and the evaluation of automatic passenger counter data from existing MAX service.

Table 8.1
LRV Demand Supply Balance

Year	PVR increase on Extensions		PVR increase on existing lines		PVR	LRV delivery	Active Fleet	Spares	OSR
	South	North	East	West					
2007					79		103	24	30%
2008		1	3	4	87		103	16	18%
2009		1	14	1 shuttle	103	22	125	22	21%
2010					103		125	22	21%
2011		Mall shuttle discontinued -1, west side peak tripper added +2			104		125	21	20%
2012					104	*	127	23	22%
2013					104		127	23	22%
2014			2		106		127	21	20%
2015	12			2	120	18	145	25	21%
2016					120		145	25	21%
2017			2		122		145	23	19%
2018		6			128	19	164	36	28%
2019	2	2			132		164	32	24%
2020					132		164	32	24%
2021		2	2		136		164	28	21%
2022				2	138		164	26	19%
2023					138		164	26	19%
2024		2			140		164	24	17%
2025			2		142	11	175	33	23%
2026		2			144		175	31	22%
2027					144	26**	175	31	22%
2028					144		175	31	22%
2029		2	2		148		175	27	18%
2030				2	150		175	25	17%
Total									

***** The 2 LRVs out of the active fleet for body rebuilds are returned to the fleet.

****** In 2027 the 26 Type 1 LRVs are due for replacement.

Appendices

- A. TCRP Report 100 “TCQSM” 2nd Edition 2003 – Chapter 5 Rail Transit Capacity
- B. Capital Improvement Program (CIP) Replacement Table
- C. PM Inspections by LRV Type
- D. Preventive Maintenance Force Account Plan Budgets
- E. Service Related Failures MDBF July, Aug. & Sep. 2010

Appendix A

TCRP Report 100

Transit Capacity and Quality of Service Manual

2nd Edition

Part 5 Rail Transit Capacity

Chapter 4 Passenger Loading Levels

Pages 5-25 to 5-29

CHAPTER 4. PASSENGER LOADING LEVELS

INTRODUCTION

Establishing the loading level of rail transit is the final step in determining capacity. After the maximum train throughput has been calculated from the inverse of the sum of signaling separation time, dwell time, and operating margin, capacity is then based only on train length and loading level.

The existing loading levels on North American rail transit vary from the relaxed seating on many commuter rail lines to the denser loadings experienced on older subway and light rail systems. These loadings offer levels of passenger comfort that are inappropriate for new systems intended to compete with the automobile.

Loading levels vary widely by transit mode and system.

The next section reviews existing rail transit loading standards. The remainder of the chapter determines a range of loading standards that can be applied in specific circumstances for each mode.

LOADING STANDARDS

Most rail transit systems have loading standards for the peak-hour, peak-point location with more relaxed standards away from entry into the city center and for off-peak times. Exhibit 5-21 shows loading standards over the peak 15 minutes for selected heavy rail systems.

Mexico City's Metro is an exception and experiences loading that can exceed 1.8 ft^2/p (0.125 m^2/p).

Exhibit 5-21
Passenger Space on Selected North American Heavy Rail Systems During Peak 15 Minutes (1995)[R9]

System (City)	Passenger Space (based on gross floor space) (ft^2/p)	(m^2/p)
NYCT (New York)	4.0 into CBD	0.38 into CBD
CTA (Chicago)	7.0 into CBD	0.67 into CBD
SEPTA (Philadelphia)	8.0 into CBD	0.77 into CBD
MBTA (Boston)	5.0 into CBD	0.50 into CBD
BART (San Francisco)	5.75-9.0	0.53-0.83
WMATA (Washington)	5.0-12.0	0.50-1.11
MARTA (Atlanta)	6.75-7.5	0.63-0.71
TTC (Toronto)	4.5-6.0	0.42-0.56
STM (Montréal)	3.4-4.0	0.31-0.38

CBD: central business district

Care should be taken in comparing and applying the service standards with hourly average loadings. Service standards are usually based on the peak-within-the-peak—15 minutes or less. The difference between 15-minute and peak hour flows can be represented by a peak hour factor.

Service standards are usually based on peak-within-the-peak loads.

The peak hour factor for New York subway trunk routes averages 0.82. Outside New York, the peak-within-the-peak period tends to be more pronounced and the peak hour factor is lower. This is due in part to the long-established Manhattan program to stagger work hours and the natural tendency of passengers to avoid the most crowded period—particularly on lines that are close to capacity.

Peak hour diversity is lower in New York than in most other cities.

In addition to standards or policies for the maximum loading on peak-within-the-peak period trains and for standards based on minimum *policy* headways, at off-peak times some operators specify a maximum standing time. This is more often a goal rather than a specific standard—20 minutes is typical.

Maximum standing time policies.

Loading levels for commuter rail are unique and uniform. Although standing passengers may be accepted for short inner-city stretches or during times of service irregularities, the policy is to provide a seat for all passengers. Capacity is usually cited at 90 to 95% of the number of seats on the train.

SPACE REQUIREMENTS

The Batelle Institute[R8] provides details of the projected body space of passengers in various situations. The most useful of these for rail transit capacity are shown in Exhibit 5-22 for males:

Exhibit 5-22
Male Passenger Space Requirements[R8]

These are suggested minimum spaces.

Situation	Projected Area (ft²)	Projected Area (m²)
Standing	1.6-2.2	0.15-0.20
... with briefcase	2.7-3.2	0.25-0.30
... with daypack	3.2-3.8	0.30-0.35
... with suitcases	3.8-5.9	0.35-0.55
... with stroller	10.2-12.4	0.95-1.15
... with bicycle (horizontal)	17.2-20.4	1.60-1.90
Holding on to stanchion	2.7	0.25
Minimum seated space	2.7-3.2	0.25-0.30
Tight double seat	3.8 per person	0.35 per person
Comfortable seating	5.9 per person	0.55 per person
Wheelchair space (ADA)	10.0 (30 in x 48 in)	0.93 (0.76 m x 1.22 m)

NOTE: Stroller and bicycle dimensions based on review of manufacturer specifications.

Pushkarev et al.[R17] suggest *gross vehicle floor area* as a readily available measure of car occupancy, recommending the following standards for the peak hour:

- *Adequate*: 5.4 ft² (0.5 m²) per passenger provides comfortable capacity.
- *Tolerable with difficulty*: 3.8 ft² (0.35 m²) is the lower limit in North America with "some touching."
- *Totally intolerable*: 2.2 ft² (0.2 m²) is the least amount of space that is occasionally accepted.

Commuter rail capacity is based on the number of seats, reduced by a peak hour factor. Commuter rail cars in North America are typically 86 ft (28 m) long and, with few exceptions, have seating for 114 to 185 passengers. The higher levels relate to bi-level or gallery cars and/or cars with 2+3 ("two-by-three") seating arrangements.

Wheeled mobility aid space provisions range from 5.9 to 12.9 ft² (0.55 to 1.2 m²); the ADA uses a 30-in. by 48-in. (760-mm by 1220-mm) space. This space can include folding or jump seats. Provision must also be made for wheelchair maneuvering and for any requirements to carry strollers, baggage, and bicycles. More space is required for powered wheeled mobility aids and ones whose occupants have a greater leg extension, less for compact and sports chairs.

The capacity for existing systems should be based on actual loading levels of a comparable service. Actual levels on a specific system or line should be adjusted for any difference in car size and interior layout—particularly the number of seats.

Maximum, full, and crush loads.

Manufacturer-specified passenger loading—*total*, *maximum*, *full,* or *crush load*—does not necessarily represent a realistic occupancy level. Rather, it reflects applying a set criteria—such as 5 or occasionally 6 passengers per square meter (0.45 to 0.56 p/ft²)—to the floor space remaining after seating space is deducted. In particular, *crush load* can represent the theoretical, and often unattainable, loading used to calculate vehicle structural strength or the minimum traction equipment performance.

Vehicle-Specific Calculations

Estimating the person capacity of a vehicle.

Detailed calculations of the person capacity of individual vehicles are not recommended. Given the wide range of peak hour occupancy that is dependent on policy decisions, elaborate determination of interior space usage is generally not practical. Reasonably accurate estimates of vehicle capacity are all that are needed. The following procedures offer a straightforward method.

The first step after obtaining the interior car dimensions is to determine the length of the car side free from doorways. Deducting the sum of the door widths, plus a setback allowance of 16 in. (0.40 m) per double door,[2] from the interior length gives the interior free wall length.

Seating can then be allocated to this length by dividing by the seat pitch:

- 27 in. (0.69 m) for transverse seating,[3] and
- 17 in. (0.43 m) for longitudinal seating.

The result, in lowest whole numbers,[4] should then be multiplied by 2 for longitudinal seating or by 3, 4, or 5, respectively for 2+1, 2+2, or 2+3 transverse seating. The result is the total number of seats. A more exact method would use the specific length between door setbacks. Articulated light rail vehicles should have the articulation width deducted. Four seats can be assigned to the articulation, if desired.

Seating area.

The floor space occupied by seats can then be calculated by multiplying transverse seats by 5.4 ft^2 (0.5 m^2) and longitudinal seats by 4.3 ft^2 (0.4 m^2). These areas make a small allowance for bulkhead seating but otherwise represent relatively tight and narrow urban transit seating. Add 10 to 20% for a higher quality, larger seat such as that found on BART.

Standing area.

The residual floor area can now be assigned to standing passengers. Light rail vehicles with step wells should have half the step well area deducted. Although prohibited by many systems, passengers will routinely stand on the middle step, squeezing into the car at stops if the doors are treadle operated.

Articulated light rail vehicles should have half the space within the articulation deducted as unavailable for standing passengers, even if the articulation is wider. Many passengers choose not to stand in this space.

Standing passengers can be assigned as follows:

- 2.15 ft^2/p (5 p/m^2), an uncomfortable near-crush load for North Americans with frequent body contact and inconvenience with packages and briefcases. Moving to and from doorways is extremely difficult.
- 3.2 ft^2/p (3.3 p/m^2) a reasonable service load with occasional body contact. Moving to and from doorways requires some effort.
- 5.4 ft^2/p (2.0 p/m^2),[5] a comfortable level without body contact, reasonably easy circulation, and similar space allocation as seated passengers.

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2 A lower set-back dimension of 12 in. (0.3 m) may be used if this permits an additional seat/row of seats between doorways.

3 Increase to 32 in. (0.8 m) for seats behind a bulkhead.

4 For more accurate results, the sidewall should be divided into the lengths between each set of doors (and, when appropriate, between the door and any articulation) and checked, or adjusted, to ensure that an integer of the seat pitch is used. This can be done by dividing the interior free wall length by the number of doorways plus one. The number of integer seat pitches in each space is then determined and used to calculate the total vehicle seating.

However, this approach can result in the seating changing radically with a small change in vehicle length, articulation length, or door width, any of which are sufficient to add or remove a row of seats between each set of doors. On a four-door car with 2+2 seating, this results in the seating adjusting up or down by 20 seats at a time—five rows of four seats. Simple calculations cannot substitute for a professional interior layout design that can optimize seating with a combination of transverse and longitudinal seats. Other design criteria can also be accommodated including the provision of wheelchair spaces and maximizing circulation space around doorways.

5 This upper level is a peak 15-minute occupancy level for standing passengers. Over the peak hour it corresponds closely to Pushkarev's[(R17)] and Jacobs'[(R12)] estimates of a U.S. rush hour loading average of 5.4 ft^2/p (0.5 m^2/p)—both seated and standing. It also corresponds to Pushkarev's and Batelle's[(R8)] recommendations for *adequate* or *comfortable* loading levels.

The middle level above is slightly relaxed from the often stated standard of four standing passengers per square meter. The so-called crush loads are frequently based on 5 or 6 passengers per square meter (0.45 to 0.56 p/ft²), the latter being more common in Europe. Asian standards for both maximum and crush loads reach 7 or 8 standing passengers per square meter (0.67 to 0.77 p/ft²). The resultant sum of seated and standing passengers provides a guide for the average peak 15-minute service loading level for the specific vehicle. Peak hour loading should be divided by the peak hour factor to get equivalent peak 15-minute loading levels. No specific allowance has been made for wheelchair, bicycle, stroller, or other wheeled device accommodation, or for reduced standing densities away from doorways. The above range of standing densities makes such small adjustments unnecessary. Cars intended for higher density loading should have a greater number of doors. Space inefficiencies at the extremities of a car are unavoidable unless the London Underground arrangement of doors at the very end of each car is adopted.

The above process can be expressed mathematically as:

Equation 5-6

$$C_c = \left[\frac{(L_c - 0.5L_a)W_c - 0.5D_n W_s D_w}{S_{sp}}\right] + N\left[\left(1 - \frac{S_a}{S_{sp}}\right)\left(\frac{L_c - L_a - D_n(D_w + 2S_b)}{S_w}\right)\right]$$

The articulated rail car schematic in Exhibit 5-23 shows the principal dimensions of this equation.

where:

C_c = car capacity—peak 15 minutes (p/car);
L_c = car interior length (ft, m);
L_a = articulation length for light rail (ft, m);
W_s = stepwell width (certain light rail only) (ft, m);
W_c = car interior width (ft, m);
S_{sp} = space per standing passenger (ft², m²):
2.15 ft² (0.2 m²)—crush load,
3.2 ft² (0.3 m²)—maximum schedule load, and
5.4 ft² (0.5 m²)—comfortable standing load;
N = seating arrangement:
2 for longitudinal seating,
3 for 2+1 transverse seating,
4 for 2+2 transverse seating, and
5 for 2+3 transverse seating;[6]
S_a = area of single seat (ft², m²):
5.4 ft² (0.5 m²) for transverse, and
4.3 ft² (0.4 m²) for longitudinal;
D_n = number of doorways;
D_w = doorway width (ft, m);
S_b = single setback allowance (ft, m):
0.67 ft (0.2 m)— or less; and
S_w = seat pitch (ft, m):
2.25 ft (0.69 m) for transverse, and
1.42 ft (0.43 m) for longitudinal.

6 2+3 seating is only possible on cars with width greater than 10 ft (3 m), and is not applicable to light rail or automated guideway transit.

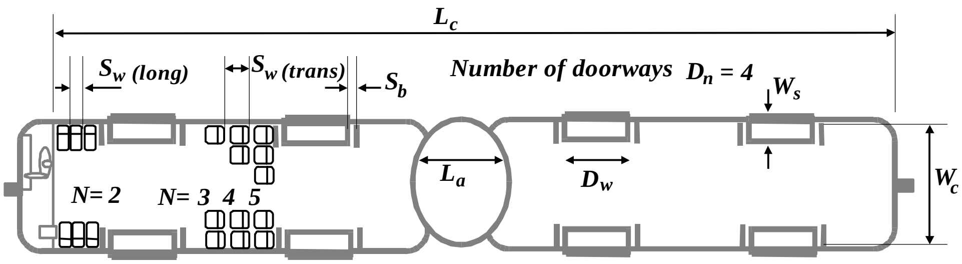

Exhibit 5-23
Schematic LRT Car Showing Dimensions(R15)

Default Method

A default method is to divide the gross floor area of a vehicle (exterior length multiplied by exterior width) by 5.4 ft² (0.5 m²) and use the resultant number of passengers as the average over the peak hour—without applying a peak hour factor. An average space over the peak hour of 5.4 ft² (0.5 m²) per passenger is the comfortable loading level on U.S. rail transit systems recommended in several reports and is close to the average loading on all trunk rail transit lines entering the CBD of U.S. cities.

LENGTH

Train length as a surrogate for capacity.

Another default method to approximate loading levels is to assign passengers per unit length. Applying Equation 5-6 to two typical light rail vehicles produces the loading levels in passengers per unit length shown in Exhibit 5-24. As would be expected, the wider and longer Baltimore car has proportionately higher loadings per meter of length. The almost generic Siemens-Düwag car used in nine systems (with some dimensional changes) has a range of 1.5 to 2.4 passengers per foot of car length (5.0 to 8.0 p/m length). The lower level of 1.5 passengers per foot length (5.0 p/m length)—with a standing space per passenger of 4.3 ft² (0.4 m²)—corresponds closely with the recommended *comfortable* loading of an average of 5.4 ft² (0.5 m²) per passenger.

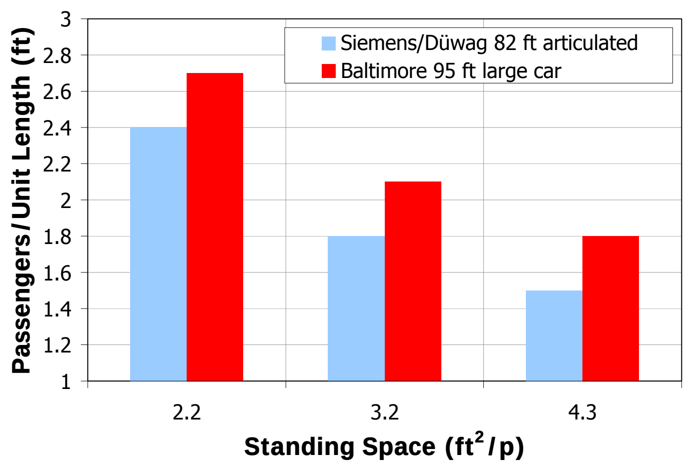

Exhibit 5-24
Linear Passenger Loading—Articulated LRVs(R15)

An alternative figure using metric units appears in Appendix A.

Applying Equation 5-6 to selected heavy rail cars produces the loading levels in passengers per unit length shown in Exhibit 5-25. As would be expected, the smaller and narrower cars in Vancouver and Chicago have lower loadings per unit length.

The more generic 75-ft (23-m) cars used in more than 12 U.S. and Canadian cities have a remarkably close data set for each of the three variations of door and seating configurations, with a range of 2.1 to 3.5 passengers per foot of car length (7.0 to 11.5 p/m of car length). The higher end of this range approaches that of crush loaded conditions.

Appendix B
Capital Improvement Plan (CIP)
LRV Replacement Table

TABLE 2. VEHICLES SYSTEMS - LIGHT RAIL VEHICLES

ITEM REQUIRED	TOTAL FLEET	ACTION NEEDED	YEAR NEEDED	CURRENT AGE FY2011	OPTIMUM/ MINIMUM REPLACEMENT CYCLE[1]	COND.	2012	2013	2014	2015	2016	FY2012-2016 TOTAL
LIGHT RAIL VEHICLES												
Type 1 LRVs (Banfield LRT)	26	Replace	2027	27	41	1	$0	$0	$0	$0	$0	$0
Type 2 LRVs (Westside LRT)	46	Replace	2034	15	36	1	$0	$0	$0	$0	$0	$0
Type 2 LRVs (Airport MAX)	6	Replace	2036	13	36	1	$0	$0	$0	$0	$0	$0
Type 3 LRVs (Interstate MAX)	27	Replace	2040	9	36	1	$0	$0	$0	$0	$0	$0
Type 4 LRVs (I-205/Mall)	22	Replace	2045	3	36	1	$0	$0	$0	$0	$0	$0
Total	**127**						**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

NOTES:
1. Replacement cycles assume preventive maintenance and progressive overhaul programs throughout vehicle life.

Appendix C

PM Inspections by LRV Type

Appendix C - Type 1 Tasks

ITEM	Comp	DESCRIPTION	Location	Frequency	N00	N01	N02	N03	N04	N05	A-End	B-End	C	UpdateDate
251	MI251	HVAC Coil Cleaning	Roof Top	81.00						1			-------	11/4/2010
135	MI135	Inspect Brake Pads and Disc	Under Car	4.50	1									11/4/2010
265	MI265	Check Door Operation and Safety System	Car Body and Interior	4.50	1								-------	11/4/2010
301	MI301	Couplers Electrical Contacts	Under Car	4.50	1								-------	11/4/2010
370	MI370	Brake and Power Test	Car Body and Interior	4.50	1								-------	11/4/2010
400	MI400	Inspect Traction Motors (Power Down)	Under Car	4.50	1								-------	11/4/2010
445	MI445	Pantograph (Power Down)	Roof Top	4.50	1						-------		-------	11/4/2010
120	MI120	Check Truck Appurtenances	Under Car	9.00		1								11/4/2010
130	MI130	Track Brake Assemblies	Under Car	9.00		1								11/4/2010
335	MI335	Test "Emergency" Mushroom Operation	Car Body and Interior	9.00		1							-------	11/4/2010
401	MI401	Traction Motor Cleaning (Power Down)	Under Car	9.00		1							-------	11/4/2010
425	MI425	Inspect Roof Mounted Equipment (Power Down)	Roof Top	9.00		1							-------	11/4/2010
132	MI132	1/4 Turn Brake Actuators	Under Car	9.00		1								11/4/2010
235	MI235	Check Window Wiper	Car Body and Interior	9.00		1							-------	11/4/2010
245	MI245	HVAC	Roof Top	9.00		1							-------	11/4/2010
340	MI340	ATS System Functional Test	Car Body and Interior	9.00		1								11/4/2010
105	MI105	Drain Labyrinth Seals	Under Car	13.50			1						-------	11/4/2010
300	MI300	Couplers	Under Car	13.50			1						-------	11/4/2010
310	MI310	Inspect Interior Electrical Compartments	Car Body and Interior	13.50			1						-------	11/4/2010
405	MI405	Clean and Inspect Exterior Electrical Compartments (Power Down)	Under Car	13.50			1							11/4/2010
325	MI325	Manual Brake Release Pump	Car Body and Interior	18.00			1							11/4/2010
155	MI155	Test Load Weigh Sensor	Under Car	27.00				1						11/4/2010
250	MI250	HVAC (Extensive)	Roof Top	27.00				1					-------	11/4/2010
225	MI225	Test Communication System	Car Body and Interior	27.00				1						11/4/2010
295	MI295	Lighting/Dest. Signs	Car Body and Interior	27.00				1					-------	11/4/2010
415	MI415	Inspect Batteries	Under Car	27.00				1				-------	-------	11/4/2010
275	MI275	Door Lubrication	Car Body and Interior	40.50					1				-------	11/4/2010
280	MI280	Door Summary	Car Body and Interior	40.50					1				-------	11/4/2010
350	MI350	Event Recorder (Train-Logger)	Car Body and Interior	40.50					1		-------		-------	11/4/2010
385	MI385	Inspect Ground Brushes (Power Down)	Under Car	40.50					1					11/4/2010
450	MI450	Pantograph (Extensive)	Roof Top	40.50					1		-------		-------	11/4/2010
185	MI185	Auxiliary Inverter (Power Down)	Under Car	40.50					1		-------		-------	11/4/2010
403	MI403	Check contactor timing (Power Down)	Under Car	40.50					1				-------	11/4/2010
190	MI190	Inspect Carbody	Car Body and Interior	40.50					1					11/4/2010
205	MI205	Operators Seat	Car Body and Interior	40.50					1				-------	11/4/2010
302	MI302	Coupler (Extensive)	Under Car	40.50					1				-------	11/4/2010
390	MI390	DC-DC Converter (Power Down)	Under Car	40.50					1			-------	-------	11/4/2010
100	MI100	Gearbox Oil Sample/Change	Under Car	40.50					1				-------	11/4/2010
137	MI137	Caliper Pivot Pin Lubrication	Under Car	40.50					1					11/4/2010
220	MI220	Check Emergency Equipment	Car Body and Interior	40.50					1				-------	11/4/2010
312	MI312	CCTV Test	Car Body and Interior	40.50					1			-------	-------	11/4/2010
330	MI330	Test Sandbox Heaters	Car Body and Interior	81.00						1			-------	11/4/2010
410	MI410	Exterior Electrical Compartments (Extensive)	Under Car	81.00						1				11/4/2010
226	MI226	PA Volume Adjustment	Car Body and Interior	81.00						1	-------		-------	11/4/2010
270	MI270	Doors Adjustment	Car Body and Interior	81.00						1	-------		-------	11/4/2010
315	MI315	Interior Electrical Compartments (Extensive)	Car Body and Interior	81.00						1				11/4/2010
371	MI371	Pad Force Measurement	Under Car	81.00						1				11/4/2010
455	MI455	Articulation Roof Linkage	Roof Top	81.00						1	-------	-------		11/4/2010
456	MI456	Articulation Floor Swivel Plate	Car Body and Interior	81.00						1	-------	-------		11/4/2010
461	MI461	Lubricate Slewing Ring	Under Car	81.00						1				11/4/2010

Appendix C Type 2 Tasks

ITEM	Comp	DESCRIPTION	Location	Frequency	N10	N11	N12	N13	N14	N15	A-END	B-END	C	UpdateDate
LF 120	MI120	Truck appurtenances	Under Car	9.00	1		1		1					22-Sep-10
LF 122	MI122	Traction motor cleaning (Power Down)	Under Car	81.00						1			---------	22-Sep-10
LF 125	MI125	Ground brushes (Power Down)	Under Car	27.00	1									22-Sep-10
LF 130	MI130	Transmission oil sample /breather /Change	Under Car	40.50									---------	22-Sep-10
LF 135	MI135	Transmission Breather (see above)	Under Car	0.00										22-Sep-10
LF 140	MI140	Track brakes	Under Car	9.00	1		1		1					22-Sep-10
LF 145	MI145	Friction brakes	Under Car	4.50	1	1	1	1	1	1				22-Sep-10
LF 147	MI147	Friction brakes fluid Sample	Under Car	81.00	1									22-Sep-10
LF 149	MI149	E.H. Unit Accumulator/M.R.U.	Under Car	27.00				1						22-Sep-10
LF 150	MI150	Sanding system	Under Car	9.00	1		1		1				---------	22-Sep-10
LF 152	MI152	Sand Box Heater Test	Car Body and Interior	81.00				1					---------	22-Sep-10
LF 155	MI155	Load Weight Sensor	Under Car	27.00		1								22-Sep-10
LF 165	MI165	ATS	Car Body and Interior	9.00		1		1		1				22-Sep-10
LF 170	MI170	Passenger seating	Car Body and Interior	0.00										22-Sep-10
LF 172	MI172	Flooring	Car Body and Interior	0.00										22-Sep-10
LF 175	MI175	Operator seat Lubrication	Car Body and Interior	40.50						1			---------	22-Sep-10
LF 180	MI180	Cab equipment	Car Body and Interior	0.00										22-Sep-10
LF 185	MI185	Windshield wiper / washer	Car Body and Interior	9.00	1		1		1				---------	22-Sep-10
LF 186	MI186	Windshield Wiper Linkage	Car Body and Interior	40.50			1						---------	22-Sep-10
LF 190	MI190	Communication system	Car Body and Interior	27.00	1									22-Sep-10
LF 192	MI192	Test Radio Power	Car Body and Interior	0.00										22-Sep-10
LF 197	MI197	Event recorder	Car Body and Interior	40.50				1			---------		---------	22-Sep-10
LF 200	MI200	Emergency equipment	Car Body and Interior	40.50										22-Sep-10
LF 205	MI205	Lighting / destination signs	Car Body and Interior	27.00				1						22-Sep-10
LF 210	MI210	Interior electrical compartments	Car Body and Interior	20.25			1						---------	22-Sep-10
LF 211	MI211	CCTV Test	Car Body and Interior	40.50				1				---------	---------	22-Sep-10
LF 212	MI212	Interior electrical compartments (extensive)	Car Body and Interior	81.00			1							22-Sep-10
LF 215	MI215	Doors Operation/Safety	Car Body and Interior	4.50	1	1	1	1	1	1			---------	22-Sep-10
LF 216	MI216	Doors Adjust and Timing	Car Body and Interior	81.00									---------	22-Sep-10
LF 220	MI220	Doors lubrication	Car Body and Interior	40.50					1				---------	22-Sep-10
LF 221	MI221	Door / Bridgeplate Summary	Car Body and Interior	40.50						1			---------	22-Sep-10
LF 225	MI225	Bridgeplates Operation/Safety	Car Body and Interior	9.00		1		1		1			---------	22-Sep-10
LF 226	MI226	Bridgeplates Adjust and Timing	Car Body and Interior	81.00									---------	22-Sep-10
LF 230	MI230	Bridgeplates lubrication	Car Body and Interior	40.50						1			---------	22-Sep-10
LF 235	MI235	Coupler electrical head	Under Car	4.50	1	1	1	1	1	1			---------	22-Sep-10
LF 240	MI240	Coupler	Under Car	13.50		1			1				---------	22-Sep-10
LF 245	MI245	Coupler (extensive)	Under Car	40.50		1							---------	22-Sep-10
LF 250	MI250	Car body (Power Down)	Car Body and Interior	40.50	1									22-Sep-10
LF 251	MI251	Articulation	Car Body and Interior	40.50				1			----------	----------		22-Sep-10
LF 255	MI255	Auxiliary Inverter (Power Down)	Roof Top	13.50		1			1				---------	22-Sep-10
LF 260	MI260	Exterior electrical compartments (extensive - Pwr Down)	Roof Top	81.00										22-Sep-10
LF 265	MI265	Propulsion TCU Download	Car Body and Interior	4.50	1	1	1	1	1	1			---------	22-Sep-10
LF 270	MI270	Propulsion container cleaning (Power Down)	Roof Top	13.50			1			1			---------	22-Sep-10
LF 275	MI275	High Speed Circuit Breaker (Power Down)	Car Body and Interior	81.00							---------	---------		22-Sep-10
LF 290	MI290	Knife switch (Power Down)	Roof Top	81.00							---------	---------		22-Sep-10
LF 300	MI300	HVAC (Power Down)	Roof Top	9.00		1		1		1			---------	22-Sep-10
LF 305	MI305	HVAC (extensive - Power Down)	Roof Top	27.00				1					---------	22-Sep-10
LF 315	MI315	Pantograph (Power Down)	Roof Top	4.50	1	1	1	1	1	1	---------	---------		22-Sep-10
LF 320	MI320	Pantograph (extensive - Power Down)	Roof Top	40.50		1					---------	---------		22-Sep-10
LF 322	MI322	Transverse shock absorber lubrication (Power Down)	Roof Top	40.50							---------	---------		22-Sep-10
LF 325	MI325	Batteries (Power Down)	Roof Top	27.00						1		---------	---------	22-Sep-10
LF 191	MI191	PA Volume Adjustment	Car Body and Interior	81.00					1			---------	---------	22-Sep-10
LF 198	MI198	Automated Passenger Counting	Car Body and Interior	0.00										22-Sep-10
LF 213	MI213	Side View CCTV	Car Body and Interior	4.50	1	1	1	1	1	1			---------	22-Sep-10

Appendix C Type 3 Tasks

ITEM	Comp	DESCRIPTION	Location	Frequency	N20	N21	N22	N23	N24	N25	A-END	B-END	C	UpdateDate
LF 120	MIL120	Truck appurtenances	Under Car	9.00		1								11/15/2010
LF 122	MIL122	Traction motor cleaning (Power Down)	Under Car	81.00						1			---------	11/15/2010
LF 125	MIL125	Ground brushes (Power Down)	Under Car	27.00				1						11/15/2010
LF 130	MIL130	Transmission oil sample /breather /Change	Under Car	40.50					1				---------	11/15/2010
LF 135	MIL135	Transmission Breather (see above)	Under Car	0.00										11/15/2010
LF 140	MIL140	Track brakes	Under Car	9.00		1								11/15/2010
LF 145	MIL145	Friction brakes	Under Car	4.50	1									11/15/2010
LF 147	MIL147	Friction brakes caliper lubrication	Under Car	81.00						1				11/15/2010
LF 149	MIL149	E.H. Unit Accumulator/M.R.U.	Under Car	27.00				1						11/15/2010
LF 150	MIL150	Sanding system	Under Car	9.00		1							---------	11/15/2010
LF 152	MIL152	Sand Box Heater Test	Car Body and Interior	81.00						1			---------	11/15/2010
LF 155	MIL155	Load Weight Sensor	Under Car	27.00				1						11/15/2010
LF 165	MIL165	ATS	Car Body and Interior	9.00		1								11/15/2010
LF 170	MIL170	Passenger seating	Car Body and Interior	0.00										11/15/2010
LF 172	MIL172	Flooring	Car Body and Interior	0.00										11/15/2010
LF 175	MIL175	Operator seat Lubrication	Car Body and Interior	40.50					1				---------	11/15/2010
LF 180	MIL180	Cab equipment	Car Body and Interior	0.00										11/15/2010
LF 185	MIL185	Windshield wiper / washer	Car Body and Interior	9.00		1							---------	11/15/2010
LF 186	MIL186	Windshield Wiper Linkage	Car Body and Interior	40.50					1				---------	11/15/2010
LF 190	MIL190	Communication system	Car Body and Interior	27.00				1						11/15/2010
LF 191	MIL191	PA Volume Adjustment	Car Body and Interior	81.00						1		---------	---------	11/15/2010
LF 192	MIL192	Test Radio Power	Car Body and Interior	0.00										11/15/2010
LF 197	MIL197	Event recorder	Car Body and Interior	40.50					1		---------		---------	11/15/2010
LF 198	MIL198	Automated Passenger Counting	Car Body and Interior	0.00										11/15/2010
LF 200	MIL200	Emergency equipment	Car Body and Interior	40.50					1					11/15/2010
LF 205	MIL205	Lighting / destination signs	Car Body and Interior	27.00				1						11/15/2010
LF 210	MIL210	Interior electrical compartments	Car Body and Interior	27.00				1					---------	11/15/2010
LF 211	MIL211	CCTV Test	Car Body and Interior	40.50					1			---------	---------	11/15/2010
LF 212	MIL212	Interior electrical compartments (extensive)	Car Body and Interior	81.00						1				11/15/2010
LF 213	MIL213	Side View CCTV	Car Body and Interior	4.50	1								---------	11/15/2010
LF 215	MIL215	Doors Operation/Safety	Car Body and Interior	4.50	1								---------	11/15/2010
LF 216	MIL216	Doors Adjust and Timing	Car Body and Interior	81.00						1			---------	11/15/2010
LF 220	MIL220	Doors lubrication	Car Body and Interior	40.50					1				---------	11/15/2010
LF 221	MIL221	Door / Bridgeplate Summary	Car Body and Interior	40.50					1				---------	11/15/2010
LF 225	MIL225	Bridgeplates Operation/Safety	Car Body and Interior	9.00		1							---------	11/15/2010
LF 226	MIL226	Bridgeplates Adjust and Timing	Car Body and Interior	81.00						1			---------	11/15/2010
LF 230	MIL230	Bridgeplates lubrication	Car Body and Interior	40.50					1				---------	11/15/2010
LF 235	MIL235	Coupler electrical head	Under Car	4.50	1								---------	11/15/2010
LF 240	MIL240	Coupler	Under Car	13.50			1						---------	11/15/2010
LF 245	MIL245	Coupler (extensive)	Under Car	40.50					1				---------	11/15/2010
LF 250	MIL250	Car body (Power Down)	Car Body and Interior	40.50					1					11/15/2010
LF 251	MIL251	Articulation	Car Body and Interior	40.50					1		----------	----------		11/15/2010
LF 255	MIL255	Auxiliary Inverter (Power Down)	Roof Top	13.50			1						---------	11/15/2010
LF 260	MIL260	Exterior electrical compartments (extensive - Pwr Down)	Roof Top	81.00						1				11/15/2010
LF 265	MIL265	Propulsion TCU Download	Car Body and Interior	4.50	1								---------	11/15/2010
LF 270	MIL270	Propulsion container cleaning (Power Down)	Roof Top	13.50			1						---------	11/15/2010
LF 275	MIL275	High Speed Circuit Breaker (Power Down)	Car Body and Interior	81.00						1	---------	---------		11/15/2010
LF 290	MIL290	Knife switch (Power Down)	Roof Top	81.00						1	---------	---------		11/15/2010
LF 300	MIL300	HVAC (Power Down)	Roof Top	9.00		1							---------	11/15/2010
LF 305	MIL305	HVAC (extensive - Power Down)	Roof Top	27.00				1					---------	11/15/2010
LF 310	MIL310	HVAC Coil cleaning	Roof Top	81.00						1			---------	11/15/2010
LF 315	MIL315	Pantograph (Power Down)	Roof Top	4.50	1						---------	---------		11/15/2010
LF 320	MIL320	Pantograph (extensive - Power Down)	Roof Top	40.50					1		---------	---------		11/15/2010
LF 322	MIL322	Transverse shock absorber lubrication (Power Down)	Roof Top	27.00				1			---------	---------		11/15/2010
LF 325	MIL325	Batteries (Power Down)	Roof Top	27.00				1				---------	---------	11/15/2010

ITEM	DESCRIPTION	Location	Frequency	N61	N62	N63	N64	N65	N66	N67	N68	N69	A-END	B-END	C	UpdateDate
LF120	TRUCK APPURTENANCES	Under Car	9.00	1	1	1	1	1	1	1	1	1				12/16/2009
LF122	TRACTION MOTOR	Under Car	81.00						1						---------	12/16/2009
LF125	GROUND BRUSH	Under Car	27.00	1			1			1						12/16/2009
LF130	TRANSMISSION OIL SAMPLE, OIL CHANGE, BREATHER CLEAN	Under Car	40.50					1				1			---------	12/16/2009
LF140	TRACK BRAKE	Under Car	9.00	1	1	1	1	1	1	1	1	1				12/16/2009
LF145	FRICTION BRAKE	Under Car	9.00	1	1	1	1	1	1	1	1	1				12/16/2009
LF147	CALIPER LUBRICATION	Under Car	0.00													12/16/2009
LF149	EHU FLUID LEVEL, ACCUMULATOR CHARGE, AND HANDPUMP	Under Car	27.00		1			1			1					12/16/2009
LF150	SANDING SYSTEM	Under Car	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF152	SANDING HEATER	Car Body and Interior	81.00			1									---------	12/16/2009
LF165	AUTOMATIC TRAIN STOP	Car Body and Interior	9.00	1	1	1	1	1	1	1	1	1				12/16/2009
LF170	PASSENGER SEATING	Car Body and Interior	0.00													12/16/2009
LF172	FLOORING	Car Body and Interior	0.00													12/16/2009
LF175	OPERATOR SEAT LUBRICATION	Car Body and Interior	45.50				1				1				---------	12/16/2009
LF180	CAB EQUIPMENT	Car Body and Interior	0.00													12/16/2009
LF185	WINDSHIELD WIPER WASHER	Car Body and Interior	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF190	COMMUNICATION SYSTEM	Car Body and Interior	27.00	1			1			1						12/16/2009
LF191	P.A. VOLUME ADJUSTMENT	Car Body and Interior	81.00									1				12/16/2009
LF197	EVENT RECORDER TEST	Car Body and Interior	40.50		1					1			---------		---------	12/16/2009
LF200	EMERGENCY EQUIPMENT	Car Body and Interior	40.50	1				1								12/16/2009
LF205	LIGHTING	Car Body and Interior	40.50			1				1						12/16/2009
LF210	CAB ELECTRICAL COMPARTMENTS	Car Body and Interior	40.50				1					1			---------	12/16/2009
LF211	CCTV TEST	Car Body and Interior	40.50					1				1		---------	---------	12/16/2009
LF212	INTERIOR ELECTRICAL COMPARTMENTS	Car Body and Interior	81.00		1											12/16/2009
LF215	DOORS OPERATION	Car Body and Interior	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF216	DOORS TIMING AND ADJUSTMENT	Car Body and Interior	81.00								1				---------	12/16/2009
LF220	DOOR LUBRICATION	Car Body and Interior	40.50			1				1					---------	12/16/2009
LF221	DOOR / BRIDGEPLATE SUMMARY	Car Body and Interior	40.50				1				1				---------	12/16/2009
LF225	BRIDGEPLATE OPERATION	Car Body and Interior	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF226	BRIDGEPLATE TIMING ADJUSTMENT	Car Body and Interior	81.00								1				---------	12/16/2009
LF230	BRIDGEPLATE LUBRICATION	Car Body and Interior	40.50				1				1				---------	12/16/2009
LF235	ELECTRICAL COUPLER CABLES & CONTACTS (B-END COUPLER)	Under Car	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF240	COUPLER	Under Car	13.50	1		1		1		1		1			---------	12/16/2009
LF245	COUPLER EXTENSIVE	Under Car	40.50	1					1						---------	12/16/2009
LF250	CARBODY	Car Body and Interior	40.50	1					1							12/16/2009
LF251	ARTICULATION	Car Body and Interior	81.00			1							----------	----------		12/16/2009
LF255	AUXILIARY INVERTER	Roof Top	40.50		1					1					---------	12/16/2009
LF260	EXTERIOR ELECTRICAL COMPARTMENTS	Roof Top	81.00						1							12/16/2009
LF265	DOWNLOAD VCU	Car Body and Interior	13.5	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF270	PROPULSION CONTAINER	Roof Top	27.00		1			1			1				---------	12/16/2009
LF275	HSCB	Roof Top	81.00					1					---------	---------		12/16/2009
LF290	KNIFE SWITCH	Roof Top	81.00						1				---------	---------		12/16/2009
LF300	HVAC	Roof Top	9.00	1	1	1	1	1	1	1	1	1			---------	12/16/2009
LF305	HVAC EXTENSIVE	Roof Top	81.00			1									---------	12/16/2009
LF315	PANTOGRAPH	Roof Top	9.00	1	1	1	1	1	1	1	1	1	---------	---------		12/16/2009
LF320	PANTOGRAPH EXTENSIVE + SURGE ARRESTOR	Roof Top	40.50	1					1				---------	---------		12/16/2009
LF325	BATTERIES	Roof Top	40.50			1			1				---------	---------		12/16/2009
LF213	SIDE VIEW CCTV	Car Body and Interior	9.00	1	1	1	1	1	1	1	1	1			---------	5/10/2010

FACILITIES MANAGEMENT - PERSONNEL SERVICES

Position Title	07/08 Actual Total	08/09 Actual Total	09/10 Budget Total	09/10 Estimate Total	10/11 Budget Total
Facilities Management:					
Director, Facilities Management			$ 100,788	$ 100,788	$ 100,788
Manager, Facilities Services			91,726	91,726	91,726
Manager, Facilities Systems			98,554	98,554	98,554
Supervisor, Facilities Management			70,992	70,992	70,992
Supervisor, Maint Facilities Management			71,055	71,055	71,055
Supervisor, Maint Facilities Management			70,950	70,950	70,950
Facilities Specialist			44,266	44,266	44,266
Operations Administrator/Coordinator			49,548	49,548	49,548
Facility Support Supervisor			70,908	70,908	
Engineer I			57,858	57,858	57,858
Assistant Supervisor			194,993	194,993	200,895
Maintenance Technician			209,513	209,513	161,900
Maintenance Technician-MTIP Program			104,756	104,756	
Janitor			105,698	105,698	108,904
Landscaper			106,171	106,171	109,391
Landscape Maintenance Technician			104,756	104,756	107,934
Plant Maintenance Mechanic			505,935	505,935	521,268
Plant Maintenance Mechanic Apprentices			112,430	112,430	115,837
Fringe Benefits			970,383	970,383	924,496
UAAL Union Pension			293,152	257,974	
UAAL Management Pension			87,880	87,880	
Workers' Compensation			11,000	11,000	11,000
Longevity Premium			57,733	57,733	60,935
Facilities Management-Rail:					
Supervisor, Maint Facilities Management			146,076	146,076	146,076
Assistant Supervisor - MOW			129,825	129,825	133,754
Facilities Maintenance Trainer			64,002	64,002	65,939
Plant Maintenance Mechanic			480,003	480,003	494,559
Facilities Landscaper			368,334	368,334	216,860
Facilities Platform Cleaner			1,393,245	1,393,245	1,435,508
Plant Maintenance Mechanic Apprentices			154,629	154,629	159,320
Fringe Benefits			1,362,881	1,362,881	1,414,335
UAAL Union Pension			551,126	484,991	
UAAL Management Pension			25,109	25,109	
Workers' Compensation			118,000	118,000	118,000
Longevity Premium			68,078	68,078	71,140
Unemployment			5,737	5,737	5,909
Unscheduled Overtime			116,401	116,401	107,533
Limited Term Employment			18,190	18,190	13,390
Attrition Ajustment			110,038	110,038	
OTO FY11 Budget Add Back					43,131
Budget Reduction			(158,768)	(158,768)	
Total			$ 8,543,951	$ 8,442,637	$ 7,403,751

FACILITIES MANAGEMENT - MATERIALS & SERVICES

Expense Category	Actual 07/08	Actual 08/09	Budget 09/10	Estimate 09/10	Budget 10/11
Facilities Management:					
Professional and Technical			$ 20,000	$ 30,000	
Mechanical/Structural Consulting			3,000	3,000	
Landscape Services			60,000	57,000	$ 40,000
Portland Mall Management Services			1,587,897	1,350,000	1,525,320
Contracted Maintenance			230,000	210,000	230,000
Office Sup., Maintenance - Custodial			340,000	340,000	300,000
Shelter Cleaning			535,010	572,000	535,010
Shelter Cleaning-Vandalism			50,000	20,000	50,000
Transit Center Cleaning			210,000	190,000	210,000
Transit Mall Cleaning			18,119	13,000	18,119
Park & Ride Cleaning			1,948	2,000	1,948
Office Maintenance - Other			5,739	6,000	2,120
Laundry			15,880	14,000	15,880
Other Services			7,390	7,000	3,695
Office Supplies			5,000	7,000	2,500
Maintenance Materials			190,000	170,000	150,000
Bus Stop Signs/Poles			5,464	3,500	3,000
Cleaning Supplies			20,000	12,000	20,000
Small Hand Tools			18,760	22,000	18,000
Other Materials			8,643	6,000	8,000
Landscape Maintenance Materials			19,529	7,000	18,000
Transit Mall Materials			17,163	10,000	17,163
Moving Services			10,000	20,000	
Utilities - Electricity			894,925	850,000	894,925
Utilities - Natural Gas			212,649	160,000	180,000
Utilities - Water/Sewer			417,576	300,000	417,576
Shelter Electrification			31,827	35,000	31,827
Telephone			18,930	22,500	18,930
Utilities - Other			82,595	95,000	82,595
Property Taxes			1,091	115,000	1,091
Dues & Subscriptions			3,411	2,000	
Local Travel/Meetings			3,000	3,000	
Education & Training			12,300	12,500	
Out-of-Town Travel			7,200	2,400	
Apprenticeship Training			25,000	12,500	20,000
Indirect Expense Allocation			(154,527)	(50,000)	(154,527)
Leases			989,976	960,000	989,976
Rentals			6,000	2,000	6,000
Sub-Total Facilities Management:			5,931,495	5,593,400	5,657,148
Facilities Management-Rail:					
Professional & Technical			3,200	2,400	
Contracted Maintenance - Landscaping			24,011	16,000	20,000
Contracted Maintenance - Fac. & Equipment			72,470	95,000	70,000
Contracted Maintenance - Elevators			125,587	110,000	125,587
Contracted Maintenance - Stations			12,000	10,000	12,000
Street Sweeper Dump Fees			2,881	2,000	2,881
Hillsboro Garage IGA			30,000	30,000	30,000
Other Services			7,324	5,000	5,000
Office Supplies			2,500	2,200	1,250

FACILITIES MANAGEMENT - MATERIALS & SERVICES

Expense Category	Actual 07/08	Actual 08/09	Budget 09/10	Estimate 09/10	Budget 10/11
Facilities Management:					
Maintenance Materials - Outside Plant			$ 93,670	$ 100,000	$ 80,000
Maintenance Materials - Shop			58,338	58,000	50,000
Shop Equipment < $5,000			12,000	8,000	8,000
Cleaning Supplies - Platforms			62,011	60,000	62,011
Small Hand Tools			6,160	5,800	5,000
Other Materials			4,825	3,000	4,000
Maintenance Materials - Landscaping			35,182	28,000	30,000
Safety Supplies			8,600	11,000	6,000
Utilities - Natural Gas			158,764	140,000	140,000
Utilities - Building Electricity			1,026,695	980,000	1,026,695
VT Utilities - Electricity			13,500	11,000	13,500
Utilities - Other Building			61,461	70,000	61,461
Utilities - Parking Garages			32,018	33,000	32,018
Tunnel Water Services			33,934	31,000	33,934
Utilities - Other Water			211,882	230,000	211,882
Education & Training			6,111	4,800	
Employee Recognition			2,800	3,000	
Rentals			9,934	3,600	9,000
Sub-Total Facilities Management-Rail:			2,117,858	2,052,800	2,040,219
			$ 8,049,353	$ 7,646,200	$ 7,697,367

Appendix D Force Account Plan Budgets

RAIL MAINTENANCE OF WAY - PERSONNEL SERVICES

Position Title	07/08 Actual Total	08/09 Actual Total	09/10 Budget Total	09/10 Estimate Total	10/11 Budget Total
Rail Maintenance:					
Manager, Rail MOW Programs	$ 79,265				
Manager, Rail MOW Operations	74,800	$ 65,669	$ 90,536	$ 90,536	$ 93,510
Training/Engineering Supervisor	56,782	65,670	68,121	68,121	68,121
Train/Eng Supervisor-Green Line	71,736	67,979	68,121	68,121	68,121
Maintenance of Way Supervisor	253,177	455,818	437,428	437,428	438,750
MOW Project Engineer	62,756	72,291	73,414	73,414	73,125
MOW Engineer IV	71,058	81,854	83,144	83,144	
Assistant Supervisor - MOW	439,900	531,437	714,035	714,035	735,646
Track Maintainer	456,153	414,103	615,403	615,403	576,413
Substation Maintainer/Apprentice	413,748	284,371	352,172	352,172	302,367
Power Maintainer/Apprentice	585,693	528,415	704,344	704,344	725,681
Signal Maintainer/Apprentice	600,695	540,968	615,407	615,407	634,059
Maintenance of Way Laborer	339,941	395,724	379,104	379,104	334,799
Field Technician/Apprentice	433,205	921,597	1,232,602	1,232,602	1,269,942
MMIS/Clerk	99,623	120,395	101,498	101,498	104,577
Fringe Benefits	2,457,511	2,585,982	2,523,248	2,523,248	2,631,355
UAAL Union Pension			938,086	825,516	
UAAL Management Pension			138,097	138,097	
Workers' Compensation	43,758	51,015	12,800	12,800	12,800
Longevity Premium			151,397	151,397	184,196
Night & Shift Differential			53,874	53,874	55,490
Unscheduled Overtime	429,907	579,865	234,970	234,970	242,019
Tool Allowance			24,429	24,429	25,162
Unemployment			9,949	9,949	10,248
Capitalized Labor/Fringe	(713,135)	(740,578)			
FY10 Part Year Adjustment			(41,772)	(41,772)	
Attrition Adjustment			149,695	149,695	
OTO FY11 Budget Add Back					22,306
Budget Reduction			(83,155)	(83,155)	
Total	$ 6,256,575	$ 7,022,575	$ 9,646,945	$ 9,534,375	$ 8,608,688

RAIL MAINTENANCE OF WAY - MATERIALS & SERVICES

Expense Category	Actual 07/08	Actual 08/09	Budget 09/10	Estimate 09/10	Budget 10/11
Rail Maintenance:					
Contracted Maintenance - Landscaping	$ 480	$ 10,359	$ 13,288	$ 25,000	$ 13,288
Contracted Maintenance - Power Facility			3,000		3,000
Contracted Maintenance - Signals	22,765	1,403	60,000	30,000	60,000
Contracted Maintenance - Track	139,939	144,483	150,000	140,000	150,000
Contracted Maintenance - OCS	20,477				
Contracted Maintenance - Bridges	100,852	69,870	36,963	35,000	36,963
Contracted Maintenance - Stations	7,416				
Contracted Maintenance - Communications	344,025	369,513	461,816	425,000	461,816
Contracted Maintenance - Fare Equipment			59,678	28,000	59,678
Contracted Maintenance - Substation		21,213	50,000	24,000	50,000
Calibration & Tool Repair	3,061	1,373	4,967	1,600	4,000
Other Services	49,467	2,715	5,967	5,000	4,000
Tickets & Passes					
Office Supplies	4,574	4,638	4,000	4,000	2,000
Freight	5,837	5,584			
Maintenance Materials - Outside Plant	2,758	540			
Maintenance Materials - Shop	2,047	523			
Small Hand Tools	13,411	19,399	5,640	14,000	4,000
Other Materials	6,372	12,461	8,774	8,000	7,000
Safety Supplies	26,947	24,551	13,900	19,000	10,000
Maintenance Materials - Fare Equipment		999	341,602	400,000	280,366
Maintenance Materials - Track	88,428	122,244	150,000	114,000	128,377
Maintenance Materials - Electrification			25,029	18,000	14,205
Maintenance Materials - Signals	113,082	205,416	166,173	160,000	124,583
Maintenance Materials - Communications	39,622	42,579	32,189	33,000	22,593
Maintenance Materials - OCS	29,541	38,201		18,000	
Maintenance Materials - Substations	38,576	26,061	25,802	28,000	21,131
Electrical Power (Propulsion)	3,106,048	3,506,712	3,815,518	4,200,000	3,696,598
Telephone	35,875	41,533	61,605	78,000	61,605
PI/PD Expense	78,075	(26,168)		16,500	
Dues & Subscriptions	438	188	500	400	
Local Travel & Meetings	339	99	500		
Education & Training	46,761	8,497	12,000	36,000	
Out-of-Town Travel	15,745	2,735	5,000	3,000	
Steel Bridge Maintenance Agreement	284,821	287,447	270,000	270,000	270,000
CDL Renewals	676	583	872	1,100	872
Employee Recognition		1,436	2,400	2,600	
Rentals	46,318	43,394	30,000	33,000	30,000
OCC Equipment & Supplies		13,199	16,000	5,000	10,000
Computer Supplies	3,206	5,389			
Contracted Maintenance - Fac. & Equipment		157			
Obsolete Inventory		68,868		7,000	
	$ 4,677,979	$ 5,078,191	$ 5,833,183	$ 6,182,200	$ 5,526,075

Appendix D Force Account Plan Budgets

RAIL EQUIPMENT MAINTENANCE - PERSONNEL SERVICES

Position Title	07/08 Actual Total	08/09 Actual Total	09/10 Budget Total	09/10 Estimate Total	10/11 Budget Total
Director, Rail Maintenance	$ 91,252	$ 63,803			
Manager, Rail Equip. Maintenance	70,463	86,055	$ 88,009	$ 88,009	$ 88,009
Manager, Rail Equip. Maintenance	76,850	90,804	92,582	92,582	92,582
Operations Specialist	17,475	49,177	51,010	51,010	51,010
Training/Engineering Supervisor	172,268	277,990	146,442	146,442	146,442
Training/Engineering Supervisor	61,129	72,458	73,221	73,221	73,221
Rail Maintenance Supervisor	469,733	535,278	512,711	512,711	512,711
Engineering Technician III	46,334	54,532	55,395	55,395	55,395
Assistant Supervisor	518,336	386,270	367,847	367,847	378,987
MMIS/Clerk	112,975	101,386	50,749	50,749	52,289
Janitor	246,931	272,937	192,894	192,894	149,062
Vehicle Cleaner/Helper	822,886	949,128	1,393,245	1,393,245	1,382,341
Vehicle Maintainer/Apprentice	4,820,469	5,002,525	5,333,349	5,333,349	5,440,126
Vehicle Maint/Apprentice Streetcar					274,754
Stores Supervisor	56,225	66,604	67,902	67,902	67,902
Assistant Storekeeper	101,673	119,987	114,752	114,752	118,229
Junior Partsman	52,325	126,594			
Partsman	187,487	172,708	109,167	109,167	112,476
Fringe Benefits	4,813,293	5,279,143	4,216,620	4,216,620	4,678,307
UAAL Union Pension			1,618,199	1,424,015	
UAAL Management Pension			163,206	163,206	
Workers' Compensation	105,612	168,876	195,000	195,000	204,656
Longevity Premium			244,331	244,331	283,571
Unscheduled Overtime	1,142,265	1,543,144	285,644	285,644	285,579
Tool Allowance			54,083	54,083	58,075
Night & Shift Differential			84,074	84,074	90,278
Unemployment			7,924	7,924	8,162
Capitalized Labor/Fringe	(876,624)	(1,419,846)			
FY10 Part Year Adjustment			(66,433)	(66,433)	
Attrition Adjustment			207,573	207,573	
OTO FY11 Budget Add Back					34,168
Budget Reduction			(321,188)	(321,188)	
Total	$ 13,109,358	$ 13,999,553	$ 15,338,307	$ 15,144,123	$ 14,638,329

RAIL EQUIPMENT MAINTENANCE - MATERIALS & SERVICES

Expense Category	Actual 07/08	Actual 08/09	Budget 09/10	Estimate 09/10	Budget 10/11
Professional & Technical	$ 4,705	$ 447	$ 5,000	$ 1,000	
Calibration & Tool Repair	9,144	6,122	5,327	8,000	$ 5,305
Contracted Maintenance		13,224	15,982	12,000	15,484
Maint. Materials - Fare Equipment	33,916				
Laundry	61,588	67,139	84,785	68,000	86,997
Other Services	3,127	1,923	21,309	5,000	20,000
Graphics Supplies	3,079	814	2,000	1,000	1,000
Office Supplies	14,439	11,994	12,000	8,000	6,000
Computer Supplies	8,482	2,541	2,000	5,000	1,000
Maint. Materials - LRV Overhaul	1,334,373	913,704	1,110,684	1,200,000	1,076,067
VT Maintenance Materials - Trolley	9,363	2,918	8,000	2,400	2,633
Repair Materials - LRV Accident			17,048	2,500	17,048
Repair Materials - Rev Equipment	8,224	30,405			
Repair Materials - LRV Vandalism	40,159	52,577	42,619	42,000	42,619
Maint. Materials - Service Equip.	9,855	18,226			
Maint. Materials - LRVs	1,497,409	1,357,123	2,152,866	1,900,000	2,085,767
Freight	75,543	58,313	68,928	56,000	68,928
Furniture & Equipment < $5,000	273	169	3,000		
Shop Equipment	87,715	100,679	70,000	88,000	68,867
Cleaning Supplies	94,939	92,520	97,265	85,000	94,234
Small Hand Tools	68,238	53,373	79,133	52,000	75,665
Other Materials	100,653	64,487	63,928	74,000	60,000
Safety Supplies	58,553	40,020	45,219	36,000	46,398
Obsolete Inventory	216	5,739		4,000	
Invoice Price Variance	(1,039)	(7,208)		2,000	
Average Cost Variance	233	(2)		200	
Local Travel & Meetings	2,166		3,000		
Telephone		3,315		2,000	
Education & Training	6,650	12,092	16,000	16,000	916
Out-of-Town Travel	5,591	19,694	5,000	4,000	
Inventory Adjustments	157,670	81,634		90,000	
CDL Renewals	680	1,776	2,144	1,200	2,267
Employee Recognition	632	5,524	6,000	2,000	
	$ 3,696,576	$ 3,011,281	$ 3,939,237	$ 3,767,300	$ 3,777,195

REM - MDBF

for the combined months of

July - August - September 2010

The number of times, during the months listed above, a symptom code is used to log in a repair on the pending worklist.

SYMPTOM CODE	RVSR T4	MDBF T4 RVSR	GOALS for 9/10 MDBF	RVSR T3	MDBF T3 RVSR	GOALS for 9/10 MDBF	RVSR T2	MDBF T2 RVSR	GOALS for 9/10 MDBF	RVSR T1	MDBF T1 RVSR	GOALS for 9/10 MDBF	TYPES 1, 2, 3, 4	MDBF All RVSR	GOALS for 9/10 MDBF
S01 AUXILIARY INVERTER FAILURE	5	71,220	150,000	27	17,204	246,539	33	27,301	125,415	9	35,472	106,534	74	27,578	140,882
S02 CONVERTER FAILURE	0			0			0			4	79,812	319,603	4	510,200	1,690,586
S03 PANTOGRAPH FAILURE	5	71,220	300,000	0		328,718	4	225,233	351,162	2	159,623	319,603	11	185,527	338,117
S04 ACCIDENT DAMAGE	2	178,050		0			0			0			2	1,020,399	
S05 ARTICULATION FAILURE	0			0		493,077	0		877,905	0		319,603	0		563,529
S06 ATS/TWC FAILURE	2	178,050	50,000	11	42,229	61,635	16	56,308	79,810	12	26,604	53,267	41	49,776	67,623
S07 CAB ELECTRIC CONTROLS	7	50,871	300,000	17	27,325	82,180	20	45,047	79,810	13	24,557	63,921	57	35,803	76,845
S08 CARBODY/CAR/CAB INTER FAILURE	76	4,686		87	5,339		160	5,631		61	5,234		384	5,315	
S09 COUPLER FAILURE	1	356,099	100,000	11	42,229	98,615	19	47,418	73,159	4	79,812	63,921	35	58,309	76,845
S10 COMMUNICATION FAILURE	39	9,131	50,000	59	7,873	24,654	109	8,265	19,509	25	12,770	15,980	232	8,797	19,889
S11 DOOR FAILURE	30	11,870	20,000	35	13,272	18,965	56	16,088	19,952	43	7,424	12,784	164	12,444	17,796
S13 FRICTION BRAKE FAILURE	11	32,373	25,000	19	24,448	41,090	41	21,974	29,264	17	18,779	26,634	88	23,191	31,307
S14 HVAC FAILURE	15	23,740	50,000	38	12,224	44,825	35	25,741	38,170	48	6,651	24,585	136	15,006	35,970
S15 LIGHTING FAILURE	39	9,131		73	6,363		132	6,825		54	5,912		298	6,848	
S16 PROPULSION FAILURE	16	22,256	25,000	13	35,732	44,825	52	17,326	31,354	35	9,121	14,527	116	17,593	27,715
S17 SANDING SYSTEM FAILURE	0		25,000	4	116,130	246,539	16	56,308	146,318	3	106,415	159,802	23	88,730	169,059
S18 TRUCK EQUIPMENT FAILURE	12	29,675	30,000	11	42,229	70,440	32	28,154	67,531	6	53,208	79,901	61	33,456	70,441
S19 VANDALISM	21	16,957		23	20,197		34	26,498		16	19,953		94	21,711	
S21 BRIDGEPLT MECHANISM & CONTRL	11	32,373	100,000	1	464,520	164,359	19	47,418	79,810	0			31	65,832	120,756
S22 ELECTRICAL CONTROLS FAILURE	0		300,000	0		493,077	2	450,467	438,953	8	39,906	319,603	10	204,080	422,647
S23 CCTV/APC/EVENT RECORDER FAILS	30	11,870	250,000	6	77,420	246,539	36	25,026	219,476	6	53,208	159,802	78	26,164	211,323
TOTALS	322			435			816			366			1,939	1,053	
SERVICE RELATED MDBF	96	3,709	5,000	155	2,997	6,125	277	3,252	5,149	182	1,754	3,591	710	2,874	4,972

Total Mileage for:

July - August - September 2010

3 Month Mileage for Type 4 Rev Cars =	356,099
3 Month Mileage for Type 3 Rev Cars =	464,520
3 Month Mileage for Type 2 Rev Cars =	900,933
3 Month Mileage for Type 1 Rev Cars =	319,246
3 Month Mileage for all Rev Cars =	2,040,798