Dallas Area Rapid Transit
Light Rail Transit

Rail Fleet Management Plan
Revision I

February 2009

RAIL FLEET MANAGEMENT PLAN

REVISION HISTORY

REVISION	REVISION DATE	DESCRIPTION OF CHANGES
B	November 1998	Light Rail Transit Fleet Management Plan –Incorporating FTA Comments
C	August 16, 2002	Light Rail Transit Fleet Management Plan – Build-Out Phase I
D	December 8, 2003	Light Rail Transit Fleet Management Plan – Various Updates
E	April 14, 2004	Fleet Management Plan SLRV – Complete Update for Build-Out Phase II
F	July 22, 2005	Fleet Management Plan SLRV – Update for latest status of Build-Out Phase II and Incorporation of PMOC Comments
G	October 2006	Fleet Management Plan SLRV – Update for current status of Build-Out Phases II & III; Incorporation of PMOC Comments
H	February 15, 2008	Rail Fleet Management Plan - Update for latest status of Build-Out Project Phases II & III
I	February 13, 2009	Rail Fleet Management Plan - Update for latest status of Build-Out Project Phases II & III

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RAIL FLEET MANAGEMENT PLAN

LIST OF EXHIBITS

LIST OF FIGURES

ACRONYMS USED IN THIS DOCUMENT

ACS	Automatic Cab Signal (System)
CBD	Central Business District (of Dallas, TX)
CBM	Condition Based Maintenance
CM	Corrective Maintenance
CROF	Central Rail Operating Facility
CT	Cycle Time
DART	Dallas Area Rapid Transit
FMP	Fleet Management Plan
FSM	Fixed Scheduled Maintenance
FTA	Federal Transit Administration
FY	Fiscal Year
HOV	High Occupancy Vehicle
HW	Headway
I	Irving (Corridor)
LRT	Light Rail Transit
LRV	Light Rail Vehicle
MLL	Maximum Link Load
MOP	Maintenance Operational Plan
NC	North Central (Corridor)
NE	Northeast (Corridor)
NW	Northwest (Corridor)
NWROF	Northwest Rail Operating Facility
OCC	Operations Control Center
OEM	Original Equipment Manufacturer
PA/VMB	Public Address/Visual Message Board (System)
PEC	Passenger Emergency Call (Device)
PM	Preventative Maintenance
PMI	Preventative Maintenance Inspection
PVR	Peak Vehicle Requirement
R	Rowlett (Corridor)
RFMP	Rail Fleet Management Plan
ROW	Right-of-Way
S&I	Service and Inspection
SCADA	Supervisory Control and Data Acquisition
SCC	Security Control Center
SLRV	Super Light Rail Vehicle
SOC	South Oak Cliff (Corridor)
TCC	Train Control Center
TPC	Train Performance Calculator/Calculations
TSP	Transit System Plan
TVM	Ticket Vending Machine
WOC	West Oak Cliff (Corridor)

WSA Ways, Structures & Amenities

1.0 Introduction

1.1 Purpose

The Rail Fleet Management Plan (RFMP) establishes the current and projected Light Rail Transit (LRT) revenue vehicle fleet size requirements for Dallas Area Rapid Transit (DART). It includes a description of the existing LRT services, planned future expansions of these services, current ridership and expected ridership growth, details on the operating spare ratio, and a discussion of current and future needs for rail vehicle maintenance. This plan is an actively managed document based on current conditions and assumptions, and is subject to future revisions on an annual basis. Future occurrences requiring an update to this plan include, but are not limited to, the following:

- strategic changes to DART LRT operations that impact peak vehicle requirements, vehicle mileage, or system load factors;
- new rail vehicle procurements or other fleet disposition changes;
- fleet rebuild, rehabilitation, or overhaul programs;
- overall LRT System expansion;
- service enhancements.

1.2 Scope

The RFMP includes DART's current fleet requirements as well as those for ongoing system expansion, projected ridership growth, and LRT vehicle procurements through Fiscal Year (FY) 2019, which is the projected date for the completion of the Build-Out Phase III Project. This document represents both current-day practices and defines the fleet needs of the LRT System based on various future changes.

Fleet size requirements in this document are based on the technical specifications of the Super Light Rail Vehicle (SLRV). The SLRV includes a low-floor center section installed in the existing two-section DART Light Rail Vehicle (LRV). The SLRV will provide additional passenger capacity compared to the LRV, which is reflected in this report. DART plans to retrofit its existing LRV fleet in stages. This fleet retrofit will be completed in conjunction with, but slightly later than, the inception of revenue service to the Northwest and Southeast corridors. Any new vehicles purchased after this fleet retrofit will be SLRVs (or functionally equivalent to SLRVs). The RFMP also provides an update to the fleet utilization concept for DART's Build-Out Phase II and III Build-Out Projects based on the current ridership data and operating plans/schedules.

2.0 Existing and Future Light Rail Transit System

The DART Board of Directors approved the first *Transit System Plan* (TSP) in 1989. This Plan was then revised in November 1995 to deal with anticipated changes in the DART service region until the year 2010. In October 2006, the DART Board of Directors approved the *2030 Transit System Plan*—which covers DART's anticipated role in regional transportation through the year 2030. The approved *Current and Future Services* Map (shown in Exhibit 2-1) includes considerations for almost 100 route miles of Light Rail Transit (LRT), 116 miles of High Occupancy Vehicle (HOV) lanes, and 32 miles of commuter rail, which, along with the bus system that serves the area, form a fully integrated intermodal transportation system.

As the backbone of DART's service provision network, the LRT System is the key to meeting the goals set forth in the TSP. The Build-Out Phase II and Phase III Projects, as part of the TSP, will compliment the existing LRT System and expand the DART service area so that the goals of the 2030 TSP may be fulfilled. Other regional projects, such as the Cotton Belt rail line and the connection to the DCTA commuter rail operation, are not addressed in this Fleet Management Plan, as operational and service changes to DART's LRT network associated with these projects are very early in the planning stages.

The existing LRT System consists of approximately 45 route-miles of double track, bi-directional light rail. This system extends from Westmoreland Station to Parker Road Station on the West Oak Cliff (WOC) and North Central (NC) Corridors, and from Ledbetter Station to Downtown Garland Station on the South Oak Cliff (SOC) and Northeast (NE) Corridors. LRT operations on the existing system operate in several types of exclusive right-of-way (ROW) including: fully grade separated, aerial, partially separated at-grade guideway with roadway crossings at-grade, mixed pedestrian mall, and subway tunnel/station operations. The existing system consists of an alignment equipped with crossovers, pocket tracks, and junctions strategically located to ensure optimal operating flexibility and enhanced system recovery during/after abnormal conditions. A schematic of the existing DART LRT System is contained in Exhibit 2-2.

The DART LRT Build-Out Phase II Project consists of an approximately 45 route-mile expansion that will more than double the existing 45 route-mile LRT System track network size to approximately 90 route-miles in length (Exhibits 2-3 and 2-4). Phase II will be completed in two distinct steps, Phase IIA and Phase IIB.

Phase IIA includes the construction of the:

- Southeast Corridor (SE);
- Northwest Corridor (NW);
- Northwest Rail Operating Facility (NWROF).

Phase IIB includes the construction of the:

- Irving Corridor (I);
- Rowlett Extension (R).

When completed in late 2010 (DART Fiscal Year 2011), a new 26.5-mile Green Line serving the Northwest and Southeast Corridors will be added to DART's existing LRT network. The Green Line starts in Pleasant Grove at Buckner Station. It will serve several regional destinations including; Deep Ellum, Baylor University Medical Center, Fair Park, Victory Park, the Dallas Market Center, the Southwestern Medical District, Love Field Airport, the City of Farmers Branch and will terminate in the City of Carrollton at North Carrollton/Frankford Road Station. A section of the Green Line will open in September 2009 (FY 2009) that will serve the State Fair of Texas and several intermediate stations (Victory, Deep Ellum, Fair Park, and J.B. Jackson, Jr. Transit Center at Martin Luther King, Jr. Stations), until such time as the rest of the Green Line is opened on December 4, 2010.

A second light rail vehicle servicing and maintenance facility, the Northwest Rail Operating Facility (NWROF), is being constructed to service the Green and Orange Line trains, and is scheduled to open in concert with the inception of service on the Green Line. A new Orange Line serving Las Colinas and D/FW International Airport will also be constructed after the year 2010. The current schedule shows service on the Orange Line opening in phases from December 2011, December 2012, and December 2013 (FY 2012-2014). Service on the pre-existing Blue Line will also be extended from Downtown Garland to Rowlett in December of 2012 (FY 2013), Exhibit 2-4.

The Build-Out Phase III Project is planned to include alterations/additions to the LRT network in downtown Dallas and an extension of the South Oak Cliff (SOC) Line to the Dallas branch of the University of North Texas (located in southern Dallas). The second Central Business District (CBD) alignment project is in the planning stages, along with the SOC-3 project. The CBD-2 Project is scheduled to open in December 2014 (FY 2015), while the SOC-3 project is scheduled to open in 2018 (FY 2019), which is illustrated in Exhibit 2-5.

2.1 Track Structure

The LRT track structure consists of double-tracked light rail mainline. A number of crossovers are incorporated into the track layout to provide for required movements at junctions and to enable operating flexibility and system recovery during abnormal conditions. Crossover spacing allows for single-track operation during emergency conditions while maintaining a 15-minute headway. Track geometry and alignment, including curvature, gradient and allowable speeds are defined in DART's Design Criteria Manual. Turnouts and crossovers are located to enable all normal expected train moves at junctions, pocket tracks, and terminal stations. Specific interlockings have been designed to maximize operational flexibility. The Build-Out Phase II Project crossovers are fully interlocked (equipped with power switches and signals) and are controlled by the TCC. The entire Build-Out Phase II Project incorporates a bi-directional, automatic cab signaling system and interlocking signals that can be controlled from the Operations Control Center (OCC) via the SCADA system that is integrated with the Train Control Center (TCC). The OCC supports operations and is responsible for controlling, monitoring, and dispatching the entire DART transit system, including LRT operations.

Exhibit 2-1
2030 Transit System Plan

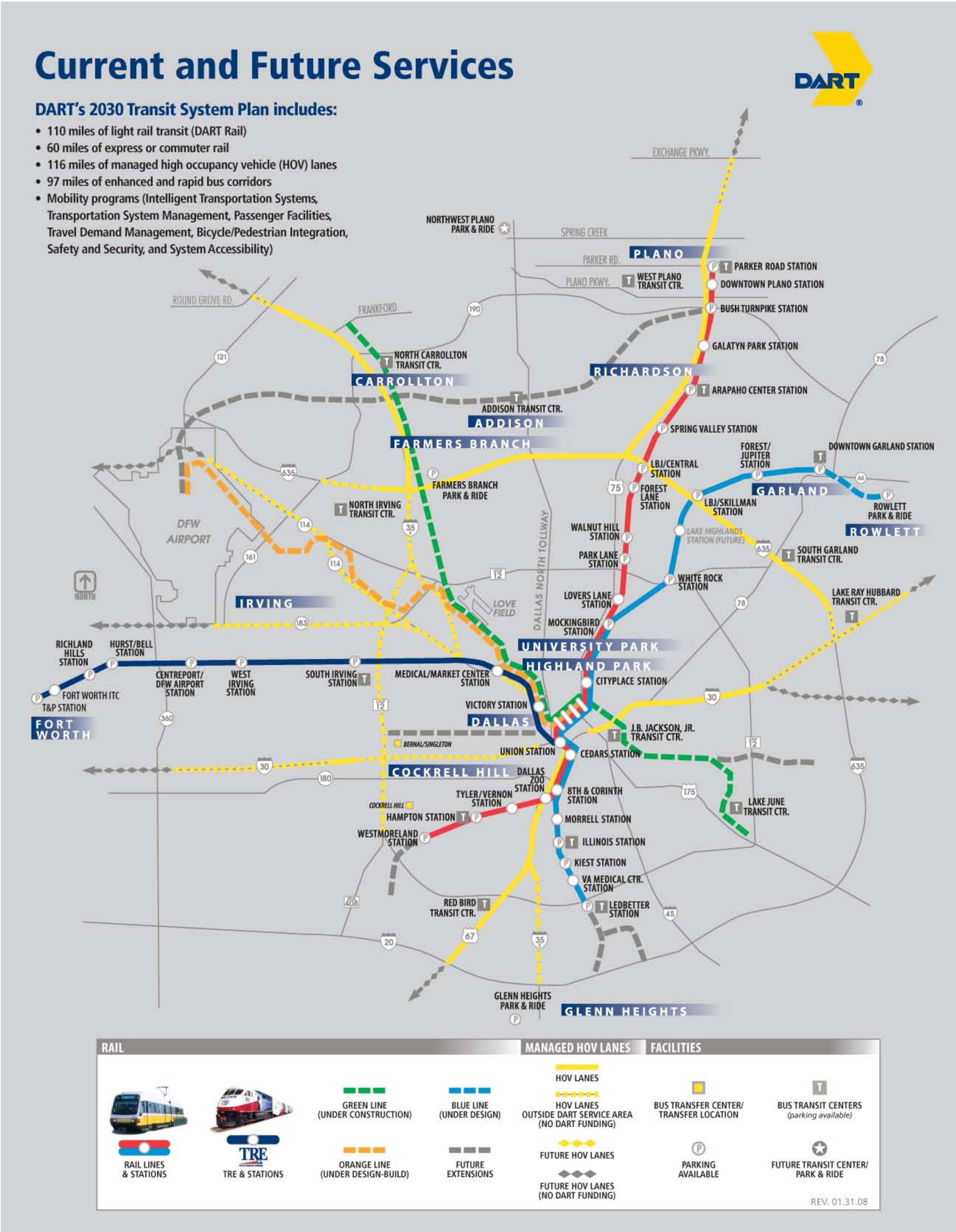


Exhibit 2-2
Existing LRT System Schematic

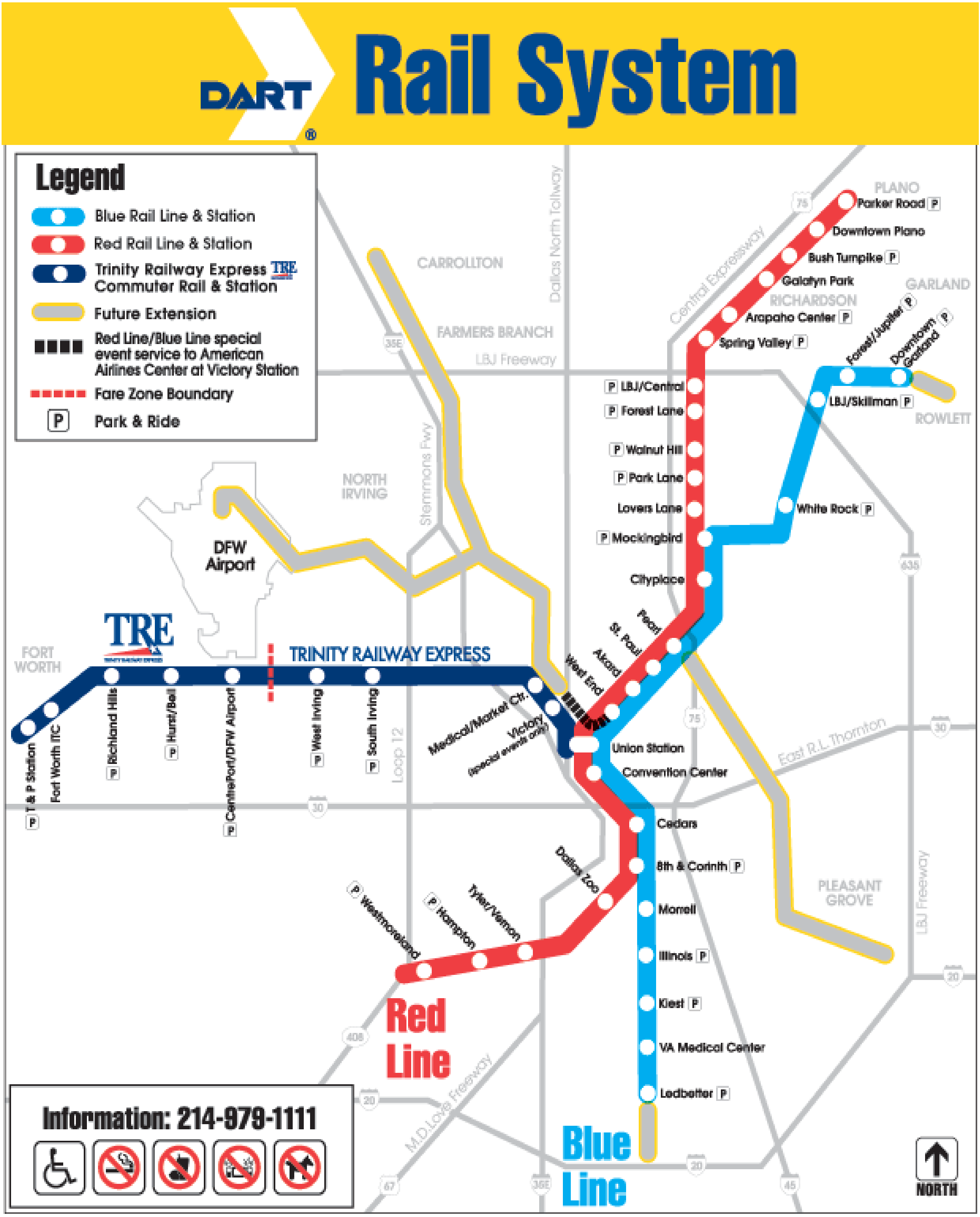


Exhibit 2-3
Existing System with LRT Build-Out Phase II Project—Green and Orange Lines

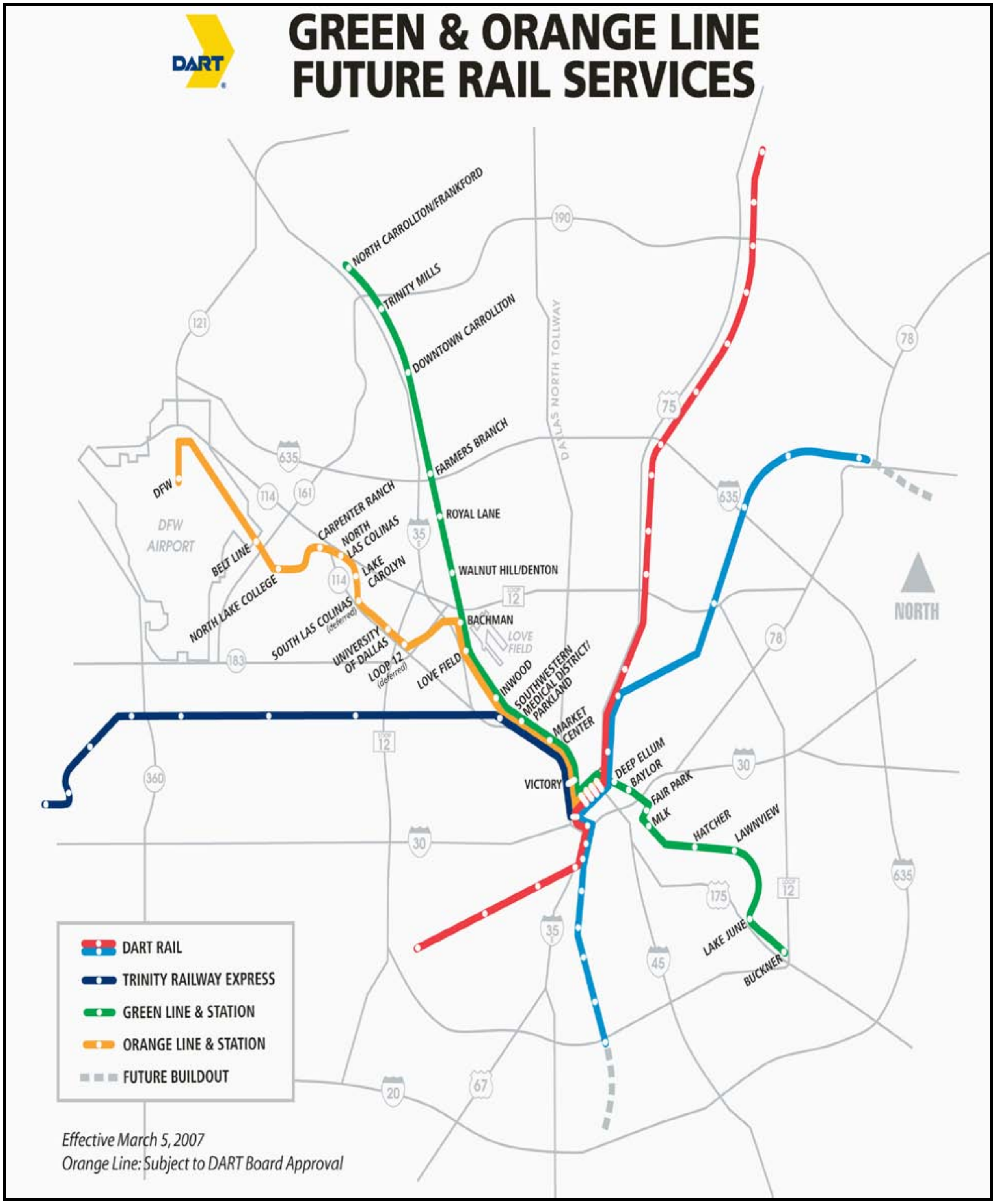


Exhibit 2-4
Existing System with LRT Build-Out Phase II Project—Rowlett Extension

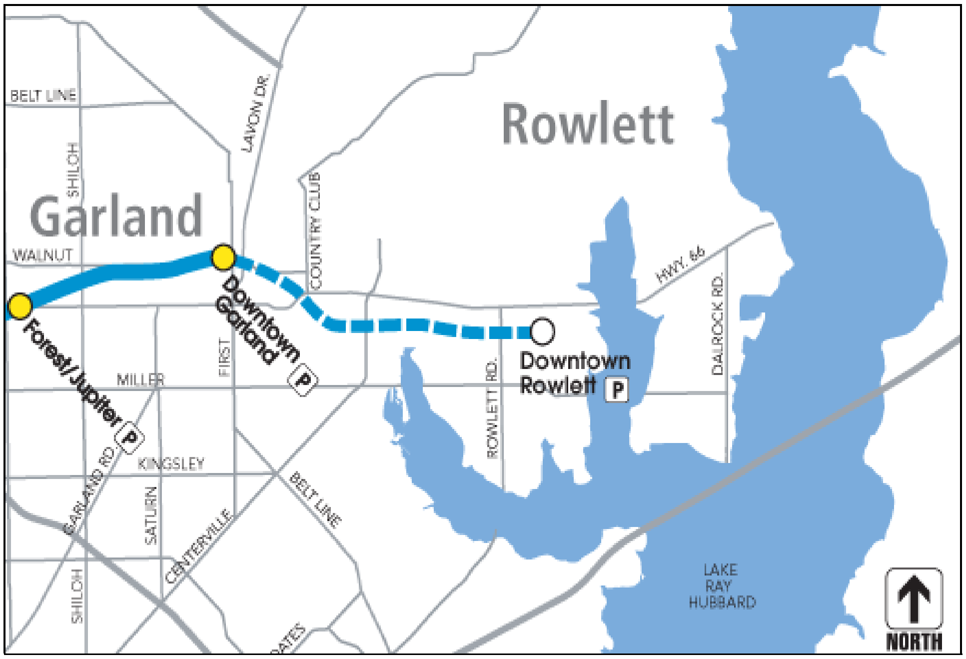
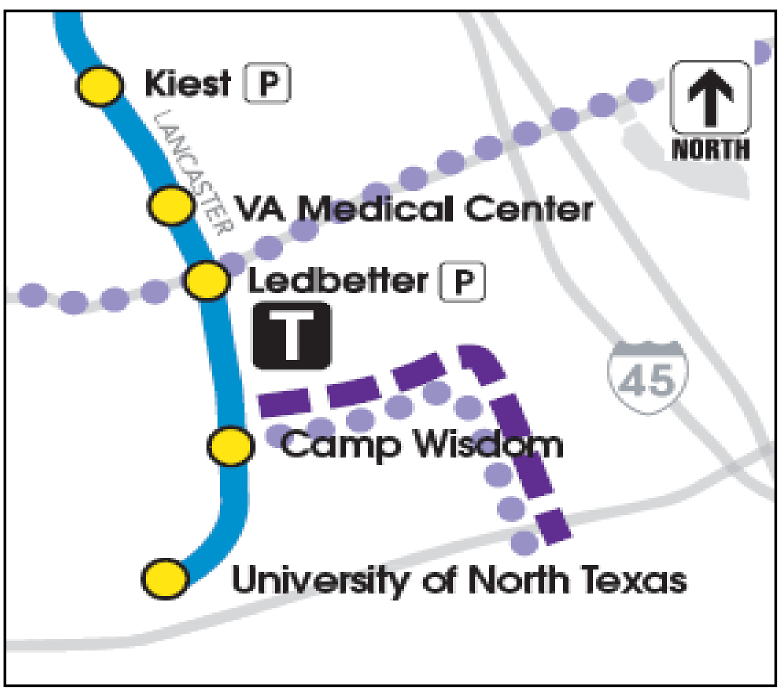


Exhibit 2-5
Existing System with LRT Build-Out Phase III Project—SOC-3



NOTE: Dashed/dotted lines shown are not part of SOC-3 Project.

2.2 Stations

There are a total of twenty-eight stations (two will be deferred from immediate construction) included in the planning for the Build-Out Phase II Project. Each station is distinguished by different architectural treatments (such as pavers and column cladding) and artwork unique to that station. Station planning emphasizes ease of multi-modal transfer for patrons, with planning for transfers between light rail trains and buses, automobiles, bicycles and pedestrian traffic. Station plans for the Build-Out Phase III Project have not yet been finalized.

2.2.1 At-Grade Stations

At-grade stations for the Build-Out Phase II Project are similar in concept and layout to those on the existing system, with some modifications. Features of at-grade stations include: canopies, crosswalks at each end of the station; a platform that is 15 ½-inches above the top-of-the rail with a 24-inch wide textured warning strip at the edge of the platform[1]; and, a fence between the tracks to discourage crossing outside the designated crosswalks. Other features include Passenger Emergency Call (PEC) devices, landscaping, architectural treatments, and artwork to complement the design of the station, pay telephones located approximately in the center of each platform, and newspaper racks at the ends of the platforms. A photograph of a representative at-grade station (side-platform) is shown in Exhibit 2-6. Some at-grade stations have a single platform in the center of the tracks and are designated center platform stations.

Exhibit 2-6
Typical At-Grade Station

[1] The platform height of existing stations will be increased from 8 inches to 15 ½ inches (at either the entire station or in the applicable boarding areas) as platforms are raised as part of the Level Boarding Initiative. This Initiative comprises several Projects, including: the Level Boarding-CBD Stations Project, the Level Boarding-Morrell Demonstration Project, and the Level Boarding-Outlying Stations Project. These Projects will be ongoing between 2008 and 2010, and have a planned completion date of December 2010.

2.2.2 Aerial Stations

Major features of aerial stations are the center platforms with a length of approximately 400 feet; concourses at street level where all Ticket Vending Machines (TVM), newspaper racks and pay telephones are located; passenger sheltering canopies; four sets of stairways and two elevators; a PEC located near each end of the platform for use in emergencies; a Public Address/Visual Message Board (PA/VMB) System, railings protecting the non-boarding side; and landscaping, as well as architectural treatments and artwork to complement the design of the station. The platform areas of the aerial stations are considered "paid" areas, and patrons are required to have the proper fare before entering the platform level of an aerial station. Exhibit 2-7 shows a typical aerial station.

Exhibit 2-7
Typical Aerial Station

2.3 Maintenance Facilities

The Build-Out Phase II Project will increase the size of the DART LRT vehicle fleet to a total of 163 units when all vehicles planned for acquisition have been accepted and enter revenue service. LRT maintenance operations and storage space functionality will be shared between the Central Rail Operating Facility (CROF) and the new Northwest Rail Operating Facility (NWROF).

2.3.1 Central Rail Operating Facility (CROF)

The Central Rail Operating Facility was constructed as part of the original DART LRT System and is the primary maintenance facility for the LRT vehicle fleet. The main facilities at this location include:

- A Service and Inspection (S&I) Facility which includes all light rail vehicle maintenance functions, including material control, offices and administrative areas; the Train Control Center, Bus Dispatch Office, Security Dispatching Center and DART Police offices.
- A Ways, Structures and Amenities Building (WSA) where all wayside and passenger amenities (bus and LRT system) maintenance, including material control, are based;
- Ancillary facilities including an interior cleaning platform, vehicle car wash, yard substation, hazardous materials storage area, and an outdoor material storage area;
- A storage yard capable of storing 120 SLRVs.

2.3.2 Northwest Rail Operating Facility (NWROF)

DART is constructing a second rail operating facility; located on a 34-acre parcel along the Northwest Corridor. The Northwest Rail Operations Facility (NWROF) will provide storage space for approximately 70 SLRVs as well as space for maintenance and administrative functions. The facility will comprise 16 double-ended storage tracks, revenue vehicle wash facilities, a two-track cleaning platform, Service and Inspection Facility (S&I), and a Ways, Structures and Amenities (WSA) building. The Service and Inspection Facility is a 73,000 square foot, two-story building consisting of the following areas: Primary Maintenance, Component Shops, Cleaning Platforms, Materials Management; Fleet Services and Rail Operations. The WSA Building is a single-story 38,500 square foot building, including warehouse space, consisting of the following areas: general repair, tool room, material storage, and personnel support facilities.

2.4 Service Characteristics

This section describes the service characteristics and operating parameters for the existing LRT System, as well as system operations in the near future. It includes hours of service, headways, train consist information, schedules, operating speeds, and other service related issues.

2.4.1 Service Design

The design of the DART LRT services described herein were formulated using DART ridership forecasts, and provide the level of service that will attract fare-paying passengers to the system. Scheduled revenue operations begin at approximately 4:00 a.m. and terminate at approximately 1:00 a.m. (the next morning), seven days per week. These hours of service are coordinated with the operations of the DART bus system, which provides feeder service to the LRT System in many instances. Peak period service on weekdays takes place between the hours of 6:00 a.m. to 9:00 a.m., and between the hours of 3:00 p.m. to 6:00 p.m., on all Line Sections. Off-peak and Saturday, Sunday and holiday services are also provided with more lengthy headways and smaller consists than on regular weekdays during peak periods.

Upon completion of the Build Out Phase II Project, train services will operate as:

- Westmoreland Station to Parker Road Station (Red Line);
- Ledbetter Station to Rowlett Station (Blue Line);
- North Carrollton/Frankford Road Station to Buckner Station (Green Line);
- DFW Airport Station to Parker Road Station or Lawnview Station (Orange Line split service in peak periods);
- DFW Airport Station to Lawnview Station (Orange Line service during non-peak periods, including all day Saturday and Sunday).

Upon inception of Orange Line Service in December 2011, the Red Line Filler Trains (Parker Road Station to West End Station) will no longer operate. Special event service may be offered as needed. Overall fleet size planning should not be impacted by special event-type services.

2.4.2 Headways and Train Consists

“Headway” is defined as the time interval between the passing of successive trains in a similar direction at a specific point on the rail system. Optimal design headways are determined by an analysis of the projected peak passenger loadings, and are generally governed (but not specifically set) by the service provision directives of the DART Board of Directors. Headways for the LRT System, as described below, are designed to meet ridership projections described in this section.

The combination of train frequency and consist size provides a level of service sufficient to carry the projected volume of passengers through the maximum load section during the peak periods. During the peak, a maximum allowable loading factor of 1.50 (or approximately 144 passengers per vehicle) is used for scheduling purposes.[2] The 1.50 load factor equates to 48 standing passengers for every 96-seated passengers per each SLRV. The peaked nature of transit travel sometimes causes this loading factor to be exceeded, but only for a short time during the rush hour peak periods. Headways and train consist sizes very rarely are overwhelmed by demand on the system. During off-peak hours, there should ideally be seats for all passengers. System element design does have an impact on headways and train consist size potential. The normal consist size will be one or two SLRVs. Red and Blue Line Stations can accommodate these consists. Central Business District (CBD) and Green Line Stations can accommodate a consist of up to three SLRVs.

Headways for the system, as operated within the confines of the Build Out Phase II Project, are shown in Exhibits 2-8 through 2-11. The headways necessary to accommodate mid-day (non-peak) service are not necessarily driven by peak ridership demands. The base level of service deemed necessary to attract ridership patronage to the system effectively determines off-peak headways. Headways longer than a certain threshold discourage off-peak ridership. Early morning or late evening service may consist of a single SLRV if conditions warrant. Weekend ridership volumes are also monitored since additional vehicles are available to provide additional service if required.

Most trains are scheduled to begin and end their trips at NWROF or CROF. Maintenance facilities will not serve a specified pool or fleet of SLRVs: operational constraints and maintenance needs will dictate where cars are stored or maintained on a daily basis. In addition to DART maintenance facilities, tail tracks may be utilized at terminal (end-of-the-line) stations for the staging or storage of trains during mid-day and overnight hours. This helps minimize empty repositioning of vehicles and other operating costs, and is consistent with DART policies. As the Build-Out Phase II Project is completed, there will be storage space available for SLRVs at the following terminal stations:

- Rowlett Station – 6 vehicles
- Parker Road Station – 12 vehicles
- North Carrollton/Frankford Road Station – 5/6 vehicles
- Beltline/DFW Station – TBD
- Westmoreland Station – 4 vehicles
- Buckner Station – 6 vehicles

DART Design Criteria requires the provision of a minimum of 500 feet of storage track at terminal stations to accommodate selected trains that are pre-positioned for the next day's operational plan. Selected stations have more than the minimum, and some stations have been exempted from this provision based on area constraints (there is no storage at Ledbetter, for instance). Some station tail tracks are abbreviated due to turnouts in place for a third (non-powered) track on which Maintenance Department vehicles are stored.

[2] See Chapter 3, Section 4.2 for more information on Load Limits and Service Standards.

Exhibit 2-8
Planned System Headways FY 2011—Opening of Green Line

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Exhibit 2-9
Planned System Headways FY 2012—Opening of Irving-1 Line Section

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<tr><td>North Las Colinas-Lawnview</td><td>2 car @ 20 min HW</td><td>2 car @ 20 min HW</td></tr>
<tr><td>North Las Colinas-Parker Road (peak only)</td><td></td><td>2 car @ 20 min HW</td></tr>
<tr><td rowspan="4">Saturday</td><td>Westmoreland-Parker Road</td><td colspan="2">2 car trains @ 20 minute headways</td></tr>
<tr><td>Ledbetter-Garland</td><td colspan="2">1 car train @ 20 minute headways</td></tr>
<tr><td>North Carrollton/Frankford-Buckner</td><td colspan="2">2 car trains @ 20 minute headways</td></tr>
<tr><td>North Las Colinas-Lawnview</td><td colspan="2">1 car train @ 20 minute headways</td></tr>
</table>

<table>
<tr><th></th><th>SERVICE</th><th>7 8 9</th><th>10 11 12 1 2</th></tr>
<tr><td rowspan="4">Sunday</td><td>Westmoreland-Parker Road</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
<tr><td>Ledbetter-Garland</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
<tr><td>North Carrollton/Frankford-Buckner</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
<tr><td>North Las Colinas-Lawnview</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
<tr><td rowspan="4">Weekday</td><td>Westmoreland-Parker Road</td><td>1 car @ 20 min HW</td><td>1 car trains @ 30 minute headways</td></tr>
<tr><td>Ledbetter-Garland</td><td>1 car @ 20 min HW</td><td>1 car trains @ 30 minute headways</td></tr>
<tr><td>North Carrollton/Frankford-Buckner</td><td>2 car @ 20 min HW</td><td>2 car trains @ 30 minute headways</td></tr>
<tr><td>North Las Colinas-Lawnview</td><td>2 car @ 20 min HW</td><td>1 car trains @ 30 minute headways</td></tr>
<tr><td rowspan="4">Saturday</td><td>Westmoreland-Parker Road</td><td colspan="2">2 car trains @ 30 minute headways</td></tr>
<tr><td>Ledbetter-Garland</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
<tr><td>North Carrollton/Frankford-Buckner</td><td colspan="2">2 car trains @ 30 minute headways</td></tr>
<tr><td>North Las Colinas-Lawnview</td><td colspan="2">1 car train @ 30 minute headways</td></tr>
</table>

Exhibit 2-10
Planned System Headways FY 2013—Opening of Irving-2 Line Section

	SERVICE	am 4	5	6	7	8	9	10	11
Sunday	Westmoreland-Parker Road	1 car train @ 30 minute headways						1 car @ 20 min HW	
	Ledbetter-Rowlett	1 car train @ 30 minute headways						1 car @ 20 min HW	
	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways						2 car @ 20 min HW	
	Belt Line-Lawnview	1 car train @ 30 minute headways						1 car @ 20 min HW	
Weekday	Westmoreland-Parker Road	2 car @ 20 min HW		2 car @ 10 min HW			2 car @ 20 min HW		
	Ledbetter-Rowlett	2 car @ 20 min HW		2 car @ 10 min HW			2 car @ 20 min HW		
	North Carrollton/Frankford-Buckner	2 car @ 20 min HW		2 & 3 car @ 10 min HW			2 car @ 20 min HW		
	Belt Line-Lawnview	1 car @ 20 min HW		2 car @ 20 min HW			2 car @ 20 min HW		
	Belt Line-Parker Road (peak only)			2 car @ 20 min HW					
Saturday	Westmoreland-Parker Road	2 car trains @ 30 minute headways						2 car @ 20 min HW	
	Ledbetter-Rowlett	1 car train @ 30 minute headways						1 car @ 20 min HW	
	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways						2 car @ 20 min HW	
	Belt Line-Lawnview	1 car train @ 30 minute headways						1 car @ 20 min HW	

	SERVICE	pm 12	1	2	3	4	5	6
Sunday	Westmoreland-Parker Road	1 car train @ 20 minute headways						
	Ledbetter-Rowlett	1 car train @ 20 minute headways						
	North Carrollton/Frankford-Buckner	2 car trains @ 20 minute headways						
	Belt Line-Lawnview	1 car train @ 20 minute headways						
Weekday	Westmoreland-Parker Road	2 car @ 20 min HW			2 car @ 10 min HW			
	Ledbetter-Rowlett	2 car @ 20 min HW			2 car @ 10 min HW			
	North Carrollton/Frankford-Buckner	2 car @ 20 min HW			2 & 3 car @ 10 min HW			
	Belt Line-Lawnview	2 car @ 20 min HW			2 car @ 20 min HW			
	Belt Line-Parker Road (peak only)				2 car @ 20 min HW			
Saturday	Westmoreland-Parker Road	2 car trains @ 20 minute headways						
	Ledbetter-Rowlett	1 car train @ 20 minute headways						
	North Carrollton/Frankford-Buckner	2 car trains @ 20 minute headways						
	Belt Line-Lawnview	1 car train @ 20 minute headways						

	SERVICE	7	8	9	10	11	12	1	2
Sunday	Westmoreland-Parker Road	1 car train @ 30 minute headways							
	Ledbetter-Rowlett	1 car train @ 30 minute headways							
	North Carrollton/Frankford-Buckner	1 car train @ 30 minute headways							
	Belt Line-Lawnview	1 car train @ 30 minute headways							
Weekday	Westmoreland-Parker Road	1 car @ 20 min HW			1 car trains @ 30 minute headways				
	Ledbetter-Rowlett	1 car @ 20 min HW			1 car trains @ 30 minute headways				
	North Carrollton/Frankford-Buckner	2 car @ 20 min HW			2 car trains @ 30 minute headways				
	Belt Line-Lawnview	2 car @ 20 min HW			1 car trains @ 30 minute headways				
Saturday	Westmoreland-Parker Road	2 car trains @ 30 minute headways							
	Ledbetter-Rowlett	1 car train @ 30 minute headways							
	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways							
	Belt Line-Lawnview	1 car train @ 30 minute headways							

Exhibit 2-11

Planned System Headways FY 2014—Opening of Irving-3 Line Section

	SERVICE	am 4	5	6	7	8	9	10	11
Sunday	Westmoreland-Parker Road	1 car train @ 30 minute headways						1 car @ 20 min HW	
Sunday	Ledbetter-Rowlett	1 car train @ 30 minute headways						1 car @ 20 min HW	
Sunday	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways						2 car @ 20 min HW	
Sunday	DFW Airport-Lawnview	1 car train @ 30 minute headways						1 car @ 20 min HW	
Weekday	Westmoreland-Parker Road	2 car @ 20 min HW		2 car @ 10 min HW			2 car @ 20 min HW		
Weekday	Ledbetter-Rowlett	2 car @ 20 min HW		2 car @ 10 min HW			2 car @ 20 min HW		
Weekday	North Carrollton/Frankford-Buckner	2 car @ 20 min HW		2 & 3 car @ 10 min HW			2 car @ 20 min HW		
Weekday	DFW Airport-Lawnview	1 car @ 20 min HW		2 car @ 20 min HW			2 car @ 20 min HW		
Weekday	DFW Airport-Parker Road (peak only)			2 car @ 20 min HW					
Saturday	Westmoreland-Parker Road	2 car trains @ 30 minute headways						2 car @ 20 min HW	
Saturday	Ledbetter-Rowlett	1 car train @ 30 minute headways						1 car @ 20 min HW	
Saturday	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways						2 car @ 20 min HW	
Saturday	DFW Airport-Lawnview	1 car train @ 30 minute headways						1 car @ 20 min HW	

		pm 12	1	2	3	4	5	6
Sunday	Westmoreland-Parker Road	1 car train @ 20 minute headways						
Sunday	Ledbetter-Rowlett	1 car train @ 20 minute headways						
Sunday	North Carrollton/Frankford-Buckner	2 car trains @ 20 minute headways						
Sunday	DFW Airport-Lawnview	1 car train @ 20 minute headways						
Weekday	Westmoreland-Parker Road	2 car @ 20 min HW			2 car @ 10 min HW			
Weekday	Ledbetter-Rowlett	2 car @ 20 min HW			2 car @ 10 min HW			
Weekday	North Carrollton/Frankford-Buckner	2 car @ 20 min HW			2 & 3 car @ 10 min HW			
Weekday	DFW Airport-Lawnview	2 car @ 20 min HW			2 car @ 20 min HW			
Weekday	DFW Airport-Parker Road (peak only)				2 car @ 20 min HW			
Saturday	Westmoreland-Parker Road	2 car trains @ 20 minute headways						
Saturday	Ledbetter-Rowlett	1 car train @ 20 minute headways						
Saturday	North Carrollton/Frankford-Buckner	2 car trains @ 20 minute headways						
Saturday	DFW Airport-Lawnview	1 car train @ 20 minute headways						

		7	8	9	10	11	12	1	2
Sunday	Westmoreland-Parker Road	1 car train @ 30 minute headways							
Sunday	Ledbetter-Rowlett	1 car train @ 30 minute headways							
Sunday	North Carrollton/Frankford-Buckner	1 car train @ 30 minute headways							
Sunday	DFW Airport-Lawnview	1 car train @ 30 minute headways							
Weekday	Westmoreland-Parker Road	1 car @ 20 min HW			1 car trains @ 30 minute headways				
Weekday	Ledbetter-Rowlett	1 car @ 20 min HW			1 car trains @ 30 minute headways				
Weekday	North Carrollton/Frankford-Buckner	2 car @ 20 min HW			2 car trains @ 30 minute headways				
Weekday	DFW Airport-Lawnview	2 car @ 20 min HW			1 car trains @ 30 minute headways				
Saturday	Westmoreland-Parker Road	2 car trains @ 30 minute headways							
Saturday	Ledbetter-Rowlett	1 car train @ 30 minute headways							
Saturday	North Carrollton/Frankford-Buckner	2 car trains @ 30 minute headways							
Saturday	DFW Airport-Lawnview	1 car train @ 30 minute headways							

2.4.3 Speeds

The maximum design speed for the track and ROW on the LRT Build-Out Phase II Project is 65 mph. This maximum design speed is consistent with that which exists on the current LRT System. In the existing LRT System, Train Operators have full control of the train speed--there is no automatic speed control system. The Build-Out Phase II Project will incorporate an automatic cab signal system (ACS), which will serve to control the maximum speed of the train. Twelve cab speed codes will be used to control SLRV operations: the 0, 10, 15, 20, 25, 30, 35, 45, 55, 60 and 65 mph codes and the "end-of-cab territory" code. Speed signs located along the right-of-way are placed in advance of a speed restriction as defined in the *DART's Light Rail System Book of Operating Rules*. Signs along the right-of-way also inform Train Operators when they may alter the speed level of the train. Several intermediate speed restrictions are located along the ROW to accommodate route alignment and other characteristics of the ROW, which serves to reduce operating speeds on certain Line Sections. Cab or wayside signals (depending on the Line Section), fencing and other system features are utilized, where necessary, to achieve the maximum authorized operating speed possible on any Line Section. Operating speeds do not exceed 45 mph on any line section where train operation is by line-of-sight rules (certain Starter System sections), or if fencing is not installed to deter trespassers from entering the ROW. In highway and street running sections, traffic signal progression sequences and the civil speed limit of the parallel highway govern LRT operations.

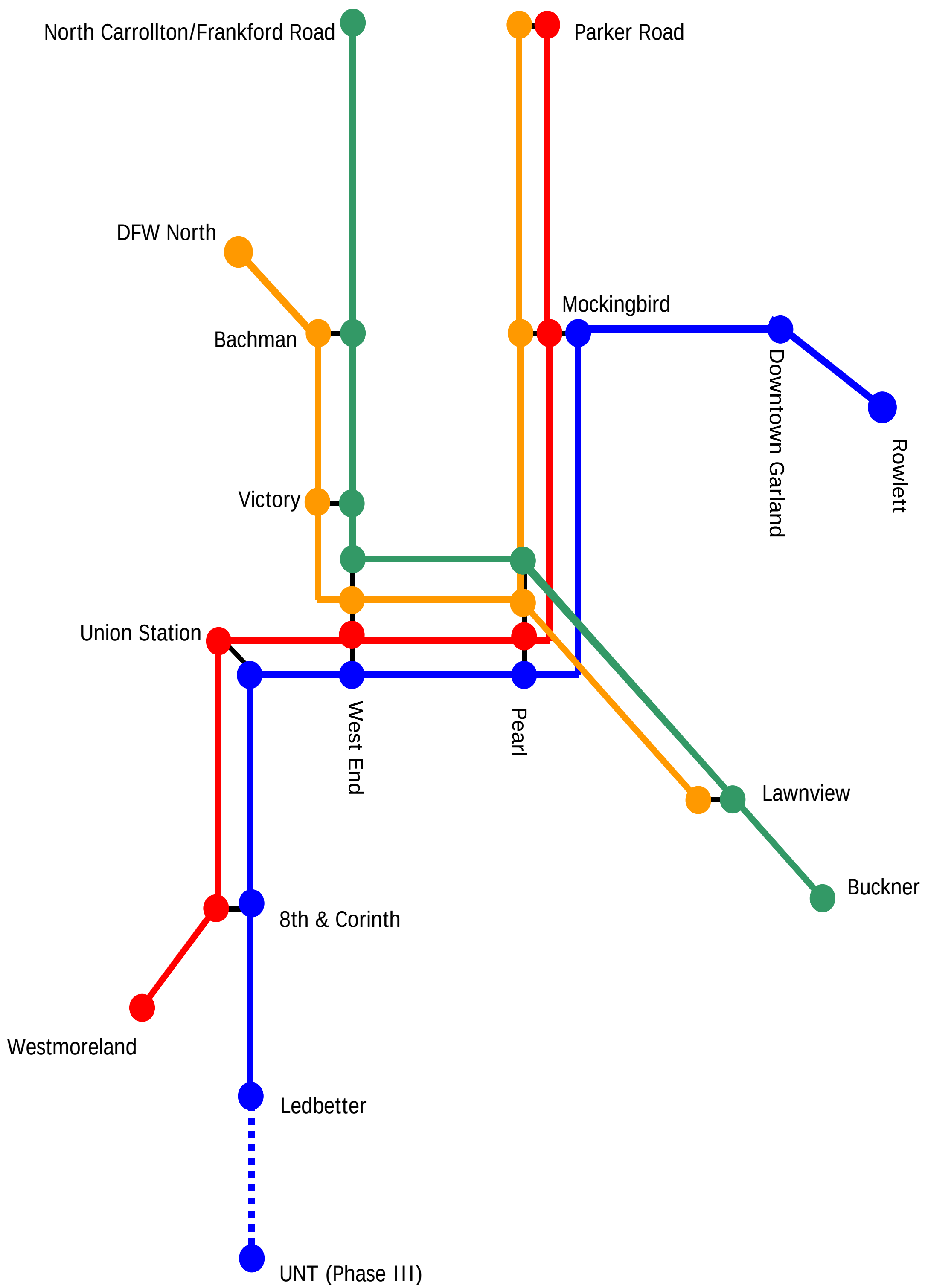
2.4.4 Schedules

The DART LRT System runs on schedules based on factors such as passenger demand, train cycle times, fleet size, and others. DART develops preliminary LRT System schedules for both weekday and weekend services. The next step of the scheduling process has integrated time of day service, headway intervals, consist sizes, train run times, combined with existing system and Build-Out Phase II Project service planning into a comprehensive system schedule. These schedules are used to determine the fleet size needed to operate at desired service levels (described in Section 4.5), determine facility and engineering requirements, estimate the required Train Operator hours, car hours, car miles, and accounting information.

Schedules are developed to assure service reliability and manage the equipment cycle to minimize the number of vehicles in operation. The system operates efficiently when it accounts for the appropriate balance between service reliability and vehicle operations. Schedules are developed using civil engineering characteristics, Train Performance Calculations (TPC), headway plans, sequencing of trains at junctions, dwell times at stations stops, turn times for equipment/operators at various locations, traffic signal sequencing, and scheduled recovery times. Services are scheduled to operate between the following points (see also Exhibit 2-12):

- Green Line – North Carrollton/Frankford Road Station and Buckner Station;
- Peak Orange Line – DFW Airport Station to Lawnview/Parker Road Stations;
- Non-peak Orange Line – DFW Airport Station to Lawnview Station;
- Red Line – Westmoreland Station and Parker Road Station
- Blue Line – Ledbetter Station and Rowlett Station.

Exhibit 2-12
Build-Out Project Phase II and III-- LRT System Operating Plan



NOTE: Second CBD alignment not shown.

2.4.5 Ridership

Normal weekday ridership for the LRT System is over 70,000 patrons per day. During the weekend, passenger counts are in the range of 20,000-30,000 patrons per day. Peak hour ridership is approximately 19% of the daily volumes. Upon completion of the Green Line and Orange Line, total daily ridership numbers are projected to nearly double for the DART LRT System. The ridership level on the Red Line has traditionally been higher than that on the Blue Line. Due to community demographics favorable to transit ridership, it is expected that the ridership on the Green Line will surpass that of the Orange Line. See Exhibits 2-13 and 2-14 for current ridership by Service Day and Time Quadrant for the LRT System.

2.5 Rail Fleet

As of February 5, 2009, DART's existing rail vehicle fleet to support the RFMP contains eighty-six (86) two-segment light rail vehicles (LRVs) and twenty-nine (29) converted three-segment SLRVs. All LRVs will be altered to become SLRVs by late 2010/early 2011. An additional forty-eight (48) newly built three-segment SLRVs will be acquired after this date, bringing the total size of the fleet to one hundred and sixty-three (163) SLRVs. KinkiSharyo USA, LLC, has manufactured all the LRVs and the C-car for the SLRV. KinkiSharyo USA, LLC, will also construct the newly-built SLRVs mentioned above.

All LRVs are currently being retrofitted with a new 30-foot center section "C-Car," of a low floor design. During this retrofit process, an additional non-operational truck is installed at the second articulation of the vehicle, increasing the number of axles on the vehicle to eight. This new vehicle style will be referred to as an SLRV. The modification process has begun and will continue until all LRVs are retrofitted. To evaluate the performance and operational requirements of an SLRV, DART, in conjunction with the manufacturer, has built a prototype SLRV. LRV #170 was retrofitted as an SLRV and was tested. The tests included comprehensive performance tests with the SLRV operating per the normal LRT schedule. The results of the performance testing indicated minor impacts to performance and run times. However, as these tests verified earlier simulations, no schedule adjustments were necessary.

The SLRV collects power from a nominal 750-volt direct current (dc) overhead contact system by means of a single pantograph on each vehicle. Four alternating current (ac) motors located at the axles on each of the end trucks power the SLRV. The C-Car trucks are not powered. The SLRVs are capable of being independently operated or as multiple unit consists. Each vehicle has cab controls located at each end. Doorways permit boarding from either low-level (center door) or raised platforms. Scheduled SLRV consists shall vary from one to three vehicles depending on the time of day and particular route. All DART SLRVs are 123 feet, 8 inches long (coupler to coupler) and have 96 seats with room for 119 additional passengers standing comfortably. A total of 178 standing passengers can be accommodated at the "crush load" for a maximum vehicle capacity of approximately 274 passengers. Figure 2-1 shows the Existing Fleet Inventory listed by vehicle ID number and the acceptance date of the vehicle, along with the SLRV conversion date.

Exhibit 2-13
Ridership by Service Day

Ridership by Service Day

Date Range included in Report: 12/1/2008-12/31/2008

Survey dates used to calculate statistics: 10/1/2008-12/31/2008

LINE Blue

Service Operated	Total Alightings	Days in Period	Average Daily Alightings	Statistical Accuracy
Weekday	552,316	21	26,301	±3.5%
Saturday	51,237	5	10,247	±6.8%
Sunday	37,416	5	7,483	±5.9%
Subtotal for BLUE LINE:	640,968	31	20,676	

LINE Red

Service Operated	Total Alightings	Days in Period	Average Daily Alightings	Statistical Accuracy
Weekday	860,150	21	40,690	±3.0%
Saturday	90,918	5	18,184	±6.7%
Sunday	60,874	5	12,175	±7.0%
Subtotal for RED LINE:	1,011,942	31	32,643	

TOTAL

Service Operated	Total Alightings	Days in Period	Average Daily Alightings
Weekday	1,412,466	21	67,260
Saturday	142,154	5	28,431
Sunday	98,290	5	19,658
Total	1,652,910	31	

Exhibit 2-14
Weekday Riders by Time Quadrant

Weekday Riders by Time Quadrant

Date Range included in Report: 12/1/2008-12/31/2008

Survey dates used to calculate statistics: 7/1/2008-12/31/2008

LINE Blue

Time Quadrant	Total Alightings	Days in Period	Average Daily Alightings	Statistical Accuracy
4 am to 9 am	158,332	21	7,540	±4.6%
9 am to 3 pm	160,854	21	7,660	±4.3%
3 pm to 7 pm	185,542	21	8,835	±4.4%
7 pm to 1 am	62,661	21	2,984	±6.5%
Total	567,389	21	27,019	

LINE Red

Time Quadrant	Total Alightings	Days in Period	Average Daily Alightings	Statistical Accuracy
4 am to 9 am	258,530	21	12,311	±4.2%
9 am to 3 pm	195,236	21	9,297	±3.5%
3 pm to 7 pm	336,449	21	16,021	±3.9%
7 pm to 1 am	90,268	21	4,298	±5.2%
Total	880,483	21	41,928	

	Total Alightings	Days in Period	Average Daily Alightings
TOTAL	1,447,872	21	68,946

FIGURE 2-1
LIGHT RAIL VEHICLE FLEET INVENTORY

VEH #	ACCEPT. DATE*	SLRV CONV.+	VEH #	ACCEPT. DATE*	SLRV CONV.+	VEH #	ACCEPT. DATE*	SLRV CONV.+
101	03/28/96		140	09/19/96		179	07/26/00	
102	12/01/95		141	04/30/99	10/22/08	180	06/19/00	
103	02/28/97		142	07/04/99	10/09/08	181	05/19/00	
104	02/22/96	10/14/08	143	07/21/99	10/27/08	182	05/05/00	
105	12/22/95	07/07/08	144	07/30/99	11/10/08	183	05/19/00	
106	05/30/96	01/12/09	145	08/10/99	11/18/08	184	08/16/00	
107	03/26/96	12/24/08	146	09/01/99	09/02/08	185	09/19/00	
108	03/21/96		147	08/24/99	11/03/08	186	10/16/00	
109	08/28/95		148	09/20/99	09/08/08	187	09/19/00	
110	02/08/96		149	10/01/99	11/26/08	188	10/16/00	
111	03/28/96		150	10/08/99	12/01/08	189	07/09/01	
112	03/28/96		151	08/03/99	06/20/08	190	10/16/00	
113	12/12/95		152	08/16/99	12/15/08	191	10/16/00	09/16/08
114	03/28/96		153	11/11/99		192	10/16/00	
115	03/28/96		154	03/15/00	12/15/08	193	10/16/00	
116	05/11/96		155	03/10/00		194	10/16/00	09/30/08
117	12/12/95		156	02/28/00		195	05/18/01	
118	03/22/96		157	02/18/00	09/24/08	196	07/12/06	01/22/09
119	03/21/96		158	02/09/00	02/02/09	197	07/07/06	07/31/08
120	03/11/96		159	12/23/99		198	11/29/06	
121	03/15/96		160	01/28/00	07/31/08	199	10/27/06	12/24/08
122	03/28/96		161	12/16/99		200	02/16/06	02/04/09
123	02/08/96		162	11/11/99		201	10/31/06	
124	03/28/96		163	12/16/99		202	10/24/06	
125	05/30/96		164	01/31/00		203	10/27/06	
126	06/06/96		165	12/06/99		204	06/29/06	
127	05/29/96		166	12/01/99		205	09/21/06	
128	05/11/96		167	12/23/99		206	10/09/06	
129	10/03/96		168	01/18/00		207	08/03/06	
130	12/11/96		169	01/31/00		208	08/11/06	
131	03/13/96		170	03/10/00	07/01/08	209	12/29/06	
132	10/25/96		171	02/18/00		210	10/09/06	
133	06/06/96		172	02/09/00		211	06/12/06	01/13/09
134	03/28/96	07/31/08	173	10/25/99		212	07/28/06	
135	05/08/96		174	11/11/99		213	07/26/06	
136	04/15/96		175	03/22/00		214	06/12/06	
137	08/08/96		176	04/27/00		215	06/29/06	
138	08/12/96		177	10/16/00				
139	07/16/96		178	10/16/00				

**Cars 101-195: dates reflect final acceptance of vehicle. Cars: 196-215 dates reflect conditional acceptance of vehicle.*
+SLRV Conversion dates reflect date of Conditional Acceptance of SLRV by DART Maintenance. Data current as of 2-5-09.

3.0 The Demand for Revenue Service Vehicles

The demand for revenue service vehicles has been established for the existing LRT System; and for the system as it will exist after the Build-Out Phase II and III Projects have been completed. This section will document the process used to determine the demand for revenue vehicles.

3.1 Overview and Factors Determining Fleet Size

Quality of service provided to patrons is ultimately the factor that determines the success of any transit system. Service quality must be maintained to promote public acceptance and increasing usage of the transit system. Quality of service is a function of the following factors:

- Network reach;
- Reliability;
- Speed;
- Frequency;
- Comfort;
- Cleanliness;
- Safety;
- Convenience;
- Operating Efficiency.

Several of these factors are primarily related to fleet size and composition of the vehicle fleet.

3.2 Process Summary

Determination of the optimal fleet size is a process that requires input from a variety of sources, and the consideration of a variety of factors. DART analysis of fleet sizing occurs during each phase of system development. Major determinants of the LRT System fleet size are:

- Current & projected ridership;
- Demographic trends in the service area;
- Changes to factors that impact system usage;
- System operating capacity;
- Addition of new rail segments;
- Addition of new stations along existing lines;
- Implementation of major overhaul program(s);
- Maintenance requirements (anticipated/unanticipated);
- Acceptable/desired headways;
- Vehicle retirement programs;
- Vehicle replacement programs;
- Acceptable/desired passenger load factors.

The process used to determine DART's LRT fleet size requirements is consistent with current Federal Transit Administrative (FTA) guidelines, as summarized below.

Step One: *Determine peak passenger demand at the maximum load points by utilizing actual counts of present ridership and estimates of future demand.* These demand estimates are made by DART Service Planning staff and are known as the *Maximum Link Loads (MLL)*. The Maximum Link Load is defined as follows: Link loads represent the total number of people that travel between any two consecutive stations within a defined time parameter. The maximum link load represents the capacity for which the system must not exceed. An MLL is determined for each major segment of a Line Section. Future passenger demand is projected based on regional growth estimates. System additions, fare pricing changes, and system access measures also influence passenger demand.

Step Two: *Define and adopt passenger load standards and calculate load factor.* Typically, the load standards adopted by DART are a statement of the quality of service DART strives to provide to the public. The DART Board of Directors sets these load standards. The philosophy followed may be stated as such: the more generous the standard in terms of seating capacity per passenger, the more attractive the service. However, a more generous (lower) load standard requires more vehicles or faster headways to accommodate patrons. The load factor is the ratio of passengers to the capacity of the vehicle.

Step Three: *Determine (calculate and/or measure) vehicle run times.* These times should include the trip time in each direction on a line segment, as well as the time allotted for vehicle and Train Operator turnaround at each terminal station, resulting in a total cycle time calculation.

Step Four: *Calculate the quantity of vehicles required at the maximum load points.* The adopted load standards are applied to the MLLs to determine the number of vehicles required on a Line Section or operating segment during a defined peak period.

Step Five: *Establish the Peak Vehicle Requirement (PVR).* The PVR is based on the selected headway and consist sizes that allow DART to comply with the passenger load standard criteria during the peak period.

Step Six: *Explain if any "gap" or ready reserve trains will be utilized in the operating strategy.* Ready reserve trains are those held in "backup" status in case of vehicle failure on the system or other emergency. These vehicles will be added to the peak vehicle requirement for revenue service.

Step Seven: *Determine the operating spares ratio necessary to meet the PVR.* This is usually expressed as a percentage of the active fleet in excess of the daily schedule requirements. It provides for a sufficient quantity of vehicles to be available for routine preventative maintenance, and also assumes a certain quantity of vehicles will be unavailable each day because of unplanned corrective maintenance. Vehicles may also be out-of-service for light or heavy overhauls, or for major structural repair.

Step Eight: *Determine the total fleet demand.* This is the sum of the quantity of vehicles required for peak scheduled service and the quantity of operating spares required. From this sum, the planned operating spare ratio can be calculated.

3.3 Step One: Determine Maximum Link Loads

3.3.1 Current Daily Ridership / Passenger Demand

Figure 3-1 shows the average weekday passenger counts from June 1996 to December 2008. Since the inception of service on the DART LRT System, and through the addition of each new Line Section, overall ridership has increased steadily. The figures presented in the passenger demand graph are largely consistent with DART Service Planning ridership projections made in advance of opening each Line Section for revenue service.

3.3.2 Daily Peak Ridership Projections / Maximum Link Loads

The Peak Vehicle Requirement (PVR) is the total quantity of rail vehicles needed simultaneously in the peak periods to satisfy passenger demand while keeping per-vehicle passenger loads at or below a predetermined mandated level. On weekdays the peak period of service is defined as two separate 180-minute time blocks – one in the morning (6 am to 9 am) and one in the evening (3 pm to 6 pm). Passenger loads are measured at each station in each Line Section throughout each peak period and are evaluated in one-hour increments to determine appropriate headway and fleet requirements. Load conditions between any two stations have been provided from data collected and prepared by DART System Planning for existing and projected system ridership.

DART System Planning has projected ridership data for the year 2013 and 2030, and from this data, the Maximum Link Loads (MLLs) can be calculated. These projections and the proposed 2013 Operations and Maintenance Plan are used as the basis for this section. The CBD section, from Pearl Station to West End Station, has not been specifically included in determining load factors on the LRT System. The stations in this section will see a greater number of trains than other Line Segments open for revenue service. Furthermore, the headways in the CBD will facilitate higher passenger tolerance to high load factors, as more patrons board and alight in the CBD than in other areas. In addition to other factors, these MLLs are key pieces of data, as they will be used to express future ridership levels on the system, and subsequently, will be the criteria used to plan and build the system based on ridership and capacity.

3.3.3 Build-Out Phases II and III

Ridership levels and peak Maximum Link Loads for the Build-Out Phase II and III Projects have been calculated. Figure 3-2 shows the MLL for the projected 2013 LRT System, while Figure 3-3 illustrates the MLLs projected on the system in 2030. Future DART LRT System operations are designed to account for the MLL for each area outlined. All forecasts have been provided by DART Capital Planning and Development.

FIGURE 3-1
DART AVERAGE WEEKDAY LRT RIDERSHIP

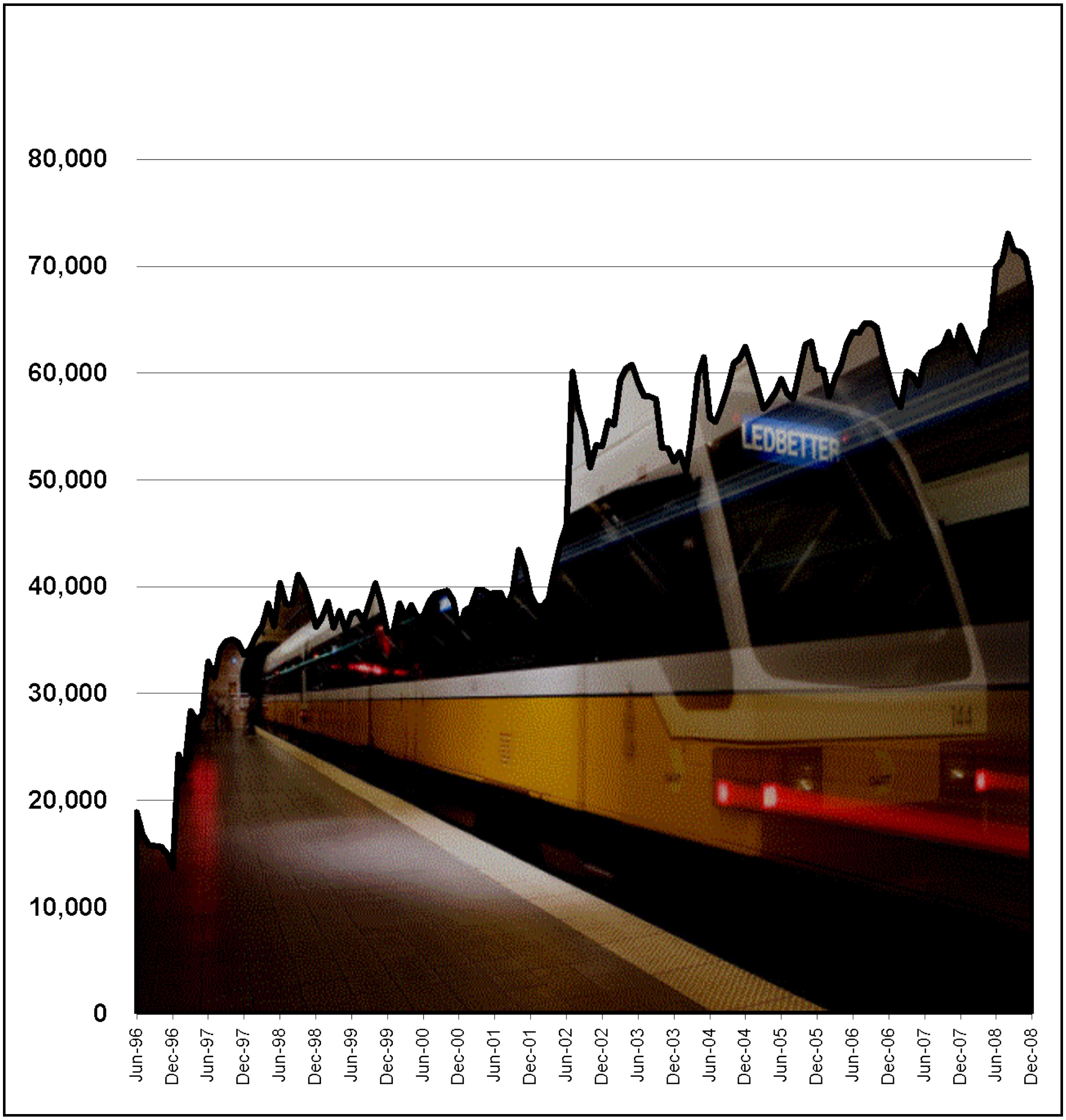
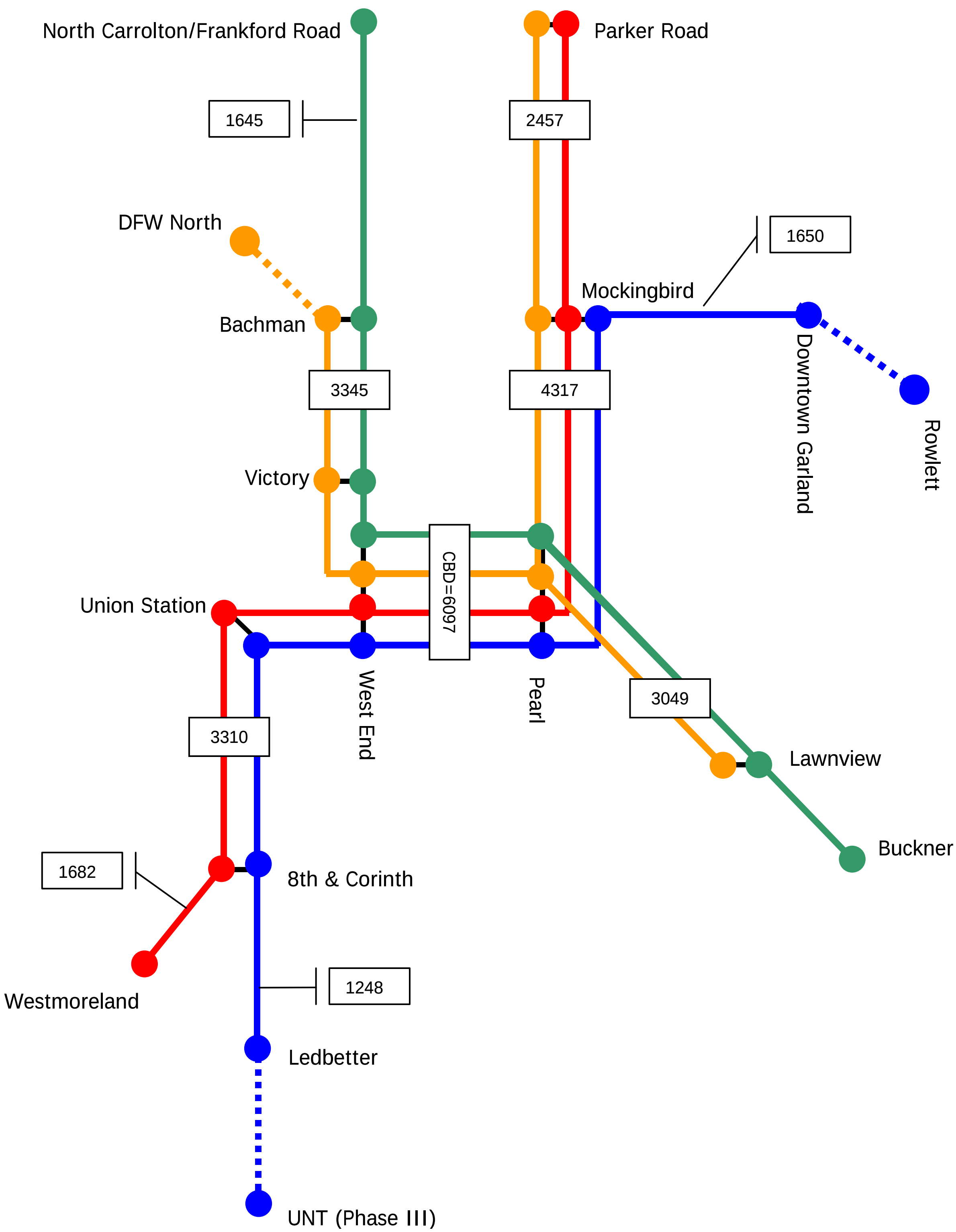
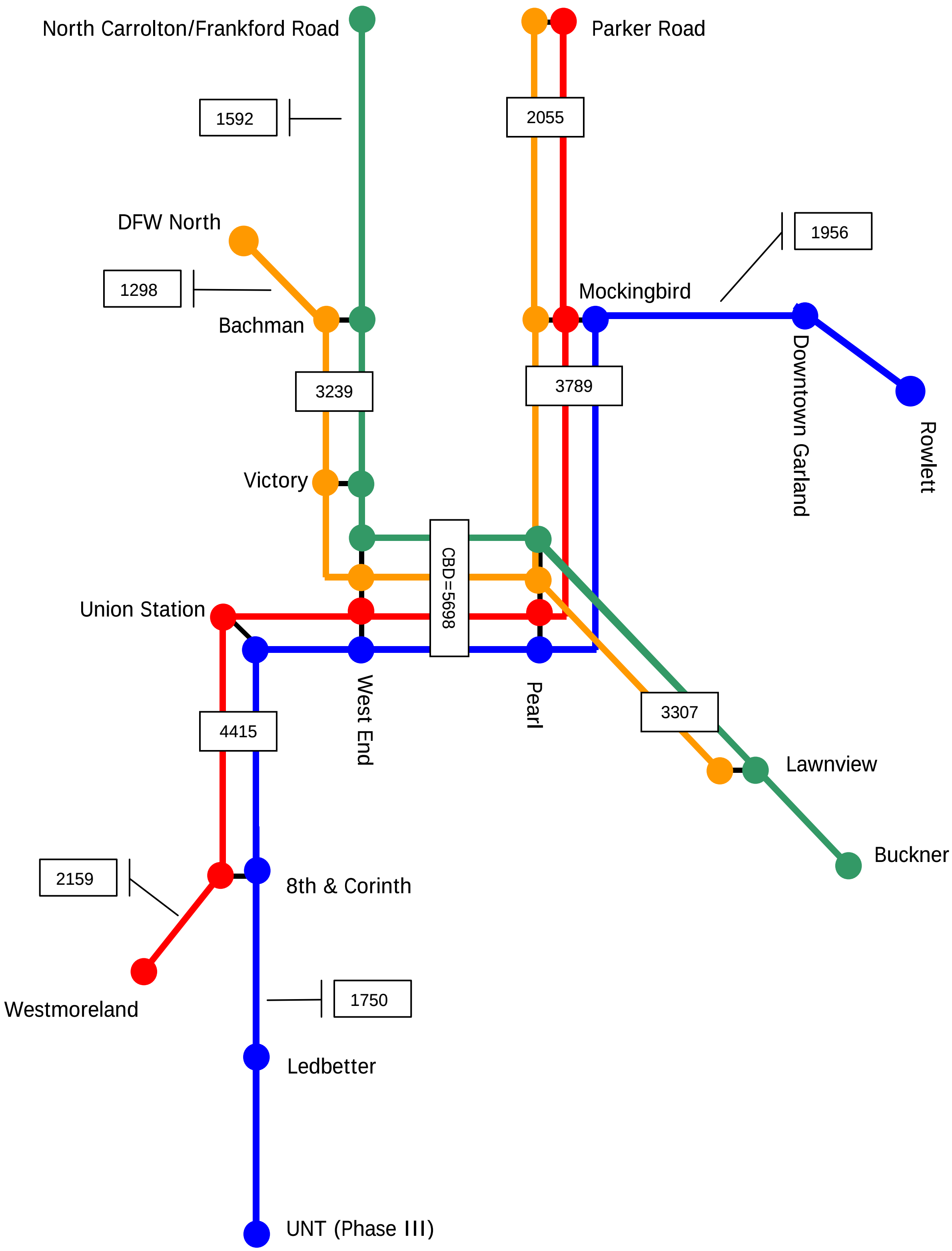


FIGURE 3-2
MAX LINK LOADS 2013 LRT SYSTEM



Based on forecasts provided in early 2009 by DART Capital Planning & Development

FIGURE 3-3
MAX LINK LOADS 2030 LRT SYSTEM



Based on forecasts provided in early 2009 by DART Capital Planning & Development.
NOTE: The addition of Cotton Belt service and DCTA service influence the projected MLLs in this map, but the projects are not shown, as they are not LRT-related.

3.4 Step Two: Define Passenger Load Standards

3.4.1 Importance of Passenger Load Standards

The passenger load standard is a prime determinant of both passenger comfort/convenience and operating efficiency. Both of these factors are important to DART because they are keys to the level of service quality provided. Passenger load standards determine patron comfort and convenience in ways such as:

- the ability to board the first train traveling in the preferred direction;
- the general probability of obtaining a seat;
- the general proximity of other standees.

Passengers will not be as comfortable riding a train with a high load standard (more passengers on a train) than they would be riding a train with a low load standard (less passengers on a train). For a patron of DART LRT System, the ideal service level would mandate that a seat be available for every LRT passenger during the peak periods. However, such an objective would be cost prohibitive and an inefficient use of equipment and investment capital for DART as a transit agency.

3.4.2 Current Passenger Load Standards

The currently approved Service Standard of the DART Board of Directors is to maintain a passenger load standard of up to 1.25 in non-peak periods, 1.50 during peak periods, and 1.75 during the peak hour of the peak period.

Passenger Load Standards: Using a figure of 1.50 passengers per available seat (144 passengers per vehicle) *average of all trains* passing the maximum load point in the peak direction during the peak period.

How Passenger Load Standards are calculated:
In this document, rail vehicle standards are expressed in terms of the number of passengers per seat.
The “not to exceed” load standard is 144 passengers per vehicle.
There are 96 passenger seats per SLRV. Load standard is determined as follows: Primary Load Standard = 144 passengers / 96 seats = 1.50

3.4.3 Future Passenger Load Standard Objectives

Load Standard Objectives: DART maintains a long-term commitment to improving the quality of service provided to customers, and maintaining a low load standard is a way to meet customer demands for a better quality service.

Achieving a reduced load standard depends on the financial capability of DART to procure, maintain, and operate any additional vehicles required to meet this standard. Physical limitations of the rail system are also a factor. It is anticipated that DART Planning will review the load standard requirements with its Board of Directors on a regular basis in conjunction with the development of capital and operating budgets for the agency.

Based on the experience with the Starter System and Build-Out Phase I openings, it is optimal to plan Build-Out Phases II and III for revenue service at load standards as detailed in Section 3.4.2. These benchmarks do provide capacity for future growth.

3.5 Step Three: Determine Vehicle Run Times

3.5.1 Train Performance Calculations

The third step in the process is to analyze the run times for an SLRV consist over each scheduled route in the system using three methods, outlined below, to produce the summary results shown in Figure 3-4:

a) Estimation – Estimates of cycle times are made based on the expected characteristics of the line extensions where detailed alignment data is not yet available. The estimates are then verified using the TPC simulations when more detailed data becomes available.

b) Time study – time measurements are taken during a test run of the consist in question over the Line Section being tested. A complete cycle is observed, including run time, station stop times, signal dwell times, and turn time at each end of the line. A base cycle time for existing Line Sections is computed from this data.

c) Train Performance Calculations (TPC) – the TPC, a computer software package, is programmed with the physical characteristics for DART's SLRVs as well as detailed information on the track layout and features where the Line Section in question has not been constructed. TPC modeling has been utilized for the Phase II Build-Out Project to determine run times. The accuracy of the TPC simulation run times have been verified for all existing line sections in revenue service. TPC run time calculations for the Northwest Corridor and the Southeast Corridor have been performed.

FIGURE 3-4
LRT Actual and Estimated Run Times

LINE SECTION		OPEN (FY)	FROM	TO	OW (min)	RT (min)	TT* (min)	CT (min)
RED	Existing	-	Westmoreland	Parker Road	66	132	18	150
BLUE	Existing	-	Ledbetter	Garland	58	116	24	140
	R-1	2013	Ledbetter	Rowlett	65	130	20	150
	SOC-3	2019	UNT	Rowlett	72	144	16	160
GREEN	NW/SE	2009	Victory	MLK	21	42	18	60
	NW/SE	2011	N. Carrollton/Frankford Rd.	Buckner	67	134	16	150
ORANGE (NC)	I/NC	2012	N. Las Colinas	Parker Road	81	162	18	180
	I/NC	2013	Belt Line	Parker Road	90	180	20	200
	I/NC	2014	DFW North	Parker Road	105	210	20	230
ORANGE (SE)	I/SE	2012	N. Las Colinas	Lawnview	57	114	16	130
	I/SE	2013	Belt Line	Lawnview	65	130	20	150
	I/SE	2014	DFW North	Lawnview	80	160	20	180

* TT for future expansion Line Sections (I- and R- sections) are estimated and include the unknowns and variations of the alignments not yet finalized or defined. Changes to TT for existing Line Sections will be made in the event of Projects taking place on the Line Section (Lake Highlands Station, Valencia Development, etc.) when all details are finalized. All TT's will be fine-tuned as alignment data is available during the final design/construction process.

OW – One Way
RT – Round Trip
TT – Turn around time
CT – Cycle Time

3.6 Steps Four and Five: Establish the Peak Vehicle Requirement (PVR)

The DART LRT system has a consist size limitation of a maximum of three (3) SLRVs, due to the physical configuration of the track and block section sizes.[3] Consists larger than three SLRVs would extend into traffic crossing areas in the CBD. In addition, one-direction operating headways are limited to 2.5 minutes in this area. To determine the optimum operation necessary within these constraints, Steps Four and Five have been combined. Varied headway and consist size have been analyzed to determine the ideal arrangement that would meet DART's load standard objective. Optimum train size, given the consist size and headway limitations, was then selected.

For each variation of headway (5-to-10-minutes) and consist size (two or three SLRVs) the resulting load factors are determined based on the established peak period Maximum Link Loads for each line section. The ridership data shown is relevant to the 60 minutes of the peak period, reflecting the "peak of the peak." Figures 3-5 through 3-20 illustrate passenger load factor calculations for a given consist size and headway time for each line section combination, as well as a summary of headway time versus consist size.

[3] Maximum consist of Green and Orange Lines=3 SLRVs, Red and Blue Lines=2 SLRVs, CBD Line - 3 SLRVs.

FIGURE 3-5
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
RED/ORANGE LINE – NORTH CENTRAL DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	2457	2055	1.07	0.89
2	6.67	96	192	9	1728	2457	2055	1.42	1.19
2	7.5	96	192	8	1536	2457	2055	1.60	1.34
2	8	96	192	7.5	1440	2457	2055	1.70	1.42
2	10	96	192	6	1152	2457	2055	2.13	1.78

Assumptions
Maximum consist size is 2 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-6
DART PASSENGER LOAD FACTORS - SLRV
RED/ORANGE LINE – NORTH CENTRAL SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	5	1.07	0.89
	6.67	1.42	1.19
	7.5	1.60	1.34
	10	2.13	1.78

FIGURE 3-7
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
RED/ORANGE/BLUE LINE – NORTH CENTRAL DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	4317	3789	1.87	1.64
2	6.67	96	192	9	1728	4317	3789	2.50	2.19
2	7.5	96	192	8	1536	4317	3789	2.81	2.47
2	8	96	192	7.5	1440	4317	3789	2.99	2.63
2	10	96	192	6	1152	4317	3789	3.75	3.29
1 & 2	5	96	96 & 192	12 (6-1, 6-2)	1728	4317	3789	2.50	2.19
2	<5	96	192	15	2880	4317	3789	1.49	1.31

Assumptions
Maximum consist size is 2 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-8
DART PASSENGER LOAD FACTORS - SLRV
RED/ORANGE/BLUE LINE – NORTH CENTRAL SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	<5	1.49	1.31
	5	1.87	1.64
	6.67	2.50	2.19
	7.5	2.81	2.47
	10	3.75	3.29

FIGURE 3-9
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
RED LINE – WEST OAK CLIFF DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	1682	2159	0.73	0.93
2	7.5	96	192	8	1536	1682	2159	1.09	1.40
2	8	96	192	7.5	1440	1682	2159	1.17	1.49
2	10	96	192	6	1152	1682	2159	1.46	1.87

Assumptions
Maximum consist size is 2 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-10
DART PASSENGER LOAD FACTORS - SLRV
RED LINE – WEST OAK CLIFF SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	5	0.73	0.93
	7.5	1.09	1.40
	8	1.17	1.49
	10	1.46	1.87

FIGURE 3-11
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
BLUE LINE – GARLAND DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	1650	1956	0.71	0.85
2	7.5	96	192	8	1536	1650	1956	1.07	1.27
2	8	96	192	7.5	1440	1650	1956	1.15	1.35
2	10	96	192	6	1152	1650	1956	1.43	1.70

Assumptions
Maximum consist size is 2 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-12
DART PASSENGER LOAD FACTORS - SLRV
BLUE LINE – GARLAND SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	5	0.71	0.85
	7.5	1.07	1.27
	8	1.15	1.35
	10	1.43	1.70

FIGURE 3-13
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
BLUE LINE – SOUTH OAK CLIFF DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	1248	1750	0.54	0.75
2	7.5	96	192	8	1536	1248	1750	0.81	1.14
2	8	96	192	7.5	1440	1248	1750	0.87	1.22
2	10	96	192	6	1152	1248	1750	1.08	1.52

Assumptions
Maximum consist size is 3 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-14
DART PASSENGER LOAD FACTORS - SLRV
BLUE LINE – SOUTH OAK CLIFF SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	5	0.54	0.75
	7.5	0.81	1.14
	8	0.87	1.22
	10	1.08	1.52

FIGURE 3-15
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
GREEN LINE – NORTHWEST DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2 / 3	5	96	192/288	12 (6-2, 6-3)	2880	1645	1592	0.57	0.55
2 / 3	7.5	96	192/288	8 (4-2, 4-3)	1920	1645	1592	0.86	0.83
2 / 3	8	96	192/288	7.5 (3-2, 4-3)	1728	1645	1592	0.95	0.92
2 / 3	10	96	192/288	6 (3-2, 3-3)	1440	1645	1592	1.14	1.11

Assumptions
Maximum consist size is 3 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-16
DART PASSENGER LOAD FACTORS - SLRV
GREEN LINE – NORTHWEST SUMMARY

		Consist Size – 2 / 3	
		2013	2030
Headway (minutes)	5	0.57	0.55
	7.5	0.86	0.83
	8	0.95	0.92
	10	1.14	1.11

FIGURE 3-17
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
GREEN / ORANGE LINE – SOUTHEAST DETAIL

Number Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2 orange, 2/3 green	5	96	192/288	18:12-2 car/6-3 car	4032	3049	3307	0.75	0.82
2 orange, 2/3 green	6.67	96	192/288	9:6-2 car/3-3 car	2016	3049	3307	1.51	1.64
2 orange, 2/3 green	7.5	96	192/288	N/A	0	3049	3307	N/A	N/A
2 orange, 2/3 green	8	96	192/288	N/A	0	3049	3307	N/A	N/A
2 orange, 2/3 green	10	96	192/288	N/A	0	3049	3307	N/A	N/A

Assumptions
Maximum consist size is 3 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-18
DART PASSENGER LOAD FACTORS - SLRV
GREEN / ORANGE LINE – SOUTHEAST SUMMARY

		Consist Size - 2 orange, 2/3 green	
		2013	2030
Headway (minutes)	5	0.75	0.82
	6.67	1.51	1.64
	7.5	N/A	N/A
	8	N/A	N/A
	10	N/A	N/A

FIGURE 3-19
DART PASSENGER LOAD FACTOR CALCULATIONS - SLRV
ORANGE LINE – IRVING DETAIL

# Vehicles in Consist	Headway in Minutes	Seats per Vehicle	Total Seats in Consist	Trains per Hour	Seats per 60 Minutes	People per 60 Minutes 2013	People per 60 Minutes 2030	Load Factor 2013	Load Factor 2030
2	5	96	192	12	2304	1345	1298	0.58	0.56
2	7.5	96	192	8	1536	1345	1298	0.87	0.85
2	8	96	192	7.5	1440	1345	1298	0.93	0.90
2	10	96	192	6	1152	1345	1298	1.16	1.13

Assumptions
Maximum consist size is 3 vehicles
Headway varies from 5 to 10 minutes
People per hour based on DART Capital Planning and Development's computer model. Equivalent to peak MLL.
SLRV fleet has 96 seats per vehicle.

Calculations
Total Seats in Consist = (seats per vehicle) x (# vehicles in consist)
Trains per Hour = (1 hour in minutes) / (headway in minutes)
Seats per Hour = (total seats in consist) x (trains per hour)
Load Factor = (people per hour) / (seats per hour)

FIGURE 3-20
DART PASSENGER LOAD FACTORS - SLRV
ORANGE LINE – IRVING SUMMARY

		Consist Size - 2	
		2013	2030
Headway (minutes)	5	0.58	0.56
	7.5	0.87	0.85
	8	0.93	0.90
	10	1.16	1.13

3.6.1 Build-Out Phases II and III

The projected peak 60 minutes of the peak period Maximum Link Loads for the Build-Out Phase II and III Projects are evaluated. Various consist sizes are used for the purposes of this evaluation. Utilizing the cycle times (CT) from Figure 3-4, the following paragraphs will describe what the load standard will be utilizing this criteria and what would be required by DART in order to achieve the ideal passenger load factors.

For the Red/Orange Line – North Central Summary (Figure 3-6) running on the Red Line at 10-minute headways with two car consists and on the Orange Line at 20-minute headways with two car consists would achieve an average passenger load factor of 1.42 during the peak period maximum link load of 2,457.

For the Red/Orange/Blue Line – North Central Summary (Figure 3-8) running at 10-minute headways with a two car consist on each of the Red and Blue Lines, and at 20-minute headway with a two car consist on the Orange Line, would achieve an average passenger load factor of 1.49 during the peak period maximum link load of 4,317. This is possible because the combined headway of the three lines will be less than 5 minutes.

For the Red Line – West Oak Cliff Summary (Figure 3-10) running 10-minute headways with a two car consist would achieve an average passenger load factor of 1.46 during the peak period maximum link load of 1,682.

For the Blue Line – Garland Summary (Figure 3-12) running 10-minute headways with a two car consist would achieve an average passenger load factor of 1.43 during the peak period maximum link load of 1,650.

For the Blue Line – South Oak Cliff Summary (Figure 3-14) running 10-minute headways with a two car consist would achieve an average passenger load factor of 1.08 during the peak period maximum link load of 1,248.

For the Green Line – Northwest Summary (Figure 3-16) running 10-minute headways with alternating two-and-three car consists would achieve an average passenger load factor of 1.14 during the peak period maximum link load of 1,645.

For the Green Line/Orange Line – Pleasant Grove Summary (Figure 3-18) both two car Orange Line consists (with 20 minute headways) and alternating two-and-three car Green Line consists (with 10 minute headways) would achieve an average passenger load factor of 1.51 during the peak period maximum link load of 3,049.

For the Orange Line – Irving Summary (Figure 3-20) running 10-minute headways with a two car consist would achieve an average passenger load factor of 1.16 during the peak period maximum link load of 1,345.

The next step is to calculate the number of train consists required on each line. The number of train consists required on each line to support the required headways can be calculated as follows:

The Red Line currently has a cycle time of 150 minutes as determined in step three. During the selected ten-minute headway period a 150-minute cycle time requires a total of 15 consists in operation.

Total number of consists are determined for the Red Line as follows: *150 minute cycle time / 10-minute headway = 15 consists required* *15 total Red Line consists required*

The Blue Line currently has a cycle time of 140 minutes, as determined in step three. During the selected ten-minute headway period a 140-minute cycle time requires a total of 14 consists in operation.

Total number of consists are determined for the Blue Line as follows: *140 minute cycle time / 10-minute headway = 14 consists required* *14 total Blue Line consists required*

The Green Line has a projected cycle time of 60 minutes in FY 2009, as determined in step three. During the selected ten-minute headway period a 60-minute cycle time requires a total of 6 consists in operation.

Total number of consists are determined for the Green Line as follows: *60 minute cycle time / 10-minute headway = 6 consists required* *6 total Green Line consists required*

The Orange Line (North Central) has a projected cycle time of 200 minutes in FY 2013, as determined in step three. During the selected twenty-minute headway period (only half the trains will operate this segment during peak periods) a 200-minute cycle time requires a total of 10 consists in operation.

Total number of consists determined for the Orange Line (NC) as follows: *200 minute cycle time / 20-minute headway = 10 consists required* *10 total Orange Line (North Central) consists required*

The Orange Line (Southeast) has a projected cycle time of 150 minutes in FY 2013, as determined in step three. During the selected twenty-minute headway period (only half the trains will operate this segment during peak periods) a 150-minute cycle time requires a total of 7.5 (8) consists in operation.

Total number of consists determined for the Orange Line (SE) as follows: *150 minute cycle time / 20-minute headway = 7.5 = 8 consists required* *8 total Orange Line (Southeast) consists required*

The number of vehicles per train consists required on each Line to support the required headways can be determined as follows (illustrated in Figure 3-21):

- For the Red Line a total of 30 vehicles are required now for the peak period operations and in the foreseeable future. (15 consists x 2 vehicles per consist = 30 vehicles). Note that this does not include extra or “filler” Red Line trains being operated from Parker Road to the CBD during morning rush hour to alleviate overcrowding.
- For the Blue Line a total of 28 vehicles are required now for the peak period operations. More vehicles will be required as the service on the Blue Line is extended. (14 consists x 2 vehicles per consist = 28 vehicles).
- For the Green Line a total of 15 vehicles would be required for the peak period operations in 2009. More vehicles will be required as the service on the Green Line is extended. [6 consists x (2 or 3) vehicles per consist = 15 vehicles].
- For the Orange Line a total of 42 vehicles would be required for the peak period operations of the North Central and Southeast Orange Line segments in 2014. (21 consists x 2 vehicles per consist = 42 vehicles).
- For Phase II there will be a requirement for 142 vehicles by FY 2014 and for Phase III there will be a requirement for an additional 6 vehicles in FY 2019.

The number of vehicles needed to meet peak vehicle demand is known as the Peak Vehicle Requirement (PVR). The distribution of peak vehicle requirement is demonstrated in Figure 3-21 along with the required cycle times. This figure also identifies the additional SLRVs required as new areas of service are opened.

FIGURE 3-21
PEAK VEHICLES REQUIRED AS EACH LINE SEGMENT IS OPENED

	Operating Section	Year Open (FY)	Cycle Time (min)	Headway (min)	Number of trains required	SLRVs per train	Operating SLRVs required	Additional SLRVs required
RED	Westmoreland – Parker Road	-	150	10	15	2	30	0
BLUE	Ledbetter - Downtown Garland	-	140	10	14	2	28	0
	Ledbetter – Rowlett	2013	150	10	15	2	30	2
	UNT – Rowlett	2019	160	10	16	2	32	2
GREEN	Victory – MLK	2009	60	10	6	2&3	15	15
	N. Carrollton/Frankford Road - Buckner	2011	150	10	15	2&3	38	23
ORANGE (NC)	N. Las Colinas – Parker Road	2012	180	20	9	2	18	18
	Belt Line – Parker Road	2013	200	20	10	2	20	2
	DFW North – Parker Road	2014	230	20	12	2	24	4
ORANGE (SE)	N. Las Colinas – Lawnview	2012	130	20	6.5 (7)	2	14	14
	Beltline – Lawnview	2013	150	20	7.5 (8)	2	16	2
	DFW North – Lawnview	2014	180	20	9	2	18	2
						Total	142	
							Total	69

Figure 3-22 is the Passenger Demand for Revenue Vehicles chart. This chart reflects the number of operating vehicles required per line per fiscal year.

FIGURE 3-22
DART PASSENGER DEMAND FOR REVENUE VEHICLES, PVR

	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
Red Line	30	30	30	30	30	30	30	30	30	30	30
Blue Line	28	28	28	28	30	30	30	30	30	30	32
Green Line	15	15	38	38	38	38	38	38	38	38	38
Orange Line (NC)	0	0	0	18	20	24	24	24	24	24	24
Orange Line (SE)	0	0	0	14	16	18	18	18	18	18	18
PVR	*73*	*73*	*96*	*128*	*134*	*140*	*140*	*140*	*140*	*140*	*142*

3.7 Step Six: Determine If Ready Service/Gap/Standby Trains Will Be Utilized

Another factor in determining the demand for vehicles is the quantity of ready service/gap/standby trains and/or vehicles required. DART does not use, and does not plan to use, standby trains in its daily operations.

3.8 Step Seven: Determine Spares Required

The first step in determining the number of operating spares required for the DART light rail vehicle fleet is to understand the Agency's maintenance philosophy. Only by further understanding the maintenance plan may the spare requirement be fully developed. Maintenance of DART light rail vehicles is essential to keep them in working order (clean, safe, reliable, and attractive) for the use of the general public. The vehicle is a major capital investment, and maintenance procedures have been developed that seek to maximize its service life and reduce the level of capital expenditures.

DART's LRV fleet has proven to be very reliable. Maintenance challenges have been present since the inception of the system, but for the most part, there have been very few maintenance issues, due to large-scale mechanical concerns, with the fleet. Of course, developing the maintenance requirements was difficult at first, due in large part to the newness of the vehicles themselves, and their relatively unique nature. At the inception of system operations, maintenance processes and procedures were governed by the original equipment manufacturer (OEM) specifications. Later operational and maintenance issues led to the adoption of a comprehensive scheduled/unscheduled maintenance plan, with both types of maintenance being performed in such a way as to minimize downtime (and thus, reduce the spare ratio). Mileage-based prescriptive maintenance procedures, along with time-based maintenance schedules, were planned and carried out at system maintenance facilities on the vehicles.

In FY 2007, the general maintenance plan was upgraded and modified to better reflect the service profile present on the DART system; as well as to better deal with existing fleet conditions. This upgraded maintenance plan, developed by the Maintenance Department, is called the Maintenance Operational Plan (MOP). While the FY 2007 plan was largely based on the principles and practices contained in the preceding plans, it should be noted that the current plan is an overhaul of these plans that incorporates both the best features of the previous plans and new developments in the rail fleet maintenance area. The development of the MOP ensures the continued success of the Maintenance Department in dealing with upkeep issues in the DART light rail vehicle fleet.

The Maintenance Operational Plan contains performance goals (and associated metrics) for the maintenance of the DART light rail vehicle fleet. While all of the goals are applicable, in a broader sense, to the maintenance of this fleet, only two are relevant to the Rail Fleet Management Plan:

- Maintaining the operating spare ratio (<14% of fleet)
- Managing the mean distance between road calls (31,584 miles-FY09 goal)

The rest of the goals are focused on the processes and procedures that will be implemented to accomplish these two major goals. To meet these goals, the MOP focuses on four established maintenance work process types, and provides a vision as to how the Maintenance Department is to focus under each. These work types are:

Condition Based Maintenance (CBM) consists of maintenance that is performed based on the condition of various light rail vehicle features. These features can include the vehicle's exterior, interior, and/or the vehicle's mechanical condition. CBM can include: a) preventative maintenance inspections (PMI) performed by skilled labor in accordance with PMI procedures (based on mileage or feature condition); or, b) light rail vehicle servicing performed by outside contractors in accordance with procedural guidance. This would incorporate vehicle cleaning, different subsystem lubrication/adjustment/replacement done on an as-needed basis, and various 10/20/60K mileage interval inspections. It is expected that 35% of fleet within the spare ratio may be in maintenance status due to CBM work, at any given time.

Corrective Maintenance (CM) encompasses curative maintenance functions performed to bring a vehicle back to operating condition, such as repair of vehicles due to accidents, mechanical failures, and/or other reported deficiencies. CM may be performed in a shop location; or, unlike other types of maintenance, may be performed as a "running repair" at the location of the vehicle failure or issue (online or on the right-of-way). CM includes repairs done by skilled labor as a result of reported defects, making new vehicles ready for service, body/interior requirements, or due to accidents. It is expected that 25% of the fleet within the spare ratio may be in maintenance status due to CM work, at any given time.

Fixed Scheduled Maintenance (FSM) includes maintenance that is performed at a scheduled interval based on the life cycle of the LRV component or system. FSM may be performed by skilled labor according to standard operating procedures. They will perform tasks such as rebuilding components or systems, replacing parts of systems, or other functions as defined. Various FSM component focus areas would be overhauled, such as the doors, pantographs, and traction motors. It is expected that 20% of the fleet within the spare ratio may be in maintenance status due to FSM work, at any given time.

Campaign Maintenance consists of maintenance that is performed to reconfigure the fleet (or a selected subset of the fleet) with modifications driven by alterations to OEM requirements and/or operating efficiencies. Campaign Maintenance is performed by skilled labor in accordance with OEM and/or engineering requirements/recommendations. It is expected that 10% of the fleet within the spare ratio may be in maintenance status due to campaign maintenance work, at any given time.

The Maintenance Department has requested the remaining 10% of the fleet within the spare ratio be allocated to account for part stocking issues or lead-time on materials fabrication/replacement/ordering times. This addition completes the allocation of the spare LRV fleet requirement, which itself was broken out of the entire LRV fleet in the overall goals of the Maintenance Department's MOP.

3.9 Step Eight: Determine Total Fleet Demand

3.9.1 Spare Ratio

The operating spare ratio has been determined using calculations contained within the Transit Cooperative Research Program's Synthesis 15, System-Specific Spare Vehicles Ratios, A Synthesis of Transit Practice, Transportation Research Board, National Research Council, National Academy Press, Washington D.C., 1995. The above-referenced document identifies the FTA reporting formula used to determine the spare ratio for Section 15 reporting purposes as follows:

$$\frac{Total\ Active\ Fleet - Peak\ Vehicle\ Requirement}{Peak\ Vehicle\ Requirement} = Operating\ Spare\ Ratio$$

DART has established that the optimal Operating Spare Ratio to maintain operations is 14%. This ratio is consistent with DART's scheduled preventative maintenance requirements as well as trends in unscheduled corrective maintenance. This operating spare ratio is within the range of values typically used by other light rail systems.

3.9.2 Summary

Figure 3-23 shows the total Peak Vehicle Requirement (PVR), total number of spare vehicles and total fleet requirement for fiscal years (FY) 2009-2019. The total fleet size for each fiscal year is determined by adding the PVR to the number of spare vehicles required (Figure 3-23).

FIGURE 3-23
DART OVERALL DEMAND FOR REVENUE VEHICLES (14% Spare Ratio)

	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
Red Line PVR	30	30	30	30	30	30	30	30	30	30	30
Blue PVR	28	28	28	28	30	30	30	30	30	30	32
Green Line PVR	15	15	38	38	38	38	38	38	38	38	38
Orange Line (NC) PVR	0	0	0	18	20	24	24	24	24	24	24
Orange Line (SE) PVR	0	0	0	14	16	18	18	18	18	18	18
Peak Vehicle Requirement	**73**	**73**	**96**	**128**	**134**	**140**	**140**	**140**	**140**	**140**	**142**
Condition Based Maintenance (35% of spare ratio)	4	4	5	7	8	8	8	8	8	8	8
Fixed Schedule Maintenance (25% of spare ratio)	3	3	4	5	5	6	6	6	6	6	6
Corrective Maintenance (20% of spare ratio)	2	2	3	4	4	5	5	5	5	5	5
Maintenance Campaigns (10% of spare ratio)	1	1	2	2	2	2	2	2	2	2	2
Spare Parts / Logistics (10% of spare ratio)	1	1	2	1	2	2	2	2	2	2	2
Spare SLRVs (14% of TFD)	**12***	**12***	**16***	**21***	**22***	**23**	**23**	**23**	**23**	**23**	**23**
Total Fleet Demand	**85**	**85**	**112**	**149**	**156**	**163**	**163**	**163**	**163**	**163**	**165**

*total does not match due to decimal and percentage rounding

4.0 The Supply of Revenue Vehicles

4.1 Existing Fleet

The DART light rail vehicle fleet numbers 115 vehicles, all built by Kinkisharyo (USA) Inc., and delivered as shown in Figure 4-1. DART is in the process of converting the existing fleet to SLRVs, as detailed in Section 2.5 and shown in Figure 4-2.

FIGURE 4-1
DART LIGHT RAIL VEHICLE PROCUREMENT HISTORY

Year	Vehicles Delivered
1996	40
1999	34
2000	21
2005	20

FIGURE 4-2
SLRV RETROFIT SCHEDULE

Date	Retrofits Completed (Cum.)
Jun 09	~40
Sep 09	52
Jun 10	88
Dec 10	112
Feb 11	115

4.2 Planned Rail Vehicle Procurements

Based on the information presented, DART plans to acquire an additional 48 vehicles (SLRVs) for Build-Out Phase IIA and IIB, with a planned delivery schedule shown in Figure 4-3.The total fleet supply will grow from 115 to 140 vehicles by FY 2011. Procurement of additional SLRVs will be necessary due to demand generated by the Build-Out Phase IIB/III Projects, and will bring the total fleet size up to 163 SLRVs by early 2011.

FIGURE 4-3
PROJECTED SLRV DELIVERY SCHEDULE
BUILD-OUT PHASE IIA, IIB, and III

Date	SLRVs Delivered
May 2010	5
June 2010	4
July 2010	4
August 2010	5
September 2010	4
October 2010	6
November 2010	4
December 2010	4
January 2011	4
February 2011	4
March 2011	4
Total SLRVs Acquired	**48**

5.0 Revenue Vehicle Demand and Supply Balance

This section illustrates the balance between vehicle demand and vehicle supply. Figure 5-1 shows the required vehicles in relation to the actual vehicle supply and the resulting vehicle balance. The surplus/deficit ratios have also been calculated.

FIGURE 5-1
DART SLRV DEMAND AND SUPPLY BALANCE
FY2009 – FY2019

	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
Red Line PVR	30	30	30	30	30	30	30	30	30	30	30
Blue PVR	28	28	28	28	30	30	30	30	30	30	32
Green Line PVR	15	15	38	38	38	38	38	38	38	38	38
Orange Line (NC) PVR	0	0	0	18	20	24	24	24	24	24	24
Orange Line (SE) PVR	0	0	0	14	16	18	18	18	18	18	18
Peak Vehicle Requirement	**73**	**73**	**96**	**128**	**134**	**140**	**140**	**140**	**140**	**140**	**142**
Spare Ratio SLRVs (14% of TFD)	**12**	**12**	**16**	**21**	**22**	**23**	**23**	**23**	**23**	**23**	**23**
Total Fleet Demand	**85**	**85**	**112**	**149**	**156**	**163**	**163**	**163**	**163**	**163**	**165**
Planned Vehicle Supply	115	121	140	149	163	163	163	163	163	163	165
Vehicle Balance	30	36	28	0	7	0	0	0	0	0	0
Surplus/Deficit (ex. Of Spare Ratio)	26%	30%	20%	0%	4%	0%	0%	0%	0%	0%	0%