



# LINK OPERATIONS & MAINTENANCE SATELLITE FACILITY

Task 2.3B

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## Core Light Rail System Plan Review



September 2012

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## Table of Contents

PROJECT DESCRIPTION.....	1
MEMO/REPORT PURPOSE .....	2
ST CONCEPTUAL OPERATING PLAN FOR CORE LIGHT RAIL SYSTEM EXPANSION.....	2
Overview .....	2
Long Range Plan Operating Assumptions and Fleet Requirements .....	4
Incremental Fleet Growth.....	6
Long Range Operations Plan Summary Observations .....	7
Long Range Operations Plan Assumptions .....	7
ST LONG RANGE O&M FACILITY REQUIREMENTS .....	8
Future O&M Facilities .....	9
North Corridor Review .....	9
South Corridor Review .....	9
East Corridor Review.....	10
Summary Corridor Review .....	10
FUTURE PROGRAM REQUIREMENTS .....	10
Satellite Car Maintenance Philosophy:.....	10
Truck Repair Area:.....	11
General comments:.....	11
End-of-Line Storage.....	11
ATTACHMENT A: Sound Transit Conceptual Operating Plan for Core Light Rail System Expansion .....	13

## FIGURES

Figure 1: ST2 Plan.....	1
Figure 2: Regional Transit Long Range Plan (2005).....	3
Figure 3: Conceptual Operating Plan for Core Light Rail System Expansion .....	5
Figure 4: Core System Expansion; O&M Facilities by Corridor.....	8

## TABLES

Table 1: Long Range Plan Operating Assumptions .....	4
Table 2: Fleet Needs for System Expansion .....	6
Table 3: Core Light Rail System Expansion by Corridor .....	7

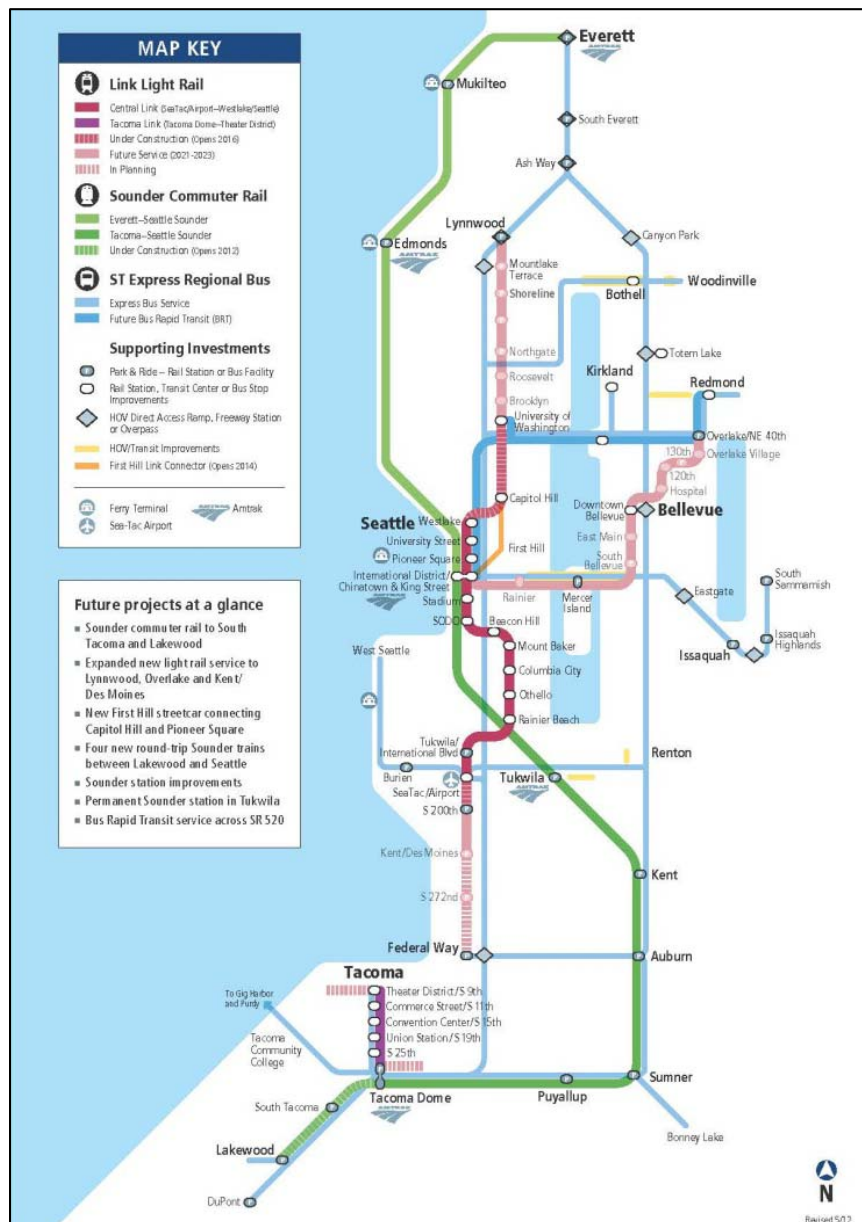
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## PROJECT DESCRIPTION

Sound Transit is currently implementing a system-wide expansion of Link light rail transit service throughout its service area. This expansion is part of the Sound Transit 2 (ST2) program of transit investments approved by voters in November 2008 (Figure 1). Sound Transit’s district encompasses the urbanized portion of the three-county central Puget Sound region, covering over 1,000 square miles and serving an area of 2.8 million people. The ST2 Plan includes light rail extensions from SeaTac to Kent/Des Moines in the south, Seattle to Overlake Transit Center in Redmond in the east, and University of Washington to Lynnwood in the north, as well as Sounder commuter rail, Tacoma Link and ST Express regional bus improvements that build on the existing regional transit system.

To implement the ST2 expansion, Sound Transit will have to increase its light rail vehicle fleet to approximately 180 vehicles by 2023. Its existing light rail operations and maintenance (OMF) facility, on a 25-acre site located south of South Forest Street and west of Airport Way in the industrial area south of Downtown Seattle, can only serve 104 vehicles. Sound Transit must construct additional operations and maintenance facility capacity to support ST2’s light rail vehicle storage and maintenance needs. The program’s vehicle acquisition and delivery schedule requires the additional capacity to be operational by the end of 2020. The Link Operations and Maintenance Satellite Facility (OMSF) Project was included in the ST2 Plan.

Figure 1: ST2 Plan



## **MEMO/REPORT PURPOSE**

Sound Transit has developed an operating plan for the expansion of the Core Light Rail System which includes extending light rail to Everett, Tacoma and downtown Redmond. The Core Light Rail System Expansion is a component of the Regional Transit Long-Range Plan (RTP), adopted by the Sound Transit Board in 2005. It has also been adopted as part of PSRC's regional Vision 2040 Plan and the Regional Transportation 2040 Plan. The purpose of this memo is to review and evaluate the Core Light Rail System Expansion operating plan provided by Sound Transit, with the focus on the operations and maintenance (O&M) facility needs associated with this expansion. This assessment will be used to help inform the ST Board decision on where the Link Operations and Maintenance Satellite Facility (OMSF) should be located to support the ST2 light rail fleet and storage requirements.

## **ST CONCEPTUAL OPERATING PLAN FOR CORE LIGHT RAIL SYSTEM EXPANSION**

### **Overview**

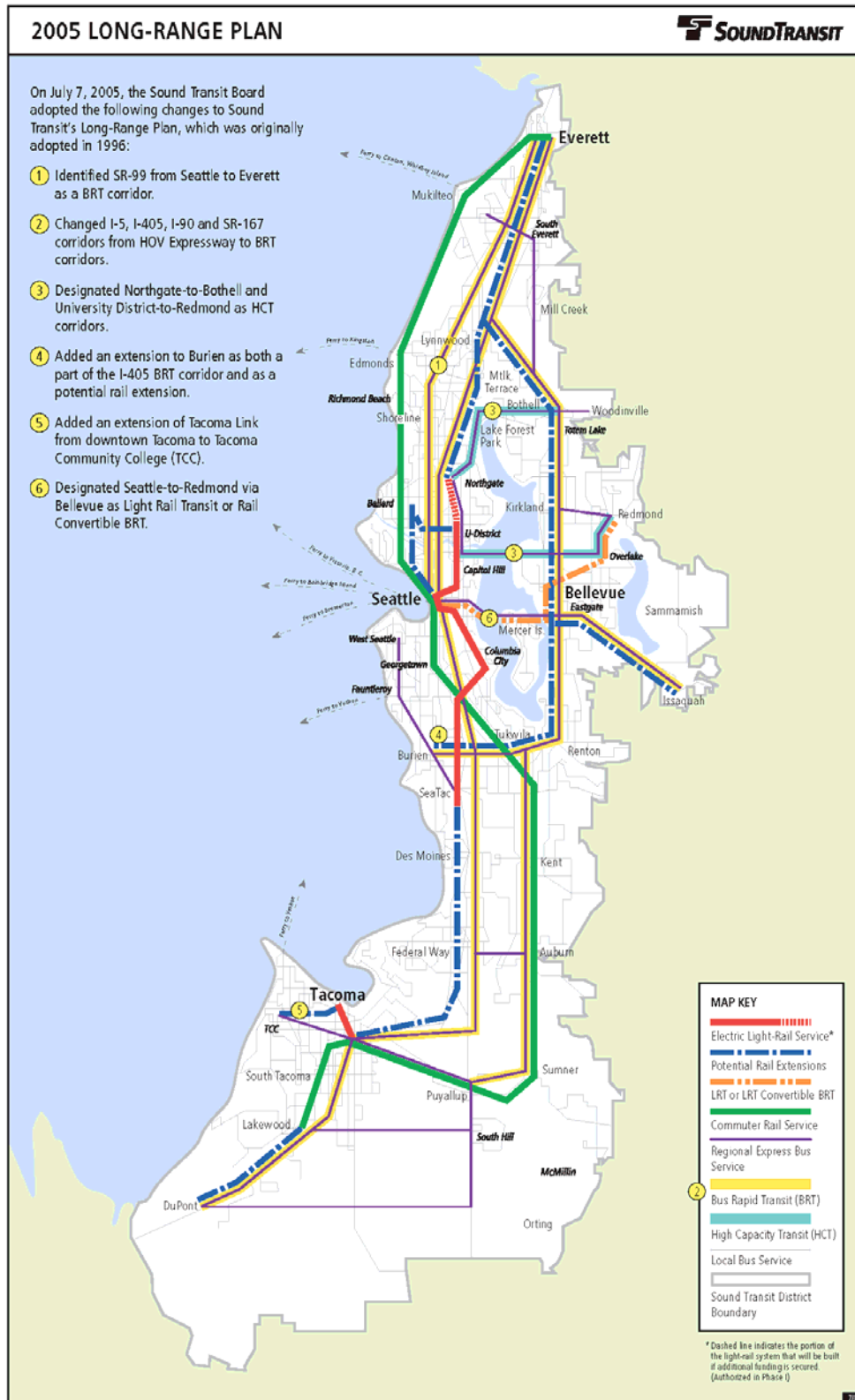
The Regional Transit Long-Range Plan (LRP), adopted by the Sound Transit Board in 2005, represents Sound Transit's goals, policies, and strategies to guide the long-term development of the High Capacity Transit (HCT) system. The LRP was developed from years of intensive planning, environmental analysis, and public outreach, and guides how the Sound Transit system can best address the region's mobility needs and support growth management objectives. The long-range plan will be implemented in a series of phases and will be updated over time.

State law charges Sound Transit with planning, building, and operating a high-capacity transportation system for the Central Puget Sound region. Sound Transit's vision for the region's HCT system — and an essential tool for the region's healthy growth — is a combined rail and regional express bus system.

That vision is to expand the capacity of the region's major transportation corridors by adding new HCT services and facilities that link regional growth and activity centers. In addition to increasing the people-carrying capacity of the region's most heavily used transportation corridors, the system also supports growth management policies, provides alternatives to sprawl and provides the connection, convenience, and mobility needed for a vital economy.

The long-range plan includes a mix of transportation improvements: bus rapid transit, regional express bus routes, commuter rail, and light rail. This Plan will be implemented in phases approved by regional voters over time. The full plan is represented in Figure 2 and includes Link light rail extensions to Everett, Tacoma, Redmond, Kirkland, Bothell, Issaquah, Ballard, and Burien (see Figure 2).

Figure 2: Regional Transit Long Range Plan (2005)



## Long Range Plan Operating Assumptions and Fleet Requirements

Sound Transit proposes four distinct operating lines to meet the demand requirements projected for the Core Light Rail System Expansion to Everett, Tacoma and Redmond, as follows (Figure 3):

- 12 minute peak service from Everett to SeaTac International Airport (SeaTac)
- 12 minute peak service from Northgate to Tacoma
- 12 minute peak service from Lynnwood to Overlake Transit Center (TC)
- 12 minute peak service from Northgate to Redmond

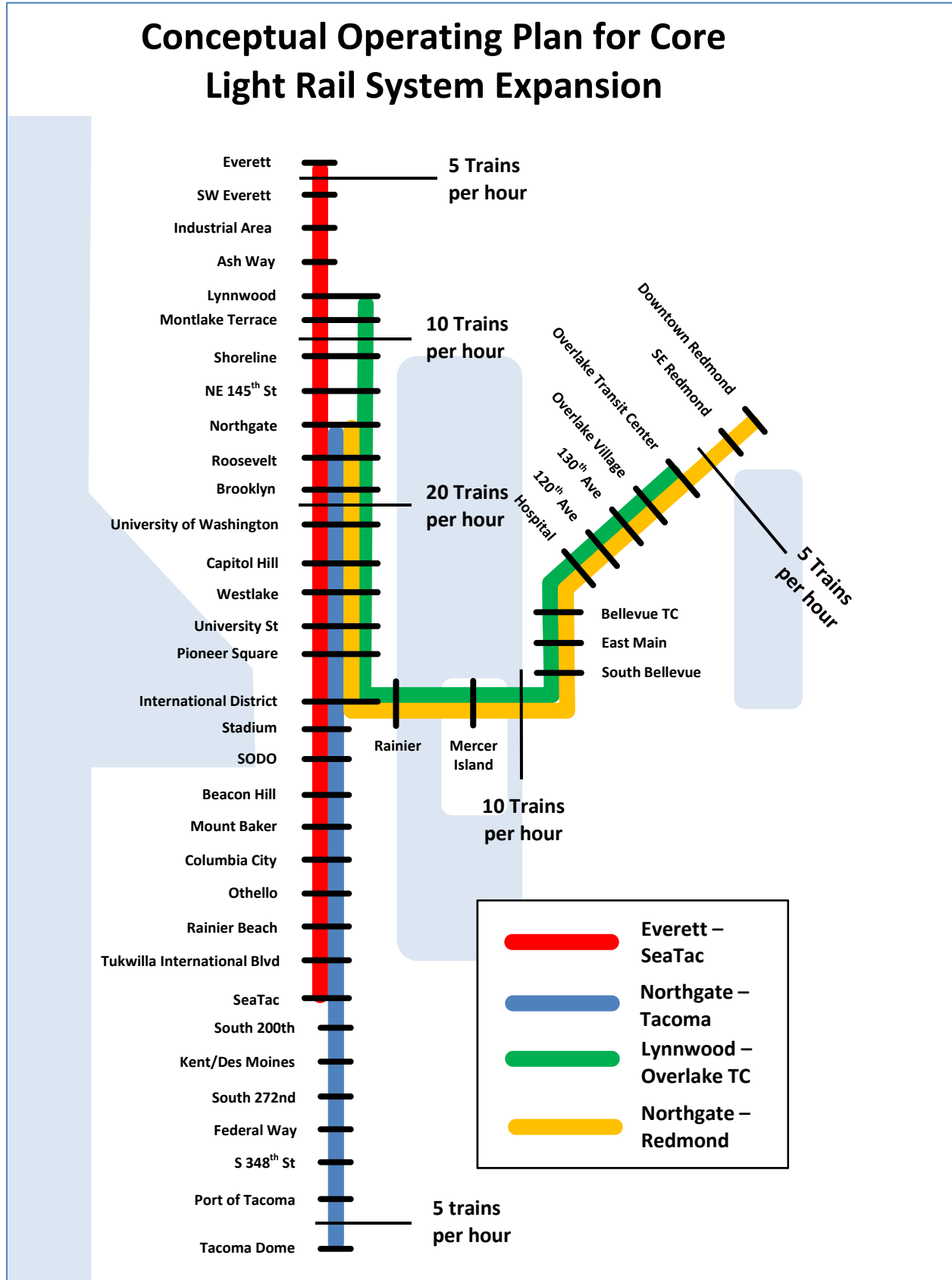
Line travel and cycle times are assumed as follows in Table 1.

**Table 1: Long Range Plan Operating Assumptions**

	<b>Everett – SeaTac/Airport</b>	<b>Northgate - Tacoma</b>	<b>Lynnwood - Overlake TC</b>	<b>Northgate - Redmond</b>
Minutes, one way	94	84	61	53
Minutes, round trip	188	168	122	106
Minutes, Lay / Turn	16	16	16	16
Minimum Cycle Time	204	184	138	122



Figure 3: Conceptual Operating Plan for Core Light Rail System Expansion



## Incremental Fleet Growth

Sound Transit currently operates Link light rail service from Westlake Station in downtown Seattle to the SeaTac/Airport Station. This full line became operational in 2009 and today runs peak period frequencies of a train every 7.5 minutes. The current fleet requirement is 35 vehicles.

In 2016 Sound Transit will open the University Link extension to the University of Washington Station and the extension to South 200<sup>th</sup> Station, south of SeaTac Airport. These openings will increase the full system fleet requirement to 62 vehicles, operating every 6 minutes in the peak periods.

Five years after the opening of University Link and South 200<sup>th</sup> Link Extension, the Northgate extension will open in 2021. According to the “North Link Final SEIS, April 2006” the Northgate extension will increase the total fleet size to 102 vehicles, with trains operating every 6 minutes.

Full build-out of the voter approved ST2 Plan extends light rail by 2023 to Lynnwood in the north (Lynnwood Link Extension), Overlake Transit Center in the east (East Link), and South 272<sup>nd</sup> in the south (Federal Way Link Extension). Given financial constraints created by the recent recession, Sound Transit will initially extend Link light rail south to Kent/Des Moines Rd until sufficient revenue is available to complete the extension to South 272<sup>nd</sup>. In anticipation of these openings, Sound Transit prepared the report: “Operations Plan - Lynnwood to Kent/Des Moines and Overlake Transit Center,” dated June 2011. The opening of East Link will mark the first time Sound Transit begins operating two distinct peak period lines: Lynnwood to Kent/Des Moines and Lynnwood to Overlake Transit Center. Each line will operate 4-car trains every 8 minutes. Full fleet requirement for ST2 is approximately 180 vehicles.

Beyond ST2 Sound Transit anticipates Link light rail extensions to Everett, Tacoma and downtown Redmond, as referenced previously. The following two tables document fleet growth for the existing system, ST2 and the Core Light Rail System Expansion (Table 2) and fleet requirements by line for the Core Light Rail System Expansion to Everett, Tacoma and Redmond (Table 3).

**Table 2: Fleet Needs for System Expansion**

Light Rail System	Fleet Requirement
Westlake to SeaTac/Airport (2009)	35 vehicles
University to South 200 <sup>th</sup> (2016)	62 vehicles
Northgate to South 200 <sup>th</sup> (2021)	102 vehicles
ST2 – Lynnwood, Overlake TC, Kent/Des Moines (2023)	180 vehicles
Core Light Rail System Expansion – Everett, Tacoma, Redmond	286 vehicles

**Table 3: Core Light Rail System Expansion by Corridor**

	Everett-SeaTac/Airport	Northgate-Tacoma	Lynnwood-Overlake TC	Northgate-Redmond	Combined
Peak Headway (min)	12	12	12	12	3
Service + gap vehicles	76	72	52	48	248
Spare cars (~15%)	12	11	8	7	38
Fleet Requirement	88	83	60	55	286

## Long Range Operations Plan Summary Observations

### Long Range Operations Plan Assumptions

Until a potential extension goes through the environmental review process, preliminary engineering, and is selected by the Sound Transit Board of Directors, there remains some variability in alignment and station definition. Near term ST2 extensions, with the exception of East Link, are currently in the process of being fully defined. Route variation, such as horizontal and vertical alignment, and station selection remain uncertain until the Board takes action on a final preferred alignment.

Link light rail extensions to Everett and Tacoma are not expected to enter into detailed analysis for several years and are subject to the highest level of uncertainty in alignment and stations. The Redmond extension is well defined and is included in the East Link environmental documentation, including FTA’s Record of Decision.

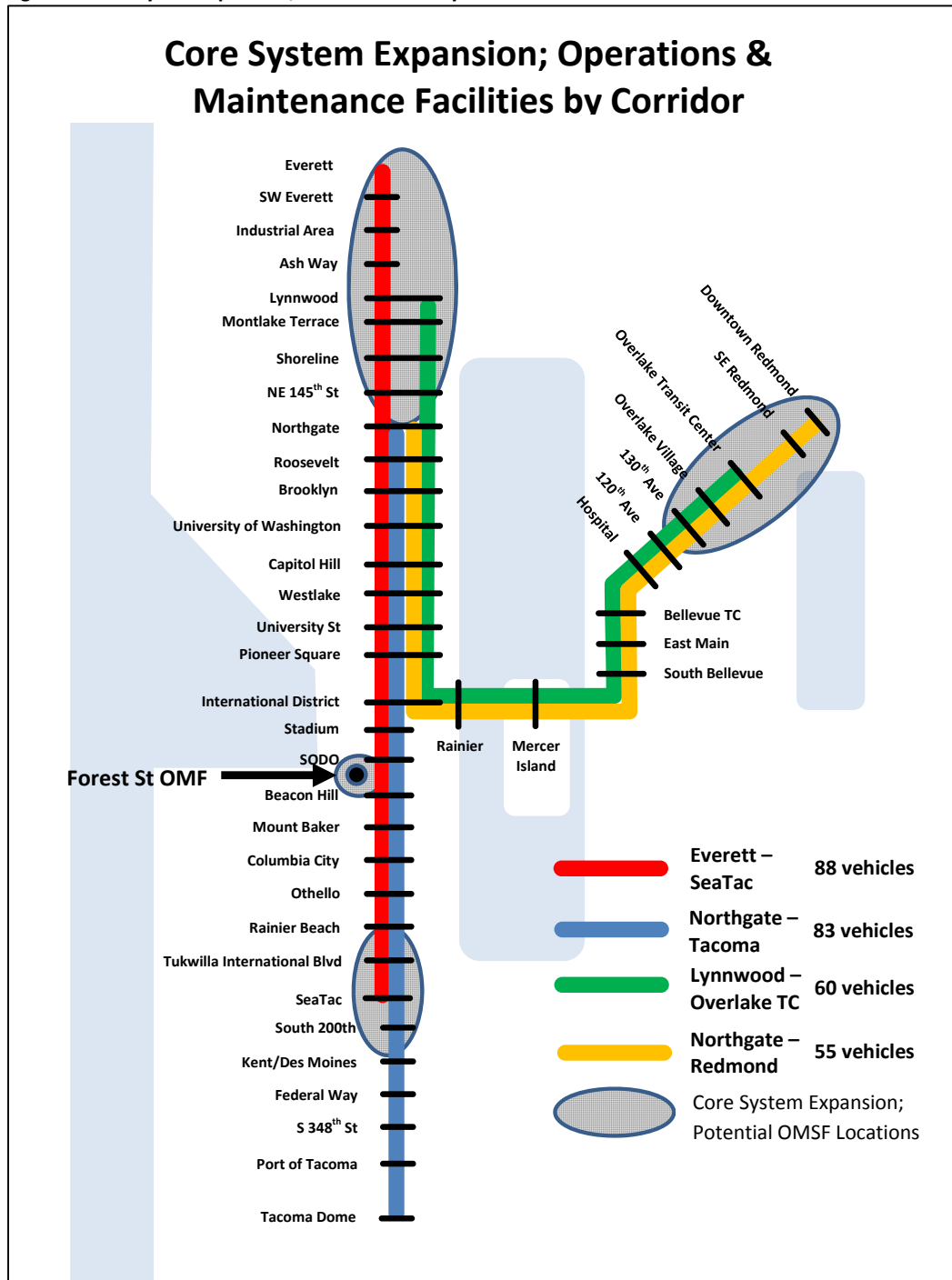
System level planning alignments for ST2 and the LRP were developed with a perspective of financial conservation – that is, generally the most expensive alignment was selected for planning purposes and matched with the financial plan to minimize financial risk in the plans. While this helps maintain financial certainty, to the extent possible, it also defines the highest speed operating segments with full grade separation, thus potentially minimizing fleet requirement estimates.

For the purpose of being conservative in estimating Core Light Rail System Expansion fleet requirements, and subsequent OMSF requirements, Sound Transit may benefit from developing a range of fleet needs for future planning purposes. **It might be appropriate to add as much as a 5% fleet size contingency to the estimated vehicle needs, resulting in a range of Core Light Rail System Expansion light rail vehicles between the 286 already estimated and 300 at a theoretical top end.** This is in addition to the 15% spare cars needed to supplement operations while vehicles rotate in and out of service for maintenance. The additional 5% fleet contingency is a facility design contingency and should be reduced as long range Link light rail extension alignments are more fully defined.

### ST LONG RANGE O&M FACILITY REQUIREMENTS

Long range fleet requirement is a principal driver of operations and maintenance facility needs. Operating consideration is the principal driver of locating those future facilities. This high level review of O&M facility requirements assumes the long range fleet needs and operating plan are correct. Figure 4 schematically illustrates the general location of Long Range operations and maintenance facility needs.

Figure 4: Core System Expansion; O&M Facilities by Corridor



## **Future O&M Facilities**

Total light rail system fleet requirement under the Everett/Tacoma/Redmond Core Light Rail System Expansion scenario is 286 light rail vehicles, 106 more than the 180 required for ST2. Accommodation of these additional vehicles, beyond the ST2 system needs, will require development of an additional (third) Link light rail operations and maintenance satellite facility.

A comparative analysis of 10 light rail operations and maintenance facilities across the west, including the Forest Street OMF, shows that the largest facility is Denver RTD's Elati facility with maintenance and storage capacity for 120 vehicles. The average size is approximately 80 vehicles.<sup>1</sup> Using this information, in combination with the fleet allocation by line, it is logical to conclude that the Core Light Rail System Expansion system maintenance and storage capacity be accommodated with a north corridor facility, south corridor facility (existing Forest Street OMF) and an east corridor facility – each capable of storing and maintaining approximately 100 vehicles.

Looking at the fleet requirements from a north-south and north-east operating line perspective (see Table 3), the combined north-south service requires 171 vehicles and the combined north-east service requires 115 vehicles. Operating efficiency and convenience is optimized when the long range line operations can be matched with facility capacity. An optimal allocation of storage and maintenance capacity by corridor is as follows:

- Forest Street OMF remains at 104 vehicles, operating the 83 vehicle Northgate to Tacoma Line and having capacity for 21 more vehicles from the Everett to SeaTac line.
- A north corridor facility, with the capacity for 67 vehicles (88 total vehicles needed to operate the Everett to Airport line minus the 21 being operated from Forest Street)
- An east corridor line with capacity to store up to 115 vehicles is desirable to operate the Lynnwood to Overlake TC line and the Northgate to Redmond line.

### North Corridor Review

Additionally, all four lines in the Core Light Rail System Expansion operating plan terminate in the north corridor (at Northgate, Lynnwood, and Everett). Hence, launching trains and locating supporting services somewhere between Northgate and Everett would be most desirable for the Core Light Rail System Expansion since all would have a short, efficient trip to the north end of the lines.

### South Corridor Review

The ST2 Plan anticipated development of the OMSF along the south corridor, but additional operational analysis has determined a second facility along the south line would not meet the operational needs of the system for two reasons: (1) intrusion into the 4-hour nightly system inspection and maintenance window; and (2) excessive deadheading costs and operational inefficiencies to deploy East Link trains. A second facility in the south corridor would mean that all morning trains would need to be dispatched on the same line, at the same time. The time window required for overnight track and systems

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<sup>1</sup> Huitt-Zollars and Maintenance Design Group, "Progress Draft – Comparative Analysis of Light Rail OMF Site Acreage," June 15, 2012.

maintenance (1:00 AM to 5:00 AM) requires that no trains be on the track during these times. To effectively dispatch all trains from one corridor would seriously impede this necessary maintenance window, or require the system opening time to be extended an additional hour, impacting riders and the morning commute.

#### East Corridor Review

Sound Transit desires to provide additional capacity for 10 additional light rail vehicles at an eastside Link light rail OMSF. Extension of light rail from Overlake Transit Center to downtown Redmond as part of The Core Light Rail System Expansion will require 10 more vehicles, and in anticipation of that future requirement, an eastside Link light rail OMSF would be the most appropriate place to store and maintain those vehicles, eliminating the need for an additional eastside facility to serve the Redmond extension.

#### Summary Corridor Review

To achieve optimal operational efficiency, the Core Light Rail System Expansion will require one facility in each the north, south and east corridor. The additional Core Light Rail System Expansion facility could be located in either the north or east corridor with no measurable long term difference in operating requirements

Long term needs require capacity for approximately 100 vehicles at each facility in each corridor. Long range expansion capacity should be factored into the sizing requirement for the ST2 OMSF, regardless of whether it is located in the East or North corridor.

## **FUTURE PROGRAM REQUIREMENTS**

The following comments are based on the needs assessment of expanded maintenance and storage capacity located in the east or north corridors. It should be remembered however, that the number of cars, location, and a fundamental operations and maintenance (O&M) plan must be finalized before the physical size, and the operational support requirements for the satellite facility can be fully developed. These observations are accurate for either the ST2 OMSF or a future Core System Expansion OMSF.

#### Satellite Car Maintenance Philosophy:

Cleaning, inspections, running repairs, and the lowest level unit or component “swap out” (for failure or repair only) will be performed at the satellite facilities. Most swapped out components/assemblies are considered to need “major” repairs will be cycled to the current Forest Street Operations and Maintenance Facility (OMF) location. Major repairs and overhauls to the vehicle sub-systems will be performed at the current Forest Street OMF location. There may be some back shop activities which would develop over time at the satellite facilities, based on cost and handling efficiencies. For example, it may not be cost effective to return a complete air conditioner assembly to the major repair facility to effect a repair that did not require specialized shop equipment, and only bench type equipment and labor. A large open work area would still have to be designed into the satellite facilities to support this “swap out” work scheme. The main exception to this philosophy is the need for a completely outfitted Wheel Truing and Truck Repair area at the satellite facilities to supplement those capabilities at the Forest Street OMF.

#### Truck Repair Area:

The facility storage and service of a fleet of 80-90 cars requires a Wheel Truing machine, 2 car positions of in-floor car hoist equipment, and truck repair capabilities. Also, the wheel truing, car hoist positions, and the truck repair equipment in the satellite facilities, should be designed to have in shop track and turntable inter-connectivity. The current Forest Street OMF is maintaining a fleet of 62 vehicles and is close to exceeding the wheel truing capacity of that facility. The wheel truing and truck repair area is separated from the in-floor hoist tracks and are not connected except by outside yard tracks. Sound Transit is in the process of installing a second set of in-floor car hoist equipment to support the truck maintenance requirements at the Forest Street OMF.

#### General comments:

The Paint Shop and Body Shop could remain at the Forest Street OMF. The impact of increased paint and body activities at Forest Street OMF cannot be predicted. Similarly, towing out of service vehicles from the east side, with a required turn-back on the north-south line, either at a future pocket track or at Northgate, also has implications for service reliability of the north-south line.

Some areas of the Forest Street OMF are now occupied by Facilities, Supervisory Control and Data Acquisition (SCADA), Power and Maintenance-of-Way (MOW) Maintenance groups. Continued occupation of this space could impact Vehicle Maintenance major repair and overhaul capacity, and space requirements with the arrival of additional vehicles.

Preliminarily operational analysis suggests that development of the Core Light Rail System Expansion has potential to overwhelm the heavy maintenance capacity of the Forest St OMF. Expansion beyond ST2 Link light rail extensions will likely require additional heavy maintenance capacity to supplement that provided at Forest St OMF.

### **End-of-Line Storage**

With respect to the potential utilization of end-of-line layover or storage facilities, such facilities should be fully developed as part of the ST2 and Core Light Rail System Expansion maintenance strategy, with specificity and clarity to understand how the layover facilities would work in concert with the maintenance facilities before a final determination can be made as to their usefulness. This should include the facility location, the number of trains to be stored at each facility, track capacity and yard requirements, and the required footprint. This clarity will need to include the additional facilities and accommodations required at each location, such as operator reporting, cleaning, running repair, vehicle and equipment security, etc. It would be beneficial to simulate the entire maintenance/layover support system to determine operational feasibility, compatibility with revenue operation and estimated operating costs.

As a general statement end-of-line storage is not widely practiced in North America. In concept, end-of-line storage might seem a practical way to reduce O&M facility size requirements. In practice, given the needs of the facilities discussed above, they require much more development than just storage and add disproportionate additional capital and operating costs beyond those associated with a slightly larger

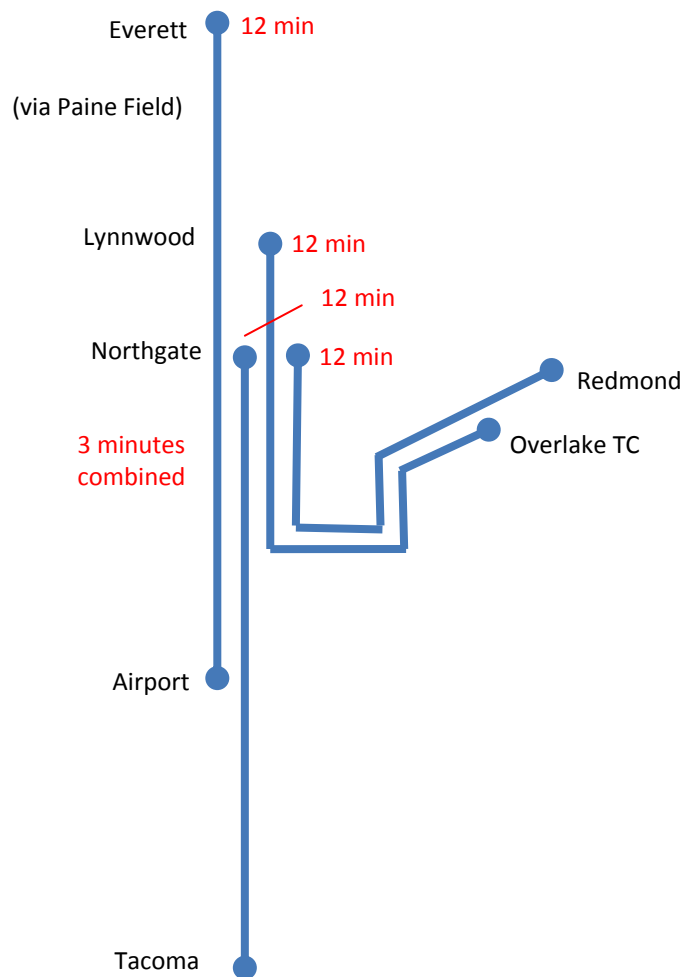
O&M facility capable of full operational requirements. They are in effect mini operating facilities in their own right and should be discouraged.



## ATTACHMENT A: SOUND TRANSIT CONCEPTUAL OPERATING PLAN FOR CORE LIGHT RAIL SYSTEM EXPANSION

The Sound Transit *Regional Transit Long-Range Plan* was adopted in July 2005. It included potential rail expansions throughout the Sound Transit district. Priority was given to the Everett-Seattle-Tacoma rail spine, as well as a rail connection to Bellevue which could be extended all the way to downtown Redmond. Other potential rail expansions include the I-405/SR-518 corridor, the I-90 corridor to Issaquah, and connections in Seattle from Ballard to downtown, and Ballard to University District.

Sound Transit has developed a conceptual light rail operating plan that assumes the system would be expanded in accordance with the priorities set in the *Regional Transit Long-Range Plan*. The conceptual operating plan, shown below, includes rail expansions beyond the ST2 Plan, including extensions to Everett in the north, Tacoma in the south, and downtown Redmond in the east. These extensions would build out the rail spine and are included in the adopted PSRC 2040 Plan. This plan is intended to help determine Sound Transit's long-range light rail fleet and operations and maintenance facility (OMF) needs.



For this operating plan, a total fleet size of 286 light rail vehicles (LRVs) is needed, as shown in the following table:

	Everett - Airport	Northgate - Tacoma	Lynnwood - Overlake TC	Northgate - Redmond	Total
Minutes, one way	94	84	61	53	
Minutes, round trip	188	168	122	106	
Minutes, Lay / Turn	16	16	16	16	
Minimum Cycle Time	204	184	138	122	
Peak period headway	12	12	12	12	
Trains	17	16	12	11	
Cars per train	4	4	4	4	
Service cars	68	64	48	44	
Gap cars	8	8	4	4	
Total service + gap cars	76	72	52	48	248
Spare ratio					15%
Spare cars					38
<b>Total fleet size</b>					<b>286</b>
<b>(total cycle time)</b>	<b>204</b>	<b>192</b>	<b>144</b>	<b>132</b>	
<b>(minutes to spare)<sup>2</sup></b>	<b>0</b>	<b>8</b>	<b>6</b>	<b>10</b>	

One way run times were developed using base run times from a June 2011 OnTrack simulation of the ST2 light rail system (Lynnwood – Kent/Des Moines – Overlake TC):

- Lynnwood – Kent/Des Moines 68 minutes
  - (Lynnwood – SeaTac/Airport) 61 minutes
  - (Northgate – Kent/Des Moines) 55 minutes
- Lynnwood – Overlake TC 61 minutes
  - (Northgate – Overlake TC) 47 minutes

<sup>2</sup> “Minutes to spare” is a subtraction of the total cycle time (headway x number of trains) minus the minimum cycle time. It indicates how much the minimum cycle time can be increased before another train must be added. If there are no minutes to spare, then another train must be added if the minimum cycle time is increased by even one minute.

Additional run times were developed for the extensions beyond the ST2 system:

- Everett – Lynnwood TC (via Paine Field): From Lynnwood TC, a 15.2-mile sample route was chosen using SR-525, SR-99, Airport Rd, SR-526 and Evergreen Way. 10% distance was added to account for unknown route circuituity and for serving Everett Station before or after downtown Everett. The resulting distance was 16.7 miles. Alignments were primarily assumed to be separated from traffic, and average speed was assumed to be 30 mph, giving a travel time of 33 minutes.
- Overlake TC – Redmond: 6 minutes was added for the extension, consistent with information in the East Link Final EIS, p 3-22.
- Kent/Des Moines – Tacoma: A 15-mile I-5 alignment previously developed for the 2007 Roads & Transit package was used. Travel time for this alignment between Kent/Des Moines and Tacoma was estimated at 29 minutes, resulting in an average speed of 31 mph.

Operating lines were developed to concentrate more frequent service in high-demand corridors, and operate less frequently where ridership demand is lower. The most frequent service would be provided between Northgate and downtown Seattle. Peak headways were assumed to be 12 minutes for each operating line, resulting in a combined 3-minute headway in the tunnel from Northgate to Int'l District / Chinatown.

The following considerations, restrictions and assumptions were used in developing this operating plan and fleet size.

#### **Operating considerations**

- Due to the capacity of lead tracks to deploy trains onto the system, LRVs for the north-south lines would be stored and deployed from OMF locations on the west side along those operating lines, whereas LRVs for lines serving the east side would be stored and deployed from OMF locations on the east side.
- To allow for the termination of operating lines (turnbacks), special track work would be required at or just beyond Lynnwood, Northgate, SeaTac/Airport and Overlake Transit Center.
- It is assumed that some trains could be stored overnight at one or more ends of the lines, especially ends which are located furthest from the OMFs. This allows services to begin without having to deadhead trains to the ends of the lines.
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#### **Operating restrictions**

- Due to a fire/life safety requirement, trains in the light rail tunnel between International District / Chinatown and Northgate must maintain a separation allowing no better than 3-minute scheduled headways in the tunnel.
- Due to traffic operations, it is assumed trains operating at-grade along MLK Jr Way S cannot operate better than 6-minute headways.

### **Operating assumptions used for fleet sizing**

- 16 minutes of total turnaround and layover time is assumed for each round trip. This time includes all security sweeps, travel time into and out of tail tracks or pocket tracks, switching ends and recovery time.
- 4-car trains will be operated in the peak periods.
- “Gap” trains are assumed to be ready for service in case of any service disruption. Two gap trains are assumed each for the Everett-Airport and Northgate-Tacoma lines. One gap train is assumed for the Northgate-Redmond and Lynnwood-Overlake TC lines. These could be stored at OMFs or in pocket tracks along the lines.
- Spare cars are assumed to be included in the fleet. The spare cars requirement is calculated by adding the LRVs required for peak period services (service cars + gap cars) and multiplying by 15%.