BROOKLYN STREETCAR
FEASIBILITY STUDY

CASE STUDY REPORT

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1.0 INTRODUCTION

The following Case Study Report was prepared to illustrate relevant streetcar components and experiences that are applicable to the Brooklyn Streetcar Feasibility Study. This report is intended to serve as a reference document to inform the study process, and to develop and evaluate streetcar system components. The information in this Case Study Report will be used as a reference for the subsequent tasks in the study.

As a starting point, ten streetcar systems that are in operation, or beyond the planning phase, were considered as potential case studies for this Case Study Report. These include:

- Portland Streetcar;
- Charlotte Streetcar;
- Seattle South Lake Union Streetcar;
- San Francisco Historic Streetcar;
- Tacoma Link Rail (Streetcar);
- Tampa Ybor City Historic Streetcar;
- Tucson Starter Streetcar;
- Kenosha Streetcar;
- Philadelphia Trolley; and
- Toronto Streetcar.

To assist the NYCDOT in the selection of three streetcar systems for the Case Study Report, summaries of these ten streetcar systems were provided by the Study Team. This document is included as Appendix A. While this Case Study Report focuses specifically on three systems, there may be times during the overall Brooklyn Streetcar Feasibility Study when lessons learned from other systems, beyond the original three selected, could be applicable. Whenever possible, the URS Team will incorporate the most relevant examples.

The NYCDOT chose the following three streetcar systems to be further studied for their applicability to a Brooklyn Streetcar:

Portland Streetcar

The Portland Streetcar demonstrates the use of modern streetcar technology in mixed street-running operation along urban streets. In addition, the Portland Streetcar offers multiple examples of utility impact mitigation techniques and well-documented economic development impacts. Other relevant lessons for Brooklyn include system expansion process, use of non-Federal funding, use of one-way pairs for operations, and strategies to deal with the integration with bike lanes and pedestrian pathways.

Seattle South Lake Union Streetcar

The South Lake Union Streetcar is a new modern streetcar system in full revenue service, similar to Portland, in a larger urban setting. The process to develop this system provides relevant information and lessons learned for Brooklyn.

Philadelphia Girard Avenue/Route 15 Trolley

Philadelphia's Route 15 trolley demonstrates the re-use of PCC heritage streetcar vehicles and existing infrastructure. In addition, the Route 15 Trolley is located in a northern climate, similar to Brooklyn, and in relatively close proximity to New York allowing study site visits. While this system is not the only example of PCC cars in operation today, it does demonstrate the lessons learned, both positive and negative, of returning a former streetcar line into regular revenue service using heritage streetcar equipment.

In coordination with the NYCDOT, the URS Team selected the most relevant system components to be investigated for the above three streetcar systems. These include:

- Planning Process Overview – Design Criteria, Alignment Decision Process, and Principal Challenges;
- System Operations – Operating Entity, Service Plan, Ridership, Bus Network, and Bicycle Integration;
- Financial Characteristics – Capital Costs, Operation and Maintenance Costs, Funding Strategies, and Economic Development; and
- Vehicle – Type, Storage and Maintenance Facilities, and Traction Power.

2.0 PORTLAND

The Portland Streetcar is an approximately eight-mile continuous loop (four miles in each direction) streetcar line serving Downtown Portland and the surrounding areas. The system demonstrates the use of modern streetcar technology in mixed street-running operation along urban streets, accommodating existing curbside parking and loading. The Portland Streetcar also offers multiple examples of utility impact mitigation techniques and well-documented economic development impacts. Other relevant lessons for Brooklyn include system expansion process, use of non-Federal funding, use of one-way pairs for operations, and strategies to deal with the integration with bike lanes and pedestrian pathways.

As shown in Figure 2-1, the Portland Streetcar travels from Legacy Good Samaritan Hospital on NW 23rd Avenue, NW Lovejoy and Northrup Streets, through the Pearl District, 10th and 11th Avenues, SW Mill and SW Market Streets, Portland State University Urban Center, SW Harrison Street, RiversPlace, Oregon Health and Science University, the Aerial Team, and to a terminus on SW Lowell Street and Bond Avenue in the South Waterfront District. Service opened in July 2001, with extensions commencing service in March 2005, October 2006, August 2007, and a fourth extension (adding another 6.6. track miles) planned to open in 2012, as shown in Figure 2-2.

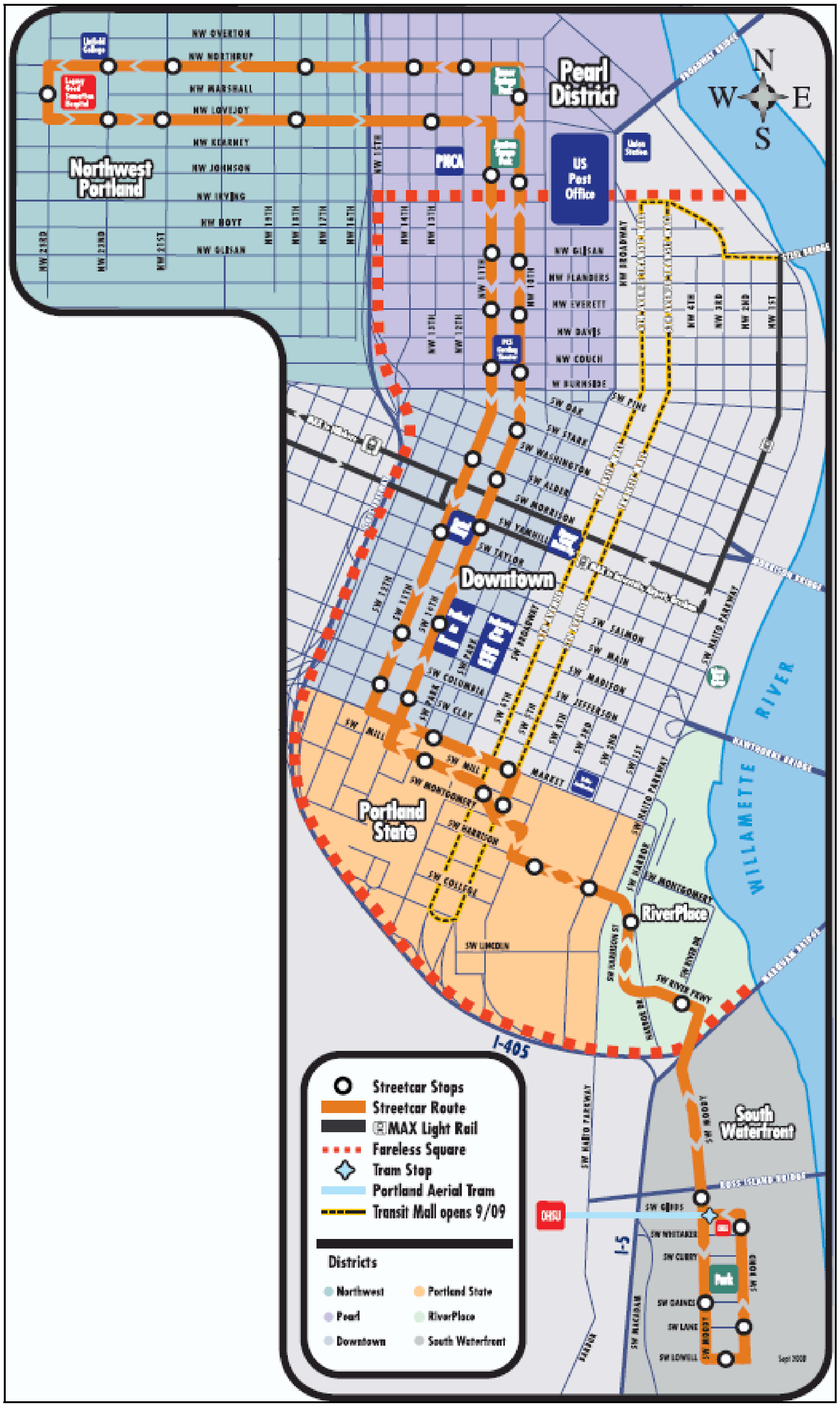
2.1 Planning Process Overview

In 1990, the City of Portland initiated a feasibility study for the Portland Streetcar to connect two major redevelopment areas – 70 acres of abandoned rail yards and contaminated brownfield sites just north of Downtown (the River District) and 128 acres of largely underused or vacant industrial land requiring environmental remediation at the opposite end of Downtown (the South Waterfront).[1] By May 1999 construction of the project began, and passenger service was first made available in July 2001 with a fleet of five modern vehicles with street-level boarding. The original route, which opened in 2001, was a 2.4-mile double track loop, connecting Portland State University and the Legacy Good Samaritan Hospital. This first segment served an already rich transit zone that offered free bus service ('Fareless Square')[2] through downtown Portland.

In March 2005, service was extended 0.6 miles of double track to RiverPlace, and in October 2006, an additional 0.6 miles of single track was extended to SW Moody and Gibbs to serve the South Waterfront. In August 2007, service began on 0.4 miles of double track extending to Lowell & Bond in the South Waterfront District. A fourth extension, the Portland Streetcar Loop Project, is planned for 2012 and will extend tracks from the Pearl District, across the Broadway Bridge, connecting via NE Weidler Street to Lloyd Center at NE 7th Avenue, south on NE MLK Boulevard to Oregon Museum of Science and Industry, and return north on NE Grand Avenue to NE Broadway and the Pearl District. The Loop Project will introduce 28 new streetcar stops.

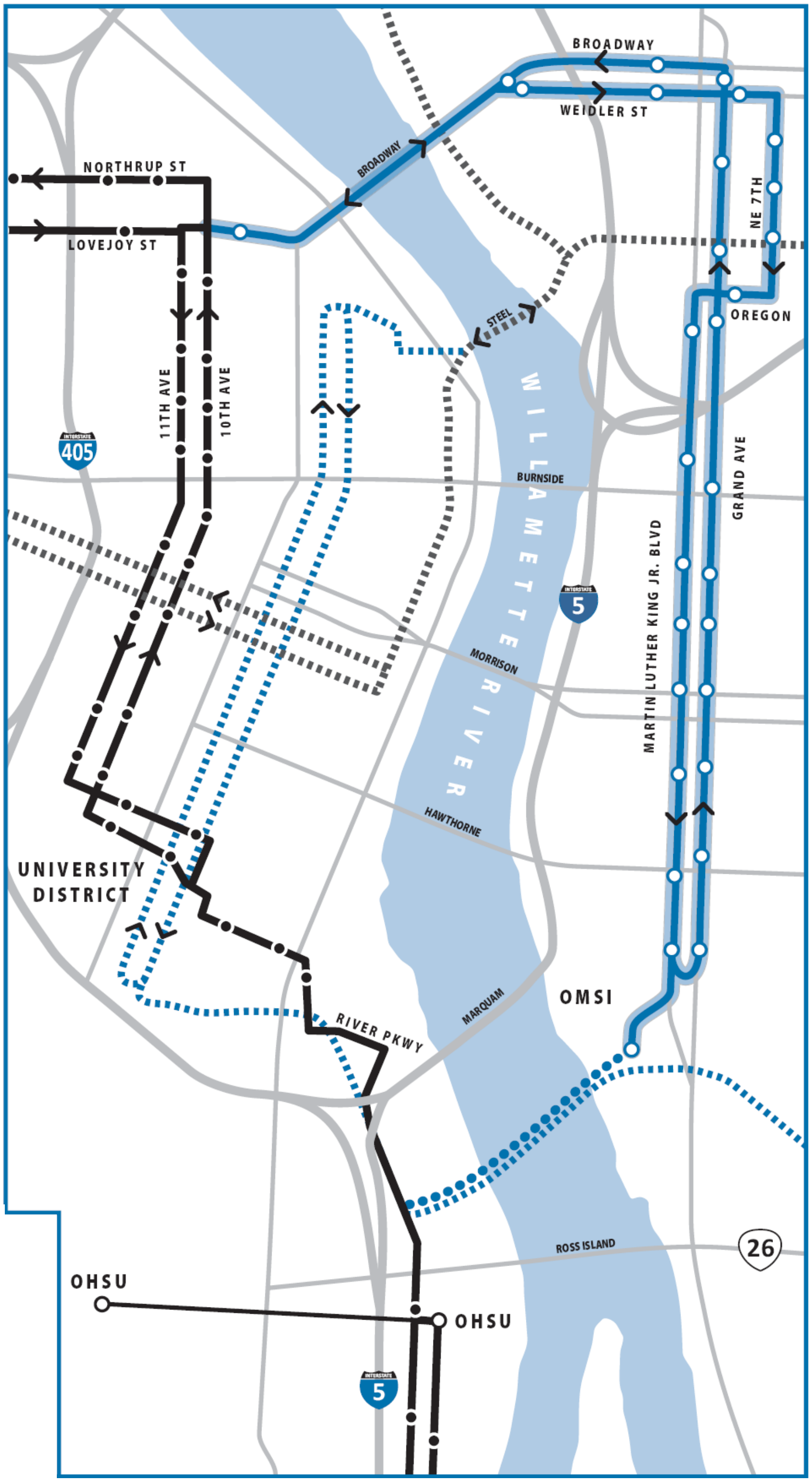
1 The Office of Transportation and Portland Streetcar, Inc., Portland Streetcar Development Oriented Transit, 2008.
2 Fareless Square was initiated 34 years ago to help address air quality issues, reduce car trips downtown, and increase transit usage. Originally, the transit system consisted of only buses, but has since expanded to four MAX lines and the Portland Streetcar. On January 3, 2010, TriMet's board of directors voted to change Fareless Square to rail-only. As a result, bus service is no longer free in downtown Portland and the Lloyd District.

Figure 2-1: Portland Streetcar Service



http://www.portlandstreetcar.org

Figure 2-2: Portland Streetcar Loop Project



URS Corporation

The Portland Streetcar was designed to fit the scale and traffic patterns of the neighborhoods through which it travels.[3] Throughout the evolution of streetcar planning in Portland, the goals have remained consistent:[4]

- Use a commitment to high quality transit service as an incentive for high density mixed-use development;
- Link neighborhoods with a convenient and attractive transportation alternative and attract new transit ridership;
- Connect major attractions in the Central City with high quality transit;
- Build and operate in mixed traffic and on existing right-of-way (ROW) at lower costs than other fixed rail options;
- Fit the scale and traffic patterns of existing neighborhoods; and
- Reduce short inner-city auto trips, parking demand, traffic congestion, and air pollution.

DESIGN CRITERIA

Streetcar design criteria include alignment geometry, speed, roadway cross section, lane selection, traffic signalization, and streetcar stops. General guidelines for these criteria are described below.

Alignment Geometry

General geometric values to illustrate typical streetcar limitations include the following:

Horizontal Curves

- Minimum horizontal radius is 82 feet (a smaller horizontal radius may be achievable depending upon vehicle capabilities); and
- Minimum curve radius is 600 feet +/- (with spirals) to achieve 25 miles per hour (mph).

Vertical curves (@ 25 mph design speed K value (K=L/A))

- Minimum vertical curve for crest K = 25 +/-; and
- Minimum vertical curve for sags K = 15 +/-.

Grades

The absolute maximum grade is vehicle dependent (typically seven to nine percent); however, the desirable maximum grade for streetcar vehicles is five percent. Even if the vehicle can achieve a certain grade, in most cases it is not desirable to exceed five percent. Almost all modern streetcar vehicles can climb a five percent grade with no issues. However, some vehicles may be limited in their capabilities at greater than five percent grades.

Portland has grades near nine percent for small (less than 200 feet) segments of the existing alignment. In these circumstances, the system was designed with grades up to nine percent, which is the maximum grade Portland's vehicle is capable of climbing while in revenue service. As a result, any future vehicles procured by Portland must be able to climb a nine percent grade to operate on these small segments. Portland has not experienced any performance issues, related to braking, on

3 Portland Streetcar, "Streetcar History", accessed November 1, 2010, http://www.portlandstreetcar.org/node/33.
4 The Office of Transportation and Portland Streetcar, Inc., Portland Streetcar Development Oriented Transit, 2008.

these small segments, even with inclement weather. However, during the fall season, when there are a lot of wet leaves on the tracks, streetcars can slip while accelerating up these higher grades. Moreover, since Portland does not receive the snow and ice that can be seen in the Northeast, Toronto is perhaps a better comparison to Brooklyn. In Toronto, grades exceeding five percent are avoided, as anything five percent or over can be a problem during snow removal.

Speed

Generally, the streetcar schematic alignment is developed to operate within 10 mph of automobile speeds. If the automobile speed for a road is 30 mph, the streetcar is designed to operate at a minimum of 20 mph. Speeds are interrupted by stops and traffic signals. Therefore, the average speed of most streetcar lines is less than 15 mph. Some areas where slower speeds are expected are listed below.

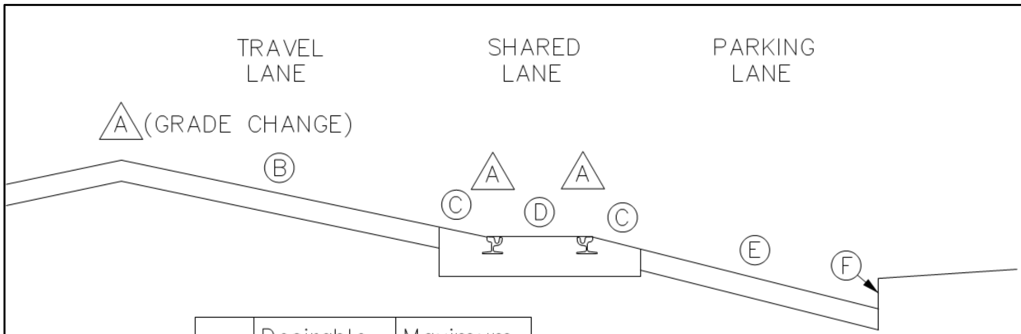
- 90 Degree turn - when the streetcar turns from one street to another, the speeds are limited to approximately five mph.
- Lane changes - when the streetcar shifts from one lane to another at an intersection where it is performing a transit-only maneuver, slower speeds (approximately 15 mph) are expected.
- Urban stops - the alignment at streetcar stops may have to shift slightly closer to the curb to interface with the platform and accommodate American with Disability Act (ADA) boarding requirements. In addition, the vehicle will stop and briefly dwell for approximately twenty seconds (potentially in mixed traffic).
- Turnouts - most turnouts (switches) for a streetcar system in a downtown environment are 25 meter (82 feet) European designs to minimize impacts to adjacent parking and sidewalks, and are limited to five to ten mph.

Roadway Cross Section

Track slabs are designed to provide a flat (zero percent) slope between the rails. Any slope greater than zero percent, or reverse super-elevation in curved sections, is undesirable and can result in uneven rail and wheel wear. A level streetcar track slab is used for all tangent track except in highly restrictive grading situations where some cross slope may be required to accommodate existing roadway cross slopes. A slight cross slope can be introduced to reduce pavement reconstruction or drainage impacts, but the best solution is to provide a zero percent cross slope between rails with flexible 1.5-feet ‘wings’ on the outer portions of the track slab guideway that vary in slope (zero to five percent) to accommodate for the overall cross slope of the existing roadway.

Generally, detailed grading is not accomplished until final design. However, the track design attempts to limit roadway reconstruction to only the track slab and installation of relocated utilities. The approach is further outlined in Figure 2-3. Figure 2-3 illustrates the general cross slope grading of the streetcar track. Typically the track is at least five feet from the curb, which puts the rail approximately 2.5 feet from the face of the curb. The area between the rail and the face of the curb is sloped similar to a gutter to carry the water to the nearest inlet. Portland uses this design methodology; and therefore, there have been no real issues with drainage in Portland, despite the city’s significant amount of rain and a zero percent cross slope between the rails.

Figure 2-3: Roadway Cross Section



	Desirable	Maximum
A	3%	5% (2–3% @ Cross Streets)
B	2%	5%
C	2–4%	4.5%
D	0%	1–2%
E	4–6%	7%
F	6"	4" (Curb Exposure)

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Lane Selection

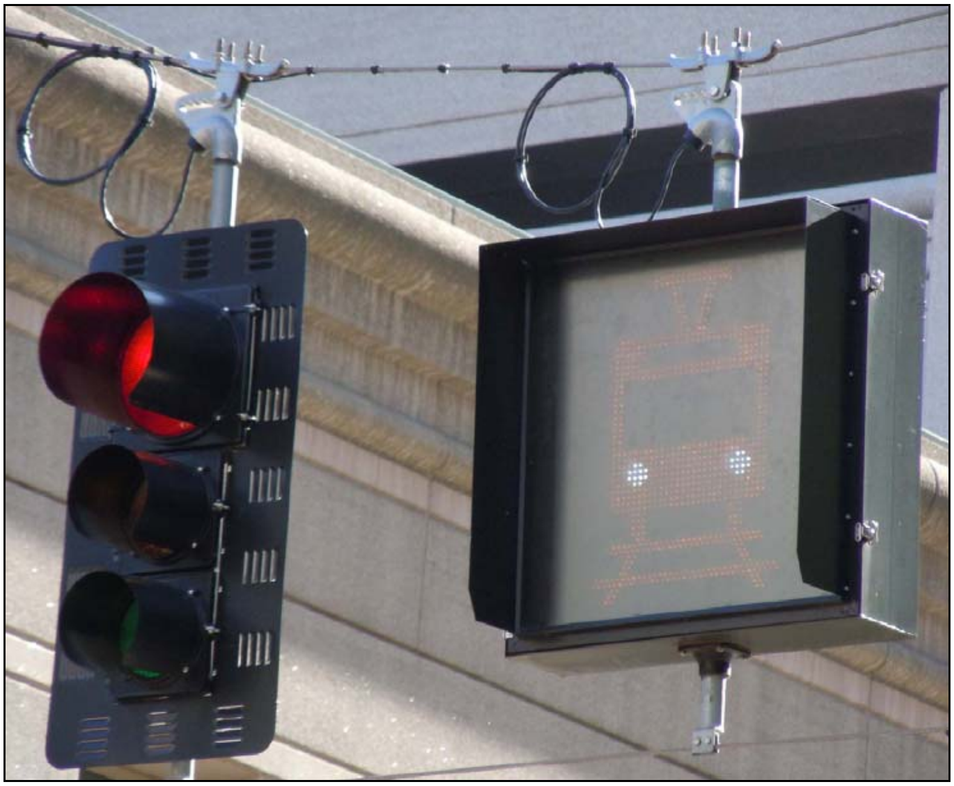
When selecting the lane to place a streetcar trackway, several factors affect the decision- making process. Existing and future traffic volumes, presence of existing utilities, presence of bicycle lanes and on-street parking, and desired station configuration all influence the lane selection of streetcar tracks on a multi-lane street. For early alignment evaluation purposes, or determining alignment options in a corridor, the pros and cons of left lane versus right lane running options are considered based on the type of street on which the streetcar will operate. For example, a wide ROW two-way street with large existing medians or continuous left turn lanes operates better with a left lane running alignment and shared median stops, which also minimizes conflicts with bike lanes and impacts to parking. Side running alignments and side stops are common to one-way couplets and narrow two-way streets, which do not have a median or left turn pockets. A detailed evaluation of the best operation is accomplished and refined once a desired alignment is selected.

The alignment of the first phase of the Portland Streetcar was primarily located in the right traffic lane, due to the lack of conflicts and because the streetcar was operating primarily on one-way streets. However, during the design of the 2005, 2007, and future 2012 extensions, the location of existing public utilities led to alternative alignments.

Traffic Signalization

Traffic signals along the streetcar route generally provide two-phase operations. Protected left-turn phases are limited to intersections with higher turn volumes. Where the streetcar operates in mixed flow in the existing traffic lane, streetcar movements are controlled by normal traffic signal operations. At locations where sight distance is limited or the streetcar must make a left-turn movement, transition into or out of special lanes, or transition into semi- exclusive operations, special transit-only signals are provided. These transit signals are physically separated from the traffic signals and will use transit-only display indications. In addition, the use of Part Time Warning Signs (PTWs), which flash "train" or a train symbol add an additional factor of safety to indicate to the automobile users that the streetcar is entering the intersection through a transit only phase, as shown in Figure 2-4.

Figure 2-4: Part Time Warning Signs



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Streetcar Stops

The type of stops considered can have a dramatic effect on the cost and urban design elements of the rail system. Stops can make architectural statements with unique canopies and artwork, or simply provide a boarding area and small shelter. The Portland Streetcar utilizes a simplistic approach by providing a streetcar specific shelter (similar to a standard bus shelter), while avoiding canopies and other costly features. These stops, as shown in Figure 2-5, generally cost between $60,000 and $100,000 each, and can accommodate one streetcar vehicle.

Figure 2-5: Portland Streetcar Stop

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The design of streetcar stops is specific to each location, as stops are designed to integrate with the existing ROW. For example, much of the Portland alignment is adjacent to parking. Therefore, bulbouts are relatively common. Bulbouts extend the corner sidewalk to the edge of the streetcar travel lane in these locations where parking is immediately bordering the streetcar. Similarly, many of the streets in Red Hook are lined with parking. Although these bulbouts are a pedestrian-friendly amenity, shortening pedestrian crosswalks, their down side is the added construction costs and the removal of parking. In addition, bulbouts can be challenging to maintain during snow removal. In areas with no parking, the streetcar runs curb tight and the stop is integrated into the sidewalk. In these cases, no bulb out from the sidewalk to meet the track is necessary.

ALIGNMENT DECISION PROCESS

As reported in the *Transportation Cooperative Research Program (TCRP): Synthesis 86: Relationships between Streetcars and the Built Environment*, it is difficult to generalize the planning and goals of streetcar systems, as each has a unique history. To obtain first-hand knowledge of the current state of the practice, a detailed survey instrument was prepared by the Transportation Research Board Synthesis Panel. This survey was administered as telephone interviews with two subjects in each of the communities studied. The two subjects were identified as a transit agency expert with institutional knowledge, economic development expert, or land use planner who managed the related land use and economic development process associated with the streetcar system.[5]

Table 2-1 includes the survey tabulation results for the Portland Streetcar. As shown in Table 2-1, streetcar route planning was focused on land use, future development, intermodal connections, and service to cultural/educational activities.

Table 2-1:
Rating of Importance of Route Selection/Planning for Operations

PORTLAND STREETCAR	RATING
Serving commuters to daily job locations	1
Serving tourists and visitors	1
Serving students	4
Connecting cultural, entertainment, or civic destinations	5
Connecting with other modes of transit (light rail, commuter rail, bus)	4
Stimulating revitalization	5
Generating affordable or workforce housing	4
Organizing new neighborhoods around transit	5
Compatibility with comprehensive/general plans	5
Notes: 1= NOT important in route planning, 5: VERY important in route planning	

TCRP: Synthesis 86: Relationships between Streetcars and the Built Environment (based on input from the Portland Development Corporation and the Executive Director of Portland Streetcar, Inc.)

Future Planning

In addition to the existing streetcar system and the Streetcar Loop Project, currently under construction, Portland has initiated the Portland Streetcar System Concept Plan (SSCP). The SSCP is a strategy for an enhanced streetcar network that is a part of a broader vision by the City of Portland to sustainably accommodate future population growth in a manner that will effectively manage the consumption of limited natural resources and reduce greenhouse gas emissions. The SSCP builds upon the success of the existing streetcar system to expand service to best serve Portland's neighborhoods and business districts.

Specifically, the 2009 *Portland Street System Concept Plan: A Framework for Future Corridor Planning and Alternative Analysis* identified and selected corridors for future Alternatives Analysis and planning studies as funding becomes available. Transit corridors citywide were assessed to determine their potential for future streetcar investment. Detailed corridor by corridor analysis, study, and discussions with corridor neighborhoods are necessary to determine if a streetcar investment is warranted. No individual corridor can move forward without a detailed analysis and planning study to address the purpose and need of a streetcar project and to comprehensively evaluate project impacts. In the fall of 2007, the SSCP Project Team developed the following mission statement and project goals:[6]

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5 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.
6 The Office of Transportation and Portland Streetcar, Inc., Portland Streetcar Development Oriented Transit, 2008.

The Portland SSCP can play a key role in shaping the City by:

- Reinforcing walkable and economically diverse neighborhoods and vibrant main streets;
- Encouraging sustainable and equitable development and infrastructure;
- Supporting reduction of vehicle trips; and
- Supporting greater accessibility, housing options, employment, and economic development.

A successful streetcar system will:

- Help Portland achieve its peak oil and sustainability strategies;
- Provide an organizing structure and catalyst for Portland's future growth along streetcar corridors; and
- Integrate streetcar corridors into Portland's existing neighborhoods.

Successful streetcar corridors need to:

- Be a viable transit option with adequate ridership;
- Have (re)development potential; and
- Demonstrate community support to make the changes necessary for a successful streetcar corridor.

Portland city planners defined a potential urban design concept for future growth and health of neighborhoods and communities, known as the "20-minute neighborhood." This concept promotes an environment where one can walk, bike, or take transit to essential amenities and services in 20 minutes. Streetcars can support and enhance this environment by connecting 20-minute neighborhoods to each other and to the regional transit network.

PRINCIPAL CHALLENGES

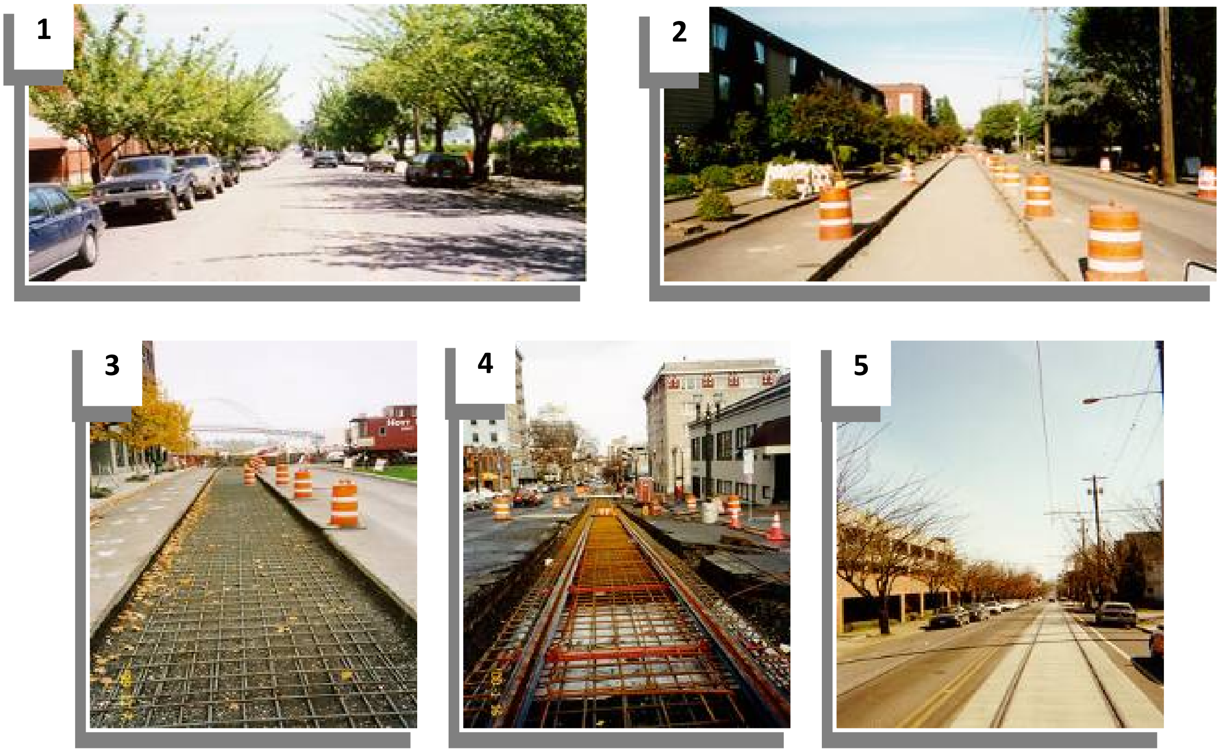
Constructability

Portland used the following construction sequence to minimize construction time and costs. These steps are visually shown in Figure 2-6.

- Sawcut and Excavate Trackway Trench (inset 2): The streetcar tracks were embedded in a concrete slab that was roughly eight feet wide and one foot deep. Sawcut lines were made in existing streets and the roadway was removed to a depth of approximately one foot. In some cases the existing road bases were adequate to support the concrete track slab, but in other areas an additional six-inch depth of excavation was required to install an aggregate base layer to support the track slab.

- Install Reinforcing Steel and Rails (inset 3 and 4): After the trackway trench was completed, track slab reinforcing steel was placed and rails were positioned to their proper alignment and profile. The rails were aligned by the use of gage ties spaced approximately every 10 feet. The gage ties held the rail in position during the subsequent concrete pour.

Figure 2-6: Portland Streetcar Construction



– Pour Concrete Track Slab: After a final check to ensure the proper rail alignment, the concrete track slab was poured. In most cases this concrete pour was done in a single lift and was either hand finished or with a slip-form paving machine that straddled the tracks.

– Final Paving and Striping (inset 5): Once the track slab concrete was sufficiently cured, the adjacent asphalt pavement was ground to allow a minimum asphalt overlay of two inches next to the tracks. The overlay was then compacted; the roadway was re-striped; and the section of roadway was reopened to vehicular traffic.

Utilities

Portland did not create a formal procedure regarding utilities, as relocations varied by utility. The Portland Streetcar engineering team identified utilities in direct conflict with the track slab. These utilities were relocated. Similarly, the public utilities had the opportunity to define conflicts. Maintenance was Portland's main concern in determining utility work.

Perpendicular utilities, or "crossings", remained in place, and were not relocated. Depending on the pipe material and utility owner's desire, perpendicular crossings were sometimes sleeved for stray current protection. Future crossings are either trenched or jacked under the track slab.

Approximately 90 to 95 percent of the utilities parallel and beneath the track slab were relocated. Very few parallel utilities remained in place. These utilities were not relocated either because there was no other option or because of sufficient depth. Deep utilities were not relocated if they were determined to have a long service life. Vehicle loads are not a significant factor in utilities, as streetcar vehicle axle weight is significantly less than typical truck loading used in design (HS-20).

Generally, the streetcar project pays for any public utility relocations (water, sewer, lighting, and signals). However, the City of Portland has used a method called “pipe life credits” to determine what portion of the relocation is paid for by the project and by the utility department. Portland assumed a sewer main life to be 75 years and a water main life to be 100 years. If a water line is 40 years old, the streetcar project paid for 60 percent of the relocation (as 40 years is 40 percent of its 100 year life span) and the utility department paid for the remaining 40 percent of the relocation.

In some segments, sewer relocations were limited to direct conflicts with the track slab and sewer mains or manholes. A condition assessment was performed on the existing line to determine if it was left in place, repaired in place, or relocated. In general, few sewer relocations were performed. For sanitary sewer condition assessments, Portland made a large amount of in-situ pipe lining repairs.

Sewer laterals were installed as needed during construction. However, no future laterals were installed as Portland assumed these would be bored and trenched beneath the track slab at a later date, which Portland successfully accomplished using the following process:

- Bore half way under the track slab;
- Install the sewer pipe;
- Fill the trench with low strength flowable fill;
- Excavate the remaining distance under the track slab;
- Install the remainder of the pipe; and
- Fill with low strength flowable fill.

In terms of sewer access, offset manholes were utilized. Manholes were only located within the first ten inches on either side of the track slab. These manholes were replaced with larger diameter manholes to adjust the ring and cover to be as far away from the slab as possible. Portland also used “Beaver Slide” manholes, with sloping access lids to allow for easier accessibility.

When working with the City of Portland water department, the streetcar project incurred unexpected costs associated with the cost of engineering and administering the relocations. As such, Portland now has an intergovernmental agreement between the streetcar project and the water department to minimize these costs. The water department initially defined a direct conflict to be a line less than three feet away from the track slab. However, as Portland’s streetcar was extended, this distance has increased to ten feet. Despite this guideline, there is a 48 inch water line less than ten feet away from the track slab that runs parallel for a portion of the alignment. If the water department ever needs to access this line and disturb the track slab, the streetcar project will pay to make any repairs needed to the track slab.

In terms of access to utilities while the streetcar is in operation, for the most part this is not an issue as parallel utilities were cleared from beneath the track slab prior to installing the track. Therefore, there is adequate access to maintain and/or replace any of the utilities. In the instances where the track was constructed over a parallel utility, an agreement between the city and utility owner was developed to establish guidelines to for utility access. Agreements were established to identify the organization (utility or streetcar entity) responsible for removing and reconstructing the track slab or, in some cases, abandoning the utility and relocating it (since that costs less than rebuilding the track).

2.2 System Operations

OPERATING ENTITY

The Portland Streetcar is managed by the Portland Office of Transportation, under the direction of the Commissioner-in-charge of Transportation. The City of Portland contracts with Portland Streetcar, Inc. (PSI) to construct and operate the streetcar system. PSI is overseen by a board of directors that includes business and residential representatives, the Mayor of Portland, and the general manager of the Tri-County Metropolitan Transportation District of Oregon (TriMet). TriMet is the public transit agency that provides public transportation for much of the three counties in the Portland area: Multnomah, Washington, and Clackamas.

The initial segment of the Portland Streetcar system was planned by the city to support and complement planned redevelopment in a former rail yard, an area that came to be known as the "Pearl District". During the planning phase the city briefed key governmental partners such as TriMet. However, the initial concept was solely the product of the city's initiative.

The city and PSI considered various methods of operating the streetcar line (using city employees, private contractors, TriMet staff, etc.). They determined that contracting with TriMet to operate the vehicles made the most economic and political sense. TriMet provided a deep well of experienced drivers trained in operating similar vehicles (light rail). Neither city employees nor a private contractor provides the same depth of resources or the level of flexibility as TriMet.

Today, Portland Streetcar is jointly owned and operated by the City of Portland and TriMet. These entities work hand and hand, as TriMet realizes the streetcar is a very beneficial asset to the transit system. In fact, TriMet was the grantee for the Streetcar Loop Project, which is currently under construction as a Federal Transit Authority (FTA) Small Starts Project.

SERVICE PLAN

The current system has a total of 46 stops, located approximately every three to four blocks. Streetcars run from 5:30 AM to 11:30 PM on weekdays (except for Friday, when service is extended to 11:45 PM), 7:15 AM to 11:45 PM on Saturdays, and 7:15 AM to 10:30 PM on Sundays. Streetcar stops are scheduled approximately every 12 minutes during most of the day Monday through Saturday, and less frequently (14 to 20 minutes) in early mornings, evenings, and on Sundays.

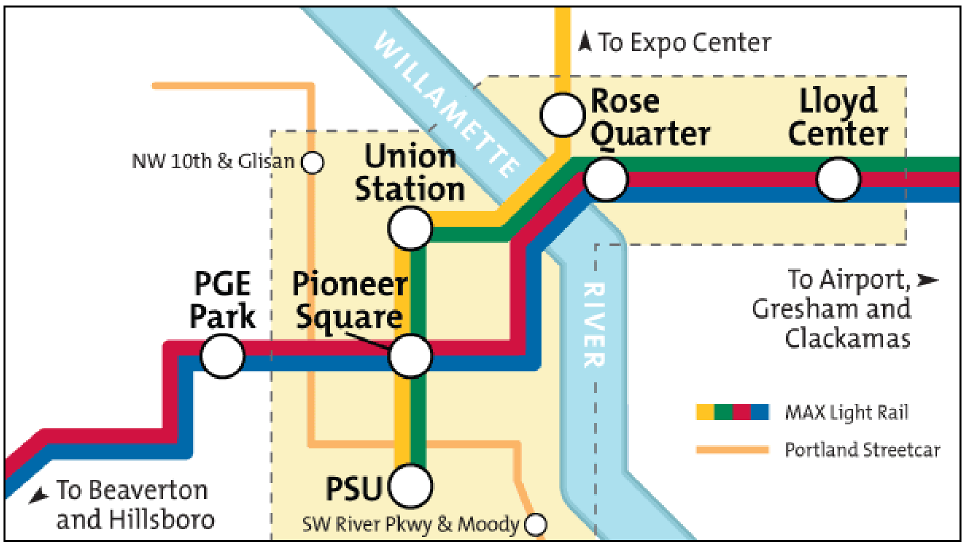
Stops on the Portland Streetcar are not made automatically. Passengers must signal a stop by pushing a level or button on a door, and the reader board inside the streetcar will read 'Stop'. Otherwise, stops are made only if new passengers are waiting at designated stop platforms.

Fares

Portland Streetcar accepts all TriMet passes and transfers, allowing free transfers between streetcar and TriMet bus and MAX (light rail) routes. The majority of the current streetcar route is within the Free Rail Zone. Outside of the Free Rail Zone, as shown in Figure 2-7, fares are as follows:

- Adult 18-64: $2.05 - valid all day on Streetcar
- Adult 65+: $1.00 - Valid all day on Streetcar
- Youth (7-17): $1.50 - Valid all day on Streetcar
- Streetcar-Only Annual Pass $100.00

Figure 2-7: TriMet Free Rail Zone



http://trimet.org/fares/freerailzone.htm

RIDERSHIP

Portland Streetcar ridership has grown steadily since opening in 2001.[7] Figure 2-8 shows a quarterly breakdown of daily ridership calculated from the opening of the system in July 2001 to the winter of 2009/2010.

Weekday ridership increased from 4,982 in summer 2001 to 11,914 in winter 2009/2010, an increase of 139 percent. In 2001, when the project first opened, original targeted ridership was 3,500 weekday rides.[8] Ridership immediately exceeded this target, and by spring 2005, with the RiverPlace extension, ridership was more than double the original goal with 7,837 rides each weekday. Saturday daily ridership has increased from 5,239 rides in summer 2001 to 7,735 in winter 2009/2010, an increase of 48 percent. Sunday ridership, while remaining lower than weekday or Saturday ridership, has increased from 3,177 average Sunday rides in summer 2001 to 5,892 rides in winter 2009/2010, an 85 percent increase.

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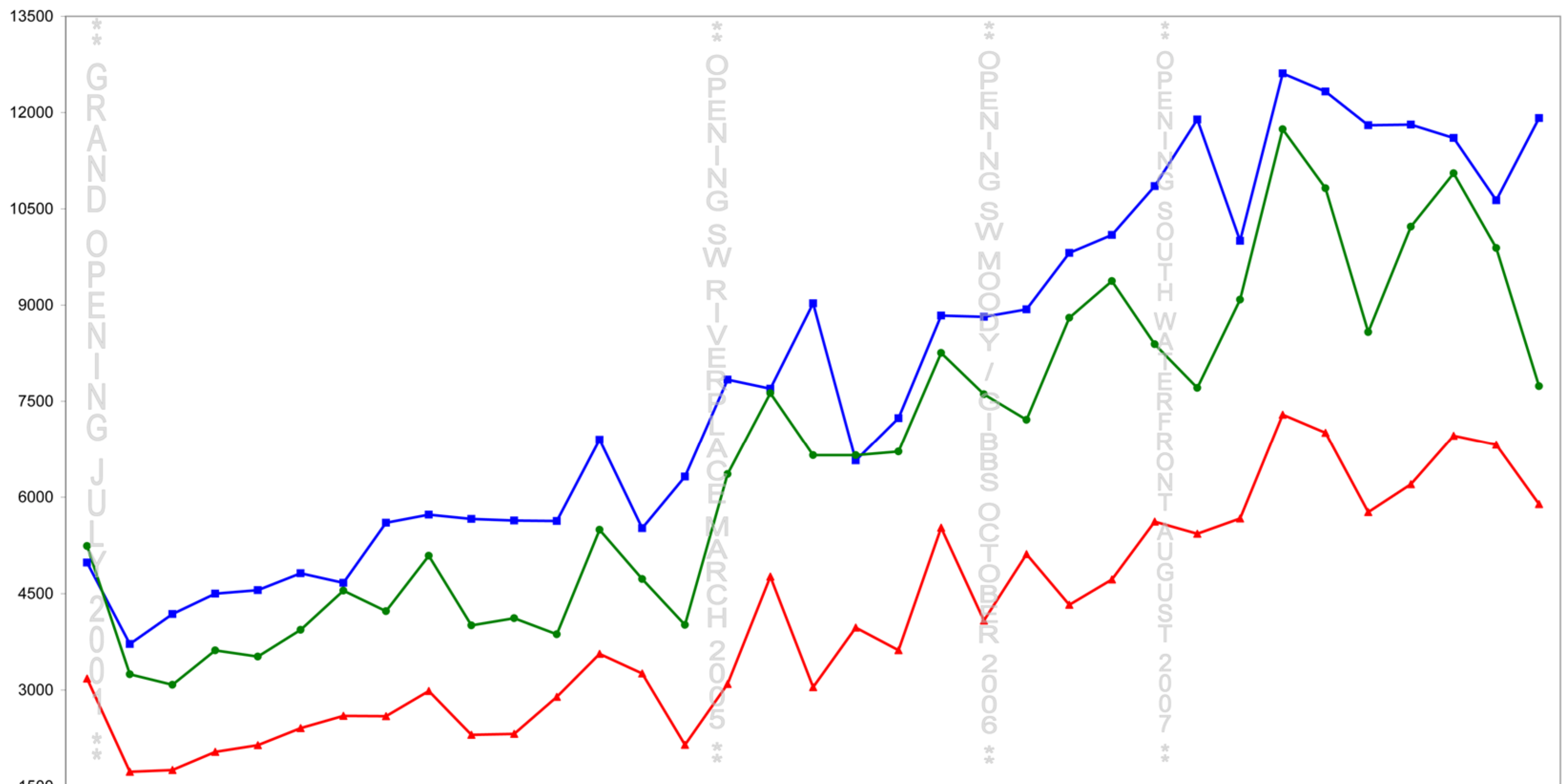
7 Burgress, E and Ashley Road, Reinventing Transit: American Communities Finding Smarter, Cleaner, Faster Transportation Solutions, Environmental Defense Fund, 2009.
8 The Office of Transportation and Portland Streetcar, Inc., Portland Streetcar Development Oriented Transit, 2008.

Figure 2-8: Portland Streetcar Daily Ridership



	Sum 2001	Fall 2001	Win 1/02	Spr 2002	Sum 2002	Fall 2002	Win 02/03	Spr 2003	Sum 2003	Fall 2003	Win 03/04	Spr 2004	Sum 2004	Fall 2004	Win 04/05 <VT>	Spr 2005	Sum 2005
Mon - Fri	4982	3715	4183	4500	4554	4817	4668	5602	5729	5662	5636	5629	6899	5518	6320	7837	7697
Saturday	5239	3244	3082	3617	3521	3937	4545	4227	5089	4006	4116	3866	5492	4727	4012	6359	7627
Sunday	3177	1729	1756	2037	2143	2407	2597	2592	2984	2302	2318	2894	3561	3258	2148	3094	4764

	Fall 2005	Win 05/06	Spr 2006	Sum 2006	Fall 2006	Win 06/07	Spr 2007	Sum 2007	Fall 2007	Win 07/08	Spr 2008	Sum 2008	Fall 2008	Win 08/09	Spr 2009	Sum 2009	Fall 2009	Win 09/10
Mon - Fri	9027	6572	7235	8836	8817	8933	9813	10092	10853	11891	10001	12611	12328	11802	11812	11605	10633	11914
Saturday	6656	6654	6712	8253	7610	7210	8800	9374	8389	7708	9083	11741	10820	8579	10221	11054	9890	7735
Sunday	3043	3971	3618	5524	4079	5113	4326	4720	5620	5430	5668	7290	7007	5767	6201	6959	6819	5892

http://www.portlandstreetcar.org/pdf/

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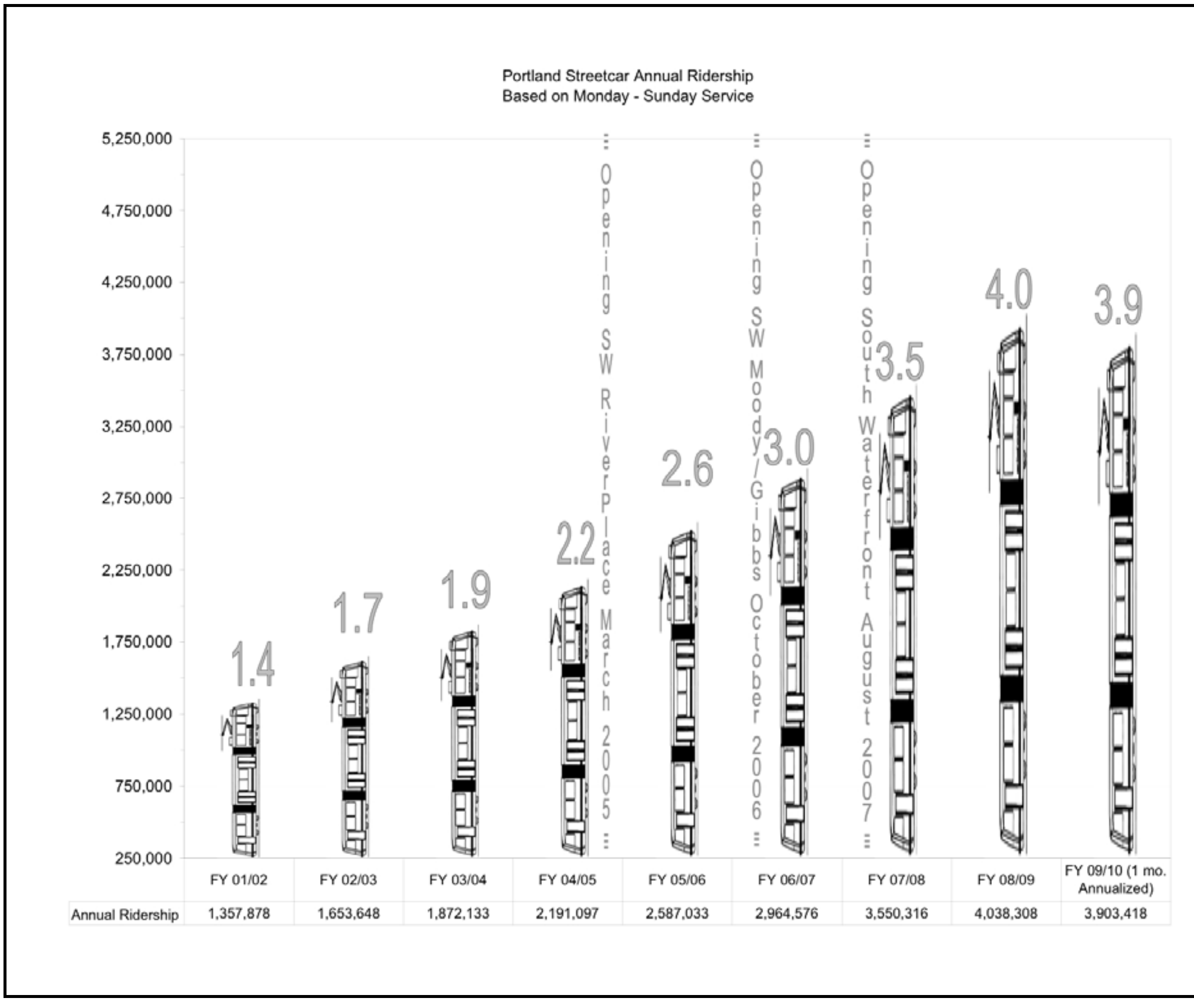
Annual ridership is shown in Figure 2-9. Annual ridership has increased from 1.4 million in FY01/02 to 3.9 million in FY09/10. Each consecutive year has seen an increase, with the exception of FY08/09 to FY09/10. During this time annual ridership decreased from 4.0 million to 3.9 million.

Figure 2-9: Portland Streetcar Annual Ridership



http://www.portlandstreetcar.org/pdf/

The Portland Streetcar reached its highest-ever spring ridership in 2010, while total streetcar ridership in the first half of the year is up by 11 percent over the same period in 2008. This increase occurred despite declining gas prices and a flagging economy that has had a negative impact on transit passenger counts elsewhere.[9]

Although growth prior to 2008 can be attributed to the expansion of the system, transportation professionals and TriMet cannot identify a direct contributor to the recent increased ridership.

9 Williams-Derry, Clark. "Portland Streetcar Defies Gravity', Sightline Daily, Northwest News that Matters, September 14, 2010.

Nothing significant has changed in or near the streetcar route (between 2008 and 2010) that explains the increase. The areas serviced by the streetcar were fully developed by 2008, no new major employers have located on the route, service has not increased, and nearby transit has basically remained the same.[10]

BUS NETWORK

TriMet operates a fleet of 651 buses on a network of eighty bus routes, as shown in Figure 2-10. Thirteen of these routes are designated “Frequent Service” bus routes, running every 15 minutes or better during the weekday morning and afternoon rush hour. TriMet’s bus routes also include express buses from downtown Portland to South Beaverton, Sherwood and Oregon City, and from Marquam Hill to Beaverton, Tigard, Southwest Portland, and Milwaukie, as well as several "cross-town" routes that do not serve downtown Portland.

The Portland Streetcar provides a north-south transit alignment through the western edge of downtown Portland, serving the Pearl District redevelopment area and traveling west to the relatively dense, older neighborhoods adjacent to NW 21st and NW 23rd Avenues. No bus routes previously (or currently) provide a similar north-south connection through the west edge of downtown into northwest Portland. As shown in Figure 2-8, two bus routes connect from central downtown to NW 21st and NW 23rd Avenues (lines 17 and 15, respectively), but they travel along W Burnside Street and do not serve the west edge or the Pearl District.

Lines 17 and 15 do serve many similar destinations in northwest Portland including Legacy Good Samaritan Hospital. Depending on where they access the system, some riders do have a choice between one of the bus routes or the streetcar. Most riders will choose the route that provides the best travel time and the most convenient access and egress. However, surveys have shown that streetcar riders differ quite a bit from bus riders. For example 70 percent of streetcar riders are considered “choice” riders, while only 51 percent of bus riders are choice riders.[11] Fewer than 12 percent of weekday streetcar trips transfer to or from a TriMet bus or light rail line.

BICYCLE INTEGRATION

In addition to the development and popularity of the Portland Streetcar, cycling use has also increased. In theory, bicycles and streetcars are complementary modes. However, in practice, many cyclists feel the Portland Streetcar has deteriorated cycling conditions, creating new hazards.[12] To examine the interaction of these two modes, the Lloyd District Transportation Management Association (LDTMA), whose mission is to support and promote the economic vitality and livability of the Lloyd District through cooperative, business-supported programs promoting efficient, balanced transportation systems, and land use patterns, engaged in a bicycle and streetcar interaction study in 2008.

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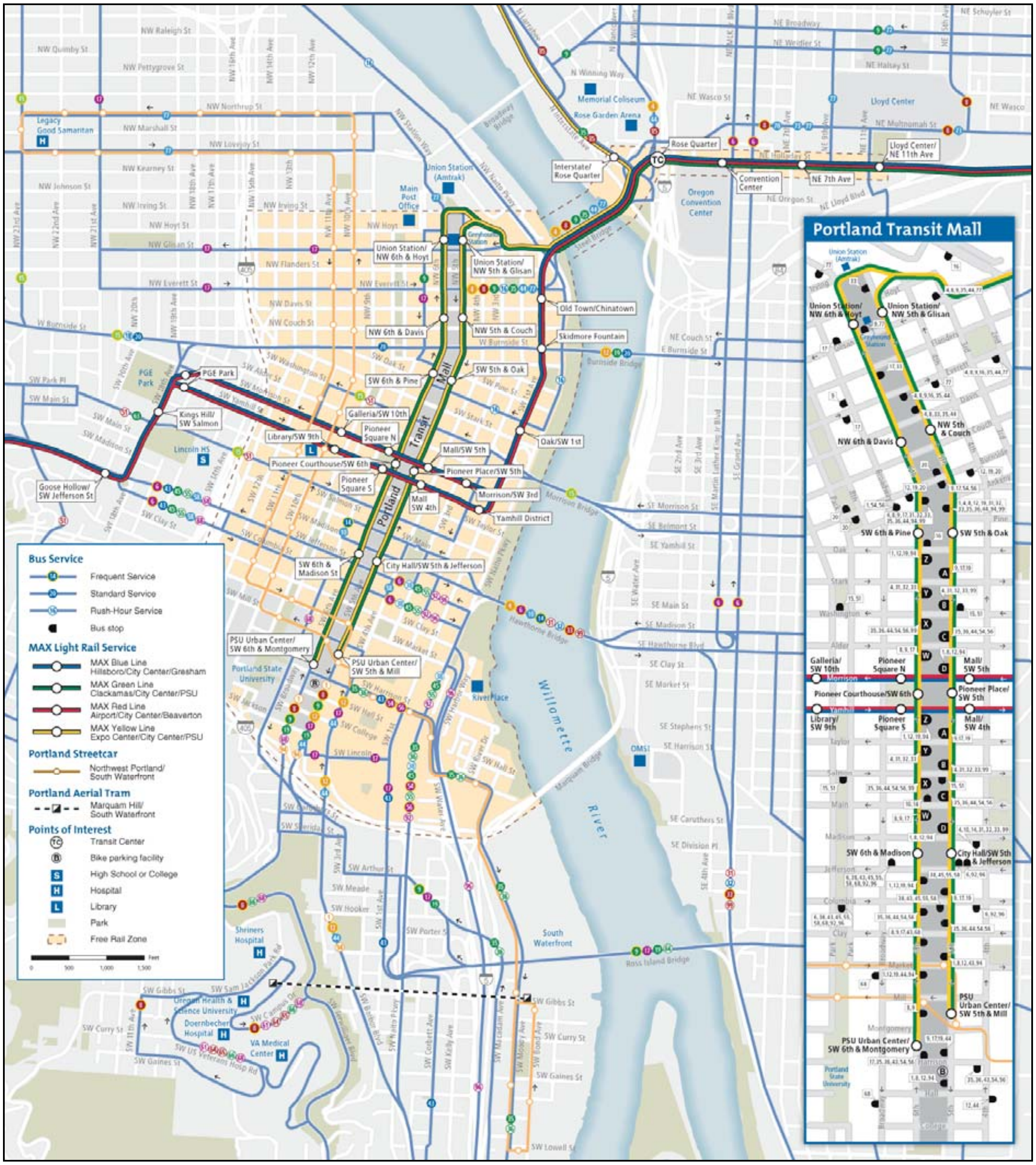
10 Williams-Derry, Clark. “Portland Streetcar Defies Gravity’, Sightline Daily, Northwest News that Matters, September 14, 2010.
11 Draft Portland Streetcar Trips, 2004 Origin/Destination Data, TriMet Marketing Information Department, 2005.
12 Atla Planning + Design, “Bicycle Interactions and Streetcars: Lessons Learned and Recommendations”, Lloyd District Transportation Management Association, October 17, 2008.

Figure 2-10: TriMet City Center Map



http://trimet.org/maps/citycenter.htm

Based on the 2008 study, *Bicycle Interactions and Streetcar Lessons Learned and Recommendations*, streetcar tracks pose a safety issue for bicyclists, and better integration of bicycle facility designs into streetcar planning is essential. Initial Portland Streetcar planning lacked the design guidelines and clear policy guidance needed to integrate streetcar and bicycles.[13] The primary issues for bicyclist-streetcar interaction are further discussed below.

Flange Gap and Angle of Crossing - Bicycle wheels and tires are very susceptible to getting caught within the gap of the streetcar track flange, as shown in Figure 2-11.

Figure 2-11: Flange Gap

http://www.altaplanning.com/App_Content/files/pres_stud_docs/Bicycle_Streetcar_Memo.pdf

Specifically, this situation occurs when a bicyclist is required to cross the tracks at less than a 60 degree angle. When a track "catches" a wheel, a bicyclist may be thrown from their bicycle and possibly suffer a severe, traumatic injury. To decrease the number of crashes caused by bicycle interaction with streetcar facilities, streetcar infrastructure is designed to minimize the number of situations a bicyclist must cross tracks at an unsafe shallow angle, or at a minimum, is designed with as close to 90 degree crossing as possible.

Right-running Tracks - Right-side running tracks and streetcar track curves, as shown in Figure 2-12, may create an instance where a bicyclist riding in the right lane chooses to cross the tracks at an angle less than 60 degrees. This is not desired and can lead to accidents. Center-running and left-running tracks are typically safer scenarios for bicyclists, as they avoid many of the conflicts between side running streetcars and parallel bike tracks.

13 Atla Planning + Design, "Bicycle Interactions and Streetcars: Lessons Learned and Recommendations", Lloyd District Transportation Management Association (LDTMA), October 17, 2008.

Figure 2-12: Streetcar Track Curves

http://www.altaplanning.com/App_Content/files/pres_stud_docs/Bicycle_Streetcar_Memo.pdf

In response to cyclist concerns, where possible, Portland has separated bicycle travel from streetcar tracks, as shown in Figure 2-13. Such bikeway facilities mark cycle tracks or bicycle lanes adjacent to streetcar tracks, with platforms designed to allow bicyclists to bypass pedestrian zones without encountering waiting pedestrians. In addition, signs (as shown in Figure 2-14) and pavement markings can be used to assist cyclists in maneuvering around track curves at safe angles. Portland continues to work with the bicycle community to develop solutions to create a safe environment for both transit and bicycle users.

2.3 Financial Characteristics

CAPITAL COSTS

The total capital cost of constructing the initial Portland Streetcar was approximately $103.2 million, or $12.9 million per track mile. This amount includes less than $25 million per alignment mile and the purchase of seven vehicles for Phase 1, $16 million ($13 million per track mile) for the 0.6 mile extension to RiverPlace and a new roadway for retained structures to provide access to properties along the riverfront (in preparation for an extension to South Waterfront), $15.8 million for the Gibbs Extension ($13 million per track mile) and the purchase of three vehicles, and $14.5 million for the 0.4 mile Lowell Extension ($12 million per track mile).[14]

14 Office of Transportation and Portland Streetcar, Inc., "Portland Streetcar Development Oriented Transit", April 2008.

Figure 2-13: Bicycle Path along Portland Streetcar

Figure 2-14: Bicycle / Streetcar Signage

URS Corporation

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The latest streetcar extension, the Portland Streetcar Loop Project, has a higher cost due to the increase in vehicle and construction costs. This 3.3 mile extension has a total capital budget of $147 million, or $44.5 million per route mile, including vehicles, engineering, administration, and construction.

OPERATION AND MAINTENANCE COSTS

The 2010 Fiscal Year Portland Streetcar operations budget for the four-mile alignment is $5.5 million.[15] Sources for this operating budget include TriMet ($3.2 million), the City of Portland Office of Transportation ($1.8 million), and fares, sponsorship, and promotions ($0.5 million).

Prior to the opening of streetcar service in 2001, the City of Portland and TriMet reached an agreement on responsibility for operating costs. TriMet estimated an approximate cost of $1.6 million per year to operate bus service to the newly developing Pearl District. (However, this estimated bus service was not identical, and was a slightly shorter route compared to the streetcar.) This amount covered two-thirds of the annual streetcar system operating cost of $2.4 million. The City of Portland and fare revenues covered the remaining one-third. At the same time TriMet and the City of Portland signed an Intergovernmental Agreement (IGA) that committed TriMet to provide two-thirds of the funding for the ongoing streetcar operations.

Subsequent to the 2001 agreement, TriMet agreed to provide an additional $400,000 per year for each of the three extensions. In addition, TriMet agreed to increase their annual contribution based on the Consumer Price Index (CPI). In 2009, due to TriMet's financial problems, a revised IGA was signed allowing TriMet to reduce their contribution to streetcar operations by eight percent. By Fiscal Year 2010, the TriMet contribution had decreased to approximately 58 percent of the total Portland Streetcar system operating costs.

The initial proportion of operating cost assigned to TriMet was based on an estimate of bus service savings and the subsequent agreement to contribute $400,000 to operate each extension was also based on a general sense of the potential bus service savings. However, TriMet Board actions recognize streetcar service is an important element of the regional transit system, and is appropriately supported through TriMet general funds regardless of a direct relationship to savings in bus operations.

The City of Portland, fare revenues, and limited private sources (i.e. streetcar stop sponsorship) account for the remaining operating funding (non-TriMet) for the Portland Streetcar. The City funding primarily comes from parking meter revenues and parking fine revenues from geographic areas that are served by the streetcar service.

FUNDING STRATEGIES

Financing of the Portland Streetcar has followed a different path and used a different mixture of funding sources for each segment constructed. The 2.4 mile first phase cost a total of $56.9 million, which was locally funded, making Portland's Streetcar a unique transportation project. The most substantial share of capital costs was financed by a municipal parking revenue bond supported by

15 http://www.portlandstreetcar.org/pdf/capital_and_operations_detail_20100908.pdf

parking fees in the area of the streetcar. Additional local mechanisms relied on value capture, including a Local Improvement District (LID) and a Tax Increment Finance (TIF) District. Major tax-exempt property owners, including Portland State University, pay the LID fee because of the benefits they receive from streetcar service.

The city and the region decided not to seek federal funding for the initial project in part due to other regional priority light rail projects (i.e. Westside MAX) that were seeking New Starts funding during that time period. The region also recognized the complexity involved with attempting to be the first streetcar project funded using the New Starts program.

Funding sources varied as each of the three subsequent, shorter segments were constructed. To date, Portland's Streetcar has been financed by approximately 79 percent local funds, including 19 percent contributed by LID funds, and 21 percent by TIF funds. Funding sources for the current system, including the three extensions, are shown in Table 2-2.

Table 2-2:
Capital Funding Sources

SOURCE OF FUNDS	AMOUNT
Bonds revenues from a parking rate increase in City-owned parking garages	$28.6 million
Tax Increment Funds	$21.5 million
Local Improvement Districts	$19.4 million
Regional Transportation Funds	$10.0 million
City funds	$8.75 million
Connect Oregon	$2.1 million
Reallocated transit funds from TriMet	$5.0 million
Transportation land sale	$3.1 million
Other sources	$4.7 million
Total	$103.2 million

Source: Office of Transportation and Portland Streetcar, Inc.

Funding sources for the fourth stage of streetcar system expansion, which will add 3.3 miles of double-tracked lines and connect the Pearl District in northwest Portland with areas across the Willamette River east of the downtown core, are shown in Table 2-3. This extension will rely more extensively on federal Small Starts funds, with $75 million, or just over 51 percent of the project, federally funded. This was the first streetcar project funded through Small Starts, which required completing an Environmental Assessment and extensive work on ridership forecasting. Local funding from a LID and the Portland Development Commission will contribute 10 percent and 19 percent, respectively.

Table 2-3:
Sources of Funds for Planned Streetcar Expansion

SOURCE OF FUNDS	AMOUNT	PERCENT
Local Improvement District	$15,000,000	10.3%
Portland Development Commission	$27,000,000	18.5%
System Development Charge	$6,000,000	4.1%
Regional Funds	$3,000,000	2.1%
Vehicles from State	$20,000,000	13.7%
Federal Transit Administration	$75,000,000	51.4%
Total Project	$146,000,000	100.0%
Source: Portland Streetcar Loop Fact Sheet, City of Portland & TriMet, September 2007		

ECONOMIC DEVELOPMENT

The Portland Streetcar has been analyzed extensively, primarily in terms of the amount, density, and timing of development it has stimulated.

Existing Development

The initial stage of the Portland Streetcar is credited with stimulating accelerated development of condominiums and specialty retail in the Pearl District, an urban revitalization area. This area garnered substantial press in the late 1990s when a major developer promoting the streetcar concept agreed to build higher densities when streetcar funding was finalized.[16] According to surveys performed for the *TCRP Synthesis 86: Relationships between Streetcars and the Built Environment*, the streetcar was one of many components of a longstanding and ongoing program to revitalize downtown Portland and reshape the city as transit- oriented.

The TCRP surveys also indicated there is no single key factor for streetcar success. Rather, a host of urban amenities have supported the streetcar and contributed to its success in Portland. These amenities include an extensive light rail system, the Fareless Square (free transit service in the downtown[17]), extensive streetscape improvements, substantial allowable density, fine-tuned parking regulations, strong design guidelines and review process, and financial incentives offered by the Portland Development Commission.
There are four distinct areas that have been the focus of streetcar-related development; Pearl District, South Waterfront, Lloyd District, and Central Eastside.

The existing zoning in all four areas is a flexible mixed use zone that allows commercial, employment, and residential uses. In the case of the Pearl District and South Waterfront, these

16 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.

17 Fareless Square was initiated 34 years ago to help address air quality issues, reduce car trips downtown, and increase transit usage. Originally, the transit system consisted of only buses, but has since expanded to light rail and the Portland Streetcar. On January 3, 2010, TriMet's board of directors voted to change Fareless Square to rail and streetcar only. Bus service is no longer free in downtown Portland and the Lloyd District.

zones were implemented as part of master planning efforts. While in the Lloyd District and Central Eastside, this zoning has been in place since the Central City Plan of 1988.

The Pearl District is served by the original streetcar alignment. Much of the area was a former rail yard and redevelopment was planned through a master planning effort that included applying an EX (Central Employment) zoning to the area. This is a mixed use zone that encourages employment but also allows residential. This zone was applied in this area through a public master planning process, which included the streetcar, parks, and other elements. The Portland Development Commission (PDC), the city's redevelopment agency also negotiated developer agreements whereby developers agreed to develop at higher densities after the city provided key infrastructure, such as the streetcar and parks.

The South Waterfront area is served by the south extensions of the streetcar. This is a former riverfront industrial area that was also planned through a master planning effort, including an evolution from industrial to mixed use, a new street grid system, and the streetcar extension. This area currently has predominantly a CX (Central Commercial) zone, which is a mixed use zone that allows for residential development with an emphasis on commercial. This zone allows for some of the highest densities outside of downtown Portland. The PDC also negotiated developer agreements with developers in this area.

The Lloyd District/Central Eastside area will be served by the Eastside Loop Streetcar scheduled to open in 2012. Unlike the Pearl District and South Waterfront, these areas are largely developed. The Lloyd District has the same CX zoning as South Waterfront and the Central Eastside along the future streetcar alignment, generally has the same EX zoning as the Pearl District. All of this zoning was in place prior to the decision to extend the streetcar to these areas. The PDC is working to support streetcar supportive infill development in these areas.

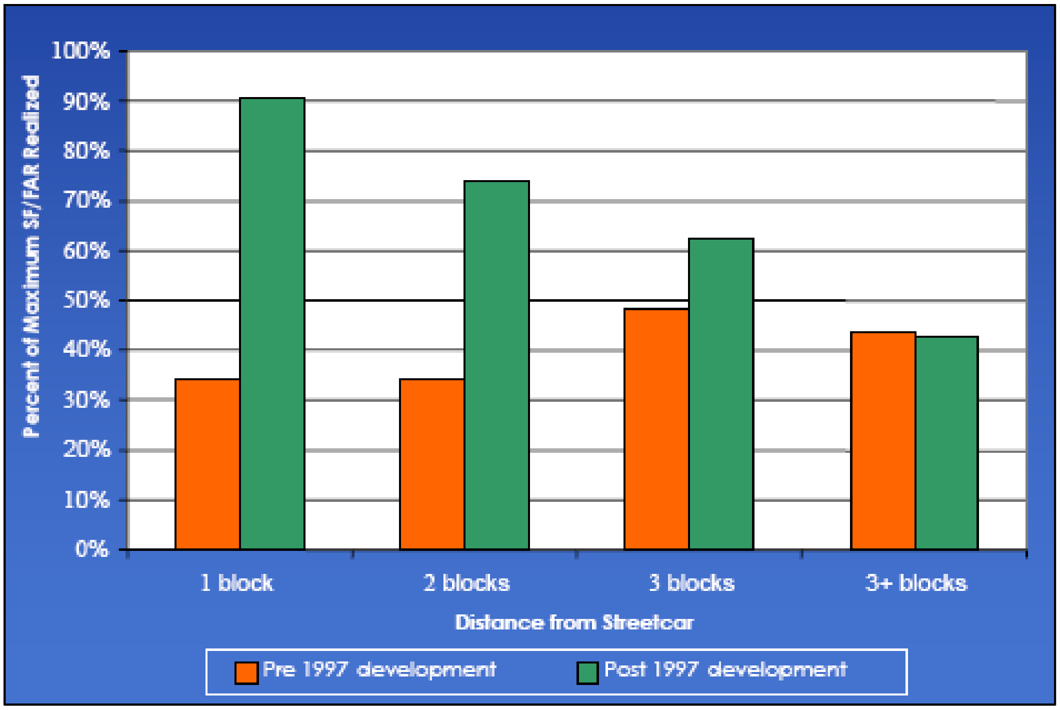
New Development

A 2005 report prepared by E. D. Hovee & Company for Portland Streetcar, Inc. analyzed the development patterns experienced after the streetcar system was announced for downtown Portland. The study looked at new development quantities before and after 1997, based on the number of blocks from the streetcar route, with the one block distance representing three blocks in width, as a result of the double streetcar tracks built with a block in between as well as another block on either side of the track.

Hovee's analysis found that between 1997 and 2004, the blocks adjacent to the streetcar attracted more and denser development. As shown in Figure 2-15, for the blocks adjacent (within one block) to the streetcar tracks, new development averaged 90 percent of allowable Floor Area Ratio (FAR) post-1997, compared to 34 percent before the streetcar. Similarly, for parcels within two blocks of the streetcar tracks, development increased from 34 percent pre-1997 to 74 percent post-1997. The streetcar shifted the attractiveness of sites adjacent or near to its tracks from moderate to high.[18]

18 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010

Figure 2-15: Portland Streetcar Development



www.piketransit.com/downloads/Portland-Streetcar-2-03202006.pdf

Based on a 2006 Portland Office of Transportation study *Portland Streetcar Development Oriented Transit, which* reported 7,248 housing units had been constructed along Portland's streetcar line by the end of 2005, the VMT savings of locating these households within a mixed use, transit-rich environment as opposed to an 'average' suburban environment was calculated. Using the estimated vehicle miles per capita decrease for residents living in mixed use, transit-rich neighborhoods of 9.8 miles, which is 26 percent lower than transit-rich but non mixed use neighborhoods and 122 percent lower than the regional average, the neighborhood around Portland's Streetcar experiences a vehicle mile savings of 60 million.[19]

However, as previously mentioned, other factors contributed to the growth in new development, including local land use policies, the construction of a light rail system, urban renewal, and the ability to use TIF funds to subsidize infrastructure and development projects. Moreover, other development trends were present in Portland at that time, such as increased developer demand for more densely developable sites, the real estate boom for condominiums offering urban lifestyles with high amenities in downtown Portland, and rising land costs.

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19 E.D. Hovee & Company, LLC, Economic and Development, Streetcar-Development Linage: The Portland Streetcar Loop, February 2008.

2.4 Vehicle

TYPE

The Portland Streetcar operates the modern Škoda -Inekon streetcar, as shown in Figure 2-16. The streetcars are a Czech design built in the Czech Republic and shipped to the United States upon completion. They have a low-floor center section between the trucks, one door on each side, and are equipped with an ADA bridge plate that extends from the vehicle doorway to allow wheelchair access, as shown in Figure 2-17. Couplers on the streetcars are hidden behind bumper skirts and are only used to move disabled units back to the yard. This safety feature protects motorists who may collide with the end of a streetcar.

Figure 2-16: Portland Streetcar at the Portland State University Stop

http://en.wikipedia.org/wiki/File:PortlandStreetcar5.jpg

The current fleet includes ten streetcars, supplied between 2001 and 2009, which were built by two different manufacturers. However, they are nearly identical in design. The streetcars have the capacity to carry up to thirty seated and 127 total passengers. Cars 001 through 005 have been in operation since 2001, while cars 006 and 007 were added in 2003. These seven were built by a now-defunct joint venture between Škoda and Inekon.

Figure 2-17: ADA Bridge Plate

URS Corporation

Due to the fact that Portland's fleet of imported streetcars have been reliable and easy to maintain, United Streetcar partnered with Skoda, and in 2006 obtained an exclusive license to manufacture Skoda-designed modern streetcars in the United States.[20] After receiving a $4 million contract to produce the nation's first domestically-manufactured modern streetcar,[21] Oregon Iron Works Inc. unveiled its first streetcar in July 2009.[22] This US-made streetcar will be used as Portland continues with its Streetcar Loop Project and adds additional vehicles to the system. The prototype vehicle, delivered in July 2009, is still in development and not currently in operation.

20 Merry Mackinnon, "Streetcars soon to be made in Oregon," Portland Tribune, May 14, 2009, accessed November 1, 2010, http://www.portlandtribune.com/news/story.php?story_id=124225153770065200.
21 "Oregon Iron Works gets contract for streetcar," Portland Business Journal, January 26, 2007, accessed November 1, 2010, http://www.bizjournals.com/portland/stories/2007/01/22/daily45.html.
22 Joe Brugger, "Transportation secretary watches as 'Made in the USA' streetcar makes debut," The Oregonian, July 1, 2009, accessed November 2, 2010, http://www.oregonlive.com/business/index.ssf/2009/07/transportation_secretary_watch.html.

STORAGE AND MAINTENANCE FACILITIES

The Portland Streetcar has a total of 10 Skoda Streetcars housed at the maintenance facility, which is located at 1516 NW Northrup (under Interstate 405) and also houses the staff of Portland Streetcar. Staff includes 24 Operators, three Superintendents, and five Maintenance Technicians from TriMet, as well as a Manager, Assistant Manager of Maintenance, Manager of Operations and Safety, Assistant Manager of Operations, and two stop and car cleaners from the City of Portland.

TRACTION POWER

A streetcar systems power supply is how electricity from the local electric utility's voltage distribution network is transferred to the streetcar vehicles. This power supply includes the traction electrification system (TES) and overhead-contact stems (OCS) for power distribution. The utility distributes power as alternating current (AC), while the power to the vehicle is direct current (DC). Therefore, the TES substation must contain transformers to convert the power to a usable voltage.

Streetcar vehicles draw power from the OCS by either a trolley pole (a spring-loaded pole with a grooved 'shoe' that straddles the wire and slides along its axis) or pantograph (a `hinged frame or tube with a wide contact surface that slides along the wire and can move laterally). Two configurations are also common for the overhead wires. A simple trolley wire is a single wire hung from pole to pole that conducts current and provides a contact surface for the trolley pole or pantograph. A catenary is a combination of wires, including an upper 'messenger' wire and a suspended contact wire. The simple trolley wire creates less of a visual disturbance. However, the advantage of a catenary system include greater overhead current distribution, greater spacing between support structures, and higher speeds.

When transferring power from the wire to the streetcar vehicles, because it is DC, the electricity must be grounded. Typically this is done by directing the current through the vehicle's steel axles and wheels. An insulation material is then used to ground any return current, avoiding any deterioration to nearby conductors.[23]

The Portland Streetcar TES and OCS power supply system includes a simple trolley wire and pantograph, as shown in Figure 2-18. Substations are spaced closely together at approximate half mile intervals. These substations are approximately 10 feet by 18 feet, small enough to be placed in unobtrusive locations. For example, one substation is situated in a city parking garage, another in an alley near the streetcar route, and several are placed in vaults under the sidewalk. As a result, no costly and disruptive excavation was necessary for underground conduit.

Instead of connecting to a medium- or high- voltage distribution line, which can be costly, the substations tap into the 480-kilowatt commercial power supplied to adjacent buildings. The steel rail, which is embedded in a concrete track slab in the street, is encased in a rubber boot. Due to the close spacing of the substations, parallel buried feeder or return cables are not necessary, and the

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23 The America Public Transportation Association and the Community Streetcar Coalition, "Street Smart, Streetcars and Cities in the Twenty-First Century", Gloria Ohland and Shelley Poticha (Oakland, CA) 2009.

single contact wire is sufficient to maintain line voltages within specified limits. This spacing also reduces the possibility of return voltage traveling to nearby underground pipes and structures.[24]

Figure 2-18: Portland Streetcar Overhead Contact System

http://sustainstl.org/is-a-sustainable-st-louis-solution-found-in-its-past/

24 The America Public Transportation Association and the Community Streetcar Coalition, “Street Smart, Streetcars and Cities in the Twenty-First Century”, Gloria Ohland and Shelley Poticha (Oakland, CA) 2009.

3.0 SEATTLE

The Seattle Streetcar is a 1.3-mile streetcar line of single- and double-track segments serving the South Lake Union neighborhood of Seattle. This system is a new modern streetcar system in full revenue service, in a larger urban setting. The planning process to develop this system provides relevant information and lessons learned for Brooklyn. First, the South Lake Union service was developed in response to a need to provide transit service to a localized area considered to have little or no existing bus or transit service. While Red Hook has an existing bus service, it is perceived by residents to be unreliable and infrequent. In addition, there is no fixed-guideway or subway service. Second, in addition to improving transit service, there was a great interest in promoting economic development in the South Lake Union neighborhood. Similarly, there are opportunities for development in Red Hook. Local investment initiated and continues to heavily fund the South Lake Union streetcar. This was possible due to the size and simplicity of the system. Third, Seattle's streetcar serves a waterfront area similar to Red Hook's waterfront area.

As shown in Figure 3-1, the South Lake Union Line travels from the Westlake hub to the Fred Hutchinson Cancer Research Center in South Lake Union, with stops every three blocks or up to one-quarter of a mile apart. Transfers can be made at Westlake to many bus routes on the surface streets and to some bus routes and Light Rail service in the Downtown Seattle Transit Tunnel's Westlake Station. Service opened in December 2007.

3.1 Planning Process Overview

In February of 2004, the Seattle Department of Transportation began a study in response to the City Council's request for information to "support decision-making about a proposed new route in South Lake Union, and about proposed extensions of the Waterfront Streetcar." The *Seattle Streetcar Network and Feasibility Analysis* provided information about the South Lake Union route and potential Waterfront Streetcar extensions, taking a preliminary look at what a future streetcar network looks like.

There was little to no bus service within this neighborhood prior to the Southlake Union Streetcar. This was primarily due to lack of ridership potential as there was little residential development in the neighborhood. Development of the streetcar was timed with the beginning of a large redevelopment phase of the neighborhood.

As reported in the *Seattle Streetcar Network and Feasibility Analysis*, based on comparing streetcars to other modes and on researching streetcar systems in other cities in North America, the following conditions were identified as contributing to successful operations:

Demand for relatively short trips where speed is not a critical factor. Streetcars are a good application for point-to-point trips in a dense, mixed-use environment. These trips do not necessarily need to be fast because the distances are not great and there may be no time advantage to using a faster mode.

Figure 3-1: South Lake Union Streetcar Service

http://www.seattlestreetcar.org/

Demand for high capacity network connections and neighborhood circulation. Streetcars have a role as neighborhood circulators working in concert with regional transit. Many cities with streetcars report that passengers ride streetcars after transferring from regional routes, despite previously being reluctant to transfer to buses for their distribution trip.

Lack of extreme street congestion and limited competition with high capacity services. Where streetcars operate in mixed traffic, reliability is vastly improved if there is less congestion on the street and limited opportunities for traffic to impede the movement of the streetcar. In addition, streetcar operations are separated from other higher capacity or high frequency routes operating on the same street to minimize space competition.

Demand for high frequency service, but without light rail capacity demands. Streetcars are generally not connected into multi-car trains and therefore do not offer high capacity. Streetcar systems typically run no less frequently than every 15 minutes and are designed to operate reliably. Adding frequency, rather than increasing vehicle size, increases demand.

Mixed uses or a variety of markets. Streetcars are good at serving multiple user markets on a single line, rather than being focused on a single market. Short workday trips are served along with trips for recreation, errands, and tourist activities.

Presence of tourists and occasional users. Streetcars encourage visitors and other occasional users to take transit, especially if the streetcar connects local and regional destinations.

Desire to accelerate planned development. Streetcars alone are not necessarily development catalysts. However, in areas that are likely to develop, a streetcar can help accelerate and organize development, encouraging transit-oriented development.

Property owners willing to contribute to the success of the streetcar. Streetcars benefit when property owners are willing to participate in aspects of the system, including financing and development orientation.

DESIGN CRITERIA

Streetcar design criteria includes: alignment geometry, speeds, roadway cross section, lane selection, traffic signals, and streetcar stops. General guidelines for these criteria are described above for the Portland Streetcar.

ALIGNMENT DECISION PROCESS

The *Seattle Streetcar Network and Feasibility Analysis* began with routes identified by the City Council then broadened to look at additional routes. A more detailed analysis was conducted to provide information to support decision-making about the South Lake Union route or potential extensions of the Waterfront Streetcar.[25]

25 Seattle's Waterfront Streetcar was in operation at the time of the Seattle Street Car Network and Feasibility Analysis; however, service ended abruptly and controversially in 2005 when the land housing its streetcar maintenance facility was taken over by the Seattle Art Museum for a new sculpture garden.

Based on the design criteria explained above, the *Seattle Streetcar Network Feasibility Study* evaluated the following potential streetcar routes:

- South Lake Union from Westlake to Yale
- South Lake Union from Yale to University of Washington
- Chinatown/International District/S. Jackson Street Corridor
- Waterfront North to Interbay
- Waterfront to SoDo and/or T-46

For each of these routes, the following attributes were considered:

- Possible termini
- Demand/market
- Land uses
- Connections to other modes
- Financing potential
- Traffic conflicts
- Dependencies
- Known issues/advantages
- Potential implementation order

South Lake Union. This corridor connects the developing South Lake Union and Denny Triangle neighborhoods with the retail core and major transportation node at Westlake Center. South Lake Union is a former light industrial area that was planned and rezoned for redevelopment to accommodate new office, research, and residential uses. It was designated in 2004 as one of the city's six urban centers where the city seeks to direct most of its residential and employment growth. Historically, the area lacked transit. Thus, the streetcar supported the development of jobs and housing in the area and became an implementing action for the urban center.

This line meets the design criteria and could be built without being dependent on, or interrupted by, any of the major construction projects anticipated in the Center City area. This corridor could be extended to serve the Eastlake neighborhood and destinations in the University district, including the University of Washington medical campus, and/or connecting to the regional transit system at NE 45th Street and Brooklyn Avenue NE.

In preparation for the feasibility of future extensions to the South Lake Union line, the city prepared the *Streetcar Network Development Report*. The previous report included connections to the former Waterfront streetcar that no longer exists. In addition, there are topographical conditions that create grade challenges in connecting the South Lake Union and Downtown Seattle areas to the waterfront via streetcar. Several corridors were identified.

The Central Streetcar Line. This corridor would connect the South Lake Union Line to downtown Seattle, the International/Chinatown District, and Seattle Center (including the Space Needle). This potential line would serve community and tourist events at Seattle Center, the high density residential area of Belltown, downtown Seattle, and the multimodal regional transportation hub served by Link Light Rail, Sounder Commuter Rail, and Amtrak rail.

The First Hill-Capitol Hill Line. This corridor would connect the Capitol Hill and First Hill high density neighborhoods, two colleges, several hospitals, and medical centers to the International District/Chinatown District and the multimodal regional transportation hub described above. This line is currently under design.

The Fremont-Ballard Line. This corridor would extend the South Lake Union Line to the north/northwest, crossing the ship canal into the Fremont and Ballard neighborhoods. These neighborhoods have a mixture of residential, commercial, office, and light industrial uses and continue to increase in density/intensity as redevelopment occurs.

The U-Line. This corridor would extend the South Lake Union Line to the north/northeast, crossing the "Montlake Cut" or ship canal, through the Eastlake neighborhood to the University District and University of Washington. The corridor is currently well served by bus service, and the University will soon be connected by Link light rail. If redundant bus service is removed from Eastlake upon opening of the Link extension, the demand for local service may increase. In addition, the corridor has a major shuttle van connecting the University of Washington Medical Center, Seattle Children's Hospital, and the various cancer research and clinics on Eastlake such as the Fred Hutchinson Cancer Center.

In addition to the *Seattle Streetcar Network and Feasibility Analysis*, the *TCRP: Synthesis 86: Relationships between Streetcars and the Built Environment* performed a survey to obtain first-hand knowledge of the current state of the practice. Table 3-1 includes the survey tabulation for Seattle's South Lake Union Streetcar. As shown in Table 3-1 streetcar route planning was focused on many factors, with only 'Generating affordable or workforce housing' ranking low.

Table 3-1:
Rating of Importance of Route Selection/Planning for Operations

SOUTH LAKE STREETCAR	RATING
Serving commuters to daily job locations	5
Serving tourists and visitors	4
Serving students	3
Connection cultural, entertainment, or civic destinations	5
Connecting with other modes of transit (light rail, commuter rail, bus)	5
Stimulating revitalization	5
Generating affordable or workforce housing	2
Organizing new neighborhoods around transit	5
Compatibility with comprehensive/general plans	5
Notes: 1= NOT important in route planning, 5: VERY important in route planning	

TCRP: Synthesis 86: Relationships between Streetcars and the Built Environment (based on input from the Director of the Department of Planning and Development, City of Seattle and the Streetcar Project Manager, Department of Transportation, City of Seattle)

Future Planning

The next stop for the Seattle Streetcar is the First Hill Streetcar Line. In November 2008, voters in the Puget Sound area approved "ST2", the mass transit expansion plan for the region. This measure builds on the Sound Move plan approved in 1996 to expand light rail, commuter rail, and express bus service. The ST2 Plan includes funding for the First Hill Streetcar connector project, which links First Hill employment centers to the light rail system via connections on Capitol Hill and in the International District. Through an interlocal agreement, the City of Seattle will build this new streetcar line with funding provided through the mass transit expansion measure. The First Hill Streetcar will connect diverse and vibrant neighborhoods on Capitol Hill, First Hill, and in the Chinatown/International District, while serving medical centers.

PRINCIPAL CHALLENGES

Constructability

As previously mentioned, in terms of constructability the South Lake Union corridor had the advantage of being constructed without being dependent on any of the major construction projects anticipated in the Center City area.

Figure 3-2: South Lake Union Streetcar Construction

As reported in the *Seattle Streetcar Network Feasibility Study*, constructing a streetcar network in Seattle was expected to be similar to the construction of peer city streetcar lines, particularly Portland. In the typical construction method for the streetcar track system, the top 12 to 18 inches of pavement is removed and replaced with rail-embedded reinforced concrete slabs within a trench approximately eight feet wide. Using low-cost methods, similar to Portland, construction began, as shown in Figure 3-2, on July 7, 2006 and was completed the following year.[26]

Construction of the South Lake Union Streetcar also involved the installation of traction power substations, relocation of utilities, and upgrading the stormwater detention system.

Utilities

The *Seattle Streetcar Network Feasibility Study* identified potential utility impacts and made the following recommendations.

- Relocate a 12-inch water main adjacent to the northbound track along Westlake Avenue from Olive Street to Denny Way.
- Explore options to minimize impacts of a 20-inch, high-pressure gas main adjacent to the southbound track along Westlake Avenue from 6th Avenue to West Thomas Street.
- Identify possible alignment conflict with overhead power lines along the north side of Fairview Avenue N.
- Identify possible need for reconfiguration to avoid conflicts with the track slabs on Westlake and several electrical vault accesses located between Stewart Street and 8th Avenue.

Following local, state, and federal regulations, potential environmental impacts to the existing combined stormwater system and drainage in the project area arising from the construction and operation of the proposed Seattle Streetcar project were evaluated.

Specifically, a stormwater pollution prevention plan (SWPPP) was prepared consistent with the Seattle Municipal Code 22.800 and the City of Seattle Standard Plans and Specifications for Municipal Construction. The SWPPP was required as a part of the NPDES Baseline General Permit and incorporated Temporary Erosion and Sediment Control (TESC) measures required to minimize sediment runoff during construction. The TESC measures help to avoid or minimize the occurrence of excavated soils and construction materials being deposited on streets or in conveyance piping, and help prevent turbid water from entering Lake Union. The SWPPP also describes the temporary Best Management Plans (BMPs) selected for water quality treatment during project construction.

Similar to Portland, Seattle did not create formal guidelines with respect to utilities. Generally, utilities running parallel to the streetcar and located within five feet of the track slab were relocated. In determining utility relocation, corrosion was Seattle's number one concern, with maintenance access second. To determine the condition of perpendicular crossings, Seattle excavated test holes (or test pits) to verify the size and location of underground utilities. If the existing utility was in poor condition, a casing was installed. Offset manholes were not used.

Laterals were installed as needed during construction, but not for future users. Since construction of the South Lake Union Streetcar, one water lateral has been installed beneath the track slab. Construction was coordinated through the City of Seattle's street maintenance department and progressed smoothly.

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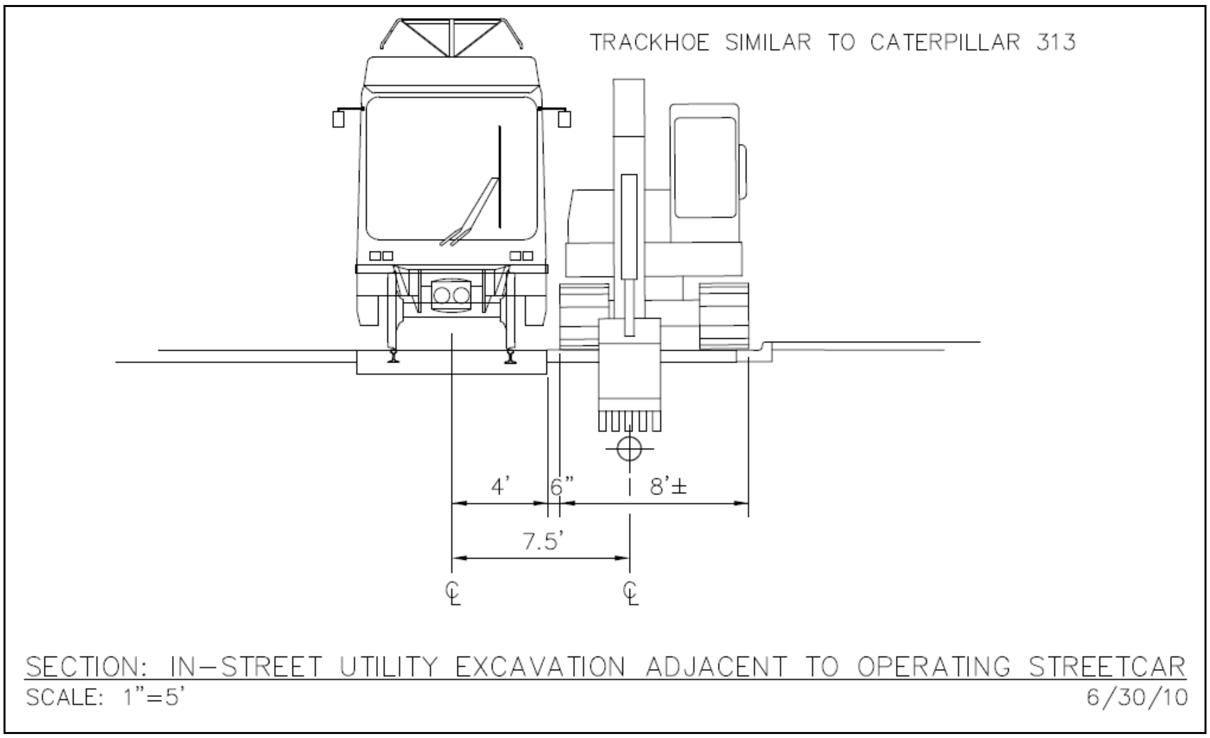
26 Peter Ehrlich, "South Lake Union Trolley/Seattle Streetcar", accessed October 18, 2010, http://world.nycsubway.org/us/seattle/southlake.html

During construction of the streetcar, Seattle Stormwater Department replaced multiple catch basins that were in poor condition. As a result, the Streetcar project exceeded its construction budget for incidental costs (traffic control, pavement patching, etc.). In the future, Seattle will ensure that the costs borne by the utility include incidentals.

In addition, for future streetcar extensions, Seattle plans to reduce relocations by allowing the track to be removed and replaced in sections to accommodate maintenance and repairs to existing infrastructure. The City will perform a "risk analysis" to determine the chance of a utility becoming damaged. In some cases, it might be easier to fix the utility in place in the future rather than relocating it to accommodate the streetcar.

In terms of access to utilities, Figure 3-3 is a graphic URS prepared for Seattle to illustrate to a utility owner the required clearances necessary between the track and the utility pipe in order to maintain access.

Figure 3-3: Utility Clearance



URS Corporation

3.2 System Operations

OPERATING ENTITY

Seattle Department of Transportation (SDOT) owns the South Lake Union Streetcar. However, SDOT does no operate any transit, and at the time did not want to get into the business. Therefore, the streetcar is operated by King County Metro, the public transit authority of King County, Washington, a division of the King County Department of Transportation. King County Metro also operates Seattle's buses, while Sound Transit contracts with King County Metro to operate some of its services. King County Metro staffs the South Lake Union Streetcar operations, and SDOT manages the facilities and other owner responsibilities.

SERVICE PLAN

The South Lake Union Streetcar runs seven days a week at approximately 15-minute intervals during the following hours:

- Monday through Thursday: 6:00 AM to 9:00 PM
- Friday and Saturday: 6:00 AM to 11:00 PM
- Sunday: 10:00 AM to 7:00 PM

These hours of operation are coordinated with other modes of transportation, such as Metro and Sound Transit buses, as well as local and regional events.

Fares

During its inaugural period, December 12 to December 31, 2007, the South Lake Union streetcar was free to ride. The fare was then increased to $1.50, followed by an increase to $1.75, and a final increase to $2.25 per trip as of March 2010. The fare of $2.25 applies to adults, with reduced fares of $0.50 for seniors, youth, and disabled riders. Children under five years of age ride free. Other transit agency passes, such as PugetPass and Metro, are accepted, along with Metro transfers. Fare box revenues cover approximately 20 percent of operating costs.

The South Lake Union Streetcar accepts Metro passes and all Metro transfers. However, Sound Transit and Community Transit transfers are not accepted. In addition, although the streetcar began with its own fare system, the South Lake Union Streetcar is currently being integrated into the regional fare card system called "Orca" (one regional card for all). Orca can be used on Sound Transit "Sounder" regional commuter rail, "Link" light rail or "Express" bus service; WSDOT ferries; KC Metro transit, Pierce Transit; Community Transit; Kitsap Transit; Everett Transit; and now SDOT streetcar. The card may be "filled" with money and used as a debit card, paying for each ride, or as a monthly/annual pass with unlimited rides within a service area.

RIDERSHIP

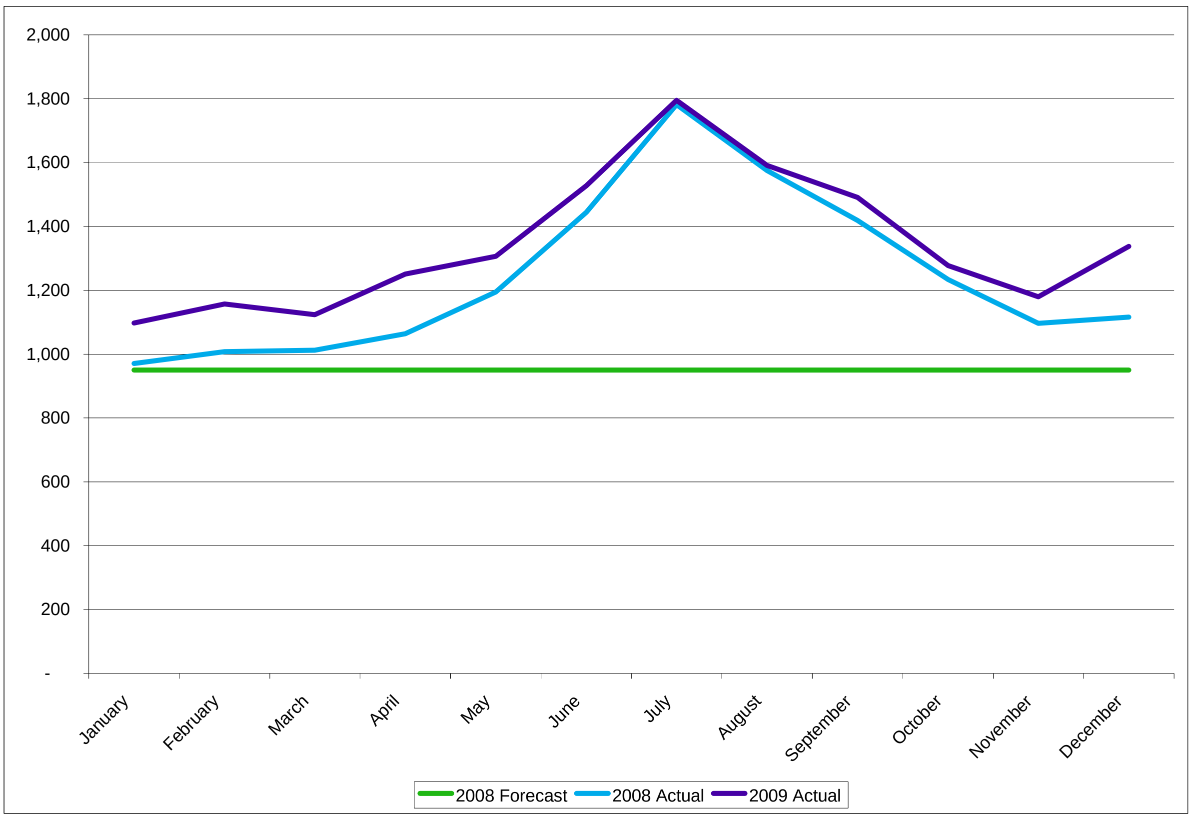
Following the initial free ride period in December 2007, the City predicted 950 daily riders throughout 2008 (7.5 percent of the system's capacity).[27] The 2008 forecast was not adjusted for monthly ridership fluctuations. In planning the South Lake Union Streetcar, the headways were determined by the number of vehicles, not the number of riders. Thus, the streetcar was projected with lower ridership percentages. Just like roads, transit systems are not designed to be at capacity on opening day.

27 Aimee Curl, "Won't You Ride the S.L.U.T?," Seattle Weekly News, January 23, 2008, accessed October 19, 2010, http://www.seattleweekly.com/2008-01-23/news/won-t-you-ride-the-s-l-u-t.php/.

On its one year anniversary, the City announced that 507,000 people had ridden the streetcar, which represents an average of 1,283 riders per day (10.2 percent capacity).[28] Average annual ridership has been approximately 450,000, and trends for 2010 suggest ridership will reach or exceed 500,000 riders for the full year.[29] During the first year of operation, peak ridership occurred during the weekends. However, by the second year of operation, weekday ridership exceeded weekend boardings. As shown in Figure 3-4, average daily ridership in 2008 greatly exceeded forecast ridership. Similarly, 2009 ridership surpassed 2008 actual ridership.

Also shown in Figure 3-4, ridership is highest during the summer months, particularly July. The South Lake Union Streetcar had record ridership in July 2010 with weekday and weekend/holiday average ridership accounting for 2,193 and 1,459 boardings, respectively.[30]

Figure 3-4: South Lake Union Streetcar Forecast and Average Daily Ridership



http://seattletransitblog.com/

28 Office of the Mayor, "Seattle Streetcar: Half million riders and counting, Mayor Nickels announces free rides for holiday season," Press Release, December 10, 2008, accessed October 19, 2010, http://www.seattle.gov/mayor/newsdetail.asp?ID=9117&dept=40.
29 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.
30 Sherwin Lee, August 4, 2010 (7:02 a.m.), "SLU Ridership Reaches a Record in July," Seattle Transit Blog, http://seattletransitblog.com/2010/08/04/slu-ridership-reaches-a-record-in-july/

Based on fare checks, approximately 80 percent of riders have a transit pass, which suggests riders are regular local users of multiple transit modes. Tourist traffic is also significant, as the streetcar itself is an attraction. Additionally, weekend ridership is increasing as riders use the streetcar to get to recreational opportunities.[31] In the future, if ridership outgrows the existing system capacity, headways will have to be more frequent with additional vehicles servicing the streetcar line.

BUS NETWORK

The South Lake Union streetcar connects to Metro bus service, as shown in Figure 3-5. Metro routes 3, 4, 5, 8, 17, 23, 25, 26, 28, 30, 39, 42, 66, 70, 71, 72, 73, 98, and 358 serve the South Lake Union area. Of these, Routes 8, 17, 23, 28, 39, 42, 71, 72, and 73 also serve a South Transit light rail stop. Route 8 (Seattle Center, Capitol Hill, Central District) and Route 25 (Montlake, University District, Laurelhurst) make convenient, useful connections at selected streetcar stops.

The streetcar also connects to SoundTransit's Central Link Light Rail, running between downtown Seattle and the Seattle-Tacoma International Airport. Service operates seven days a week, from 5:00 AM to 1:00 AM Monday through Saturday and from 6:00 AM to midnight on Sundays. Central Link passengers can transfer to the South Lake Union Streetcar at the Westlake stop.

Additionally, the South Lake Union Streetcar connects to the Seattle Center Monorail, providing service between downtown Seattle and the Seattle Center. The Monorail departs every ten minutes (every five minutes or less during special events) from the station at Seattle Center (across from the Space Needle) and from Westlake Center Mall (at Fifth and Pine Street). Each trip takes two minutes to cover the one-mile route. Each train can carry up to 200 passengers per trip. At Westlake Center, as shown in Figure 3-6, passengers can transfer to the South Lake Union Streetcar.

31 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.

Figure 3-5: Metro Transit Downtown Seattle

http://metro.kingcounty.gov/tops/bus/area_images/CBDSeattleMap_1010.pdf

Figure 3-6: Westlake Hub on the opening of the Streetcar

http://sdotblog.seattle.gov/2009/08/12/making-connections/

In addition to integration with the Seattle bus network, each of the eleven streetcar stops are conveniently located a short walk from other transportation hubs. The Westlake Center is a transportation hub that serves as the terminus for the streetcar and Seattle Center Monorail terminus with stops for Metro buses and Sound Transit's Link Light Rail. The last streetcar stop on Westlake is approximately 1.5 blocks north of the Westlake Link light rail tunnel station. Streetcar-bus connections are within one to two blocks.

BICYCLE INTEGRATION

Seattle's streetcar system integrates with bicycle planning by allowing bicycles in the center section of streetcar vehicles. However, as previously described for the Portland Streetcar, bicycle and streetcar interaction can create safety issues. The safety of Seattle's Lake Union Streetcar tracks in relation to bicyclists has been receiving negative attention.[32] Bicycle tires can become caught in the track flange that holds the streetcar wheel within the train. As reported by the Seattle Times and local television stations, several bicyclists suffering crashes due to the tracks recently filed a lawsuit. For future lines, the City is leaning towards a median running streetcar to avoid conflict with bike lanes adjacent to the curb.

32 Millie Magner, "Bicycling and the South Lake Union Streetcar," Examiner, June 5, 2010, accessed October 26, 2010, http://www.examiner.com/bicycle-transportation-in-seattle/bicycling-and-the-south-lake-union-streetcar.

3.3 Financial Characteristics

CAPITAL COSTS

The total capital cost of constructing the South Lake Union streetcar line was approximately $50.5 million. This amount included $25 million from a Local Improvement District (LID) and $25.5 million provided by various local, state, and federal sources.

OPERATION AND MAINTENANCE COSTS

Similar to the share of capital costs, the City of Seattle planned to leverage local support for the operation and maintenance of the streetcar system. The two phase Operations and Maintenance Financing Plan involved a partnership between the City of Seattle, King County Metro, and the private sector. Although the streetcar would be operated by King County Metro, operating costs would be covered through investment from the city and other agencies or organizations.

As reported in the 2005 *South Lake Union Streetcar Capital Financing and Operating and Maintenance Plan*, Table 3-2 summarizes planned revenue sources for Phase One of the South Lake Union Streetcar Operations and Maintenance Financing Plan, which began with the initial streetcar service and extended through mid-2009.

Table 3-2:
South Lake Union Phase One Projected Operation and Maintenance Expenses and Sources

	2007	2008	2009 (JAN – JUN)	TOTAL
O&M Expense	814,176	1,592,649	777,118	3,183,943
Revenue Sources				
Farebox Recovery	123,750	286,318	163,053	573,120
FTA 5307/5309	63,000	131,040	68,141	262,181
Operations Fund[1]	627,426	1,175,292	545,924	2,348,641

1. Operations Fund sources include the sale of sponsorships and the bulk purchase of streetcar passes.

2005 South Lake Union Streetcar Capital Financing and Operating and Maintenance Plan

As shown in Figure 3-2, a large percentage of operation and maintenance expenses would be funded by private contributions through the Operation Fund. The Operations Fund includes revenues from a sponsorship program (including the sponsorship of vehicles and stations), participation in a Streetcar Amenities Guide, and bulk ticket pre-sales. Bulk tickets sales are not included in the farebox recovery, which is defined as revenues the streetcar accumulates in farebox and fare revenue from trips made using the Orca card through the Regional Fare Collection Agreement with local transit agencies such as Metro and Sound Transit. One example of bulk sales is through employers in the South Lake Union area as the streetcar can assist in meeting Commute Trip Reduction goals, a Washington State regulation.

Table 3-3 summarizes planned revenue sources for Phase Two of the South Lake Union Streetcar Operations and Maintenance Financing Plan, which began in the summer of 2009.

Table 3-3:
South Lake Union Phase Two Projected Operation and Maintenance Expenses and Sources

	2009 (JUL – DEC)	2010	2011	2012	2013	2014	2015	2016
O&M Expense	777,118	1,592,158	1,631,007	1,670,804	1,711,571	1,753,334	1,796,115	1,839,940
Revenue Sources								
Farebox Recovery	163,053	366.888	408,691	451,538	495,457	540,473	586,615	633,910
FTA 5307/5309	68,141	141,733	147,402	153,298	159,430	165,807	172,440	179,337
Operations Fund[1]	85,375	164,585	158,177	151,518	144,598	137,408	129,935	122,170
King County Metro	460,549	918,952	916,737	914,449	912,086	909,645	907,125	904,522

1. Operations Fund sources include the sale of sponsorships and the bulk purchase of streetcar passes.

2005 South Lake Union Streetcar Capital Financing and Operating and Maintenance Plan

During Phase Two, three important transportation projects were scheduled to occur: Sound Transit's LINK Light Rail service, the Seattle Monorail Project's Green Line, and the Alaskan Way Viaduct and seawall project. These transportation projects will have a substantial impact on transit delivery in Seattle, and the South Lake Union streetcar will provide an important feeder service to both systems at the Westlake multi-modal hub. As a result, King County Metro will pay 75 percent of the operations of the streetcar after farebox recovery, and city of Seattle will pay the remaining 25 percent through the Operations fund and the Federal Transit Administration funds.

As referenced in the King County Metro Transit, *2007 Annual Management Report*, public transportation fund revenues included $678,478 in South Lake Union Streetcar non-operations fund revenues. Of the $678,478 in non-operation fund revenues, $110,220 was used for transit operations and $568,258 was used for capital expenses. In 2007, operating expenditures for the South Lake Union Streetcar totaled $148,167. Operations included providing design, facility, and vehicle maintenance support, as well as staff training and customer information for start up of the South Lake Union Streetcar.

As reported in King County Metro Transit, *2008 Annual Management Report*, 2008 the South Lake Union Streetcar contributed $2,382,572 in non-operation fund revenues to King County's public transportation fund. Of this amount, $2,194,965 was allocated for transit operations and $187,607 was allocated for capital expenses. In 2008, operating expenditures for the South Lake Union Streetcar totaled $1,915,893, which is slightly higher than the original projections.

FUNDING STRATEGIES

In 1981, waterfront businesses formed the LID to contribute $1.1 million to the construction of the waterfront streetcar. The LID was advantageous because the South Lake Union area has several major property owners participating with the City of Seattle on revitalization.

To estimate the value of a LID, an assessment for each parcel must be agreed upon. This assessment is based on 1) the special benefits the parcel receives as a result of the improvement relative to the total special benefits accrued to the LID; and 2) the amount of the project the LID will pay for. In Seattle, the special benefits were determined through an appraisal process called a "Special Benefits Study," which measures the special benefits, or the increase in value, experienced by parcels as a result of a public improvement project. Instead of utilizing a strict engineering-style approach to allocate assessments to properties on square footage of land, distance from station, lineal foot, or some other physical relationship, the City of Seattle valued the before and after values of each property within the LID. The difference constitutes the special benefits.

The Final Special Benefits Study found that in the aggregate, the before value of all properties in the LID zone totaled $5.385 billion, and the after aggregate value was $5.454 billion. This represents a "special benefit" value of $69 million. Because the City of Seattle was seeking to assess a total of $25.7 million through the LID assessment process, it captured 38 percent of the "special benefits" value indicated.[33]

The adoption of the LID worked well because the South Lake Union area has several major property owners participating with the city of Seattle on revitalization, including Vulcan Properties (a private development company) and the University of Washington. The University, as a tax-exempt entity, still pays the LID fee because of the benefits it receives from the streetcar line. In addition, the proposal to develop a streetcar in South Lake Union attracted the support of property owners. Adjacent property owners formed a group called "Build the Streetcar" to advocate for and support the LID.

ECONOMIC DEVELOPMENT

The South Lake Union has become an attractive new area for development in Seattle. As reported in the *Transportation Cooperative Research Program (TCRP): Synthesis 86: Relationships between Streetcars and the Built Environment*, without the streetcar (or improved bus service), it would have been much harder to attract firms. The area has attracted company headquarters, including Amazon.com, Group Health Coop, and PATH. Part of the attraction for these companies is the campus feel of the area and the convenient connection to the Central Business District. The streetcar, as part of a broader strategy, is credited with giving the South Lake Union area an advantage over other areas of the city.

In terms of marketing, the streetcar has had an impact on the development market, with projects being sold and promoted as being on the line or within one block of the line. Vulcan, as the major land owner in the area, has been careful to bring the types of retail it considers most compatible, avoiding an emphasis on national retailers. City staff sees the success of the area as a combination of the urban center zoning, Vulcan's actions, and the development of the streetcar.[34]

33 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.
34 Golem, R. and J. Smith-Heimer, TCRP Synthesis 86: Relationships between Streetcars and the Built Environment, Transportation Research Board, National Research Council, Washington, D.C., 2010.

New Development

Washington State does not allow tax increment financing and is limited in terms of the types of financial incentives it can offer developers or businesses. As such, zoning is the primary controlling incentive used for municipal planning. Most new development in the area is being built to the maximum zoning allowances.

As one of six urban centers, the City increased height limits to 90 feet to allow denser development in South Lake Union. Previously, height limits were specifically increased to accommodate biotech and allow an 85-foot, five-story building. In addition, all parking requirements were eliminated, allowing the market to determine the necessary parking. Public parking garages are not available in the area, and the nearest garage is at the Seattle Center.

Changes in Future Land Use Plans and Regulations

The City of Seattle is now working on site-level zoning regulations for its comprehensive plan and is looking to increase height limits to allow high-rise buildings and density. The streetcar is viewed as supporting greater height and density.

In addition, following Vulcan's lead in obtaining LEED building certification from the U.S. Green Building Council, much of the development along the line is seeking LEED certification. Future zoning changes allowing greater downtown heights and densities may lead to a future City requirement for projects to obtain LEED Certification to be eligible for density bonuses.

The City has adopted a concept for streetcar expansion to continue the line north across Lake Union toward the University of Washington, as well as to other established urban neighborhoods. Other lines would run through the downtown area to various destinations and down through to West Seattle.

3.4 Vehicle

TYPE

The South Lake Union streetcar uses the Inekon TRIO 12 vehicle, as shown in Figure 3-7, a double-ended, three-section articulated electric streetcar with a low floor center section.[35] The Inekon TRIO 12 streetcars have the capacity to carry up to 140 passengers (27 seated) and feature regenerative braking, on-board passenger information system with audible announcements and digital displays, and a Global Positioning System (GPS) system for real-time arrival information at stations and on the internet. The streetcar stations feature raised platforms for easy boarding and digital displays of real-time arrival information.

35 This is the same vehicle as used in the Portland system, but with modifications.

Figure 3-7: South Lake Union Streetcar on Test Ride

http://www.inekon-trams.com/seattle_streetcar.html

Each streetcar features three sets of doors on each side: one-panel at each end next to the cab and double two-panel sets in the lower passenger area. Under one of the two-panel door sets on each side of the streetcar, there is a retractable bridgeplate that allows disabled passengers to board the vehicle. The system is controlled by the operator with passenger request controlled by interior/exterior push-buttons that feature stripe switches and Intercom system. Passenger counting is accomplished by the INIT passenger counter with sensors mounted above each door set.

STORAGE AND MAINTENANCE FACILITIES

As reported in the 2005 *South Lake Union Streetcar Capital Financing and Operating and Maintenance Plan*, a maintenance facility at the southwest corner of Fairview Avenue N and Valley Street was built as part of the South Lake Union Streetcar for daily vehicle maintenance and inspections and minor repairs. This maintenance facility building is approximately 112 feet by 55 feet, eight inches. Two additional yard storage tracks were also built.

TRACTION POWER

Seattle used a similar traction power system as the Portland Streetcar. For stray current, one of the interesting things Seattle did was to use a different concrete mix with resistivity for the track slab, in addition to rubber boots.

Specifically, for the future First Hill Streetcar, the streetcar will be powered with a traction power system featuring traction power substations (TPSS) and an overhead contact system. Up to four TPSS may be required. The City and King County Metro are analyzing the potential for some of the substations to be joint use of existing Metro trolley bus substations. The City also has reserved space for a TPSS within the City-owned King Street Station. Sound Transit has designed the Capitol Hill

Station of the University Link Light Rail project to provide space for a future streetcar TPSS. If joint use of the Metro TPSS is not pursued, TPSS are commonly located in existing parking garages or parking lots close to a streetcar alignment, through agreements with the facility owners.

4.0 PHILADELPHIA

Route 15 (Girard Avenue Trolley) is an approximately eight-mile heritage streetcar line along Girard Avenue and Richmond Street through North and West Philadelphia. This system was selected for review as a case study because it demonstrates the re-use of PCC heritage streetcar vehicles and existing infrastructure. The borough of Brooklyn, including the Red Hook neighborhood also had a historical streetcar system, which used PCC cars. In addition, the Route 15 Trolley is located in a northern climate, similar to Brooklyn, and in relatively close proximity to New York allowing study site visits. Some of the operating conditions experienced by SEPTA would be similar in Red Hook, as both areas have similar street widths (narrow) and on-street parking. While this system is not the only example of PCC cars in operation today, it does demonstrate the lessons learned, both positive and negative, of returning a former streetcar line into regular revenue service using heritage streetcar equipment.

The line began operation in 1895 between Richmond and Norris and 54th and Girard. In 1902, the route was extended to 63rd and Girard, and in 1903, service was further extended to Richmond and Allegheny. In 1956, trolley service continued turning at the Richmond Loop at Westmoreland Street.[36] Service was suspended and replaced with buses in 1992, due to escalating streetcar maintenance costs associated with the aging fleet of streetcar vehicles. Trolley service was restored in September 2005, when SEPTA was awarded federal funding to restore PCC cars and rehabilitate the existing streetcar track and infrastructure.

As shown in Figure 4-1, the western terminus is at the intersection of Girard Avenue and 63rd Street. Traveling east Girard Avenue and Route 15 briefly overlap, along with the Route 10 trolley. After crossing over the Paoli/Thorndale Line at the intersection with Belmont Avenue, the line passes by the Philadelphia Zoo, loops partially around the south side of Girard College, rejoins Girard Avenue, and passes St. Joseph's Hospital. Further east, Route 15 crosses the Broad Street Line's Girard Station and the Route 23 bus line. Girard Avenue ends at Exit 23 on Interstate 95, where it connects to the Route 60 bus, another former trolley line.

4.1 Planning Process Overview

The Route 15 began service as one of the city's bustling electric rail lines. Philadelphia neighborhoods were built along the various trolley lines, which were first operated by independent companies and later combined into the Southeastern Pennsylvania Transportation Authority (SEPTA). The operation of Philadelphia's trolley lines was challenging, because although SEPTA operated the trolley service, they did not own or operate Philadelphia's city streets. However, SEPTA was responsible to maintain the portion of the city street between the rails.

In 1992, the last of the three trolley lines – Route 56, Route 23 (the longest line in the World), and Route 15 were eliminated. The decision to temporarily suspend streetcar service was a result of the aging infrastructure and equipment, and the realized cost savings of replacing the lines with bus service.

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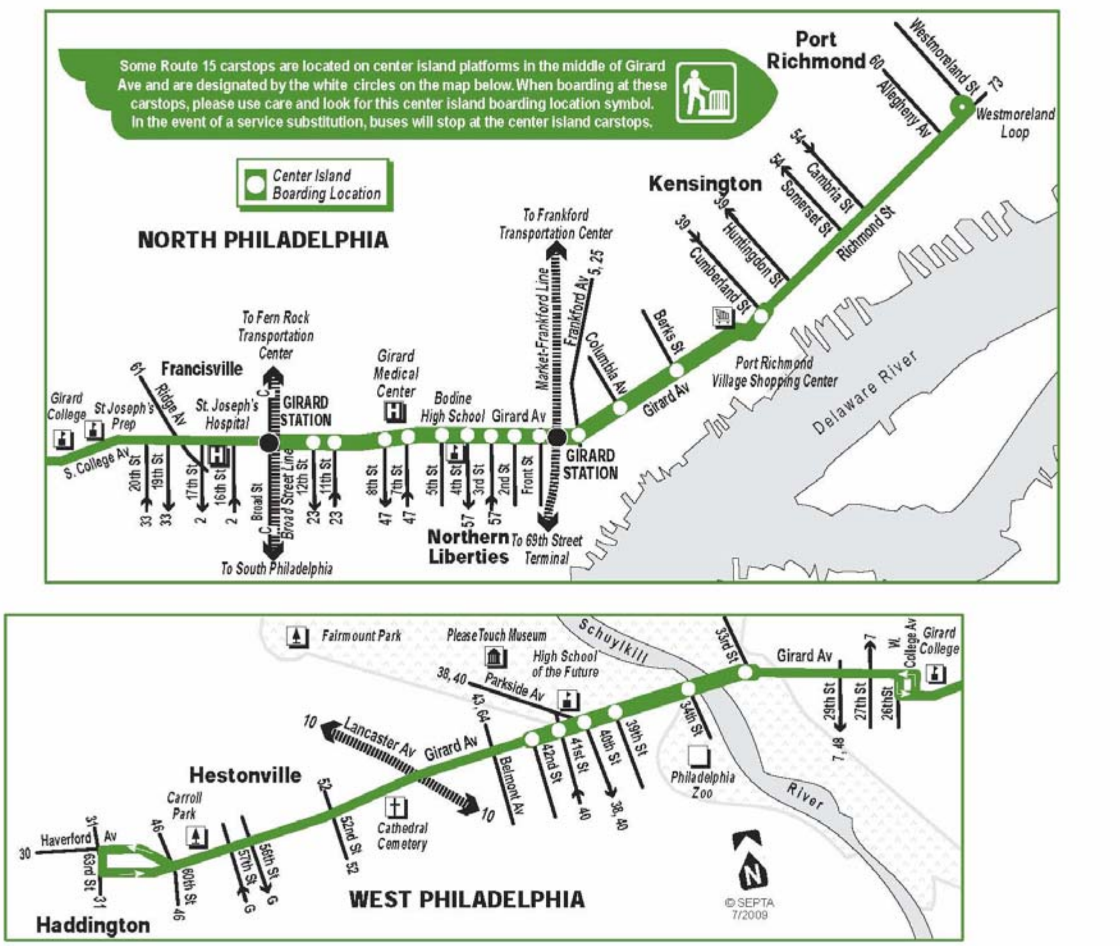
36 Philadelphia Trolley Tracks, "1974 Brochure: The History of Trolley Cars and Routes in Philadelphia", accessed November 2, 2010, http://www.phillytrolley.org/1974history/8-9.html.

Figure 4-1: Route 15 Trolley Line Map



http://www.septa.org/maps/trolley/pdf/015.pdf

Route 15 was replaced with diesel bus service in 1992 with a promise that trolley service would be reinstated in 1997. During a September 1997 City Council hearing, SEPTA General Manager Jack Leary announced SEPTA's plan to restore trolley service as an upgraded light rail, with articulated light rail vehicles, which can operate on both subway and street surfaces.[37] However, due to lack of funding, SEPTA was forced to pull back on this commitment.

The return of trolley service to Girard Avenue was then initiated by a local string of communities, with strong political support, who argued trolley service triggers economic development. The group of active and vocal citizens, known as the Trolley Jollies, was intent on seeing streetcar service returned.[38] Route 15 returned to trolley service in September 2005.

37 Philadelphia Trolley Tracks, "Route 15 / Girard Avenue Trolley", accessed December 13, 2010, http://www.phillytrolley.org/route15.girardavenue.html
38 Samuel Scheib, "Through the Looking Glass", *Trip Planner Magazine*, Fall 2009.

DESIGN CRITERIA

Streetcar design criteria includes: alignment geometry, speeds, roadway cross section, lane selection, traffic signals, and streetcar stops. General guidelines for these criteria are described above for the Portland Streetcar. However, because Route 15 was a previous trolley line, an existing streetcar track was in place. Some track reconstruction work and traffic signalization was necessary, as described later in the Constructability section.

ALIGNMENT DECISION PROCESS

Route 15 used the original Girard Avenue alignment, which had been replaced by diesel buses from 1992 through 2005. Although the decision to replace the line was trigged by anticipation for economic growth along the corridor, the process lacked the master planning approach, as presented with both Portland and Seattle. The alignment decision process for Route 15 was focused on restoring the existing service (as promised), rather than considering investment opportunities for a 21st Century Philadelphia. Variants to the original Girard Avenue alignment were not considered.

A majority of the Route 15 alignment has a median ROW, with both near- side and far-side stops. This ROW is legally restricted to trolleys and left-turning vehicles at certain intersections, but it is not physically protected. As a result, the ROW is widely used for left turns and through traffic. In addition to generating delays through queue volumes, these illegal traffic flows increase the chance of accidents or disruptions, degrading the trolley rider's experience and weakening the potential for economic development benefits.[39]

PRINCIPAL CHALLENGES

Service Reliability

Since the Route 15 trolley line was reinstated in 2005, SEPTA has experienced reliability issues. Most of the line runs within mixed traffic, along narrow streets, as shown in Figure 4-2. In years past, Girard Avenue's roadway cross sections were of sufficient width to allow simultaneous operation of both streetcar vehicles and automobiles. However, as the prevalence of larger vehicles such as sport utility vehicles (SUVs) has grown, the corridor's narrow streets are no longer as accommodating. Operating space is further compromised during the winter months when there is snowfall. Along Route 15's narrow streets (which are similar to Red Hook's narrow streets, as shown in Figure 4-3) it is not uncommon for a trolley to be blocked by a double parked vehicle, as streetcars can only travel along the provided tracks. Frequently, streetcar operators must stop the streetcar and exit the vehicle to move an adjacent vehicle mirror that is blocking the streetcar ROW. In addition, SEPTA's has used vehicles equipped with bumpers designed to move double-parked vehicles out of the way.

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39 Delaware Valley Regional Planning Commission, "Speeding up SEPTA, Finding Ways to Move Passengers Faster, 2008.

Figure 4-2: Route 15 Narrow Streets

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Figure 4-3: Red Hook Narrow Streets

URS Corporation

Moreover, there are numerous segments where the trolley right of way is intended to be exclusive, but is unprotected aside from fairly unobtrusive overhead signage. This leads to a circumstance where no segment is exclusive in reality.[40] As a result, delays occur on a daily basis, due to various reasons (i.e. traffic incidents, emergency situations, and weather conditions). A majority of these delays last 15 to 20 minutes; however, some delays, for example those attributed to major traffic accidents can last much longer.

The Delaware Valley Regional Planning Commission 2008 Report, *Speeding up SEPTA, Finding Ways to Move Passengers Faster*, reported Route 15 incident delays from May 2007 through July 2007. Based on this data, incidents of many types occur throughout the Route 15 alignment, and in aggregate, generate more than one full day of delay. The chief delay generator during this period was emergency personnel activity, followed by vehicles parked too close to the rail.

Service can also be interrupted due to the low clearances along some portions of the corridor, clearances, as shown in Figure 4-4. Despite warning signage, overhead contact system wires are regularly torn down at locations where there are low clearances Additionally, the establishment of center island platforms resulted in unexpected accidents by motorists. These accidents further exacerbate delays.

Figure 4-4: Route 15 Overhead Contact Wire Clearances

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During heavy delays, or when the system requires maintenance and is shut down, substitute bus service is instituted. Buses are selectively pulled from various lines to provide substitute service. To

40 Delaware Valley Regional Planning Commission, "Speeding up SEPTA, Finding Ways to Move Passengers Faster, 2008.

minimize impact, track work is typically planned during the summer months, when transit demand is lower.

Constructability

The restoration of Route 15 incorporated actuation of traffic signals and traffic signage and replaced traffic signal controllers at 36 intersections along Girard Avenue. The new controllers are interconnected with fiber optic cable to allow progression to the City of Philadelphia's signal network. This allows interactive communications and programming from the City's central control facility to correct signal malfunctions, implement progression schemes, and diagnose on-street operational problems as they occur. As reported by SEPTA, this communication network is used regularly. When an incident occurs, a message is sent to the control center, and the significance, associated delay, and mitigation measures are determined. Also reported by SEPTA, the Route 15 trolley runs without traffic signal preemption.

Associated intersection hardware, such as traffic signal heads, poles, conduit, cable, junction boxes, and regulatory signs, were replaced as needed. Construction also included the rehabilitation and/or construction of new substations, feeders, cables, overhead, and track. Approximately 25 percent of the track was replaced. Construction began in January 2002,[41] and progressed at a rate of approximately one block every two weeks.

As part of the track work, pedestrian islands, as shown in Figure 4-5, were added to accommodate wheelchair loading and unloading. The pedestrian islands from the previous trolley service were very narrow and did not meet ADA regulations. Even with the new ADA-compliant pedestrian islands, about one third of the Route 15 bus stops were discontinued because there is no safe place for wheelchair loading and unloading.[42]

Utilities

During construction, locating the underground utilities became a major issue along segments of the alignment, and at least one incidence of breaking an existing water main occurred, according to SEPTA officials involved in the track reconstruction. There were also numerous times when work affected unexpected utility connections to adjacent homes. Much of this was due to a lack of accurate as-built drawings reflecting the location of utilities. SEPTA officials indicated that the initial estimates to "rehabilitate" the system proved to be less than what was actually required, and the allotted budget for the entire project turned out to be insufficient given the conditions encountered during construction.

41 SEPTA Capital Projects Update, Flexible Funded Projects, January 2008, accessed November 2, 2010, http://www.septa.org/reports/pdf/flexprojects08.pdf.
42 Samuel Scheib, "Through the Looking Glass", Trip Planner Magazine, Fall 2009.

Figure 4-5: Route 15 Pedestrian Islands

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Post construction, SEPTA coordinates with the city utility departments when access or repair is necessary. For example, if the water department has a problem and needs to dig into the track to access a water pipe, they contact SEPTA. During utility work, SEPTA replaces the trolley service with buses.

4.2 System Operations

OPERATING ENTITY

Route 15 is operated by SEPTA, a regional municipal authority serving 3.8 million people in and around Philadelphia. SEPTA also operates other forms of public transit, including bus, subway, subway-surface trolley lines, elevated rail, commuter rail, and light rail.

SERVICE PLAN

Route 15 operates 24 hours a day, at approximate 15 minute headways. During weekday peak hours, Route 15 operates at ten minute increments, and less frequently during weekends and off peak hours.

Fares

The base fare for trolley service is $2.00, which is the same as SEPTA's bus and subway service. Cash is accepted; however, the exact fare must be used. Customers purchasing various ticket packages receive discounted fares. Similarly, tokens, which can be used for bus, subway, or trolley service, can be purchased at the discounted rate of $1.55 each. Discounted fares may be purchased at stations, from over 400 retail sales locations, and online at www.shop.SEPTA.org.

If a trip requires more than one transit mode in the same direction of travel, a transfer may be purchased for an additional $1.00. A re-transfer may also be purchased for an additional $1.00. The purchase of a transfer must occur when a customer boards the first service used, and a re-transfer must be purchased on the second service.

RIDERSHIP

SEPTA's Annual Service Plan for Fiscal Year includes an Annual Route Performance Review for each route. For Route 15, ridership forecasts for 2011 are 10,992 weekday passengers (number of total boardings, i.e. unlinked passengers) and 3,297,600 annual passengers. Compared to FY 2010 forecasts, this is an increase of 2.3 and 2.8 percent from 10,742 weekday and 3,206487 annual passengers, respectively.

To record actual ridership, SEPTA performs ride checks, as shown in Figure 4-6. Based on the ride checks taken from July 2003 through October 2010, ridership along the Girard Avenue trolley has increased. Ridership also fluctuates based on the time of year, lower during summer months, compared to fall or winter months.

Average daily ridership along Route 15 from 1990 through 2009 is shown in Figure 4-7. As previously mentioned, Route 15 was operated by a trolley until 1992, when the line was replaced by diesel bus service. Trolley service was then reinstated in 2005. During both transitions (trolley to bus and bus to trolley), ridership initially decreased. This was likely a result of passengers adjusting to the new service. Particularly when trolley service resumed in 2005, SEPTA experienced an operating learning curve. With reduced reliability, potential passengers used other service within the vicinity.

As reported by SEPTA's Manager of City Service Planning, Steve D'Antonio, ridership in a transit city like Philadelphia can be misleading. Service along Girard Avenue never went away, only the mode changed.[43] Route 15 (whether trolley or bus) operates between an elevated rail and subway line, through transit dependent neighborhoods, and is five blocks from Temple University. High ridership is inevitable with such demand, no matter the mode. Passengers are more concerned with on-time performance.

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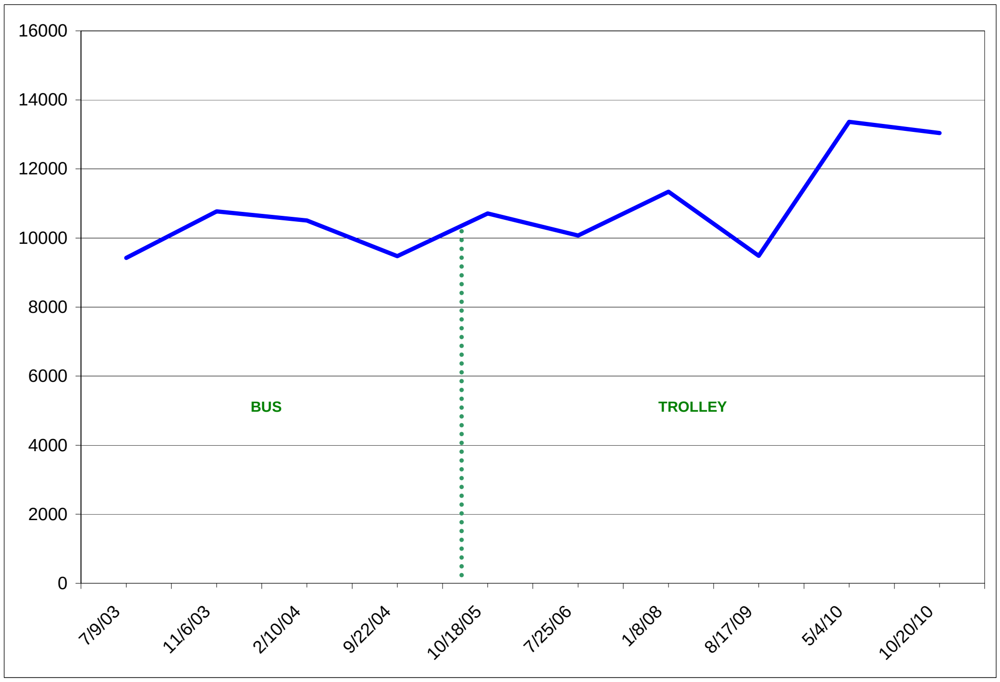
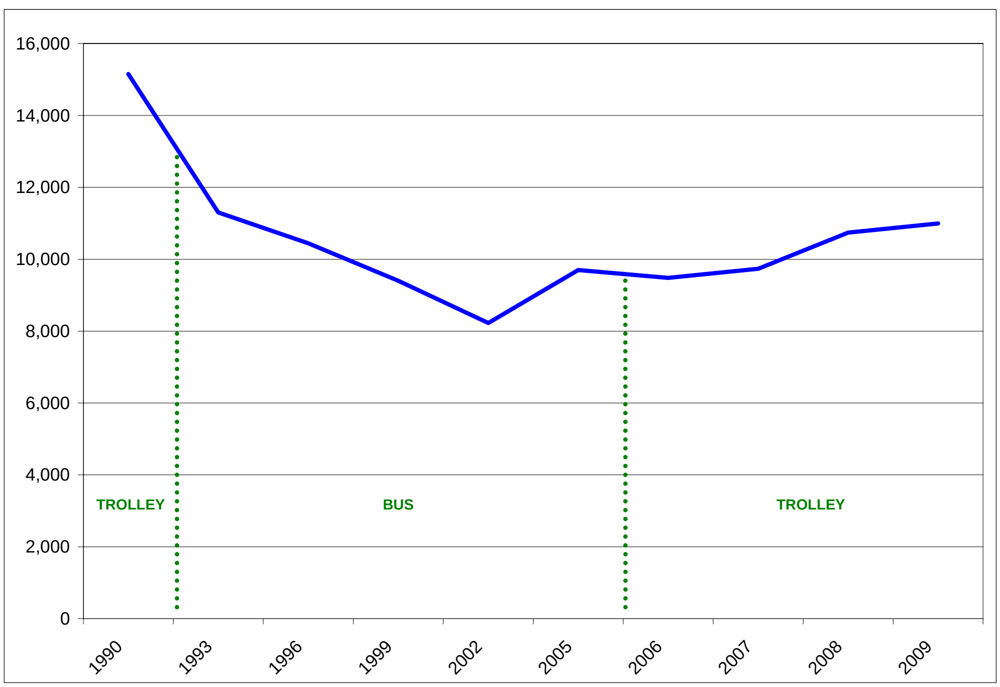
43 Samuel Scheib, "Through the Looking Glass", Trip Planner Magazine, Fall 2009.

Figure 4-6: Route 15 Weekday Ride checks (Bus/Trolley)



SEPTA

Figure 4-7: Route 15 Average Weekday Ridership (Trolley/Bus/Trolley)



SEPTA

BUS NETWORK

Route 15 connects to various SEPTA bus routes. Traveling from east to west, passengers may connect to the following bus routes: Routes 33, 2, 23, 47, 57, 5, 25, 39, 54, 60, and 73. Route 15 also serves as a feeder service to the Market-Frankford and Broad Street subway lines.

In addition to Route 15, SEPTA operates seven other trolley lines, as shown in Figure 4-8 and Figure 4-9. Routes 10, 11, 13, 34, and 36 (Figure 4-8) serve West Philadelphia as streetcars (in mixed traffic) and operate in an exclusive underground tunnel serving Center City Philadelphia. Routes 101 and 102 (Figure 4-9) operate in an exclusive ROW serving the Philadelphia suburbs of Drexel Hill, Springfield, and Clifton Heights. Route 15 is distinctive, because it is the only trolley line that does not operate on an exclusive ROW.

BICYCLE INTEGRATION

SEPTA encourages bicyclists to use transit service to complete journeys to work or personal trips. Most vehicles can accommodate two-wheeled, manually powered or electrically assisted bicycles, and folding bicycles are permitted on all vehicles at all times. In addition, many SEPTA facilities have bicycle racks. Since the tracks have been there for more than a hundred years, there was no learning curve for cyclists negotiating streets with streetcar tracks, as with new systems in other cities.

4.3 Financial Characteristics

CAPITAL COSTS

In 2000, SEPTA was able to secure the necessary capital funding to begin the restoration of Route 15. Restoration work included renewing the existing track, overhead wires, and substations. In lieu of purchasing new vehicles, in 2002 a contract was awarded to Brookville Equipment Corporation for the refurbishment of 18 vehicles. Concurrently, several capital improvements were initiated to prepare for the restoration of streetcar service.

Approximately 25 percent of the track was replaced, pedestrian islands were added, and signal priority (extending cycles and preemption) was provided. (As reported by SEPTA, Route 15 signal priority is no longer in use.) Total capital costs include the following:[44]

- Infrastructure (rehabilitation/construction of new substations, feeders, cables, overhead, and track) - $48 million
- Signals (improved trolley stops and preferential traffic signals and installation of 36 intersections along Girard Avenue) - $5 million
- Streetscapes - $0.5 million

Vehicles (rehabilitation of 18 1947 PCC streetcars) - $30 million

44 American Public Transportation Association, "APTA Streetcar and Heritage Trolley Site", accessed November 2, 2010, http://www.heritagetrolley.com/planPhiladelphia4.htm.

Figure 4-8: SEPTA Routes 10, 11, 13, 15, 34, and 36 Trolley Line Map

http://www.septa.org/maps/trolley/city.html

Figure 4-9: SEPTA Routes 101 and 102 Trolley Line Map

OPERATION AND MAINTENANCE COSTS

Route 15 operating costs, which are approximately $10 million, include both variable expenses and fixed costs. FY 2010 variable expenses are based on actual Route 15 Vehicle Hours and Vehicle Miles (FY 2009) and Cost-per-Mile figures (FY 2010) derived from the entire SEPTA City trolley system. Variable expense (vehicle operations and maintenance) include the following:

- Operations Labor – $3.4 million
- Propulsion Power – $387,000
- Maintenance Parts – $457,000
- Maintenance Labor – $591,000 (Route 15's per-vehicle-mile maintenance costs are $4.88 (which compares to $3.01 for buses.[45])
- Claims Paid – $1.3 million

Fixed Costs are based on total Peak Vehicle requirements (FY 2009) and cost-per-peak-vehicle figures (FY 2009) derived from the entire SEPTA City system. FY 2009 fully allocated expenses (ROW and facilities maintenance, overhead and administration) amount to $3.8 million.

These costs are shared by SEPTA and the City of Philadelphia. SEPTA uses a formula based on the vehicle miles traveled, peak ratios and number of vehicles to determine the City split.

FUNDING STRATEGIES

SEPTA received Federal Flexible Funding for infrastructure work along Route 15. Flexible Funding was initiated through the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) legislation to provide opportunities to state and local governments allowing the option of using some Federal Highway Administration (FHWA) funds for transit projects and vice versa. SEPTA received $4.8 million in Flexible Funding, which was used for the rehabilitation / construction of new substations, feeders, cables, and track.

ECONOMIC DEVELOPMENT

Route 15 was justified for economic redevelopment reasons. However, since service returned in 2005, little development has occurred. Local businesses along the Girard Avenue corridor have indicated the new trolley line did not bring in a new crowd of tourists.[46]

This lack of development can be attributed partly to the economic recession that began in 2008/9. However, limited planning was also a large determinant. Despite hopes for economic growth along the corridor playing heavily into the decision to replace the line, the process lacked a master planning approach, as shown with other streetcar systems throughout the United States.

Recent development, related to the Pennsylvania Department of Transportation's reconstruction of the Interstate I-95 Girard Avenue interchange provides the possibility for future development. During the Pennsylvania Department of Transportation's reconstruction of Interstate I-95 when the

45 Samuel Scheib, "Through the Looking Glass", *Trip Planner Magazine*, Fall 2009.
46 Brian Rademaekers, "Historic trolley off track", October 13, 2010, accessed December 17, 2010, http://www.philly.com/community/Historic_trolley_off_track.html?viewAll=y

Girard Avenue Bridge will be closed, Route 15 will be rerouted to allow eastbound trolley service to continue through to the Market-Frankford Subway Elevated Line. The Route 15 Turnback Loop project, which is currently under construction, as shown in Figure 4-10, includes construction of a trolley turnback along Route 15 at Frankford Avenue. This turnback, being constructed along Frankford Avenue from Girard Avenue to Delaware Avenue, will become a permanent feature of the trolley line, providing new track and overhead wire and traffic signal improvements at Girard and Delaware Avenues. The Route 15 Loop will carry passengers to and from the SugarHouse Casino, as shown in Figure 4-11.

Figure 4-10: Route 15 Loop Construction along Frankford Avenue

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Figure 2-11: SugarHouse Casino

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4.4 Vehicle

TYPE

Route 15 uses PCC II cars, as shown in Figure 4-12, which are 1947 Presidential Conference Committee (PCC) streetcars that were completely rebuilt at a cost of $1.3 million per vehicle. Eighteen vintage trolley cars were disassembled down to bare metal and rebuilt to create a unique vehicle that blends the historical appearance with modern passenger amenities. The cars were rebuilt by Brookville Equipment Company, located in Brookville, Pennsylvania.

The PCC II cars are 46 feet, 6 inches long, 8 feet, 5 inches wide, and 11 feet, 9 inches high. Seating capacity is 46 passengers without wheelchairs) or 40 passengers with two wheelchairs. With the addition of standing passengers, total capacity reaches 113 passengers. Passenger amenities include:

- Automatic heating and air conditioning;
- Wheelchair accessibility at the center door and additional interior features designed in collaboration with the disability community;
- Newly designed interior (stainless steel seating with cloth-upholstered inserts);
- Passenger Stop Request and PA system; and
- Original style "Art Deco" lighting.

Figure 4-12: SEPTA PCC Trolley Vehicle

http://www.trolleyville.com/tv/times/oct2003/oct03.htm

The PCC cars, which were painted in their original green and cream, rather than SEPTA's white with red and blue stripes, were chosen largely due to their cost savings, as well as their historic aesthetic. SEPTA also considered the Kawasaki light rail vehicles (LRV), which are used on the other Philadelphia trolley lines. However, LRVs cost $3.2 to $3.5 million per car, which is more than double the cost of refurbishing a PCC car.

Despite the lower cost and romantic appeal, PCC cars do have some disadvantages. PCC cars have a lower capacity when compared to modern streetcar vehicles. Although the rehabilitation included ADA compliance, the wheelchair lifts can be a timely process, due to the numerous flaps (required to accommodate the existing infrastructure), as shown in Figure 4-13. PCC cars also have less flexibility than LRVs. While LRVs can operate on all of SEPTAs trolley lines, the PCC cars can only operate on surface tracks, and not through the various trolley tunnels.

Figure 4-13: PCC Wheelchair Lift

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In addition, SEPTA's PCC cars were refurbished to have a useful life of 15 years, as opposed to the LRV lifespan of 30 plus years. As the current fleet has been in operation for over five years, SEPTA will need to replace the Route 15 fleet in less than ten years. Moreover, SEPTA uses 16 vehicles of the 18-car fleet to operate Route 15. This results in a tight spare ratio in the case of breakdowns or incidents. SEPTA reports PCC car breakdowns are few; however incidents related to weather, traffic accidents, or emergencies occur more often.

STORAGE AND MAINTENANCE FACILITIES

The refurbished PCC II Route 15 Trolley vehicles are stored at Callowhill Depot. Callowhill Depot is located in the heart of West Philadelphia, on the southwest corner of the 5900 block of Callowhill Street. The bus and trolley bays are across the street. The depot is surrounded by 59th, Vine, 58th, and Callowhill Streets. SEPTA's Callowhill Depot also serves the Route 10 Trolley and bus Routes 21, 30, 31, 38, 40, 42, 43, 44, 46, 52, 65, 121, 400, 401, 403, 404, 406, 407, 408, 409, 410, and the Market-Frankford OWL.

Light repair work occurs at the Callowhill Depot; however, vehicles are sent to SEPTA's Elmwood facility for major repairs. The Elmwood Carhouse (or Elmwood Loop), located at 73rd Street and Elmwood Avenue in the Elmwood Park section of West Philadelphia, is a storage facility and alternate terminus for the SEPTA Route 36 trolley. The facility also stores and maintains cars from Routes 11, 13, and 34.

Future Improvements

As reported in SEPTA's Fiscal Year 2010 Capital Budget and Fiscal Years 2010-202121 Capital Program, SEPTA has allocated $115,600,000 the replacement of the 96-year old Callowhill Garage. The Callowhill Garage, which was originally constructed as a trolley carbarn, is ill equipped to support the needs of a modern bus fleet. A myriad of deficiencies and limitations currently exist at this garage, such as the poor condition of the roof and underground drains; obsolete equipment; and narrow bus storage bays, which limit vehicle maneuverability. The new facility will also include a new trolley shop and storage yard. The trolley shop will be used to perform running repairs for SEPTA's trolleys operating on the Route 10 and Route 15 Trolley Lines.

TRACTION POWER

The Route 15 Trolley used the previous traction power system, but included renewed overhead wires. SEPTA's Route 15 Trolley has a total of three substations used to service the entire 8.5 mile long line. SEPTA used these existing substations, because there was no space or land available for new substations. Working with the aging infrastructure resulted in some poor conditions. Specifically, the underground cables for the return wire were encased in 90-year old octagonal terracotta sleeves. When the old cables were pulled to make room for new ones, the sleeves moved, making it very difficult to install new cables, and at times requiring additional digging.

5.0 SUMMARY OF LESSONS LEARNED

The following matrix summarizes the relevant service components of the Portland Streetcar, Seattle's South Lake Union Streetcar, and Philadelphia Route 15 Trolley and a brief summary of lessons learned and relevant reference to the Brooklyn Streetcar Feasibility Study.

Table 5-1: Case Study Summary and Relevent Reference to BSFS

Streetcar Service Components	Portland Streetcar	South Lake Union Streetcar	SEPTA Route 15	Relevant Reference to the BSFS
Design Criteria	General guidelines only: Alignment geometry, speed, roadway cross section, lane selection, traffic signalization, and streetcar stops	General Guidelines Only: Alignment geometry, speed, roadway cross section, lane selection, traffic signalization, and streetcar stops	Existing streetcar track, which required some rehabilitation and traffic signalization	Design criteria should take into consideration both criteria developed for other streetcars as well as existing MTA and other NYC standards
Alignment Decision Process	Most important factors: land use, future development, intermodal connections, and service to cultural/educational activities	Most important factors: serving commuters and tourists, intermodal connections to cultural activities, future development, and land use	N/A (Route 15 was an existing trolley/bus line)	Goals should consider land use, intermodal connections, and future development
Principle Challenges	Unexpected costs associated with the cost of engineering and administering utility relocations	Exceeded construction budget for incidental costs (traffic control, pavement patching, etc.), due to utility repairs	N/A (Route 15 was an existing trolley/bus line)	Early utility coordination with both public/private entities is a key factor in establishing guidelines for mitigating utility impacts, and can influence alignment selection A contingency budget itemized by potential risks: unexpected utility relocations, traffic control modifications, etc. should be considered; and a risk assessment should be performed early on
Operating Entity	TriMet	King County Metro	SEPTA	TBD

Table 5-1: Case Study Summary and Relevent Reference to BSFS

Streetcar Service Components	Portland Streetcar	South Lake Union Streetcar	SEPTA Route 15	Relevant Reference to the BSFS
Service Plan	Weekdays - 5:30 AM to 11:30 PM, 12 minute intervals	Weekdays – 6:00 AM to 9:00 PM, 15-minute intervals	Weekdays - 24 hours, 10 minutes during peak and less during off peak	Philadelphia offers an example of 24-hour service
Ridership	09/10 Quarter average weekday ridership - 11,914	Record July 2010 ridership - 2,193 weekday boardings	FY 2010 average daily ridership - 9,575	Portland and Seattle demonstrate that streetcar ridership builds from first year of operation
Bus Network	Connections to bus routes: 35, 36, 43, 54, 56, and 77	Metro routes 3, 4, 5, 8, 17, 23, 25, 26, 28, 30, 39, 42, 66, 70, 71, 72, 73, 98, and 358 serve the South Lake Union area	Connections to bus routes: 2, 5, 23, 25, 33, 39, 47, 54, 57, 60 and 73	Connections to existing bus and subway should be an integral part of system planning
Bicycle Integration	Flange gap and crossing angles, interface at stops etc. need to be evaluated.	Flange gap and crossing angles, interface at stops etc. need to be evaluated.	No issues reported; however existing flange gap is wider and could create safety concerns	Bike advocacy groups should be involved early in the planning process; and design elements should be developed to minimize impacts and employ techniques from Portland and Seattle
Capital Costs	$103.2 million (not including the Streetcar Loop Project currently under construction)	$50.5 million	$83.5 million	Capital costs could be reduced by employing Portland's low-cost approach to stations; however, Philadelphia's labor and utility costs more likely reflect Brooklyn costs
Operation and Maintenance Costs	$5.5 million	$2.0 million	$6.2 million	Generally O&M costs for streetcars run 30 percent higher than bus

Table 5-1: Case Study Summary and Relevent Reference to BSFS

Streetcar Service Components	Portland Streetcar	South Lake Union Streetcar	SEPTA Route 15	Relevant Reference to the BSFS
Funding Strategies	Municipal parking revenue bond, Local Improvement District, and Tax Increment Finance District.	Local Improvement District	Federal Flexible Funding	Portland and Seattle demonstrate increased development within two to three blocks of the route; the value of development could be captured as a means of helping pay for system
Economic Development	Shifted the attractiveness of sites adjacent or near to the streetcar tracks from moderate to high	Credited with giving the South Lake Union area an advantage over other areas of the city	Little to no economic development impact	See above funding strategy
Vehicle Type	Modern Škoda - Inekon and Inekon TRIO 12 Approximate acquisition cost ($3.5 to 4.5 million)	Modern Inekon TRIO 12 Approximate acquisition cost ($3.5 to 4.5 million)	Refurbished 1947 Presidential Conference Committee (PCC) Approximate acquisition cost ($1.5 million)	Portland and Seattle's modern vehicles provide have more amenities, larger capacities, and provide easier ADA compliance; however Philadelphia's refurbished cars have lower acquisition and capital costs
Storage and Maintenance Facilities	1516 NW Northrup – located just outside of the central business district under a freeway Ramp 90 feet x 88 feet, 8 inches	Fairview Avenue N and Valley Street 112 feet x 55 feet, 8 inches	Callowhill Depot 490 x 440 feet (also serves other SEPTA vehicles)	Facility location influences alignment process Although there is flexibility in size and shape of facility, the MTA practice is for enclosed vehicle storage facility, which would require larger footprint

Table 5-1: Case Study Summary and Relevent Reference to BSFS

Streetcar Service Components	Portland Streetcar	South Lake Union Streetcar	SEPTA Route 15	Relevant Reference to the BSFS
Traction Power	Traction electrification system (TES) or overhead-contact system (OCS), small substations spaced closely together at approximate half mile intervals, and a simple trolley wire overhead contact system	Similar to Portland	Used the previous traction power system, but included renewed overhead wires and the reconstruction of substations	Visual impacts of the OCS should be mitigated very early in the planning process; the case studies demonstrate under-ground location of substations is viable; substation size can be flexible

In addition to the summary provided in Table 5-1, the case studies of the Portland Streetcar, South Lake Union Streetcar, and SEPTA's Route 15 Trolley provide several lessons learned.

DESIGN CRITERIA

Portland and Seattle utilized a combination of Light Rail Criteria, TCRP reports, other codes, and lessons learned from European tram operators to develop project specific guidelines. However, no formal design criteria were developed for either streetcar system. The engineers and city took a "best practices" approach and worked together to clearly identify the minimum requirements of each project. Due to the close coordination between the city and engineers, this did not result in any major issues. In fact, it encouraged an open dialog between the owner and engineer to establish project specific minimum guidelines that focused on the goals and objectives of each individual project.

SEPTA experiences several issues related to design criteria. The design of the trolley system called for center island station platforms. However, Philadelphia motorists were not used to the location of the new platforms and a number of accidents occurred as cars ran into the center islands. Similarly, the majority of the Route 15 alignment has a median ROW, with both near- side and far-side stops. This ROW is legally restricted to trolleys and left-turning vehicles at certain intersections, but because it is physically protected, it is widely used not for left turns and through traffic. Moreover, there are numerous segments where the trolley right of way is intended to be exclusive, but is unprotected aside from fairly unobtrusive overhead signage. In addition, there are very tight clearances at several under-grade bridges on the Route 15 line. Despite warning lights and restrictions, the overhead trolley wire is frequently torn down.

A future Red Hook streetcar should take into consideration the criteria developed for other streetcars, the lessons learned in Philadelphia, as well as existing MTA and other NYC standards. In terms of a potential alignment in Red Hook, land use, intermodal connections, and future development should be considered. As shown in Philadelphia, a streetcar system that lacks a master planning approach results in service reliability concerns, and does not gain from economic growth as shown in both Portland and Seattle.

CONSTRUCTABILITY

Portland instituted a shallow track, single pour system that minimized excavation and expedited construction. Once the utilities are out of the way, the track and all civil components (roadway and sidewalk reconstruction) were accomplished at a pace of approximately three blocks in three weeks (one block is approximately 200 feet). Following the track and civil construction, the overhead cable system, lighting, and traffic signals were installed. This process, as shown in Figure 5-1, which was developed to minimize the impacts to adjacent businesses and has worked fairly well. As such, the process was also instituted in Seattle.

Figure 5-1: Portland Streetcar Construction

http://www.walkerevanseffect.com/blog/the-columbus-streetcar-construction-impact-memo/

For SEPTA's Route 15, in some areas the original track was in good condition and did not need to be replaced. However, a block by block inspection of the system was required to determine the work necessary to rebuild and restore service. This contributed to additional cost and construction time. In some areas, no girder or flanges were left and the asphalt was holding the track together.

UTILITIES

Portland did not create a formal procedure regarding utilities, as relocations varied by utility. The Portland Streetcar engineering team worked with each private utility to identify conflicts evaluating utilities on a "case by case" basis. Similar to Portland, Seattle did not create formal guidelines with respect to utilities. Generally, utilities running parallel to the streetcar and located within five feet of the track slab were relocated. However, both Portland and Seattle had to establish general guidelines as part of each project to use as a baseline for identifying potential impacts. The DOT should coordinate with both public/private entities early on to establish guidelines for mitigating utility impacts. Similarly, the identification of potential utility locations can influence alignment selection.

During construction of Philadelphia's Route 15 Trolley, as-built drawings were not available for the locations where the existing track had to be replaced or repairs to underground cables had to be made. In one instance, available drawings indicated the water main was at a certain depth. However, during construction, the contractor hit a shallow force main on Girard Avenue under the viaduct leading to Market Street East Station, causing significant flooding. In other areas, the plumbing and underground cable to residential homes was affected, as a result of the unavailability of as-built drawings to confirm utility locations. Early, open, and clear communication between utility companies will avoid similar issues in Brooklyn.

Early coordination will also reduce the potential for unexpected costs, as experienced in both Portland and Seattle. Specifically, the Portland Streetcar project incurred unexpected costs associated with the cost of engineering and administering the water utility relocations. As such, Portland now has an intergovernmental agreement between the streetcar project and the water department. Similarly, during construction of the South Lake Union streetcar, the Seattle Stormwater Department replaced multiple catch basins that were in poor condition. As a result, the Streetcar project exceeded its construction budget for incidental costs (i.e. traffic control, pavement patching). A contingency budget itemized by potential risks (unexpected utility relocations, traffic control modifications, etc) should be considered for a Brooklyn streetcar.

For future streetcar extensions, Seattle plans to reduce relocations by allowing the track to be removed and replaced in sections to allow for maintenance and repairs to existing infrastructure. Similarly, a "risk analysis" should be performed in Red Hook to determine the chance of a utility becoming damaged. In some cases, it might be easier to fix the utility in place in the future rather than relocate it to accommodate the streetcar.

BICYCLE INTEGRATION

Both the Portland Streetcar and the South Lake Union Streetcar experience safety issues with bicycle integration. Bicycle wheels and tires are very susceptible to getting caught within the gap of the streetcar track flange. Specifically, this situation occurs when a bicyclist is required to cross the tracks at less than a 60 degree angle. When a track "catches" a wheel, a bicyclist may be thrown from their bicycle. To decrease the number of accidents, streetcar infrastructure should be designed to eliminate crossings with less than 60 degree crossing angles and be designed with as close to 90 degree crossing as possible.

In addition, right-side running tracks and streetcar track curves may create an instance where a bicyclist riding in the right lane chooses to cross the tracks at an angle less than 60 degree. This is not desired and can lead to accidents. Center-running and left-running tracks are typically safer scenarios for bicyclists, as they avoid many of the conflicts between side running streetcars and parallel bike tracks. Signs and pavement markings can be used to assist cyclists in maneuvering around track curves at safe angles.

In planning a streetcar in Brooklyn, bike advocacy groups should be involved early in the planning process. Design elements should be developed to minimize impacts and employ techniques from Portland and Seattle. Both cities continue to work with the bicycle community to develop solutions to create a safe environment for both transit and bicycle users. For example, Seattle is considering a median running streetcar to avoid conflict with bike lanes adjacent to the curb.

FUNDING STRATEGIES

Both Portland and Seattle exemplify that the value of development can be captured as a means of helping to finance a system. Financing of the Portland Streetcar has used a different mixture of funding sources for each segment constructed. However, the 2.4 mile first phase is particularly unique as the total cost of $56.9 million was completely locally funded. The most substantial share of capital costs was financed by a municipal parking revenue bond supported by parking fees in the area of the streetcar. Additional local mechanisms relied on value capture, including a Local Improvement District and a Tax Increment Finance District. Because Portland did not use Federal funding on the first phase, they were not required to adhere to the *Buy America Act* for the purchase of streetcar vehicles.

Similarly, to fund the South Lake Union Streetcar, waterfront businesses formed a Local Improvement District to contribute $1.1 million to the construction of the waterfront streetcar. The adoption of the LID worked well because the South Lake Union area has several major property owners participating with the city of Seattle on revitalization, including private developers and the University of Washington.

Contrastingly, although the return of the Route 15 trolley was initiated through local community and political support, SEPTA's Route 15 Trolley experienced funding shortfalls. Unlike Portland and Seattle, Philadelphia did not have local financial investment. Due to this lack of funds, only the portions of Route 15's existing infrastructure in the worst condition were replaced Also, Instead of streetcars traversing the wide portion of Girard Avenue in a reserved ROW, they were designed to run on the existing alignment, sharing the center lanes with left-turning automobiles. SEPTA received $48 million in Federal funding, which was used for these infrastructure costs.

ECONOMIC DEVELOPMENT

In terms of economic development, both Portland and Seattle demonstrate increased development as a result of a streetcar system. Portland's streetcar shifted the attractiveness of sites adjacent or near its tracks from moderate to high. However, other factors likely contributed to the growth in new development, including local land use policies, the construction of a light rail system, urban renewal, and the ability to use TIF funds to subsidize infrastructure and development projects.

Similarly, Seattle's South Lake Union neighborhood has experienced growth since the development of a streetcar system. Like Portland, economic development was triggered by a multitude of factors, such as the urban center zoning, major developers, and the development being sold and promoted as being on the streetcar line or within one block of the streetcar.

The Girard Avenue corridor has not experienced this type of growth. Although the return of the Route 15 trolley was justified for economic redevelopment reasons, the planning process lacked a master planning approach, as shown with other streetcar systems throughout the United States. The DOT should adhere to this lesson learned, and use a more holistic approach when planning and designing a streetcar system for Brooklyn.

CONCLUSION

The case studies presented in this report demonstrate the multitude of planning components that comprise a streetcar system. These factors collectively determine the future success or demise of a streetcar operation. As the BSFS continues along with the future planning and design of a Red Hook streetcar, the examples provided in this Case Study Report should be considered. Streetcars provide a historic, romantic appeal and have transformed blighted districts into vibrant areas. However, in these success stories contributing factors were implemented in a master planning approach. As such, it is critical that a holistic approach be applied to the planning and design of a Red Hook streetcar.

APPENDIX A

URS

PROJECT NOTES

Client:	**NYCDOT**
Project Name:	**Brooklyn Streetcar Feasibility Study**
Location:	**Brooklyn, NY**
Project Number:	**10312392**
Issue Date:	**20 SEPT 2010**

TO: **Chris Hrones, NYCDOT**

FROM: **Stephen Gazillo, URS**

SUBJECT: **Brooklyn Streetcar Feasibility Study: Summary of Potential Streetcar Case Study Systems**
NYCDOT – ESA: Transportation Planning, Transportation Engineering, Urban Design and Related Services, Citywide. PIN: 84107MBTR187

To assist NYCDOT in the selection of three streetcar systems for the Task 2.1 Case Study Report, we have put together notes/brief summaries of the 10 streetcar systems listed in the Brooklyn Streetcar Feasibility Study task order scope. While the case studies will focus specifically on three systems, there may be times during the study when lessons learned from other systems, beyond the original three selected, could be applicable. Whenever possible, the URS Team will incorporate the most relevant examples into this study.

CASE STUDY SYSTEMS

Portland, OR Streetcar

System Summary: First modern streetcar system in the U.S, began as 2.4 mile loop, expanding now to a nearly 8 mile system with 11 cars now operating (first U.S. built modern streetcars now in manufacturing). System most often cited for positive economic development, cost-effectiveness, strong ridership and innovative financing. Significant data on Portland available, as history of operations dates back to 2001.

Applicability to Brooklyn: This system demonstrates use of modern streetcar technology in mixed street-running operation along urban streets; multiple examples of utility impact mitigation techniques; well-documented economic development impacts, system expansion process, funding, use of one-way pairs for operations, integration with bike lanes and pedestrian pathways.

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Charlotte, NC Streetcar

System Summary: This is a ten-mile planned system that will connect various downtown Charlotte neighborhoods and the to the new LYNX LRT system. Portions of starter system infrastructure built; received Urban Circulator grant funds.

Applicability to Brooklyn: Older infrastructure in east coast downtown area; development of rules of practice for utility impact mitigation; innovative shallow depth track slab design used.

Seattle, WA Seattle South Lake Union Streetcar

System Summary: South Lake Union system is a 2.6 mile 11-stop loop system. Seattle streetcar network now in development as a result of initial success of South Lake.

Applicability to Brooklyn: new modern streetcar system in full revenue service, similar to Portland in larger urban setting.

San Francisco, CA Historic Streetcar

System Summary: San Francisco Muni operates 17 historic PCC streetcars painted in schemes of other city's old streetcars on the F Market and Fisherman's Wharf routes. First opened in 1995, extension to the Wharf in 2001. Operates in regular revenue service by Muni, in-street running, tourist attraction.

Applicability to Brooklyn: Similar to the historic trolley proposed by Brooklyn Historic Railway Association (BHRA).

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Tacoma, WA Tacoma Link Rail (Streetcar)

System Summary: Modern streetcar, 1.6 mile starter primarily single-track system; initiated August 2003. System is street running but mostly in exclusive right-of-way.
Applicability to Brooklyn: Example of modern streetcar connecting to a multi-modal facility.

Tampa, FL Ybor City Historic Streetcar

System Summary: Replica streetcar system (9 Birney cars) operates in exclusive lane over 2.4 miles system, 15-minute headways in peak with section operating in contra-flow lane.

Applicability to Brooklyn: Use of Special Assessment Tax districts, naming rights and advertising for funding; contra-flow operation in sections; example of tourist impacts and economic development impacts.

Tucson, AR Starter Streetcar

System Summary: Proposed double track along most of the alignment; approximately 4.4 mile system operating primarily on two-way streets in mixed traffic with left turn lanes.
Applicability to Brooklyn: Currently in design; have some clearance issues; new system is extension of older historic trolley line segment. Simulation and visualization use.

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Kenosha Streetcar, Kenosha, WI

System Summary: this is a 2.1 mile streetcar system begun in 2001 and operating in a loop with 17 stops. System operates on grassy median for approximately half the route. Five donated Toronto PCC cars were refurbished.
Applicability to Brooklyn: Example of use of refurbished PCC cars and city operated system. Very low budget start-up ($5 million for entire system).

Philadelphia Trolley, Philadelphia, PA

System Summary: Rt. 15 Girard Avenue line has operated in street running by SEPTA on an 8.5 mile route. Use of older heritage PCC refurbished equipment, one of few U.S. cities with continuous streetcar operation.
Applicability to Brooklyn: example of older east coast system using heritage PCC streetcar vehicles.

Toronto Streetcar, Toronto, ON

System Summary: Largest operating streetcar system in North America in street running mixed-traffic. This has been a 47-mile, 11 routes in system. Some upgrades to exclusive lanes.
Applicability to Brooklyn: Example of complete streetcar system. Upgrades in process. Potentially valuable for lessons learned.

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