Seattle Transit Study

for Intermediate Capacity Transit

Final Report

December 2001

City of Seattle
Strategic Planning Office

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for Intermediate Capacity Transit

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Strategic Planning Office
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Overview

Context and Objectives

The Seattle Transit Study for Intermediate Capacity Transit was a collaborative, interagency effort to plan a seamless public transportation system within Seattle, one that would serve the city's future local and regional travel needs. The lead agency for the Seattle Transit Study (STS) was the City of Seattle, who initiated the study as part of its broader transit improvement strategy, the Seattle Transit Initiative. A Project Management Team (PMT) was formed to guide the STS; it consisted of representatives from the Initiative's partner agencies: various City of Seattle departments (Strategic Planning Office (SPO), SeaTran, Department of Neighborhoods, and Seattle Center); King County Metro, Sound Transit; Washington State Department of Transportation (WSDOT); and the Elevated Transportation Company (ETC).

The project vision was to investigate the feasibility of and develop a plan for enhanced-capacity transit services that would be interconnected, and operate faster and more reliably than existing bus service. The proposed "intermediate capacity transit" (ICT) system would link Seattle's neighborhoods to each other and to the regional transportation system via key transportation corridors. The study objectives were as follows:

- Determine the locations, technologies, and service levels where intermediate capacity transit services would be cost-effective in improving mobility
- Serve as a foundation for future ICT system definition and potential future funding

Process and Chronology

This project began with a review of existing city transit services and development of 45 preliminary routes for investigation. These 45 routes were then reviewed using demographic, geographic, and other relevant data in order to assess their relative transit market potential. The conclusion drawn from this exercise was that the routes which exhibited the greatest transit market potential could be broadly grouped into seven general transit corridors.

After the preliminary investigation, the STS PMT outlined a scope of work and retained a consultant to provide technical analyses of potential routes, service schemes, and technologies within the seven corridors. Figure 1 (page 5) shows the location of the seven initial ICT corridors.

The project scope of work was designed so that the study could progress in stages, thus providing the flexibility to tailor tasks within the next stage to reflect the results of the previous stage. Stage I examined potential ICT improvements in the seven broad corridors, evaluating various improvement scenarios against each other and against performance criteria established by the PMT. Findings from the Stage I evaluation were used to select corridors (from the original seven) for more-refined analysis in Stage II.

Figure 2 shows the two corridors selected for Stage II analysis: the Lake City–Northgate–Ballard–Downtown corridor, and the West Seattle–Downtown corridor. Figure 2 also shows the three other corridors that were not examined in Stage II but were concluded to possess good potential for ICT improvements (and thus worthy of possible Stage II-level analysis at a future date.) Major work elements for Stage II included developing specific route and technology combinations within the two chosen corridors; using these to develop detailed cost, ridership and impact information; and assessing the feasibility of and relative advantages between the specific routes and technologies. Finally, an implementation plan would be developed in Stage III, outlining potential funding strategies and institutional arrangements for the construction and operation of recommended ICT services.

This report focuses on the analyses performed within Stage II on the two selected ICT corridors, summarizing the findings, conclusions and recommendations that resulted from this work.

Note that at the conclusion of Stage II, it was determined that Stage III would not be undertaken by this study team, partly in consideration of the fact that major aspects of Stage III would be pursued by the ETC in their efforts to plan for and implement a monorail system. The City will continue to coordinate with STS partner agencies in planning and implementing improvements to transit speed and reliability citywide, and may in the future examine the remaining three recommended ICT transit corridors for possible ICT-type improvements.

Stage I Overview

Stage I work elements included a physical inventory of the seven corridors; development of initial ridership estimates; development of initial capital and operating cost estimates; and the development of conceptual transit technologies and alternatives in each corridor. It was concluded from these analyses that there may be feasible intermediate capacity transit options in five of the project corridors:

- Aurora–Greenwood–Downtown
- Ballard–Fremont–U-District
- Downtown & Environs
- Lake City–Northgate–Ballard–Downtown
- West Seattle–Downtown

The potential feasibility of these corridors was based upon their performance in attracting both existing and new transit riders, as demonstrated by the results of ridership forecasts for various ICT technologies. It was also based on the relative costs of implementing ICT in these corridors and a qualitative assessment of potential impacts within the corridors.

Further, beyond each of the above corridors' potential to attract transit ridership independently, taken together these five corridors—along with the planned Link light rail system through Seattle—would comprise a higher-capacity, higher-reliability, faster and comprehensive inter-neighborhood and inter-city transit system for Seattle, thus achieving one of the major goals of the Seattle Transit Initiative.

Because of the limited STS resources available, other on-going and anticipated transit planning efforts, as well as the desire to prioritize implementation among corridors, it was decided that only a limited number of the five corridors would be carried forward for detailed analysis under Stage II of the study. City of Seattle staff identified three alternatives to assist the PMT in selecting Stage II corridors. These alternatives included combinations of corridors and are shown below in Table 1.

TABLE 1 **STAGE II STS CORRIDOR ALTERNATIVES**

Alternative 1	*Alternative 2*	*Alternative 3*
Lake City–Northgate–Ballard–Downtown	Lake City–Northgate–Ballard–Downtown	Lake City–Northgate–Ballard–Downtown
West Seattle–Downtown	West Seattle–Downtown	West Seattle–Downtown
	Ballard–Fremont–Wallingford–U-District	Downtown & Environs

The PMT selected Alternative 2 as their preferred alternative. The consensus of the PMT was that these three corridors held the greatest need for transit improvements and greatest potential for attracting new transit riders.

Given the limited overall project budget and schedule, City staff recommended that only two of these corridors be analyzed in detail within Stage II, and the PMT concurred. These corridors were Lake City–Northgate–Ballard–Downtown and West Seattle–Downtown (see Figure 2). For the preferred alternative's remaining corridor (Ballard–Fremont–Wallingford–U-District), City staff proposed to undertake (in a separate effort) an examination of potential improvements to existing transit service along the North 45th Street corridor. The goal of this separate effort would be to reduce travel times for bus transit riders along the corridor, improve service reliability, and create more capacity for transit services while supporting neighborhood goals as set out in Neighborhood Plans.

In summary, the rationale for PMT's and City staff's Stage I conclusions and recommendations were as follows:

- Lake City–Northgate–Ballard–Downtown corridor performed best across modes in forecasted ridership and cost-effectiveness.
- Current Metro bus service makes direct and frequent connections between downtown and West Seattle, and between downtown and the northwest sector. Therefore, providing service along these corridors using ICT technologies would improve transit services for a large existing market.
- Taken together, the Lake City–Northgate–Ballard–Downtown and West Seattle–Downtown corridors would provide a north-south transit spine on the western side of Seattle, mirroring Sound Transit's light rail system. This would result in a good geographical distribution of transit capital investment if both projects were developed for implementation. The potential outcome would be nearly all city sectors receiving higher-capacity transit capital investment.
- Selecting only two corridors allows for concentration of resources within a limited study budget and schedule. Numerous potential study routes for each mode are available along the Ballard–U-District corridor—each with their own design and community impact challenges—making for a complex level of analysis within a single corridor. Moreover, a detailed analysis of the downtown area would be covered to a significant degree in Stage II since the north–south adjacent areas would be examined within the recommended corridors as they approach and travel through downtown.

FIGURE 1
Corridor Map for Stage I Analysis

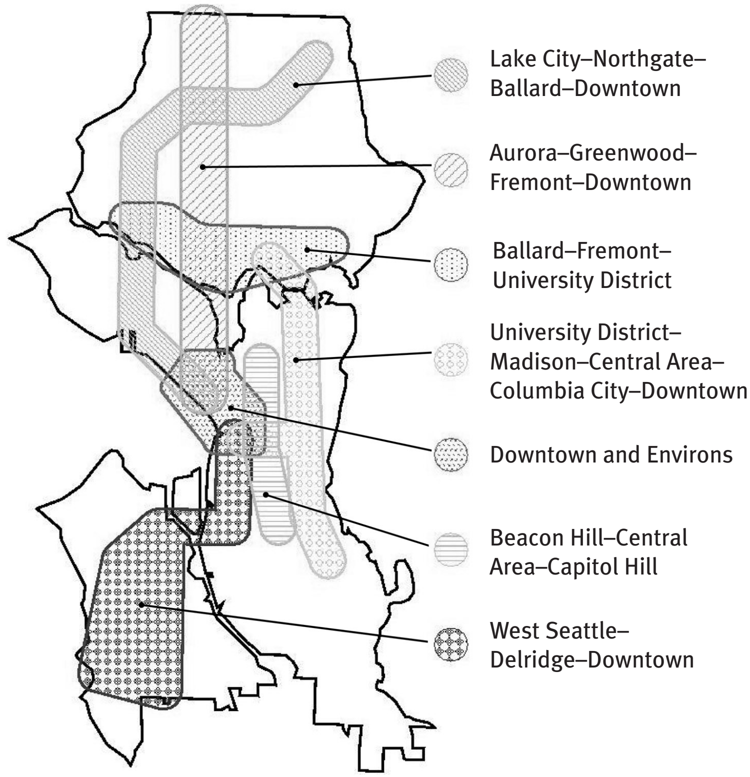
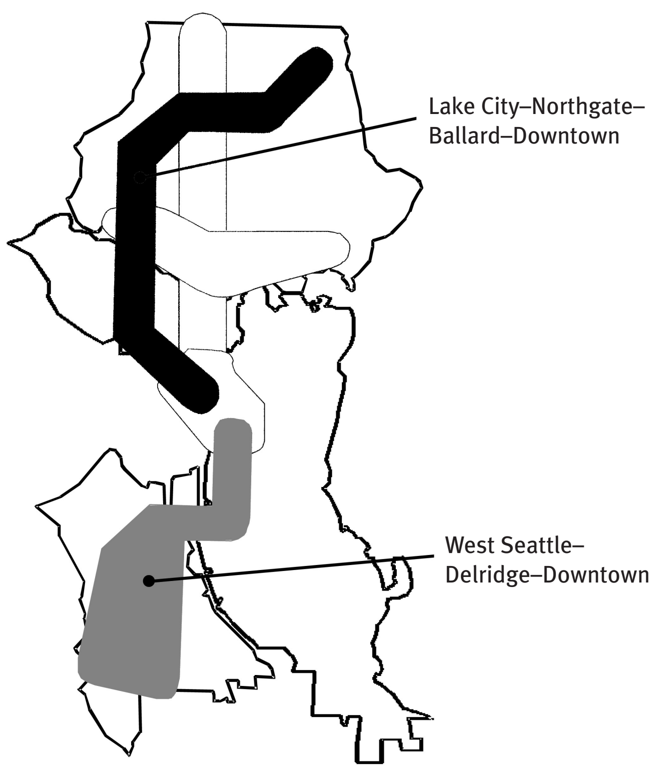


FIGURE 2
ICT Recommended Corridors, Including Corridors for Stage II Analysis



Public
Involvement

6

Public Involvement

The public involvement component of this project included the presentation of study materials at various points in the study to the general public and selected stakeholder groups, as well as solicitation of comments and public participation.

Stage I

The public open houses for Stage I were conducted over two days in October 2000. Advertising for these meetings was done by postcard, press release, brochures to Neighborhood Service Centers and the Seattle Public Libraries, as well as the City of Seattle web site.

The two main goals of the Stage I open houses was to share findings from the Stage I analysis and to obtain input and ideas about the study corridors, technology and sample routings. Open house attendees were asked to write their questions or comments on large flip-chart sheets at various points in the presentation, on a provided comment form, or by writing or e-mailing the Seattle Transit Study project manager directly.

After the Stage I open house meetings were conducted, additional analysis was undertaken to address the comments and concerns received. The majority of comments received from participants of the open houses and others writing in regarded issues such as:

- Loss of parking
- Impacts to pedestrian and bicycles
- Impacts on the physical landscape
- Safety
- Accessibility of transit for disabled users

Comments and concerns raised by the attendees were taken into consideration when selecting two corridors for further analysis in Stage II.

Stage II

For Stage II of the STS, a greater level of public outreach and input gathering was conducted. Public open house meetings were held and were supplemented by meetings with groups of key stakeholders identified for each corridor.

The key stakeholders meetings included focused participation from neighborhood organizations, advocacy groups and the business community. These meetings ensured that the ideas and concerns of local businesses, community members, and other interest groups were considered in the route development, refinement and evaluation. Stakeholder meetings were held in April and July, and over 30 community leaders participated.

Input from these resulted in the following general categories of issues and concerns regarding potential ICT services along the two Stage II corridors:

- Parking
- On-street parking impacts
- "Hide-and-ride" impacts
- Usefulness of and impacts from park-and-rides at transit stations
- Impacts to freight mobility
- Impacts to bicyclists and pedestrians
- Attractiveness of service and potential benefits to current transit riders
- Integration of neighborhood feeder transit service and other transportation modes into ICT system

Similar to Stage I, the Stage II public open houses were designed and conducted to share information on specific technical findings for this stage of the study. The attendees were again asked for their input and comments regarding the proposed routings within each of the two corridors, and for their concerns regarding the routes, the ICT technologies and the findings. Three open houses were held on June 26, 27 & 28, 2001, and a total of approximately 100 people attended. Other Stage II public outreach activities during Stage II included:

Website. The STS website was reformatted and continually updated during Stage II, providing the public internet access to most of the information generated during this stage. The website also contained a method for submitting comments on-line.

Newsletter. A newsletter was mailed out in May 2001 to update the public on progress during Stage II and to invite them to the June open houses.

Summary Report. A summary report was developed at the completion of the STS in October 2001, and was distributed to public libraries, neighborhood service centers, and mailed to over 6000 people.

Transit Technology

Three transit technology categories were considered for the provision of intermediate capacity transit. Two of the three—bus rapid transit (BRT) and streetcar systems—would share space on roadway facilities, and one technology option would be a grade-separated, elevated-guideway system.

Bus Rapid Transit

BRT service would be provided on articulated transit buses operating in bus-only lanes on city arterial streets. Proposed BRT lanes were assumed to be curbside with stops and stations in the sidewalk area. Proposed BRT service would be on low-floor, clean diesel, rubber-tired vehicles.

Streetcar System

A streetcar (or tram) system would include vehicles operating on rails imbedded in the pavement of city streets. Streetcar systems were assumed to be center-of-street operations with stations and stops in a center median. A streetcar would have one- to two-car electric trains.

Elevated Transit System

An elevated transit guideway system could be either steel-wheeled or rubber-tired and could have either a driver or be fully automated. For the purposes of analyses performed within this study, a fully automated, rubber-tired system was assumed. Additionally, all possible elevated technologies could have either center-of-street or curbside support column placement, but in most cases center-of-street columns were assumed. See Figures 3, 4 and 5 for typical street cross-sections representing the three technologies.

Operating Characteristics

The assumptions described below for the operating characteristics of the study technologies were utilized in developing the year 2020 ridership forecasts, the travel time estimates, and the capital, maintenance and operating cost estimates produced during Stage II. Ridership forecasts and travel time estimates were generated using Sound Transit's incremental transit model (updated and validated for a 1999 base year.)

BRT lines were assumed to have approximately four stops per mile, with variations depending upon the route and areas served. These systems were assumed to have peak-hour headways of 5 minutes and off-peak headways of 7.5 minutes. The average speed of these systems (including dwell time) was estimated to be 11 miles per hour.

Streetcar lines were assumed to have stop spacing similar to BRT, with approximately four stops per mile. For some routes longer sections of express service were assumed. These systems were assumed to have peak-hour headways of 5 minutes and off-peak headways of 7.5 minutes. The average speed of these systems (including dwell time) was estimated to be 13 miles per hour.

Elevated transit lines were assumed to have approximately one stop per mile. Their assumed headways were slightly shorter than for the other technologies, with peak-hour headways of 3 minutes and off-peak headways of 5 minutes. The average speed of these systems (including dwell times) was estimated to be 28 miles per hour.

Assumptions for fare structure and payment were made with the intent of limiting boarding and transfer delay. The fares for all three technologies were assumed to be equal and part of a coordinated regional transit fare system, thus allowing transfers between ICT and other public transit providers (e.g. Sound Transit and King County Metro) to take place seamlessly and without surcharge. Passenger fare payment was assumed to be made by a proof-of-payment system. Together these assumptions tended to reduce the dwell times for ICT technologies below those for most existing local bus services.

FIGURE 3
Typical Bus Rapid Transit Technology

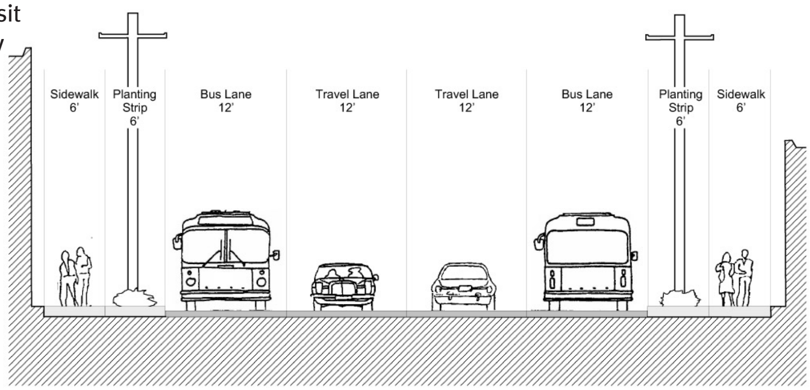


FIGURE 4
Typical Streetcar Technology

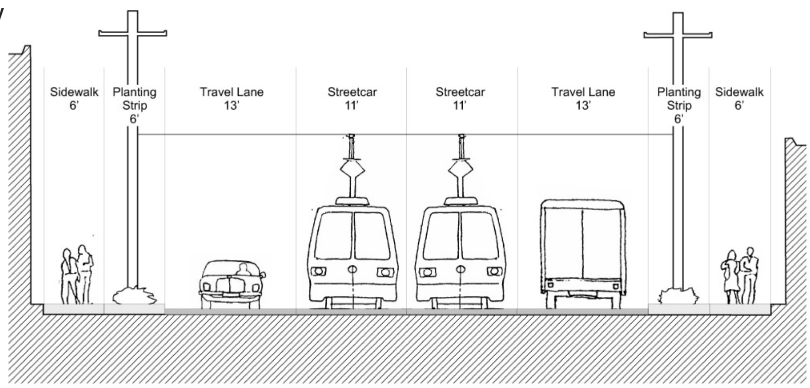
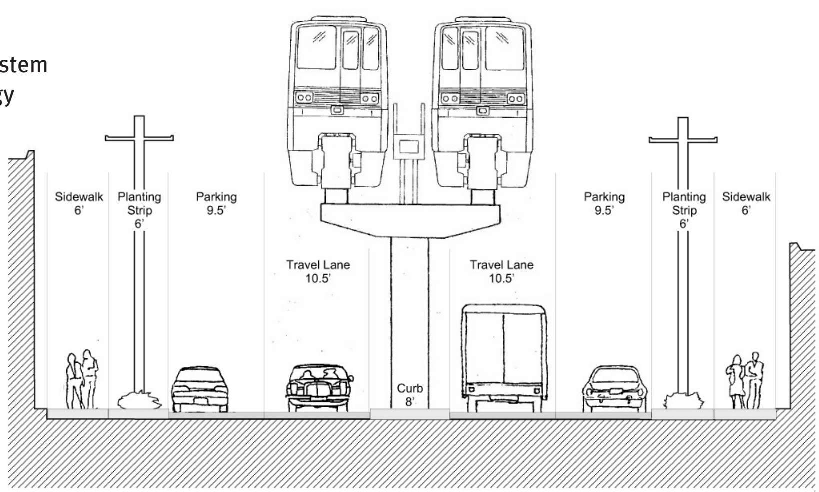


FIGURE 5
Typical Elevated Transit System Technology



Potential Corridors & Routes

Stage II Corridors

The corridors chosen for analysis and route refinement in Stage II of the STS were the Lake City–Northgate–Ballard–Downtown and the White Center–West Seattle–Downtown corridors. These corridors were selected from the Stage I analysis because they presented the most promising results. The other corridor presenting promising results—Aurora–Fremont–Downtown—is being studied in more detail as part of a WSDOT study and therefore was not carried forward in this study.

The Lake City–Northgate–Ballard–Downtown corridor had the highest ridership potential, and one of the best cost-per-rider figures found in Stage I. The White Center–West Seattle–Downtown corridor presented a wide range of ridership results across all technologies, cost-per-rider figures for elevated options appeared promising, and West Seattle has limited transportation connections to other areas in Seattle.

The Lake City–Northgate–Ballard–Downtown corridor extends from 145th Street NE, along Lake City Way, east to Northgate and Crown Hill, south to Ballard, Interbay, Queen Anne and to downtown Seattle. The White Center–West Seattle–Downtown corridor begins in either White Center or Fauntleroy, travels north to the West Seattle Junction, east across the Duwamish to the SODO area, then turns north to downtown Seattle. See Figure 6 to review the corridors selected for Stage II analysis.

Stage II Routes

At least one route was developed for each technology in the two corridors. In the Lake City–Northgate–Ballard–Downtown corridor primary and secondary routes were developed. Primary routes were typically more direct and traveled along the west side of Queen Anne Hill, following an Interbay route. Secondary routes for this corridor were designed to examine an alternative that was less direct to downtown, but included activity areas in Fremont and South Lake Union. To provide service to these areas, secondary routes would travel down the east side of Queen Anne Hill, following a West Lake Union routing. See Figures 7 through 12.

The West Seattle–Downtown corridor presented fewer options for significantly different routings, so only primary routes were developed for this corridor. However, there were various alternative routings in particular locations for each technology's primary route. The West Seattle routes traveled from either White Center or Fauntleroy north to the West Seattle Junction, then east using either Spokane Street or the West Seattle Bridge, where all routes traveled north to downtown Seattle via the Alaskan Way Viaduct, 1st Avenue South or the E-3 Busway. See Figures 13 through 15.

Lake City–Northgate–Ballard–Downtown

This corridor includes Northgate, Uptown and Downtown Urban Centers, the hub urban villages of Lake City and Ballard, and the Aurora-Licton Springs and Crown Hill residential urban villages. The corridor has considerable commercial, retail, office, multi-family housing present at Northgate and in the Downtown urban centers, which provides good bi-directional travel demand possibilities.

While the Downtown urban center clearly generates the primary demand in this corridor, Northgate is particularly suited for intermediate capacity transit service as well due to it's location immediately adjacent to I-5, its major activity and employment centers (North Seattle Community College, Northgate Mall and Northwest Hospital), and the concentration of multi-family residential, commercial and retail development in close proximity the mall. Of the three sample routes under consideration, two routes extend beyond Northgate to Lake City, which also has a moderate amount of multi-family residential and commercial land uses, however at a smaller scale than those found in Northgate.

Land uses between Lake City and Northgate are primarily small-scale commercial and retail activities and single-family residential uses. The area between Northgate and Ballard is also primarily single family residential, but with major north-south crossings at Aurora Avenue North and Greenwood Avenue North, where both commercial development and multi-family housing is found. Holman Road NW and 15th Avenue NW both serve as commercial and retail strips for the surrounding single-family residences. Ballard has a mixture of moderately dense residential development, commercial and retail uses, as well as industrial and warehouse activities associated with the Ship Canal.

The Interbay area (between Ballard and downtown Seattle) is dominated by transportation, utilities, and communication land uses. There is considerable warehouse and industrial activities in this area, as well as a concentration of multi-family housing. Moving south to the Uptown and Downtown urban centers industrial uses are replaced by high density residential, office, commercial, and retail uses.

West Seattle–Downtown

This corridor includes the Downtown urban center, West Seattle Junction Hub urban village, and the residential urban villages of Westwood-Highland Park and Morgan Junction. The corridor has a moderate concentration of commercial, retail, mixed-use, and multi-family housing present at the West Seattle Junction Hub urban village.

Five sample routes under consideration in this corridor include four routes traveling to the Downtown urban center, and one traveling between the Admiral residential area and the West Seattle Junction Hub urban village. As with most other study corridors, the Downtown urban center is the primary generator of travel demand in this corridor.

The corridor is highly residential with a majority of single-family development. The West Seattle Junction Hub urban village is centered on California Avenue SW, between approximately SW Genesee and SW Edmunds Streets. California Avenue SW from SW Admiral Way to approximately SW Morgan is the main commercial and retail strip for the West Seattle area. This strip is also were most all of the mixed-use and smaller scale multi-family housing is located.

A large amount of multi-family housing is located between SW Juneau and SW Morgan Streets along 35th Avenue SW and along Delridge Way SW, between SW Orchard and SW Henderson Streets. In the Westwood-Highland Park area a moderate amount of multi-family housing exists with both moderate and small scale commercial and retail land uses. Near the Fauntleroy ferry dock the primary land use is single-family residence with only a very small amount of multi-family and retail development.

Between West Seattle Hub urban village and the Downtown urban center is the Duwamish manufacturing and industrial center. From SW Avalon Way and SW Andover Street east and north into downtown Seattle the predominate land uses are transportation, utilities, communications, industrial and warehouse areas, with scattered retail and commercial uses.

FIGURE 6
Stage II Corridor Map

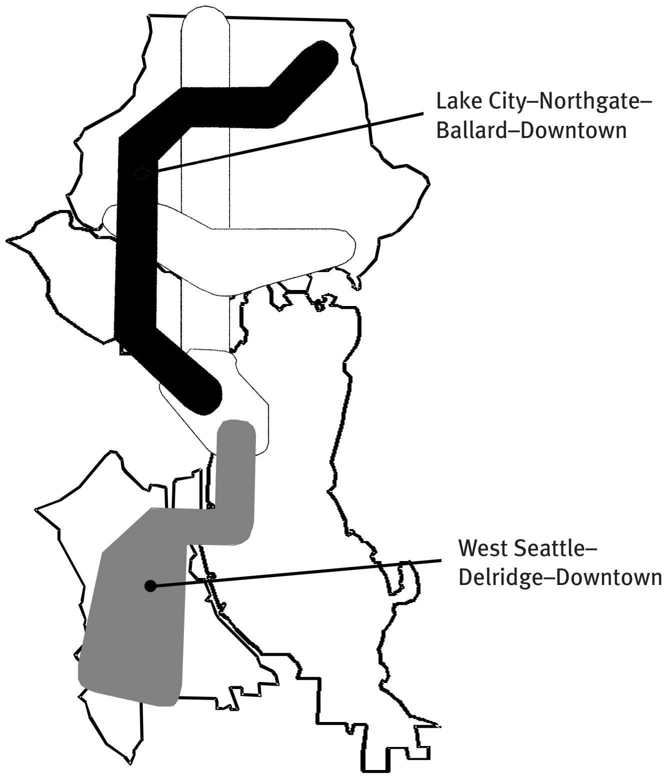


FIGURE 7
Lake City – Downtown Primary Bus Rapid Transit Route

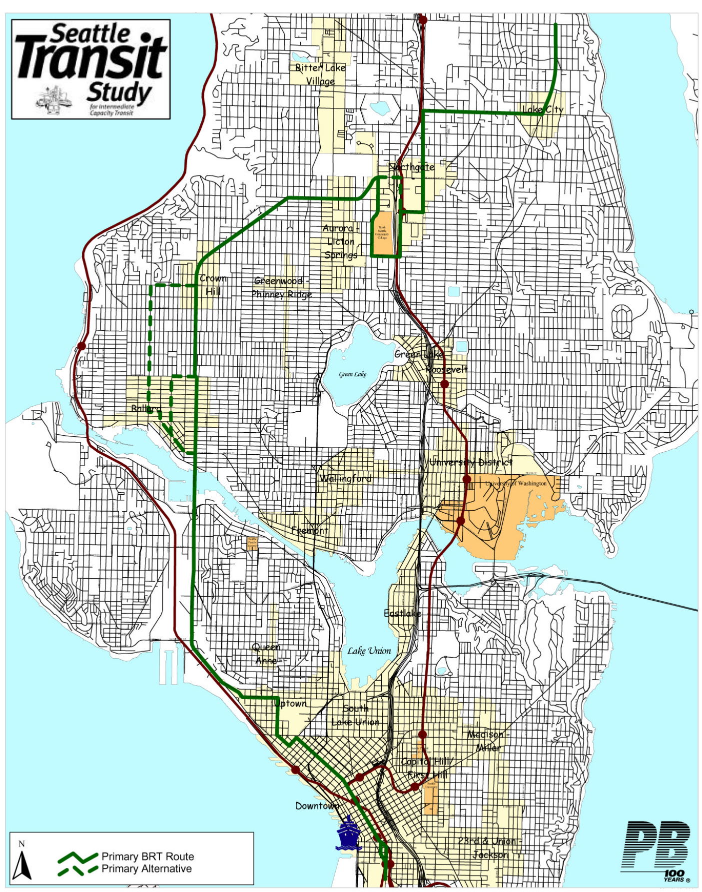


FIGURE 8
Lake City–
Downtown
Primary Streetcar
Route

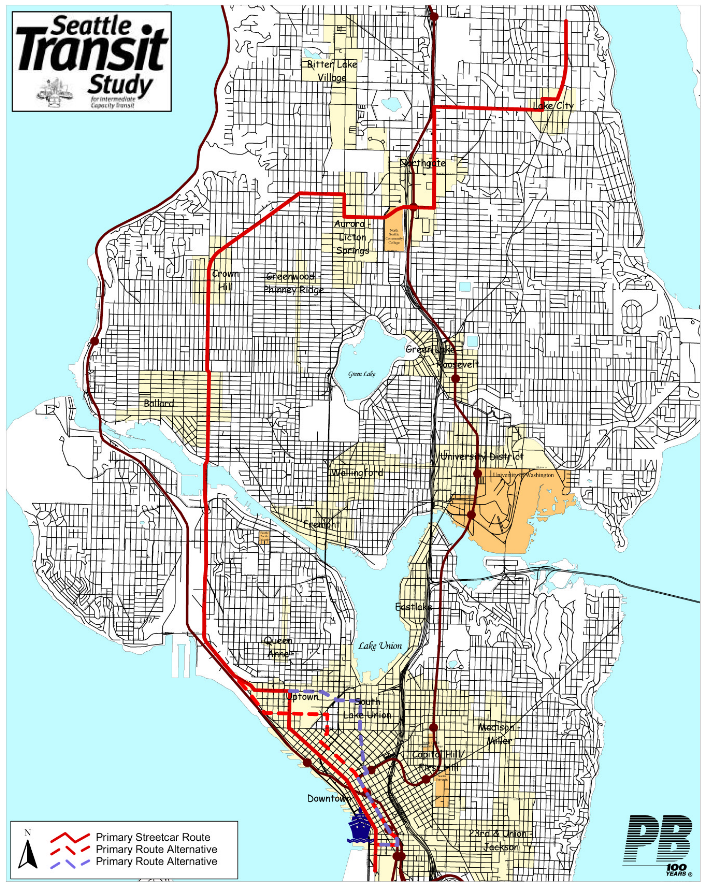
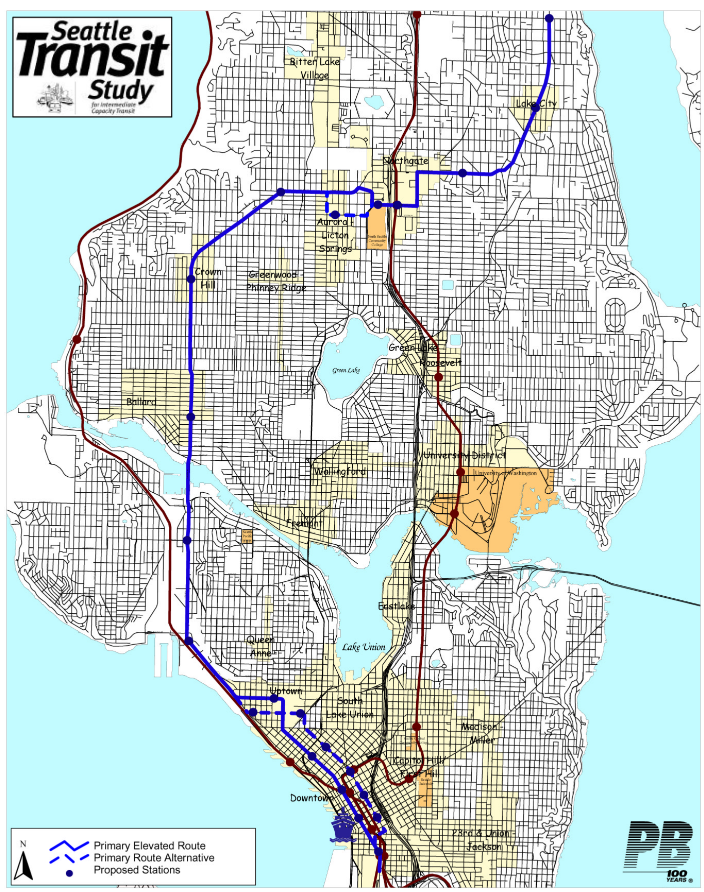


FIGURE 9
Lake City–
Downtown
Primary Elevated
Transit Route



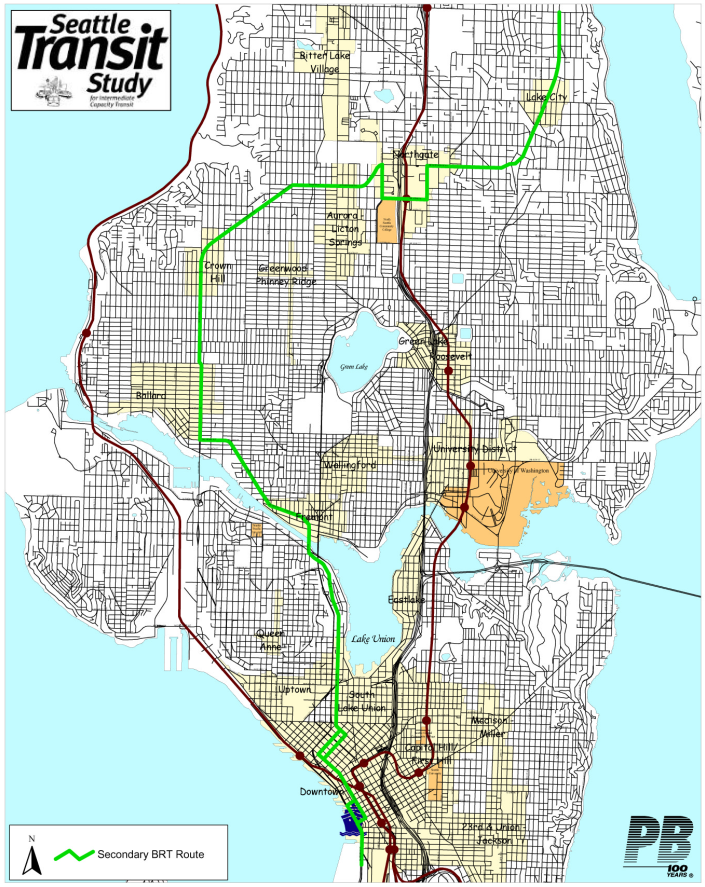


FIGURE 10

Lake City–Downtown Secondary Bus Rapid Transit Route

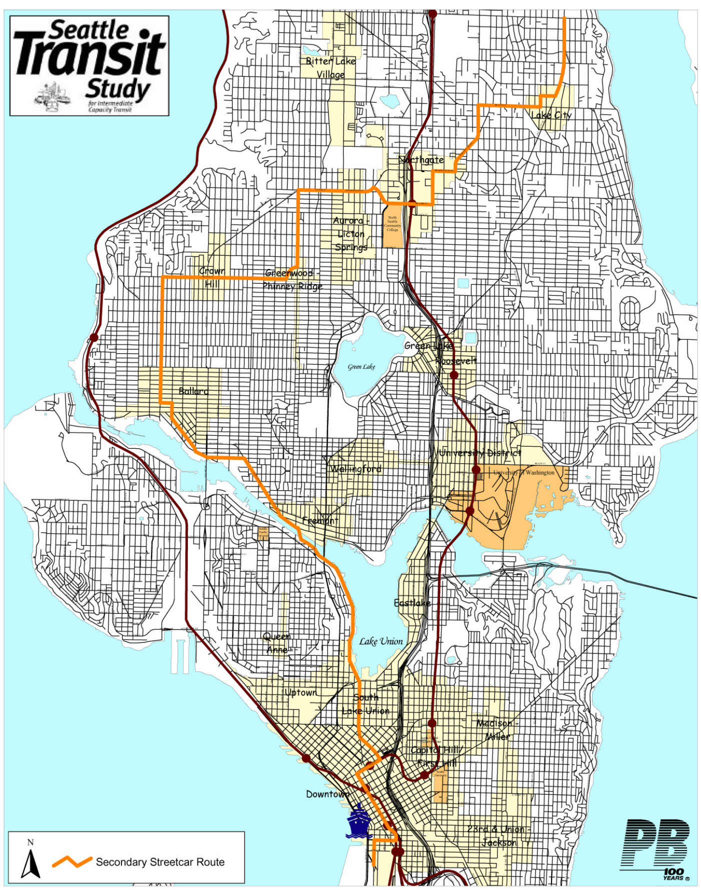


FIGURE 11

Lake City–Downtown Secondary Streetcar Route

FIGURE 12
Lake City–Downtown Secondary Elevated Transit Route

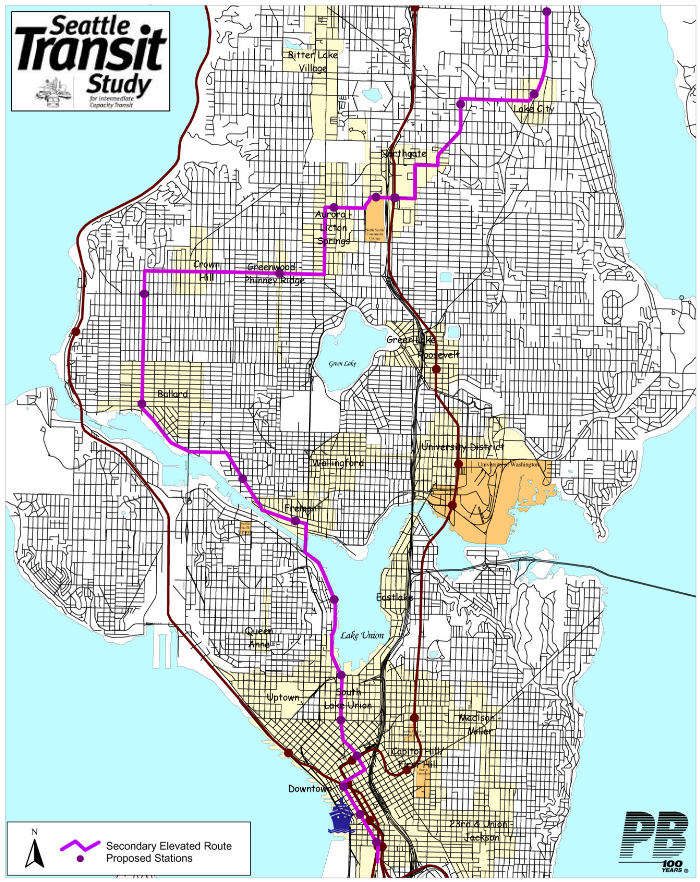
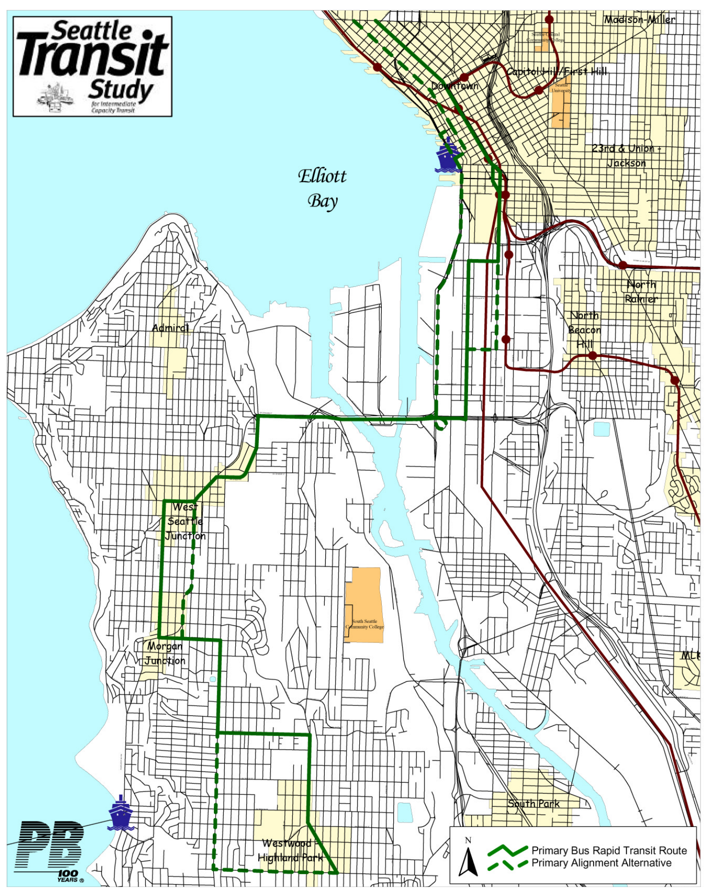


FIGURE 13
West Seattle–Downtown Bus Rapid Transit Route



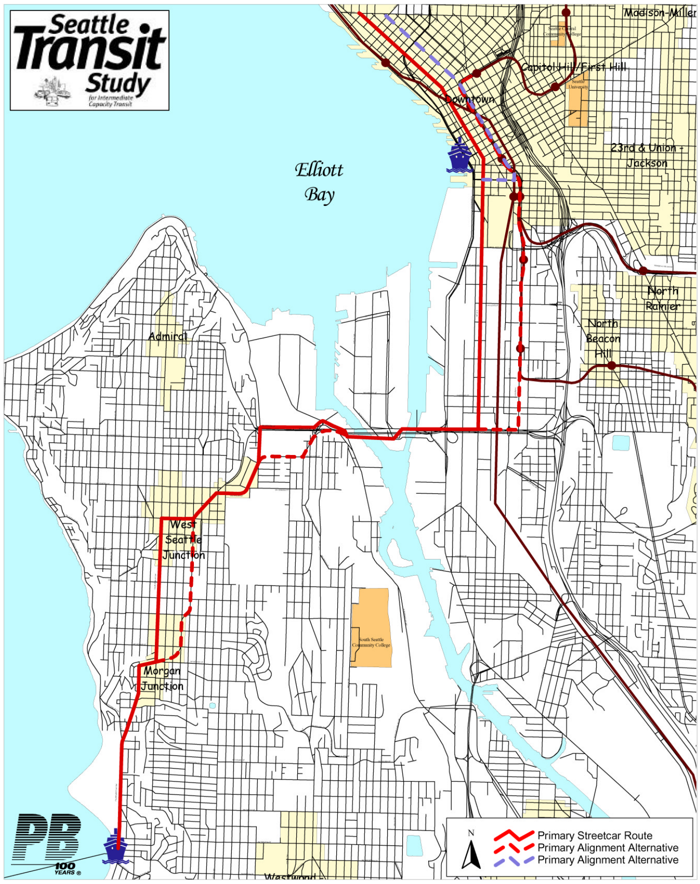


FIGURE 14
West Seattle–
Downtown
Streetcar Route

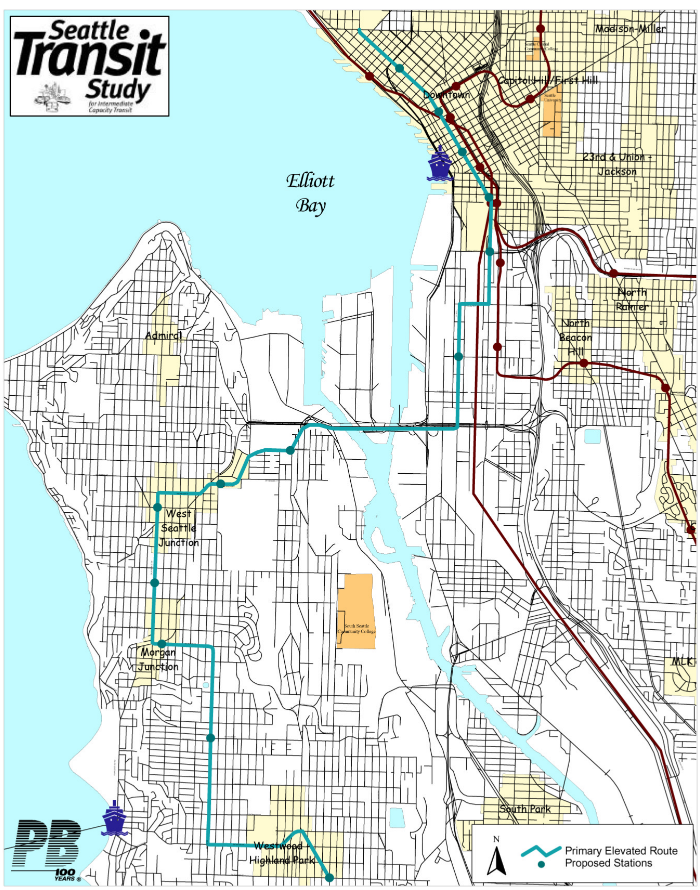


FIGURE 15
West Seattle–
Downtown
Elevated
Transit Route

Findings

Specific routes from the two corridors were paired together to form an integrated system. These pairings were developed so that the analysis of the proposed routes provided a comprehensive view of a system that would benefit riders throughout the City of Seattle. The pairings also allowed for and efficient and cost effective modeling process and were used as model groups. Table 2 identifies each model group and its routes.

Routes were paired based on technology and directness of route. In general, each model group pairing had the same proposed transit technology with the exception of model group 4 which paired the Secondary Lake City–Northgate–Ballard–Downtown Elevated route with the West Seattle–Downtown DSTT Streetcar route. Table 2 below identifies each model group and its route pairings used for the modeling process.

TABLE 2 **STAGE II STS MODEL GROUPS**

Model Group	*Lake City–Northgate Ballard–Downtown*	*West Seattle– Downtown*
1	Primary BRT Route	1st Avenue South BRT Route
2	Secondary BRT Route	Alaskan Way Viaduct BRT Route
3	Primary ETS	Primary ETS
3b	Primary ETS to Crown Hill	Primary ETS to West Seattle Junction Only
4	Secondary ETS	Downtown Seattle Tunnel Streetcar Route
5	Primary Streetcar	Primary 1st Avenue Streetcar Route
6	Secondary Streetcar	Secondary Streetcar Route
7	Primary ETS to Northgate	Primary ETS to West Seattle Junction Only

Presented below are selected highlights and significant findings from the modeling and analyses performed in Stage II. These analyses and the related findings were developed for the purpose of evaluating the corridors and the alternative ICT routes and technologies within them. This was accomplished by comparing them to each other for forecasted performance, estimated costs and potential impacts, and each relative to the existing transit system's performance and operating conditions. These comparisons, when measured against a set of Stage II evaluation criteria, were used to guide the conclusions and recommendations made by the PMT and the City at the end of Stage II.

Ridership

Ridership findings were derived from the transit model output that was generated for the groupings of route and technology alternatives within each corridor (see Table 2). The forecast year was 2020. Network assumptions for all 2020 alternatives included full completion and operation of Sound Transit Link light rail and commuter rail systems, restructuring of the bus transit system to support Link and the ICT alternatives, and anticipated roadway improvements, such as general capacity expansion along I-405, completion of SR-509, and of the regional freeway HOV system.

Boardings. Elevated routes generated the highest number of daily boardings compared to the other technologies. Anticipated daily boardings for elevated routes ranged from 56,100 in the north to 25,400 in the south. Limited stop streetcar routes generated the next highest boarding numbers with 49,600 in the north and 23,500 in the south. Streetcars, with stops approximately every quarter mile, generated daily boardings of 33,500 in the north to 10,800 boardings in the south. Bus rapid transit technology generated less than 20,000 daily boardings on each route, with the exception of the Primary Lake City–Downtown route, which generated 32,500 daily boardings. (It should be noted that for BRT routes, the number of boardings listed represents only those for the BRT service specifically designed for, and running along the ICT corridor. Therefore, BRT boardings do not include boardings for other bus routes that may travel along the BRT's bus-only lanes.) Figure 16 shows the estimated 2020 annual boardings by model group.

New Trips. This is the number of additional (new) trips that each proposed route and technology combination is expected to generate for the overall transit system ridership in the Puget Sound region. Elevated technologies generated the largest number of new trips, particularly for the Lake City–Downtown routes. Interestingly, in the West Seattle–Downtown routes, the number of new trips forecast was similar across all three technologies. For example, new trips generated by the elevated routes were only about 100 trips greater than those generated by BRT, while streetcar generated approximately 500 new trips less.

Cost Findings

Capital, operating and maintenance costs for each route and technology alternative were estimated using unit costs derived from planning studies for similar transit improvements nationally, and from actual construction and operation experiences both nationally and internationally.

Capital Cost by Component. Nearly all component costs (line, station, support facilities and right-of-way) were estimated to be highest for the elevated routes. Only the vehicle component for streetcar was higher than for elevated. As expected, component costs for BRT were estimated to be considerably less than for either streetcar or elevated technologies.

Capital Cost per Mile. The costs were estimated to be highest for the elevated routes. The average streetcar costs per mile were estimated at approximately 50 to 60 percent of those found for elevated. Cost-per-mile findings for BRT were estimated to be considerably less than for either streetcar or elevated technologies; typically BRT costs were about 25 percent of those for streetcar. Figure 17 shows the capital cost per mile by model group.

Operations & Maintenance Cost. Of the three technologies, streetcar was estimated to have the highest operating and maintenance costs, and BRT the lowest. Much of the overall cost differences were a result of the higher operating costs for a driver labor force assumed necessary for streetcar and BRT, as opposed to the fully-automated operation assumed for elevated. However, the shorter elevated routes were estimated to have operating and maintenance costs on par with the full-system BRT routes.

Impact Findings

The STS study team collected available data for each impact category throughout Stage I and Stage II. Physical environment information, built environment information, parking data, and traffic count data were collected and compiled. The data was then categorized, mapped, and further developed in order to evaluate the Stage II route and technology combinations. The following paragraphs detail the data collection, categorization, and development of data for each impact category.

Natural Environment. This analysis requires extensive data collection and research to accurately and fully understand impacts to the natural environment along each proposed route. As a result, the effort for Stage II focused on determining readily available data that could be displayed graphically and incorporated into comprehensive maps, thus facilitating a quick visual assessment and comparison between route and technology alternatives where impacts may be expected. This level of analysis was deemed adequate for evaluating the relative potential impacts among alternatives, and appropriate for the analytical level of detail undertaken within the STS.

A significant indicator of relative potential environmental impacts is the number of water-crossings requiring new in-water supports by route. Hence, to assess and compare the potential impacts to water crossings (and other natural elements), a series of maps were created depicting streams, water bodies, and steep-slopes overlaid with the routes and technology alternative for each corridor.

Built Environment. This includes neighborhood character—the general mixture of land uses within roughly defined neighborhoods adjacent to the routes—rights-of-way, pedestrian and bicycle facilities, cultural and historic landmarks and districts, parks, schools, and other aspects of the physical environment. In general, the same method used to evaluate potential impacts to the natural environment was used for the built environment. This was done by creating various maps showing the locations of the elements identified above and using these maps as appropriate to quantitatively and qualitatively assess and compare the relative potential impacts between the route and technology alternatives.

Generally, elevated technologies were considered to affect neighborhood character to a greater extent than either BRT or streetcar technologies, due to the right-of-way requirements as well as visual impacts. This expectation was confirmed in part, by the right-of-way costs associated with elevated systems, which were estimated to be considerably higher than the BRT or streetcar right-of-way costs. ROW cost values varied from $2.9 million for BRT service to $72.4 million for elevated service.

Conversely, elevated systems appeared to impact pedestrians and bicyclists to a lesser degree, than the proposed BRT or streetcar systems. Streetcar technology was considered to have the greatest impact to bicyclists due to the in-street rails, which may pose a hazard to cyclists. Possible impacts to cultural and historic districts and sites are largely related to route placement and the incidence of historic sites or districts along the route. Routes that traveled through historic districts were considered to be more disruptive than routes that were in an adjacent street. Proposed streetcar lines that traveled along previous streetcar routes (i.e., those of the pre-1950's system in Seattle) were considered to be somewhat less disruptive than "new" streetcar routes. Elevated systems were considered to be more disruptive to residential neighborhoods—due to the need for an elevated structure—than streetcar or BRT systems.

Parking. At-grade BRT and streetcar systems were anticipated to adversely affect on-street parking to a greater degree than elevated systems, as they would require more in-street right-of-way space than an elevated route. Additionally, routes that travel through residential areas or routes that were not located on arterial streets (where parking is typically available) would have larger segments where parking removal would be required. Parking removal was anticipated to be greatest along the West Seattle–Downtown routes that extended to the White Center area, and on the Lake City–Northgate–Ballard–Downtown secondary routes.

Traffic. These impacts were assessed by analyzing and comparing the forecasted traffic conditions at ten intersections at various points along the proposed ICT routes. Traffic forecasts were developed by projecting future intersection volumes from existing volumes using the City of Seattle's EMME/2 model for the year 2020. The intersections were then analyzed by simulating the various future build conditions (proposed technology modifications) at each. One aspect of traffic analysis the study did not undertake was to forecast the mode shift that would occur under the various future build conditions. However, even without the projected mode shift, the analyses could still be used to compare relative impacts of the various route and technology combinations.

As found for parking impacts, traffic impacts were projected to be greatest for the at-grade BRT and streetcar systems. BRT and streetcar systems typically required two dedicated travel lanes, in some cases this could be parking, but in others it required the removal of one or two travel lanes. Elevated systems were anticipated to require approximately one travel lane, which could be accommodated through parking removal or by a single lane removal. However, for all technologies a degradation in level-of-service at the analyzed intersections was projected under both future baseline and future build conditions.

Measures of Effectiveness

The measures of effectiveness provide an indication of the ability of a proposed route and technology combinations to attract riders to the system. This can be expressed by the number of new riders who would use the proposed ICT route or by the speed at which passengers progress to their destination on the proposed route.

Transit Mode Share. Routes with grade-separated operations were forecast to attract more new riders, due to higher average operating speeds. This estimated increase in new riders also applied to routes with extended express (very limited stop) service. The primary (full-system) elevated route was forecast to attract the highest number of new riders, at approximately 3.9 million new annual riders in 2020. The shortened elevated route (Northgate to West Seattle Junction) was forecast to attract 3.2 million new annual riders in 2020. The primary BRT route was forecast to generate 3.1 million new riders, while the elevated-streetcar combination route (Lake City–Downtown Secondary Elevated and West Seattle–Downtown DSTT Streetcar route) was forecast to generate 3 million new riders by 2020. Streetcar routes with typical stop spacing (4 stops per mile) were forecast to generate the lowest number of new riders by 2020.

Travel Speed. Grade-separate routes were projected to be faster than proposed at-grade BRT and streetcar routes. Elevated technology routes were forecast to have end-to-end (Lake City to White Center) travel times of less than 60 minutes. BRT and streetcar routes were forecast to have end-to-end travel times ranging between 90 and 120 minutes, with the exception of the primary streetcar route, which was forecast to take 85 minutes.

Cost Effectiveness

These measures are an indicator the value of providing the proposed transit service. The measures compare the cost of providing the proposed service compared to the benefits received. The measures evaluated for Stage II were all based on quantifiable benefits of providing an intermediate capacity transit service. Criteria to estimate perceived or "intangible" benefits of providing such additional transit service, such as possible rider preference for rail vehicles over buses, were not developed.

Annualized Cost per ICT Boarding Passenger. This measures the cost (capital and operating) of providing the proposed ICT service on a yearly basis divided by the annual number of passengers. Elevated and streetcar technologies were estimated to have higher capital and operating costs than BRT; therefore, providing BRT service was estimated to have the lowest annualized cost per ICT boarding passenger. Providing elevated service was estimated to be considerably lower than providing streetcar service on an annualized per passenger basis. Cost estimates for BRT service ranged from $2.60 to $6.65 per ICT passenger, and elevated service ranged from $5.75 to $9.60. Streetcar service ranged from $6.50 to 13.90 per ICT boarding passenger.

Incremental Cost per Incremental Passenger. This measure assesses the added cost required to provide the service for each new rider gained by implementing the new service. The costs associated with implementing the proposed service are valued for each additional passenger served, beyond those served by the existing system.

Due to BRT's estimated lower capital and operating cost, the incremental cost per incremental passenger was also projected to be the lowest of the three technologies. BRT's incremental cost per incremental passenger cost was estimated to range from $8.90 to $17.45 per passenger. Even with elevated systems' higher projected costs, its higher forecast for new riders would help off-set the costs. Hence, estimated incremental costs per incremental passenger for elevated routes were forecast to be better than those for streetcar systems. Incremental costs per incremental rider for elevated systems were estimated to range from $34.35 to $74.55 per passenger, while incremental streetcar system costs per incremental passenger were expected to range from $47.50 to $510.35. See Figure 18.

Annual Value of Travel Time Savings per Annualized Cost. This measures the amount of time saved by passengers using the existing service compared to the cost of providing the proposed service.

The secondary BRT route was estimated to have the highest annual value of travel-time savings compared to all other routes studied under Stage II. The shortened elevated routes (Crown Hill to West

Seattle Junction and Northgate to West Seattle Junction) were estimated to produce the next best results. The secondary streetcar route was projected to have the poorest results of all Stage II routings.

Incremental O & M Cost per Incremental Passenger Mile. This measures the added operating and maintenance cost required to provide the proposed service by each new rider mile. The operating and maintenance costs associated with implementing the proposed service are valued for each additional passenger mile logged above those logged under the existing system.

Technologies with a high level of automation and high ridership were forecast to produce favorable results in this category. Elevated routes were estimated to have an incremental operations and maintenance cost per incremental passenger mile of $0.25. Streetcar routes with typical stop spacing (4 stops per mile) were forecast to perform poorly, with incremental costs of $2.85 and $3.65. BRT technologies produced mixed results that varied from $0.40 to $1.05 and appeared to be based more on routing than technology.

FIGURE 16
2020 Annual Boardings on Proposed ICT Model Groups

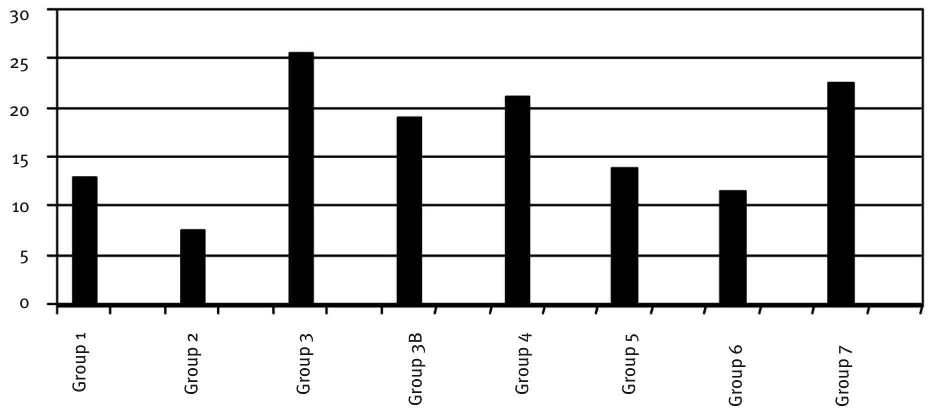


FIGURE 17
Capital Cost per Mile by Model Group

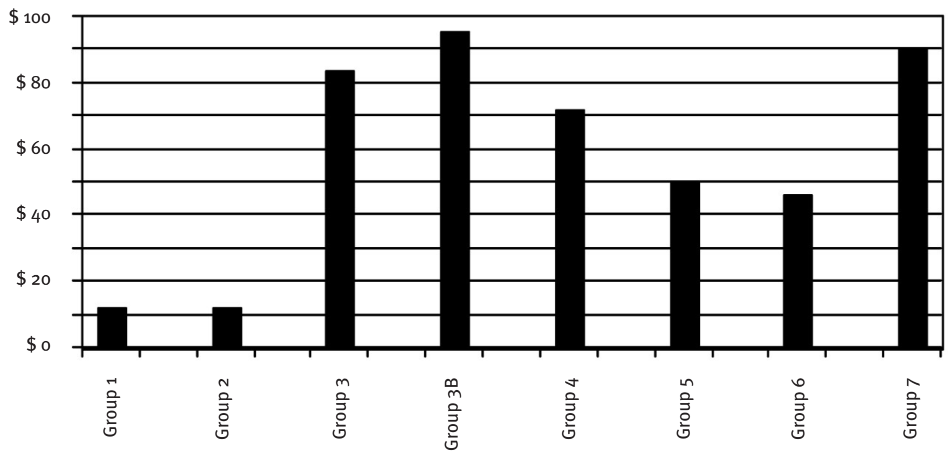
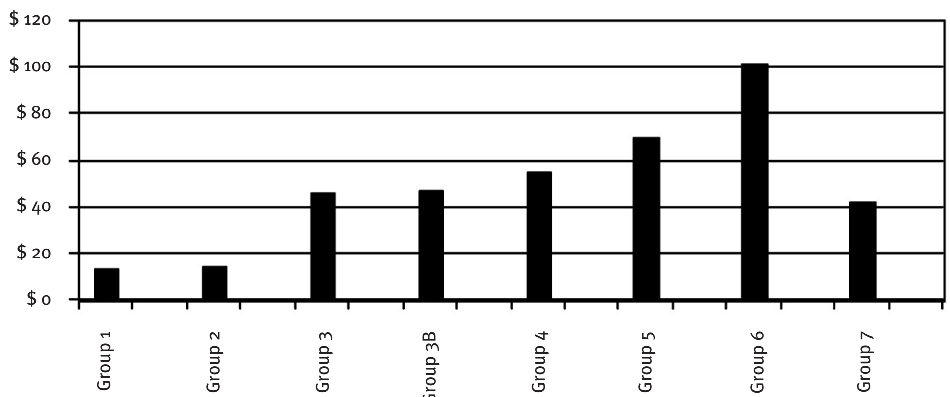


FIGURE 18
Incremental Cost per Incremental Passenger by Model Group



Conclusions & Recommendations

Various general conclusions were drawn for each corridor based on the technical findings and the comments from stakeholders, neighborhoods and businesses. Using these conclusions together with the knowledge of major future transportation projects within the City, a set of recommendations were developed by City staff and affirmed by the PMT. The results are summarized below.

West Seattle Corridor

Overall, the West Seattle–Downtown corridor did not present clear technology findings. All three technologies were projected to generate similar ridership levels, with an elevated system anticipated to attract more new riders while posing higher costs and more engineering difficulties (from having to negotiate the industrial area and the Duwamish waterway.) Streetcar ridership projections varied based on the level of grade-separation, but were generally forecast to be lower than ridership levels projected for elevated and bus rapid transit systems. However, when the streetcar stop spacing is increased from 1/4 mile to 1 mile, this technology begins to show similar ridership and speed as elevated. Projected BRT ridership was generally favorable, but in some cases at the expense of ridership on other bus routes. Additionally, BRT service is not anticipated to produce high travel-time savings, due to the relatively fast existing bus route speeds to/from downtown on the Alaskan Way Viaduct; however, BRT improvements are estimated to require much lower cost than the other technologies. In summary, no one technology appears more feasible than another between West Seattle and Downtown.

Other significant conclusions

- ICT service to White Center does not appreciably increase system ridership
- Extending the system from West Seattle Junction to White Center would increase capital costs over 50%
- Neighborhood and traffic impacts are likely to be highest along the routes between Morgan Junction and White Center

Recommendations

- ICT improvements should be made between Downtown and West Seattle Junction or Morgan Junction.
- Further analysis should be done across a wide range of technology alternatives, as there may be opportunities to incorporate improvements into the other major transportation projects planned for the South Downtown area, such as the Alaskan Way Viaduct.

- Multi-modal transit hubs should be provided at potential stations near West Seattle Junction and Delridge Avenue SW at the West Seattle Bridge to improve integration of ICT with other transit service and with other transportation modes

North Seattle Corridor

An ICT route between Northgate, Ballard and downtown exhibits the most promise. An elevated system provides the greatest expected travel-time savings; hence, the ridership forecasts for an elevated system in this corridor are much higher relative to the other technologies. Due to these projected ridership levels on elevated routes, the cost effectiveness measures produce favorable results as well. Engineering of an elevated system along this corridor is anticipated to be relatively straightforward, with the crossing of the Ship Canal posing the greatest challenge.

Other significant conclusions

- As a regional urban center and regional transit hub Northgate is an important destination for ICT service. Extending service to Northgate would make the most of the investment of building a new structure over the Ship Canal.
- Elevated routes that serve the Interbay area provide the most direct connection between Ballard and downtown; hence, they were projected to have slightly higher ridership than routes serving Fremont and south along Westlake.
- Serving the Uptown area west of the Seattle Center is advantageous from a ridership standpoint, but poses challenges for routing to Downtown through either the Belltown or South Lake Union areas from the standpoint of impacts to these communities and the Seattle Center.

Recommendations

- Elevated ICT improvements should be made to connect Downtown, Ballard and Northgate with a dedicated ICT structure crossing the Ship Canal. Further analysis is necessary to determine whether the Fremont and South Lake Union areas should ultimately be served along the final route.
- Multi-modal transit hubs should be provided in Ballard and Northgate to improve integration of ICT with other transit service and with other transportation modes.

Policy Recommendations

The five ICT corridors identified at the conclusion of Stage I of the Seattle Transit Study, along with the two Sound Transit regional high-capacity transit corridors form the backbone of a network for transit improvements within Seattle. Figure 19 shows the recommended ICT system vision. Improvements along these corridors could take 20-30 years or more to implement. These corridors should be integrated into existing City of

Seattle plans and programs so they may be considered as part of any future work.

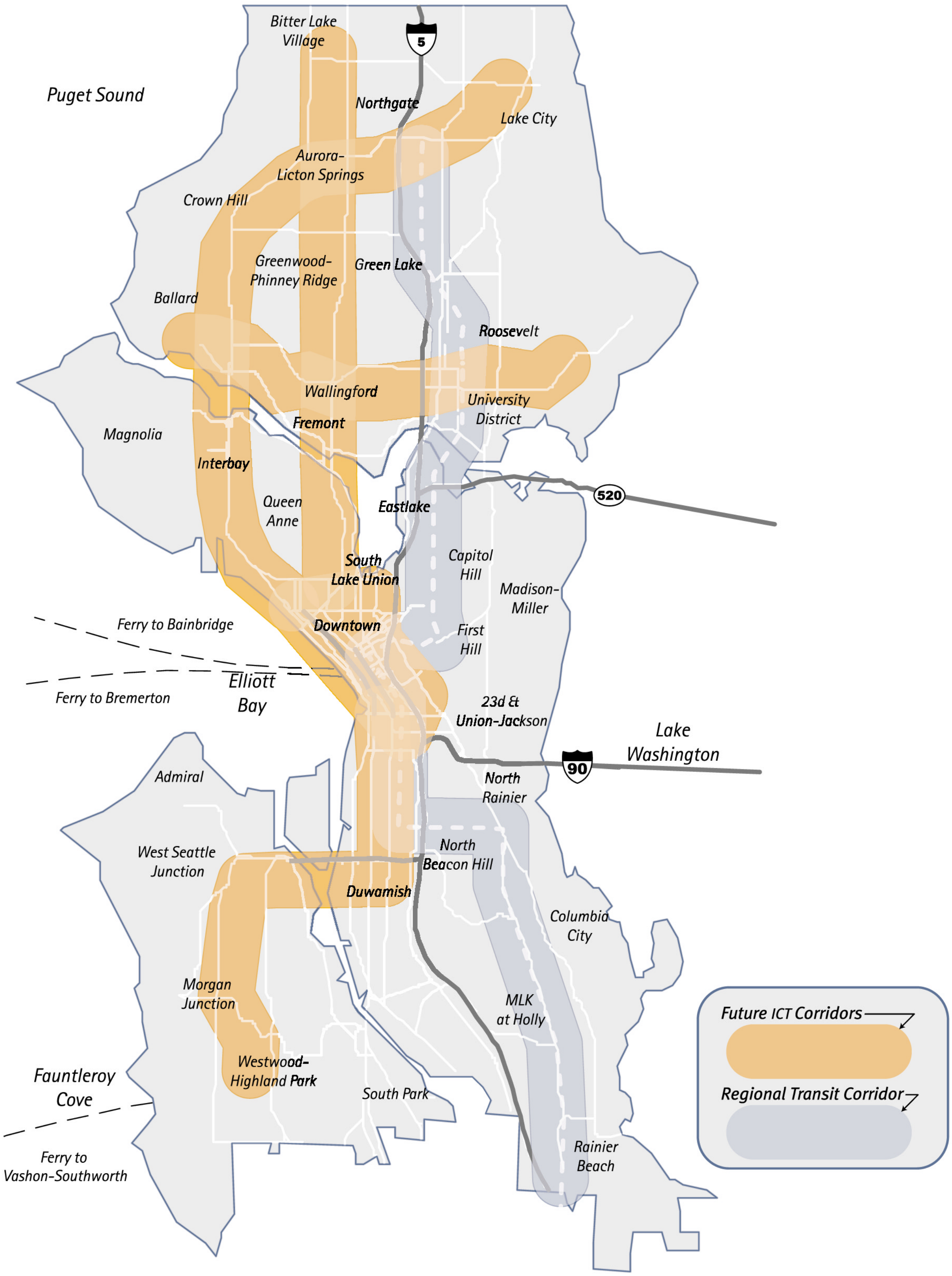
- Work with the Seattle City Council to amend the Comprehensive Plan to identify the five Seattle Transit Study corridors and two Sound Transit corridors as the City's long-range, high-capacity transit vision and identify key supporting policies for this vision.
- Look for opportunities and efficiencies while examining other major transportation projects—such as the Viaduct, SR-519, Spokane Street Viaduct—to help fulfill this long-range vision or to make other transit improvements.

Other Recommended Actions

The City should work with the STI partner agencies on the following actions toward fulfilling the vision of an integrated transit system in Seattle:

- Work with ETC Council and staff to develop a viable Seattle Popular Transit Plan.
- Work with King County Metro and neighborhoods from Ballard to the U-District to develop an interim transit improvement project along this corridor.
- Examine the potential for developing multi-modal transit hubs at four key future ICT stations.

FIGURE 19
Recommended
ICT System Vision



Prepared by PRR