Ultra-High-Speed Ground Transportation Business Case Analysis

Final Report

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JAY INSLEE
Governor

STATE OF WASHINGTON
Office of the Governor

Prosperity and growth in the Pacific Northwest have generated an appetite for innovative solutions that better connect our region and opportunities to carry us into the future. My vision for the megaregion — stretching from Washington, north to British Columbia, and south to Oregon — includes a transportation system that is fast, frequent, reliable, and environmentally responsible. Such a system would unite us in our common goals related to economic development, shared resources, affordable housing, new jobs, tourism, multimodal connections, and increased collaboration.

The ability to travel each segment between Seattle, Portland, and Vancouver, B.C. in less than an hour will revolutionize the way we live, work, and play in the Pacific Northwest. Moreover, it helps us preserve the natural beauty and health of our region by enabling faster, cleaner, and greener trips between our region's largest cities.

This Business Case Analysis is the result of a year of collaboration between the states of Washington and Oregon, the province of British Columbia, and Microsoft, and builds on a 2017-2018 feasibility study. It provides even greater confidence that an ultra-high-speed ground transportation system in the Pacific Northwest is worth the investment.

This is a bold undertaking that reflects the collective vision of businesses, government officials, and non-profit leaders from across the three jurisdictions. They recognize the transformative potential of improved cross-border collaboration and greater regional connectivity. I invite all of you to join me in moving this evolving concept forward as we look to broaden the base of understanding and support; develop a viable governance structure; and further refine plans for implementation. Let's make this happen!

Very truly yours,

Jay Inslee
Governor

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In appreciation

Special thanks to members of the UHSGT Advisory Group who provided input on the analysis from a variety of perspectives. The group included representatives from the public, private and nonprofit sectors in Washington, Oregon, and British Columbia. Members represented the following organizations and agencies:

- British Columbia Ministry of Jobs, Trade and Technology
- British Columbia Ministry of Transportation
- British Columbia Office of the Premier
- City of Portland
- City of Seattle
- City of Surrey
- City of Vancouver
- Consul General of Canada
- Futurewise
- King County
- Microsoft
- Oregon Department of Transportation
- Oregon Metro
- Oregon Office of the Governor
- Oregon Transportation Commission
- Portland Business Alliance
- Puget Sound Regional Council
- Seattle Chamber of Commerce
- TransLink
- Transportation Choices Coalition
- Washington Building Trades
- Washington Roundtable
- Washington State Dept. of Commerce
- Washington State Dept. of Transportation
- Washington State Governor's Office
- Washington State House of Representatives
- Washington State Senate

WSP also thanks its subconsultants – Steer, EnviroIssues, Paladin Partners, and Transportation Solutions – for their valuable contributions to this report.

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Executive Summary

Study context

At the 2016 Emerging Cascadia Innovation Corridor Conference, US and Canadian business and government leaders discussed how collaborating across the US–Canada border could enrich the region by expanding trade and forging collaboration in technology, research, transportation, and education. The State of Washington Governor Jay Inslee and British Columbia Premier Christy Clark issued a memorandum of understanding pledging to work together to create a new technology corridor, including an ultra-high-speed ground transportation (UHSGT) system to better connect the corridor's major hubs and towns and promote the economic growth of the Cascadia Innovation Corridor. With the support of regional business, labor, environmental, and government leaders, Governor Inslee and the State Legislature requested that the Washington State Department of Transportation (WSDOT) study the feasibility of a UHSGT that would connect Vancouver, British Columbia (BC); Seattle, Washington (WA); and Portland, Oregon (OR).

In 2017-2018 WSDOT undertook a preliminary UHSGT Feasibility Study (2017-2018 Feasibility Study) that constituted an important first step in understanding and quantifying the potential benefits of a new transportation system in the Cascadia megaregion, reaching from Vancouver, BC to Portland, OR. UHSGT is defined as a system that could connect Vancouver, BC; Seattle, WA; Portland, OR, and points in-between and beyond, with frequent trains running at speeds as high as 250 miles per hour (400 kilometers per hour) that could reduce travel time between the major cities to less than an hour. The project team used the Federal Railroad Administration's Conceptual Network Connections Tool (CONNECT) to estimate the ridership, revenue, capital and operations and maintenance (O&M) costs, and public benefits at an order-of-magnitude level. The 2017-2018 Feasibility Study projected annual ridership of 1.7 million to 2.1 million in 2035, and estimated capital costs ranging from $24 billion to $42 billion (2017).

In 2018, the Washington State Legislature moved UHSGT forward and approved funding to conduct a business case analysis. WSDOT was joined by the Oregon Department of Transportation, the Province of British Columbia, and Microsoft as funding partners and oversight contributors via representation on a Steering Committee. Moreover, an Advisory Group was formed to provide input from public, private and non-profit representatives from throughout the megaregion.

The resulting 2019 Business Case presented herein is informed by a series of technical reports produced by the project team over the last year, including the following:

- **Benefit Analysis Technical Memorandum** (Appendix A), which evaluates the monetizable user and social benefits associated with the project.
- **Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion** (Appendix B), which examines the potential for transformative economic impacts due to UHSGT in the megaregion
- **Corridor Planning Technical Memorandum** (Appendix C), which delineates conceptual service attributes, hypothetical routes, and potential major and minor station locations that would best support investment in UHSGT

- **Ridership and Revenue Forecasts** (Appendix D), which includes a travel demand model for intercity services between Vancouver, BC; Seattle, WA; and Portland, OR; and intermediate locations to test ridership and revenues for a series of scenarios
- **Final Draft Funding and Financing Strategy Plan** (Appendix E), which includes suggested near- and long-term strategies for obtaining new sources of funding to support pre-development activities, construction, and long-term operation of the project
- **Candidate Governance Structures Report** (Appendix F), which includes recommendations for potential governance models structured to effectively deliver and manage UHSGT that would include all three jurisdictions

UHSGT purpose and vision

The need for continued additional transportation infrastructure investment in the Cascadia megaregion is clear—crowded roads, congested airports and limited intercity rail service constrain the mobility of residents, businesses, and tourists. Vancouver, BC; Seattle, WA; and Portland, OR, have the fourth, sixth, and tenth-most congested roads in North America, respectively. Airport delays are making air travel increasingly unreliable, and the travel time and frequency of intercity rail service are not competitive for most trips.

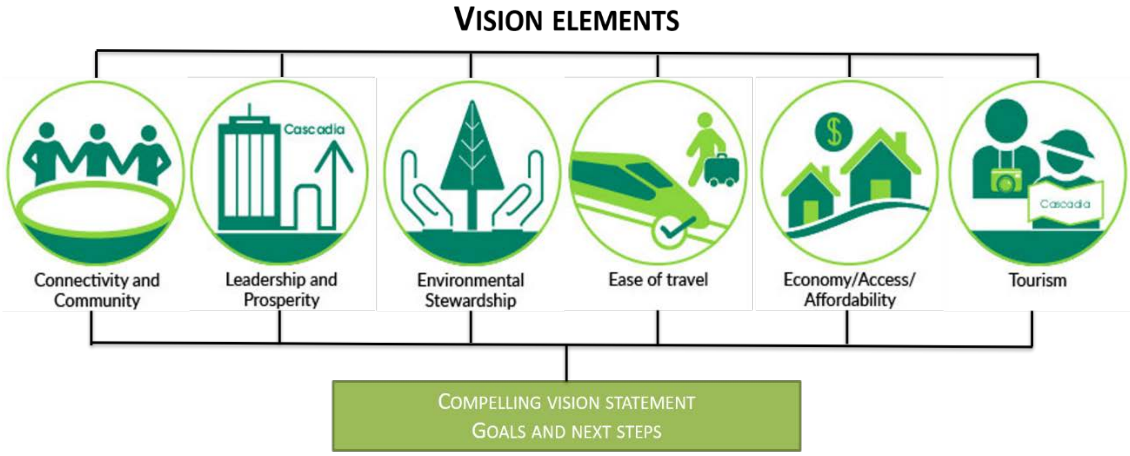
WSDOT estimated that adding a lane in each direction of US Interstate 5 through the state would cost approximately $108 billion in 2018 dollars. Current plans for expansion at the region's airports may not be sufficient to accommodate an expected doubling of demand. Amtrak's Cascades rail service shares an alignment with freight rail and Sounder transit operations, which limits the opportunity to reduce travel times and improve frequencies. However, the success of major local initiatives to raise public funds for new transit development (such as the 2016 Sound Transit 3) demonstrates a public willingness to invest in new ground transportation systems.

The issues of increasing congestion, lack of capacity, and unreliable existing transportation networks has led to a need to set out a vision to unlock a globally competitive, equitable, and sustainable Cascadia megaregion. The vision elements illustrated in Figure ES-1 were identified by the UHSGT Advisory Group and Steering Committee, integrating feedback from interviews with community and business leaders, to guide the development of this effort. A successful UHSGT system would be designed to promote each of these vision elements in the Cascadia megaregion.

The USHGT Advisory Group and Steering Committee recognized the importance of social equity and economic inclusion as core values during all phases of planning and implementation. They recommend that decision makers consider the following:

- How communities and individuals will be affected by new infrastructure
- Identify opportunities to elevate the quality of life through economic development, job creation and accessibility
- Address damaging burdens that might result from factors such as alignment selection, station locations, hiring practices, and land use.

Figure ES-1: UHSGT Vision



Note: As developed with UHSGT Advisory Group and Steering Committee

The 2019 Business Case assessment has resulted in a clearer, more comprehensive and detailed picture of the wide range of benefits that would accrue to the region should an UHSGT system be built. It provides policymakers and stakeholders details on the strategic, economic, environmental, and financial case for UHSGT in the Cascadia megaregion. The data generated by the analyses reinforces the compelling case for this cost-effective and transformative project, provides government and business leaders with a better understanding of the unique characteristics and travel demands of the Cascadia megaregion, outlines steps to secure funding and financing, and provides a governance framework—important factors to consider if the project moves forward.

Reduced journey times, improved reliability and better connections would enable easy and quick access to the region's major cities and towns

The 2019 Business Case demonstrates that UHSGT can be among the most effective transportation investment solutions to promote the economic health and growth of the Cascadia megaregion. UHSGT offers an opportunity to transform mobility beyond what current travel modes can provide. The reduced journey times—comparable to air travel—improved reliability, and the potential for direct downtown-to-downtown connections would enable residents and visitors to easily and quickly access the region's major cities and towns.

The Business Case for UHSGT provides the following key benefits or outcomes:

- A **better-connected megaregion** resulting from faster journeys, increased capacity, and reduced congestion
  - UHSGT would achieve this by integrating the megaregion's major commercial hubs and population centers including intermediate stations along a new transportation spine using a greener, environmentally advanced travel mode.
  - Travel times between each of the three major cities would be less than an hour for each segment, with connections to other transportation modes at all stations.

   - Travelers are projected to shift to UHSGT with annual ridership exceeding 3 million trips and **farebox revenues exceeding $250 million**, which could result in one of the best performing rail services in North America.
   - There is a clearly stated willingness of travelers in the region to **shift to UHSGT from other modes** and support **greener modes of travel** that provide shorter travel times and more reliable service with a significant reduction in greenhouse gas emissions.
- A **stronger, more productive megaregion** as more businesses/jobs locate in the Cascadia megaregion due to the dramatically improved access to housing, jobs, schools, and other destinations, as well as the creation of new regional industry clusters. Once implemented, UHSGT would catalyze the **transformation** of the Cascadia regional economy into a more dynamic, globally competitive, megaregion.
- A **more affordable megaregion** as residents benefit from easier access to more affordable housing as well as wider access to higher-paying jobs and opportunities. This would improve mobility for residents throughout the megaregion and support a commitment to developing an equitable transportation network.
- A **cleaner environment** by shifting trips to more sustainable modes, reducing carbon emissions and environmental impacts, protecting habitats and improving the resilience of the transportation network.
- A **better value infrastructure investment** than possible alternative projects, whether interstate highways or airport expansion.
- **Broad support from businesses, other stakeholders, and travelers** given its ability to unlock sustainable growth, would make the Cascadia megaregion more competitive, and deliver higher quality, more cost-effective and safer journeys compared to existing road or air options.
- A **modern delivery approach** drawing on proven governance and procurement models plus innovative funding mechanisms.
   - These include lessons learned from other similar infrastructure projects related to funding mechanisms, phasing approaches, private investments, risk management, governance structure, and public accountability
   - Recent trans-border and international models include the Gordie Howe International Bridge, Vancouver's Canada Line, Montreal's REM, UK HS1/Channel Tunnel, and London's Crossrail.

UHSGT provides a better-connected megaregion

Potential UHSGT station areas and routes studied are designed to integrate major commercial hubs, population centers, intermediate stations and existing transportation modes.

A UHSGT system can support the growth of the Cascadia megaregion by providing a more integrated transportation network. The identification of major hubs for testing is straightforward; however, the creation of a high-performing network also requires an analysis of intermediate stations. The entire system must be evaluated for its impact from a policy and quantitative perspective, including considering ease of access across the Cascadia megaregion, journey times, and ultimately ridership forecasts.

The Corridor Planning Technical Memorandum (Appendix C) undertaken in support of the 2019 Business Case identified and analyzed potential station areas and outlined their attributes in a series of fact sheets. Station areas studied included (from north to south): Vancouver, BC (including Vancouver International Airport); Surrey, BC; Bellingham, WA; Everett, WA; Seattle, WA; Bellevue/Redmond, WA; Tukwila, WA; Tacoma, WA; Olympia, WA; Kelso-Longview, WA; Portland, OR (including Portland International Airport).

Station areas were combined into three basic scenarios that prioritized connections to existing or committed local transit networks, including transit (bus and light rail), commuter rail, and Amtrak services. Within these scenarios, variations differing in intermediate stops and stopping patterns were developed. Conceptual routes (approximately 310 miles long or 500 kilometers) linking the station areas based on 220 mile per hour (350 kilometers per hour) design criteria were developed to generate trip travel times and conceptual timetables. This information by scenario variation was then provided as inputs to the ridership and revenue model.

Potential routes look to integrate commercial hubs, population centers, intermediate stations, transportation modes

The iterative work with the ridership model (described below) demonstrated that the addition of intermediate stops increased ridership volumes, despite the incremental increase in travel times. The project team also worked with a higher frequency of service than in the 2017-2018 Feasibility Study. Both factors contributed to higher volumes of ridership as compared to the earlier study.

The result of the corridor planning work is a comprehensive understanding of the potential of each station area to contribute to the vitality of a new transportation network by examining connections and creating opportunities that do not currently exist.

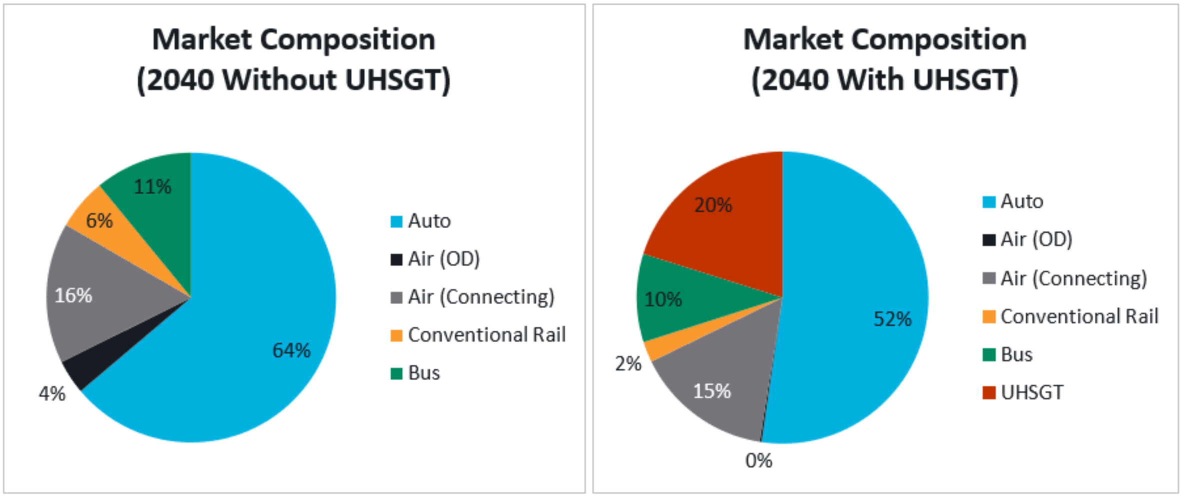
UHSGT will result in significant shifts away from alternative travel modes

Enhanced Ridership and Revenue Forecasts (Appendix D) undertaken for the 2019 Business Case created an intercity travel demand model to test UHSGT ridership in the Cascadia megaregion using travel preference assumptions obtained through a comprehensive stated preference survey. The results of this survey—in which 74% of survey respondents stated they would “definitely try UHSGT”—allow the 2019 Business Case indicate that travelers would shift from auto and air travel to a new UHSGT system for a significant percentage of intercity trips.

The ridership model survey results show that UHSGT almost completely captures the direct intra-regional air travel market. Depending on the scenario, UHSGT will capture between 12% and 20% of total intercity trips (Figure ES-2).[1]

[1] Figure ES-2 illustrates the market composition for one scenario where UHSGT accounts for 20%of intercity trips; other scenarios have smaller shares.

Figure ES-2: 2040 Demand by Mode Comparison Without and With UHSGT



The ridership volumes forecasted in the enhanced Ridership and Revenue Forecasts (Appendix D) exceed those estimated in the 2017-2018 Feasibility Study. The significant reduction in travel times, combined with more reliable and higher frequency services, would result in a better-connected megaregion with major shifts in existing trips from auto and air to UHSGT. Travelers would be able to arrive earlier or leave later from origins, tailor travel schedules to meet individual needs, and have more time to conduct business or enjoy leisure activities. Depending on the scenario, between 1.7 million and 3 million annual trips would be made by 2040. Ridership on UHSGT would be more than three times the current number of travelers on intercity rail in the Pacific Northwest corridor.

From a revenue perspective, the potential of UHSGT would be even greater. UHSGT is projected to generate between $156 million and $250 million in fare revenues annually by 2040 (2019 prices). This level of revenue could make UHSGT in the Cascadia megaregion corridor one of the highest performing intercity rail services in North America. Early comparisons of costs and revenues suggest that projected farebox revenue could be expected to cover operating costs by 2055. In the nearer term, a 10% increase in ridership or a 10% decrease in operating costs would allow UHSGT to cover its operating costs by 2040.

Between 1.7 and 3 million annual trips and $156-250 million in annual revenue

UHSGT may perform even better, since the methodology and assumptions used in the ridership and revenue projections were conservative. The assumptions in the ridership report do not reflect recent projections of increasing highway congestion across the Cascadia megaregion as well as any real increases in auto or air operating costs. In addition, increased ridership is likely to occur due to improved integration with future connecting services and the potential for additional induced demand resulting from enhanced economic activity arising from investment in UHSGT. Accordingly, if implemented effectively, there is significant potential to attract even more riders to UHSGT.

UHSGT supports a stronger, more productive megaregion

A well-developed UHSGT would integrate and strengthen the ability of the Cascadia megaregion to compete globally in key industries. By doing so, more businesses and jobs will locate in the Cascadia megaregion due to the dramatically improved access to housing, jobs, schools, and other destinations, as well as the creation of new regional industry clusters. For example, the organizations active in the knowledge economy (including technology, university, medical) have shown that they increasingly gravitate toward dense urban areas to attract qualified employees and build connections to wider markets. A new UHSGT system would maximize these agglomeration effects by offering a high-performance transportation link to connect the existing and future talent pools, employers, and centers of innovation throughout the region.

The link between connectivity and global competitiveness has been clearly demonstrated by Microsoft CEO Brad Smith, who offered this insight in 2018:

> *Our ability to compete in the world's economy will be enhanced dramatically by having a region that is 6 million inhabitants strong versus two or three regions of 3 million each. By combining the sub-regions, it is the only way for this megaregion to reach scale. None of the sub-regions can get to 6 million by itself.*

Drawing upon the selection of station areas, UHSGT could improve connections among industry clusters, enterprise accelerators (web-based investors), world-renown research institutions, qualified labor, and financial and logistics organizations providing fundamental services for a strong regional economy. UHSGT would sustain and build upon the growth already underway by collapsing distances, and thus provide employers with access to a much larger workforce, and provide workers with a greater variety of employment options. The value of quicker, easier, and more reliable transportation links (including UHSGT) have been demonstrated elsewhere around the world where UHSGT projects have been implemented.[2]

Economic benefits will yield a robust return on investment to the region

UHSGT is expected to generate three types of economic benefits: (1) direct user benefits such as travel-time savings; (2) social benefits such as reductions in greenhouse emissions; and (3) wider economic benefits (WEBs) linked to an increase in jobs, higher productivity, and other economic impacts resulting from the significant improvement in connectivity.

UHSGT catalyzes the megaregion's global competitiveness

The 2019 Business Case used forecasted ridership volumes to calculate a range of direct use and social benefits, including travel time and vehicle cost savings, safety and reduced crashes, reduced emissions, and productivity gains. These benefits were estimated to exceed $14 billion, yet they tell only part of the story. The WEBs were estimated in the Initial Estimate of Economic Impacts published as an addendum to the

[2] Various studies, including *The Economic Benefits of HS1 10 Years On,* HS1 Ltd. with Input from Volterra Partners.

2017-2018 Feasibility Study.[3] It estimated that as many as 160,000 permanent new jobs in the wider economy could be unlocked by UHSGT, generating as much as $355 billion in additional economic activity.[4] The ridership data generated in the 2019 Business Case exceeds the inputs used in the 2017-2018 Feasibility Study, which, combined with regional economic factors being stronger, indicates that the level of overall economic activity is anticipated to be even greater.

UHSGT supports a more affordable and equitable Cascadia megaregion

UHSGT can support a more affordable megaregion by improving the time, convenience, and connections between areas with lower housing costs and employment centers, whether directly or via improved local connections. While average wage growth in Vancouver, BC; Seattle, WA; and Portland, OR; has been a little over 20% since 2010, housing costs have increased by 60% or more, which is nearly twice the North America rate. Combined with the increase in transportation costs as a percentage of household incomes, this indicates there is a serious affordability crisis across the Cascadia megaregion. UHSGT can foster more dense transit-oriented residential development near stations and open up new areas to large-scale, mixed-use development where residential and office development can be built in close proximity. UHSGT can increase housing supply and help create live-work communities with complementary changes in land-use policies.

UHSGT can support a cleaner environment

Washington state, Oregon, and British Columbia are all committed to reducing harmful emissions and creating healthier environments for their residents. The State of Washington estimates that the transportation sector accounts for 44% of all its greenhouse gas emissions. An UHSGT system—powered by electricity from green energy sources—can support the Cascadia megaregion in creating a better environment by reducing carbon emissions.

Could reduce carbon emissions by 6 million metric tons over 40 years

UHSGT would shift trips to more sustainable modes, thus reducing environmental impacts, protecting habitats and improving the resilience of the transportation network. Rail travel has historically been one of the most environmentally friendly modes of travel, generating 12 times less carbon dioxide (CO_2) emitted than air and 3 to 5 times less than automobiles.

Over the first 40 years of operations, UHSGT would avoid release of 6 million metric tons (tonnes) of CO_2, as a result of 27 million avoided flight miles and 6.1 billion avoided vehicle miles in the Cascadia megaregion. In addition, every year on average of more than 960 metric tons of harmful non-CO_2 pollutants (e.g., particulate matter, carbon monoxide, and nitrogen oxide) would be kept out of the ecosystem.

[3] *WSDOT 2017-2018 UHSGT Feasibility Study: Addendum, Initial Estimate of Economic Impacts.*https://www.wsdot.wa.gov/publications/fulltext/LegReports/1719/UltraHighSpeedGroundTransportation_FINAL.pdf

[4] The addendum did not include estimates of economic impacts on the Portland, OR area.

UHSGT would also transform the environmental footprint of the megaregion by encouraging denser development near stations and improved local connections through transit, cycle, and walking facilities. UHSGT can play a key role in the Cascadia megaregion by further reducing its carbon footprint and matching the more efficient levels achieved in Europe and Japan. There is a potential to achieve zero emission levels should the all-electric system rely solely on clean power sources, such as hydro, wind and solar energy.

UHSGT can be a better value infrastructure investment

The capital cost estimates in the 2017-2018 Feasibility Study ranged from $24 billion to $42 billion (2017). Capital costs will be affected by alignment geometries, station locations, and topography to minimize the need for expensive tunneling (compared to at-grade or aerial viaduct structures). Estimated operating costs in the 2019 Business Case are similar to those presented in the 2017-2018 Feasibility Study. The estimated operating costs of additional UHSGT roundtrips were offset by lower estimated operating costs per service and at stations.

UHSGT can be a better value infrastructure investment than possible alternative projects that can support the growth of the Cascadia megaregion. While there are several significant transportation infrastructure projects committed in the Cascadia megaregion, most of these are to address localized congestion hotspots such as the US I-5 improvements around Tacoma, the central Puget Sound region's ST3 transit expansion package, or the airport expansions at Seattle-Tacoma International Airport or Vancouver International Airport.

Cascadia megaregion future growth is at risk without substantial increase in infrastructure investment. UHSGT could mitigate the need for some future infrastructure projects such as further major expansions of US I-5, estimated to possibly exceed $108 billion or building an additional runway, which could exceed $10 billion. In addition, UHSGT provides greater reliability and increased capacity than highway or airport options. Reliability on high-speed rail services can reach 99% on-time performance compared to less than 80% for air services and widely variable auto journey times. Constructing a UHSGT transportation spine can be designed to allow for a range of services, including intercity, commuter/regional, and high-value freight as shown in other places around the world that have constructed high-speed rail lines.[5] By providing a range of services, this spine can exceed the existing capacity of the US I-5/ Canada Highway 99 highway corridor.

UHSGT has broad support from businesses, stakeholders, and travelers

Support from business leaders is linked to UHSGT's ability to promote strong and sustainable growth, to make the Cascadia megaregion more competitive, and to deliver higher-quality and safer journeys compared to existing road or air options. Specifically, the region's business community recognizes that UHSGT would help solve real-world issues and that these benefits are tangible. These stakeholders view the UHSGT system as a tool

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[5] For example, more than half of the capacity of the UK HS1 line is used for commuter rail services and freight such as car parts, fresh produce and other high value products. On the Northeast Corridor, nearly 80% of services are commuter rail and freight in addition to Amtrak intercity service.

for both overcoming existing structural economic challenges in the region as well as a unique opportunity to unlock untapped potential in the region.

Business representatives have pointed out that if the region does not move quickly, various elements of today's lifestyle and economy will decline, grow substantially worse, and within decades threaten the Northwest as we know it. One business leader described UHSGT, "by creating a strong bond from Vancouver to Seattle to Portland, we're building connections that allow us to compete on a global level." Another business leader remarked, "knowing the unbelievable congestion that is occurring every day in the Vancouver-to-Seattle-to-Portland corridor, can you imagine what that will be like in 50 years?"

The overarching economic benefits resulting from UHSGT identified by business leaders include greater connectivity; access to a larger, more cohesive pool of qualified talent throughout the region; and better facilitation of research and other innovation. They have clearly expressed the concern that the region must do something now to ensure prosperity in future years.

Imagine what congestion will be like in 50 years without this system

Travelers also exhibited a high interest in UHSGT. Based on a survey of existing intercity travelers in the Cascadia megaregion, 74% indicated a willingness to "definitely try" UHSGT. Combined with additional trips from induced demand generated by additional trips made possible by the impacts of shorter journey times and higher density near UHSGT stations, demand is likely to be strong.

UHSGT can be successfully achieved using a modern delivery approach

While the challenges in delivering UHSGT are significant, evidence from this assessment suggests that the project can be delivered and operated successfully. The key to this success would be to draw on effective governance and procurement models used on other trans-border and international infrastructure projects. Developing an effective funding and operating strategy would also be critical in the successful delivery of UHSGT.

An overview of trans-border and large-scale infrastructure projects (domestic and international) strongly indicates that UHSGT would require a multi-jurisdictional governance model that ensures robust and timely decision making while protecting public accountability. In addition to a bi-national and bi-state authority, actual project delivery could be facilitated through the creation of a separate public entity tasked with the design, procurement, and financing of UHSGT. Government oversight of this entity would ensure both transparent accountability and performance. The project would also need to ensure compliance with laws governing international agreements and project delivery mechanisms, among other issues, both for two US states and Canada.

This approach would build on that being used to deliver the Gordie Howe International Bridge linking the US and Canada and lessons learned from the successfully delivered Channel Tunnel between the United Kingdom and France. Key objectives include the following:

- Achieve an effective transfer of risks to those who are best able to manage them.
- Ensure effective public accountability while protecting timely decision making.
- Retain control and flexibility to meet future needs in the project owner's hands
- Achieve competitive pricing while aligning incentives.

Experience over the last several decades in the US and internationally suggests that costs can be further reduced by mobilizing private-sector expertise and financing. Nevertheless, the project would likely require some measure of public investment to pay for the upfront costs to design and construct the new transportation service. Such public investment can be spread over the combined construction and operating term of the project; whereby upfront private financing would be recovered with public funds linked to the successful delivery of the project's key deliverables to a set of strict criteria. This "availability payment" approach has been used in many recent projects in the US on toll roads; Canada on both road and rail projects; and world-wide to incentivize the private sector to deliver the project on-time, within budget, and to a set of performance targets established in the contract. By doing so, UHSGT can be delivered cost effectively by the private sector while ensuring public accountability.

Assembling the funding for a large-scale infrastructure project requires a clear strategy and timeline for pursuing project funding through all stages of project delivery: project initiation (near term), project development (intermediate term), and construction and O&M (long term). The 2019 Business Case has created a framework that will be updated as the project progresses. The outline of this strategy is shown in Table ES-1.

Table ES-1: Funding Strategy and Timeline

	Project Initiation	Project Development	Construction and O&M
Timeline	Present to 2 to 3 years	Approximately 3+ years	Dependent on phasing
Scope	• Governance • Stakeholder engagement • Pre-environmental clearance • Conceptual engineering	• Environmental clearance • Preliminary engineering • Risk assessment • Procurement	• Land acquisition • Vehicles • Final design • Construction • O&M
Strategy	• Rely on readily available funding streams to deliver scope. • Begin outreach to secure state, provincial, private, and federal funding to support project development.	• Support project development through federal, state, local and private funding. • Begin proper technical, executive, and legislative outreach to secure support for any alternative funding streams needed. • Explore private investment to line up construction and O&M funding streams well in advance.	• Support construction and O&M through a sustainable, long-term funding streams tied to the economic benefit of the project, supplemented with new federal funds • Financing: issue public or private debt as needed to cover capital deficits during the construction stage.

Recommended next steps

The 2019 Business Case identifies a series of next steps. These have been split into steps that can be progressed based on the availability of funds as designated by the Washington State Legislature in the 2019-2021 Transportation Budget (ESHB 1160), and other not-yet-funded priorities as summarized below:

Initial steps in accordance with the direction of the Washington State Legislature

- Establish an initial steering committee comprised of designated representatives from each of the three jurisdictions (Washington, Oregon and British Columbia) to carry out governance study and other activities described below.
- Finalize the preferred governance model including general powers, operating structure, legal and contracting requirements.
- Assess the current laws in the state and provincial jurisdictions and identify any proposed changes to laws, regulations, and/or agreements that are needed to proceed with development.

Additional activities to evaluate depending on available funding

- Develop a statement of purpose and need for UHSGT, drawing on the conclusions of the business case report
- Develop conceptual alignment options for further study
- Develop potential funding and financing alternatives
- Identify and pursue funding to enable planning and design at the preliminary environmental assessment level
- Finalize the communications plan and identify a possible outreach engagement strategy

Additional activities currently not-yet-funded

Preliminary environmental assessment planning and design:

- Develop specific alignment alternatives during the preliminary design and pre-environmental phases.
- Continually refine cost estimates based on selected alignments and station locations.
- Assess impact of future increased highway congestion and other possible changes on ridership forecasts (including sensitivities).
- Expand ridership analysis to include commuter and local travel markets.
- Further analysis of the economic impact of UHSGT including both user and wider impacts and possible application of Canadian guidelines.
- Continue exploration of emerging technology options.

Robust outreach and engagement:

- Greatly expand the stakeholder engagement process to include a wider cross-section of residents, businesses, tribes, interest groups, policy makers, and travelers.

- Focus on equity, access and affordability by ensuring equitable representation on decision-making groups, including advisory groups and councils, and Incorporating, encouraging and supporting equity throughout the public consultation and outreach program.
- Refresh the Advisory Group roles and responsibilities.
- Assess private involvement options in delivery to incentivize robust and cost-effective delivery through integration of design, procurement, construction, and operational requirements.
- Coordinate findings with local jurisdictions and governments to have UHSGT reflected and supported in local and regional plans and programs.
- Examine in more detail published and emerging local and regional transportation plans to better understand how UHSGT can complement other infrastructure priorities.

Economic impact analysis:

- Commission a comprehensive Wider Economic Benefits (WEB) analysis to better understand agglomeration and other impacts applying WebTAG guidance as used on projects in Canada.
- Compare similar projects both within the Cascadia megaregion and elsewhere to benchmark assumptions and incorporate lessons learned.
- Review sensitivities (positive and negative) to ensure economic analysis is well understood.

Funding and financing strategy:

- Consult with the Advisory Group, local stakeholders, business groups, and developers on the feasibility of potential funding and financing alternatives.
- Progress funding strategy options with a focus on viability of alternative funding streams that can minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries.
- Begin discussions with involved state, local, and private stakeholders to mobilize support and secure funding contributions that are readily available to support the project initiation stage.
- Simultaneously begin discussions with involved stakeholders and government leaders that can champion substantial state/provincial and US and Canadian federal funding to support the project development stage.
- Identify and secure a sustainable funding mechanism that will support the project's construction and O&M costs.
- Build a funding and financing model based on refined cost and revenue estimates when all sources of revenues become more realistic.

Governance and delivery:

- Once established, the multi-jurisdictional entity should also examine the following:
  - Establishing a separate delivery company to split responsibilities of policy and funding from delivery and implementation, in part to improve the decision-making process and transparency on public accountability.
  - Outlining roles and responsibilities for integrated project teams to be formed that include members from the delivery company, the governing entity, and other relevant organizations.
  - Developing outcomes-based requirements soon after establishing the delivery company to ensure clarity on project deliverables.
- Ensure the delivery entity has full implementation powers to apply for federal grants and loans, acquire property, enter into agreements and contracts, develop its own procurement processes, and raise funding, including borrowing/issuing bonds.
- Establish an independent regulatory scheme during the project definition stage to protect users, stakeholders, and affected parties, as well as challenge project performance.

Conclusions

The 2019 Business Case demonstrates the UHSGT concept would be an effective transportation project, and once implemented UHSGT would likely to have a transformative impact on the Cascadia megaregion.

- UHSGT would move over 3 million passengers a year, and produce $165 million in revenues after the first few years of ramp-up.
- Including intermediary stops in Surrey, Bellingham, Everett, Tacoma, Olympia, Kelso/Longview and others would expand UHSGT ridership notwithstanding minor time penalties.
- Revenues from the farebox are expected to cover operating expenses in the long term.
- UHSGT calls for very high-tech power and guidance systems and could catalyze a new industrial base around the production of high-speed rail equipment.

UHSGT as a travel mode would support sustainable growth.

- Fixed guideway systems encourage concentrated growth around accessible station areas.
- UHSGT would contribute substantially to the reduction of greenhouse gases from a sector of the economy—transportation—that currently accounts for more than 40% of all emissions.
- The cost of UHSGT would be less than that of expanding other modes, and there are funding and financing strategies that can make UHSGT a reality.

UHSGT would transform the Cascadia region into a globally competitive, sustainable megaregion, by creating a stronger, more productive, more environmentally sound, and better connected megaregion.

1 Introduction

The Cascadia megaregion—Vancouver, BC; Seattle, WA; and Portland, OR—is among the fastest growing and most economically and culturally dynamic megaregions in North America. Since the 1950s, state, provincial, and regional governments have explored the concept of a high-speed, ground-based alternative to the auto and air modes that have been the predominant form of transportation.

In 1992, the Washington State Department of Transportation (WSDOT) published a *High-Speed Ground Transportation Study*, which identified a north-south corridor between Vancouver, BC; Seattle, WA; and Portland, OR; as a potentially valuable investment in addressing highway and air system congestion, as well as maintaining the quality of life in and economic vitality of Washington state. The study successfully presented a high-level case for implementing a high-speed ground transportation system, including potential alignments and technology options, ridership forecasts, capital and operating cost projections, and wider economic and environmental impacts. However, it also raised and left open ended several issues, including coordination with other states/provinces, existing policies and processes related to governance, and funding and financing strategies.

WSDOT conducted a follow-up study in 2017–2018, the *Ultra-High-Speed Ground Transportation Feasibility Study* (2017-2018 Feasibility Study), to update the 1992 work. This study was born out of formal partnership between Washington state and British Columbia (BC) provincial governments, and was informed by an active, multi-disciplinary Advisory Group that consisted of stakeholders from throughout the Ultra-High-Speed Ground Transportation (UHSGT) corridor, including the state of Oregon. The study considered several conceptual corridors, including connecting corridors to Spokane, WA, and from Portland, OR, to Sacramento, CA. The 2017-2018 Feasibility Study also considered alternative technologies, including high-speed (steel wheel) rail, maglev , and hyperloop. The project team used the Federal Railroad Administration's Conceptual Network Connections Tool[3] to estimate the ridership, revenue, capital and operations and maintenance (O&M) costs, and public benefits at an order-of-magnitude level.

While certain elements of the system's feasibility were updated as part of the 2017-2018 Feasibility Study, including corridor concepts, potential economic impacts, funding sources and financing mechanisms, and governance structures, nonetheless various informational gaps were identified, notably more reliable ridership forecasts and economic analysis, and the need for a broader business case to address such gaps in detail and provide a comprehensive framework for evaluating the UHSGT concept.

In 2018, the states of Washington and Oregon, together with the Canadian province of BC, and private-sector company Microsoft, commissioned a follow-on study to develop a business case analysis of a UHSGT system providing up to 250 miles per hour (mph)/400 kilometer per hour (kph) service connecting Vancouver/Surrey, BC; Seattle/Bellevue, WA; and Portland, OR.

The current study provides an independent business case assessment of the strategic, economic, financial, and deliverability case for UHSGT in the Cascadia megaregion. This business case analysis is informed by a series of technical reports produced by the project team, including the following:

- **Benefit Analysis Technical Memorandum** (Appendix A), which evaluates the monetizable user and social benefits associated with the project.
- **Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion** (Appendix B), which examines the potential for transformative economic impacts due to UHSGT in the Portland, OR, to Vancouver, BC, megaregion
- **Corridor Planning Technical Memorandum** (Appendix C), which delineates conceptual service attributes, hypothetical routes, and potential major and minor station locations that would best support investment in UHSGT
- **Ridership and Revenue Forecasts** (Appendix D), which includes a travel demand model for intercity services between Vancouver, BC; Seattle, WA; and Portland, OR; and intermediate locations to test ridership and revenues for a series of scenarios
- **Funding and Financing Strategy Plan** (Appendix E), which includes suggested near- and long-term strategies for obtaining new sources of funding to support pre-development activities, construction, and long-term operation of the project
- **Candidate Governance Structures Report** (Appendix F), which includes recommendations for potential governance models structured to effectively deliver and manage UHSGT that would include all three jurisdictions

This 2019 UHSGT Business Case Analysis Report (2019 Business Case) sets out the challenges and opportunities facing the Cascadia megaregion, the importance of high-performance transportation to address them, potential UHSGT route(s) and ridership demand, direct and indirect benefits of UHSGT, and possible next steps.

The development of the 2019 Business Case included the establishment of an Advisory Group, which comprise approximately 30 members representing economic, transportation, and jurisdictional interests, and public, private and non-groups throughout the study corridor between Greater Vancouver, BC, and Portland, OR. The group met formally six times between July 2018 and June 2019, and reviewed and provided feedback on planning inputs and draft conclusions presented by the project team. Advisory Group members were asked to share key insights on engineering, economic, and policy feasibility to ensure the team considered various perspectives in the study. Outputs from the group helped guide the project team throughout the study.

1.1 Cascadia megaregion challenges and opportunities

The remainder of this chapter sets out the key factors relating to the Cascadia megaregion and how it has changed over the past 20 years and is forecast to change in future years. The project team, with input from the UHSGT Advisory Group, has summarized the key points described in detail in Appendix A: Benefit Analysis Technical Memorandum and

Appendix B: Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion.

1.2 Cascadia megaregion background

The states of Washington and Oregon and the Canadian province of BC historically share common identities along economic linkages and social directives that transcend state and national borders, demonstrating exemplary cross-border relations between the US and Canada. Strategic relationships have been and continue to be developed across regional networks among entrepreneurs, innovators, policymakers, industrialists, and academics who strengthen the inter-sector ties that foster economic development and improve the region's quality of life.

Current cross-border investments indicate a growing need for free movement and exchange of people and ideas

The Cascadia megaregion—Vancouver, BC; Seattle, WA; and Portland, OR—comprises several economic clusters focused on high value-added industries as well as traditional resource-based industries that have supported the megaregion's impressive growth. Historically, each of the metropolitan areas within the megaregion developed semi-independently following World War II as they transitioned from traditional resource-based regional economies into more export-driven economies. This led to Seattle and Portland developing strong manufacturing economies spearheaded by Boeing in Seattle and Nike and Intel in Portland. Vancouver by contrast developed a more financial services-based economy driven in part by its ties to investors from Asian nations. More recently development has been spearheaded by technology leaders, including Microsoft and Amazon.

While the metropolitan regions have developed semi-independently, significant amounts of cross-border investment and operations have occurred between Vancouver and Seattle. This cross-border investment is indicative of a growing need for free movement and exchange of people and ideas within the Cascadia megaregion. For example, several companies including Microsoft, Amazon, and Tableau Software have headquarters in Seattle and satellite operations in Vancouver. The population and employment for the megaregion is shown in Table 1.

Table 1: Summary Statistics of Major Metropolitan Centers in the Cascadia Megaregion

City Center	Population, City	Population, Metro Area	Total Employment, Metro Area	Total Employment Growth (MSA) 2010-2017	Population Growth (City) 2010-2017
Vancouver, BC	631,486	2,463,431	1,276,900	7.99%	4.6%
Seattle, WA	724,745	3,867,046	2,051,300	20.5%	18.7%
Portland, OR	647,805	2,451,560	1,279,700	16.14%	10.7%
Total	**2,004,036**	**8,782,037**	**4,258,884**	**15.59%**	**11.4%**

Sources: US Census Bureau, 2017; Statistics Canada, 2016; Bureau of Labor Statistics, 2018
Note: Calculated as the total growth rate from 2010 to 2017 for the reference area (2011 to 2016 for Vancouver, BC).

The strong growth in the region, which exceeded earlier forecasts, is expected to continue well into the future. The Portland, OR, metropolitan area is expected to reach a population of 3 million by 2040 and 3.5 million by 2060, up from an estimated 2.4 million in 2015. Similarly, Vancouver, BC, metropolitan area population is expected to reach 3.7 million in 2035 up from 2.8 million in 2016. The Seattle, WA, metropolitan area has the highest population of the metropolitan areas in the Cascadia megaregion at nearly 4 million, and it is expected to grow to 5.5 million by 2040. Altogether, the major metropolitan centers in the Cascadia megaregion are expected to add 3.5 million residents by 2040.[6] Similar gains are expected in the region's employment, with Portland, OR; Seattle, WA; and Vancouver, BC; expected to add at least a combined 2 million jobs by 2040. Infrastructure investments will be required to expand the capacity of the transportation network and to accommodate the anticipated growth in population and employment within the Cascadia megaregion.

Population growth has significantly exceeded earlier forecasts and that trend is expected to continue well into the future

These metropolitan areas are among the top economic performers in North America. As a megaregion economy with combined resources in labor and capital, the Cascadia megaregion would be comparable with global economic leaders. Compared with peer North American metropolitan areas, the combined employment and populations of the principal metropolitan areas of the Cascadia megaregion are ranked second- and fourth-highest, respectively, as shown in Table 2.[7]

[6] Various published reports, including *Metro Vancouver Transport 2050*, *Puget Sound Regional Transportation Plan*, and *Oregon Metro Regional Transportation Plan*

[7] Note that these comparisons are restricted to metropolitan areas; they are not megaregion comparisons. Still they reflect a general comparison of the size of Cascadia's combined urban concentration compared with other peer metropolitan areas were the Cascadia region's constituent metropolitan areas to be connected within one hour's time.

Table 2: Employment and Population by Metropolitan Area in North America, 2018

Metropolitan Area	Employment (2018, Ranked Order)	Population (2018)	Population Ranking of All Metros
New York-Newark-Jersey City, USA	9,835,600	19,979,477	1
Cascadia	**6,596,900**	**9,068,178**	
Los Angeles-Long Beach-Anaheim, CA	6,163,000	13,291,486	2
Chicago-Naperville-Elgin, IL	3,781,500	9,498,716	3
Dallas-Fort Worth-Arlington, TX	3,433,700	7,539,711	4
Toronto, CAN	3,353,000	6,341,935	6
Houston-The Woodlands-Sugar Land, TX	3,083,400	6,997,384	5
Philadelphia-Camden-Wilmington, PA-NJ-DE	2,940,500	6,096,372	9
Atlanta-Sandy Springs-Roswell, GA	2,787,100	5,949,951	10
Washington, DC-Arlington-Alexandria, VA	2,706,600	6,249,950	7
Miami-Fort Lauderdale-West Palm Beach, FL	2,682,000	6,198,782	8
San Francisco-Oakland-Hayward, CA	2,440,200	4,729,484	13
Montreal, CAN	2,187,100	4,255,541	16
Phoenix-Mesa-Scottsdale, AZ	2,107,900	4,857,962	12
Detroit-Warren-Dearborn, MI	2,032,100	4,326,442	15

Sources: US Bureau of Labor Statistics, Statistics Canada, US Census Bureau

Using 2016 data from the Organization for Economic Co-operation and Development (OECD), the productivity per capita of these top-ranked metropolitan areas are compared in Table 3. Comparing the productivity per capita provides a standardized measure of regional relative productivity while removing some errors or distortion caused by the geographical differences between the metropolitan areas. The Cascadia megaregion is among the best performing metropolitan areas in the OECD by growth in productivity over the last 10 years, signaling the collective strength of the megaregion's constituent metropolitan areas. The benefits of improved high-speed transportation linkages for the region would take advantage of the existing economic

Cascadia megaregion is among the best performing metropolitan areas based on growth in productivity over the last 10 years strength and potential of the individual metropolitan areas to enable greater productivity gains.

Table 3: Gross Domestic Product (GDP) per Capita in Current-Day US Dollars of Top 20 Metropolitan Areas by GDP, 2016

Metropolitan Area	GDP per Capita (US$, 2016)	10-Year % Change in GDP per Capita (2006-2016)
San Francisco (Greater), CA	$99,041	19.0%
Seattle, WA	$79,894	13.4%
Boston, MA	$78,993	12.0%
New York City (Greater), NY	$75,092	10.1%
Washington, DC (Greater), USA	$70,828	3.9%
London, United Kingdom (2015)	$69,090	8.5%
Cascadia Megaregion	***$65,463***	**10.8%**
Portland, OR	$65,113	7.9%
Philadelphia (Greater), PA	$65,021	11.5%
Paris, FRA	$62,806	12.0%
Chicago, IL	$62,581	6.2%
Houston, TX	$62,239	-5.1%
Dallas, TX	$61,666	5.0%
Los Angeles (Greater), CA	$58,372	7.9%
Atlanta, GA	$57,801	0.3%
Miami (Greater), FL	$48,580	-5.3%
Toronto, CAN	$44,780	6.6%
Vancouver, CAN	$43,459	6.3%
Tokyo, JPN	$42,420	-2.2%
Toyota, JPN	$41,866	0.7%

Source: Organization for Economic Co-operation and Development

1.3 Challenges to continued growth

The Cascadia megaregion faces challenges to continued growth in a more sustainable manner, as well as mitigation of the current problems of congestion, long journey times, high cost of living, skill shortages, and international borders. If these problems are not adequately dealt with, barriers to growth will intensify and the competitive position for the megaregion will suffer.

While the Cascadia megaregion is not unique in suffering from an inadequate transportation system, it does possess some of the most congested networks in North America with Vancouver, BC; Seattle, WA; and Portland, OR; ranking as the 4th, 6th, and 10th worst cities in North America for traffic delays.[8] Regional mobility also suffers from lack of

[8] TomTom World Congestion Index, 2016

extensive local transit, cycling, and walking facilities to many locations. Airports in the region also experience delays common across North America's aviation system. While investment is continuing to counter some of the worst problems (for example, US I-5 improvements around Tacoma, WA, and the Vancouver, BC, Skytrain extension to Langley), these projects will deal only with localized issues and will not provide the significant change in mobility required. The border between Canada and the US is also a barrier that the committed infrastructure projects do not currently address; in turn, this has constrained economic activity across Cascadia. Despite this, daily vehicle trips between Vancouver, BC, and Washington state have increased by 40% since 2009. Therefore, the effects of this cross-border barrier will be increasingly felt as the megaregion continues to grow.

A high-speed transportation system would leverage existing strong economy — enabling sustained future economic growth

The megaregion also faces the challenge of a high cost of living resulting from lack of affordable housing, relatively weak wage growth, and other factors. Wages have increased by less than one-third the rate of housing costs over the past decade. Lack of affordable housing has led many people to move to remote locations across the megaregion and experience subsequent long travel distances to get to jobs, schools, or leisure activities. In both the Vancouver, BC, and Seattle metropolitan regions, over one-third of households are burdened by high housing costs as a percentage of income, indicating housing affordability issues.[9] Growth in knowledge industries (including technology, university, medical) has exacerbated skills shortages across Cascadia.

The Cascadia megaregion has had historically strong growth and is forecast to continue. A high-speed transportation system would leverage the existing strong economy of the region, thus enabling sustained economic growth in the future. Stakeholder interviews help shed light on real-world issues that are top concerns of the region's business community. Business stakeholders provided feedback about the need for UHSGT to facilitate the continued development of the regional economy. According to the business stakeholders interviewed, a new high-speed transportation system would provide the six overarching economic benefits shown in Table 4.

Table 4: Key Themes from Stakeholder Interviews

	UHSGT Benefits Identified by Stakeholders
1.	Regional economic integration due to greater connectivity
2.	Access to a larger, more cohesive pool of qualified talent throughout the region
3.	Increased affordable housing opportunities and choice
4.	Support for specialized freight movement in e-commerce and technology-based industries

[9] Statistics Canada uses housing costs exceeding 30 percent or more of income as a threshold for assessing affordability. Seattle's is based on more than 40 percent of household income.

5.	Significant economic benefits to specific industries uniquely positioned to benefit from much broader regional access and reach, including the following: • Sports and entertainment industries • Innovation sector (including aviation and ocean transportation) and the cruise ship industry
6.	Facilitation of research collaboration among business enterprises, universities, and public and private research institutions

Stakeholders view a high-speed transportation system as a tool for both overcoming existing structural economic challenges in the region as well as a unique opportunity to unlock economic transformation and untapped potential in the region. Amazon for example used the quality of transportation infrastructure as a top criteria during its search for a new HQ2 location.

Tool to overcome existing economic challenges and opportunity to unlock untapped potential

Improved connectivity can attract new and expanded businesses in addition to improving the global competitiveness of businesses already in the Cascadia megaregion.

1.4 Economic effects of UHSGT

UHSGT could be a transformational investment in the economies of the Cascadia megaregion, generating a potential $355 billion in economic growth. In addition to conventional benefits of infrastructure investment, such as reduced journey times and less congestion on existing highways and at airports, UHSGT would unlock transformative benefits associated with enhanced connectivity between geographically distant cities. This would:

- Result in more integrated regions that function as a single, more diversified economy.
- Lead to larger labor markets for employers from a wider geographic reach.
- Allow workers access to a broader pool of employers and range of industries.
- Facilitate greater housing choices in areas with supply and affordability constraints.

Major structural barriers hindering regional economic growth, such as constrained pools of labor or a lack of affordable housing, are not easily mitigated through conventional public policies and investments, despite the best efforts of state and local public stakeholders. For example, employment growth has outpaced population growth in the Vancouver, BC; Seattle, WA; and Portland, OR; metropolitan areas since 2010, which is unlikely to be sustainable without being able to expand both the size and skills of the region's workforce. This has been a major factor in housing costs far exceeding wage growth.[10]

UHSGT could help address issues of affordable housing, labor shortages, and job opportunities

[10] OECD Data, Statistics Canada, Bureau of Labor Statistics, Zillow, Canadian Real Estate Association

Coupled with an effective set of policies and a cohesive mix of public and private stakeholder strategies, UHSGT would play a catalytic role in mitigating these structural barriers, helping to develop a stronger, more integrated Cascadia megaregion that is better positioned to compete in the 21st-century global economy.

A well-developed UHSGT would integrate regional assets and strengthen the ability of the Cascadia megaregion to compete globally in key industries. For example, the organizations active in the knowledge economy (including technology, university and medical) increasingly gravitate toward dense urban areas to attract qualified employees and build connections to wider markets. A new UHSGT system would maximize these agglomeration effects by offering a high-performance transportation link to connect the existing and future talent pools, employers, and centers of innovation throughout the region.

Such enhanced connectivity would result in several economic benefits, including the following:

- Creation of new regional industry clusters and higher growth potential of existing industry clusters
- Stronger growth potential for businesses resulting from access to a larger and more diverse labor pool
- Increased equity for workers and residents in the form of improved access to housing and job opportunities
- Greatly reduced costs and environmental impacts throughout the region from lower motor vehicle and air travel

Integrating regional assets to strengthen ability to compete globally in key industries

Furthermore, a high-speed transit spine between Vancouver, BC; Seattle, WA; and Portland, OR; would maximize the value of existing transportation networks through enhanced multimodal connectivity and reduced travel times for the region's employees, residents, and visitors.

1.5 Lessons learned from international case studies

High-speed rail (HSR) systems around the world have had success addressing each of these structural barriers to economic growth. Complete case studies are available in Appendix B: Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion.

For example, Eurostar/High Speed 1 (HS1) transformed connectivity between the United Kingdom, France, and Belgium. The services provide passenger and freight HSR services as well as rail shuttles transporting road vehicles through the Channel Tunnel, similar to Amtrak's Auto Train. Overall, user benefits have been calculated as much as $15 billion (compared to the $9 billion initial cost), while wider benefits have added a further $7 billion, including the increase in land values near the HS1 stations.[11] New development has been witnessed near HSR stations, including at Lille, France; Kent, United Kingdom; and London's Kings Cross and Stratford.

Crossrail in London, scheduled to be completed in 2020 at a cost of $20 billion, is projected to increase London's public transportation network capacity by 10% and generate over $55 billion in benefits.[12] Similarly, the Paris-Bordeaux HSR opened in 1989, and in the ensuing 20 years, the Great Bordeaux region has grown by over 1 million people with a shift in jobs from agriculture toward aerospace, small high-tech business, and a growing university sector. Closer to home, Montreal's REM project has been planned to both expand the region's transportation capacity and transform access from areas currently suffering from poor access to the downtown and major international airport, unlocking station locations to new commercial and residential development.

Key lessons from evidence elsewhere is that transforming connectivity, which is a key outcome from building HSR, results in economic growth that can well exceed upfront costs. It enables cities such as London to compete more effectively and sustainably with international competitor city/regions such as New York City and Paris. The improved connectivity can also grow the region's job base and increase the number of well-paying jobs by attracting knowledge economy businesses. The UHSGT concept for the Cascadia megaregion would build on lessons learned from these projects to facilitate continued strong development of the regional economy. Chapter 2 describes the UHSGT concept.

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[11] HS1 First Interim Evaluation Report (UK DfT & Atkins -2013) & Economic Impact of HS1 (HS1 & Volterra – 2009)

[12] Crossrail Business Case Report (Crossrail – 2010) & Crossrail Property Impact & Regeneration Report (Crossrail & GVA – 2018)

2 The UHSGT Concept

This chapter describes the major steps undertaken during the corridor planning work. The emphasis during this conceptual phase has been on developing multi-modal connections to existing and planned infrastructure and in maximizing ridership as a key benefit of improved intercity transportation. The potential station areas, route, service types, frequency are summarized below and described in more detail in Appendix C: Corridor Planning Technical Memorandum.

The UHSGT concept described in this chapter is subsequently evaluated in Chapters 3 through 6: Strategic Case, Economic Case, Financial Case, and Deliverability and Technical Case, respectively.

2.1 Station areas

As a first step in the corridor planning, eight potential station areas were identified and assessed at a high level to illustrate the range and characteristics of locations that could be served by a new UHSGT spine. Public benefit criteria for the station area assessment included market capture potential, multimodal interconnectivity, value capture potential, land use plans and policies, and equity considerations. A series of preliminary fact sheets and maps were compiled and included in Appendix C for the following potential station area locations:

- Vancouver, BC (includes Surrey, BC)
- Bellingham, WA
- Seattle, WA
- Bellevue/Redmond, WA
- Tacoma, WA
- Olympia, WA
- Kelso-Longview, WA
- Portland, OR

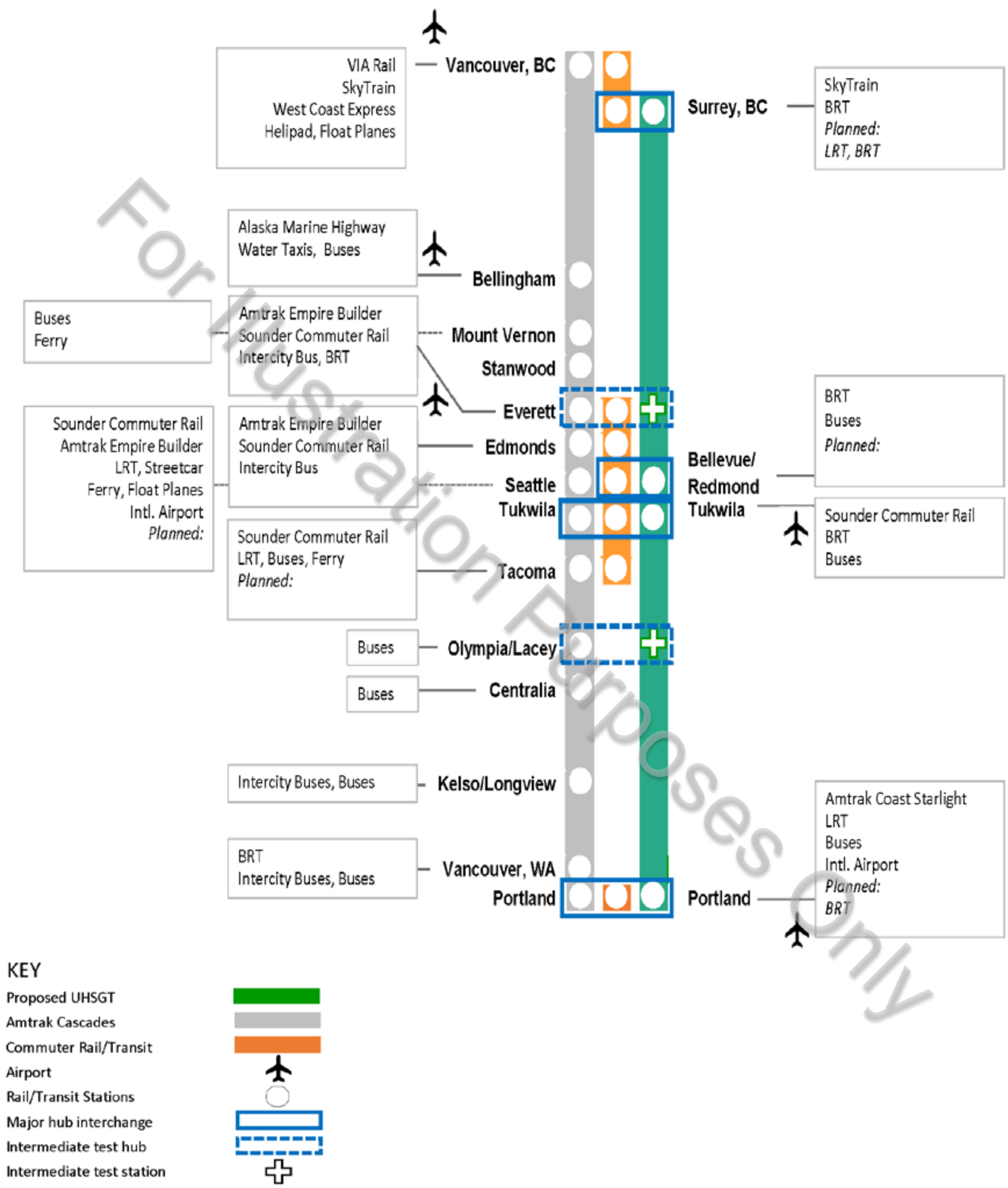
Potential station areas in Tukwila and Everett, WA, were added as the project progressed.

2.2 Scenarios

The development of scenarios was an iterative process. For the purposes of this business case analysis, a combination of potential station area locations together with their hypothetical route comprises a scenario. Preliminary combinations of station areas were examined to identify the potential network capabilities of a new UHSGT spine and the possibilities of integrating new and existing rail and transit stations into a multimodal transportation system for the benefit of regional and local mobility.

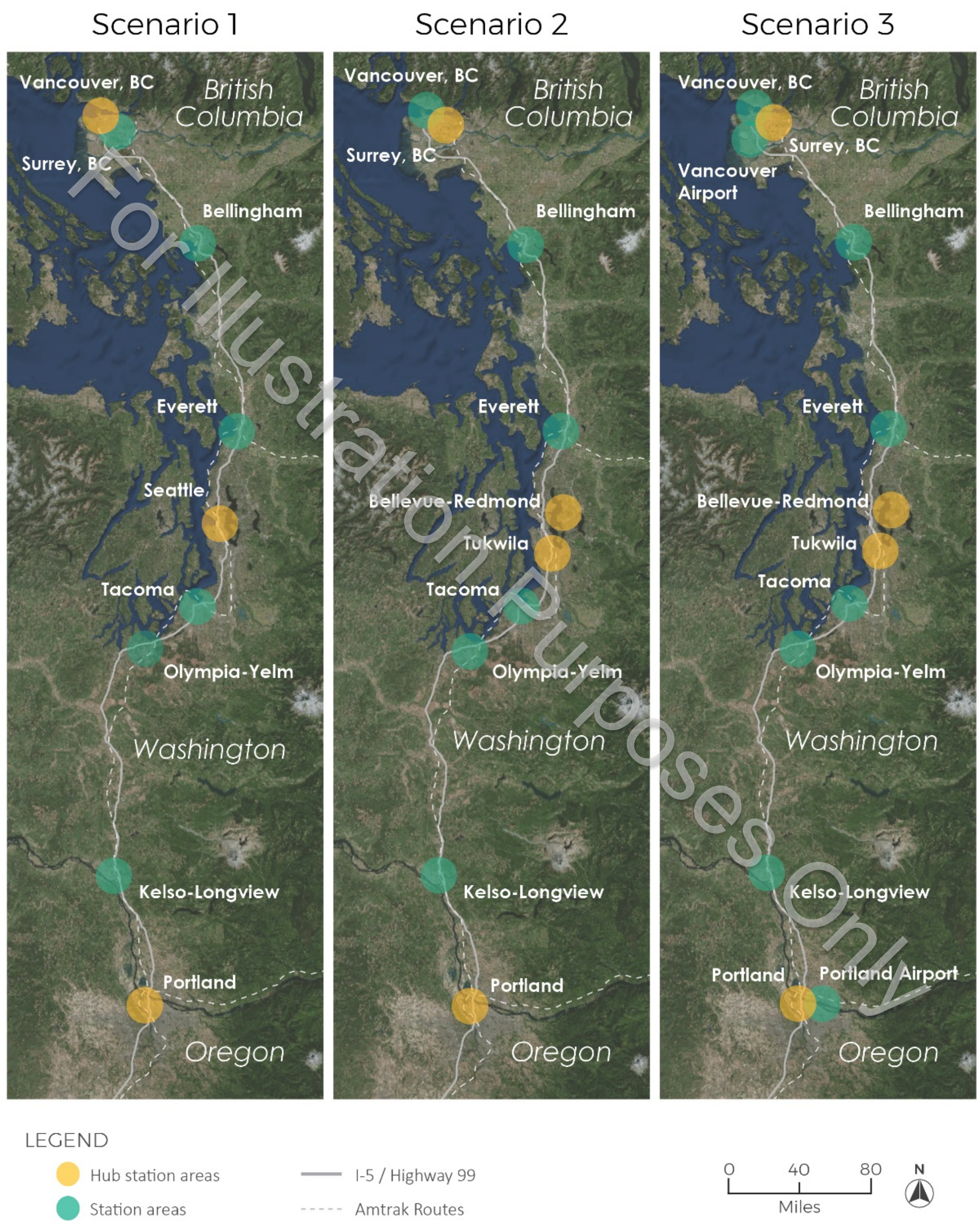
As an alternative to a downtown Seattle station stop, a major station stop in Bellevue/Redmond was considered. Figure 1 illustrates the potential connections of UHSGT to the existing and planned network with the example of major hub stops in Bellevue/Redmond and Tukwila, WA.

Figure 1: Potential UHSGT station areas and connections to existing and planned rail and transit services



Following several iterations and input from the Steering Committee and Advisory Group, three illustrative scenarios (see Figure 2) were developed for further study. Scenario 1 would connect the major hubs of Vancouver, BC, and Portland, OR, through a hypothetical route through downtown Seattle. Scenario 2 would travel eastward of Seattle through new major hubs at Bellevue/Redmond and Tukwila, WA. Scenario 3 would build from Scenario 2 with extensions for the Vancouver, BC, and Portland, OR, international airports. Within Scenarios 1 and 2 variations were included that considered Surrey, BC, as the northern terminus of the UHSGT spine.

Figure 2: Illustrative UHSGT Scenarios with Key Station Areas



In total, nine scenario variations were developed for subsequent ridership modeling and were linked to market and socioeconomic factors as well as serving different potential station areas. Table 5 provides a summary of the stations served by each scenario variation.

Table 5: Summary of Stations Served by Scenario Variation

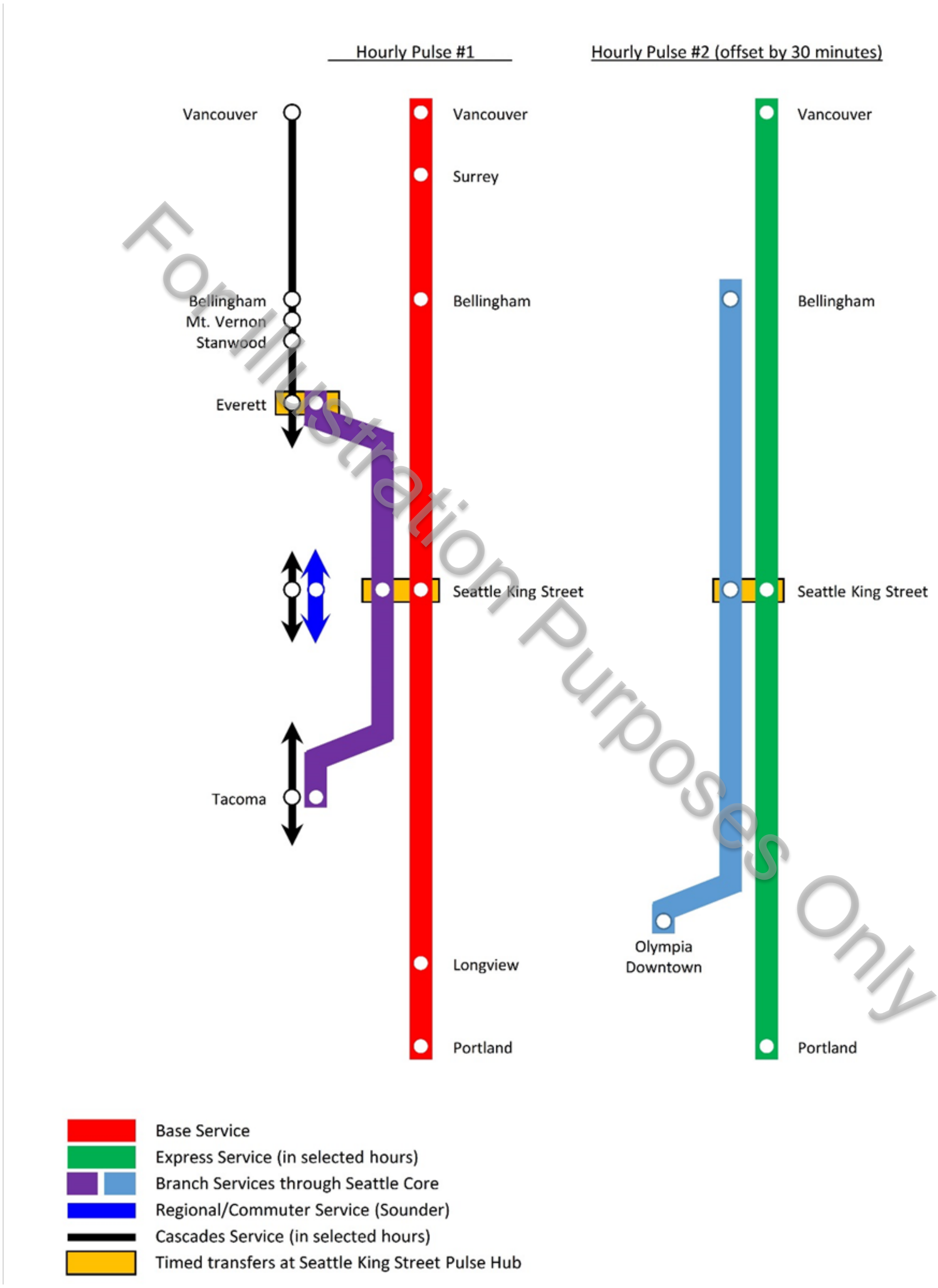
Station	1A	1B	1C	1D	1E	2A	2B	2C	3
Vancouver, BC	X	X	X	X		X	X		X
Bellingham, WA	X	X		X	X	X	X		X
Bellevue/Redmond, WA						X	X	X	X
Tukwila, WA						X	X		X
Olympia/Yelm, WA	X				X	X			X
Kelso/Longview, WA	X	X		X	X	X	X		X
Portland Airport, OR									X

2.3 Service types and travel times

Most of the scenario variations featured different combinations of intermediate stations along the UHSGT spine. In two scenario variations, branch service was considered to provide access to downtowns located off the UHSGT spine. Modifying the spine to directly access the downtowns of these intermediate cities could render the geometry of the route too curvy to allow for high-speed travel, and the increased number of stops would also add dwell time. In these variations, service at major hubs—Seattle, Bellevue/Redmond, and Tukwila, WA—featured a “pulse hub” concept that links trains and creates guaranteed, timed passenger connections. These timed connections are designed to reduce the burden and time of needing to change trains, while enabling services along the UHSGT spine to maintain sufficiently high travel speeds.

Figure 3 provides an illustrative example of a “pulse hub” concept in Seattle, combined with branch service, as modeled in Scenario 1B.

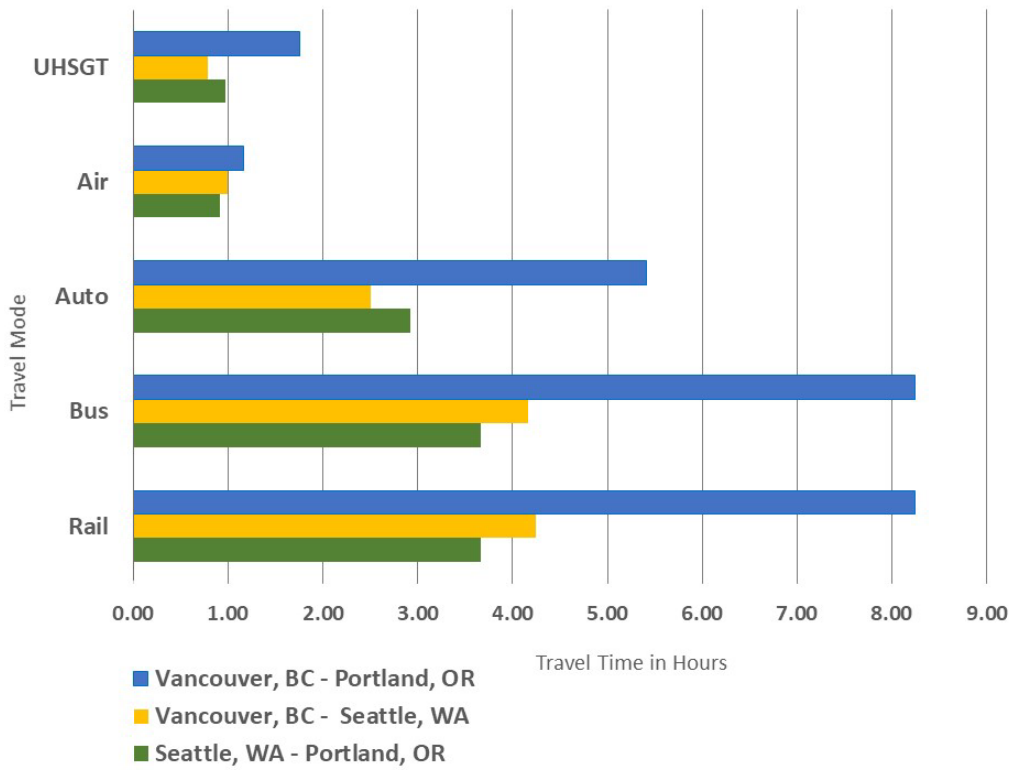
Figure 3: Example Schematic of "Pulse Hub" Service Concept in Seattle



To estimate travel times between station areas, a hypothetical route that would accommodate a design speed of 220 mph (350 kph) was assumed, and conceptual timetables were then developed for each scenario variation. Travel times and service types were incorporated by the ridership team into a series of model runs for each scenario variation.

UHSGT would offer significant travel-time savings compared to existing modes of travel in Cascadia, particularly auto and intercity rail. UHSGT travel times using express service between Seattle, WA, and Vancouver, BC (47 minutes) and Seattle, WA, and Portland, OR (58 minutes) would be comparable to air travel.

Figure 4: Travel Times by Mode (hours)



Seattle to Vancouver in 47 minutes and Seattle to Portland in 58 minutes

However, travel times via air do not typically incorporate the time necessary for transit to the airport and completing check-in, security checks, and customs processing at the airport, which can vary from 30 minutes to over 3 hours, depending on the season and whether the flight is domestic or international. The proposed UHSGT system is expected not to be significantly affected by congestion, excess stops, and lengthy processing times for security and customs. The average UHSGT travel time would be achieved more reliably than other modes of travel.

2.4 UHSGT ridership demand

To better reflect the actual journey experienced by travelers in the region, total "door-to-door" journey durations (Table 6) were used in the ridership model to estimate demand. The average time required to reach stations and airports, to go through security screening, and to wait for boarding at the gate/station/terminal was added to the average travel time by mode.

Table 6: Average Total Journey Duration using Selected Mode for the Major Travel Segment (hours:minutes)

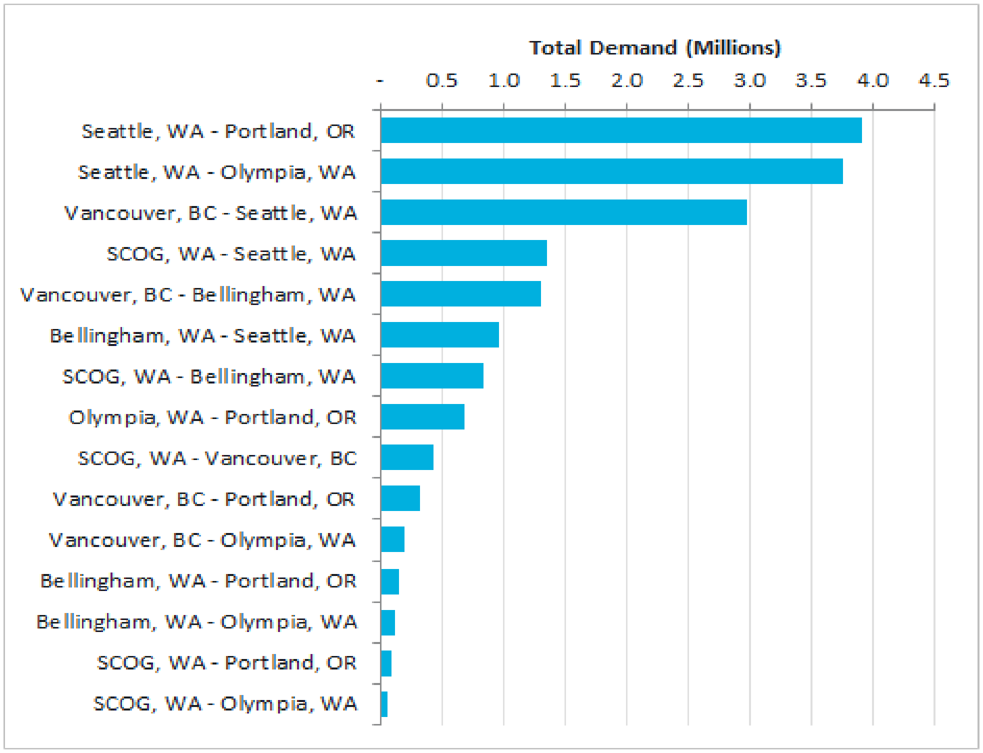
City Pair	UHSGT (Proposed)	Auto (Current Conditions)	Air (Current Average)
Seattle – Vancouver	1:45	3:30	3:00
Seattle – Portland	1:30	3:00	2:30
Portland – Vancouver	2:45	5:30	3:30
Bellingham – Seattle	1:00	2:30	3:00
Everett – Portland	1:45	4:00	2:30
Tacoma – Vancouver	2:15	4:00	3:00
Olympia Yelm – Portland	1:15	2:00	NA
Bellingham – Olympia	1:15	3:30	NA

Note: Journey duration assumes 30-minute access/egress time to travel to/from airports and rail/UHSGT stations. Air trips also have 60-minute check in and security time. A 30-minute delay was assumed for international UHSGT, air, and auto crossings.

Demand for the new UHSGT service was forecast using logit choice models that sought to estimate the share of travelers who would switch from their existing mode of travel to UHSGT. The principal inputs used to construct the models were existing trips, by origins and destinations, in 2017; times and costs of travel by auto, air, intercity rail, intercity bus, and UHSGT; and behavioral parameters that represent how travelers respond to choices between travel options. The geographic basis for these inputs and the modeling framework was a set of 53 model zones spanning seven metropolitan areas along the project corridor that are anticipated to receive UHSGT service.

The “in-scope” market represents current demand for travel along the project corridor from travelers who might consider traveling by UHSGT in the future. The total size of the in-scope market and its breakdown at the origin-destination (O-D) level were estimated using a variety of data sources, including travel-demand models from local metropolitan planning organizations, third-party-provided trip matrices estimated using cellphone traces, and secondary data collected from existing tools and sources. Figure 5 illustrates the in-scope demand at the metropolitan area pair level that was used as an input to the demand forecasting models.

Figure 5: In-Scope Demand for Travel Between Metropolitan Areas, 2017



Note: SCOG refers to Skagit Council of Governments

The share of in-scope travelers who would switch modes was estimated at an O-D level, which considered the times and costs of travel for the respective existing mode and UHSGT and a set of behavioral parameters that were estimated from a behavioral survey and used to compute a generalized cost of travel as a combination of various time and cost elements. The survey presented respondents with several scenarios for which they were asked to choose between using their current travel mode and UHSGT, based on various time and cost attributes for each mode. Their responses enabled modelers to infer the weight or importance they attached to time and cost elements. The greater the difference between the generalized costs, the more it allocated to the “cheaper” mode. Finally, the models also considered the potential for UHSGT to induce additional travel due to its attractiveness from a time and/or cost perspective, using the difference in total generalized costs before and after the introduction of UHSGT.

Applying the models described above yielded an overall capture rate (share of travelers switching from different modes) of between 10% and 18% in 2040, depending on service scenario. Rail had the highest percentage capture rate, between 29% and 59%. While UHSGT would offer improved intercity travel times over traditional intercity rail at the cost of higher fares, the large range between the lowest and highest capture was attributable to the fact that this capture was highly dependent on the number of intermediate locations served by UHSGT. Air had the second-highest capture rate, between 16% and 18%, which was attributable to the fact that air and UHSGT tend to attract similar market segments—

primarily business travelers with a high value of time—and for many key markets UHSGT offers lower intercity travel times and higher frequencies. Table 7 summarizes the capture rate and captured/induced trips by existing mode for the low and high ridership scenarios.

Table 7: Capture Rate and Captured/Induced Trips for Low and High Ridership Scenarios, 2040

Existing Mode	UHSGT Low Scenario (2C)		UHSGT High Scenario (1D)	
	Capture Rate	Captured Trips	Capture Rate	Captured Trips
Auto	8%	0.8M	16%	1.5M
Air	16%	0.5M	18%	0.5M
Rail	29%	0.2M	59%	0.5M
Bus	1%	0.0M	8%	0.1M
Induced	N/A	0.2M	N/A	0.4M
Total	**10%**	**1.7M**	**18%**	**3.1M**

Based on these capture rates and ridership numbers, UHSGT is estimated to assume a market share of between 12% and 20% in 2040, as illustrated in Figure 6. Note that the UHSGT market share is higher than the forecast capture rate due to the inclusion of some induced demand. This level of demand could be more than triple the existing demand on Amtrak Cascades, and would make UHSGT the second-highest ridership corridor in North America after the Northeast Corridor.

Estimate that between 12 and 20 percent of current intercity trips would shift to UHSGT

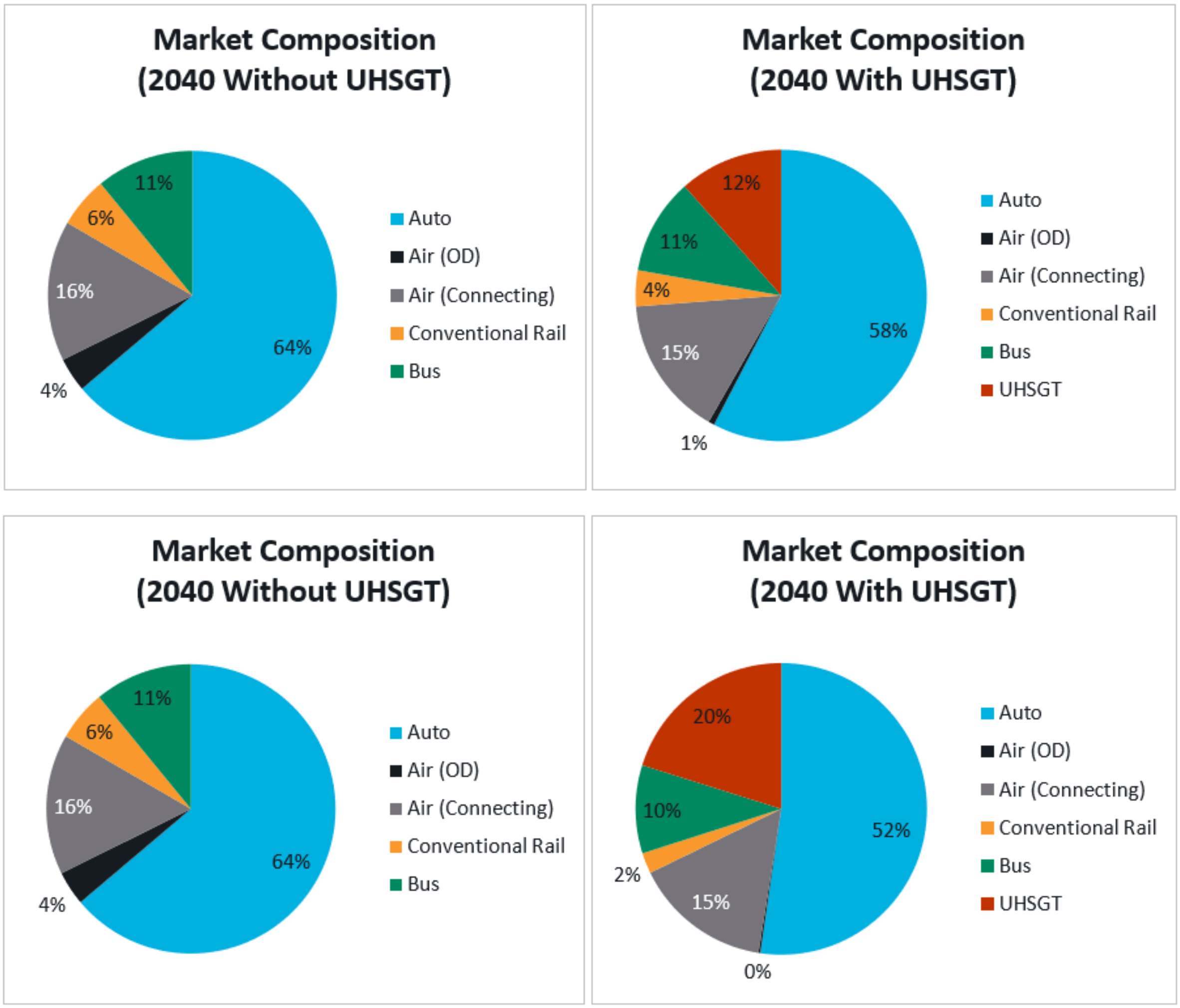
Farebox revenue forecasts for the various scenarios were developed based on a $0.52 fare[13] per passenger mile (2019 dollars) across the entire system, which was assumed to remain constant in real terms throughout the forecasting period (2017 through 2055). This translated to forecasted 2040 revenues of $156 million and $250 million for the low and high ridership scenarios, respectively.

UHSGT may perform even better, since there are key areas where the ridership and revenue projections are generally conservative. Effectively, most of these assumptions forecast no real change in costs, journey times, or ease of access compared to today. For example, fuel prices and other auto costs do not change and marginally reduce in real terms as do air fares. No worsening of intercity congestion is assumed on either roads or airports despite recent evidence showing that highway corridors are reaching full capacity across the Cascadia megaregion and increased journey times are being experienced in Vancouver, BC; Seattle, WA; and Portland, OR;.[14] In addition, survey results suggested that 74% of

[13] This value is similar to average fares per passenger mile for regional service on the US Northeast Corridor ($0.53). Average Acela fares per passenger mile are higher (about $0.97).
[14] Various sources, including TomTom Congestion Index 2016

respondents would “definitely try UHSGT.” Accordingly, if implemented effectively, there is a huge potential to attract additional riders to UHSGT throughout the corridor.

Figure 6: Market Composition by Mode With and Without UHSGT (2040 Low and High Scenarios)



Various sensitivity tests indicate that increases in the above costs and/or journey times can have a positive impact on demand for UHSGT. A region-wide 10% increase in driving times in 2040, due to increased roadway congestion or other factors, is forecast to provide a 9.3% increase in currently forecast ridership for 2040. Changes to other assumptions (e.g., increased auto costs and air fares) were found to have a smaller, yet still positive, impact on UHSGT demand. While possible policy measures such as the introduction of congestion pricing or managed toll lanes were not examined in detail, the sensitivity of UHSGT demand to longer auto journey times or large changes in total costs suggests that total UHSGT ridership could be significantly higher than forecast in this assessment. Table 8 summarizes the key sensitivity tests that were conducted on 2040 UHSGT demand.

Table 8: Key Sensitivity Tests on Forecast UHSGT Demand, 2040

Sensitivity	% Change Ridership	% Change Revenue
Gas prices 10% higher	1.2%	1.4%
Other auto operating costs 10% higher	0.7%	0.8%
Auto journey times 10% higher	9.3%	9.4%
Air fares 25% higher	1.4%	1.5%
Air frequency 50% lower	0.3%	0.3%
UHSGT fares 20% lower	17.9%	-4.2%
UHSGT fares 50% lower	52.1%	-20.6%
UHSGT journey times 25% lower	7.9%	8.9%
UHSGT frequency doubled	4.2%	4.1%
Population and employment growth 25% higher per year	8.4%	8.4%

Further details on sensitivity tests and assumptions used in developing the demand forecasts are included in Appendix D: Ridership and Revenue Report.

2.5 Technology options

The corridor planning process largely worked on the assumption of deploying conventional HSR technology, producing hypothetical routes and timetables with design speeds of approximately 220 mph (350 kph) to reflect the best available practices of conceptual planning and design. The benefits and drawbacks of conventional HSR have been studied extensively throughout the US and realized in HSR systems worldwide. Engineering and operational information for maglev and hyperloop technologies is not yet available at the same level of detail, although work on these technologies is advancing rapidly.

Maglev and hyperloop are stand-alone technologies and would not allow for blended service on the new spine or an integration of existing rail network assets to amortize the infrastructure cost and utilize common rights-of-way. Stations, however, could be designed to allow for transfers between technologies at designated hubs.

2.5.1 Hyperloop

Hyperloop with its anticipated high speeds and private initiative driving its development has the potential to transform the movement of people and freight, and create new economic realities that are inconceivable today. Hyperloop vehicle speeds are planned to be significantly higher than conventional HSR (some proponents suggest speeds could exceed 500 mph/800 kph) and average door-to-door travel times would be faster than air service, especially if the fixed guideways are located closer to and population centers.

As such, any hyperloop system would have significantly different and unique design guidelines and operating models than conventional HSR or maglev. Hyperloop also has the potential to deliver significant capital and operating cost savings relative to conventional HSR, the former due to smaller physical footprints and the latter a result of automated operation (reduced labor costs), fewer moving parts (e.g., no wheel-rail interfaces), and reduced aerodynamic drag.

The engineers and planners at Virgin Hyperloop One have contributed their expertise during this study and several planning iterations have been undertaken at a high level, examining route geometry criteria and resulting maximum speeds. The higher speeds would require significantly less curvature along a route than envisioned during the corridor planning and ridership and revenue work, which aimed to incorporate a series of intermediate stations in addition to the major hubs.

As exciting as this technology is, hyperloop remains a commercially unproven technology and as compared to HSR may pose additional risks if implemented in the near term.

- **Delivery:** The technology has not been commercially deployed. Although a test track exists in Nevada, it has not been evaluated for passengers. The eventual project owner could be taking on significant technical delivery risks.
- **Competitiveness:** Conventional HSR has seen gradual speed improvements over the past several decades, and should they continue to do so, hyperloop’s speed advantage may diminish. In Cascadia, model sensitivity testing demonstrated that travelers were not particularly sensitive to minor changes in journey times on UHSGT. The potential speed advantage of hyperloop over conventional steel wheel technology would require further analysis.
- **Costs:** While the case for hyperloop is partially built on lower costs than conventional HSR, a working commercial system has not been deployed, and there is limited evidence drawing from the 10%-30% designs that have been completed that indicates the actual costs of implementing a hyperloop system.
- **Revenue:** Because costs are unknown, the level of pricing required to pay for operating and potentially capital costs, as well as whether this pricing will be acceptable to travelers, is also unknown.

Hyperloop also presents a series of operational and technical challenges that will need to be examined in greater detail:

- **Balancing speed vs. capacity:** Although travel speeds are a significant improvement over HSR, current proposed hyperloop concepts have focused on lower capacity vehicles (26-28 passengers per vehicle). An operating concept that reliably and safely addresses peaking would likely need to be adapted to accommodate high intercity demand along a single, linear corridor in the Cascadia megaregion.
- **Alignment design:** To realize significantly improved travel speeds over conventional HSR, a hyperloop alignment would have a much lower tolerance for horizontal and/or vertical curves than conventional HSR. In densely developed urban areas, this could

require costly construction of tunnels and/or elevated structures to achieve the needed straight alignment.

- **Safety:** Design processes will need to develop infrastructure that can maintain high speeds while meeting safety requirements, including emergency stopping and evacuations, which is particularly relevant in a region that experiences seismic activity.
- **Approvals and regulations:** Given the untested nature of hyperloop technology, it is expected to undergo a lengthy, complex federal approval process in both the US and Canada to ensure compliance with various codes and regulations, which may need to be amended to take into account this new technology. Other processes may also need to be undertaken at the state/provincial level to the extent not preempted by federal regulation.

Given the extent and scope of the challenges identified above, further study into technical and operational solutions will be needed to fully set out a competitive business case for selecting hyperloop as the preferred technology on the corridor.

2.5.2 Maglev

Maglev (derived from magnetic levitation) is a transportation technology that has been developed over the past 50 years using magnets to repel and float the vehicle forward. A key advantage of the technology is its ability to operate at high speeds, taking advantage of the lack of friction. At between 200 mph to 400 mph (320 kph to 640 kph), maglev technology can compete favorably with high-speed rail and airplanes.

Maglev technology is still considered an experimental technology with only one high-speed line currently in public operation, serving Shanghai Pudong (China) airport. The Shanghai Maglev Train, also known as Transrapid, has a top speed of 270 mph (420 kph) and operates between Shanghai Pudong International Airport and Pudong, Shanghai.

Since the Great East Japan Earthquake in 2011, there has been a renewed focus on building resilient infrastructure to provide alternative routes along main transportation arteries in Japan. Concerns about the resiliency of the Tokaido Shinkansen line, now over 50 years old, as well as the need for additional capacity resulted in the decision to build a new high-speed ground transportation trunk system between Tokyo, Nagoya, and Osaka. The Chuo Shinkansen project will link these major cities using the first large-scale superconducting maglev system operating at speeds up to 311 mph (500 kph).

The Central Japan Railway company is building the first section of the new Chuo Shinkansen between Tokyo and Nagoya (286 km) with a planned completion in 2027. A second segment, extending the line from Nagoya to Osaka is in the planning stages. The Yamanashi Maglev Test center has been open and demonstrating this technology to the public for over 20 years. It was significantly expanded in 2013 and has been used to test prototype vehicles and refine maintenance practices. It has also been providing public “experience rides” to obtain passenger feedback and improve the passenger experience. The Yamanashi test track is planned to be repurposed and incorporated into the new Chuo line. When completed, the trip from Tokyo to Nagoya will be reduced from 1 hour 40 minutes on the Tokaido line today to only 40 minutes on the Chuo line, a savings of 1 hour.

There are a few other instances of maglev services; however, these are primarily lower speed lines. Examples of these types of services include maglev services to Seoul Incheon (South Korea) airport and the Linimo line, an "Urban Maglev" system in Japan. Both services have top speeds of around 62 mph (100 kph). Among the challenges in implementing maglev systems has been the higher costs to construct the lines compared to conventional HSR systems, as well as high energy costs. This challenge is particularly evident in Japan where some segments of conventional steel wheel HSR lines are targeted for transition to maglev technology. The incremental benefits of maglev technology have often been hard to justify against cost and risk, especially where there is an existing or proposed conventional HSR line with spare passenger carrying capacity, as is common in Europe and Japan. Interestingly, China—which constructed much of its over 18,000 miles (29,000 km) of high-speed network at greenfield locations—chose conventional rail technology rather than maglev. Although maglev technology should not be ruled out at this stage, it should be considered only if a competitive business case can be made over and above conventional HSR or hyperloop technologies.

2.6 Capital and operating costs

2.6.1 Capital cost projections

The current phase of UHSGT project planning did not include the conceptual engineering of a proposed alignment. The costs associated with the construction of a fixed guideway system, including stations, is highly dependent upon the specific location and geography of the proposed alignment. Sections that would require underground stations and tunnels are significantly more expensive to construct than at-grade sections or areas that require an aerial viaduct. Right-of-way (ROW) acquisition costs can also differ significantly depending on location, and the requirements for ROW differ between the construction types.

The capital cost estimates in the 2017-2018 Feasibility Study range from $24 billion to $42 billion (2017).

2.6.1 Operating and maintenance cost projections

The anticipated farebox revenue discussed in Section 2.4 would be used to offset the operating and maintenance (O&M) costs required to run the UHSGT system. O&M costs are linked to recurring costs for train operations, infrastructure maintenance, station operations, control center and field operations, staff, and insurance. A unit cost approach was used to assess Scenario 1E as a representative scenario with 21 roundtrips per day on a route length of 305 miles (491 km). Unit cost assumptions were developed based on a review of other similar existing and planned systems in the US, Europe, and Japan.

The operating costs for train operations per roundtrip were estimated to be lower in the 2019 Business Case as compared to the 2017-2018 Feasibility Study. Similarly, the station operating costs were also estimated to be lower per station. However, the 2019 Business

Case assumed 9 more roundtrips and an additional station as compared to the highest ridership alternative in the 2017-2018 Feasibility Study. Insurance costs were also added to Scenario 1E in the 2019 Business Case. As a result, the annual operating costs are anticipated to be about 13.5% higher than in the earlier study.

However, the higher ridership volumes forecast in the 2019 Business Case would result in higher revenues, which would allow O&M costs to be covered by fare revenue by 2055 – a finding similar to the 2017-2018 Feasibility Study. An increase in ridership of about 10% or decreases in operating costs of about the same magnitude could also result in a full offset of O&M costs by revenue in 2040.

2.7 Summary of UHSGT concept

The corridor planning process evaluated several conceptual routes and station area locations along the corridor for testing purposes, and ultimately three illustrative scenarios were selected for the development of travel times and conceptual time tables. This exercise was developed to assess ridership demand and operating cost estimates using a refined set of data and analytical tools. The routes would provide for a maximum design speed of 220 mph (350 kph) and connect major employment centers (emphasis on high-tech firms), educational institutions, tourism centers, and transportation hubs along the corridor. Stations in major downtown centers, such as Vancouver/Surrey, BC, and Portland, OR, could be conveniently located in the heart of business, employment, cultural, and entertainment activity for their respective regions, while other intermediate station locations, such as Kelso/Longview, WA, were selected for the purposes of this planning stage to serve as business incubators and catalysts for residential and commercial development around the station areas.

Depending on the station areas ultimately served and various governance and operational decisions, there is the potential for UHSGT to offer seamless, interline connections to other scheduled modes of travel. UHSGT station stops at existing rail stations and transit hubs could facilitate first- and last-mile connections to existing transit buses, commuter rail, and light rail systems, as well as connections to Amtrak long-distance trains to points not directly served by UHSGT, including those south and east of the Cascadia megaregion. In addition, the inclusion of stations at Vancouver, BC, and Portland International Airports on the UHSGT spine or on timed branch connections, could encourage air travelers to cover the shorter, intra-regional leg of their trip on UHSGT while traveling the long-haul leg by air, as witnessed at some European airports such as in Amsterdam. With these intermodal connections, the new UHSGT spine would serve to improve and catalyze the network capability and capacity of the entire regional transportation system.

3 Strategic Case

3.1 Introduction

This chapter sets out the strategic case for UHSGT, including how a new transportation system would affect the Cascadia megaregion, and thus transform the economic and environmental landscape. The strategic case identifies the vision for the project, how improving mobility and interconnectivity would affect the megaregion's economy, and the opportunity that a high-speed transportation network offers in unlocking a more sustainable and equitable society.

The strategic case is one of four cases (i.e., Strategic, Economic, Financial, and Deliverability) methodology that is used in Canada (Transport Canada and many provinces), the United Kingdom, Australia, and other countries to assess the feasibility and impact of transportation projects and service initiatives. The information in this chapter draws from and builds on the work included in the other UHSGT documents, particularly Appendix B: Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion, and Appendix C: Corridor Planning Technical Memorandum.

3.2 UHSGT vision and case for change

The vision for UHSGT is to advance the economic, social, and environmental conditions in the Pacific Northwest by improving mobility and interconnectivity in the corridor between Vancouver, BC; Seattle, WA; and Portland, OR. Table 9 outlines these goals and objectives.

Table 9: UHSGT Goals and Objectives (as agreed with UHSGT Advisory Group and Steering Committee)

Goals	Objectives
Stimulate economic growth and innovation.	• Support the growth of existing and future employers by expanding the effective labor market in a meaningful way. • Allow the region to compete for larger companies. • Spur investment throughout the region, with emphasis on building the innovation economy. • Consider and target potential areas for new growth.
Provide efficient and sustainable mobility.	• Create a viable mode choice for intercity travel. • Deliver optimal value for investment. • Promote sustainable and environmentally responsible mobility.
Promote regional integration.	• Improve transportation connectivity among population, employment, technology, cultural, and knowledge centers. • Enhance existing and future residents' access to equitable interregional transit. • Integrate UHSGT with existing and future intermodal systems to form a comprehensive regional transportation network.

The world is undergoing profound change as the combined effects of globalization, technology, information access, and changes in cultural norms are leading to new challenges and opportunities. The Cascadia megaregion has been at the leading edge of many of these changes, including the rise of technology giants Amazon, Microsoft, and Intel. Clusters of highly productive and fast-growing industries have helped drive employment and population growth. These factors have led to a more dynamic economy, with a higher standard of living for many.

However, while much of the change has been positive, pressure on housing supply, existing communities, skills, and the environment present a challenge in delivering a better Cascadia, not just a bigger megaregion. Decision makers should consider how communities and individuals will be affected by new infrastructure; identify opportunities to elevate the quality of life through economic development, job creation and accessibility; and address damaging burdens that might result from factors such as alignment selection, station locations, hiring practices, and land use.

What is the case for the region to invest in UHSGT?

The need for additional infrastructure investment in Cascadia is clear—crowded roads, congested airports, and the general lack of high-quality local connections have increased pressure to augment capital infrastructure investment. Vancouver, BC; Seattle, WA; and Portland, OR; have the 4th, 6th, and 10th most congested roads in North America, respectively. Airport delays have increased nationwide, costing the US economy $33 billion.[15] The success of major local initiatives to raise public funds (such as 2016 Sound Transit 3 in Washington state) highlights this willingness to support additional funding for transportation

What is largely missing in this debate is the potential benefits from an entirely new mode of transportation. UHSGT offers the opportunity to provide a transformative change in mobility. In addition to conventional benefits of infrastructure investment, such as reduced journey times and less congestion on existing highways and at airports, UHSGT would unlock transformative benefits associated with enhanced connectivity between geographically distant cities. This would:

- Result in more integrated regions that function as a single, more diversified economy.
- Lead to larger labor markets for employers from a wider geographic reach.
- Allow workers access to a broader pool of employers and range of industries.
- Facilitate greater housing choices in areas with supply and affordability constraints.

Major structural barriers hindering regional economic growth, such as constrained pools of labor or a lack of affordable housing, are not easily mitigated through conventional public policies and investments, despite the best efforts of public stakeholders. Coupled with an effective set of policies and a cohesive mix of public and private stakeholder strategies, UHSGT can play a catalytic role in mitigating these structural barriers, helping to develop a

[15] Various sources, including “Cost of US Aviation Flight Delays” (FAA and UC Berkeley, 2010)

stronger, more integrated Cascadia megaregion better positioned to compete in the 21st-century global economy.

The case for UHSGT is in its potential ability to transform this dynamic and generate the following benefits for the Cascadia megaregion:

- A **better-connected megaregion** resulting from faster journeys, increased capacity, and reduced congestion
  - UHSGT would achieve this by integrating its major commercial hubs and population centers, including intermediate stations along this new transportation spine using a greener, environmentally advanced travel mode.
  - Travel times between each of the three major cities would be less than an hour for each segment, with connections to other transportation modes at all stations.
  - Forecasted initial ridership volumes could exceed 3 million annual trips soon after opening and farebox revenues could exceed $250 million per year, making this the best performing high-speed service in the North America outside the Northeast Corridor.
  - There is a clearly stated willingness of travelers in the region to **shift to UHSGT from other modes** and support **greener modes of travel** that provide shorter travel times and more reliable service with a significant reduction in greenhouse gas emissions.
- A **stronger, more productive megaregion** as more businesses/jobs locate in Cascadia due to the dramatically improved access to housing, jobs, schools, and other destinations, as well as the creation of new regional industry clusters. Once implemented, UHSGT would serve as a catalyst in the **transformation** of the Cascadia regional economy into a dynamic, globally competitive, megaregion.
- A **more affordable megaregion** as residents benefit from easier access to more affordable housing as well as wider access to higher-paying jobs and opportunities. Improving mobility for residents throughout the megaregion supports a commitment to developing an equitable transportation network.
- A **better environment** by shifting trips to more sustainable modes, reducing carbon emissions and environmental impacts, protecting habitats, and enabling healthier lifestyles across the megaregion, as well as improving the resilience of the transportation network
- A **better value infrastructure investment** than possible alternative projects, whether interstate highways or airport expansion
- **Broad support from businesses, other stakeholders, and travelers** given UHSGT's ability to unlock sustainable growth, make the Cascadia megaregion more competitive, and deliver higher quality, more cost-effective and safer journeys compared to existing road or air options

- A **modern delivery approach** drawing on proven governance and procurement models plus innovative funding mechanisms
  - These will include lessons learned from other similar infrastructure projects related to funding mechanisms, phasing approaches, private investments, risk management, governance structure, public accountability
  - Recent trans-border and international projects include the US Gordie Howe International Bridge, Vancouver's Canada Line, Montreal's REM, UK HS1/Channel Tunnel, and London's Crossrail.

Although the upfront costs in building UHSGT would be substantial, making a purely private investment case unlikely, this assessment does indicate that the public investment case is strong. User benefits would be higher compared to many other recent transportation projects and the modal shift from auto and air would be substantial given the significant journey time savings. The UHSGT transportation spine would also has the capacity to grow over time, serving other non-intercity markets, depending on how the megaregion develops.

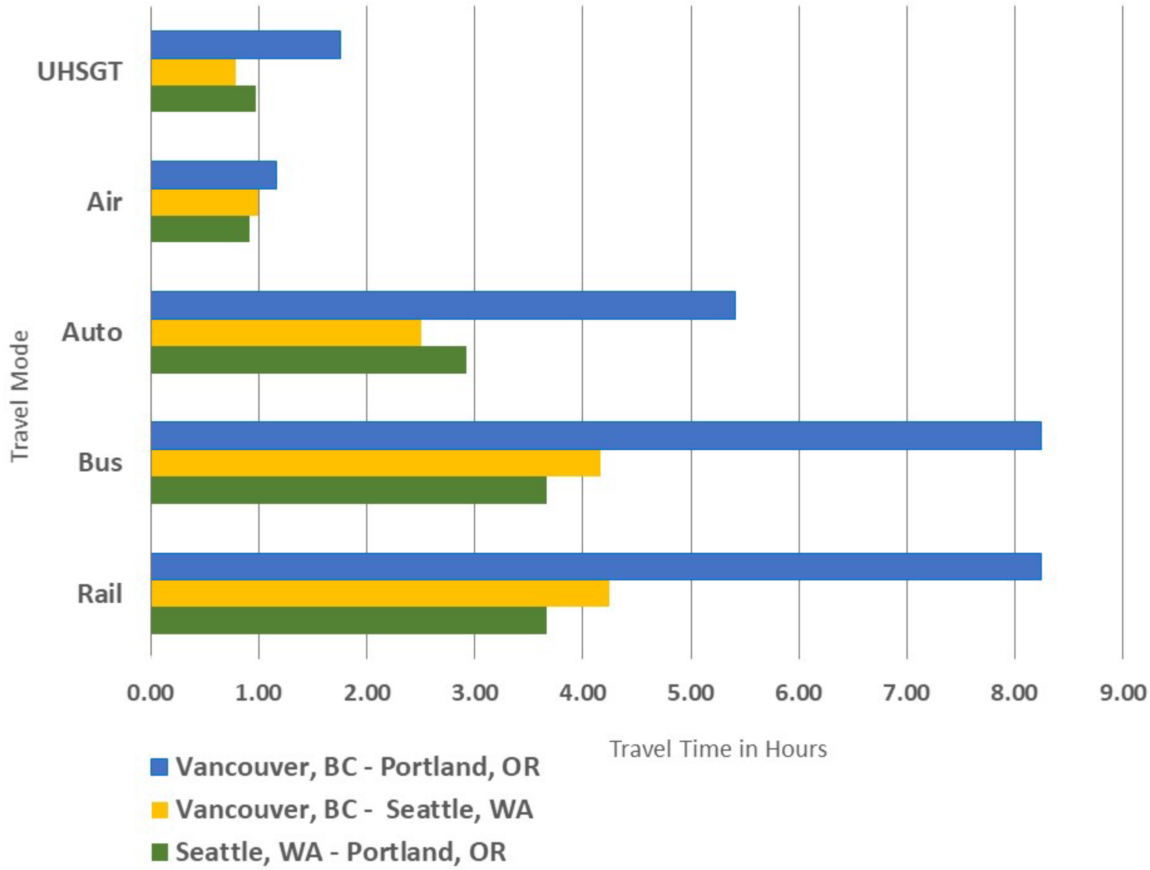
The benefits of UHSGT would be substantial, even though this assessment has used reasonable conservative assumptions on construction and operational costs in this early planning stage. In addition, a range of demand-related assumptions—including no real increase in fuel prices, air fares, or journey times—have been applied despite forecast of future population and employment growth and limited investment for existing infrastructure projects to mitigate current and future congestion. As a result, actual demand, along with direct and wider benefits, are likely to be higher than that presented.

The seven potential key benefits of UHSGT resulting from the analysis are discussed in the following sections.

3.3 A better-connected megaregion

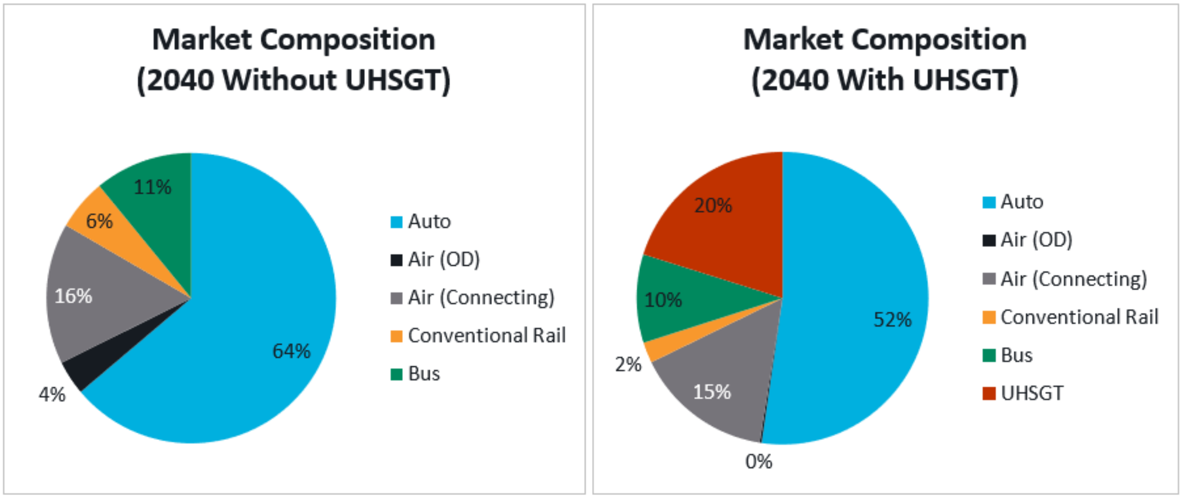
At the heart of the case for UHSGT is its ability to transform journeys across the Cascadia megaregion. The analysis suggests that UHSGT would result in reduced journey times, both between the major cities of Vancouver/Surrey, BC; Seattle, WA; and Portland, OR; and importantly, to smaller population and employment centers such as Bellingham, Everett, Tacoma, Olympia, and Kelso/Longview, WA. In most cases, journey times would be reduced by half, and in some cases by much more. Integration with expanding local transit networks supports journey time savings as well as provides an environmentally advanced travel mode. Even compared to air travel, UHSGT would save most people time on a door-to-door basis, as shown in Figure 7.

Figure 7: Travel Times by Mode



This significant change in journey times would lead to several user benefits, including the ability to tailor travel schedules to meet individual needs, more time to conduct business or enjoy leisure activities, and increased productivity en-route. UHSGT is estimated to take significant modal share from existing air and auto travel options despite using reasonably conservative assumptions on future travel costs, journey times, and reliability, which might increase modal shifts toward UHSGT. Increased frequencies compared to alternative travel options may also reduce perceived journey time. Figure 8 illustrates the predicted share of travelers in the Cascadia megaregion by travel mode with and without UHSGT in 2040 for an example service scenario, where the various positive attributes of UHSGT would drive almost 20% of the market to use it for intercity trips.

Figure 8: Forecast Mode Share by Travel Mode With and Without UHSGT (High Scenario)



Quicker and more reliable journeys may also generate additional trips as people consider it easier to travel to a range of destinations. Evidence from other regions that have implemented an HSR line indicates that generated or induced trips could more than double demand, and in the case of London/Paris/Brussels cross-channel intercity rail and air trips tripled between 1994 and 2018. Figure 9 highlights the significant expansion of area that would be able to easily travel to Vancouver, BC; Seattle, WA; and Portland, OR; in two hours or less compared to much greater travel times today.

In addition to quicker journeys, UHSGT would significantly increase transportation capacity across the Cascadia megaregion. Capacity of a HSR line typically exceeds the peak capacity of a four-lane interstate highway or a two-runway airport.[16] Effectively, UHSGT could double the transportation capacity on the main US Interstate-5/ British Columbia Highway 99 (I-5/Highway 99) corridor. The modeled UHSGT services would use only a relatively small proportion of the 16 trains per hour capacity that a UHSGT line could accommodate. The new transportation spine could unlock a range of services that could meet not just intercity journeys but additional services such as commuter-based services around Vancouver, BC; Seattle, WA; and Portland, OR;, unlocking additional benefits beyond those estimated in this assessment. The United Kingdom's HS1 line has over 20 million annual trips, of which roughly half are from high-speed commuter services. Similarly, less than half of trips on the Northeast Corridor in the US are on intercity Amtrak services.

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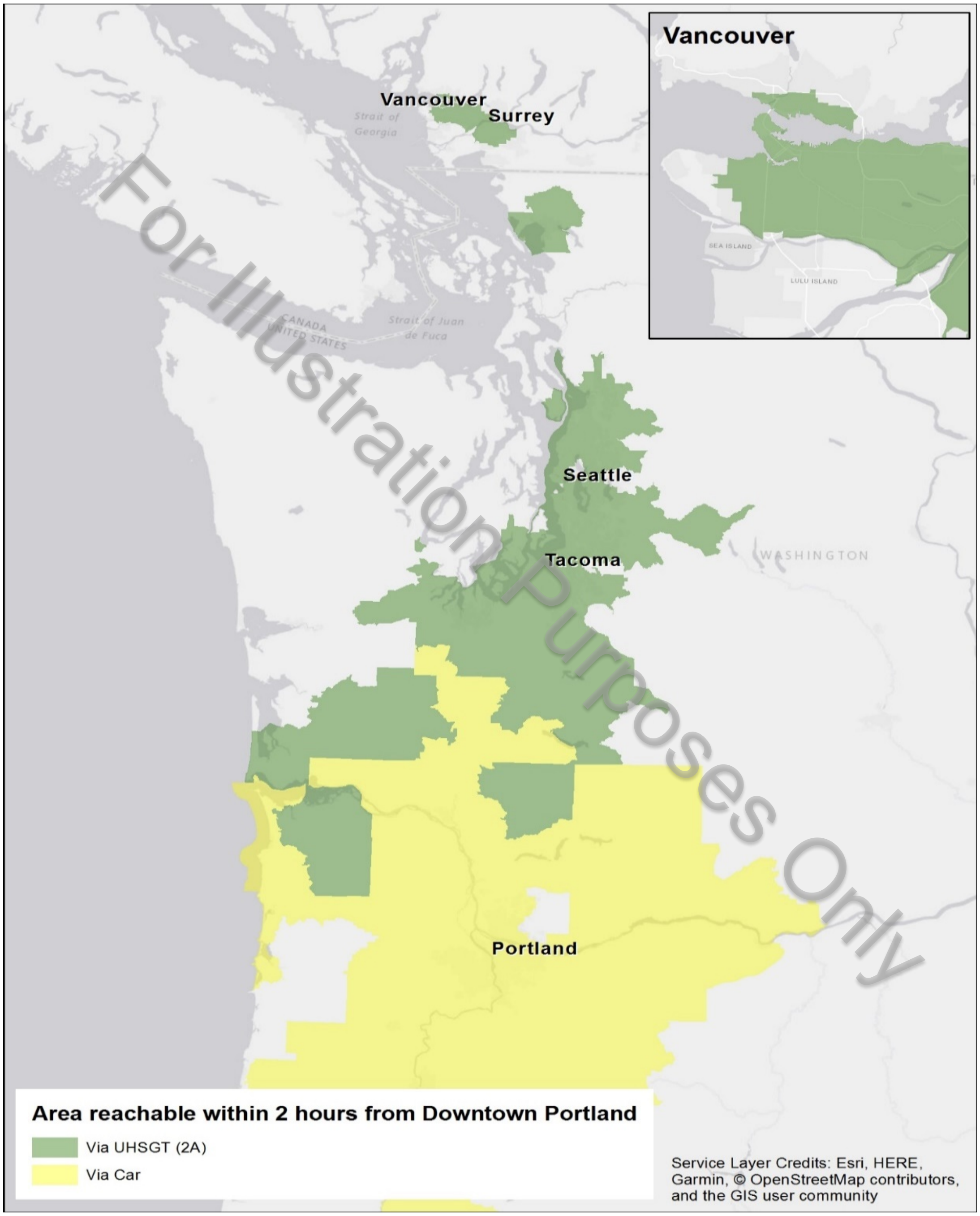
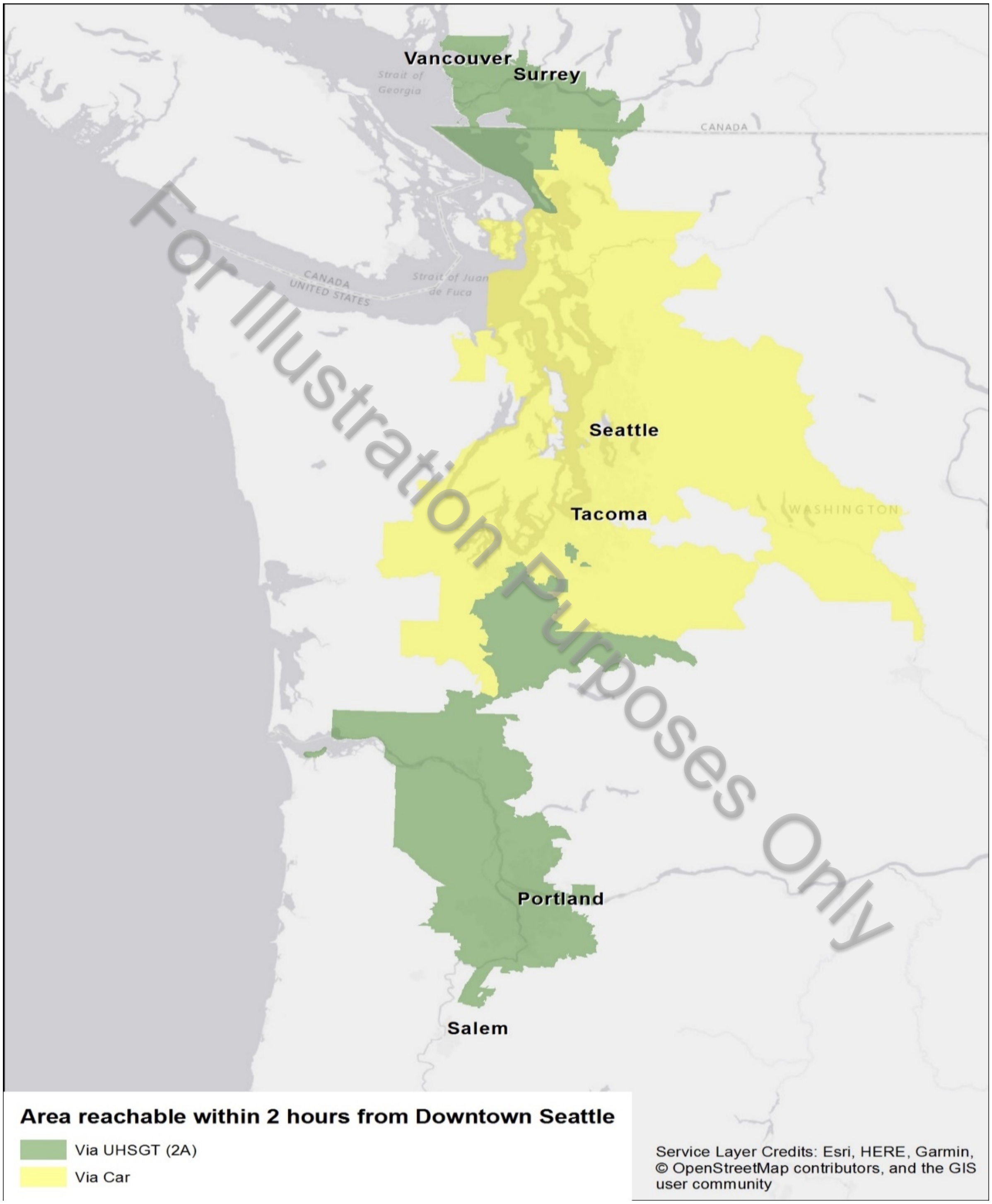
[16] An interstate highway lane can typically accommodate 2,000 vehicles per hour or 3,100 people based on 2017 average vehicle occupancy of 1.55, which translates into 24,800 people per hour for a four-lane highway. Most two-runway airports typically schedule around 60 takeoffs/landings per hour with average aircraft size of 220 seats at 80% occupancy, which translates into 10,600 people per peak hour. A typical HSR train can operate 16 trains per hour with around 1,000 seats per train at 80% occupancy, which translates into 25,600 people in a peak hour.

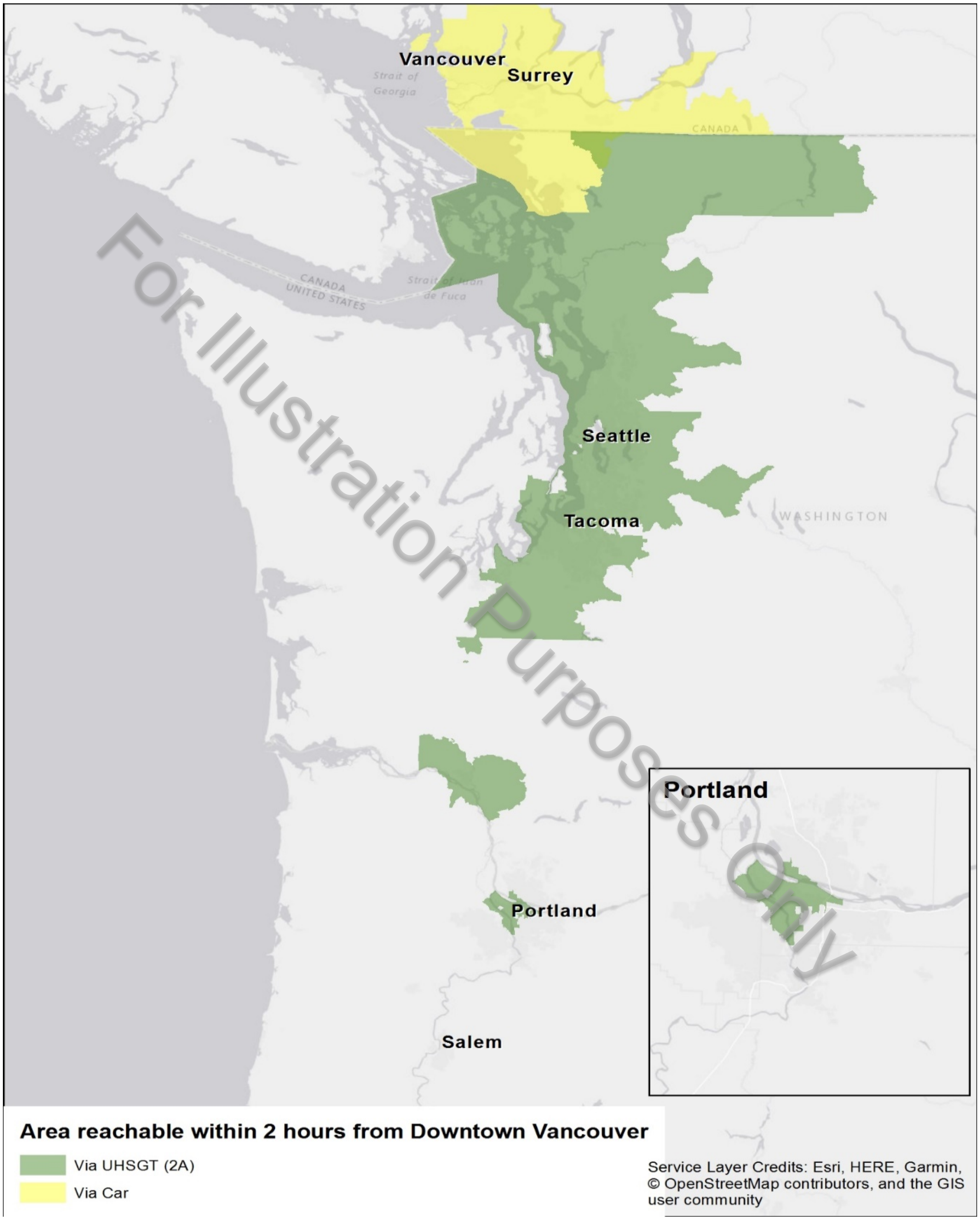
Figure 9: Areas Within Two Hours Travel of Portland, OR; Seattle, WA; and Vancouver, BC; by UHSGT and Auto



Note: Graphics are based on approximate travel times—actual times may vary according to a more developed service plan or stopping patterns or changes in highway congestion.



Note: Graphics are based on approximate travel times—actual times may vary according to a more developed service plan or stopping patterns or changes in highway congestion.



Note: Graphics are based on approximate travel times—actual times may vary according to a more developed service plan or stopping patterns or changes in highway congestion.

UHSGT may also reduce congestion on existing highway routes that currently suffer from extreme congestion. Vancouver, BC; Seattle, WA; and Portland, OR; rank as the 4th, 6th, and 10th worst cities for congestion in North America, respectively, with average traffic delays in peak hours of 40 minutes around Seattle, which is equivalent to a 34% increase compared to free flow rates.[17] The state of Washington estimates that congestion costs over $3.2 billion annually. Additional transportation capacity can help mitigate some urban congestion hot spots as well as the I-5/Highway 99 corridor and the three major airports. Moving existing intercity and commuter service off freight-owned ROWs would also increase capacity for freight service.

3.4 A stronger, more productive megaregion

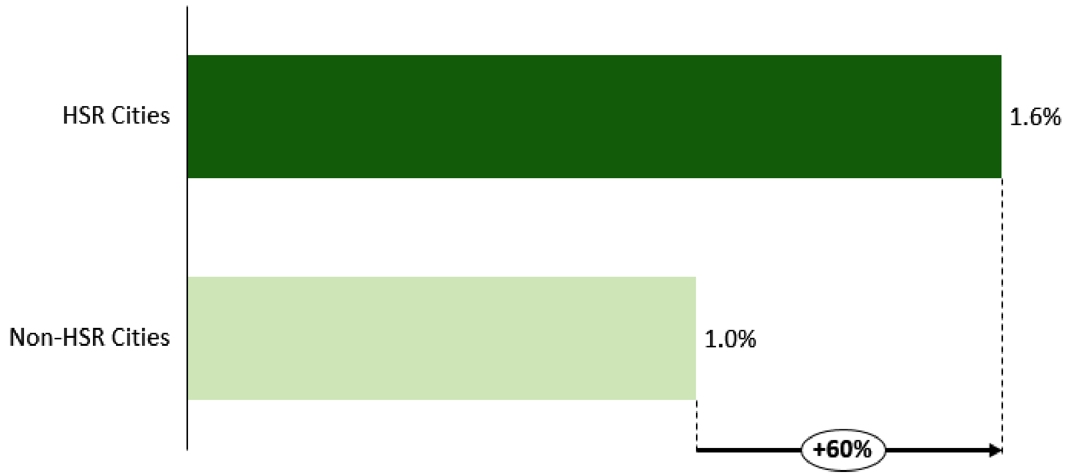
Based on research of the economic benefits of other high-speed transportation systems, a UHSGT system in the Cascadia megaregion would support growth across industries. UHSGT would improve connections between industry clusters, enterprise accelerators, world-renowned research institutions, qualified labor, and financial and logistics organizations, providing fundamental services for a strong regional economy. Quicker, easier, and more reliable transportation links, including high-speed ground transportation, have shown to attract new businesses as well as wider growth to companies, whether small, medium, or large, in other regions that have implemented HSR.[18]

UHSGT would also accelerate the growth of the high-value industries associated with the modernized knowledge economy. The results can range from the added value generated by the expertise and skills of specialized labor to collaborative partnerships between educational research institutions, industry firms, public organizations, and workforce development programs to drive innovation in established markets and emerging industries. The organizations active in the knowledge economy (includes technology, university, medical) increasingly gravitate toward dense urban areas to attract qualified employees and build connections to wider markets. A new UHSGT system would maximize these agglomeration effects by offering a flexible, high-performance transportation link to connect the talent pool, employers, and centers of innovation throughout the region. Figure 10 shows that Japanese cities with HSR stations grow significantly faster than those without. UHSGT would be expected to deliver similar relative benefits, given that annual growth rates have been higher in Cascadia than Japan.

[17] TomTom Worldwide Congestion Index, 2016 data

[18] Various studies including The Economic Benefits of HS1 10 Years On (HS1 & Volterra 2017) & Impacts of French High-Speed Rail Investment (University of Pennsylvania, 2014)

Figure 10: Average Annual Population Growth in Japanese Cities With and Without HSR Stations



Source: *High-Speed Rail: Lessons for Policy Makers from Experience Abroad,* Research Institute of Applied Economics, University of Barcelona

As further described in Chapter 4, this assessment includes a US Department of Transportation (USDOT) compliant calculation of benefits resulting from UHSGT. The benefits are quantified for several relatively narrow impacts that are linked to direct user benefits such as journey times savings, changes in fuel use, and environmental and safety benefits. These benefits, while significant (estimated by this assessment to exceed $14 billion), tell only part of the picture of the value of UHSGT.

The wider economic benefits were estimated in the Initial Estimate of Economic Impacts published as an addendum to the 2017-2018 Feasibility Study.[19] The 2017-2018 Feasibility Study into UHSGT[20] undertook a complex economic assessment of the wider economic impacts of the project. The assessment was based on a Transportation Regional Economic Development Impact System model (TREDIS) evaluation that tests the economic impacts of any major investment, considering a range of economic factors, including job creation, location, and changes in salaries. The 2017-2018 TREDIS outputs estimate that 38,000 direct construction jobs, 3,000 direct operating/maintenance jobs, and between 116,000 and 160,000 wider jobs could be generated from UHSGT. This represents around 3% of total jobs in the Seattle and Vancouver, BC, metropolitan areas (Portland was not included in the TREDIS assessment), which indicates a reasonably positive impact. Table 10 outlines some of these benefits, highlighting that the estimated additional GDP is more than 12 times the discounted upfront costs of building UHSGT.

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[19] Addendum Ultra-High- Speed Ground Transportation Study Initial Estimate of Economic Impacts https://www.wsdot.wa.gov/publications/fulltext/LegReports/1719/UltraHighSpeedGroundTransportation_FINAL.pdf

[20] Ultra-High-Speed Ground Transportation Study report for WSDOT

Table 10: Economic Benefits of a High-Speed System Between Vancouver and Seattle, 2017

Employment Impacts	2.4 to 3.4 million total additional job-years of employment
Economic Growth	$264 billion to $355 billion in additional GDP (discounted)

Source: WSDOT Ultra-High-Speed Ground Transportation Feasibility Study, 2017-18

While a comprehensive economic impact analysis update has not been conducted as part of this assessment, some indications of the possible change in impacts can be interpolated. The 2019 Business Case estimates higher ridership than that forecast in the 2017-2018 Feasibility Study. Combined with stronger Cascadia economic growth than documented in the previous study and that Portland was not included in the 2017-2018 TREDIS assessment, it can be expected that the wider impact of UHSGT would also be higher. By combining the economic factors identified in the 2017-2018 TREDIS assessment with the user benefits identified in this assessment, UHSGT is likely to generate benefits more than 12 times the costs of building the new transportation spine.

In Canada, United Kingdom, Australia, and other countries, a business case analysis includes the wider benefits unlocked by an infrastructure investment. In addition, the methodology used to measure economic benefits in other countries, including Canada, permit farebox revenues to offset the costs associated with the proposed project. Use of this methodology would show a further increase in UHSGT's return to the taxpayer. Utilization of a WEB assessment, applying a web-based, multimodal guidance on appraising transportation projects (WebTAG) that was developed in the United Kingdom and has been used in Canada to assess the impacts of the proposed Toronto-to-Windsor HSR line, may show more comprehensive results. Applying WebTAG would allow the analysis to consider updated cost and ridership information as well as assess the impacts on business location decisions.

3.5 A more affordable megaregion

The Cascadia megaregion contains a number of cities with thriving economies. The success in creating new higher-paying jobs in Vancouver, BC, Seattle, and Portland, OR, has increased demand for housing. This has led to the cost of housing escalating as new residential construction has struggled to keep pace with population and employment growth.

This situation has generated concern about workers being able to afford housing in proximity to their places of employment, according to discussions with key political and business leaders. The affordable housing challenge is directly related to transportation because easy access to jobs and the cost of the commute are prime factors in evaluating where workers live. From 2010 through 2018, housing prices have increased by 62% in the metropolitan area of Seattle-Tacoma-Bellevue, while Portland, OR-Vancouver, WA-Hillsboro, OR, saw a growth rate of 60% and metro Vancouver, BC, saw even higher price growth of 93%. Over the same period, housing prices in other regions of the US were significantly lower, with a national market growth rate of just 37%. This contrasts with average wage growth of a little over 20% in the same period, which indicates that there is a serious housing crisis across the Cascadia megaregion.

UHSGT would sustain and build upon the growth already underway in these cities by improving the time, convenience, and connections along the corridor. UHSGT would collapse distances, providing employers with access to a much larger workforce and workers with a greater variety of employment options. While the proposed system would foster further growth in the megaregion economy driving the housing affordability challenge, UHSGT can also address the problem by providing shorter, faster commutes between areas with lower housing costs and employment centers, whether directly or via improved local connections. More directly, UHSGT can also foster more-dense, transit-oriented, residential development near stations and open up new areas to large-scale mixed-use development. This kind of development, in which residential and office development can be built in close proximity to increase housing supply and help create live-work communities, can benefit lower-income households that currently spend up to 15.7% of their take home income on transportation costs.[21]

In order for UHSGT to maximize its positive impact on housing, a number of complementary measures would need to be put into place, including better local and regional zoning policies to encourage higher-density and less-expensive housing near UHSGT stations; less development in remote locations with poor access, building on Portland's greenbelt principles; pro-active policies on transit-oriented development; and better local connections to UHSGT stations to widen access to land that may more easily permit affordable housing development.

It will be important to commit to social equity and economic inclusiveness as core planning and development principles. An equitable decision-making process would incorporate these priorities throughout planning and development to identify and evaluate the potential benefits and disadvantages of proposed alternatives on historically marginalized populations. An early step would be to identify the partner jurisdiction with the highest standards for equity programs and activities and to work to ensure that the entire project meets or exceeds those standards.

3.6 A cleaner environment

The challenge to reduce greenhouse gas emissions (GHG), improve air quality, and enhance the local and global environment is becoming a critical issue facing the world. Decisions on infrastructure investment are increasingly considering the impact on the environment. Investing in UHSGT offers an opportunity to create a more sustainable transportation network for the entire Cascadia megaregion.

[21] Pew Charitable Trust Household Expenditure and Income, 2014

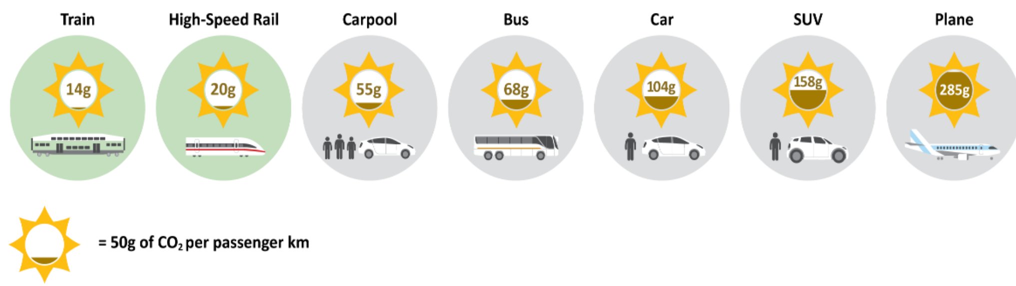
Political and business leaders across the Cascadia megaregion have committed to reducing GHG and meet the challenges of climate change. The states of Washington and Oregon and the province of British Columbia recognize that climate change poses serious threats to the economic wellbeing, public health, natural resources, and the environment of the region. Mitigating the impacts of climate change and achieving these GHG reduction goals are key priorities for each jurisdiction, as indicated by the following:

- In 2018, British Columbia launched Clean BC, a plan that creates a clear path to the province's 2030 climate target of 40% emissions reductions below 2007 levels.
- Oregon is upholding the tradition of leading on environmental stewardship with the passage of the nation's first coal-to-clean law, eliminating out-of-state coal-fired electricity by 2030 while increasing renewable energy to 50% by 2040.
- Washington state is required to limit overall emissions of GHG in the state by 2035 to 25% below 1990 levels.
- In May 2019, Governor Jay Inslee of Washington state signed an unprecedented suite of clean energy legislation into law, ushering in aggressive timelines for decarbonizing the Washington state's economy and transforming the state's energy landscape.

Transportation is one of the biggest contributors to GHG and wider damage to the environment, including runoff into rivers and other watercourses, particulate matter damaging human health, and impacts to salmon runs and orca populations in the Puget Sound, Columbia River, and British Columbia waterways. The State of Washington estimates that the transportation sector accounts for 44% of all its GHG emissions. While there has been progress in developing cleaner and more efficient vehicles across modes, transportation is one of the fastest growing contributors to GHG.

Rail travel has historically been one of most environmentally friendly modes of travel. Compared to air travel, rail emits between 5 and 12 times less carbon dioxide (CO_2) than air and 3 to 5 times less than automobiles. Figure 11 highlights these comparisons. Innovations in technology, such as electricity generation, can have an even more dramatic impact. For example, Eurostar, which operates the London-Paris/Brussels HSR network, is now a carbon-neutral travel option that includes the offset of pollution generated by food waste on board its trains. Eurostar electricity is from zero-emission sources such as wind, solar, and hydro, and further reductions in energy use are targeted. More broadly, electric rail travel also reduces other forms of air pollution such as ozone, particulate matter, and nitrogen dioxide, which have serious impacts on human health and natural habitats.

Figure 11: CO_2 Emissions Comparison between Different Modes of Travel



Source: European Environment Agency

Over the first 40 years of operations, UHSGT would avoid release of 6 million metric tons (tonnes) of CO_2, due to 27 million avoided flight miles and 6.1 billion avoided vehicle miles in the Cascadia region. In addition, every year on average more than 960 metric tons of harmful non-CO_2 pollutants, such as particulate matter, carbon monoxide, and nitrogen oxide, would be kept out of the ecosystem.

UHSGT can also lead to a transformation of the environmental footprint for the megaregion. Cities typically have much lower environmental impacts than suburban or even rural areas on a per person or capita basis. Better local connections to UHSGT stations would allow the Cascadia megaregion to increase density in areas with good transit, cycle, and walking facilities, which could support more sustainable practices such as zero-emission power, water harvesting, and recycling/composting of waste. By doing so, UHSGT can be a key component in helping Cascadia further reduce its carbon footprint matching the more efficient levels achieved in Europe and Japan.

Resilience is another likely benefit of UHSGT. Looking at other well-established HSR networks such as Japan's Shinkansen or France's TGV, the ability to operate services during periods of disruptions—whether they are weather related or natural disasters such as earthquakes or volcanic eruptions—is a common attribute compared to road and air modes of travel. As the intensity and frequency of major weather events increase, having a transportation network that is less prone to serious disruptions will be important.

3.7 A better value infrastructure investment

Investment in transportation infrastructure can support increased economic activity as well as mitigate some current congestion issues. However, while a number of significant transportation infrastructure projects are committed in the Cascadia megaregion, most of these are to address localized congestion hotspots such as the US I-5 improvements around Tacoma, the central Puget Sound region's ST3 package of transit expansion, Vancouver's Regional Transportation Plan, or Portland's ongoing improvements to transit and cycling infrastructure.

The UHSGT business case does not assume any savings can be made from committed or planned projects if UHSGT is constructed. However, further investment in infrastructure across the Cascadia megaregion over and above committed projects will be necessary.

The need to continue to invest in preservation of current infrastructure and to build additional projects throughout the Cascadia megaregion is necessary to address existing problems of congestion, poor reliability, and inadequate connectivity. The current US I-5 projects alone are expected to cost nearly $2 billion, and Vancouver, BC; Seattle, WA; and Portland, OR; committed urban infrastructure investments will only partly relieve pressure on the megaregion's transportation network. Likewise, planned airport investments at Seattle and Vancouver of $2 billion and $9 billion, respectively, may not provide the capacity needed to address the significant increase in air travel demand. Far larger expenditures, invested in higher capacity projects, are therefore needed to unlock the region's potential.

Investing in UHSGT provides the opportunity to minimize or change investment in further road or airport projects in the longer term. For example, widening US I-5 by one lane in each direction across Washington state is estimated to cost in excess of $108 billion. Much of this additional work could be avoided if UHSGT were constructed. An additional runway at a typical large international airport can exceed $10 billion, including land acquisition, environmental approvals, construction, and related works. Neither of these alternatives provide the potential increase in capacity provided by UHSGT. A 2-track UHSGT spine could carry as many as 32,000 people in the peak hour, which would be greater than the existing capacity of the I-5/Highway 99 corridor between Vancouver, BC and Portland, OR.

In addition, UHSGT provides greater reliability and increased capacity than highway or airport options. Reliability on HSR services can reach 99% on-time performance compared to less than 80% for air services and widely variable auto journey times. Constructing a UHSGT transportation spine can be designed to allow for a range of services including intercity, commuter/regional and high-value freight as shown in other places around the world that have constructed HSR lines.[22]

The substantial investment in UHSGT (estimated in the 2017-2018 Feasibility Study at $24 billion to $42 billion, compared to equivalent investments in highway or airport transportation infrastructure, presents a more equitable way to test the value of a high-speed transportation spine compared to other possible projects. The opportunity cost of not building UHSGT could be significant.

3.8 Broad support from businesses, stakeholders, and travelers

The benefits that could be generated by UHSGT are understood by businesses and other regional stakeholders. In particular, the region's business community recognizes that UHSGT would help address real-world issues and lead to tangible benefits.

A number of key business stakeholders provided feedback about the need for UHSGT to facilitate the continued development of the regional economy. Interviewees included key representatives from large and small businesses, the manufacturing industry, major air carriers and shipping lines active in the Cascadia megaregion, professional sports teams, research and educational

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[22] For example, more than half of the capacity of the United Kingdom HS1 line is used for commuter rail services and freight such as car parts, fresh produce, and other high-value products. On the Northeast Corridor, nearly 80% of services are commuter rail and freight rather than Amtrak intercity.

institutions, major established and start-up tech companies, utilities, and various other individual businesses and organizations. The interviewees shared their insights into current and foreseeable difficulties in their own and similar organizations without an adequate solution for meeting the current and future challenges. One particularly powerful statement that summed up this concern was “Knowing the unbelievable congestion that is occurring every day in the Vancouver-to-Seattle-to-Portland corridor, can you imagine what that will be like in 50 years?”

According to the business stakeholders interviewed, a new regional UHSGT system would provide the six overarching economic benefits listed in Table 11.

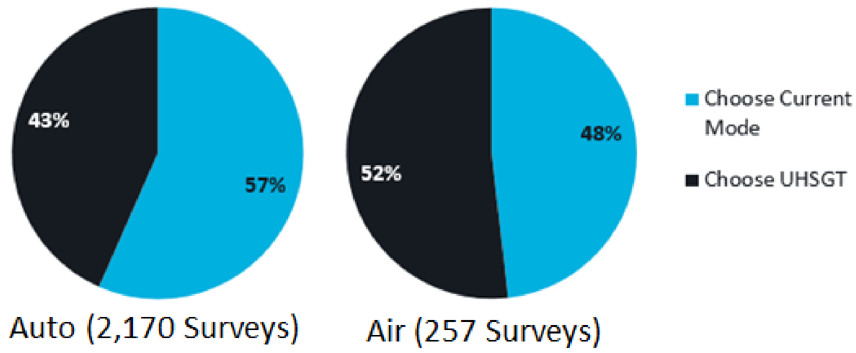
Table 11: Key Themes from Stakeholder Interview

	UHSGT Benefits Identified by Stakeholders
1.	Regional economic integration due to greater connectivity
2.	Access to a larger, more cohesive pool of qualified talent throughout the region
3.	Increased affordable housing opportunities and choice
4.	Support for specialized freight movement in e-commerce and technology-based industries
5.	Significant economic benefits to specific industries uniquely positioned to benefit from much broader regional access and reach, including the following: • Sports and entertainment industries • Aviation and ocean transportation sectors, including the cruise ship industry
6.	Facilitation of research collaboration among business enterprises, universities, and public and private research institutions

These stakeholders view the UHSGT system as a tool for both overcoming existing structural economic challenges in the region and as a unique opportunity to unlock economic transformation and untapped potential in the region. Interviewees stated that UHSGT would help create economic integration through much greater connectivity, facilitating shared markets and creating “entrepreneurial hot beds.” Furthermore, UHSGT would provide major benefits in terms of creating a unified, coherent, more accessible, flexible, cross-border talent pool, particularly within the science, technology, engineering, and mathematics fields that are so integral to the Cascadia economy.

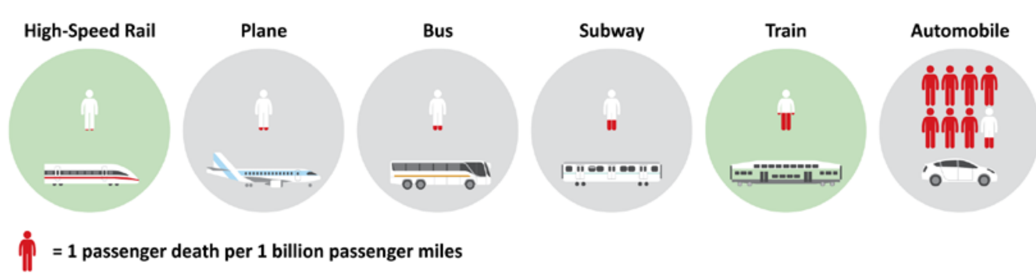
In addition to businesses, a detailed stated preference survey of current Cascadia intercity travelers indicates strong interest in an alternative to traveling by car, bus, or air, as shown in Figure 12. A significant number of respondents (70%) stated they would “definitely try UHSGT”, while around 50% would regularly use UHSGT, which could result in even more demand for UHSGT than forecast. The forecast included a reasonably conservative assessment of mode shift, including assuming no worsening of journey times on roads or air than today, no real increase in fuel prices or airfares, nor changes in employment or housing locations to be closer to UHSGT stations. These changes in mode attractiveness have occurred with many other transportation projects, such as Vancouver’s Canada Line, London’s Crossrail, and the United Kingdom’s HS1 line connecting to Paris and Brussels.

Figure 12: Mode Choice of Existing Travelers (UHSGT vs Auto or Air)



Another feature that travelers, businesses, and other stakeholders value is UHSGT's ability to improve passenger safety in the region. Rail is one of the safest modes of travel, with some of the lowest accident rates per mile (km) of any mode, as shown in Figure 13. Even with the conservative analysis assumption on modal shift, UHSGT would be expected to reduce passenger fatalities and serious injuries by between 36 and 71 people in its first 40 years of operation. In addition to these reductions in deaths and significant injuries, UHSGT is expected to reduce accidents resulting in minor injuries or property damage by 2,375 and 5,470, respectively. Such reductions in roadway accidents would make Cascadia a safer place for its residents, businesses, and visitors.

Figure 13: Passenger Deaths per 1 Billion Passenger Miles, 2000 to 2009



Source Northwestern University Study 2010

3.9 A modern delivery approach can be used for UHSGT

While the challenges in delivering UHSGT would be significant, evidence from this assessment suggests that the project can be delivered and operated effectively. The key to this would be to draw on effective governance and procurement models used on other trans-border and international infrastructure projects. Developing an effective funding and operating strategy would also be critical in the successful delivery of UHSGT.

Evidence from elsewhere in the US, Canada, and other countries indicates that UHSGT is unlikely to be delivered using traditional public procurement approaches. The public sector would need to mobilize private-sector and/or international expertise to optimize the design, delivery, and operations processes. Specifically, governments would need to create a more effective governance model that ensures robust and timely decision making as well as protecting public accountability. This can be best done through the creation of a separate public company tasked with the design, procurement, and delivery of UHSGT. Government oversight of the company could ensure both public accountability and challenge performance. The project would also need to ensure compliance with legislation regarding international agreements and project delivery mechanisms, among other issues, both for the US and Canada.

This approach would build on that being used to deliver the Gordie Howe International Bridge between the US and Canada and lessons learned from the successfully delivered Channel Tunnel between the United Kingdom and France, which opened in 1994. The following key considerations need to be addressed to ultimately deliver a Value for Money project (assessing the return on an investment based on the whole-life costs compared to alternative choices such as depositing the funds in a bank):

- Achieve effective transfer of risk to those who are best able to manage them.
- Ensure effective public accountability while protecting timely decision making.
- Retain control and flexibility to meet future needs in the project owner's hands.
- Achieve competitive pricing while aligning incentives.

While ongoing costs to operate, maintain, and renew UHSGT could be realistically recovered through farebox and other revenues generated by services, the project would require public investment to pay for the upfront costs to design and construct the new transportation line. Therefore, some form of public payment mechanism would be required. However, the amount of public funding required can be spread over both the construction and long-term operating period. This can be done through the "availability payment" model used on public-private partnership (P3) projects in the US, Canada, Mexico, Europe, and much of Asia. Upfront private financing is recovered with public funds, linked to the successful delivery of the project's key deliverables based on a set of strict criteria. This has been an effective approach because the private sector is incentivized to deliver the project on-time, on budget, and to a set of performance targets established in the contract.

3.10 Summary

The strategic case assessment has resulted in a clearer, more comprehensive and detailed picture of the wide range of benefits that would accrue to the region due to UHSGT. The data generated by the analyses reinforces the compelling case for this cost-effective and transformative project, and provides government and business leaders with a better understanding of the unique characteristics and travel demands of the Cascadia megaregion.

The strategic case demonstrates that UHSGT can be the most effective transportation investment solution to promote the economic health and growth of the Cascadia megaregion. An investment in UHSGT offers an opportunity to transform mobility beyond what current travel modes could provide. The reduced journey times (comparable to air travel), improved reliability, and the potential for direct downtown-to-downtown connections, would enable residents and visitors to easily and quickly access the region's major cities and towns.

The Business Case for UHSGT provides the following key benefits or outcomes:

- A **better-connected megaregion** resulting from faster journeys, increased capacity, and reduced congestion
- A **stronger, more productive megaregion** as more businesses/jobs locate in Cascadia
- A **more affordable megaregion** as residents benefit from easier access to more affordable housing as well as wider access to higher-paying jobs and opportunities
- A **better environment** by shifting trips to more sustainable modes, reducing carbon emissions and environmental impacts, protecting habitats, and enabling healthier lifestyles
- A **better value infrastructure investment** than possible alternative projects, whether interstate highways or airport expansion
- **Broad support from businesses, other stakeholders, and travelers** given its ability to unlock sustainable growth, make the Cascadia megaregion more competitive, and deliver higher quality, more cost-effective and safer journeys compared to existing road or air options
- A **modern delivery approach** drawing on proven governance and procurement models plus innovative funding mechanisms.

4 Economic Case

4.1 Introduction

This chapter sets out the quantification of the previously described benefits of UHSGT. The information in this chapter draws from and builds on the work included in earlier documents completed during the 2019 Business Case, including Appendix B: Memorandum Assessing Potential Economic Gains in the Cascadia. The quantified benefits include common measures such as user benefits (travel and cost savings), reductions in emissions, safety benefits (averted private vehicle collisions), and the number of jobs created/sustained during the construction period. All dollar values presented are 2019 USD. In addition to the quantifiable benefits, this chapter discusses a number of potential benefits that have not been quantified.

4.2 UHSGT benefits

UHSGT is expected to generate three types of economic benefits: (1) direct user benefits such as travel-time savings; (2) social benefits such as reductions in GHG emissions; and (3) wider economic benefits (WEBs) linked to an increase in jobs, higher productivity, and other economic impacts resulting from the significant improvement in connectivity. Direct user benefits are experienced by travelers on the UHSGT system, including travel-time benefits and operating and maintenance costs savings for those who switch from other modes. External/social benefits improve the wider society by reducing the cost of travel in the region. WEBs are increasingly considered for large, transformative projects where forecasted growth in economic activity goes beyond direct impacts. Table 12 provides some examples of these types of benefits.

Table 12: Benefit Categories

Benefit Type	Description	Type of Benefits
User	Benefits to travelers on the UHSGT system	• Travel-time benefits • Cost savings for those who switch from other modes
External/Social	Benefits to wider society by reducing the cost of travel in the region	• Environmental benefits (reduced emissions) • Safety benefit from reduction in car accidents • Reduced roadway pavement damage • Operational time savings from reduced airport passenger congestion
WEBs	Increase in economic activity	• Increase in jobs beyond those directly generated by project • Higher productivity linked to higher wages

The user and external/social benefits were estimated as follows:

- **Travel-time savings:** Estimated based on mode shift predictions from the ridership forecasts and by comparing travel times on existing modes (auto, bus, and air) to travel times using UHSGT. The financial value of the time saved is produced using the value of time.
- **Operational time savings:** Estimated based on monetizing the avoided costs to air passengers and air service carriers due to flight delays associated with airport congestion**.**
- **Productivity gains of UHSGT captured and induced demand:** Auto and air travelers have limited opportunities to conduct productive activities during travel due to the need to operate the vehicle or to the lack of uninterrupted stretches of time. As a result, traveler travel time is regarded as wasted in time appraisals. However, for captured UHSGT travelers, the availability of information technology and ease of travel enable productive use of travel time for business and leisure travelers. For induced travel productivity, benefits are accrued on the basis that induced trips would not occur if users were more productive not making the trip.
- **Environmental:** Emissions reductions are estimated based on the reduction in vehicle miles/kilometers from auto and air trips. UHSGT could realize further benefits depending on the technology chosen. Noise pollution related to auto travel is also reduced, providing a benefit to local residents.
- **Safety:** Estimated on the basis of avoided injuries, fatalities, and property damage from auto accidents. The number of avoided accidents is a reduction in auto vehicle miles traveled/vehicle kilometers traveled (VMT/VKT) resulting from mode shift from auto to UHSGT.
- **Auto fuel and O&M savings:** Estimated based on reduced VMT/VKT resulting from the mode shift to UHSGT.
- **Roadway pavement:** Estimated based on the reduced auto VMT/VKT and therefore reduced costs of maintaining roadways.
- **Residual value:** An appraisal of the remaining capital value of the project at the end of the analysis period related to the predicted life expectancy of the project beyond the analysis period. This value captures the remaining utility of the project as a balancing debit to the upfront capital costs, evaluating the user and social benefits relative to the capital value of the project apportioned to the analysis period.

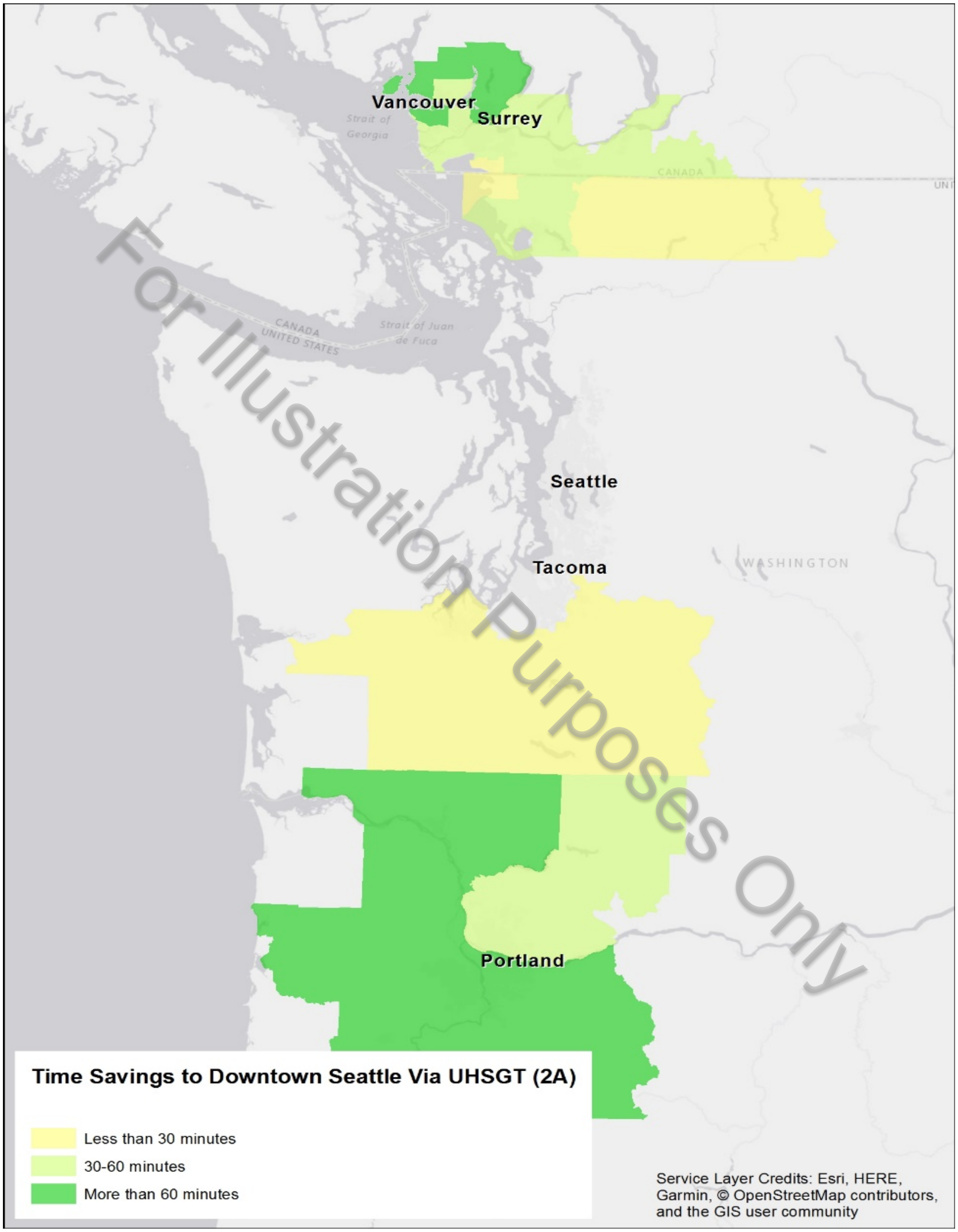
The benefits shown in Table 13 have been estimated for Scenario 1D (see Chapter 2). All benefits have been discounted to calculate the present value of benefits that occur in the future.

Table 13: Discounted Benefits for Scenario 1D (2019 USD millions)

Benefit Category	Scenario 1D
Travel-Time Saving	$5,120
Operational Time Savings	$67
Productivity Gains of UHSGT Captured and Induced Demand	$1,297
Environmental (Emissions)	$308
Safety	$185
Auto Fuel and O&M	$697
Roadway Pavement Damage	$3
Residual Value	$2,869
Total	**$10,550**

Travel-time savings are the most significant portion of the societal benefits of UHSGT. With the potential of cutting many journey times in half, UHSGT would provide users with the ability to start their trips earlier or later, stay longer, and generally be more flexible. The ability to use that time more productively on UHSGT is also tied to these changes. As shown in the example in Figure 14 for travel-time savings to Seattle, in the scenarios with stations only in Vancouver, BC; Seattle, WA; and Portland, OR; significant travel-time savings can be realized.

Figure 14: Travel-Time Savings to Downtown Seattle via UHSGT



Beyond user benefits, UHSGT would also reduce environmental impacts and improve passenger safety in the region. UHSGT can be part of the solution for reducing the environmental impacts of transportation, generating between 5 and 12 times less GHGs as auto and air modes, respectively, as well as even more significant impacts on particulate matter. Rail is one of the safest modes of travel with some of the lowest accident rates per mile (km) of any mode, as shown earlier in Figure 13. Such reductions in roadway collisions would make the Cascadia megaregion a better environment for its residents, visitors, and businesses.

It is important to note that most of the assumptions used in determining the benefits generated by UHSGT are based on reasonably conservative views on future changes of prices, journey times, and reliability of the existing transportation network. Effectively, no constraints were applied, such as increases in fuel prices or air fares from competing auto or air modes. It was further assumed that the existing network would see no real deterioration of journey times despite evidence of increased congestion across the megaregion in the past few years. In addition, no real deterrents have been assumed, such as the introduction of congestion pricing, managed lanes on US I-5, or other options as have been proposed. These conservative assumptions limit modal shift and thereby reduce the benefits generated.

4.3 UHSGT operating costs

Estimated operating costs for UHSGT are shown in Table 14. These costs include the ongoing operating costs to provide the proposed UHSGT services, and the scheduled costs for the renewal and replacement of assets (R&R) to ensure the long-term provision of services in a safe and efficient manner. All costs have been discounted to calculate the present value of costs incurred in the future.

Table 14: Discounted Operating Costs for Scenario 1D

Cost Category	Scenario 1D (2019 USD millions)
Net O&M Costs	$3,044
Net R&R Costs	$465

4.4 Alternative projects/offset costs

Government jurisdictions throughout North America are facing an environment where it costs billions to preserve and maintain parts of existing highway and airport facilities in a state of good repair capable of handling today's traffic volumes. For example, beyond the Cascadia megaregion, Colorado is upgrading a 10-mile (16 km) stretch of US I-25 at a cost of $1.2 billion, while the US I-4 Ultimate project in Orlando that is reconstructing 21 miles (35 km) of highway has a price tag of $2.3 billion. These projects are complex and must maintain as much existing capacity as possible while delivering the project, further increasing costs.

Investing in UHSGT provides the opportunity to reduce or change investment in further road or airport infrastructure projects in the longer term. WSDOT estimates that widening US I-5 in Washington state by one lane in each direction would cost at least $108 billion. Likewise, airport expansion projects such as an additional runway at a major international airport can exceed $10 billion. Much of this additional work could be reduced if UHSGT were constructed, thereby reducing the net capital cost of UHSGT to the Cascadia megaregion. Neither of these projects would provide the potential uplift in capacity provided by UHSGT. A two-track UHSGT alternative would provide six and eight times the capacity that an additional lane on an interstate highway or a new runway can provide, respectively.

Therefore, while the economic analysis is based on the conservative assumption that UHSGT would not reduce further road or airport investments, it is likely that some change would result. It is even possible that the capital costs for UHSGT would be net zero as the result of reductions in spending elsewhere. Currently, no alternative infrastructure investment has been proposed as would be required to undertake a complete benefit-cost-analysis As the UHSGT project progresses, alternatives should be identified to provide a better assessment of its value to the Cascadia megaregion.

4.5 Sensitivity testing

The assumptions used to conduct the benefit analysis are considered relatively conservative. Most of these assumptions forecast no real change in current transportation factors, including costs, journey times, or ease of access. For example, fuel prices and other auto costs do not change and are marginally reduced in real terms during the evaluation period. Similarly, no worsening of congestion is assumed on either roads or airports despite recent evidence that shows a deterioration across the Cascadia megaregion.

Various sensitivity tests indicate that increases in the above costs and/or journey times can have a positive impact on demand for UHSGT. Two of these tests have been included in the benefit analysis—a 20% increase in driving times due to increased roadway congestion and other factors, and a 30% increase in auto operating costs due to increased fuel costs and other factors. Both scenarios result in higher demand for UHSGT.

Table 15 summarizes the demand sensitivity tests that were tested in the benefit analysis. These tests show a small uplift in the societal benefits.

Table 15: Discounted Benefits for Sensitivity Tests (2019 USD millions)

Benefit Category	+20% Auto Driving Time	+30% Auto Operating Cost
Travel-Time Saving	$6,975	$5,185
Operational Time Savings	$67	$67
Productivity Gains of UHSGT Captured and Induced Demand	$2,060	$1,454
Environmental (Emissions)	$380	$308
Safety	$286	$189

Auto Fuel and O&M	$984	$873
Roadway Pavement Damage	$3	$3
Residual Value	$2,869	$2,869
Total	**$14,483**	**$10,950**

While the increased vehicle operating costs scenario would result in a small change to the benefits, the increased auto travel-time test would result in significantly more benefits. This highlights one of the strengths of UHSGT—faster and more reliable travel-time advantages over existing modes—especially as highways and roads are likely to experience increased congestion in the future. It is important to note that implementing a range of policy measures that may be required to manage congestion on the existing transportation network is likely to have a larger impact than those analyzed. For example, introducing a congestion charge for the core urban areas of Vancouver, BC; Seattle, WA; and Portland, OR; and setting the rates applied in London and proposed in New York City would increase vehicle operating costs by, in some cases, more than 50%. This is likely to have a larger impact on shifting people from auto to UHSGT than indicated in Table 15; therefore, higher benefits could be generated.

4.6 Wider economic impacts

UHSGT could realize additional benefits beyond those discussed above. An economic impact analysis would calculate both the societal impacts and the effect of expenditures on business revenues and profits, tax revenues, labor income, and the number of jobs resulting from construction and operation of a project.

UHSGT would provide the region with better connections and faster travel times between city pairs, which would increase economic activity. The high-speed link would support the growth of existing and future employers by significantly expanding the effective labor market. By providing more people/areas with access to fast, reliable access to Vancouver, BC; Seattle, WA; and Portland, OR; as well as other regional centers, UHSGT would make the region more attractive to large companies. Considering the continuous progression of communities and businesses in the Cascadia megaregion, UHSGT would build on the existing socioeconomic linkages to generate more productive value from every dollar spent and invested in the region.

In the 2017-2018 Feasibility Study, the construction of UHSGT was estimated to produce 38,000 construction jobs and 3,000 operating jobs. Implementation of the high-speed corridor was also estimated to unlock between 116,000 and 160,000 additional jobs annually, or 3% of the total Seattle, WA/Vancouver, BC, job market, through agglomeration benefits. The 2017-2018 Feasibility Study ridership estimates used in the analysis were below the current estimates, suggesting that the economic impacts of UHSGT would likely be higher than the 2017-2018 Feasibility Study estimates. Solely considering the 2017-2018 Feasibility Study estimates, UHSGT's economic impact would well outweigh its upfront costs. Table 16 outlines some of these benefits, highlighting that the estimated additional GDP would be many times the upfront costs of building UHSGT.

Table 16: 2017 Economic Benefits of a High-Speed System Between Vancouver, BC, and Seattle, WA

Employment Impacts	2.4 million to 3.4 million total additional job-years of employment
Economic Growth	$264 billion to $355 billion in additional GDP

Note: Estimates of wider economic impacts are from the *WSDOT 2017-2018 UHSGT Feasibility Study: Addendum, Initial Estimate of Economic Impacts.*

Lessons learned from other high-speed rail projects around the world provide insights as to how UHSGT could successfully deliver these economic impacts. A key factor is the catalytic potential of local economic benefits that can be maximized when public leaders and stakeholders embrace and plan for the new service and stations. Lille, France, in the 1970s and 1980s had an industrial-driven economy that was in steep decline. The addition of HSR made the city a key interregional connection. City leaders recognized the economic development opportunity and chose to locate the station in the city's core. They developed a visionary masterplan that included a mix of new office and retail, and throughout the city, increases in office and tourism demand have occurred.

5 Financial Case

5.1 Introduction

This chapter sets out the financial impacts for UHSGT, including the financial implications to the region of the new transportation system as well as identifying the potential sources of funding for constructing the infrastructure and operating services. The financial case is one of four cases (Strategic, Economic, Financial, and Deliverability) used in Canada and in a number of countries to assess the feasibility and impact of transportation projects and service initiatives.

The information in this chapter draws from and builds on the work included in the 2017-2018 Feasibility Study and Appendix E: UHSGT Funding and Finance Strategy Plan. While possible financing options were also identified during the study, given the early stage of development for UHSGT, this financial case focuses on the options to fund both short-term and long-term costs, including the upfront capital costs and ongoing operating costs.

5.2 Background

Infrastructure is one of the critical elements needed to enable economic activity. While infrastructure has traditionally been funded through public investment, constraints on public funds have led to more pressure to consider alternative income streams while still considering the economic, social, or environmental benefits of a project. While revenues directly generated by UHSGT passengers would be significant, they are unlikely to be sufficient to cover the full costs of the project. The scale of UHSGT would require substantial funding, both during its planning, design, and construction stages, and to support ongoing services.

The UHSGT project study team identified funding options, organized by federal, state/provincial, or regional governments, as well as alternative funding sources. Each funding source was assessed based on the following factors:

- Funding availability
- Potential to support the project considering the eligibility requirements and funding availability of the funding source, whether high, medium, low, or no potential
- Timing of funding program and available funds
- Matching requirements
- Ability to combine with the funding program with a Public Private Partnership (P3), whether yes, no, or unlikely

In addition, the analysis considered each funding source according to the following criteria:

- Relative magnitude, stability, and potential future growth of funding
- Long-term and near-term historic funding trends

The evaluation of potential funding sources determined the most promising funding options, based on the above listed criteria, for the UHSGT project. A total of 52 funding sources were evaluated, including 15 federal options (from both the US and Canada), 11 state and provincial options, 16 alternative funding options, and 10 financing mechanisms. The eligibility requirements for many of the existing funding sources are extensive, and eligibility for funding would vary depending on the final UHSGT project scope. Table 17 summarizes the most promising traditional funding programs for UHSGT.

Table 17: Promising Traditional Funding Mechanisms

Traditional Funding Options	Type of Funding
US Department of Transportation (USDOT) Consolidated Rail Infrastructure and Safety Improvements Program	US Federal
USDOT Capital Investment Grants: New Starts	US Federal
USDOT Better Utilizing Investments to Leverage Development grant program	US Federal
USDOT High-Speed Intercity Passenger Rail Program	US Federal
Investing in Canada Fund/Federal Gas Tax Fund	Canadian Federal
Oregon Statewide Transportation Improvement Fund	Oregon
New tax measure (requires legislative enabling)	Washington

5.3 UHSGT affordability

The UHSGT project study team developed a series of alternative scenarios to construct a new high-speed spine linking Vancouver, BC; Seattle, WA; and Portland, OR; and other cities across the Cascadia megaregion. The scenarios have been assessed on the basis of the physical, geographic, and service planning impacts, as well as on the basis of the ridership, financial, and economic impact analyses. Table 18 provides the estimated range of key costs and revenues to deliver UHSGT.

Table 18: Estimated Key Costs and Farebox Revenues for UHSGT, 2040

Item	UHSGT Scenario 1D Estimate (2019 Prices except Capital Costs)
Capital Costs	$24 billion to $42 billion*
Average Annual Operating/Maintenance Costs (2040)	$277 million
Annual Ridership (2040)	3.1 million
Annual Farebox Revenues (2040)	$250 million

* From 2017-2018 Feasibility Study

Demand is estimated to result in significant farebox revenues to pay for most of the ongoing costs to provide UHSGT services. It is estimated that with either a less than 10% increase in ridership or 10% decrease in costs (both of which are based on a set of conservative assumptions), UHSGT could more than pay for ongoing costs without requiring any external support.

The scale of funding required to build, operate, and maintain UHSGT would be considerable. While the existing funding programs could provide a meaningful share of funding for the project, it is unlikely to be enough to provide the level of contributions required to fund the capital works or operating costs not paid from farebox revenues. Therefore, additional funding streams from alternative sources or mechanisms would be required.

5.4 UHSGT challenge and funding options

Around the world, there is now a clear expectation that a large proportion of funding for major transportation investments should be secured from alternative sources rather than relying solely on traditional government sources. The rise in the use of P3 delivery mechanisms on toll roads/managed lanes, airports, and even some rail projects can be linked to finding new funding sources as well as improving project delivery. An example of this is Vancouver's Canada Line, which was successfully delivered through a P3 model and was partially funded by premium fares to the airport as well as non-farebox revenue sources and more traditional public contributions.

The challenge for UHSGT is identifying an alternative funding strategy that would meet the capital costs for the infrastructure and ongoing O&M costs for services that are both financeable as well as politically acceptable. A benchmark for developing and securing approval for an alternative funding strategy is London's Crossrail, which established the case for public investment in transformative transportation infrastructure. A series of tests were established for Crossrail that followed a few broad principles that should form the basis for most future large and complicated transportation investments:

- A significant proportion of funding required to deliver the infrastructure project is from local or regional sources rather than traditional public grants.
- The project should be able to cover its longer run operating, maintenance, and ideally renewal costs through recurring income sources, such as farebox revenue.
- A mix of local funding sources can be secured that are supported by local businesses, developers, and users.
- The wider economic benefits of the project are significant and increased taxes can help recover any initial public/government outlay (particularly through increased productivity, generating additional and higher-paying jobs).

5.5 Beneficiaries pay principle

One of the most important aspects of any proposed investment is the question of the scale of change it can generate directly or unlock indirectly. Investment in UHSGT would provide a significant change in the capacity and capability of the Cascadia megaregion's transportation network, supporting growth in a more sustainable manner than other alternatives such as road widening or airport expansion. The transformational impact of UHSGT and the additional scale and productivity of economic activity, in the form of additional jobs, homes, and productivity, is set out in the Strategic Case and Economic Case chapters. These impacts provide a range of potential ways in which the value of additional housing, jobs, and economic activity can be captured.

At the heart of the assessment of potential alternative funding sources is the concept of "beneficiary pays." This concept is based on the principle that those who benefit from the improvement in transportation should contribute to its cost. While traditional infrastructure funding would come only from direct beneficiaries such as passengers, considering indirect or wider economic beneficiaries can yield important benefits both in terms of spreading the financial burden (and risk) and increasing public understanding and enhancing equity. For example, new transportation infrastructure can enhance property values, increase housing supply, or improve business productivity through increased sales due to easier access enabled by the new service. This approach can also create an investment cycle in which transportation infrastructure generates benefits to a series of beneficiaries, with different funding mechanisms then capturing a proportion of these benefits to repay the initial infrastructure investment.

This process is typically led by the public sector, whereby an initial capital outlay in the form of a transportation investment is subsequently repaid by additional income from the project beneficiaries, such as through a combination of increased fare receipts, development levies from additional housing and commercial development, or business taxes through higher sales or profits. Again, the United Kingdom is a useful example where both the funding of London's Crossrail and Northern Line Extension are largely based upon this principle. Other countries have also used this approach, most notably Montreal's REM rail network with some funding secured through land value capture and France's Paris/Tours to Bordeaux HSR line and related local connections where funding from commercial development and a local payroll tax called the Versement were secured to repay the initial debt raised. Figure 15 illustrates the beneficiary pays principle.

Figure 15: "Beneficiary Pays" Principle

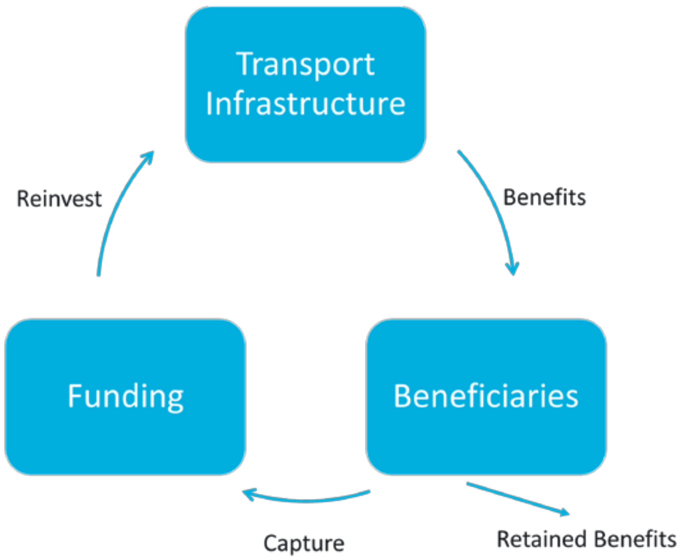


Table 19 sets out the potential beneficiaries from UHSGT, including how they may benefit from its construction and operation.

Table 19: Potential Beneficiaries of Transportation Infrastructure Investment

Beneficiary	How they benefit from transportation	How it could be captured
Businesses/ Workers	• Agglomeration as greater productivity and lower costs arise from the concentration of economic activity. The increased concentration has a productivity "bonus" that is shared between businesses and workers that can lead to increased revenues and/or reduced costs. In addition, businesses benefit from being able to draw from a wider pool of prospective employees who can more easily access their business.	• Business property tax (retention or supplement) • Workplace parking levy
Transportation Users	• Reduced journey times, improved reliability, and/or increased frequency.	• Intelligent charging/premium fares

	These benefits allow users to access a wider pool of jobs and can lead to productively gains where both may result in financial benefits to the user.	• Parking levy • Operator access fee • Farebox surplus

5.6 UHSGT potential funding sources

For UHSGT, traditional funding sources for transportation infrastructure identified in Table 19 would not be enough to deliver the project or ongoing services. Several alternative funding sources appear promising, in particular value capture mechanisms given the potential impact at and around the new stations. Tax Increment Financing and special tax assessment districts have successfully funded a portion of several transportation infrastructure projects in the US and Canada. The revenues from these approaches may be enhanced by establishing a transit-oriented development or special assessment district to encourage development around stations throughout the corridor. In addition, cap-and-trade funding or carbon pricing could provide a promising revenue stream if adopted by state or provincial governments. Table 20 summarizes promising value capture and additional alternative funding options.

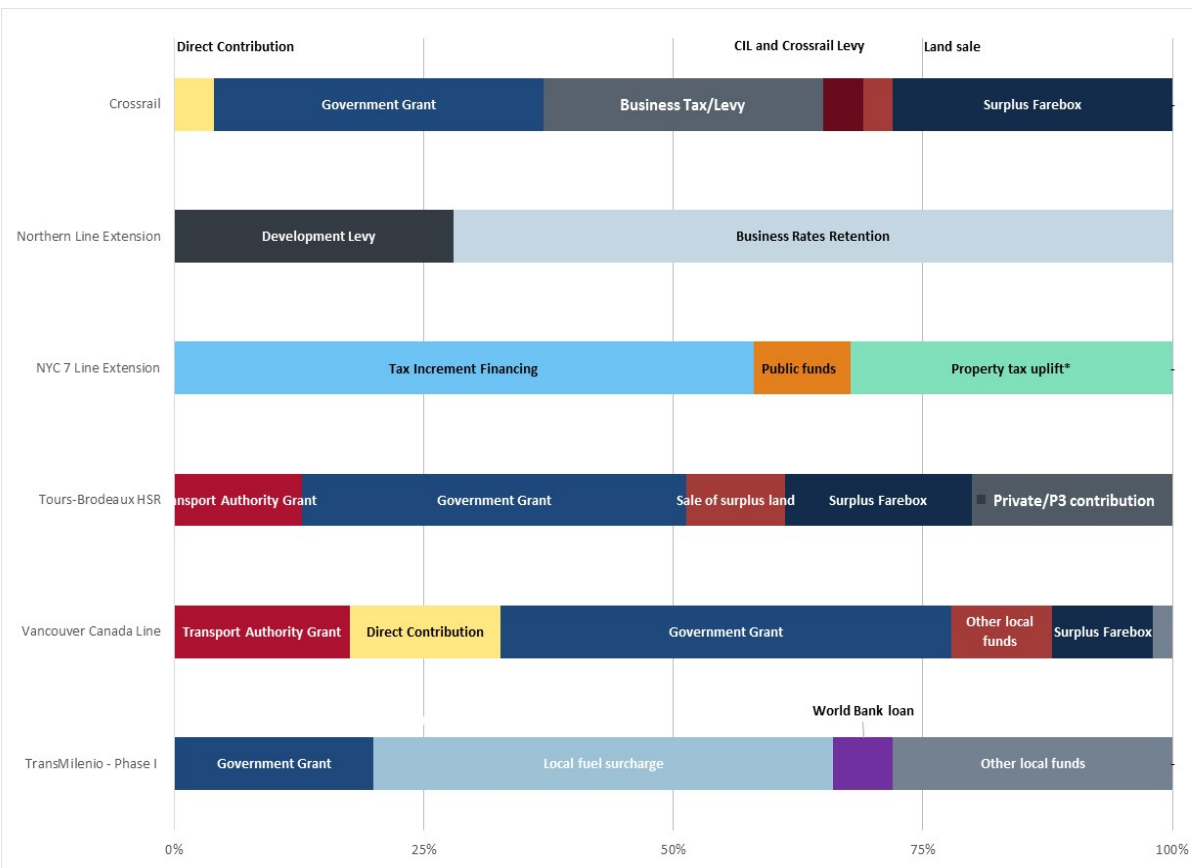
Table 20: Promising Value Capture Mechanisms and Alternative Funding Options

Value Capture Mechanisms
Tax Increment Financing
Special Tax Assessments/Districts
Development Impact Fees
Community Revitalization Finance Act
Infrastructure Financing Tool Program
Local Revitalization Financing Program
Local Infrastructure Project Area Financing
Land Value Return and Recycling
Alternative Funding Options
Transit-Oriented Development policy lever
Joint Development
Commuter Tax
Business Taxes
Congestion Pricing
Highway Tolls
Passenger Facility Charge
Cap-and-Trade/Carbon Fee

A number of international transportation projects have tapped into locally/regionally generated sources for funding that seek to capture a proportion of the generated benefits. A notable example of a successful application of a local funding mechanism is London's Northern Line Extension, which created an Enterprise Zone that enables 100% of the incremental business rates (local business taxes in the United Kingdom) to be retained locally for 25 years. Similar to Tax Increment Financing, this mechanism alone is expected to contribute over 70% of the total project cost. With the addition of the funds collected via development levies, of which a portion will be dedicated to the project, the funding potential will be sufficient to fully fund the extension.

In the US, a high-profile project was the extension of the New York City number 7 subway line to Hudson Yards. The $3+ billion Hudson Yards redevelopment included an extension of the subway, in addition to road and public space enhancements. While there have been changes in the financing of the infrastructure works due to delays in developments, most funding is being generated from developer contributions and an increase in property taxes generated by the development and surrounding properties. This future property tax income stream will help pay off the initial debt raised to construct the subway and other public works. Figure 16 shows the breakdown of funding packages for recent transportation projects around the world.

Figure 16: Funding Packages from Recent Transportation Projects



Source: Steer research based on various public documents

A variety of local funding mechanisms, complemented by traditional government grants, can allow infrastructure projects to be delivered. It would be important to tailor the funding strategy to the context of the transportation development, particularly in terms of beneficiaries, local powers, and legislation. The funding strategy should be divided into three chronological stages: project initiation (near term), project development (intermediate term), and construction and O&M (long term). The three stages are defined as follows:

- **Project Initiation** includes activities that should be accomplished within the first two to three years of the project delivery timeline. These activities may include, but are not limited to, creation of governance structure; planning and refined project definition, including purpose and need; preliminary consideration of National Environmental Policy Act (NEPA) clearance (Pre-NEPA) and equivalent Canadian/BC environmental policies; preliminary engineering that outlines alternative routes and station locations; governance; and stakeholder engagement/public consultation, which would include BC's commitment to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).
- **Project Development** would begin after the project initiation stage is complete, occurring roughly three years from now. This stage should include, but is not limited to, achieving the following: final Tier 1 NEPA/programmatic environmental assessment clearance and Project NEPA/environmental assessment review for initial operating segment, final engineering/design, and establishing the project delivery approach.
- **Construction and O&M** would likely begin six to eight years from now and would include construction (including right-of-way acquisition), followed by the O&M period when service operation begins. The long-term strategy is contingent on effective planning and, most importantly, on securing a sustainable funding source in advance of the construction and O&M stages.

The proposed project funding/financing strategy must include multiple, parallel outreach efforts by the program to mobilize support that would lead to committed funding from federal, state/provincial, regional, private, and local funding sources. Each stage would have decision points before proceeding to the next stage. Table 21 summarizes the stages.

Table 21: UHSGT Potential Funding Strategy, Scope of Project and Timeline

	Project Initiation	Project Development	Construction and O&M
Timeline	Present to 2 to 3 years	Approximately 3+ years	Dependent on phasing
Scope	• Governance • Stakeholder engagement • Pre-environmental clearance • Conceptual engineering,	• environmental clearance • Preliminary engineering • Risk assessment • procurement	• Land acquisition • Vehicles • Final design • Construction • O&M
Strategy	• Rely on readily available funding streams to fund planning elements. • Begin outreach to secure state, provincial, private,	• Support project development through federal, state, and local funding.	• Support construction and O&M through sustainable, long-term funding streams tied to the economic benefit of

	and federal funding to support project development.	• Begin proper technical, executive, and legislative outreach. • Explore private investment to line up construction and O&M funding streams well in advance.	the project, supplemented with new federal funds. • Financing: Issue public or private debt as needed to cover capital deficits during the construction stage.

The key milestones for project success include the following:

- Establish a workable governance structure and corporate organization or authority to act as the project lead.
- Develop a coordinated stakeholder engagement approach.
- Begin discussions with involved state, local, and private stakeholders to mobilize support and secure funding contributions that are readily available to support the project initiation stage
- Simultaneously begin discussions with involved stakeholders that can champion substantial state/provincial and federal funding to support the project development stage.
- Identify and secure a sustainable funding mechanism that supports the project’s construction and O&M costs.
- Perform a detailed analysis of potential long-term revenue streams, including revenue potential, projection of market trends, and analysis of legislative requirements.
- Consider financing needs to cover any funding shortfalls during the construction period.

6 Deliverability and Technical Case

This chapter describes the proposed approach for delivering and governing a UHSGT project in the Cascadia megaregion, setting out procurement models and governance structures, key challenges and risks in building UHSGT, and project dependencies during delivery. The information in this chapter draws from and builds on the work included in the other UHSGT documents, particularly Appendix F: Recommendation of Candidate Governance Structures.

6.1 Deliverability challenge: governance

The ability to successfully deliver any infrastructure projects depends, in large part, on a robust governance process. Governance concerns the process for which a project is developed and delivered, including in particular, the roles and responsibilities of different parts of the organization and how decisions are made. At the heart of this is the structure of an entity that would be responsible for overseeing the planning, design, construction, and operation of a UHSGT project. As with delivery models, selecting the governance approach for this project would require careful consideration of cross-border and interstate issues.

6.1.1 Cross-border agreements and legislative authorizations

Some interstate/province agreements are already in place regarding the development of UHSGT in the Cascadia megaregion. Most recently, in October 2018, the State of Washington and the Province of British Columbia signed a Memorandum of Understanding (MOU) to:

> *Continue support for the business case analysis of a new ultra-high-speed corridor between Portland, Seattle and Vancouver B.C., with speeds as high as 250 mph (400 km/h), and begin exploring the possibility of a new multi-jurisdictional Ultra High Speed Corridor authority that could lead the project in any agreed-upon subsequent phase(s).*

Previously, the states of Washington and Oregon had also agreed in a 2012 MOU to cooperate in the development of the "Pacific Northwest Rail Corridor" between Eugene, OR, and Vancouver, BC, as one of the five HSR corridors originally designated by the Federal Railroad Administration as directed by the Intermodal Surface Transportation Ace of 1991 (ISTEA).

Beyond interstate/province MOUs and agreements, however, a future government entity responsible for delivering UHSGT would need to be authorized that complies with relevant statutory prescriptions, particularly those dealing with bi-national organizations:

- The **US Constitution** stipulates that states shall not "enter into any agreement or compact with another state or with a foreign power" without the consent of Congress, although it has been interpreted that as long as a proposed bi-national authority does not encroach on the supremacy and centrality of the federal government, it can be formed without Congressional consent.

- **Washington** state law limits the joint exercise of powers to other states in the US, while its P3 law does permit the state to enter into agreements with Canadian provinces for trans-border transportation projects.
- **Oregon** state law permits state agencies to exercise joint authority with another state or foreign nation.
- While **British Columbia** has the authority to enter into cross-border agreements, the federal **Canadian government** has jurisdiction over rail lines that operate across an international border.

6.1.2 Examples of International Governance Models

The US and Canada have successfully formed joint entities or otherwise partnered to deliver transportation projects, primarily highway bridges on the Saint Lawrence Seaway and in the Great Lakes region. Beyond North America, a number of complex, intercity/international rail projects have been delivered in Europe using new or innovative governance structures. Some of these examples are outlined below:

- The **Gordie Howe International Bridge** will connect Detroit, MI, and Windsor, ON, across the Detroit River. It is financed entirely by Canada and procurement is being undertaken by a Canadian Crown Corporation; however, major project decisions require approval by a joint Michigan/Ontario authority. The authority's jurisdiction covered tasks such as approving procurement documents and processes, approving requirements of individual P3 agreements, and allocating costs. Since the bridge was ultimately entirely financed on the Canadian side, a separate authority was created to implement the procurement.
- The **Saint Lawrence Seaway International Bridge** connects New York state and the province of Ontario, serving approximately 2 million crossings per year. It is jointly owned by the Saint Lawrence Seaway Development Corporation (a US governmental agency created under federal law) and the Federal Bridge Corporation (created as an instrumentality of the Canadian federal government). These mirror organizations allow the parties to work together without a single joint authority. The bridge is operated by a Canadian corporation that charges each of the parties for their respective share of bridge operating costs.
- The **Channel Tunnel** is a rail tunnel linking the United Kingdom and France and provides an example of a vertically separated railway. An international treaty was established to provide the right to construct, fund, operate, and maintain the tunnel by a publicly listed company. Operation was in the form of a 65-year operating concession (similar to a P3 structure) that allows the company to recover its initial $6 billion investment through user charges, retail revenues from terminals, and utility rights. Independent public economic and safety regulations were established through the treaty to monitor the concession and protect the interests of users of the tunnel, competitors to the tunnel (primarily ferry companies), as well as the general public.

- Also in Europe, **Crossrail** will provide a new, 73-mile railway across Central London, adding 10 new stations and new links to London's key business districts. A separate delivery company was established, with clear output requirements set by the government client/sponsor that were linked to the sponsor's business case. While key decisions were agreed upon with the sponsor, the delivery company was empowered to deliver the project, including integrating civil, systems, and operational works. The sponsor also employed an expert advisor team to provide impartial evidence of progress and impacts of any proposed changes. Crossrail was funded by a mix of government grants, surplus fare revenues, and locally raised levies (business and land value capture fees).

6.1.3 Lessons Learned

The ultimate governance structure to deliver UHSGT and realize the benefits outlined in this business case would ultimately be selected by the relevant parties in the Cascadia megaregion. Above all, it should be sufficiently resilient to withstand changes in political views and public funding opportunities over the many years needed to plan, design, and construct a project of this scope. That said, similar projects have been successfully delivered and implemented around the world, and the examples listed above, as well as various others identified in Appendix F: Recommendation of Candidate Governance Structures, offer a variety of lessons and insights that are particularly applicable to UHSGT and the Cascadia megaregion in general:

- **Legislative authorization** would be needed to permit each party to enter into international and interstate/province agreements without impairing federal or state sovereignty.
- A **common vision and set of goals** should endure for the life of the project and be developed through strong stakeholder engagement.
- A **separate delivery entity** should be established to split responsibilities of policy and funding from delivery and implementation, in part to improve the decision-making process.
  - This entity should have **full implementation powers** to apply for federal grants and loans, impose fees and charges to help finance capital costs, acquire property, enter into agreements and contracts, develop its own procurement processes, borrow money, and issue bonds.
  - **Integrated project teams** are necessary to ensure the many aspects required to deliver a project are working together and have simple reporting/decision making lines.
- **Outcomes-based requirements** should be developed early during project development to ensure clarity on project deliverables.
- **Private involvement in delivery** (e.g., P3s in many cases) can incentivize robust and cost-effective delivery through integration of design, procurement, construction, and operational requirements.

- **Alternative funding tools** can minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries.
- An **independent regulatory scheme** should be set up to protect users and challenge project performance.

6.2 Deliverability challenge: procurement/delivery model

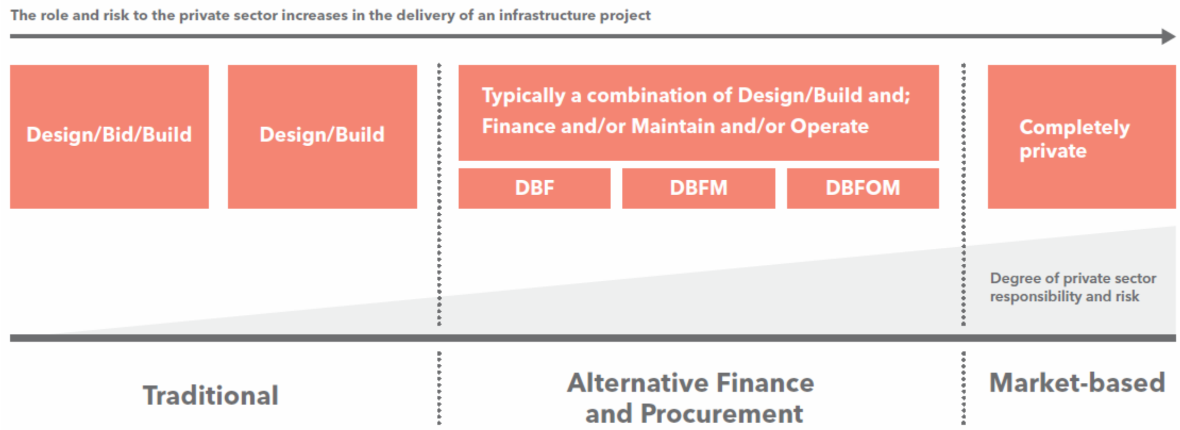
The ability to successfully develop, design, procure, construct, and operate/maintain large-scale transportation infrastructure has become increasingly challenging. As the built environment has grown in geographic scale and density, finding a route to build even the simplest of infrastructure projects becomes complex. Issues ranging from environmental protection, stakeholder engagement, funding uncertainty, engineering uncertainty and changing technical standards have led to complicated and time-consuming decision-making for many projects. This is the environment that UHSGT (or any infrastructure project) faces.

A variety of approaches may be considered for procuring different elements of the UHSGT delivery; they span from planning to design to construction to operation. These approaches should be developed to address the following objectives, all of which are linked to ultimately delivering a better value project:

- Achieve effective transfer of risks to those who are best able to manage them.
- Mobilize private-sector and/or international expertise, where appropriate, to optimize the design, delivery, and operations processes.
- Retain control and flexibility to meet future needs in the project owner's hands.
- Achieve competitive pricing while aligning incentives.

In addition, recent projects have given rise to a number of different project delivery models ranging from Design/Build to Early Contractor Involvement (ECI). The potential of more private involvement, for example P3s, has been explored for its ability to achieve several of the above objectives. The scope and extent of private-sector involvement may vary by project or work element. Figure 17 illustrates various procurement models that differ by degree of private-sector involvement.

Figure 17: Range of Infrastructure Procurement Models



Source: Metrolinx GO Expansion Full Business Case, November 2018

The key attributes of traditional/conventional and alternative procurement approaches are summarized in the following sections.

6.2.1 Conventional Approaches

Conventional procurements, mostly of the design-bid-build variety whereby firms separately and sequentially bid for the design and construction phases of work, are commonly used to deliver public infrastructure. These procurements and projects typically feature low integration risks, and specific, clearly defined detailed requirements. As a result, potential is limited for design innovation. Private contractors are selected through a competitive tender process, responding to a prescriptive specification.

Alternatively, a more permissive design-build (DB) model allows one firm or joint venture to perform both design and construction work in parallel where permitted. This model is widely used where the output requirement is clearly defined, but there may be opportunity for more innovation during the detailed design phase.

6.2.2 Alternative Procurement Models

Transferring elements of project delivery to the private sector has been gaining acceptance around the world in the past 20 years. Procurement models that transfer partial or full responsibility to the private sector (e.g., P3s) can take on a variety of approaches:

- Design-build-finance (DBF), where contractors must finance work during construction with payment only upon substantial completion
- Design-build-finance-maintain (DBFM), which transfers responsibility for long-term maintenance to the contractor(s)
- Design-build-finance-operate-maintain (DBFOM), which also transfers responsibility for long-term operations

Experience over the last several decades in the US and internationally suggests that mobilizing private-sector expertise can more effectively deliver UHSGT at a lower price than traditional public procurement approaches. Nevertheless, the project would likely require some measure of public investment to pay the upfront costs to design and construct the new transportation line. Such public investment can be spread over the combined construction and operating term of the project, whereby upfront private financing is recovered with public funds linked to the successful delivery of the project's key deliverables to a set of strict criteria. This "availability payment" approach has been used in many recent projects in the US on toll roads, Canada on both road and rail projects, and around the world to incentivize the private sector to deliver the project on-time, within budget, and to a set of performance targets established in the contract. By doing so, UHSGT can be delivered cost effectively by the private sector while ensuring public accountability.

These P3 models can transfer delivery and whole-life performance risks to the contractor/delivery company. To the extent that these risks are transferred, project specifications can be less prescriptive and more performance-based, which incentivizes contractors to optimize their design and delivery approach to maximize long-term benefits and minimize life-cycle costs. As with design-build models, these P3 approaches also encourage innovation during the design and construction phases, while also ensuring that project deliverables are still met in terms of the outcomes required.

Other procurement tools should also be actively considered in compliance with applicable government procurement law to ensure effective development of the design, approval, and procurement phases. For example, Early Contractor Involvement (ECI) where private contractors are invited to review, comment, and propose improvements to concept proposals has been embedded in more effective and cost-efficient projects. ECI, combined with competitive dialogue throughout the design and procurement process, has been used extensively for procuring broadband and other public utility projects such as power stations.

6.3 Deliverability challenge: risk management

Given the size, scope, and duration of the UHSGT project, a large number of challenges and risks would need to be managed effectively. Selecting the appropriate delivery model and governance structure would be key in managing these risks. The risks should be shared in an equitable fashion between the project owner, delivery company, and any other relevant parties, and they should be owned by the party(ies) best placed to manage and mitigate them.

Below are some key risks and challenges to delivering UHSGT:

- **Performance risk:** New railways and ground-based transportation links may not operate as planned or expected because rolling stock, signaling, track layouts, and/or staff and crew do not perform as expected.
- **Revenue risk:** Often related to performance risk, revenue risk recognizes the fact that actual revenues for the operator may be materially different from forecast revenues, particularly during the initial ramp-up stages of operation.
- **System integration risk:** Railways are inherently complex infrastructure projects, often integrating with existing infrastructure and systems (e.g., existing rail stations and track

in Seattle, WA, and/or Portland, OR). Failure to realize such integration can be driven by a number of causes and issues; in turn, it can result in schedule delays and cost overruns on the delivery of UHSGT itself.

- **Construction disruption risk:** As UHSGT is being delivered, there could be service impacts on existing rail corridors that parallel or overlap with the final UHSGT alignment. Furthermore, construction work in close proximity to local communities may generate complaints regarding noise and vibration.

While all of these risks can be managed and mitigation plans can be developed, careful consideration of these and other risks would need to be explored in some depth as UHSGT progresses.

6.4 Deliverability challenge: dependencies

If implemented, UHSGT would be a significant investment and a transformative infrastructure and mobility project that would affect communities along the Vancouver, BC; Seattle, WA; and Portland, OR corridor and throughout the Cascadia megaregion. At the same time, other transportation improvements are being planned and/or could be under construction while UHSGT is being delivered. As such, beyond considering the project's strategic, economic, and financial cases, the project team would need to consider how it would affect these other committed, proposed, or funded projects.

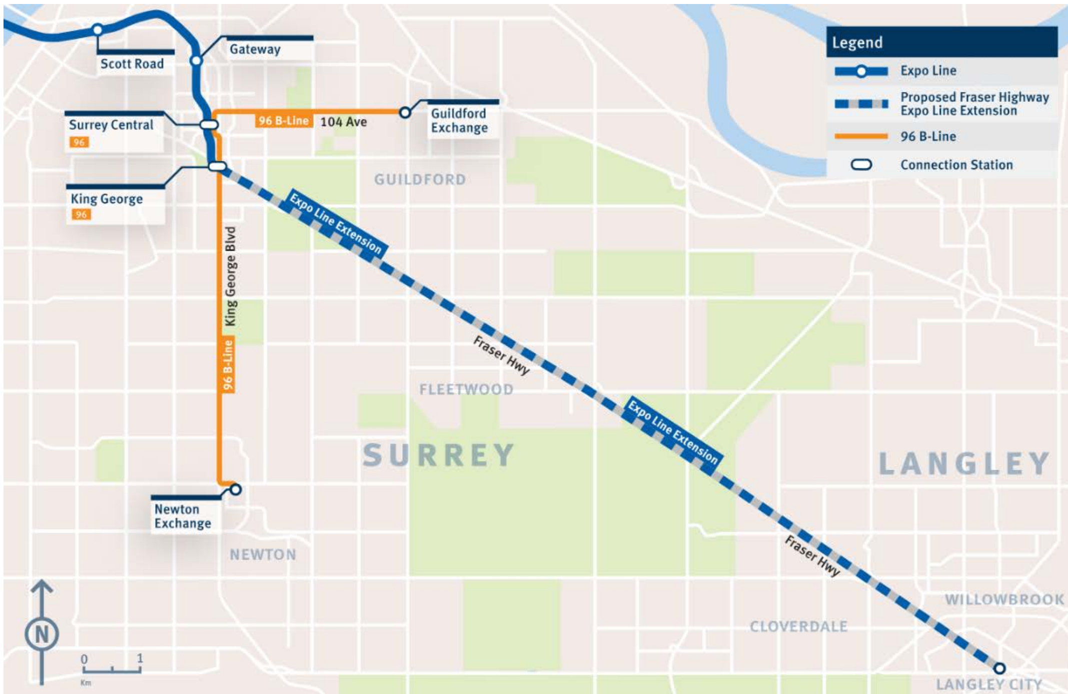
This section reviews potential transportation projects on or along the UHSGT corridor that UHSGT may accommodate:

- **Complementary to:** UHSGT may enhance the use of the infrastructure
- **Competitive to:** UHSGT may subtract travel demand from the infrastructure
- **Replacement to:** UHSGT may mitigate the need for the project, thereby realizing a savings

6.4.1 Surrey Langley Skytrain

A 10-mile (16-km), eight-station Surrey Langley Skytrain line that will extend from Surrey's King George Station to 203rd Street in the city of Langley, is in the final stage of a decision on funding. The project would connect with the existing Expo Line that serves Surrey Central, and in doing so would greatly improve transit access for residents and workers along the new line to the potential location of a potential UHSGT terminus or station. Figure 18 illustrates this corridor, identified as one of the key corridors for transit investment in *Translink's 10-Year Vision for Metro Vancouver Transportation*.

Figure 18: Proposed Route of Surrey Langley Skytrain



Source: Surrey Langley Skytrain project website, May 2019

Given the geographic scope of the project, it is likely to play a **complementary** role to UHSGT by providing significantly improved public transit access to a potential UHSGT terminus or station at or near Surrey Central. Current public transit travel times from Langley Centre to Surrey Central range from 40 to 50 minutes; both the travel times and reliability would see significant improvements once the project is fully built out.

6.4.2 Sound Transit 3 (ST3)

ST3 represents a comprehensive package of capital projects and service improvements that are being planned for the central Puget Sound region. It calls for major investments in new light rail lines across the region, providing new service to Everett, Bellevue, and Redmond, as well as connecting two existing, disparate lines in Seattle and Tacoma and expanding Sounder commuter rail services. Altogether, 62 new miles (100 km) of commuter rail are planned, completing a 116-mile regional system that is projected to serve approximately 600,000 riders per day. In addition, new bus rapid transit service would complement light rail, connecting Bellevue, Tukwila, and Lynnwood on the eastern shore of Lake Washington. Figure 19 provides a schematic overview of the proposed network.

Figure 19: Overview of Sound Transit 3 Improvements

Source: Sound Transit 3 project website, May 2019

Similar to the Surrey Langley Skytrain, ST3 is likely to drive significant improvements in accessing UHSGT stations throughout the Seattle area (whether Seattle, Bellevue, Tukwila, Tacoma, or Everett); therefore, it is viewed as largely a **complement** to UHSGT. With careful planning and collaboration with Sound Transit, UHSGT could provide a cost-effective service where the complexity of further enhancements of existing transit may be high (i.e., further increasing frequency of Sounder services).

6.4.3 Regional Highway Improvements

As the primary north-south highway along the UHSGT corridor, US I-5 is prone to congestion in various locations, notably in urban areas such as Portland, OR, and Seattle, WA. WSDOT has a number of highway improvement and congestion relief projects in progress throughout Washington state, including the US I-5 Joint Base Lewis-McChord Area Improvements project in Lakewood and the US I-5 High-Occupancy Vehicle Program in Tacoma and greater Pierce County.

Similarly, the Oregon Department of Transportation is currently implementing the US I-5 Rose Quarter Improvement project in central Portland to address traffic and connection issues.

Auto travel remains the dominant mode of intercity travel within the Cascadia megaregion and is the primary mode from which UHSGT would capture existing travelers. As such, UHSGT could both **compete** against and **replace** the need for additional intercity highway improvement projects that may be required in the future.

6.4.4 Airport Improvements

The Cascadia megaregion's airports have embarked on a broad set of expansion and improvement projects to their facilities. Seattle-Tacoma International Airport (Sea-Tac) is the most congested and delay-prone of the major airports in the region, and as such has laid out plans and secured funding for the largest suite of improvements, valued at around $2 billion, including a Concourse D Annex that will add six gates, a new International Arrival Facility that will almost double the number of gates available for international flights (from 12 to 20), and various renovations and modernizations to existing terminals and concourses.

Similarly, Vancouver International Airport is planning and constructing a series of incremental terminal expansions, particularly its international and trans-border terminals as part of a wider $9 billion package of works.

Meanwhile, PDXNext is a series of major investments to the terminal facilities and passenger experiences at Portland International Airport, albeit without any explicit terminal or gate capacity expansion.

UHSGT would likely play dual roles in **competing** against and **replacing** the need for some airport improvements, similar to the highway improvements described above. While air travel accounts for a lower absolute number of existing trips, it is expected that UHSGT would capture a very large share of trips, primarily origin-destination trips solely within the corridor, but potentially also connecting itineraries within the region as part of longer trips where UHSGT could replace the short, intra-Cascadia megaregion portion as seen in other countries with integrated airport/HSR services, such as France, the Netherlands and Germany. This could reduce the future need for expanded terminals and airfield capacity or allow the new capacity to be more efficiently deployed in serving longer-distance markets.

The airports have also identified a range of ground transportation and airport access/egress improvements, including consolidated ground transportation centers and new or refurbished parking garages. In a scenario where UHSGT has stations at Vancouver International and Portland International Airports and could serve downtown-to-airport trips, it could again be a **competitor to and/or replacement** for some of these ground transportation projects.

7 Conclusions

7.1 The case for UHSGT

The 2019 Business Case demonstrates the UHSGT concept is an effective transportation project, and once implemented, UHSGT is likely to have a transformative impact on the entire Cascadia megaregion. The overarching conclusions are that UHSGT delivers the following key benefits and outcomes:

- A **better-connected megaregion** resulting from faster journeys, increased capacity, and reduced congestion
  - It will achieve this by integrating its major commercial hubs and population centers including intermediate stations along this new transportation spine using a greener, environmentally advanced travel mode.
  - Travel times between each of the three major cities would be less than an hour for each segment, with connections to other transportation modes at all stations.
- Travelers will shift to UHSGT with ridership exceeding **3 million annual trips and farebox revenues exceeding $250 million**, making this the best performing rail service in North America outside the Northeast Corridor between Washington, DC, Philadelphia, New York and Boston.
- There is a clearly stated willingness of travelers in the region to **shift to UHSGT from other modes** and support **greener modes of travel** that provide shorter travel times and more reliable service with a significant reduction in greenhouse gas emissions.
- A **stronger, more productive megaregion** as more businesses/jobs locate in the Cascadia megaregion due to the dramatically improved access to housing, jobs, schools, and other destinations, as well as the creation of new regional industry clusters. Once implemented, UHSGT would catalyze the **transformation** of the Cascadia regional economy into a dynamic, globally competitive, megaregion.
- A **more affordable megaregion** as residents benefit from easier access to more affordable housing as well as wider access to higher-paying jobs and opportunities. Improving mobility for residents throughout the megaregion supports a commitment to developing an equitable transportation network.
- A **better environment** by shifting trips to more sustainable modes, reducing carbon emissions and environmental impacts, protecting habitats, and enabling healthier lifestyles across the megaregion, as well as improving the resilience of the transportation network
- A **better value infrastructure investment** than possible alternative projects, whether interstate highways or airport expansion
- **Broad support from businesses, other stakeholders, and travelers** given its ability to unlock sustainable growth, make the Cascadia megaregion more competitive, and

deliver higher quality, more cost effective and safer journeys compared to existing road or air options

- A **modern delivery approach** drawing on proven governance and procurement models plus innovative funding mechanisms.
  - These include lessons learned from other similar infrastructure projects related to funding mechanisms, phasing approaches, private investments, risk management, governance structure, and public accountability
  - Recent trans-border and international models include the Gordie Howe International Bridge, Vancouver's Canada Line, Montreal's REM, UK HS1/Channel Tunnel, and London's Crossrail.

7.2 Recommended next steps

The 2019 Business Case identifies a series of next steps. These have been split into steps that can be progressed based on the availability of funds as designated by the Washington State Legislature in the 2019-2021 Transportation Budget (ESHB 1160), and other not-yet-funded priorities as summarized below:

Initial steps in accordance with the direction of the Washington State Legislature

- Establish an initial steering committee comprised of designated representatives from each of the three jurisdictions (Washington, Oregon and British Columbia) to carry out governance study and other activities described below.
- Finalize the preferred governance model including general powers, operating structure, legal and contracting requirements.
- Assess the current laws in the state and provincial jurisdictions and identify any proposed changes to laws, regulations, and/or agreements that are needed to proceed with development.

Additional activities to evaluate depending on available funding

- Develop a statement of purpose and need for UHSGT, drawing on the conclusions of the business case report
- Develop conceptual alignment options for further study
- Develop potential funding and financing alternatives
- Identify and pursue funding to enable planning and design at the preliminary environmental assessment level
- Finalize the communications plan and identify a possible outreach engagement strategy

Additional activities currently not-yet-funded

Preliminary environmental assessment planning and design:

- Develop specific alignment alternatives during the preliminary design and pre-environmental phases.

- Continually refine cost estimates based on selected alignments and station locations.
- Assess impact of future increased highway congestion and other possible changes on ridership forecasts (including sensitivities).
- Expand ridership analysis to include commuter and local travel markets.
- Further analysis of the economic impact of UHSGT including both user and wider impacts and possible application of Canadian guidelines.
- Continue exploration of emerging technology options.

Robust outreach and engagement:

- Greatly expand the stakeholder engagement process to include a wider cross-section of residents, businesses, tribes, interest groups, policy makers, and travelers.
- Focus on equity, access and affordability by ensuring equitable representation on decision-making groups, including advisory groups and councils, and Incorporating, encouraging and supporting equity throughout the public consultation and outreach program.
- Refresh the Advisory Group roles and responsibilities.
- Assess private involvement options in delivery to incentivize robust and cost-effective delivery through integration of design, procurement, construction, and operational requirements.
- Coordinate findings with local jurisdictions and governments to have UHSGT reflected and supported in local and regional plans and programs.
- Examine in more detail published and emerging local and regional transportation plans to better understand how UHSGT can complement other infrastructure priorities.

Economic impact analysis:

- Commission a comprehensive Wider Economic Benefits (WEB) analysis to better understand agglomeration and other impacts applying WebTAG guidance as used on projects in Canada.
- Compare similar projects both within the Cascadia megaregion and elsewhere to benchmark assumptions and incorporate lessons learned.
- Review sensitivities (positive and negative) to ensure economic analysis is well understood.

Funding and financing strategy:

- Consult with the Advisory Group, local stakeholders, business groups, and developers on the feasibility of potential funding and financing alternatives.
- Progress funding strategy options with a focus on viability of alternative funding streams that can minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries.

- Begin discussions with involved state, local, and private stakeholders to mobilize support and secure funding contributions that are readily available to support the project initiation stage.
- Simultaneously begin discussions with involved stakeholders and government leaders that can champion substantial state/provincial and US and Canadian federal funding to support the project development stage.
- Identify and secure a sustainable funding mechanism that will support the project's construction and O&M costs.
- Build a funding and financing model based on refined cost and revenue estimates when all sources of revenues become more realistic.

Governance and delivery:

- Once established, the multi-jurisdictional entity should also examine the following:
  - Establishing a separate delivery company to split responsibilities of policy and funding from delivery and implementation, in part to improve the decision-making process and transparency on public accountability.
  - Outlining roles and responsibilities for integrated project teams to be formed that include members from the delivery company, the governing entity, and other relevant organizations.
  - Developing outcomes-based requirements soon after establishing the delivery company to ensure clarity on project deliverables.
- Ensure the delivery entity has full implementation powers to apply for federal grants and loans, acquire property, enter into agreements and contracts, develop its own procurement processes, and raise funding, including borrowing/issuing bonds.
- Establish an independent regulatory scheme during the project definition stage to protect users, stakeholders, and affected parties, as well as challenge project performance.

Washington State Department of Transportation

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix A

Benefit Analysis
Technical Memorandum

July 2019

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Contents

Tables

Executive Summary

This Technical Memorandum describes the assumptions, methodology, and results of the benefit analysis (BA) developed for the Ultra High-Speed Ground Transportation Study. A BA is a limited tool for evaluating the monetizable user and social benefits associated with the project. Its primary utility is for comparing alternative system alignments and service plans. The goal of the BA is to quantitatively determine how the forecasted ridership for alternative system alignments relates to the relative measured economic valuations of the project. Also analyzed is the sensitivity of the measured benefits to changes in operating or cost conditions of roadway and airport facilities in the Interstate 5 corridor. This analysis assumes design, final engineering and construction activities will occur from 2027 to 2034, followed by an operational period of 40 years. The life of the UHSGT system is expected to be at least 100 years, therefore the analysis does not monetize the system's total lifetime benefits, only those captured within the 40-year analysis period.

While the BA produces quantified outputs measuring the impacts of operating a new UHSGT system in the region, there are limitations to the conclusions that can be drawn from the results. The analysis does not capture broader economic benefits including increases in jobs and economic activity. As shown in the 2017 Study, which estimated these factors, the overall return on investment of the project may be 7 to 10 times its costs. Additionally, the analysis primarily provides a comparison of ridership scenarios and alignments based on preference-based surveys; additional planning, design, pre-engineering and modeling work would need to be performed to develop the BA inputs to determine the cost-effectiveness of the proposed project with sufficient precision.

The three scenarios selected for the analysis were selected from the Ridership and Revenue Report. "Scenario 1C" illustrates a three-stop alignment with an express service, "Scenario 2A" is eight-stop alignment with a base and express service, and "Scenario 1D" is a nine-stop alignment with a base and express service.

The proposed project is estimated to generate measured user and social benefits valued at $10.6 billion in discounted 2019 US dollars (USD) for Scenario 1D, $9.6 billion in discounted 2019 USD for Scenario 2A, and $8.2 billion in discounted 2019 USD in Scenario 1C. The undiscounted and discounted values for the project benefits for each scenario are shown in Table ES-1.

Table ES-1: Total Project Lifecycle Benefits by Scenario, Millions of 2019 USD

	Total Project Lifecycle Benefits	Total Project Lifecycle Benefits (4% Discount)
Scenario 1D	$56,157	$10,550
Scenario 2A	$52,453	$9,639
Scenario 1C	$47,267	$8,371

As the modeled ridership is a function of the stated preferences of users between modes of travel based on travel speed, reliability and convenience, the analysis includes sensitivity testing to determine the effect on travel behavior under certain simulated operational conditions. Congestion on roadways, especially highway roads in dense urban areas, and regional airports negatively affects personal and business travel and regional economic development. Using the sensitivity testing outputs from the ridership model, the analysis simulates the effect of roadway congestion on travel behavior by increasing auto journey times by 20%, which results in an 18% increase in ridership and up to a 37% increase in project benefits. The results of the sensitivity testing are shown in Table ES-2.

Table ES-2: Benefits Due to Longer Auto Journey Time, Millions of 2019 USD

Testing Scenario	Project Lifecycle Benefits	Project Lifecycle Benefits (4% Discount)	Percentage Change in Benefits from Base Scenario
Scenario 1D	$72,168	$14,483	37%
Scenario 2A	$66,392	$13,061	36%
Scenario 1C	$56,344	$10,603	29%

Results:

The results of the benefit analysis suggest the following:

1. Based on the analysis of the project's identified monetizable benefits, the analysis shows the ridership scenarios result in significant user and social benefits for the region, while developing greater connectivity between local transit systems and increasing access to housing and employment opportunities.
2. As the key assumptions underlying the ridership model included only planned and funded roadway improvement projects and omitted the effect of roadway congestion, the initial results from analyzing the base scenario can be regarded as understated.
3. The sensitivity testing shows users will increasingly shift to the UHSGT system for intercity trips in the region as average auto journey times increase and generate benefits at a greater rate than the increase in ridership.
4. The results for Scenario 1D and 2A illustrate that the higher number of stations on the alignment result in a greater catchment area for user-trips and increase connectivity throughout the region.
5. Based on the limited precision of the cost and ridership inputs for the model, due to the early stage in the system planning process, the BA cannot definitively determine the economic feasibility of the proposed UHSGT system, but it does provide valuable insights into determining the utility of such a system for regional users and can be used to guide decisions on determining the system's alignment and the size of its catchment area. A detailed Economic Impact Analysis and Environmental Impact Study would highlight the comprehensive effect of economic development and environmental and social impacts of the project over time.

8 Introduction

A benefit analysis (BA) was conducted as a component of the WSDOT Ultra High-Speed Transportation Business Case Analysis. The following section describes the BA framework, evaluation metrics, and report contents.

8.1 Benefit Analysis Framework

The type of BA described in this report is an evaluation framework that assesses the social and environmental economic advantages (benefits) of an investment alternative. Benefits and costs are quantified in monetary terms to the extent possible. The overall goal of a BA is to assess whether the expected social and environmental benefits of a project justify the investment, without accounting for broader economic factors such as growth in jobs and economic activity. This BA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits).

The BA framework involves defining the parameters of a Base Case or "No Build" Case and the "Build" Case, then comparing the outputs of the alternatives for the project built as proposed. The BA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes is determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit methodology as determined by industry best practices and guidelines by governmental agencies and non-profit organizations. This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No Build base case and the Build Case, as well as alternative Build scenarios;
- Estimating benefits during project construction and operation, including 40 years of operations beyond the project's completion when benefits accrue;
- Using recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2019 US Dollars. In instances where benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values;
- Discounting future benefits with real discount rates of 4 percent consistent with best practices[23].

[23] Real discount rates for public high-speed rail projects by location: 3% (Germany), 3.5% (Great Britain), 4% (Japan, Netherlands, Sweden), 3-7% (US Federal Railroad Administration), 5% (Spain)

8.2 Report Contents

The report contains an evaluation of the benefits related to the projected ridership of three proposed alignments, Scenarios 1D, 2A and 1C, from the Business Case Report. Section 2 provides an overview of the project and the parameters of the benefit analysis. Section 3 provides a detailed description of the methodology and assumptions underlying the analysis and the results of the benefit analysis. Section 4 provides an overview and results of sensitivity testing based on the ridership modeling of the base Build scenario. Section 5 provides a summary of the analysis results and a discussion of variables outside of the scope of the analysis.

9 Project Overview

9.1 Description

The proposed Ultra High-Speed Ground Transportation System (UHSGT) would serve as a central transit spine connecting users to intermediate cities and metropolitan areas of the Cascadia megaregion, from Vancouver, BC to Portland, OR. The system would provide reliable high-speed intercity connections competitive with auto and air travel on travel time and convenience, while reducing the social impacts of travel and enabling productivity benefits for users. Amidst increasing congestion on roadways and at regional airports amidst strong economic and population growth, an UHSGT system provides a modern infrastructure solution for 21st Century problems.

9.2 General Assumptions

The evaluation period of the BA will be a period of construction from 2027 to 2034 followed by 40 years of operations from 2035 to 2074. The analysis utilizes a discount rate of 4% to measure the change in the value of benefits over the course of the evaluation period and maintain their value in constant 2019 dollars. Non-governmental proponents of best practices in evaluating the value of transit systems over time identify a discount rate of 2% to 3% to adequately capture the change in value over time, while the US Federal Railroad Administration suggests a discount rate of 3% to 7% to evaluate projects for grant funding. The discount rates used to evaluate the cost-effectiveness of high-speed rail projects in Europe and Japan range from 3% to 5%. A discount rate of 4% balances the risk of the private market with the financial security of administration under a public agency.

9.3 Base Case and Build Case

The analysis will compare the social and user benefits from operating the UHSGT system, the “Build Case”, to the relative effects of not building the project or any other expansion of roadway or airport capacity, the “No Build Case”. The “Build Case” includes examining a lower ridership scenario (Scenario 1C), a moderate ridership scenario (Scenario 2A), and a higher ridership scenario (1D), resulting in the comparison of three modeled outputs in total. Examining the three ridership scenarios gives insight into the effect of ridership levels on the estimated economic valuation of the UHSGT system, which can help inform the decision on a system alignment and service plan. The “No Build Case” provides the baseline demand and total journey time for auto, intercity bus, intercity rail and air travel assuming no unplanned or unfunded projects will be undertaken into the future to expand capacity or otherwise affect the travel behavior of existing and future users.

10 Project Benefits

The proposed UHSGT system will result in quantified user and social benefits, as well as qualitative benefits that cannot be monetized, but have a significant impact on the regional economy and communities. As a high-speed intercity transportation system, the primary benefits for users will include travel time savings over other modes of travel and productivity gains for existing and new users. With auto users being the clear majority of travelers in the regional transportation corridor, the shift to the UHSGT system will significantly reduce auto vehicle-miles traveled, resulting in social benefits such as, but not limited to, reduced emissions, reduced crashes and reduced pavement damage. As the population and economic activity in the region is projected to grow, the benefits of those avoided costs will cumulatively grow as well.

The user and social benefits associated with the UHSGT system can be monetized using factors derived from industry and governmental sources reflective of best practices in benefit analysis. As part of the state preferences survey and the ridership demand forecasting, Steer developed value of time factors for users of each mode of travel to evaluate the monetized value of travel time savings. The factors used to evaluate the benefits are projected on a time series through the analysis period accounting for the effects of changes in technology, cost inflation and market price variability. Future project benefits are evaluated at a discount rate of 4 percent in constant 2019 US dollars (USD). The benefit categories included in the BA are described in Table 1.

Table 22: Project Impacts by Benefit Category

Benefit Category	Description	Monetized	Qualitative
Travel Time Savings	Reduced travel time over other modes of travel	√	
Vehicle Operating and Maintenance Costs & Fuel Savings	Reduced costs related to repair, operation and depreciation; reduced fuel consumption and/or mode-shift to more energy-efficient alternative	√	
Productivity Gains for Captured and Induced Demand	Productivity gains for travelers utilizing the UHSGT service	√	
Reduced Incidents	Reduction in fatalities, injuries and property damage related to auto crashes	√	
Reduced Road Damage	Reduced auto trips alleviates pavement damage	√	
Reduced Emissions	Reduced emissions related to reduced fuel consumption and/or mode-shift to more energy efficient alternative	√	
Commuter Benefits	Improved connectivity and reduced travel time increases reliable access to work opportunities		√

Benefit Category	Description	Monetized	Qualitative
Access to Affordable Housing	Improved connectivity and reduced travel time increases access to housing opportunities		√
Multimodal Network Connectivity	Improved access and reliability of connections between regional and local transit systems reduces dependence on auto traffic and shares economic development		√

10.1 Demand Projections

The benefit analysis utilizes ridership projections with total person-hours traveled and total trips for travelers using auto, intercity bus, intercity rail and air travel based on traffic forecasts developed by regional planning organizations throughout the corridor, as described in the Ridership and Revenue Report. The demand projections describe a baseline demand for existing modes of travel and a scenario demand for existing travel modes plus the captured and induced demand for the UHSGT system. The traffic forecasts of the demand model are based on the following assumptions:

- The trip length, duration and mode of travel of the users is dependent on the present-day transportation infrastructure without no unplanned or unfunded expansion of highway, rail or airport capacity after 2015;
- The currently planned expansion of the regional light rail and bus system in the Puget Sound region managed by Sound Transit and its partners, known as "ST3";
- The roadway network is "unconstrained", which means trip length and duration is not affected by congestion or the implementation of congestion management strategies;
- The decision by the user to shift modes of travel is based on a survey of stated preferences weighing reliability, travel speed and convenience by users of the regional transportation system.

While the ridership model does not exhaustively account for how conditional factors, other than the perceived value for the UHSGT system, may affect travel behavior, it provides an accurate representation of future user behavior and the relative value given to the services provided by alternative alignments of the proposed UHSGT system.

The forecasted changes in travel behaviors, included the shift in travel mode for existing users and the induced demand by new users, for Scenario 1C, a three-station alignment with stops in Seattle, Portland and Vancouver, is shown in Table 2 below.

Table 23: No Build and Build Demand Projections – Scenario 1C Base Scenario

Variable	Project Opening Year		Final Year of Analysis	
	No Build	Build	No Build	Build
Auto –Trips	1,669,592,025	1,668,813,460	2,663,817,235	2,662,555,776
Air –Trips	2,683,671	2,262,105	4,315,147	3,594,074
Rail –Trips	852,104	525,362	1,350,189	836,392
Bus – Trips	1,706,388	1,666,382	2,692,828	2,629,904
Induced Demand – Trips		219,668		364,800
Auto – Vehicle Miles Traveled	21,726,019,467	21,650,626,816	34,728,290,926	34,605,702,016
Auto – Person-Hours Traveled	1,037,729,542	1,035,082,624	1,658,209,305	1,653,912,678
Air – Person-Hours Traveled	7,023,260	5,929,959	11,368,951	9,488,775
Rail – Person-Hours Traveled	3,485,561	1,935,723	5,513,733	3,080,620
Bus – Person-Hours Traveled	5,815,971	5,614,328	9,168,567	8,851,741
Induced Demand – Person-Hours Traveled		437,826		731,110
Total Fare Revenue		$157,470,823		$314,889,666

Source: Steer Ridership Model

Table 3 below shows the forecasted changes in travel behaviors, included the shift in mode for existing users and the induced demand by new users, for Scenario 2A, an eight-station alignment with stops in the region's large metropolitan areas and intermediate cities.

Table 24: No Build and Build Demand Projections – Scenario 2A Base Scenario

Variable	Project Opening Year		Final Year of Analysis	
	No Build	Build	No Build	Build
Auto –Trips	1,669,592,025	1,668,434,876	2,663,817,235	2,661,927,464
Air –Trips	2,683,671	2,223,481	4,315,147	3,529,390
Rail –Trips	852,104	497,297	1,350,189	789,224
Bus – Trips	1,706,388	1,645,348	2,692,828	2,595,569
Induced Demand – Trips		301,161		503,358
Auto – Vehicle Miles Traveled	21,726,019,467	21,622,004,774	34,728,290,926	34,557,954,364
Auto – Person-Hours Traveled	1,037,729,542	1,034,009,127	1,658,209,305	1,652,126,320
Air – Person-Hours Traveled	7,023,260	5,805,556	11,368,951	9,281,326
Rail – Person-Hours Traveled	3,485,561	1,861,881	5,513,733	2,951,839
Bus – Person-Hours Traveled	5,815,971	5,522,426	9,168,567	8,701,096
Induced Demand – Person-Hours Traveled		590,541		994,393
Total Fare Revenue		$194,586,371		$314,889,666

Source: Steer Ridership Model

Table 4 below shows the forecasted changes in travel behaviors, included the shift in mode for existing users and the induced demand by new users, for Scenario 1D, a nine-station alignment with stops in the region's large metropolitan areas and intermediate cities.

Table 25: No Build and Build Demand Projections – Scenario 1D Base Scenario

Variable	Project Opening Year		Final Year of Analysis	
	No Build	Build	No Build	Build
Auto –Trips	1,669,592,025	1,668,226,328	2,663,817,235	2,661,606,208
Air –Trips	2,683,671	2,210,099	4,315,147	3,517,935
Rail –Trips	852,104	384,621	1,350,189	612,078
Bus – Trips	1,706,388	1,584,391	2,692,828	2,498,457
Induced Demand – Trips		389,618		641,119
Auto – Vehicle Miles Traveled	21,726,019,467	21,607,611,457	34,728,290,926	34,535,942,621
Auto – Person-Hours Traveled	1,037,729,542	1,033,476,129	1,658,209,305	1,651,310,111
Air – Person-Hours Traveled	7,023,260	5,769,955	11,368,951	9,249,579
Rail – Person-Hours Traveled	3,485,561	1,470,861	5,513,733	2,338,679
Bus – Person-Hours Traveled	5,815,971	5,309,507	9,168,567	8,363,236
Induced Demand – Person-Hours Traveled		769,035		1,274,593
Total Fare Revenue		$223,716,400		$360,269,316

Source: Steer Ridership Model

Using these demand projections, the BA can quantify the potential user and social benefits resulting from users of other modes of travel shifting to the UHSGT system and compare the economic value of the alignments.

10.2 Base Scenario Benefits

10.2.1 Travel Time Savings

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities. The estimation of benefits from travel time savings is shown in Table 5.

Table 26: Estimation of Travel Time Savings, Millions of 2019 USD

Ridership Scenario	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$314	$166	$21,109	$5,123
Scenario 2A	$275	$147	$18,828	$4,566
Scenario 1C	$219	$117	$14,922	$3,620

10.2.2 Operational Time Savings

Operational time savings includes the time savings related to avoided flight delays affecting air passengers and airline passenger carriers as a result of congestion at airports. The volume of air passengers at regional airports can impact the security and processing time, plane turnaround time and commuting time for departing and connecting passengers. Due to the on-time scheduling of flight services and the constraints on airport capacity, flight delays at one airport can affect the punctuality of flights throughout the network, resulting in cascading delays for passengers and airline passenger carriers. The estimation of benefits from operational time savings is shown in Table 6.

Table 27: Assumptions for Calculating Operational Time Savings

Assumption Description	Value of Time
Airport Operator Non-Fuel Cost of Delay per Minute of Total Flight Delay[1]	$47.21
"Non-Disrupted" Passenger Delay per Minute of Total Flight Delay[2]	1.06 minutes
"Disrupted" Passenger Delay per Minute of Total Flight Delay[1]	31.19 minutes
Composite Airport Time Delay Propagation Multiplier (SEA & PDX)[3]	1.498
Minutes of Total Flight Delay per Passenger (SEA & PDX)[4]	0.061

[1] Air Transport Association, 2017 US Passenger Carrier Cost of Delay, http://airlines.org/dataset/per-minute-of-delays-to-u-s-airlines/.
[2] National Center of Excellence for Aviation Operations Research (NEXTOR), "Total Delay Impact Study: A Comprehensive Assessment of the Cost and Impacts of Freight Delay in the United States", FAA, 2010.
[3] MITRE Corporation, "Calculating Delay Propagation Multipliers for Cost-Benefit Analysis", US Federal Aviation Administration, 2010.
[4] Bureau of Transportation Statistics, "On-Time Performance – Flight Delays At A Glance", 2019, FAA.

Using these assumptions about the impacts of projected air passenger-trips shifting to the UHSGT system, the estimation of operational time savings for each scenario is described in Table 7 below.

Table 28: Estimation of Operational Time Savings, Millions of 2019 USD

Ridership Scenario	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)

Scenario 1D	$4	$2	$275	$67
Scenario 2A	$4	$2	$249	$60
Scenario 1C	$3	$2	$197	$48

10.2.3 Productivity Gains of Captured Demand and Induced Demand

Since time travel savings defines the difference in travel time for a passenger between two modes of travel as retained productive time, the availability of information and communication technologies (ICTs) and the non-involved nature of traveling by an UHSGT system provides the opportunity for rail passengers to utilize this journey time productively. Auto and air travelers have limited opportunities to conduct productive activities during travel due to the need to operate the vehicle or lack of uninterrupted stretches of time, therefore their travel time is regarded as wasted in time appraisals.[24] However, for UHSGT travelers, the availability of information technologies and the uninterrupted nature of travel enables productive use of travel time for business and leisure travelers. Business travelers using rail services are conservatively estimated to use an hour of their travel time conducting productive work, while about a third of total rail passengers use their travel time in a productive way.[25,26]

Considering the positive utility of travel time for the users of the UHSGT system and that business travelers constitute an average of 18 percent of estimated travel-hours, the assumption was made that 20 percent of the total journey time for the captured demand is utilized for productive activities by leisure and business travelers. The value of travel time used to evaluate these productive gains is a weighted blended rate of values of time of users shifting from one mode of travel to the UHSGT system, retaining consistency with the measurement of the travel time savings.

Induced demand refers to passenger-trips on the UHSGT system that would not have occurred on any other mode of travel; without the UHSGT, the trips would not be taken. As induced demand trips are not shifting from another mode of travel to the UHSGT system, those passengers do not experience a comparative savings in travel time and do not have a value of time relative to other modes of travel. The implicit value of time for induced passenger-trips is therefore defined as their willingness to pay the average fare price to use the UHSGT system. By dividing the number of projected annual passenger-trips by the projected annual revenues for each year in the analysis period, the value for each induced passenger-trips is calculated to be $82.06 USD per passenger-trip. The results of estimating productivity gains for captured and induced demand are shown in Table 8.

[24] Glenn Lyons & John Urry, “Travel time use in the information age”, 2004.
[25], Steer Davies Gleave, “The Case for Rail”, 2002, Transport 2000.
[26] P.L Mokhatarian & I. Salomon, “How derived is the demand for travel? Some conceptual and measurement considerations”, 2001, Transportation Research.

Table 29: Estimation of Productivity Gains of Captured and Induced Demand, Millions of 2019 USD

Ridership Scenario	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$79	$42	$5,346	$1,297
Scenario 2A	$65	$35	$4,411	$1,070
Scenario 1C	$59	$32	$4,004	$972

10.2.4 Emissions Reductions

This project will create environmental and sustainability benefits relating to reduction in air pollution associated with decreased automobile and commercial truck travel. Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide.

Emissions from auto vehicles are calculated based on vehicle-miles traveled using factors determined by the California Air Resources Board (CARB) EMFAC 2017 mobile source inventory database, while the emissions from airplanes are determined by the 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories published by the UN's Intergovernmental Panel on Climate Change (IPCC) based on seat-miles traveled and takeoffs and landings. The social cost of carbon is derived from the 2016 Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis published by the US Environmental Protection Agency (EPA), while the social costs of non-CO_2 emissions are derived from the 2018 BA Guidance published by the USDOT. The social cost of carbon emissions developed by the Canadian government to evaluate the impacts of regulatory processes is provided in Table 9 for comparison.

Table 30: Schedule of Projected Social Cost of Carbon, Dollars per metric ton of CO2 (discounted at 3%)

	2020	2030	2040	2050	2060*	2070*
US EPA[1] (USD2007)	$42	$50	$60	$69	$80	$93
Environment and Climate Change Canada[2] (CA$2009)	$45	$55	$65	$75	$87	$101

*Values are extrapolated beyond 2050 with an average constant growth rate of 1.5% per year

[1] US Environmental Protection Agency, "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis", 2016.

[2] Environment and Climate Change Canada, "Technical update to Environment and Climate Change Canada's Social Cost of Greenhouse Gas Estimates", 2016.

Using the assumptions for the social cost of carbon emissions from the EPA and the social cost of non-carbon emissions from the USDOT, the estimated emissions reductions for the project are described in Table 10 below. The highest reduction in carbon emissions as a result of the project, about 6 million metric tons of CO_2, is equivalent to 670 million gallons of fuel saved or 14.6 million auto roundtrips between Vancouver BC and Portland, OR over the analysis period[27].

[27] US EPA, Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Table 31: Estimation of Emissions Reductions, Millions of 2019 USD

Ridership Scenario	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$23	$12	$1,181	$308
Scenario 2A	$21	$11	$1,087	$283
Scenario 1C	$21	$11	$1,098	$287

10.2.5 Safety and Reduction in Auto Crashes

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from the project. The values of crashes are calculated by the severity of injuries suffered per the Maximum Abbreviated Injury Scale and the Value of a Statistical Life, per USDOT guidance. The variables include fatalities, minor and serious injuries, and property damage of avoided auto crashes. Using the average statewide crash rates per million vehicle-miles traveled (VMT) for highways and major arterials in Washington State derived from 2007 to 2017, the number of avoided crashes is estimated from the reduction in auto vehicle-miles traveled as a result of the project. The results of the safety benefits from the reduction in auto crashes are shown in Table 11.

Table 32: Estimation of Reduction in Auto Crashes, Millions of 2019 USD

Ridership Scenario	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$14	$7	$717	$185
Scenario 2A	$12	$7	$634	$164
Scenario 1C	$9	$5	$457	$118

Source: WSDOT, WSP USA

10.2.6 Vehicle Operating and Maintenance Cost Savings

Vehicle operating cost savings includes the cost of fuel, as well as maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. Consumption rates per VMT are used to calculate the vehicle operating cost savings. Estimates of VMT and unit costs for each component of vehicle operating cost are applied to the consumption rates to calculate the total vehicle operating cost. The estimated reduction in vehicle operating costs, including additional out-of-pocket costs such as user fees and parking fees, are presented in Table 12.

Table 33: Estimation of Vehicle Operating and Maintenance Cost Savings, Millions of 2019 USD

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$52	$28	$2,703	$697
Scenario 2A	$46	$24	$2,396	$617
Scenario 1C	$34	$18	$1,768	$455

10.2.7 Reduction in Pavement Damage

The state of good repair benefits assessed in this analysis include maintenance and repair savings, deferral of replacement cost savings, as well as reduced VMT which leads to less road and pavement damage. The reduction in pavement damages results in savings for the public agencies maintaining the roadways, shown here in Table 13.

Table 34: Estimation of Reduction in Pavement Damage, Millions of 2019 USD

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (4%)	Undiscounted	Discounted (4%)
Scenario 1D	$0.2	$0.1	$10	$3
Scenario 2A	$0.2	$0.1	$9	$2
Scenario 1C	$0.1	$0.1	$6	$2

10.3 Benefit Analysis Base Build Scenario Results

The benefit categories described above represent the productive utility and economic savings of the UHSGT system for users and the net social benefits for non-users in the Cascadia region. The calculation of these benefits is based on the cost savings for the agencies maintaining the road infrastructure, passenger vehicle owners, and airline operators, productivity gains for captured demand and induced demand for the UHSGT system, travel time savings for users of the UHSGT system shifting from other modes of travel, reduced costs of delay for airport passengers, and the reduction of CO_2 and non-CO_2 emissions. These benefits would be generated according to the stated preferences of current users of auto, intercity bus, regional rail and air travel based on travel time, reliability and the comparison of perceived costs. The benefit analysis does not account for changes in travel behavior based on the effect of congestion on roadways and airport facilities or increased travel costs related to managed roadways. The total undiscounted and discounted values of the project lifecycle benefits for each scenario of the project are described in Table 14.

Table 35: Total Project Lifecycle Benefits by Scenario, Millions of 2019 USD

	Total Project Lifecycle Benefits	Total Project Lifecycle Benefits (4% Discount)
Scenario 1D	$56,157	$10,550
Scenario 2A	$52,453	$9,639
Scenario 1C	$47,267	$8,208

11 Sensitivity Testing for Alternative Build Scenarios

As mentioned in the previous section, the modeled ridership in the analysis illustrates the effect of changes in stated preferences for alternative modes of travel in the regional highway network at free-flow capacity, or "unconstrained", speeds. The model does not capture the effects in travel behavior resulting from congestion on the roadways and at airports or any increase in vehicle operating costs, such as rising fuel prices, congestion pricing, or costs of managing roadways.

As the Interstate 5 Corridor is regularly impacted by congestion, especially in the dense urban areas, testing the sensitivity of the modeled ridership to these effects provides an insight into how roadway congestion and rising vehicle costs would impact the shift in travel modes. Table 15 below shows the effect of increases in auto journey times and vehicle operating expenses on UHSGT system ridership, revenue and passenger-miles.

Table 36: Sensitivity Testing of Modeled Ridership, Passenger-Miles and Revenue

Testing Scenario	Ridership	Revenues	Passenger-Miles
Auto Journey Times 10% Longer	9.3%	9.4%	9.3%
Auto Journey Times 20% Longer	18.6%	18.8%	18.6%
Vehicle Operating Cost 10% Higher	0.7%	0.8%	0.8%
Vehicle Operating Cost 30% Higher	2.1%	2.4%	2.4%

11.1.1 20% Increase in Auto Journey Time

The results of the base scenario analysis illustrate how users would shift to the UHSGT system from other modes of travel based on considerations of travel time, service reliability and cost considerations. These stated preferences are based on the assumption of free-flow system speeds, which does not account for the effects of current or future levels of congestion, and does not consider future unplanned or unfunded projects to expand capacity or the deployment of congestion management systems, such as congestion pricing or managed roadways. In such a constrained system, latent demand captures the benefit for local trips to backfill into available capacity on the interstate highway as a result of the mode-shifted auto passengers. The valuation of the latent demand per trip is at least equal to the value of a person's time and the cost of operating the vehicle; in most cases, the user will experience greater utility due to higher travel speeds and/or shorter journey distances by using the interstate highway. The estimation of benefits from latent demand is shown in Table 16.

Table 37: Estimation of Latent Demand Benefits, Millions of 2019 USD

Testing Scenario	Latent Demand Benefits (Undiscounted)	Latent Demand Benefits (4% Discount)
Scenario 1D	$11,324	$2,785
Scenario 2A	$10,021	$2,463
Scenario 1C	$7,214	$1,774

The total benefits and the percentage change in benefits due to a 20% increase in auto journey time are shown in Table 17. Considering the current travel times for auto users on intercity trips, the prevalent congestion in urban areas along the Interstate 5 highway corridor adds significant time to the free-flow trip duration for local commuters and regional travelers above a 20% premium. Portland, Seattle-Tacoma and Vancouver, BC contend with regular congestion on major roadways, extending peak hour traffic to almost half the day.[28]

Table 38: Benefits Due to 20% Longer Auto Journey Time, Millions of 2019 USD

Testing Scenario	Project Lifecycle Benefits	Project Lifecycle Benefits (4% Discount)	Percentage Change in Benefits from Base Scenario
Scenario 1D	$72,168	$14,483	37%
Scenario 2A	$66,392	$13,061	36%
Scenario 1C	$56,344	$10,603	29%

The percentage change in benefits shows the high elasticity of demand for the UHSGT system and the effect of persistent roadway congestion on how users change their travel behavior. In Scenario 1D, UHSGT system ridership increased by approximately 19%, while the total benefits increased by 37%.

[28] WSDOT, “2018 Corridor Capacity Report”, https://www.wsdot.wa.gov/publications/fulltext/graynotebook/corridor-capacity-report-18.pdf.

11.1.2 Additional $0.10 Per Vehicle Mile

As constant congestion increasingly becomes an issue for mobility and economic activity in the region and the conventional funding of roadway improvements proves insufficient, city and state agencies may increase taxes or charge user fees as an additional revenue source or as a tactic for managing roadway use. Conversely, increasing congestion and roadway damage could result in higher vehicle operating costs. A marginal increase of 10 cents per mile, equivalent to a 30% increase in vehicle operating costs, results in an increase in benefits by 3% to 4%, shown below in Table 18.

Table 39: Total Benefits and Change Due to Higher Vehicle Operating Costs, Millions of 2019 USD

Testing Scenario	Project Lifecycle Benefits	Project Lifecycle Benefits (4% Discount)	Percentage Change in Benefits from Base Scenario
Scenario 1D	$57,760	$10,950	4%
Scenario 2A	$53,725	$9,957	3%
Scenario 1C	$48,354	$8,649	3%

The model for the ridership forecast assumed the roadways in the region would not be subject to additional taxes or user charges related to the roadway infrastructure, yet tolled highways are an increasing viable measure for managing roadway congestion and financing roadway improvements in the region. While shifts in ridership seems to be inelastic to changes in vehicle operating costs, changes in travel behavior related to the additional cost of congestion charges or roadway user fees generally occurs in a lockstep fashion, rather than a linear change. On an intercity auto trip, the use of managed roadways could incur an additional one-time cost of $2 to $20, based on the average prevailing rate, the length of trip, and the road facility used. Therefore, the system would see a significant shift in the mode of travel as the cumulative cost of roadway user fees reached a specific threshold, which is not defined in the ridership model.

11.1.3 Required Ridership for Economic Feasibility of the Project

In the context of evaluating the user and social benefits of the UHSGT system, the results of the BA provide value in comparing the monetizable benefits of alternative scenarios. Such an analysis has natural limitations in quantifying the total economic value of a project, as some benefits cannot be captured or monetized, yet have profound effects on the users and the economy. For example, the economic impact of direct expenditures on labor income, employment and business and tax revenues is not considered in the BA model, nor may the total cost of the loss of ecosystem services be captured in the social cost of emissions.

12 Summary of Results

12.1 Benefit Analysis Results

The table below presents the evaluation results for the project. The benefits are estimated in constant 2019 US Dollars over an evaluation period extending 40 years beyond system completion in 2035.

For scenario 1D, the total benefits over the analysis period were estimated at $10.6 billion. For scenario 2A, the total benefits over the analysis period were estimated at $9.6 billion. For scenario 1C, the total benefits were estimated at $8.2 billion. The breakdown of the results of the benefit analysis is shown in Table 19 below.

Table 40: Benefit Analysis Results, Millions of Discounted 2019 USD

BA Metric	Scenario 1D	Scenario 2A	Scenario 1C
Total Benefits	$10,550	$9,639	$8,208

Source: WSP USA

The benefits above provide a way to compare how the alternative ridership scenarios would produce different levels of benefits for users and non-users of the UHSGT system. Due to the assumptions underlying the ridership forecasts, the overall results of the analysis demonstrate a conservative, and by no means exhaustive, estimation of potential user and social benefits. In Section 6.3, the effect of changes in roadway capacity conditions is demonstrated in a series of sensitivity tests to demonstrate the elasticity of demand for the proposed UHSGT system. Evaluating the differences in generated benefits illustrates the scale of social and user benefits associated with the number of stations along the alignment and the system service plan. As the benefits are largely driven by ridership, Table 20 below shows the total benefits over the project lifecycle for each ridership scenario by benefit category.

Table 41: Estimation of Project Lifecycle Benefits by Scenario, Millions of Discounted 2019 USD

Benefit Category	Scenario 1D	Scenario 2A	Scenario 1C
Travel Time Savings	$5,123	$4,566	$3,619
Operational Time Savings	$67	$66	$48
Productivity Gains and Induced Demand	$1,297	$1,070	$972
Emissions Reductions	$308	$283	$287
Safety and Reduced Crashes	$185	$164	$118
Vehicle Operating Costs	$697	$617	$455
Road Condition	$3	$2	$2
Noise	$2	$2	$1
Total	**$7,681**	**$6,770**	**$5,506**

Source: WSP USA

12.2 Sensitivity Testing Impacts on the Benefit Analysis

Sensitivity testing provides insights into how users would change their travel behaviors given certain environmental conditions and how it would affect the generation of user and social benefits. The assumptions underlying the ridership model illustrates how users would change their travel behavior given the option to use the proposed UHSGT system based on their perceptions of travel speed, reliability and convenience of the service. Evaluating the characteristics of the projected ridership allows for the comparison of system performance between modes of travel but does not fully incorporate the effect of travel conditions on travel behavior.

12.2.1 Constrained System with 20% Longer Auto Journey Times

Roadway congestion throughout the Interstate 5 corridor is a constant issue for commuters, intercity travelers and commercial drivers, affecting the mobility of the regional workforce and the development of economic activities. Increasing auto journey times replicates the effect of roadway congestion, an issue particularly affecting urban areas regarded as candidates for station locations. With 20% longer auto journey times, ridership on the UHSGT system would grow by approximately 19%, resulting in an increase in total benefits up to 37%. The change in benefits for each scenario is shown in Table 21.

Table 42: Benefits Due to Longer Auto Journey Time, Millions of 2019 USD

Testing Scenario	Project Lifecycle Benefits	Project Lifecycle Benefits (4% Discount)	Percentage Change in Benefits from Base Scenario
Scenario 1D	$72,168	$14,483	37%
Scenario 2A	$66,392	$13,061	36%
Scenario 1C	$56,344	$10,603	29%

12.2.2 Higher Vehicle Operating Costs Related to Road Usage

As an alternative to modeling the effect of network congestion, city and state agencies may choose to increase taxes or charge user fees as an additional revenue source for maintaining and building new roadway improvements or as a tactic for managing roadway use. Conversely, increasing congestion and roadway damage could result in higher vehicle operating costs. Unlike constant congestion effects, changes in travel behavior related to required user fees or tolls is exhibited in a lockstep fashion when the costs of driving cross the threshold of diminishing returns. As congestion pricing and tolling are more openly discussed in the region’s metropolitan areas to combat congestion, the costs of driving begin to accumulate much faster and higher than modeled here. Table 22 shows the effect of a marginal increase of 10 cents per mile, equivalent to a 30% increase in vehicle operating costs, on travel behavior, yet the mode-shift effect can be expected to significantly higher as the costs of managed roadways can be $2 to $20 per trip.

Table 43: Benefits Due to Higher Vehicle Operating Costs, Millions of 2019 USD

Testing Scenario	Project Lifecycle Benefits	Project Lifecycle Benefits (4% Discount)	Percentage Change in Benefits from Base Scenario
Scenario 1D	$57,760	$10,950	4%
Scenario 2A	$53,725	$9,957	3%
Scenario 1C	$48,354	$8,649	3%

12.3 Balancing Quantitative Analysis with Qualitative Effects

The benefit analysis can be very effective at monetizing user and social benefits using factors developed by industry and governmental sources, yet is limited in capturing all of the benefits associated with a project. Some effects cannot be reasonably quantified and attributed to the performance of the system or are outside of the scope of the analysis. The region will experience latent beneficial effects resulting from the construction and operation of a high-speed transportation system in the corridor, including improved access to employment, housing and recreational opportunities and reliable multimodal connectivity between local and regional transportation systems. High-speed rail stations are frequently the hub for high-density commercial and residential development, serving as centers for leisure and economic activities while providing convenient and timely connections to the rest of the region at a performance beyond other modes of travel. While most likely not the primary option for commuters, the utilization of the UHSGT system by intercity travelers will free up capacity on roadways and rail transit for local and commuter trips and in airports for connecting and international air travelers. The outputs of the benefit analysis provide a comparison of the economic benefits of alternative alignments and levels of service for the UHSGT system, but, due to the constraints of the inputs in this stage of the planning, it cannot be a reasonable determinant of the project’s overall economic feasibility. In addition to the user and social benefits described in the benefit analysis, the economic feasibility of the UHSGT system will be determined by analyzing the economic impact of the system’s construction and operation and the examining how the system enables the development of the megaregional economy.

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix B

Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion

July 2019

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Executive Summary

This memorandum highlights the potential benefits from investment in ultra-high-speed ground transportation (UHSGT) in light of the unique economic attributes of the Cascadia megaregion. The Cascadia megaregion is defined as the area stretching from the city of Eugene in central Oregon to the coastline cities of Vancouver and Victoria in the Canadian province of British Columbia. The megaregion economy's unique characteristics include its commitment to environmental sustainability and strong industry clusters in creative, manufacturing, and technology-driven fields. The megaregion has a population of 9.1 million and employment of 6.6 million, largely driven by the three major metropolitan areas of Portland, Oregon, Seattle, Washington, and Vancouver/Surrey, British Columbia.

UHSGT has the potential to be a transformational investment in the economies of the Cascadia megaregion. In addition to conventional benefits of infrastructure investment, such as reduced journey times and less congestion on existing highways and at airports, UHSGT unlocks more transformative benefits including:

- Enhanced connectivity between geographically distant cities, resulting in more integrated regions that can function like a single, more diversified economy
- A deeper labor markets for employers, thanks to enhanced connectivity Greater access for workers to a broader pool of employers and range of industries
- Enhanced interregional connectivity to facilitate greater housing choices in areas with supply and affordability constraints

Major structural barriers – such as the international border -- hindering regional economic growth, such as constrained pools of labor or a lack of affordable housing, are not easily mitigated through conventional public policies and investments, despite the best efforts of state and local public stakeholders. Coupled with an effective set of policies and cohesive mix of public and private stakeholder strategies, UHSGT can play a catalytic role in mitigating these structural barriers, helping to develop a stronger, more integrated Cascadia megaregion better positioned to compete in the 21st-century global economy.

Such enhanced connectivity will result in several economic benefits, including:

- The creation of new regional industry clusters and higher growth potential of existing industry clusters
- Stronger growth potential for businesses, resulting from access to a larger and more diverse pool of labor
  - Increased equity for workers and residents in the form of dramatically improved access to housing and job opportunities
  - Greatly reduced costs in the region as a whole and positive environmental impacts from lower motor vehicle and air travel.

Furthermore, a high-speed transit spine from Portland, Oregon to Seattle, Washington to Vancouver/Surrey, British Columbia would maximize the value of existing transportation networks through enhanced multimodal connectivity and reduced travel times for the region's employees, residents, and visitors.

Based on research of the economic benefits of a regional high-speed transportation systems, a UHSGT system in the Cascadia megaregion would accelerate the growth of the high-value industries associated with the modernized knowledge economy. UHSGT will improve connections between industry clusters, enterprise accelerators, world-renown research institutions, qualified labor, and financial and logistics organizations by providing fundamental services for a strong regional economy.

The success of a megaregion relies on reducing the barriers of time and space between communities, high-value employment, foundational and emerging industries and socioeconomic institutions with innovative land use practices grounded by a reliable, multimodal transportation system. A UHSGT system brings a region closer together, enabling greater access to growing opportunities for our communities, businesses and cities.

Previous analyses estimate 2 to 3 million new job-years and a $300 billion boost in gross domestic product (GDP) from UHSGT investment

The 2017-2018 Ultra-High Speed Ground Transportation Plan Feasibility Study (2017-2018 Feasibility Study) estimated the economic impact of a high-speed system between Vancouver and Seattle. Results of this initial analysis included the following economic impacts:

Table ES-1: Previous Analysis of Economic Benefits of a High-Speed System Between Seattle and Vancouver[29]

Employment Impacts	2.4 to 3.4 million total additional job-years of employment
Economic Growth	$264 billion to $355 billion in additional GDP

These results are based on estimates of reduced travel times between the two economies and the resulting benefits to businesses, including far greater access to labor, suppliers, and customers resulting from the delivery of UHSGT.

Project capital costs alone will generate several hundred thousand job-years from the planning and construction of the system, in addition to the economic impacts stemming from the many resulting benefits of the project noted above. Job-years are defined as the equivalent number of one-year-long, full-time jobs supported by the project. For example, if one full-time job is supported for two years, it therefore represents two job-years. This

[29] https://www.wsdot.wa.gov/publications/fulltext/LegReports/17-19/UltraHighSpeedGroundTransportation_FINAL.pdf

metric is particularly useful to evaluate the planning and delivery phase of major infrastructure projects, which are characterized by a ramp-up of expenditure and activities in various sectors over several years, such as engineering and other professional services in earlier stages, and construction-related activities in later phases of the process. Previous economic analyses of major infrastructure investments show a wide range of job-year impacts, from approximately 8,000 to 12,000 job-years per $1 billion in capital spending. Assuming the midpoint of that range (10,000 job-years per $1 billion), the capital cost estimate range ($24 billion to $42 billion) from the 2017-2018 UHSGT Study suggests that delivering the project will generate 240,000 to 420,000 job-years of employment.

Regional business leaders reiterate the real-world economic challenges that UHSGT will solve

Economic modeling of large-scale employment and economic growth can sometimes be difficult to tie to the tangible, real-world issues facing businesses and employees today. Therefore, in support of the 2019 UHSGT Business Case Analysis, stakeholder interviews were conducted to help shed light on how UHSGT will help solve issues that are at the front of the minds of the region's business community. A number of business stakeholders provided feedback about the need for a high-speed rail system to facilitate the continued development of the regional economy. The interviewees shared their insights into current and foreseeable difficulties in their own and similar organizations, acknowledging that they were without an adequate solution for meeting the current challenges.

According to the business stakeholders interviewed, a new regional UHSGT system would provide the six overarching economic benefits shown in the following table.

Table ES-2: Key Themes from Stakeholder interviews

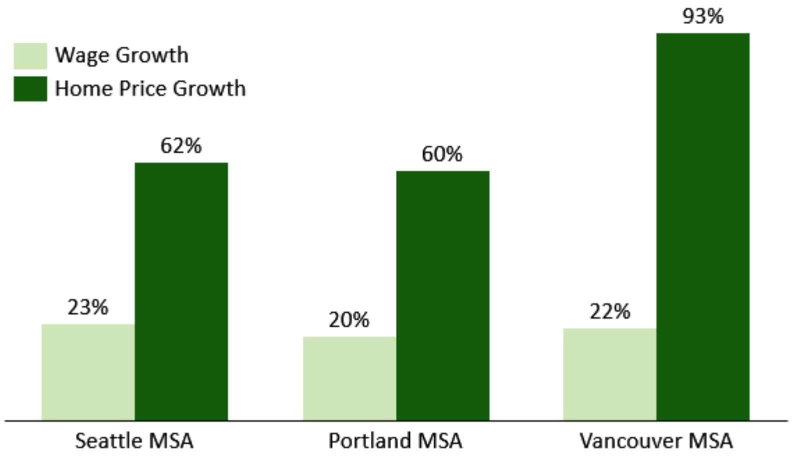
	UHSGT Benefits Identified by Stakeholders
1.	Regional economic integration due to greater connectivity
2.	Access to a larger, more cohesive pool of qualified talent throughout the region
3.	Increased affordable housing opportunities and choice
4.	Support for specialized freight movement in e-commerce and technology-based industries
5.	Significant economic benefits to specific industries uniquely positioned to benefit from much broader regional access and reach, including: • sports and entertainment industries • aviation and ocean transportation sectors, including the cruise ship industry
6.	Facilitation of research collaboration among business enterprises, universities and public and private research institutions

These stakeholders view the UHSGT system as a tool for both overcoming existing structural economic challenges in the region, as well as a unique opportunity to unlock economic transformation and untapped potential in the region.

UHSGT will provide the region's workforce and residents with a larger, more diverse economic opportunity and housing choice

In a region facing the challenges of some of the highest housing costs in North America, the lack of equitable access to housing amidst a steadily growing demand presents a drag on the regional economy. High living costs can negatively affect the recruitment of necessary qualified talent, push disadvantaged residents further away from opportunities in employment and education, and discourage the recruitment of new businesses and the expansion of existing industries, dampening overall economic growth and increasing socioeconomic disparities.

Figure ES-1: Growth in Mean Annual Wage and Home Prices in Metropolitan Areas of Cascadia Megaregion, 2010-2018



Sources: OECD Data, Statistics Canada, Bureau of Labor Statistics, Zillow, Canadian Real Estate Association

UHSGT would sustain and build upon the growth already underway in these cities by improving the time, convenience, and connections along the corridor, while alleviating the cost pressures of businesses and residents concentrating in urban cores. UHSGT would decrease the constraints of distances, providing employers with greater access to a larger pool of qualified labor, while residents would have access to a greater variety of employment, education and housing options. The improved regional network connectivity could enable high-density residential development in urban cores, reduce congestion on roads and at airports, and improve transit access between intermediate cities and urban cores.

UHSGT will spur station area development opportunities

Transit hubs, such as commuter and intercity rail stations, are attractive destinations for commercial users and households seeking the benefits of proximity to multi-modal access. As a result of this demand, high-density development opportunities will be created at UHSGT station areas. These new development opportunities will further add to the potential for increased housing choice cited above and generate increased fiscal revenue to local jurisdictions from property taxes and on-site economic activity. Studies determined the effects of a high-speed rail system are generally underreported in conventional economic impact analyses, yet effectively support residential and commercial development in urban cores and intermediate cities. For example, recent experiences with high-speed rail projects in the United Kingdom report an almost 50% increase in permits for residential and commercial development around new Crossrail stations with significant increases in fiscal revenue driven by the development.

UHSGT will improve economic linkages and catalyze continued growth

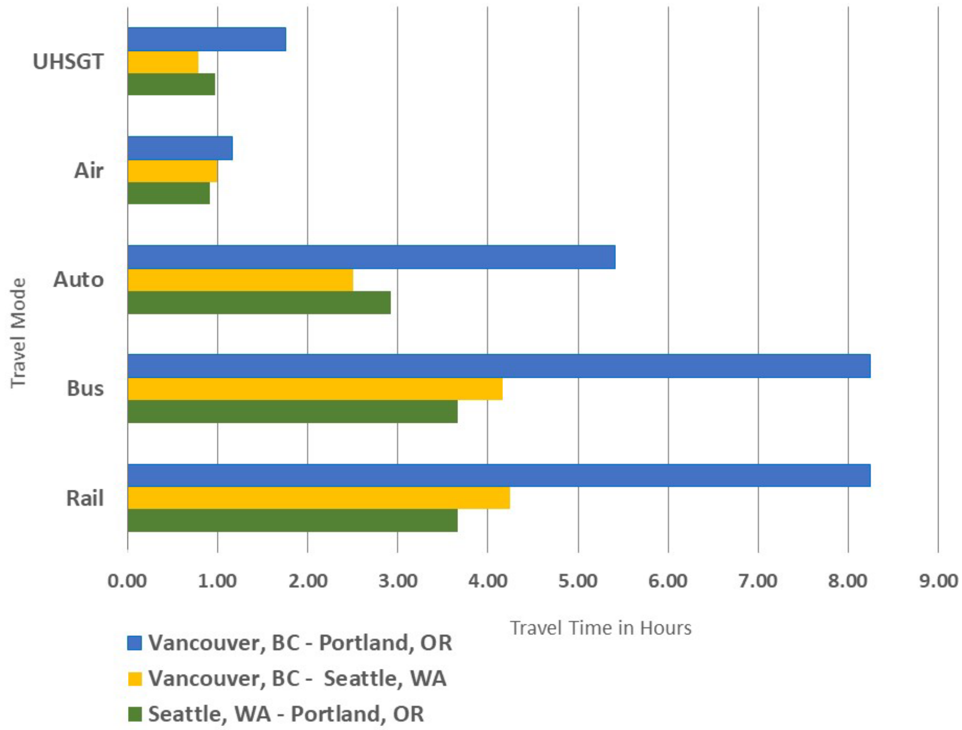
A substantial body of research describes the impact of a high-speed rail system on the trend for similar firms to group together, known as "agglomeration," to take advantage of local suppliers and clients, share transportation and logistics networks, and develop economies of scale. As businesses active in the knowledge economy increasingly gravitate towards dense urban areas to attract qualified employees and build connections to wider markets, a regional UHSGT system offers the flexibility, performance and connectivity to join them. While Portland, OR, Seattle, WA and Vancouver, BC are individually competitive in a number of traditional and high-tech industries, as a megaregion, local firms can leverage shared advantages in complementary industries to grow beyond their local environments.

UHSGT will reduce the barriers of geography in linkages between labor, businesses, research institutions, financing organizations and logistics companies. These linkages provide the critical ingredients for growth in the knowledge economy. The Cascadia Venture Accelerator Network, a group of about 50 industry partners in finance, information technology, research and entrepreneurial enterprises from Oregon, Washington and British Columbia, identified the development of regional transportation linkages as a key driver for innovation. A new UHSGT system would facilitate the connections necessary for the region to continue competing in the global market and to meet the social and technological challenges of the 21st Century.

UHSGT will reduce travel times and congestion on existing roadways

Another key source of value for the system is in the shorter journey times for users due to faster average travel speeds, shorter wait times, greater service reliability and access to transit. UHSGT is a competitive option compared to auto, bus and air travel, with UHSGT express travel between the three major hubs being completed in just under an hour.

Figure ES-2: Travel Time (hours) by Mode



The flexibility, convenience and performance of a new UHSGT system is projected to shift travelers from road and air travel, while inducing new demand for trips which would not otherwise happen. The resulting mode-shift would help alleviate road congestion in urban areas and major highways throughout the corridor, reducing delays for commuters, freight traffic and local residents. In addition to economic benefits, high-speed rail systems exhibit a substantially lower fatality rate than all other surface transportation options. Passenger traffic diverted from auto and bus travel would therefore result in fewer deaths and injuries due to the lower overall average incident rate.

UHSGT is a key ingredient to competing on a global economic scale

The Cascadia megaregion has several key elements that position it to compete in the global economy of the 21st century, including strong concentrations of high-growth, knowledge-economy sectors focused on innovation, a well-educated workforce, and an attractive physical landscape and focus on sustainably maintaining the environment, to name a just few key strengths. However, the region faces several challenges that are typical of robust, high-growth economies that represent potential barriers to future economic growth and resilience. Many of these issues are interconnected and a byproduct of rapid regional growth, such as increasingly limited housing supply, insufficient access to labor force, and traffic congestion, that serve to reduce overall livability, quality of life, and future growth potential. Such issues will eventually reduce the region's ability to attract new businesses, hamper growth of existing businesses, and reduce the region's attractiveness to potential new employees and households. Just as the Cascadia megaregion has benefited from businesses and employees seeking to avoid the extreme costs borne by the unsustainable growth of the Bay Area, the economies that comprise the megaregion will eventually experience similar outcomes without major, structural investments in its infrastructure.

UHSGT will be an expensive, unprecedented infrastructure project that many may consider to be “aspirational” in nature. However, few investment alternatives have the potential to generate structural economic benefits that serve to overcome major barriers to continued economic growth, such as the enhanced industry diversity needed to be resilient to economic cycles, improved access to housing, and access to a larger, more diverse labor force. Such an investment will position the Cascadia megaregion for sustainable, long-term economic growth and global competitiveness.

13 Project description and previous economic analysis

The Washington state Governor's office and State Legislature asked the Washington State Department of Transportation (WSDOT) to study ultra-high-speed ground transportation (UHSGT) from Vancouver, British Columbia, to Portland, Oregon. The proposed investment would facilitate safer, faster, more reliable, and environmentally friendly travel within the 310-mile (500-kilometer) corridor. Development of the project would facilitate regional connectivity by enhancing mobility between the three major city centers constituting the core of the Cascadia megaregion. The initial phase of the proposed transportation investment would focus on providing a high-speed alternative to travelers between Portland, Oregon; Seattle, Washington; and Vancouver, British Columbia. Figure 1 illustrates the Cascadia megaregion and its corresponding metropolitan centers.

Figure 20: Cascadia Megaregion

Source: America 2050[30]

Major infrastructure projects such as UHSGT can have significant impacts on the regional economy, supporting businesses in creating new jobs as well as jobs directly generated due to the project. Such a system also provides the opportunity to build additional housing and helps enable the region to grow in a more environmentally sustainable fashion. In addition, the ability to shift demand away from roads and airports will reduce congestion on existing transportation routes, which will yield further benefits.

The 2017-2018 Feasibility Study[31] included a preliminary economic impact analysis focused strictly on quantitative economic metrics including jobs per year, labor income, business output, and value added resulting from spending on project spending on construction and operations and maintenance, and from the benefits of greater market access resulting from the system. The assessment included the use of a highly theoretical and conceptual framework, assumptions, and high-level modeling tools.

The full methodology and findings can be found in the technical memo referenced in the note. In summary, the Federal Railroad Administration's (FRA) CONNECT modeling tool was used to estimate travel demand and travel times for market sheds for several hypothetical connections between Vancouver, BC, Seattle, WA and Portland, OR. To estimate wider economic impacts from agglomeration effects, the TREDIS economic modeling tool was employed. The TREDIS model, well established within the transportation economics community, estimates the impact of greater market access for firms to labor and to end user and other intermediate supplier markets to obtain impacts on the productivity, output, and employment of firms. Based on changes in market access to different-sized labor market sheds, the TREDIS model estimated that the theoretical UHSGT system would generate between 116,000 and 160,000 new permanent jobs on average per year over a 21- year analysis period – about a 2 percent upward increase in regional employment.

While this result is informative, it has limitations, and additional modeling would be beneficial in future stages of work. Limitations include the following:

[30] America 2050. http://www.america2050.org/cascadia.html
[31] WSDOT Ultra-High-Speed Ground Transportation Feasibility Study, February 2018. https://www.wsdot.wa.gov/publications/fulltext/LegReports/17-19/UltraHighSpeedGroundTransportation_FINAL.pdf

- The TREDIS model did not include the impact of connections to Portland.
- The CONNECT model is a sketch planning tool; the travel demand modeling work being done in this phase is far more sophisticated, being based on stated preference survey work.

TREDIS does not account for the potential transformational effects of an UHSGT system. It essentially assumes a static economy, remaining essentially constant in terms of its structure, mix of industries, efficiency, land use patterns, etc.

Given the unknowns of the project, the results of that analysis were described as an “early first look” at the economic development potential of the project and are based on economic modeling approaches based on available information at that time. This megaregion report builds on the preliminary quantitative analysis by providing more context on the unique characteristics of the economy of the Cascadia megaregion, and a review of literature and analysis of the economic impacts of existing high-speed systems. The following sections will explore some of the most significant economic impacts which are likely to occur in the Cascadia megaregion as a result of delivering UHSGT.

14 Cascadia region context

The states of Washington, Oregon and province of British Columbia historically share common identities along economic linkages and social directives across state and national borders, demonstrating exemplary cross-border relations between the US and Canada. Global firms headquartered in the Seattle, WA area, such as Amazon, Microsoft and Weyerhaeuser, maintain satellite offices in Vancouver, BC to leverage the local qualified workforce, industry cluster linkages, and access to international markets. Likewise, Portland, OR and Vancouver, BC based companies, such as Nike and Lululemon, have an employment presence throughout the Cascadia megaregion. Organizations, such as the Cascadia Innovation Corridor Coalition and Cascadia Venture Acceleration Network, build strategic relationships across regional networks between entrepreneurs, innovators, policymakers, industrialists, and academics to strengthen inter-sector ties in a bid to foster economic development and improve our quality of life. The cities and people in the region continually demonstrate a collective attitude of leveraging innovative thinking and technologies to develop solutions for pressing regional and global challenges. The addition of a new UHSGT system would facilitate the logistics of these critical interactions to be globally competitive and would symbolize the positive economic and technological direction of the Cascadia megaregion.

14.1 Historical economic and demographic context

Cascadia is a diverse megaregion driven by a vibrant demographic profile and a robust economy. The megaregion is comprised of several economic clusters focused on high value-added industries, as well as traditional resource that have supported the megaregion's impressive growth. Accordingly, increased connectivity within the megaregion is likely to continue to foster this dynamic, as well as enhance its economic development potential.

As noted in the previous feasibility study, the economic development of each of the metropolitan areas of the Cascadia megaregion – Portland, OR, Seattle, WA and Vancouver, BC – have somewhat similar histories. [32] Each grew as resource-based regional economies tied to their ports and internal river systems connecting to agricultural and other resource hinterlands. Post-World War II, the economies of each metropolitan region diversified. Seattle's economy was led by major manufacturing activity spearheaded by Boeing and associated aerospace manufacturing. In Portland, Nike and Intel, among others, led the economic boon. Vancouver's post-war economy, by contrast, was somewhat more financial services-based, led in part by its ties to investors from Asian nations. A second and even greater wave of development occurred with technology leaders such as Microsoft and Amazon, headquartered in greater Seattle.

As also noted in the feasibility study, significant amounts of cross-border investment and operations occur between Seattle, WA and Vancouver, BC indicating a growing need for free movement and exchange of people and ideas, internally within firms and among different but related firms. This is particularly found across the border between the U.S. and Canada. For example, Microsoft, Amazon, and Tableau Software all are headquartered in Seattle, WA but have established satellite operations in Vancouver, BC. Refer to Table 1 for an overview of population and employment in the Cascadia megaregion.

Table 44: Summary Statistics of Major Metropolitan Centers in the Cascadia Megaregion

City Center	Population, City[1 2]	Population, Metro Area[3 4]	Total Employment, Metro Area[5 6]	Total Employment Growth (MSA) 2010-2017[7]	Population Growth (City)[8] 2010-2017
Portland, OR	647,805	2,451,560	1,279,700	16.14%	10.7%
Seattle, WA	724,745	3,867,046	2,051,300	20.5%	18.7%
Vancouver, BC	631,486	2,463,431	1,276,900	7.99%	4.6%
Total	2,004,036	8,782,037	4,258,884	15.59%	11.4%

[1] US Census. 2017. https://censusreporter.org/
[2] Statistics Canada. 2016. https://www12.statcan.gc.ca/census-recensement/2016/
[3] US Census. 2017. https://censusreporter.org/
[4] Statistics Canada. 2016. https://www12.statcan.gc.ca/census-recensement/2016/
[5] Bureau of Labor Statistics. 2018. https://www.bls.gov/eag/
[6] Statistics Canada. 2016. https://www12.statcan.gc.ca/nhs-enm/
[7] Calculated as the total growth rate from 2010 to 2017 for the reference area (2011 to 2016 for Vancouver).
[8] Calculated as the total growth rate from 2010 to 2017 for the reference area (2011 to 2016 for Vancouver).

[32] "Ultra-High Speed Ground Transportation Study: Initial Estimate of Economic Impacts," Memorandum prepared for Scott Richman, by Toni Horst et al, AECOM, January 29, 2018.

14.2 The Cascadia megaregion – how does it compare in the global economy?

The “America 2050” initiative by the Regional Plan Association (RPA) is a major research undertaking to identify groupings of metropolitan areas with strong regional socioeconomic linkages, including employment centers, housing communities, and transportation systems.[33] The RPA identified 11 “super” megaregions in the U.S. and Canada, including the Northeast Corridor from Washington, DC to New York City to Boston; the Texas Triangle with Austin, Dallas-Fort Worth, and Houston; the areas of Southern and Northern California; the Great Lakes area; the Greater Toronto and Hamilton area in Canada; and the Cascadia megaregion.

The Cascadia megaregion is defined by the RPA as the entire area from the city of Eugene in central Oregon to the coastline cities of Vancouver and Victoria in the Canadian province of British Columbia. It can be characterized by its commitment to environmental sustainability while hosting industry clusters in creative, manufacturing, and technology-driven fields.

14.2.1 Statistical measures of global size and competitiveness

The metropolitan areas of Seattle, WA, Portland, OR and Vancouver, BC are among the top economic performers in North America. Their combined resources of labor and capital in an integrated megaregion economy would be comparable to global economic leaders. Compared with its North American peer metropolitan areas, the combined employment in the principal metropolitan areas of the Cascadia megaregion is ranked second-highest in 2018 and fourth-highest for population, as shown in Table 2. Note that these comparisons are restricted to metropolitan areas; they are not megaregion comparisons. Still, they reflect a general comparison of the size of Cascadia’s combined urban concentration compared with other peer metropolitan areas. Were the Cascadia region’s constituent metropolitan areas to be connected by an UHSGT system, they might essentially become one extended metro area.

Table 45: Employment and Population by Metropolitan Area in North America, 2018

Metropolitan Area	Employment (2018, Ranked Order)	Population (2018)	Population Ranking of All Metros
New York-Newark-Jersey City, USA	9,835,600	19,979,477	1
Cascadia	**6,596,900**	**9,068,178**	**4**
Los Angeles-Long Beach-Anaheim, USA	6,163,000	13,291,486	2
Chicago-Naperville-Elgin, USA	3,781,500	9,498,716	3
Dallas-Fort Worth-Arlington, USA	3,433,700	7,539,711	5
Toronto, CAN	3,353,000	6,341,935	7
Houston-The Woodlands-Sugar Land, USA	3,083,400	6,997,384	6
Philadelphia-Camden-Wilmington, USA	2,940,500	6,096,372	10
Atlanta-Sandy Springs-Roswell, USA	2,787,100	5,949,951	11
Washington, DC-Arlington-Alexandria, USA	2,706,600	6,249,950	8
Miami-Fort Lauderdale-West Palm Beach, USA	2,682,000	6,198,782	9
San Francisco-Oakland-Hayward, USA	2,440,200	4,729,484	14
Montreal, CAN	2,187,100	4,255,541	17
Phoenix-Mesa-Scottsdale, USA	2,107,900	4,857,962	13
Detroit-Warren-Dearborn, USA	2,032,100	4,326,442	16

Sources: US Bureau of Labor Statistics, Statistics Canada, US Census Bureau

[33] America 2050. http://www.america2050.org/cascadia.html

Using international data from the Organisation for Economic Co-operation and Development (OECD) in 2016, the combined production output, measured in terms of Gross Domestic Product (GDP), of the principal metropolitan areas in the Cascadia megaregion ranked 11th among the top 20 large individual metropolitan areas of OECD members from around the world, as shown in Table 3. Most of the comparable metropolitan areas in the table include multiple metro areas; for example, Dallas, TX includes both the cities of Dallas, TX as well as Fort Worth and Arlington, TX. The individual domestic production values for Seattle, WA, Portland, OR and Vancouver, BC are included in Table 6 for additional comparison.

Table 46: GDP in Constant 2016 US Dollars by Metropolitan Area in OECD

Ranking	Metropolitan Area	GDP (millions US$, 2016)
1	New York (Greater), NY	$1,520,918
2	Tokyo, JPN	$1,504,564
3	Los Angeles (Greater), CA	$1,042,052
4	Seoul, KOR	$846,565
5	Paris, FRA	$759,198
6	London, UK	$717,772
7	San Francisco (Greater), CA	$662,582
8	Washington, D.C. (Greater), USA	$638,466
9	Higashiosaka, JPN	$604,868
10	Chicago, IL	$597,417
11	***Cascadia***	***$560,056***

Due to geographical differences amongst the metropolitan areas included in the top rankings, comparing the combined total productivity of the principal metropolitan areas in the Cascadia megaregion introduces some potential error and distortion in the comparisons. Calculating the productivity per capita of the metropolitan areas, as shown in Table 4, provides a more standardized measure of the region's relative productivity. The Cascadia region is among the best performing metropolitan areas in the OECD by growth in productivity per capita over the last 10 years, indicating the collective economic strength of its individual metropolitan areas. The benefits of improved high-speed transportation linkages throughout the region would take advantage of the economic potential of its individual metropolitan areas for greater productivity gains.

Table 47: GDP per Capita in Current-day US Dollars of Top 20 Metropolitan Areas by GDP in OECD, 2016

Metropolitan Area	GDP per capita (US$, 2016)	10-Year % Change in GDP per Capita (2006-2016)
San Francisco (Greater), CA	$99,041	19.0%
Seattle, WA	$79,894	13.4%
Boston, MA	$78,993	12.0%
New York (Greater), NY	$75,092	10.1%
Washington, D.C. (Greater), USA	$70,828	3.9%
Cascadia	***$65,463***	**10.8%**
Portland, OR	$65,113	7.9%
Philadelphia (Greater), PA	$65,021	11.5%
Paris, FRA	$62,806	12.0%
Chicago, IL	$62,581	6.2%

Metropolitan Area	GDP per capita (US$, 2016)	10-Year % Change in GDP per Capita (2006-2016)
Houston, TX	$62,239	-5.1%
Dallas, TX	$61,666	5.0%
London, UK	$59,892	8.5%
Los Angeles (Greater), CA	$58,372	7.9%
Atlanta, GA	$57,801	0.3%
Miami (Greater), FL	$48,580	-5.3%
Toronto, ON	$44,780	6.6%
Vancouver, BC	$43,459	6.3%
Tokyo, JPN	$42,420	-2.2%
Toyota, JPN	$41,866	0.7%
Higashiosaka, JPN	$36,014	3.5%
Seoul, KOR	$35,202	26.8%
Mexico City, MEX	$23,038	4.4%

14.3 Business clusters, megaregions, and UHSGT

A key to understanding the benefits of UHSGT relates to how modern knowledge-based economies compete and grow. Instead of focusing on individual firms, growth increasingly depends on the development of business clusters. These are characterized by complex networks and synergies among industries and institutions, involving a range of interrelated activities such as research and innovation, financing, production, management, public policy, and infrastructure. Harvard Business School's Michael Porter – the world's leading academic expert in economic clusters – has consistently noted the importance of transportation links as one of the contributors to cluster growth and competitive advantage.[34]

While better accessibility contributes to an area's productivity and to the strengthening of business clusters in general, UHSGT is uniquely suited to *linking* areas across megaregions and to strengthening major economic clusters. Clusters are stronger, more productive, and more competitive when the "density" of interactions increases. Megaregions, anchored by one or more Global Cities, provide the basis for competing at a global scale – US megaregions need to compete against existing and emerging global cities in Asia, Latin American, and elsewhere. [35] The competition from these emerging areas – many of which have or are developing advanced high-speed rail networks (HSR)[36] – will be fierce.

There is a growing body of theory related to the economic and social interactions that characterize megaregions and the benefits of high-speed rail in strengthening them. The University of Chicago's Saskia Sassen – a leading expert on Global Cities – has characterized the potential for competitive advantage arising from increased diversity of economic and social interactions:

> *"…a megaregion can incorporate diversity into a single economic megazone. Indeed, in principle, it could create conditions for the return of particular (not all) activities now outsourced to other regions or to foreign locations. This would expand the project of optimizing growth beyond the usual preference for state-of-the-art sectors (such as office and science parks) and include a greater diversity of economic sectors."* [37]

[34] Michael Porter, "Location, Competition, and Economic Development: Local Clusters in a Global Economy" *Economic Development Quarterly*, Vol. 14. No 1. February 2000.
[35] Saskia Sassen, *The Global City: New York, London, Tokyo.* 2000. Princeton; Sassen, *Cities in a World Economy*. 2000. Thousand Oaks, California.
[36] Note: this report references research and findings from studies of existing high-speed rail (HSR) networks; UHSGT represents a broader definition, which could include HSR, magnetic levitation (maglev), and/or hyperloop. For the purposes of this report, economic findings specific to existing systems leveraging HSR technology are assumed to have relevance to UHSGT more generally.
[37] Saskia Sassen, "Megaregions: Benefits Beyond Sharing Trains and Parking Lots?", in *The Economic Geography of Megaregions*, published jointly by the Policy Research Institute for the Region, Woodrow Wilson School, Princeton and the Regional Plan Association as part of America 2050. 2007.

Other researchers also have focused on megaregion growth and global city competitiveness: Peter Taylor's Globalization and World Cities Project notes the importance of expanded and more efficient international air service connections, something which the UHSGT system in the Cascadia megaregion could greatly enhance. The Globalization and World Cities Project ranks cities such as London, New York, Paris, Tokyo, and Los Angeles as "alpha" world cities and several up-and-coming locations such as Sao Paolo, Madrid, Moscow, Seoul, and San Francisco as "beta" world cities due to a number of factors including the quality of local, regional and international transportation links.[38]

Case studies of specific industries confirm the potential for increased economic integration among areas served by an UHSGT system. A study conducted on behalf of the orthopedics industry in Warsaw, Indiana, the largest concentration of orthopedics developers and manufacturers in the United States, found significant productivity benefits and substantial potential for increasing critical face-to-face interactions among researchers, teaching hospitals, national surgeon leaders, equipment vendors, and sales representatives. In addition, the connectivity provided to Chicago, IL and the rest of the Midwest high speed rail network was considered by industry executives to be critical to future recruitment and retention.[39] In Texas, several Houston-area business advocacy organizations recognized the economic development potential of the Texas Central high-speed rail project connecting Houston to Dallas, TX the state's two largest commercial centers, representing half of the state's population.[40] In the UK, the HS1 high-speed rail link utilized by cargo rail services, domestic commuter services, and Eurostar passenger services connecting London to cities in continental Europe generated at least $5 billion in economic and social benefits in its first ten years of service.[41]

From a megaregional perspective, transportation and communications linkages prominently factor into enabling the increased development of knowledge-sharing activities, such as arts and cultural production, research and development, and regional commerce. The industries strongly linked to a knowledge-based economy center around personal communications and movement, including business services; biotechnology research; information technologies development; music and film production; advanced manufacturing; and marketing, design, and publishing. Improved transportation and communication linkages reduce the costs and geographical barriers associated with the movement of qualified labor and goods and services, thereby enhancing regional economic productivity.

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[38] Globalization and World Cities Project: For list of Alpha and Beta cities, see http://www.lboro.ac.uk/gawc/citilist.html
[39] Parsons Brinckerhoff, for Orthoworx, Economic Impacts of Midwest High Speed Rail on the Orthopedics Industry in Warsaw, Indiana, January 2011. http://orthoworxindiana.com/newsletters/Passenger-Rail-Study-1_11_2011.pdf
[40] Texas Central High-Speed Rail, "Houston-Area Business Organizations Show Support for Texas' High-Speed Train". https://www.texascentral.com/posts/houston-area-business-organizations-show-support-texas-high-speed-train/
[41] Global Rail News, "Economic benefits of HS1 revealed as high-speed line turns 10". https://www.globalrailnews.com/2017/09/18/economic-benefits-of-hs1-revealed-as-high-speed-line-turns-10/

15 Economic impacts of UHSGT

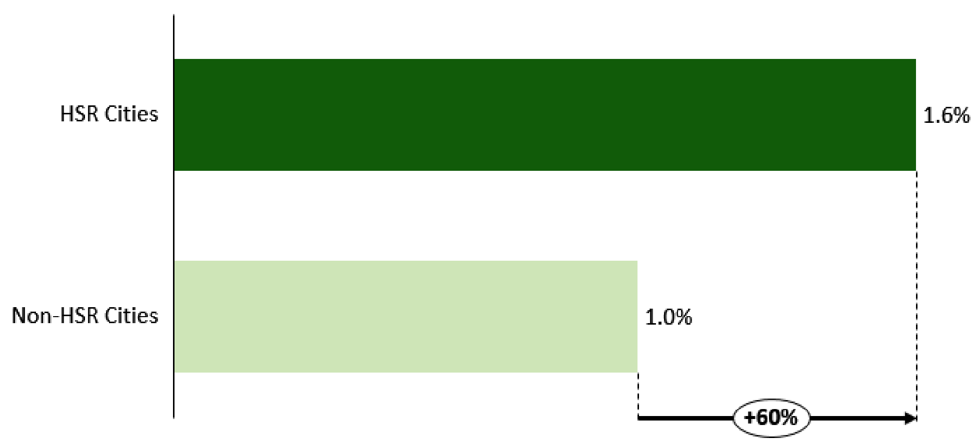
15.1 Megaregions in the research literature

A strong consensus exists among academic researchers – in fields such as economics, geography, business, and management – that investment in transportation infrastructure such as UHSGT fosters increased economic productivity and contributes strongly to a region's competitive advantage. In addition, high speed rail uniquely facilitates increased face-to-face interactions among high-value activities – for example, among scientific and technical research and universities, corporate headquarters, global finance and business services, and media and cultural centers.

Researchers such as Daniel Graham at the University of London – a major contributor to new methods of economic evaluation of transportation investments in the UK – have documented the impact of high-speed rail in achieving "agglomeration" economies, which arise because of the advantages that result to firms from the concentration of economic activities near one another.[42]

A growing body of literature suggests that agglomeration benefits are significant. One researcher found that traditional economic models underestimate the economic impact of high speed rail investment associated with agglomeration benefits by 10 to 80 percent.[43] Other studies from Europe, using sophisticated economic models, suggest that agglomeration-related economic benefits will account for up to 40 percent of total benefits, with a likely range of 10 to 20 percent.[44] As shown in Figure 2, Studies of Japanese cities with HSR stations showed areas achieved average population growth rates of 1.6 percent while bypassed cities grew at 1 percent, indicating that cities with stations have the potential to capture significantly more than their fair share of regional growth.[45]

Figure 21: Average Annual Population Growth in Japanese Cities with and without HSR Stations



Similarly, intermediate German cities connected via high speed rail to Frankfurt and Cologne experienced a 2.7 percent increase in GDP due to the increase market accessibility to the larger cities.[46]

15.2 Agglomeration benefits of UHSGT – value unlocking mechanism

As described, the development of the UHSGT project would allow for safer, faster, more reliable, and efficient travel among the three major city centers of the Cascadia megaregion. The continued development in these metropolitan areas will lead to greater density in population and economic activities, resulting in the exponential growth in potential and acting as a multiplier of agglomeration benefits. A new UHSGT system would function as a central transit spine through the region, providing a critical transportation link for high-speed intercity travel while establishing multimodal connections with local transit systems. Accordingly, the resulting infrastructure investment would unlock economic value for people, businesses, and other stakeholders while driving the agglomeration of metropolitan populations and industries throughout the megaregion.

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[42] Graham, Daniel J. "Agglomeration Economies and Transport Investment," Discussion Paper No. 2007-11, International Transport Forum, Joint Transport Research Centre, OECD (December, 2007)
[43] Preston, John; Larbie, Adam; Wall, Graham. "The Impact of High Speed Trains on Socio-Economic Activity: The case of Ashford (Kent)." 4th Annual Conference on Railroad Industry Structure, Competition and Investment, Universidad Carlos III. Madrid, 2006.
[44] de Rus, G. (ed.), *Economic Analysis of High Speed Rail in Europe,* Fundacion BBVA, Bilbao Spain 2009.
[45] Albalate, Daniel and Bel, Germa (2010) High-Speed Rail: Lessons for Policy Makers from Experiences Abroad, GiM-IREA Universitat de Barcelona
[46] Ahlfeldt, Gabriel M. and Feddersen, Arne*, From Periphery to Core: Economic Adjustments to High Speed Rail*, University of Hamburg. 2010.

Broadly, any project could generate two types of impacts:

- Direct or user benefits, such as reduced travel time, increased reliability, increased safety, and reduced emissions (discussed in Section 3 above)
- Indirect effects related to economic development resulting from changes in business output and consumer spending

Currently, the megaregion is served by rail via Amtrak Cascades passenger rail services, intercity bus service, air travel, and private road vehicles. As shown in Table 5, the successful deployment of an UHSGT system would reduce total journey durations[47] within the megaregion, with reduced travel times between both major city centers as well as smaller population and employment centers.

Table 48: Average Total Journey Duration using Selected Mode for the Major Travel Segment (hours:minutes)

City Pair	UHSGT (Proposed)	Auto (Current Conditions)	Air (Current Average)
Seattle – Vancouver	1:45	3:30	3:00
Seattle – Portland	1:30	3:00	2:30
Portland – Vancouver	2:45	5:30	3:30
Bellingham – Seattle	1:00	2:30	3:00
Everett – Portland	1:45	4:00	2:30
Tacoma – Vancouver	2:15	4:00	3:00
Olympia Yelm – Portland	1:15	2:00	NA
Bellingham – Olympia	1:15	3:30	NA

Note: Assumes 30-minute access time for travel to/from airports and rail/UHSGT stations. Air trips also include 60-minute check in and security time. 30-minute delay assumed for international crossings.

The reduction in travel time would generate significant value for UHSGT passengers and users of other modes of travel, due to reduction in congestion on roadways and in airports. In addition to travel time savings, network reliability can act as a multiplier by maximizing system-wide user benefits, yet is often overlooked in conventional commercial analyses due to difficulties with measuring its effects. Travel times via air travel do not typically incorporate the time necessary for transit to the airport and completing check-in, security checks and customs processing at the airport, which can vary from 30 minutes to over three hours, depending on the season and whether the flight is domestic or international. The proposed UHSGT system is expected not to be significantly affected by congestion, excess stops, and processing times for security and customs. Therefore, it is reasonable to assume the average travel time would be achieved more reliably than other modes of travel.

The ridership forecasts performed as part of the 2019 UHSGT Business Case Analysis include the effects of regional economic and population growth on future potential ridership based on present market conditions. The forecasts do not account for growth directly resulting from the deployment of the UHSGT system. From 2006 to 2016, the metropolitan areas in the Cascadia megaregion grew by 15.3% in population and 27.3% in GDP, making them competitive with their global peers. The deployment of an UHSGT system would leverage the increasing population density and economic growth in metropolitan areas to develop and increase access to opportunities for firms and residents. These agglomeration effects, not calculated in the ridership forecasts, would act as multipliers for direct user benefits and indirect social benefits associated with a new UHSGT system due to the greater potential catchment area around the transit stations. Research on transit-oriented development shows there is a preference for urban populations, employment centers, and education and research facilities to locate near regional transit hubs. This allows them better access to qualified labor and to develop linkages with establishments in similar industries, thus demonstrating the potential for localized economic development near UHSGT stations.[48]

15.3 Wider economic benefits (WEBs)

A number of countries build on the framework of a conventional benefit-cost analysis (BCA) maintained by the US Department of Transportation by incorporating wider economic development effects resulting from "agglomeration economies." These benefits arise from reduced "effective" density – that is, reducing travel times between firms and workers, increasing price competition for goods and services by improving market selection, and expanding labor markets, as described below. This basket of agglomeration benefits is referred to as Wider Economic Benefits (WEBs).

[47] See note in Table 5.
[48] P Rietveld, F.R. Bruinsma, H.T. van Delft, and B. Ubbels, Economic Impacts of High Speed Trains – Experiences in Japan and France: Expectations in the Netherlands. https://research.vu.nl/ws/portalfiles/portal/1758890/20010020.pdf

WEBs are a collection of social impacts that accrue to the people, businesses, and other stakeholders and arise from structural changes to the regional economy that result from the transportation investment unlocking broader, in-direct impacts by potentially correcting market imperfections. These imperfections can be thought of as situations in which prices of goods and services, observed or not, do not correspond to the costs to society as a whole.[49] WEBs attempt to measure benefits that traditional benefit cost analyses fail to measure, and are concerned with the wider benefits to the economy from an increase in accessibility provided by a transportation investment.

WEBs are usually categorized into several components, each addressing a series of potential benefits identified in the regional economics literature:

- Agglomeration economies: Firms and workers benefit from proximity, which allows for improved choice of inputs in production; greater exchange of information between workers and faster learning from increased face-to-face contact; increased specialization of workers and firms; and improved matching between workers' skill and experience and their employers' job requirements. All these effects are found to increase productivity.
- Imperfect competition: This results in higher prices for specific goods or services. Increased accessibility increases competition (for example, purchasers of specialized business services can rely on a wider pool of potential suppliers) and reduces costs.
- Labor supply: Two types of impacts can be studied here – impacts from labor supply and impacts from employment relocation. Employment relocation impacts generally require special models that consider how employment and residential decisions will be impacted by transportation investments. Impacts due to employment relocation tend to be modest. Labor supply impacts, however, can be more significant although less than agglomeration impacts. Impacts due to labor supply consist of increased work effort as travel times and costs for commuting decline. Hence users might devote that additional time to work, which results in additional tax revenues. While some of these impacts are captured in the user benefits that accrue to commuters, user benefits do not include tax impacts arising from these two impacts.

A benefits analysis of UHSGT is included as Appendix A to in the 2019 UHSGT Business Case Analysis. While the appraisal of transportation investments has long incorporated direct user benefits in traditional assessments, the inclusion of wider economic benefits, to inform the development of business cases, is a relatively new approach that has been gaining momentum around the world. As discussed above, WEBs attempt to quantify the second order effects that can be expected from large-scale transportation investments. Given that these impacts tend to directly relate to broad based economic development objectives, their evaluation and acknowledgement serves as a significant component of a robust business case and appraisal process. Several large transportation authorities currently publish and maintain guidance with respect to the use of WEBs for transportation appraisals, as well as suggest their incorporation into traditional business cases analysis when appropriate.

The UK Department for Transport added Wider Economic Benefits into its Transport Analysis Guidance (TAG) over 10 years ago. The WebTAG guidance provides tools and information for the investigation and assessment of WEBs impacts. Similarly, the Norwegian Centre for Transport Research has identified over 20 countries that have incorporated WEBs into their transport appraisal guidance.[50] Among them, the Centre identified Canada, Australia, Japan, and the EU15 countries as having incorporated WEBs guidance into their appraisals, while acknowledging that recommended methods across countries differ substantially and no consensus has yet been reached. Nonetheless, the importance and scale of these impacts are widely recognized as significant and therefore their incorporation into business case analysis should be investigated and pursued.

The Initial Estimate of Economic Impacts conducted as part of the 2017-2018 UHSGT Feasibility Study employed WEB analyses. That study determined significant uplift in conventional benefit categories resulting from agglomeration and similar measures for achieving greater economic densification, as described above. The agglomeration benefits by industry sector shown in Table 6 are drawn from the Toronto to Windsor High Speed Rail feasibility report. It shows that even a higher-speed rail project can generate WEB benefits reaching into the billions of dollars in Net Present Value terms of a life cycle of a project – in this case, over a 60-year period.

[49] Department of Infrastructure, Regional Development and Cities. https://atap.gov.au/tools-techniques/wider-economic-benefits/
[50] Norwegian Centre for Transport Research. 2014. "The role of Wider Economic Impacts in Official Transport Appraisal Guidelines in 22 Countries." https://www.toi.no/getfile.php/1339250/Publikasjoner/T%C3%98I%20rapporter/2014/1382-2014/summary%20wider%20economic%20impacts%20v002.pdf

Table 49: Agglomeration Benefits by Industry Sector Generated by Toronto – Windsor High-Speed Rail Project

Agglomeration Benefits by Industry Sector	Annual Benefit 2031 (2021 $ Millions)	Annual Benefit 2041 (2021 $ Millions)	NPV 60 Year (2021 $ Millions)
Manufacturing	$8.4	$15.8	$260
Construction	$2.5	$5.1	$80
Consumer	$3.0	$6.5	$100
Producer	$23.1	$54.3	$860
Total	$37.0	$81.7	$1,300

15.3.1 WEBs Case Study: Crossrail

A good example of the impacts generated by transformative transportation projects is with the Crossrail project in the United Kingdom. Since approval was granted in 2008, forecasts of its impact on real estate and economic development indicators have been performed and subsequently tracked. The idea being that if the project were to catalyze economic development, there should be a proportional increase in real estate activity in anticipation of its opening. A comprehensive report on property impacts published in 2018 sought to assess and track the performance of expectations set forth in an earlier 2012 study. Overall, the report found the forecasted impacts from the previous study would likely exceed projected impacts when the project was approved in 2008.[51] Among the report's findings:

- From 2008 to 2016, approximately 48 percent of permitted planning applications across London were within close proximity to a new Crossrail station. The proportion has continuously increased by a range of about 20 percent in 2009 to a high of 67 percent in 2016.
- The total value of properties within 1 kilometer of a Crossrail station has risen by an estimated $7 billion; while permits for 59,000 residential units, 3.1 million square meters of new office space, and over 256,000 square meters of retail floor space have been allocated.
- An additional increase in property values in excess of $27 billion through a combination of higher-density development and other changes is predicted.

The impact of transformative projects such as UHSGT can also generate higher-paying jobs based on the relationship between density of economic activity and productivity. For instance, reduced journey times to jobs, schools, and homes would allow businesses to have easier access to wider labor pool of employees, which can yield productivity gains and ultimately higher wages. In addition, agglomeration-type impacts can be generated due to the synergies of people and businesses being in closer proximity given the improved access and increased capacity of the transportation network. This could lead to additional jobs being created, as well as higher wages for existing jobs. Ultimately, additional taxes would be generated from these productivity gains.

The historical experience of large-scale projects such as Crossrail provide an indication of the scale and magnitude of economic benefits that might be expected with the UHSGT project. The quantum of value generated ranges from as little as 5 percent to 15 percent of direct user benefits, to 50 percent in the case the UK HS2 project, or even doubling total benefits as illustrated by Crossrail.[52]

Ultimately, investment in UHSGT may prove to be a major catalyst for continued growth in the Cascadia megaregion generating higher wages through increased productivity, enabling higher employment potential through high-density development and increased market accessibility, and increasing overall economic activity. Further analysis, considering the specific impacts of UHSGT on Cascadia region, is warranted as the project progresses to better understand the user and the wider economic effects of enhancing transportation linkages.

[51] GVA. 2018. http://www.crossrail.co.uk/news/articles/number-of-homes-and-jobs-created-by-delivery-of-elizabeth-line-far-exceeds-predictions.
[52] Various reports, including GO-Expansion Business Case (2018), HS2 Business Case reports (2011 – 2017) and Crossrail Business Case (2010-11).

16 Industry/sector impacts

In an increasingly technology-driven economy, developments in the information technology sector generate spill-over benefits for other industries, such as advanced manufacturing, biomedical research and clean energy technologies, resulting in growth opportunities throughout the regional economy. The comparative advantage of the region's information technology firms in the global market serves as an asset to industries in the region that can leverage the technologies for higher added-value to goods and services and higher labor productivity. In a knowledge economy where the added value come from the expertise and skills of specialized labor, an UHSGT system facilitates the mobility and versatility of such high-value resources. Additionally, it enables collaborative partnerships between educational research institutions, industry firms, public organizations and workforce development programs to drive innovation in established markets and support emerging industries. These organizations that are active in the knowledge economy increasingly gravitate towards dense urban areas to attract qualified employees and build connections to wider markets. A new UHSGT system would maximize these agglomeration effects by offering a flexible, high-performance transportation link to connect the talent pool, employers and centers of innovation throughout the region.

16.1 Economic transformation – the knowledge and technology-based economy

As noted in several previous studies related to the Cascadia megaregion's economy, the cutting edge can be found in key industry clusters centered around information technology, advanced technological manufacturing, analytic instrumentation, cloud computing, virtual reality and big data software development, among others. While the information technology sector is among several industries with comparative advantage in emerging megaregions throughout North America, the sector continues to drive economic advancement in the U.S., led by Silicon Valley in California.

Collaborating with research institutions and incubator facilities to implement new concepts into design and production, technology-based clusters, more than almost any other sector, leverage global supply chains and labor resources to provide their goods and services to markets around the world. Moreover, their value added per worker is among the highest of all industry sectors, with correspondingly high wages per worker.

The analysis identifies the "traded industry clusters" driving economic growth in the Cascadia megaregion and developing the potential for future economic transformation. The Institute for Strategy and Competitiveness identified 51 traded clusters – a subset of all industry clusters – that are highly export-oriented, selling their goods and services outside of the region. Traded industry clusters are especially important to the economic competitiveness and growth of regions since, according to regional economic base theory, export industries generate the greatest dollar impact overall for every dollar of output due to strong multiplier effects.

By examining the industry cluster data from 1998 to 2016 for the Portland, OR, Seattle, WA and Vancouver/Surrey, BC metropolitan areas, the analysis tracks changes in employment by traded industry cluster and the concentration of industry employment relative to the national average, known as the "location quotient." The location quotient is defined as the ratio of the local employment in a specific industry sector as a percentage of the total local employment divided by the national employment of the specific industry sector as a percentage of the total national employment. A location quotient of 1 means the local employment in an industry cluster is the same as the national average; if it is over 1, the local employment for a specific industry cluster is more concentrated than the national average. Traded clusters are export-oriented, serving markets outside of the region while generating income for the local market; they generate 50 percent of the income, 36 percent of the employment, and 96.5 percent of the patents of the US economy.[53]

Analyzing industry clusters over time identifies mutually supportive industries between the metropolitan areas in the Cascadia megaregion, the attractiveness of the region for specific industry labor and firms, and the potential for greater regional synergies due to reduced transaction costs and barriers, such as improved communication and transportation linkages.

In addition to understanding the economic structures underlying the regional economy, the analysis of industry clusters identifies drivers in the regional economy affecting other industries, such as information technology and analytical instruments. The goods and services provided by the information technology and analytical instrument cluster affect the operational and production systems of numerous other industry clusters, such as cloud-based computing, information management software, real-time information systems, and precision manufacturing software. The availability of these technologies to local and out-of-region industries results in gains in cost-efficiency and operational effectiveness, translating into higher production value. Therefore, employment in the information technology and analytical instruments clusters serves as an indicator for firms of neighboring industries in the region enjoying higher production values and higher average incomes. For instance, nine of the top ten employment clusters in the information technology and analytical instruments industry in Table 7 are in the top 15 metropolitan areas in the OECD by GDP per capita. The Cascadia megaregion has a significant presence in these high-growth, high-productivity industries.

[53] US Cluster Mapping Project. http://www.clustermapping.us/cluster .

Table 50: Employment in Information Technology and Analytical Instruments Industry Cluster, By Economic Area in North America, 2017

Economic Areas	IT-Related Employment (2017, Ranked Order)
San Jose, CA	150,325
Cascadia Megaregion	***115,829***
Los Angeles, CA	83,833
Boston, MA	81,159
New York, NY	63,932
Minneapolis, MN	46,261
Dallas, TX	34,350
Chicago, IL	33,783
Washington, DC	28,804
Toronto, ON	24,414
Montreal, QC	12,968

In addition to providing insights into the productivity of industry firms, analyzing industry clusters illustrates the diversity and resilience of the regional economy. From 1998 to 2016, the location quotients of several industries in the Seattle, Portland, and Vancouver metropolitan areas grew, indicating the regional economy's capability to mutually support and gain from existing and growing industries. The relative strength of the Cascadia region is even more powerful in key high-value industries such as information technology, water transportation, and marketing, design and publishing, as shown in Table 8.

Table 51: Industry Clusters with a Location Quotient over 1 in Seattle, Portland, and/or Vancouver, 2016

Industries More Concentrated than the National Average	
Agricultural Inputs and Services*	Insurance
Apparel	Lighting and Electrical Equipment*
Business Services	Marketing, Design and Publishing*
Coal Mining	Medical Devices*
Distribution and Electronic Commerce*	Music and Sound Recording*
Downstream Metal Products	Performing Arts*
Education and Knowledge Creation*	Printing Services*
Financial Services	Recreational and Small Electric Goods*
Distribution and Electronic Commerce*	Transportation and Logistics*
Furniture	Wood Products
Hospitality and Tourism	
Industries More Concentrated than Twice the National Average	
Aerospace Vehicles and Defense	Forestry
Communications Equipment and Services*	Information Technology and Analytical Instruments*
Fishing and Fishing Products	Video Production and Distribution

Footwear	Water Transportation*

*These industry clusters have location quotients over 1 in at least two metropolitan areas

The location quotients of the industry clusters provide a snapshot of the regional economy at one point in time; the values in

Table 9 provide a comparison of location quotients and employment for regional industry clusters by metropolitan area in 2016. The relationship between the location quotient and employment of an industry can be described as the concentration and the magnitude of economic activity. Generally, the concentration of firms and labor in an industry translates into the production of goods and services with a similar degree of added value. Therefore, a location quotient above the national average indicates a high level of economic value, even if their employment is relatively minor. An industry with a high location quotient and a significant employment base takes advantage of the efficiencies of greater economies of scale, resulting in exponential production value.

Table 52: Select Industry Clusters in Cascadia Megaregion with Location Quotients, Industry Employment, and % of Total Metropolitan Area Employment, 2016

Regional Industry Clusters	Portland- Vancouver-Hillsboro (OR)		Seattle-Tacoma-Bellevue (WA)		Greater Vancouver (BC)	
	Emp. (000s) (% of MSA)	Location quotient	Emp. (000s) (% of MSA)	Location quotient	Emp. (000s) (% of MSA)	Location quotient
Information Technology & Analytical Instruments	25.1 (0.7%)	2.71	73.3 (10.4%)	4.12	11.6 (2.7%)	1.75
Marketing, Design & Publishing	12.9 (3.5%)	1.17	24.2 (3.4%)	1.15	13.4 (3.1%)	1.24
Communications Equipment & Services	1.7 (0.5%)	0.47	9.3 (1.3%)	1.37	13.5 (3.2%)	4.27
Aerospace Vehicles & Defense	3.4 (0.9%)	0.80	93.4 (13.3%)	11.47	1.4 (0.3%)	0.35
Distribution & Electronic Commerce	57.9 (15.8%)	1.23	78.0 (11.1%)	0.86	49.7 (11.6%)	1.02
Recreational & Small Electric Goods	1.7 (0.5%)	1.42	3.2 (0.5%)	1.35	1.9 (0.4%)	1.10
Water Transportation	3.7 (1.0%)	1.52	10.4 (1.5%)	2.23	6.9 (1.6%)	2.53
Food Processing & Manufacturing	10.6 (2.9%)	1.26	10.3 (1.5%)	0.63	11.0 (2.6%)	1.03
Agricultural Inputs & Services	1.3 (0.4%)	1.63	0.5 (0.1%)	0.31	2.6 (0.6%)	1.61
Performing Arts	2.8 (0.8%)	0.93	5.9 (0.8%)	1.03	5.4 (1.3%)	1.27
Education & Knowledge Creation	28.7 (7.8%)	1.12	31.7 (4.5%)	0.65	39.8 (9.3%)	1.12
Business Services	90.5 (24.7%)	0.92	178.9 (25.4%)	0.94	88.8 (20.8%)	1.06

Industry firms and employment can be affected by changes in regional microeconomics and national and global macroeconomics. As a result, the concentration of industry-specific firms and labor can change over time. Positive change in the location quotients of regional industry clusters from 1998 to 2016 indicates developing industry clusters yet to reach maturity. The industry clusters shown in the following table have shown growth in all three of the Portland, Seattle, and Vancouver metropolitan areas, indicating emerging industries throughout the Cascadia megaregion. The increasing concentration of these industry clusters throughout the region indicates the expansion and sharing of skilled labor and firm expertise from one metropolitan area to its neighboring metropolitan areas.

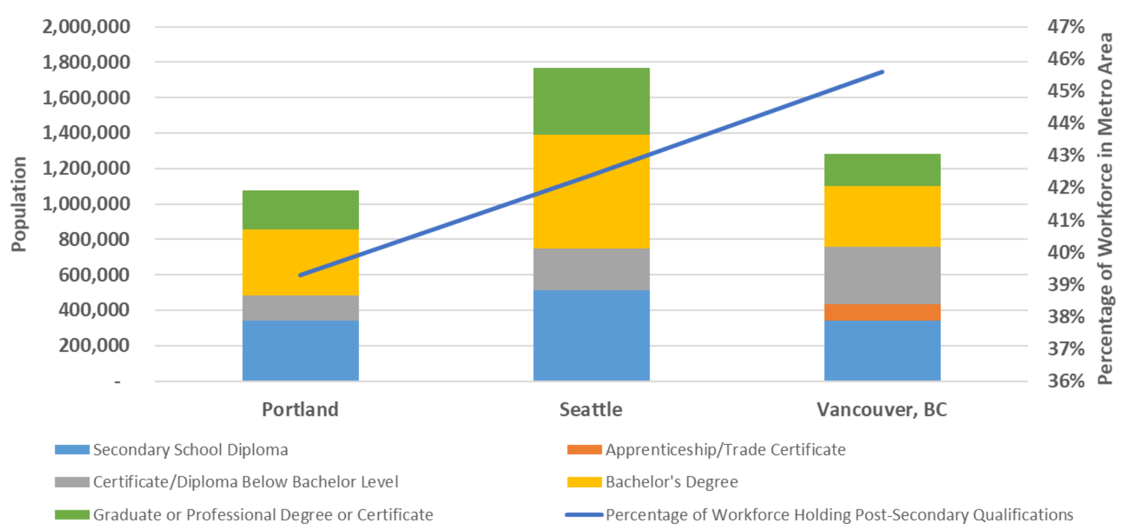
Table 53: Emerging Industries in All Three Cascadia Metropolitan Areas, Change from 1998 to 2016

Emerging Industry Clusters in All Metropolitan Areas of the Cascadia Megaregion	
Aerospace Vehicles and Defense	Lighting and Electrical Equipment
Apparel	Marketing, Design, and Publishing
Biopharmaceuticals	Metalworking Technology
Food Processing and Manufacturing	Recreational and Small Electric Goods
Footwear	Vulcanized and Fired Materials
Jewelry and Precious Metals	

16.2 Workforce Characteristics

The knowledge economy increasingly relies on a labor force with specialized knowledge and skills, generally information technology and other highly specialized STEM-related skills requiring advanced degrees and certifications. The demand for specialized production labor, from advanced manufacturing to software design to green building construction, can be met in technical schooling, professional degrees, and advanced postgraduate studies. Figure 3 shows that all three metropolitan areas have relatively well-educated populations. Seattle hosts the highest number of post-secondary degree holders per capita, while Vancouver hosts the highest number of post-secondary degree holders as a percentage of the local workforce. In addition, foreign-born residents in Vancouver make up a higher percentage of degree holders and the labor force than the regional average, illustrating their access and appeal to a qualified international workforce.

Figure 22: Highest Educational Qualification Held by Population, by Metropolitan Area, 2016



Considering the demographics and qualifications of the regional population, the participation of qualified labor in the employment market indicates the utilization rate of regional resources and the value they add in the production of goods and services. Several factors can affect the rate of participation of the population in the workforce, including high opportunity costs of employment, lack of sector-specific positions, mismatch in qualifications and local job requirements, retirement planning, and family planning.

Although the megaregion's workforce is relatively well educated, the enhanced mobility offered by UHSGT would help improve overall access to this labor force. While further research would be required, UHSGT can have a positive impact on helping to enable the further growth in higher paying jobs, as well as improving access to those jobs from the greater Cascadia megaregion. Improving access to higher paying jobs would be a significant benefit for the wider regional population, especially for people from disadvantaged backgrounds and/or who live in disadvantaged communities, and driving demand for ridership. Experiences from other countries, such as the United Kingdom, demonstrate the need for concurrently implementing policies on developing occupational skills, creating access to job databases, and involving potential employers in the creation of workforce development strategies.

16.3 Innovation

The economy of the Cascadia megaregion performs with global peer metropolitan areas on the metrics of GDP growth, population growth and GDP per capita, yet the value of a new UHSGT system comes in facilitating collaborative partnerships in the knowledge economy to drive innovative development. At the end of 2015, Seattle, WA and Portland, OR were amongst the top five metropolitan areas in the US in the number of utility patents published per 10,000 employees, ranked at number 3 and 5, respectively.[54] Technology-driven industry sectors in the region rely on a network of businesses, private research institutions, government agencies, public organizations and academia to maintain established markets, support emerging industries and develop new technologies and processes. A new UHSGT system would support the region's innovation hubs by improving labor mobility, distributing economic activities between the urban cores and intermediate cities, reducing the monetary and temporal costs for business interactions, and facilitating high-density commercial and residential development around transit hubs.

Memoranda of Understanding (MOUs) between British Columbia and the state of Washington on collaboration in the innovation sector helped encourage formation of the Cascadia Innovation Corridor (CIC). A private sector-led cross-border initiative, the CIC fosters connections between internationally recognized polytechnic universities, launched the Seattle-Vancouver Financial Innovation Network and continuously advocates for improved transportation connections throughout the region.[55] The Cascadia Venture Accelerator Network, an organization of nearly 50 technology, investment and research partners from British Columbia, Washington and Oregon, aims to match start-up enterprises with researchers and funding to cultivate cross-border collaborations. In the knowledge economy, a premium is placed on flexible, high-speed personal travel due to the high value placed on the specialized skills and expertise necessary for the next-generation of businesses and occupations.

[54] US Cluster Mapping Project. https://clustermapping.us/
[55] Provincial Government of British Columbia. "Cascadia Venture Acceleration Network to boost cross-border tech innovation". https://news.gov.bc.ca/releases/2017JTT0161-002032

17 Other benefits of UHSGT – equitable access to housing and employment

As observed in the stakeholder interview themes in Table ES-2, a key consideration – and a major obstacle to be overcome – in transforming and growing the megaregion's economy is finding a way to house the burgeoning economy's workforce. In particular, this includes accommodating a workforce to serve the cutting-edge tech sectors that are likely to drive economic transformation. This workforce lies within a demographic that may not be able to afford the rising housing prices found in the urban areas of Seattle, Vancouver, and Portland.

Portland, OR, Tacoma, WA, Seattle, WA and Vancouver/Surrey, BC are growing cities within the Cascadia megaregion with thriving economies. Their success in creating new higher-paying jobs has created increased demand for housing, and the cost of housing has escalated as new residential construction has struggled to keep pace with population and employment growth. This situation has generated concern about housing affordability – workers have increased difficulty finding affordable housing in proximity to their places of employment and development pressures have induced urban sprawl. The housing challenge is related to transportation. For many workers, it is not simply a question of finding an affordable home, it is a question of how close that home will be to their work and the cost of the commute, measured in dollars and time.

UHSGT would sustain and build upon the growth already underway in these cities by improving the time, convenience, and connections along the corridor. UHSGT would collapse distances, providing employers with access to a much larger workforce and workers with a greater variety of employment options. While the proposed system would foster further growth in the megaregion economy driving the housing affordability challenge, UHSGT can also address the problem by providing shorter, faster commutes between areas with lower housing costs and employment centers. UHSGT would also foster more dense transit-oriented residential development near stations and open up new areas to large-scale mixed-use development where residential and office development can be built in close proximity to create live-work communities. However, to achieve these objectives, the planning and design of the UHSGT system should include three key objectives:

- Coordinate with local government authorities to ensure that land use plans and regulations encourage residential development at scale in proximity to planned stations
- Coordinate with transit agencies to develop and provide transit service that connects with the new stations
- Locate stations not only at the center of the larger thriving cities, but also in places with lower housing costs that would benefit from and have capacity for new development

17.1 Incorporating equity

The UHSGT Advisory Group recommended that early in the planning process a commitment be made that social equity and economic inclusiveness are core values in developing the UHSGT system. Decision-makers should consider how communities and individuals will be affected by new infrastructure; identify opportunities to elevate the quality of life through economic development, job creation and accessibility; and address damaging burdens that might result from factors such as alignment selection, station locations, hiring practices, and land use.

They recommended next steps related to social equity and economic inclusiveness during the planning process should include:

- Developing a clear statement that social equity and economic inclusiveness are core values of the project and ensuring the project team can use an equitable decision-making process
- Using a process that puts equity at the center of decision-making to identify and evaluate the potential benefits and disadvantages of proposed projects on historically marginalized populations
- Ensuring equitable representation on decision-making groups, including advisory groups and councils.
- Incorporating, encouraging and supporting equity throughout the public consultation and outreach program.
- Identifying which partner jurisdiction has set the highest standards for equity programs and activity and then ensuring the whole project meets or exceeds those standards.

17.2 Recent History

Three cities within the Cascadia Corridor – Seattle, WA, Tacoma, WA and Portland, OR – are ranked near the top of the Forbes' 2018 list of the fastest growing American cities, with housing prices growing at rates between 9.8 percent and 13.6 percent in the preceding year. The growth rate in housing prices from 2010 to 2018 in the metropolitan area of Seattle-Tacoma-Bellevue was 62 percent, while Portland-Vancouver-Hillsboro saw a growth rate of 60 percent. Over the same period, the housing prices of the national market grew at a rate of 37 percent. The population, employment, and home price numbers shown in Table 11 illustrate how house price increases are outpacing even the rapid growth in jobs, population and wage growth, an indicator of a serious housing crisis in the making.

Table 54: Growth in Population, Number of Jobs, Mean Annual Wage and Home Prices in Metropolitan Areas of Cascadia Megaregion, 2010-2018

	Population Growth	Employment Growth	Growth in Mean Annual Wage	Home Price Growth
Seattle-Tacoma-Bellevue MSA	14%	24%	23%	62%
Portland-Vancouver-Hillsboro MSA	16%	24%	20%	60%
Great Vancouver CMA	15%	19%	22%	93%

Sources: OECD Data, Statistics Canada, Bureau of Labor Statistics, Zillow, Canadian Real Estate Association

In Canada, Surrey is one of the fastest growing cities, poised to become the biggest city in B.C. by 2041.

Similar to the growing cities of Seattle, WA and Portland, OR the housing market in Vancouver, BC experienced a spike in property values of 93 percent from 2010 to 2018, a challenge to affordable living in the area amidst rising employment and population growth. The rapid increase in house prices in Vancouver may be explained by a multiplicity of factors, such as limited developable land, high-end housing construction, and high-income growth, particularly resulting from foreign investment from China and other Asian countries.

Although households seeking affordable housing would incur a cost for using UHSGT, if the system expanded access to a larger inventory or more attainably-priced housing, there will in theory be a break-even point between the added monthly cost of UHSGT and monthly housing costs (in the form of rent or mortgage payments). A study conducted in 2018 demonstrated that HSR in Japan helped reduce land costs and increased access to affordable housing:

> *"That HSR increases the convenience of living in outlying suburbs of crowded and expensive cities is self-evident. What has not been heretofore clear is whether or not HSR may serve as one of the solutions to a lack of affordable housing. Were HSR to induce rapid economic growth along the line, it is possible that housing nearby would be more rather than less expensive. In this study we examined the experience in Japan, and we found that over a fifty-five years period, the Shinkansen eased land costs and relieved some of the pressure on home prices in major cities."*[56]

An in-depth housing access analysis is recommended in future phases to gain further insight into this dynamic in the Cascadia megaregion.

17.3 Station Locations

A look at municipalities along the corridor that are potential locations for UHSGT stations reveals that in smaller cities, such as Bellingham, Everett, Kelso and Olympia, WA housing costs are substantially lower in dollar terms than the larger cities such as Portland, OR and Seattle, WA. However, from an equity standpoint, the combined costs of housing and transportation in these smaller, less densely developed cities are significantly higher as a proportion of income than in the larger cities where public transportation is more available and incomes are higher (Table 12). In Bellingham, WA for example, an average resident pays more than 50 percent of their $53,145 average income to cover housing and transportation costs, whereas an average Seattle, WA resident pays $400 more for housing but overall a smaller share (46%) of a higher income ($70,475) on housing and transportation.

Table 55: Average Income and Housing and Transportation Expenditures in Urban Areas in Washington State and Oregon, 2017

	Avg. Income	Housing Cost/Month	Housing % of Income	Transportation % of Income	H/T Combined % of Income
Everett	$70,475	$1,299	22%	18%	40%
Bellingham	$53,145	$1,239	28%	23%	51%
Seattle	$70,475	$1,734	30%	16%	46%
Tacoma	$70,475	$1,347	23%	18%	41%
Olympia	$61,677	$1,305	25%	20%	45%

[56] Nickelsburg, Jerry. 2018. High-Speed Rail Economics, Urbanization and Housing Affordability Revisited: Evidence from the Shinkansen System. UCLA Anderson School of Management

Kelso	$47,452	$959	24%	26%	50%
Portland	$60,286	$1,456	29%	19%	48%

Source: Center for Neighborhood Technology, Housing and Transportation Affordability Index

While this disparity is in large part due to differences in income, it is also explained on the supply side by the fact that in smaller cities there is less transit service and commuting distances tend to be longer. While residents in these smaller areas pay a bit less out of pocket for transportation in absolute dollar terms (car ownership costs are higher in dollar terms in the larger, denser urban areas because of parking and other ownership costs), transportation costs as a share of income are higher in the smaller areas. Moreover, those costs only reflect out-of-pocket expenses. Travel times are not included in those costs. If they were, the transportation costs would be much higher in these smaller areas. For example, a bus or train ride from Bellingham, WA to Seattle, WA now takes over two hours and service is irregular.

UHSGT would open these smaller towns and cities to development and improve their accessibility to employment centers in larger cities. When combined with more local transit improvements within the jurisdiction of these smaller towns and cities, UHSGT would further improve access. The effect would be to provide less costly housing alternatives than those families now face in the major cities of the Cascadia megaregion, while reducing the costs of transportation (both out-of-pocket and the imputed costs of travel time and convenience), which now make these less densely settled and less well-served areas more expensive from a total transportation cost perspective. The need for this type of improved regional connectivity will grow more urgent if current trends in population, employment, and housing production continue over the next 20 years and result in increased housing cost disparities.

UHSGT could further alter the current housing and transportation equation by connecting residents in the smaller cities with lower housing costs to jobs along the corridor. For residents of Bellingham, for example, the new UHSGT service would provide access to a much larger range of employment opportunities, including higher-paying jobs in Seattle, WA. Depending on the fare structure, a new service might reduce the percentage of income that workers in the smaller cities devote to housing and transportation. In addition, a UHSGT service would make smaller cities more attractive locations for employers, bringing them closer to lower-cost housing for workers. These types of benefits have been seen with the introduction of new high-speed rail systems in China, England, France, and Japan. As described earlier, however, success would require extensive coordination with local governments to facilitate transit-oriented development in areas around the stations and transit agencies to enhance connecting service to the stations.

If UHSGT stations are located near areas where new mixed-use development can be built at scale, the results for addressing regional housing needs and maximizing social value would be even more significant, offering greater livability and overall quality of life for residents and workers in the megaregion These locations provide an opportunity to generate new live-work communities, comprehensively planned to address the needs of growing companies and their work forces. UHSGT would provide the swift connections to larger cities needed to sustain business operations, but much of the workforce might live in these new communities and might not need to rely on transit or motor vehicles to get to work. Low-density areas, such as underused districts zoned for industrial use, have proven well-suited to this kind of development if they can be connected by rail to population centers.

18 Examples of HSR elsewhere and lessons learned

There are a number of case studies which highlight the impacts of other high speed rail systems and transformative transportation infrastructure projects and identify some of the lessons that could be learned which could be applied to UHSGT.

18.1 Eurostar/HS1 (UK/France/Belgium)

In the 1990s, three separate projects transformed connectivity between the United Kingdom, France, and Belgium. These systems are used by passenger and freight high speed rail services, as well as rail shuttles transporting road vehicles through the Channel Tunnel similar to Amtrak's Auto Train along the U.S. eastern seaboard. HS1 in the UK is a 67-mile (108-kilometer), high-speed rail line, with 4 new stations, connecting London with the Channel Tunnel. The $9 billion project, which was completed in 2007, is now the responsibility of a 30-year private operator concession.

The impact of HS1 has been demonstrated to be positive on the regional and national UK economy. Capacity on regional/commuting services has increased by over 40 percent, while average journey times have decreased by between 30 and 45 minutes, with some trips taking half the time from before HS1 opening. Growth on international services has increased by nearly 50 percent (to over 11 million in 2018, or around a 70 percent share of the air/rail/bus market) and on regional/commuting services by 25 percent. Overall, user benefits have been calculated as much as $15 billion, while wider benefits are expected to add a further $7 billion, including the increase in land values near the HS1 stations (in particular at London Kings Cross and Stratford stations). Further increases can be expected that are linked to the development of more robust station area master plans at the other two UK stations, as well as consideration of the impact of new, higher-paying jobs near the HS1 station sites (for example Google's European headquarters). On the French side, Lille has also seen increased economic activity due to high speed rail, including over 8 million square feet of new commercial development constructed and a 272-acre development zone unlocked.

18.2 Paris – Bordeaux HSR (France)

The second high-speed rail line built in France opened in 1989 and linked Paris with the southwest of the country – to Le Mans and Tours, putting these two cities within about one hour's reach of Paris. Other services continue onto the existing rail network to cities such as Nantes, La Rochelle, and Bordeaux. In 2006, the HSR line to Bordeaux was approved to increase capacity, reduce journey times, and stimulate the regional economy. Improvements to local connections were also made at Bordeaux and other stations, as well as a set of transit-oriented development-style plans.

A public-private partnership (P3) concession was signed with the private LISEA consortium in 2010, transferring responsibility for design, construction, funding, operation and maintenance for the 180-mile (290-kilometer) extension over a 50-year period. Funding for the $9 billion project (which opened in 2017) was split roughly 50 percent public grants and private funds with the P3 company recovering its initial investment through access charges, retail/property and availability payments for meeting contractual targets on completion of works, operating performance, etc.

The economic impact of the new HSR line has been significant in unlocking opportunities that would have been harder to secure without its construction. Over the past 20 years, the Greater Bordeaux region has grown by over 1 million people with a shift in jobs from agriculture toward aerospace, new small high-tech businesses, and a growing university sector. The impending arrival of HSR was a catalyst for a number of developments, including the creation of a regional and city station master plan that developed policies to exploit the better connectivity of HSR. The plan set out the need for improved local connections to the HSR station (rapid transit, bike and walking routes) and new public spaces, and established a development zone for 16,000 new homes and over 20,000 new jobs near the station, primarily on rail or city-owned land. Most of the proposals in the master plan have either been completed or are well underway, including commercial and residential developments, many of which are unlikely to have occurred without HSR and the master plan.

> **Case Study: Lille, France**
>
> In the 1970s and 1980s, Lille's industrial-driven economy was in steep decline. However, the addition of high-speed rail made the city of 200K people a key interregional connection, with access to Brussels in 40 minutes, Paris in 60 minutes, and London in 1 hour and 40 minutes.
>
> City leaders, including the mayor, recognized the economic development opportunity, chose to locate the station in the city's core. They developed a visionary masterplan including a mix of new office and retail uses. Beyond the station area development, Lille has seen increases in office and tourism demand in other parts of the city as well.
>
> **Key lesson learned**: Catalytic potential of local economic benefits are maximized when public leaders and stakeholders embrace and plan for the new service and

18.3 Crossrail (London, UK)

When completed in 2020, Europe's largest infrastructure project (costing $20 billion) will provide a new 73-mile (117-kilometer) cross-central London railway with 10 new stations (largely underground) and 13 miles (21 kilometers) of new twin-bore tunnels. The project includes new transport links to London's key business districts of the City, West End, and Canary Wharf, as well as Heathrow Airport and the emerging district of Stratford. Each station links to the existing London Underground and/or UK national rail network, and provides connections to local buses. The project, which has enabled over 1 million jobs to be located in greater London, also includes improvements to walking and cycling facilities. Road traffic constraint measures were identified and are being implemented as part of a local complementary measures project at every Crossrail station along with local development master plans.

The case for Crossrail was linked to its ability to increase capacity of London's public transportation network by 10 percent, improve connectivity across the city/region, and improve business competitiveness. The 2010 business case estimated that over $55 billion of benefits could be directly linked to Crossrail (over three times the upfront and long-term costs), in particular to its ability to improve business productivity and allow the city/region's job base to grow and increase the number of well-paying jobs (over $100,000 annual salary). In doing so, Crossrail enables London to compete more effectively, and sustainably, with other international competitor city/regions such as Paris, New York, and Tokyo as approximately one-third of high-paying jobs are global in nature. More recent analysis suggests that the case for Crossrail is now stronger with a January 2018 study estimating that property values within 1 mile (1.6 kilometers) of a Crossrail station have already increased by $7 billion and will increase by at least $27 billion by 2026. This is in part due to the forecast that over 180,000 new homes and 200,000 new jobs are expected to be created along the Crossrail route by 2026.

Over two-thirds of Crossrail's funding was from alternative sources, including future surplus farebox, development and business taxes. A critical factor in securing approval to implement these new charges was to demonstrate the value of Crossrail to people, businesses, and the environment. For example, analysis showed the value to businesses of having increased capacity and a more reliable rail network, as well as the advantages of reduced journey times on sales, productivity, and access to a greater pool of people, both for jobs or as customers. This could be worth $55 billion to the regional economy, and possibly more – about 10 percent of this amount is being captured to represent the benefits unlocked by Crossrail.

Major economic gains have already been unlocked and a significant pipeline has already developed providing support for the catalyzing role Crossrail has played in the development of the region. The pattern seems to be replicating with the proposed Crossrail 2 project where property prices have increased along the route since it was first announced in 2013. Some rents have increased by more than 20 percent in less than five years.[57] Likewise, London's Jubilee Line Extension, which was completed in 1999, has seen significant increases in property values near stations, which when combined with other wider impacts has exceeded initially estimated user benefits.[58]

18.4 REM (Montreal, Canada)

The Regional Express Metro (REM), is a new 40-mile (64-kilometer) integrated rail line linking downtown Montreal with the North, South and West communities in the region, as well as the international airport. It will enhance the regional transportation network, adding capacity as well reducing journey times and improving reliability. Connections to the existing public transportation networks are to be built along with area master plans to encourage development around the new REM stations.

The benefits generated by the project are significant for the local area and include travel time savings averaging over 10 minutes per trip, direct and indirect job creation, and an estimated increase in land values of around $4 billion. Specifically, the project serves over 250,000 jobs and 170,000 university students in the downtown Montreal area. The cost of $5 billion for REM is financed through grant funding from the Canadian federal and Quebec provincial governments and a public-private partnership arrangement with CDPQ Infrastructure funded by public pension funds. Approximately 10 percent of funding will draw from land value capture measures, including a development levy of $7.50 per square foot on properties near REM stations.

18.5 Lessons Learned

While there are a number of factors specific to each one of these transformational projects, some common lessons could be useful in the development of UHSGT to both unlock economic growth for Cascadia and support a more equitable megaregion. These factors include:

- Develop plans aligned to key outcomes agreed to with decision makers and stakeholders, including user benefits (such as time savings), economic growth, and environmental/sustainability impacts
- Ensure plans are assessed against realistic alternatives and/or model impacts are understood
- Develop planning policies to unlock economic growth opportunities that encourage higher-density development within 1 mile (1.6 kilometers) of station sites
- Develop and agree on area master plans before finalizing project station plans
- Agree on supporting public infrastructure (including local connections) to ensure forecast ridership materializes and improve development opportunities
- Provide commercial incentives required to unlock transit-oriented development (for example, density bonuses or development restrictions at non-station locations)

While not in the scope of this analysis, further analysis is recommended to shed more detailed light on the potential economic development benefits that UHSGT could have on the three primary economies of Portland, OR, Seattle, WA and Vancouver/Surrey, BC, as well as the potential benefits that smaller areas along the alignment may achieve with station areas. This could include more in-depth, quantifiable analysis on the overall improvements to access to affordable housing for workers, increased labor access for businesses, economic diversification, and station area development potential.

[57] Gladfish. https://www.gladfish.com/is-now-the-time-to-invest-in-property-near-crossrail-2/
[58] Transport, wider economic benefits and impacts on GDP, UK Department for Transport, 2005

Washington State Department of Transportation

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix C

Corridor Planning Technical Memorandum

July 2019

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Contents

Figures

Tables

Exhibits

19 Introduction

As a key component of the 2019 Ultra-High-Speed Ground Transportation (UHSGT) Business Case Analysis (2019 Business Case), the corridor planning work lays out the physical, geographic and service planning foundation for ridership forecasts, financial modeling, and economic impact analyses.

The Pacific Northwest corridor runs north-south from Vancouver, BC to Portland, OR, and is served currently by multiple passenger transportation modes: commercial air travel to and from five cities in the region, auto and bus along Interstate 5, and Amtrak Cascades along the BNSF Railway alignment. Transit and commuter rail systems also serve local trips along the corridor. To be successful a new north-south UHSGT addition to the Pacific Northwest corridor would need to offer travelers a journey that is faster, more frequent, more reliable and/or more cost effective than the current mode options. Increasing congestion on I-5 and at the airports, plus limitations on the speed and frequency Amtrak Cascades rail passenger service point to opportunities to develop an improved corridor transportation system.

The corridor planning process is subject to intense scrutiny due in large part to its physical nature and anticipated impact on land use. However, much like the economic impact and financial analyses, the corridor planning analysis illustrate what is possible in the region and should not be interpreted as a decision-making tool for future track alignments or station locations.

19.1 Corridor Planning Process

The major steps in the corridor planning work and key data inputs and outputs are depicted in Figure 1. Corridor planning's role in a business case analysis is to analyze and illustrate the range of intercity connections through a series of scenarios and options that meet the goals and objectives and provide data to support the business case analysis, including cost effectiveness and economic benefits. In this conceptual phase of corridor planning, the emphasis has been on developing multi-modal connections to existing and planned infrastructure and in maximizing ridership as a key benefit of improved intercity transportation. Ridership is an important component for estimating fare revenue and operating costs. More detailed scenarios, including the identification of specific station locations and the conceptual engineering of potential alignments, would be examined in subsequent phases of project planning.

This memo includes the following sections:

- Section 2 presents the vision statement and the supporting goals and objectives.
- Sections 3 presents an overview of the socio-economic conditions of the Pacific Northwest region that would be served by the implementation of a new north-south UHSGT system. This section includes an overview of the corridor's population, employment, and geography.
- Section 4 presents the station area selection criteria and discusses the characteristics of the long list of candidate station area locations.
- Sections 5 discusses the development of the preliminary scenarios including a discussion of service types.
- Section 6 describes the illustrative scenarios and scenario variations that were developed for ridership testing.
- Section 7 outlines the anticipated capital and operating costs.

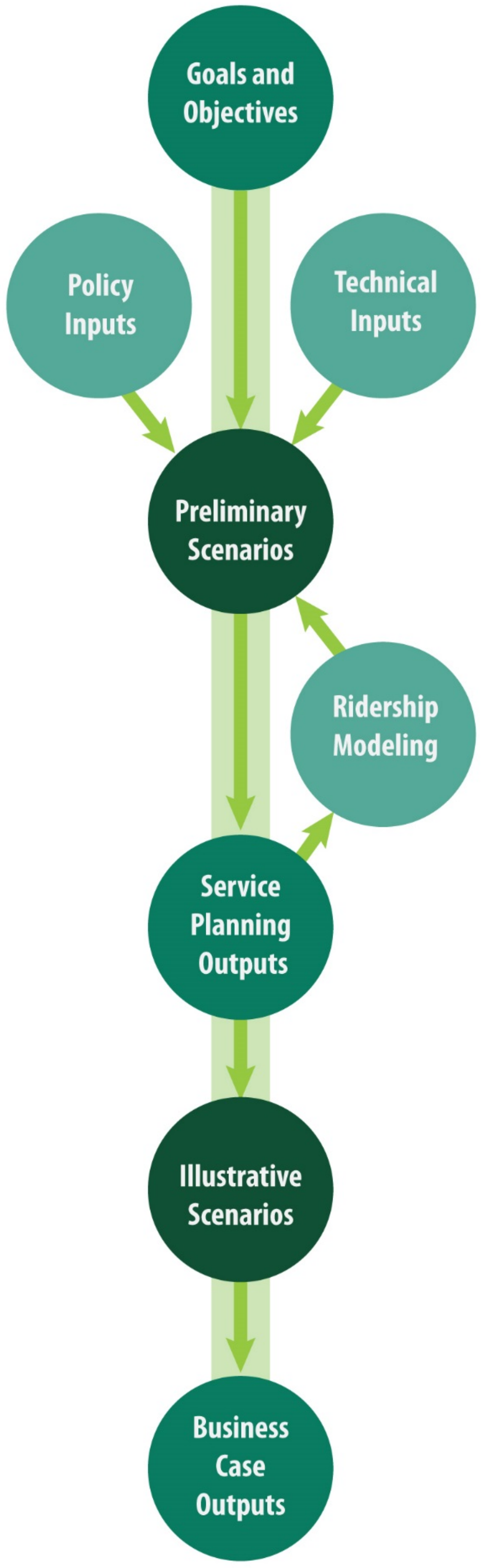


Figure 23: Corridor Planning Process

20 Vision, Goals and Objectives

The vision for UHSGT is to advance the economic, social, and environmental conditions in the Pacific Northwest by improving mobility and interconnectivity in the corridor between Portland, Seattle, and Vancouver, BC.

Three principal goals and associated objectives were developed to support the vision and are described below in Table 1.

Table 56: Corridor Planning Goals and Objectives

Goals	Objectives
Stimulate economic growth and innovation	• Support the growth of existing and future employers by expanding the effective labor market in a meaningful way • Allow the region to compete for larger companies • Spur investment throughout the region, with emphasis on building the innovation economy • Consider and target potential areas for new growth
Provide efficient and sustainable mobility	• Create a viable mode choice for intercity travel • Deliver optimal value for investment • Promote sustainable and environmentally responsible mobility
Promote regional integration	• Improve transportation connectivity among population, employment, technology, cultural and knowledge centers • Enhance existing and future residents' access to equitable interregional transit • Integrate UHSGT with existing and future intermodal systems to form a comprehensive regional transportation network

The corridor planning vision, and the goals and objectives were presented and discussed at the second meeting of the Advisory Committee on October 9, 2018.

Figure 24: Corridor Context

21 Pacific Northwest Socio-Economic Conditions

21.1 Existing Conditions and Patterns

In 2015, the Pacific Northwest region, comprising 12 US counties and one Canadian province, was home to 9.6 million people. The three large metro areas of Vancouver, BC; Seattle, WA; and Portland, OR account for 8.8 million of these residents, and economic activity provides almost 4.5 million total jobs, comprising over 90% of the corridor totals. Population and employment levels are projected to grow over 30% by 2040. Although areas outside metro regions are less densely populated, these areas are also expected to grow by over 30%. Table 2 presents an overview of the region's existing and forecast population and employment.

In addition to total numbers, patterns of population and employment density are of interest when determining the proposed reach of a new corridor system. The variety of population and employment patterns along the corridor provides several travel markets that could be served by UHSGT. These include business-related travel, tourism/leisure, personal-business, commuting (regular or intermittent) and connections to other intercity modes.

Using Geographical Information Systems (GIS) a series of maps were created illustrating the pattern of population and employment densities by census block and transportation analysis zones (TAZ) along the corridor. The maps, shown in Figure 3 and Figure 4, are visual representations of the same data that were used in the ridership model. As illustrated, the residential population in 2015 is spread out evenly along the coast between Vancouver, BC and Seattle, WA and along I-5 south of Seattle, WA. This settlement patterns reflects the predominance of automobile as the major means of transportation as well as land use policies which supported single family home zoning. The employment density pattern, in contrast, is concentrated around city and town core districts.

The implementation of a new north-south UHSGT system could be designed in coordination with local land use plans to support these patterns or to create new patterns that support further densification of housing or to create new areas of affordable housing. The UHSGT system, with its local and regional travel implications, should be designed in close coordination with local jurisdictions and governments to share findings, ensure integration with existing plans and programs and to ensure a balance between transit, commuter rail and intercity stakeholders.

Business travelers may be more likely to use a transportation system that connects economic centers and potentially airports. Leisure travelers would have their own set of destinations. Many of the region's jobs are knowledge-based activities including high-tech, manufacturing, and education/research, whose workers are perceived to value short and frequent travel times. One of the goals of this UHSGT Business Case Analysis is to determine the likely distribution of trip purpose and of origin and destinations on a new UHSGT system, which could be used to inform future decision-making.

Figure 25: Population Density, 2015

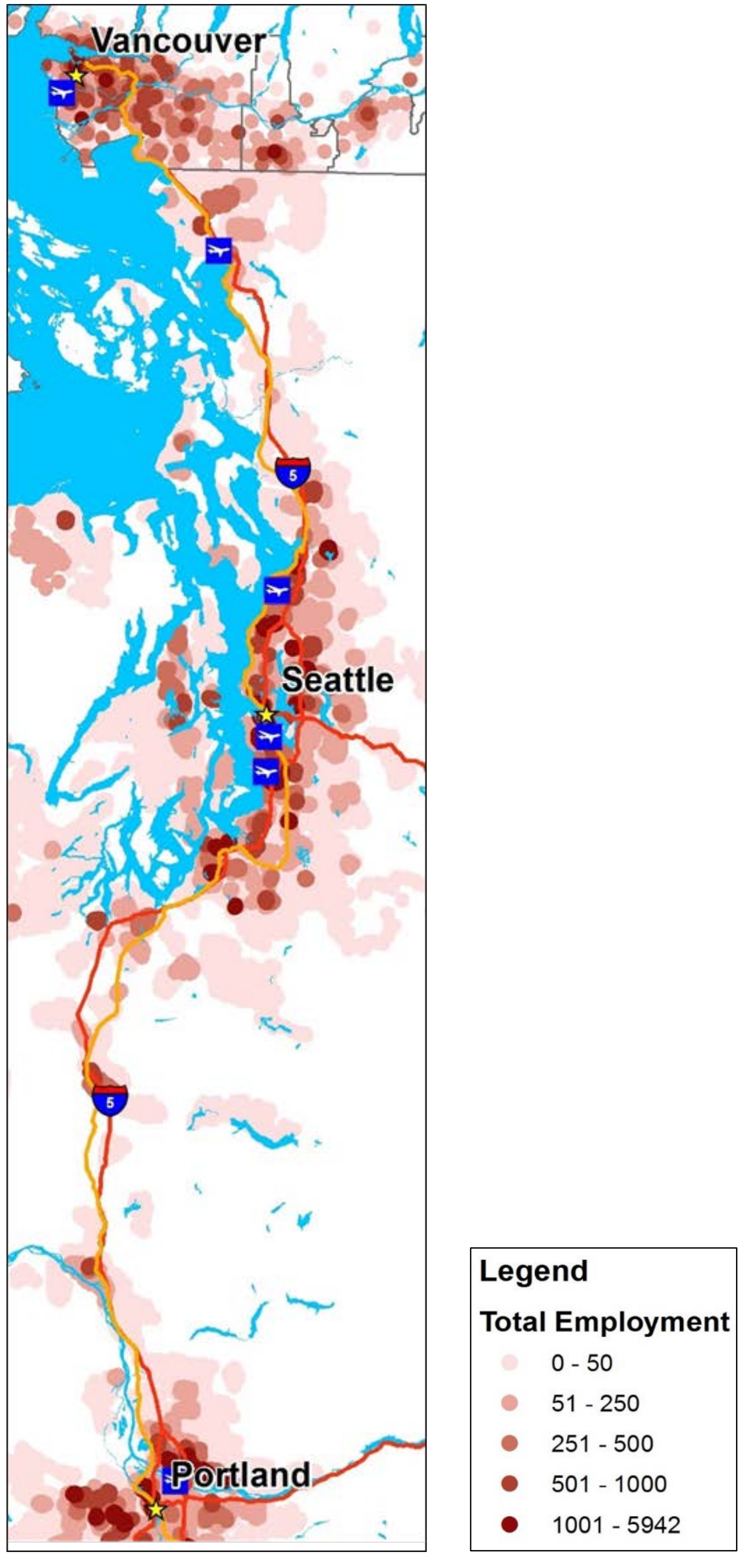


Figure 26: Employment Density, 2015

Table 57: Corridor Population and Employment

Metro Areas	2015 Population (M)	2040 Population (M)	2015 Employment (M)	2040 Employment (M)
Greater Portland[1]	2.4	3.0	1.1	1.4
Seattle Region[2]	4.0	5.0	2.2	3.1
Vancouver, BC Region	2.4	3.4	1.2	1.8
Metro Area Subtotal	8.8	11.4	4.5	6.3
Intermediate Counties	**2015 Population**	**2040 Population**	**2015 Employment**	**2035 Employment**
Cowlitz	0.10	0.12	0.04	
Lewis	0.08	0.09	0.03	
Skagit	0.12	0.16	0.05	
Thurston	0.27	0.37	0.10	.19
Whatcom	0.21	0.29	0.09	.12
Intermediate County Subtotal	0.78	1.03	0.31	
Corridor Total	9.6	12.4	4.8	

[1] Clackamas, Columbia, Multnomah, Washington, and Yamhill Counties in Oregon, and Clark and Skamania Counties in Washington. Source: Metro 2018 Urban Growth Report Discussion Draft July 3, 2018, Appendix 1- 2018 Regional Economic Forecast

[2] King, Pierce, Snohomish, and Kitsap Counties. Puget Sound Regional Council Vision 2040, December 2009.

[3] 2040 Washington state Growth Management Projections- Medium Series

21.2 First Screen of Station Area Locations

Large scale maps depicting population and employment density and the location of selected industrial clusters were created. Maps were also developed for an initial series of potential stations area locations to acquaint the Steering Committee and Advisory Group with the available data and set up informed comparisons between locations on the corridor. This socio-economic data was also used to inform the Memorandum Assessing Potential Economic Gains in the Cascadia Megaregion (Business Case Report- Appendix B).

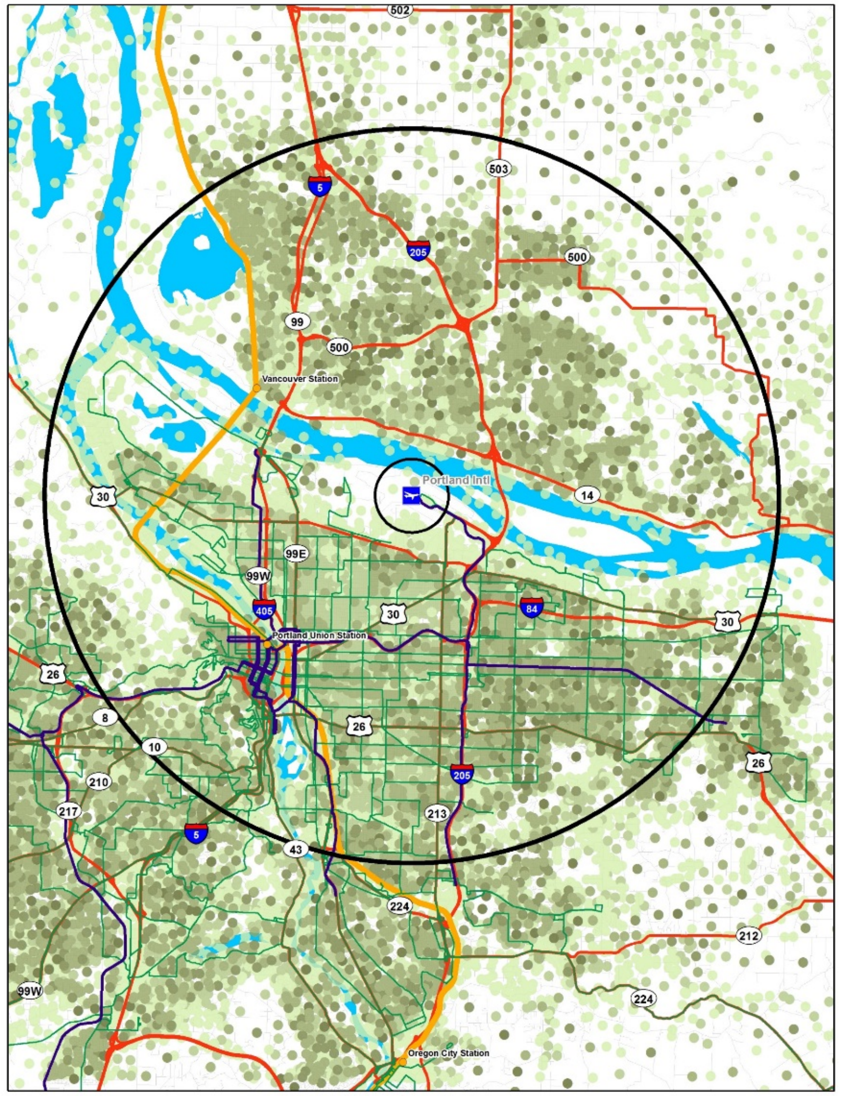
Using an Amtrak station or other transportation node as a centroid, each station area map includes intermodal and transit systems and exhibits the following spatial data within a 10-mile radius:

Population Concentrations (2015 Census data)
Population by census block/TAZ

Employment Concentrations (2015 Census data)
Number of employees by census block/TAZ by place of employment

Innovation Industries
Number of information technology establishments (2015) by zip code

Figure 5 illustrates a set of three large scale maps for Portland, OR. Large scale maps were also made for Tacoma, WA and Bellevue/Redmond, WA and are included in Exhibit A.



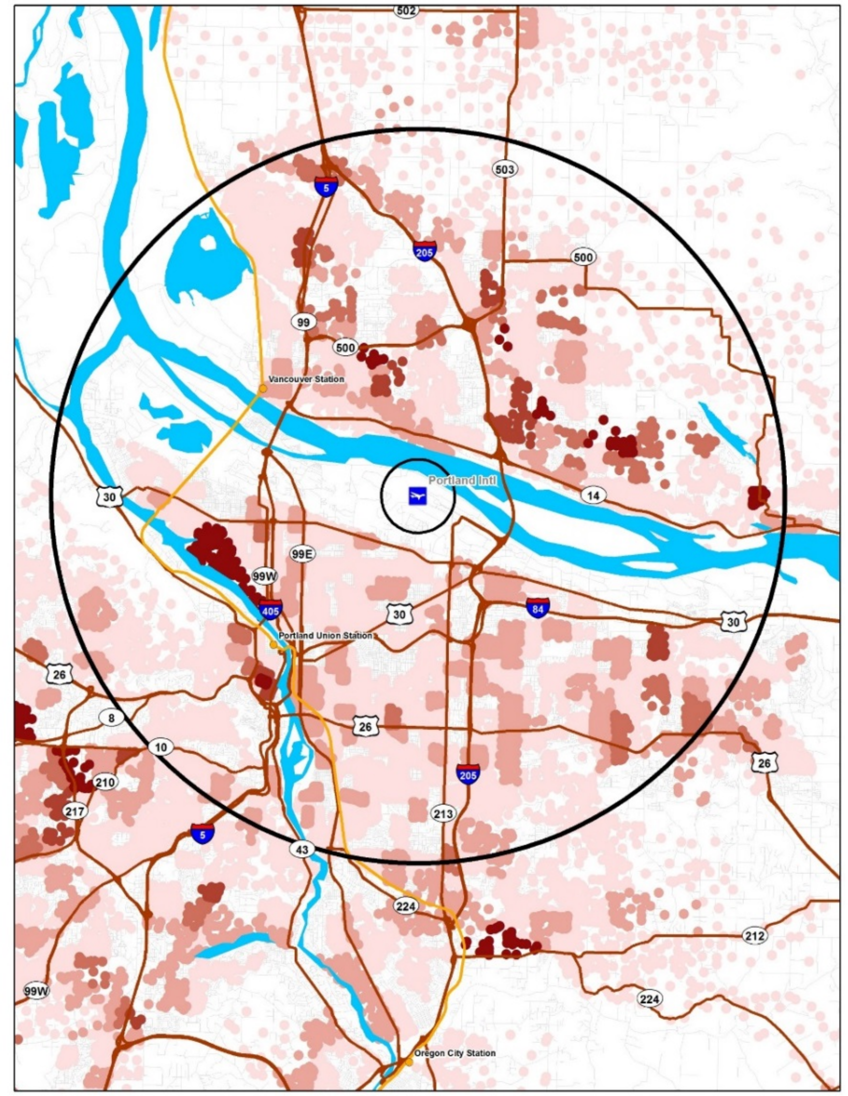
Portland, OR Population

Legend

- Airports
- Amtrak Cascades Station
- TriMet Rail System
- Bus Routes
- Amtrak Cascades RailLine

Total Population

- 0 - 24
- 25 - 81
- 82 - 186
- 187 - 411
- 412 - 1034



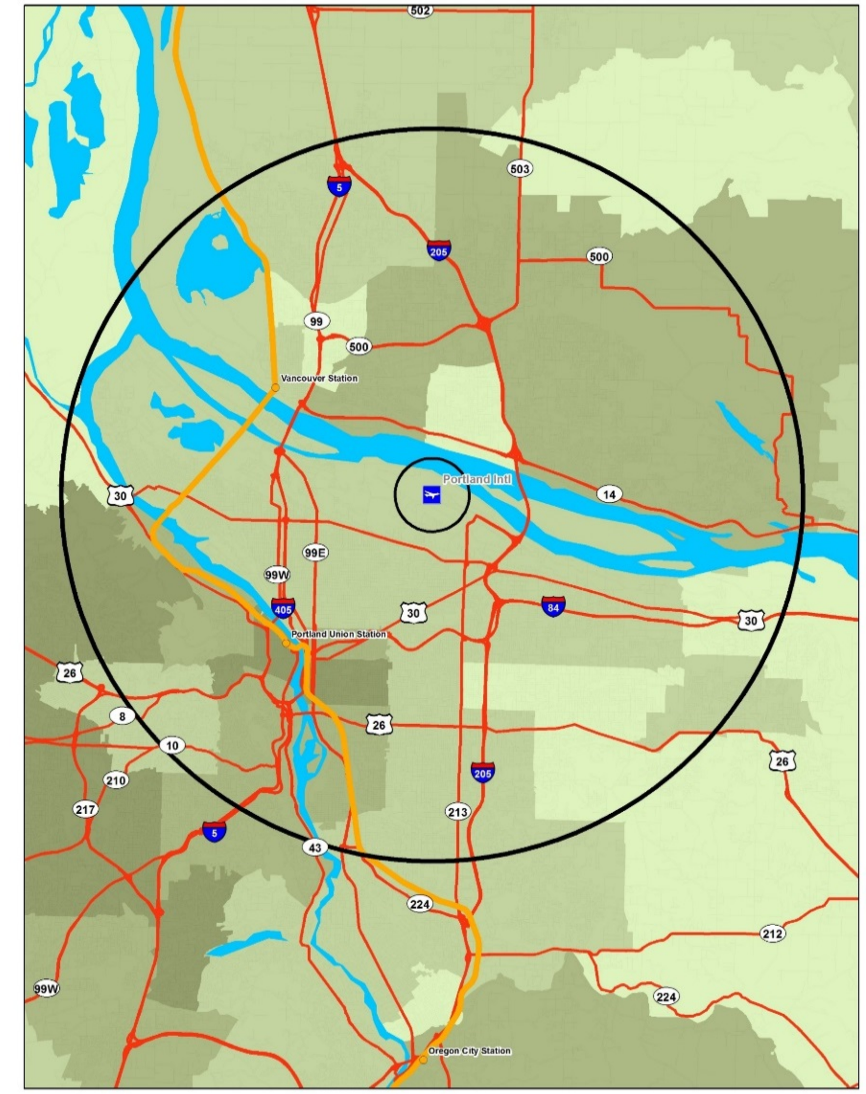
Portland, OR Employment

Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

Total Employment

- 0 - 50
- 51 - 250
- 251 - 500
- 501 - 1000
- 1001 - 5942



Portland, OR Information Technology

Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

IT Establishments

- 1 - 10
- 11 - 27
- 28 - 59
- 60 - 126
- 127 - 321

Figure 27: Socio-Economic Data

Maps for Portland, Oregon

22 Station Area Assessments

Building off the 2017-2018 UHSGT Feasibility Study (2017-2018 Study), eight city regions were chosen for station area assessments: Vancouver, BC; Bellingham, WA; Seattle, WA; Tacoma, WA; Olympia, WA; Kelso-Longview, WA; and Portland, OR. These station areas locations were identified to illustrate places that could be served by a new UHSGT system. Identification of potential station area locations and their use in assembling scenarios proceeded under the guidance of the Steering Committee and Advisory Group throughout the process.

Station area criteria were developed as a first step toward identifying potential station locations. A set of public benefit criteria were reviewed by the Advisory Group in Autumn 2018. Table 3 presents the revised criteria, which included land use, transportation, economic, equity and land use categories, and the proposed measures and impacts associated with each. The criteria are also discussed in more detail by category in the sections below.

Fact sheets addressing the five selection criteria were prepared for each of the eight potential station area locations. The fact sheets include summary data, maps, and reference documents collected from a wide range of sources (see Exhibit B).

Table 58: Station Area Evaluation Criteria

Category	Impact on Ridership	Measure
Market Capture Potential	Features that generate intercity rail ridership	Population, employment, number of businesses, institutions, and key innovation industries
Multimodal Interconnectivity	Presence of travel options that increase station area accessibility	Connection to existing and planned intercity and local/regional transport systems
Value Capture Potential	Local capacity to levy private participation	Existing and/or planned high-intensity mix of activities
Land Use Policies/Plans	Areas conducive to land and business development	Projected population and employment, planned development and redevelopment areas
Equity Considerations	Equitable access to employment and affordable housing opportunities	Projected population and employment distribution and densities in city and regional plans

22.1 Market Capture Potential

Market Capture Potential measured destinations within the station areas that draw intercity, national, and international person trips. These destinations could increase both tourism and business travel, bringing economic gains from a non-local source. The destinations under consideration included:

- Large universities and colleges
- Hotel rooms
- Attractions
- Large employers and high-tech companies
- Convention centers

22.2 Multimodal Interconnectivity

Multimodal Interconnectivity assessed the number of potential transit links at a potential station area with UHSGT as well as connections between UHSGT and intercity destinations. Many UHSGT passengers will begin or end their trips beyond walking distance of stations, making transit connections important, particularly in station areas with managed parking. Maps were created for each stations area illustrating the potential access to highways, major roads, transit lines, rail stations, ferry locations and airports.

Travel modes under consideration included: urban/regional transit (light rail, commuter rail, heavy rail, bus rapid transit, streetcar, bus lines, and ferries), and intercity travel modes (intercity buses such as Greyhound, national passenger rail services, and airports). It is measured by counting the number of lines for each mode. Future numbers are identified using the Regional Transportation Plans and other planning documents for each station city.

22.3 Land Use Plans and Policies

Land use plans and policies would indicate current zoning and planned uses that could either support, delay or curtail property development conducive to fixed guideway alignments and/or station locations. In addition, information on state, regional, and local plans and policies relevant to UHSGT would also be useful for ascertaining if locations could support UHSGT related development.

22.4 Value Capture Potential

Value capture potential is evaluated at a high-level to give a sense of existing and future relative land values. Higher density, mixed-use growth centers tend to have higher land values may have greater potential for value capture due to the forecasted high demand for new development and redevelopment coupled with high land and building improvement values. Future land use maps depict the areas planned for increased residential or employment density, mixed uses, improved transportation infrastructure, and/or economic development.

22.5 Equity Considerations

Maps of Area Median Income (AMI) and minority population portray each station area's demographic makeup. Because income is relative to place, and some of the regions contain multiple counties and states, area median measures for low-income and minority populations are used to provide consistent comparisons. Minority populations include those who identify as non-white or Hispanic/Latino. Canadian information was collected from Statistics Canada for visible minorities (persons, other than aboriginal peoples, who are non-Caucasian in race or non-white in color) and prevalence of low income based on the low-income thresholds.

22.6 Station Area Fact Sheet Methodology

Potential station areas in the selected city regions were compared by estimating statistics for activities and places within a three-mile or six-mile radius, centered around their downtown, central area or key node such as an airport or Amtrak Station.

For the large metropolitan regions (Vancouver/Surrey, BC, Seattle, WA, and Portland, OR) a three-mile radius was drawn around three locations: central city/downtown, peripheral city (i.e., a smaller city in proximity to the major city), and airport. The Seattle assessment included Seattle downtown, Tukwila, and Bellevue/Redmond. The Vancouver/Surrey, BC assessment included Vancouver downtown, Vancouver International Airport and Surrey, BC. The Portland, OR assessment included Portland downtown, Rose Quarter and Portland International Airport. The three-mile radii avoid overlapping station area circles and enables comparison of the relative strengths of the station areas in each metropolitan region.

Together, the three identified areas, central city, peripheral and airport, paint a picture of the trade-offs for locating a station in different parts of the metropolitan regions. The comparison between central city and peripheral station areas depicts the trade-off between ridership and cost: central city stations are anticipated to provide greater access to more people, jobs, and attractions, resulting in higher ridership, but are also likely to cost more to construct and operate. Peripheral station areas may allow for a lower capital cost, but could have lower multi-modal access to population, jobs, and attractions. Station areas at airports, also outside the central cities, have the benefit of connecting UHSGT with air travel.

Intermediate station locations were assessed using a six-mile radius, centered on the existing Amtrak station and extending into surrounding areas. The measures for each criterion provide a relative comparison among the intermediate stations. Although additional trip generators for UHSGT riders exist outside the three and six-mile radii, the catchment areas allow for side-by-side comparison within and among the three metro regions, and among the intermediate cities.

Station area fact sheets for each of the five criteria were prepared to describe the key characteristics of the eight city regions. The fact sheets include summary data, maps, and reference documents collected from a wide range of sources, including adopted plans and policies, Census Bureau and other demographic databases, and other research of publicly-available information.

22.6.1.1 Criterion 1: Market Capture Potential

Market Capture Potential was measured by identifying destinations within the three or six-mile station areas that draw regional, national, and international person trips. The destinations have a capacity to increase both tourism and business travel, bringing economic gains from a non-local source. Although additional attractions for UHSGT riders exist outside the three and six-mile radii, the catchment areas allow for side-by-side comparison within and among the three metro regions, and among the intermediate cities. The destinations were identified as follows:

- Large universities and colleges were identified using professional local knowledge and research expertise to locate schools with over 2,000 students.
- Hotel room counts where identified by researching tourism, travel, and media websites.

Ultra High-Speed Ground Transportation Stud
Station Selection Criteria
SEATTLE Multi-modal Interconnectivit

	Downtown Seattle	Bellevue	SeaTac/Tukwila
Rail transit (existing/additional planned)	2 / 6	0 / 2	2 / 1
BRT and streetcar (existing/additional planned)	6 / 3	0 / 1	2 / 1
Intercity Connections (Ferry/Bus/Rail)	5 / 1 / 3	0 / 0 / 0	0 / 0 / 0
Bus lines	55	8	7

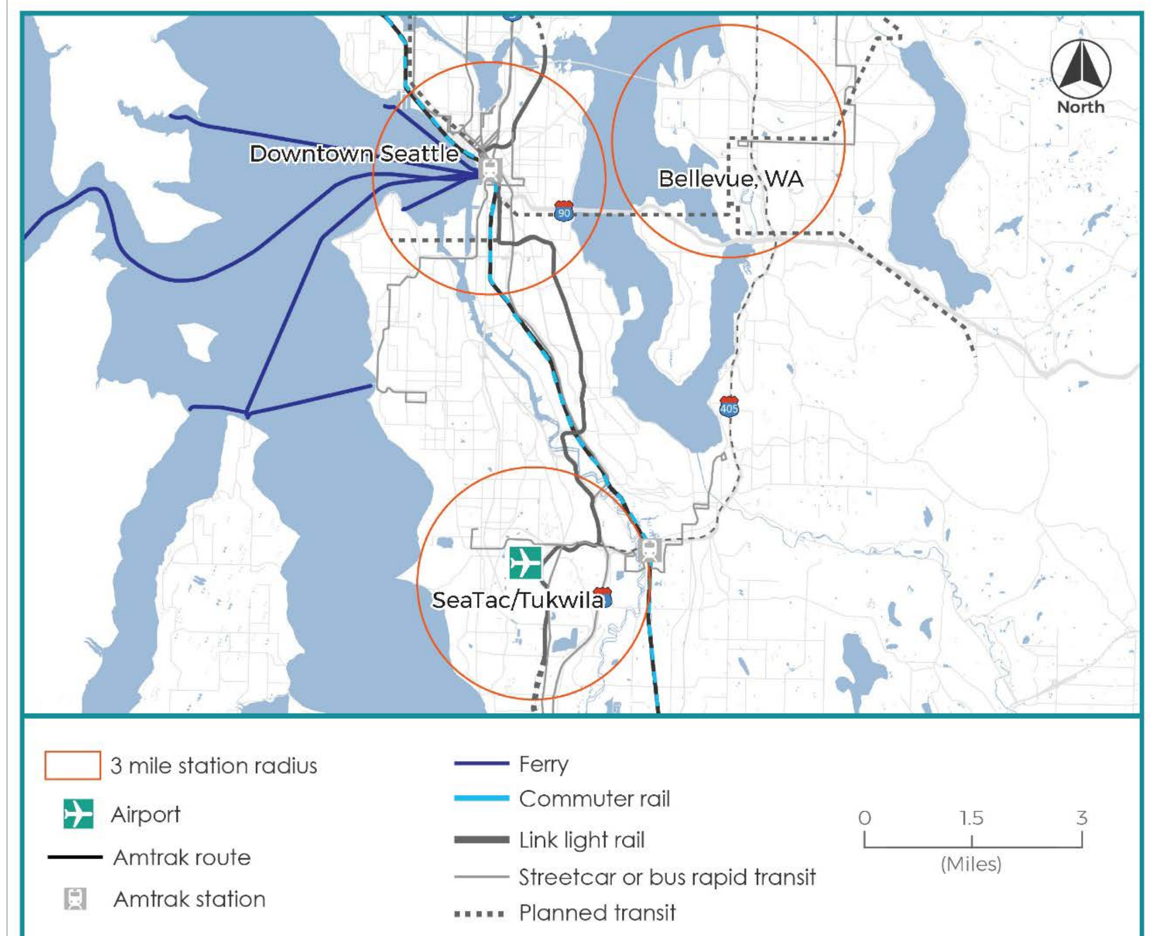


Figure 28: Intermodal Connections Fact Sheet for the Seattle Region.

22.6.1.2 Criterion 2: Multimodal Interconnectivity

Multimodal options for passenger transportation and freight movement exist throughout the corridor. The three large metro regions have well-developed and growing rail and bus urban/ regional transit services. Other station cities also have bus transit systems and several have ferry connections. Commercial airports serve each of the three metro areas, plus Everett and Bellingham, Washington.

Intercity Transportation Modes include:

- Airlines (Commercial carriers)
- Railroads (Amtrak passenger rail service and freight railroads including BNSF, UP and short line railroads)
- Auto and Truck: Highways (I-5, BC Highway 99 and Canadian Highway 1 in BC)
- Intercity buses (Bolt, Greyhound, and Amtrak Thruway)

Regional transit services include:

- Greater Portland (MAX light rail, frequent bus, streetcar)
- Puget Sound (Link light rail, Sounder commuter rail, frequent bus, streetcar, ferry)

Vancouver, BC Region (SkyTrain, West Coast Express commuter rail, frequent bus, ferry) Measuring connectivity to multiple modes includes looking at the potential for transfers to intercity travel modes (intercity buses such as Greyhound, national passenger rail services, and airports) and transfers to urban/regional transit (light rail, commuter rail, heavy rail, bus rapid transit (BRT), streetcar, frequent bus lines, and ferries. Connectivity was evaluated by identifying the number of lines for each mode. Existing numbers were identified using local transit agency maps and professional local knowledge. Future numbers were identified using the Regional Transportation Plans and other planning documents for each station city.

The intermodal connectivity criterion helps to depict and compare probable connections to UHSGT as well as connections from UHSGT to other regional destinations. In addition:

- The destination for many passengers will be outside the walking distance of UHSGT stations, making transit connections a potential part of their trip.
- UHSGT stations may have no, or limited, private vehicle parking, making intermodal connectivity an important consideration when examining the trade-offs between station areas.

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

VANCOUVER, BC — **Land Use Plans and Policies**

Population and Employment

	Downtown Vancouver, BC	Surrey, BC	Vancouver, BC Airport
Existing population (2016)	464,835	255,134	172,721
Future population (2035)	547,772	347,192	234,402
Population growth (2016 - 2035)	18%	36%	36%
Existing jobs (2016)	394,733	115,435	99,922
Future jobs (2035)	438,445	154,506	119,892
Job growth (2016 - 2035)	11%	34%	20%

Source: Data from TransLink transportation analysis zones. Population and employment are within 3 mile buffers of station locations.

Plans and policies

Regional
Metro Vancouver 2040 (2011)

Downtown Vancouver, BC
Transportation 2040 (2012)
Vancouver Tourism Master Plan (2013)
Greenest City Action Plan (2015)

Surrey, BC
Surrey Transportation Strategic Plan (2008)
Surrey Official Community Plan (2014)

Vancouver, BC Airport
Richmond Official Community Plan (2012)
Richmond City Centre Area Plan (2012)

The regional district is expected to grow by 1.1 million people between 2011 and 2041 (2.36 to 3.44 million) and by 0.6 million jobs (from 1.2 to 1.8 million).

Source: Metro Vancouver 2040 Shaping Our Future Adopted by the Greater Vancouver Regional District Board on July 29, 2011 Updated to July 28, 2017

Figure 29: Land Use Plans and Policies Fact Sheet for Vancouver/Surrey, BC

22.6.1.3 Criterion 3: Land Use Plans and Policies

Land use plans and policies were evaluated using current and forecasted population metrics and station area plans and policies relevant to high-speed ground transportation. Population numbers were collected through a GIS analysis using TAZ and Forecast Analysis Zone (FAZ) data. Current years, 2015 and 2016, were selected as available. Future years, 2035 and 2040, were identified in accordance with regional growth plans and data availability.

Station area plans and policies were identified through professional and local expertise. To provide regional context, state and regional plans and policies and regional growth estimates from the region's growth plan were identified.

22.6.1.4 Criterion 4: Value Capture Potential

Value capture analyses are typically performed on a parcel-level scale, such as the identification of vacant and underutilized lots in a station area to form an understanding of areas with high potential for redevelopment. However, to examine value capture potential on a high-level, future land use maps in regional and City growth plans were reviewed.

Future land use maps depict the areas planned for increased residential or employment density, mixed uses, improved transportation infrastructure, and/or economic development. Each of these elements is important to consider when selecting a station area to further study by identifying trade-offs between station locations based on planned future conditions. High-density growth centers, for instance, may have greater potential for value capture due to the forecasted high demand for new development and redevelopment coupled with high land values and high value of building improvements.

22.6.1.5 Criterion 5: Equity Considerations

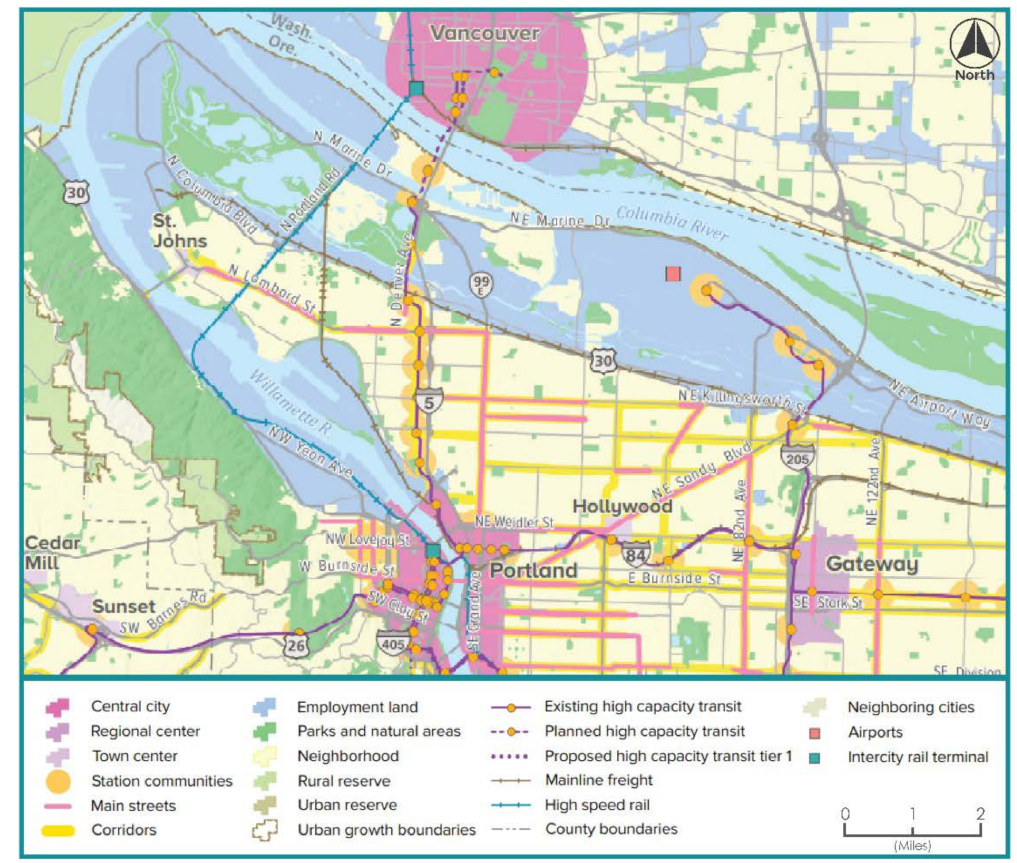
Area Median Income (AMI) and minority population maps were used to paint a high-level picture of the region's demographic makeup. Because income is relative to place, and some of the regions contain multiple counties and states, AMI was used as a method for consistent comparison. To portray concentrations of lower-income populations, average AMI for the counties was calculated and the respective census tracts below and above that average were identified. This methodology is consistent across all regions and cities.

Minority populations include those who identify as non-white or Hispanic/Latino. Concentrations of minority populations were identified by calculating percent people of color per county and identifying census tracts with a percent minority population below and above the respective county's average.

Canadian information was collected from Statistics Canada for visible minorities (persons, other than aboriginal peoples, who are non-Caucasian in race or non-white in color) and prevalence of low income based on the Low-income cut-offs, after tax. Canadian information on First Nation reserves is also included on separate maps within the fact sheets.

Ultra High-Speed Ground Transportation Study
Station Screening Criteria

GREATER PORTLAND — **Value Capture Potential**



Planned future land use with higher density multi-use areas have potential to equate to higher value capture. *Source: Oregon Metro 2040 Growth Concept*

Downtown Portland

The station is located in the Portland Metro "central city," which serves as the principal business, employment, cultural and entertainment location for the region.

Vancouver, WA

The station is located in downtown Vancouver, WA, which is designated as a "central city," that exists north of Portland in Washington state.

Portland Airport

The station is located in an "employment land" designation, which is defined by Oregon Metro as regionally significant industrial areas or employment areas that include a mix of employment uses.

Figure 30: Value Capture Fact Sheet for the Greater Portland Region

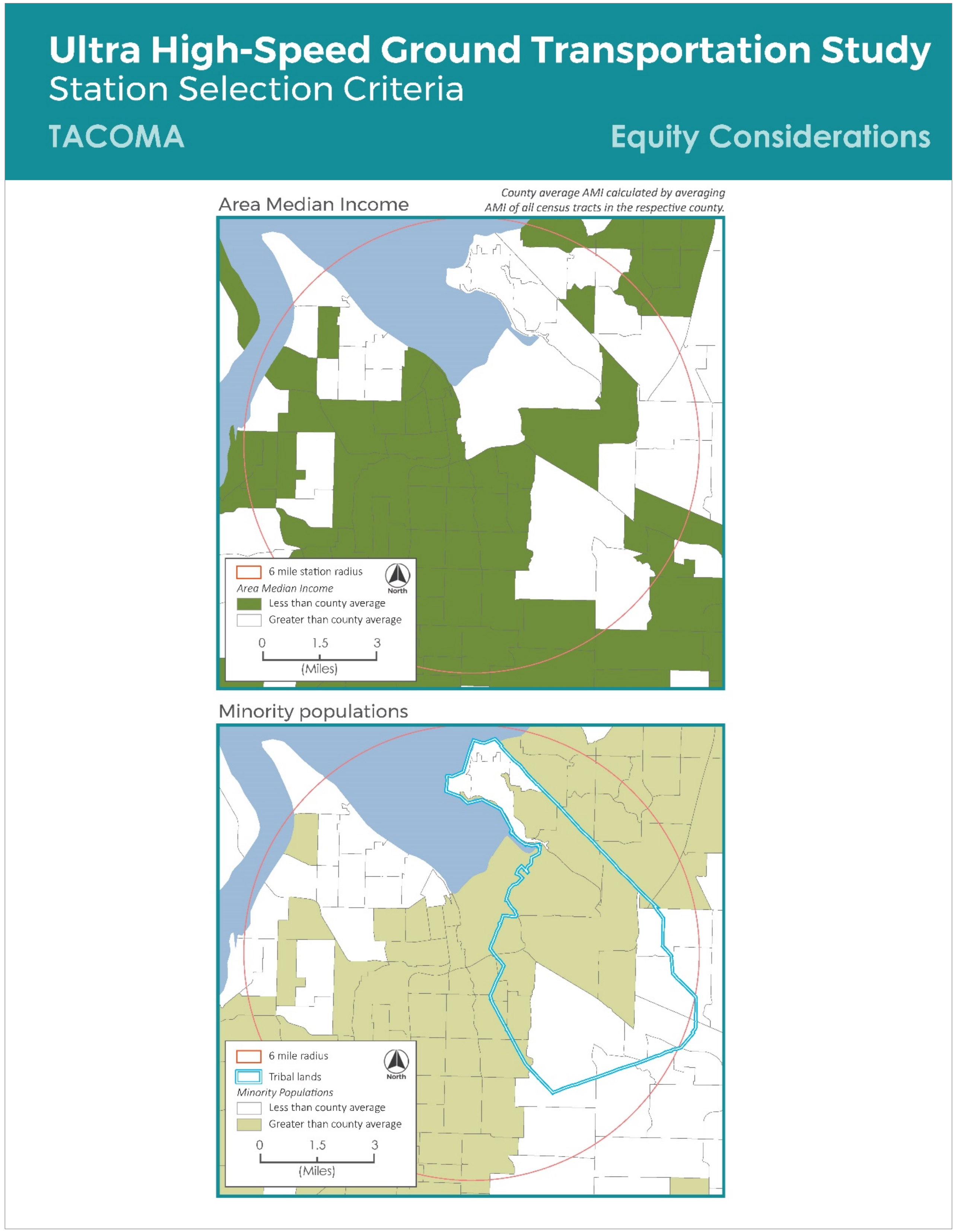


Figure 31: Equity Considerations Fact Sheet for Tacoma

23 Preliminary Scenarios

23.1 Scenario Development Methodology

The development of scenarios was an interactive process that strived to balance station area combinations with hypothetical routes that could accommodate UHSGT. For the purposes of this business case analysis, the selection of potential station area locations together with their hypothetical route comprises a scenario. Throughout the corridor planning process, the corridor planning team worked with the ridership team to develop scenarios that would promote network connectivity throughout the region and maximize intercity ridership on UHSGT. The ridership results are discussed in detail in the Ridership and Revenue Forecasts, Appendix D to the Business Case Report.

Considerations during the formulation of the preliminary scenario included:

- Station area characteristics as described in Chapter 5
- Existing and planned transportation systems in the corridor, including local/regional connections to potential UHSGT stations
- Projected intercity travel demand in the corridor and between origin and destination pairs
- Policy considerations.

Guiding principles included:

- Each scenario will use combinations of intermediate stations to test ridership volumes
- Ability to connect station areas along a relatively straight alignment.
- Priority given to intermodal ridership connections
- Consideration given to phasing
- Distances between station areas will affect operational costs

In addition to connecting major population and economic nodes, scenarios were developed to reflect policy considerations such as the inclusion of potential greenfield areas to encourage new sites for development. Improving access to affordable housing was a consideration; however, this phase of the study did not advance into a level of socio-economic and local land use planning necessary to make useful recommendations regarding station areas and affordable housing.

23.2 Understanding Potential Intermodal Connections

To develop an understanding of how an UHSGT system could interact with the existing and planned transportation network, two preliminary scenarios were diagrammed. Scenario 1 connects Vancouver, BC with Portland, OR by a route that would include downtown Seattle, WA. Scenario 2 connects Vancouver, BC with Portland, OR by a route that would include major hubs at Bellevue/Redmond and Tukwila, WA. Each of these preliminary scenarios was defined by its major hubs; the intermediate stations were not yet set. The diagrams shown in Figure 10 and Figure 11 illustrate the potential intermodal connections to transit, Amtrak Cascades and airports that would be achieved based on a variety of station area combinations possible in preliminary Scenarios 1 and 2.

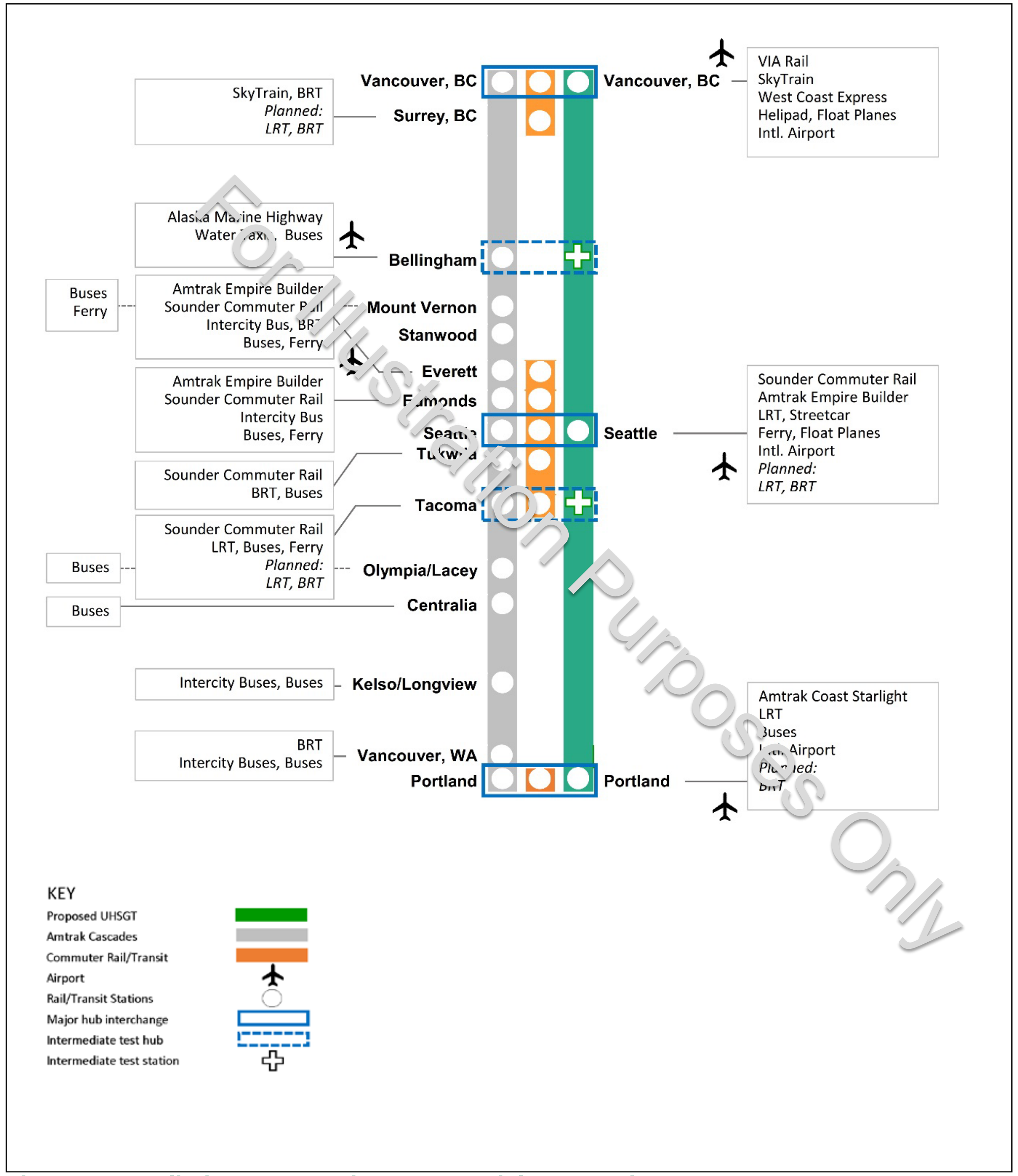


Figure 32: Preliminary Scenario 1 Intermodal Connections

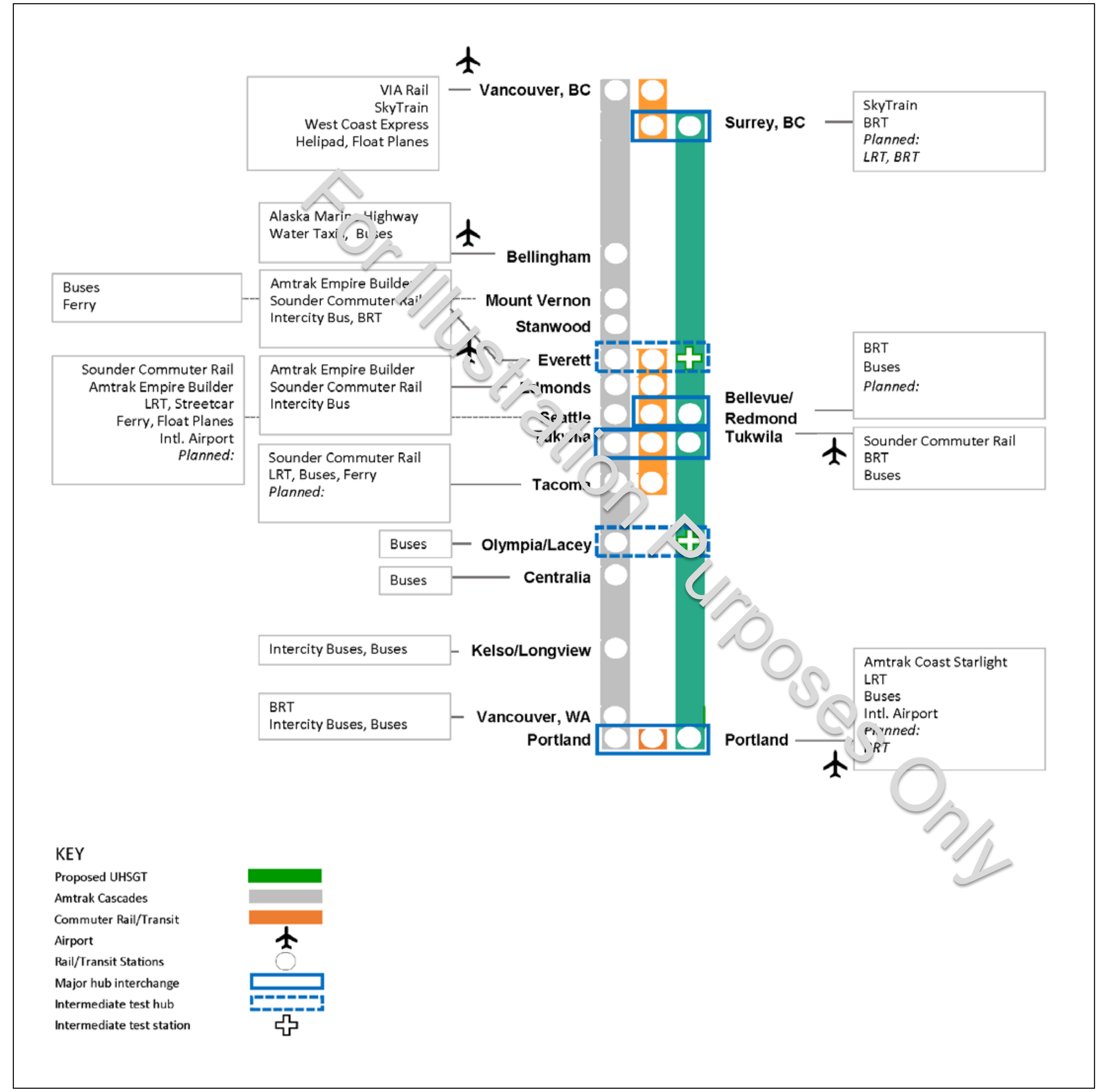


Figure 33: Preliminary Scenario 2 Potential Intermodal Connections

23.3 Early Service Planning Concepts

For each of the preliminary scenarios, service planning concepts were developed that included combinations of station stops and operating patterns. These concepts included:

- A simple stopping pattern at only three metropolitan regions (Vancouver, BC, Seattle, WA, and Portland, OR),
- Combinations of intermediate and city pair station stops (Surrey, BC, Bellingham, Everett, Tacoma, Olympia/Yelm, and Kelso/Longview),
- Continued examination of an eastside station in the Seattle metropolitan region, and
- Inclusion of airport UHSGT stations in addition to stops at the major hubs.

To attract ridership and offer a balance of frequent service, shorter travel times and access to more station areas, various service types in combination were considered for each scenario. The service types considered were:

- Express – hourly service only to major hubs during peak periods
- Base hourly – service to all intermediate and major hub stations
- City pair service – additional service during peak periods for O-D pairs with high existing demand.

The service type combinations for preliminary Scenario 1 and preliminary Scenario 2 are illustrated in Figure 12 and Figure 13.

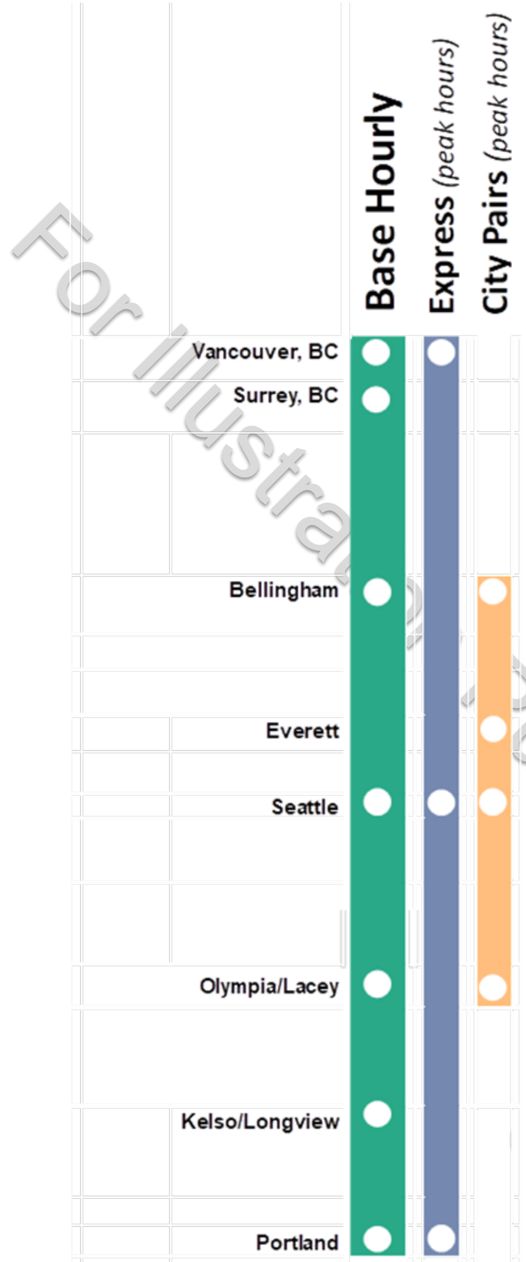


Figure 34: Preliminary Scenario 1 Service Types

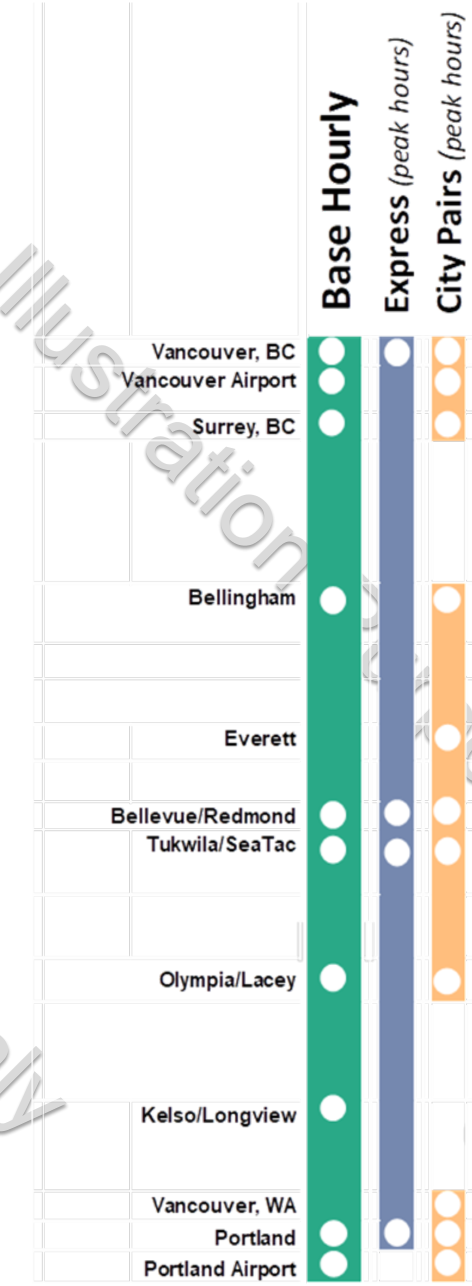


Figure 35: Preliminary Scenario 2 Service Types

23.4 Travel Times

To estimate travel times between station areas, a hypothetical route that would accommodate a design vehicle speed of 220 mph/350 kph was assumed, and mileage between stations was estimated. Working with Viriato software the three service types and associated stopping patterns as shown in the diagrams were coded by milepost into the schedule simulation model. Attention was focused on creating timed transfers between express, base and city services to maximize passenger access. This process produced conceptual timetables for each preliminary scenario. An excerpt from an early conceptual timetable is shown in Figure 14. Frequency, travel times, and stopping patterns were then outputted to the ridership team for a series of model runs for each preliminary scenario.

This conceptual information is a proxy for the type of service that could be provided on the potential UHSGT system.

23.5 Preliminary Results

The early ridership test model runs assumed half hourly service during most of an 18-hour operating day provided by a combination of express and base service with additional city pair service during peak periods. However, this type of city pair service, which did not serve the downtowns of the intermediate stops did not perform well and this type of service was not progressed for further study. Subsequent model runs expanded the operating day by an hour and adjusted the frequency of service to provide 21 daily round trips. A higher frequency of 30 daily round trips was also tested by the ridership team.

The combination of express and base service using 21 and 30 daily round trips was progressed as service planning concepts for scenario ridership testing. With input from the Advisory Group and Steering Committee, the range of scenarios continued to be developed. It was important to Committee members that multiple combinations of station areas be developed and analyzed as part of the corridor planning and ridership forecasts. In addition to ridership, the implementation of a UHSGT system would improve the connectivity between key activity nodes across the Cascadia region and potentially bring economic development to selected station areas. The potential economic impacts of this improved system are discussed in Appendix B to the Business Case.

Scenarios were developed for the business case report as examples of a potential UHSGT system so that key benefits and costs of such a system could be analyzed for proof of concept prior to an in-depth engineering design. It is important to highlight that station areas are subject to change and specific station locations have not been determined as part of the 2019 Business Case. Information on potential station areas has been collected to inform this phase of the UHSGT study. Station area locations would be added as needed and updated during subsequent phases of analysis and development that will occur during future phases of the UHSGT project.

Rail Service Planning

VANCOUVER - SEATTLE - PORTLAND Southbound

Filter: Trains from train group version: 'Very High Speed Trains - v2 220'.

Validity: daily

Time window: 5:00 - 23:00

mi		Train type	CITY	EXP	CITY	BASE
		Train number	201	101	201	1
mi		From:				
0	**VANCOUVER**			5:40		6:01
13	**Surrey**			|		6:09
54	**Bellingham**		5:49	|		6:27
117	**Everett**		6:12	|		|
145	**SEATTLE**		6:25	6:28	↴	6:58
	SEATTLE		↳	6:30	6:33	7:00
199	**Olympia**			|	6:52	7:20
	Olympia			|		7:21
261	**Kelso/Longview**			|		7:44
308	**PORTLAND**			7:28		8:07
		To:				

Figure 36: Early Conceptual Timetable Southbound Peak AM

24 Illustrative Scenarios

Following several iterations and input from the Steering Committee and Advisory Group, three illustrative scenarios (see) were developed for further study. Scenario 1 connects the major hubs of Vancouver, BC and Portland, OR through a hypothetical route through downtown Seattle. Scenario 2 travels eastward of Seattle through major hubs at Bellevue/Redmond and Tukwila, WA. Scenario 3 builds from Scenario 2 with extensions that serve the Vancouver, BC and Portland, OR International Airports. Within Scenarios 1 and 2 variations were included that considered Surrey, BC as the northern terminus of the UHSGT spine.

The interactive process of combining potential station area locations with hypothetical routes that would service UHSGT resulted in a series of variations within each scenario. These scenario variations considered the ridership benefits of a stand-alone spine, multiple intermediate stations, airport connections, and an integrated network concept with branch services that would link travelers from local transportation services to the new intercity corridor. The summary of stations served by scenario variation is included in Table 4.

Table 59: Summary of Stations Served by Scenario Variation

Station	1A	1B	1C	1D	1E	2A	2B	2C	3
Vancouver Airport, BC									X
Vancouver, BC	X	X	X	X		X	X		X
Surrey, BC	X	X		X	X	X	X	X	X
Bellingham, Wash.	X	X		X	X	X	X		X
Everett, Wash.		X		X			X		
Bellevue/ Redmond, Wash.						X	X	X	X
Seattle, Wash.	X	X	X	X	X		X		
Tukwila, Wash.						X	X		X
Tacoma, Wash.		X		X			X		
Olympia/ Yelm, Wash.	X				X	X			X
Olympia, Wash.		X		X			X		
Kelso/Longview, Wash.	X	X		X	X	X	X		X
Portland, Ore.	X	X	X	X	X	X	X	X	X
Portland Airport, Ore.									X

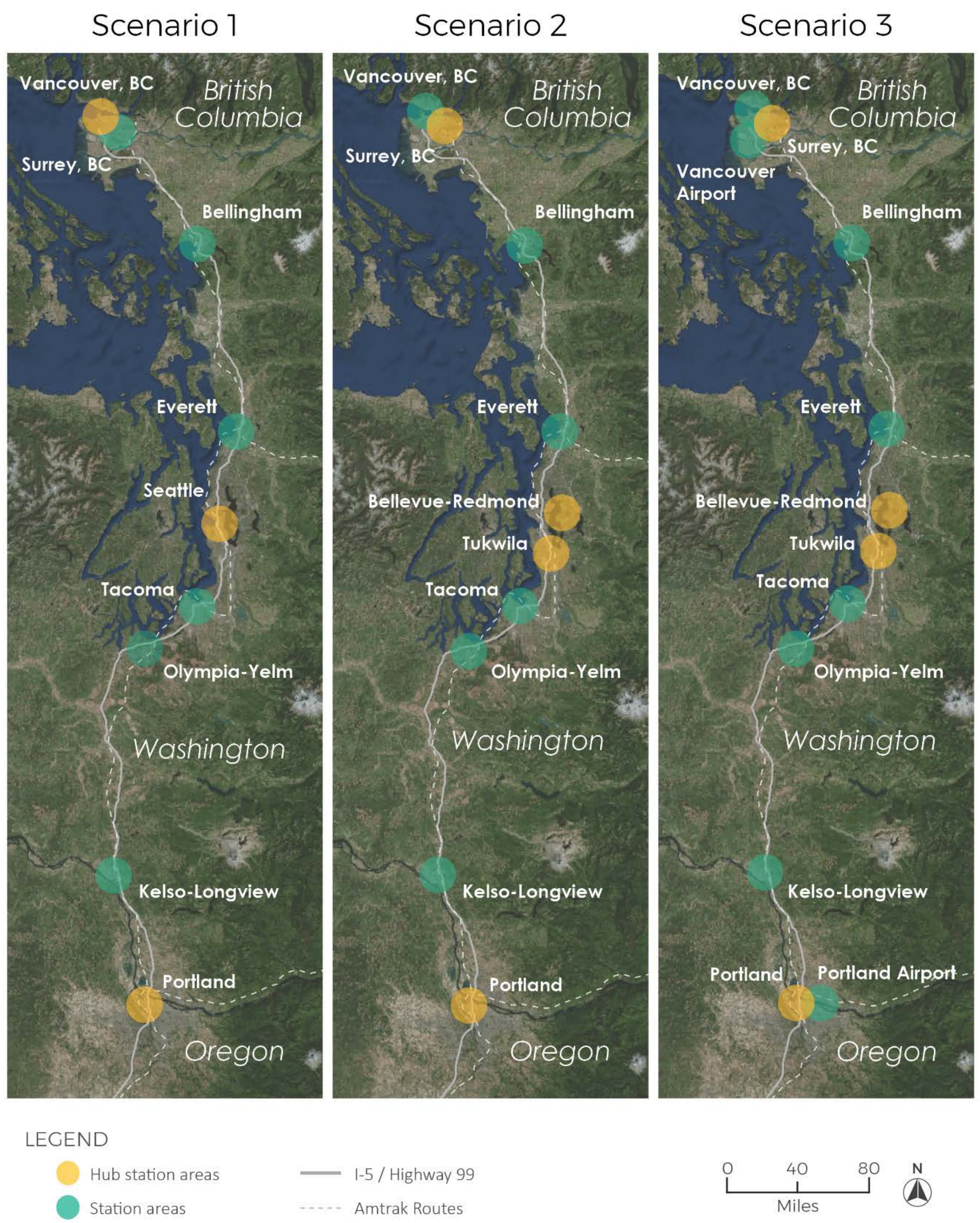


Figure 37: Illustrative Scenarios

24.1 Scenario 1

Scenario 1 is based on a hypothetical route that would serve station area locations in the central cites of Vancouver, BC, Seattle, WA and Portland, OR Given this new UHSGT spine, several service concepts were developed to test the ridership potential of this system:

- 1A provides service to the three major hubs of Vancouver, BC, Seattle, WA and Portland, OR and to intermediate stations at Surrey, BC, Bellingham, WA, Olympia/Yelm, WA and Kelso/Longview, WA.
- 1B builds off the service provided in 1A and adds branch line services to stations in Everett and Tacoma and moves the Olympia station off the UHSGT main line and onto branch service with a station in central Olympia.
- 1C would connect only the major hubs of downtown Vancouver, BC, Seattle, WA and Portland, OR with no intermediate station stops.
- 1D adds UHSGT stops to Scenario 1A in Everett,WA and Tacoma, WA.
- 1E is a variation of 1A with the northern terminus of the UHSGT spine in Surrey, BC rather than Vancouver, BC.

24.2 Scenario 2

Scenario 2 is based on a hypothetical route that would run eastward of the Scenario 1 alignment to serve station area locations at new hubs in Bellevue/Redmond and Tukwila, WA. As with Scenario 1 various service concepts were developed to test the ridership potential of this system.

- 2A provides service to the four major hubs of Vancouver, BC, Bellevue/Redmond, WA, Tukwila, WA, and Portland, OR and to intermediate stations at Surrey, BC, Bellingham, WA, Olympia/Yelm, WA and Kelso/Longview, WA.
- 2B builds off the service provided in 2A and adds branch line services to stations in Everett, Tacoma and Bellevue/Redmond, WA and moves the Olympia station off the UHSGT mainline and onto branch service with a station in central Olympia, WA.
- 2C connects only the downtowns of Surrey, BC, Bellevue/Redmond, WA, and Portland, OR.

24.3 Scenario 3

Scenario 3 extends the alignment in 2A to serve both the Vancouver, BC and Portland, OR airports.

Comparisons among the scenario variations will test the ridership implications for intermediate stations, airport connections in the three metro areas, and branch services to Tacoma, Everett, and Seattle downtown. This conceptual information is a proxy for the type of service that could be provided on the potential UHSGT system.

24.4 Service Concepts, Diagrams and Timetables

Service concepts were created for each of the scenario variations to visualize how the service types would work together, complement each other and potentially connect to other transportation modes on the corridor. These concepts are illustrated by scenario variation in Figure 16, Figure 17 and Figure 18

In each scenario variation, a series of service types and stopping patterns connecting the station areas was developed, which vary by frequency and stations served. These included:

- **Base** service connecting all major and intermediate stations on the UHSGT spine;
- **Express** service serving stations in the primary urban areas of Vancouver-Surrey, BC; Seattle-Bellevue/Redmond-Tukwila, WA; and Portland, OR; and
- **Branch services** off the spine to serve the downtown areas of cities such as Tacoma, Everett, and Olympia, with timed transfers to base and express trains, as well as existing commuter rail service, at major stations.

A pulse hub concept was used to link trains/create timed passenger connections at key hubs. These scenarios are intended to maximize connectivity by creating pulse hubs where convenient transfers among multiple trains are possible. Timed transfers are available to other branch-spine Origin-Destination (O-D) pairs, such as Olympia-Portland or Everett-Bellingham. All branch services are assumed to be electrified services

Each diagram in the figures below depicts the UHSGT services by scenario variation alongside the existing Amtrak Cascades service and indicates the station areas where travelers could transfer from one service to another. In Figure 16 the three Scenario 1 variations each feature combinations of base and express services. In Figure 17 Scenario 1B illustrates the branch services concept with pulse hubs at Seattle. Scenario 1C presents a simple three-stop pattern and no intermediate stations.

Figure 18 illustrates the Scenario 2 variations together. Scenario 2A features a combination of base and express services with a dual major hub in Bellevue/Redmond and Tukwila, WA to serve the greater Seattle metropolitan region and provide connections to Amtrak Cascades. Scenario 2B features a branch services concept with pulse hubs in Bellevue/Redmond and Tukwila, WA. Scenario 2C presents a simple three-stop pattern and no intermediate stations. Figure 19 illustrates Scenario 3 which features a combination of base and express services.

Working with Viriato software, the service types and associated stopping patterns as shown in the diagrams were coded by milepost into the model to prepare for a new series of ridership model runs. Attention was focused on creating timed transfers between express, base and city services to maximize passenger access. This process produced conceptual timetables for each scenario variation. The conceptual timetable in Figure 20 indicates the spine and branch departure times and the arrival times at hubs and terminating points for southbound service in the AM peak in Scenario 1B.

Frequency, travel times, and stopping patterns were then outputted to the ridership team to inform model runs conducted for each scenario variation.

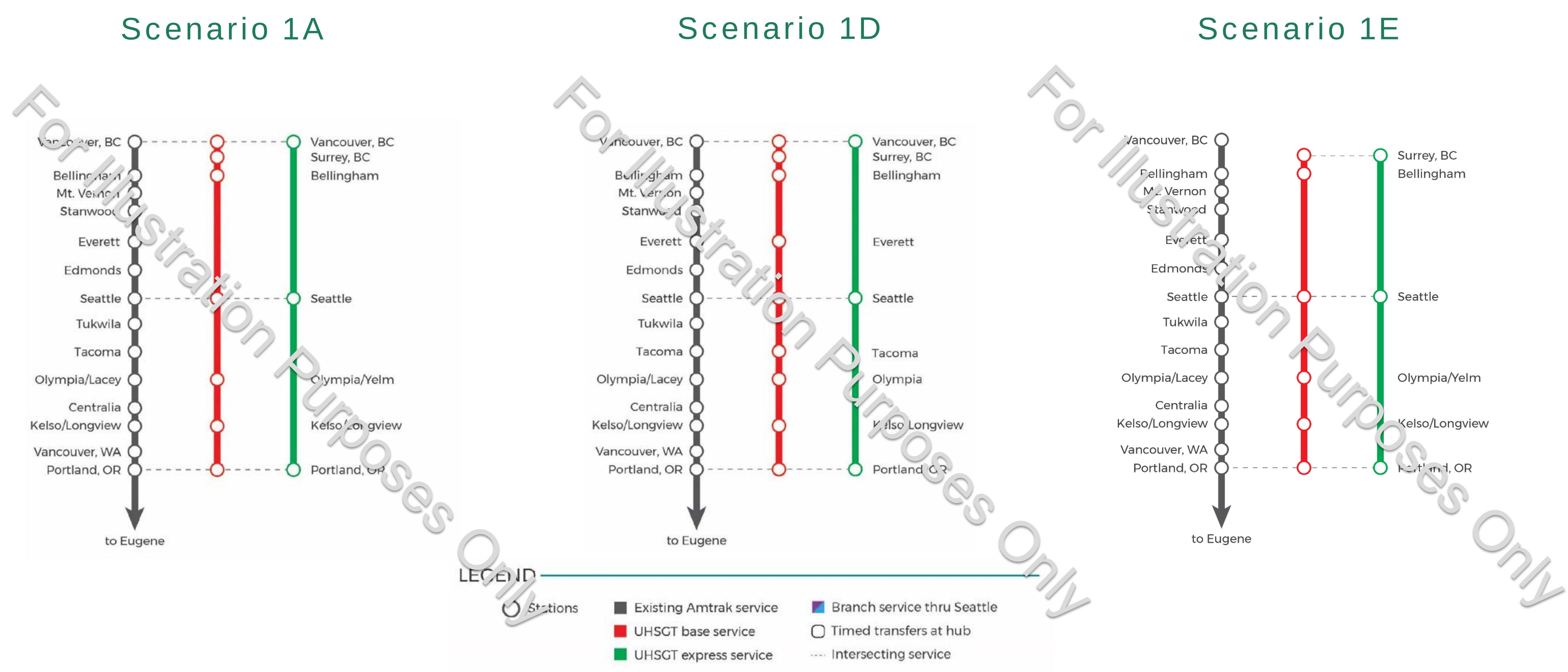


Figure 38: Service Diagrams – Express and Base Services Scenario 1

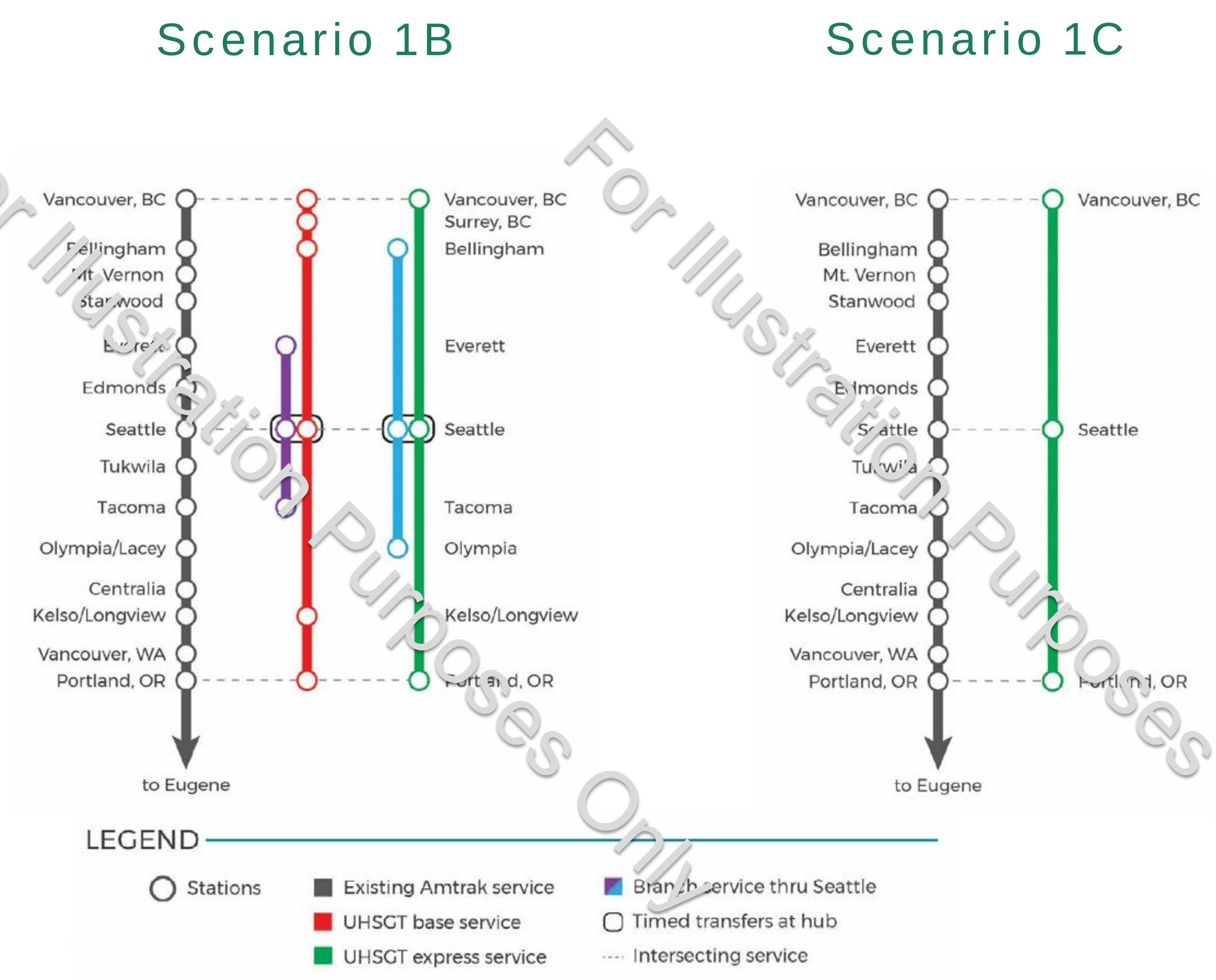


Figure 39: Service Diagrams – Branch and Three-Stop Services Scenario 1

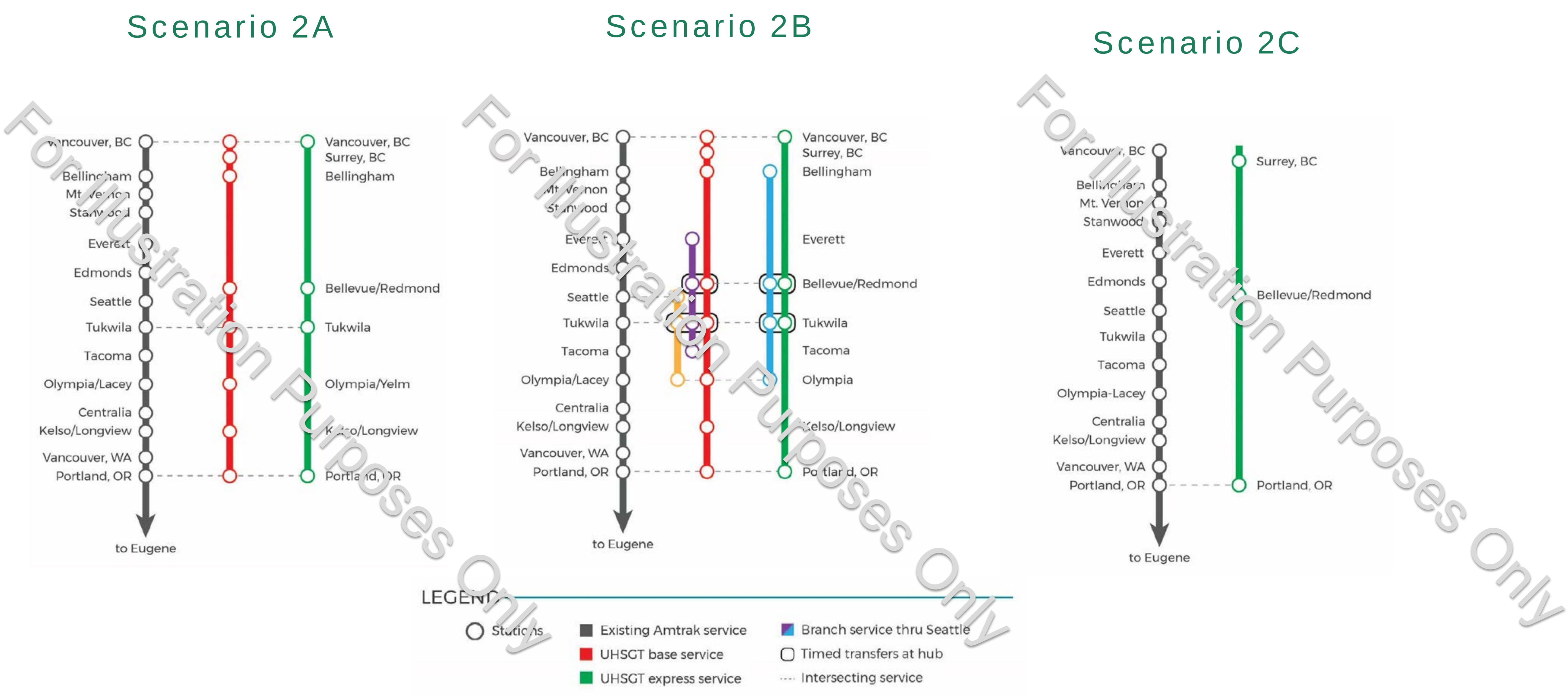


Figure 40: Service Diagrams – All Services Scenario 2

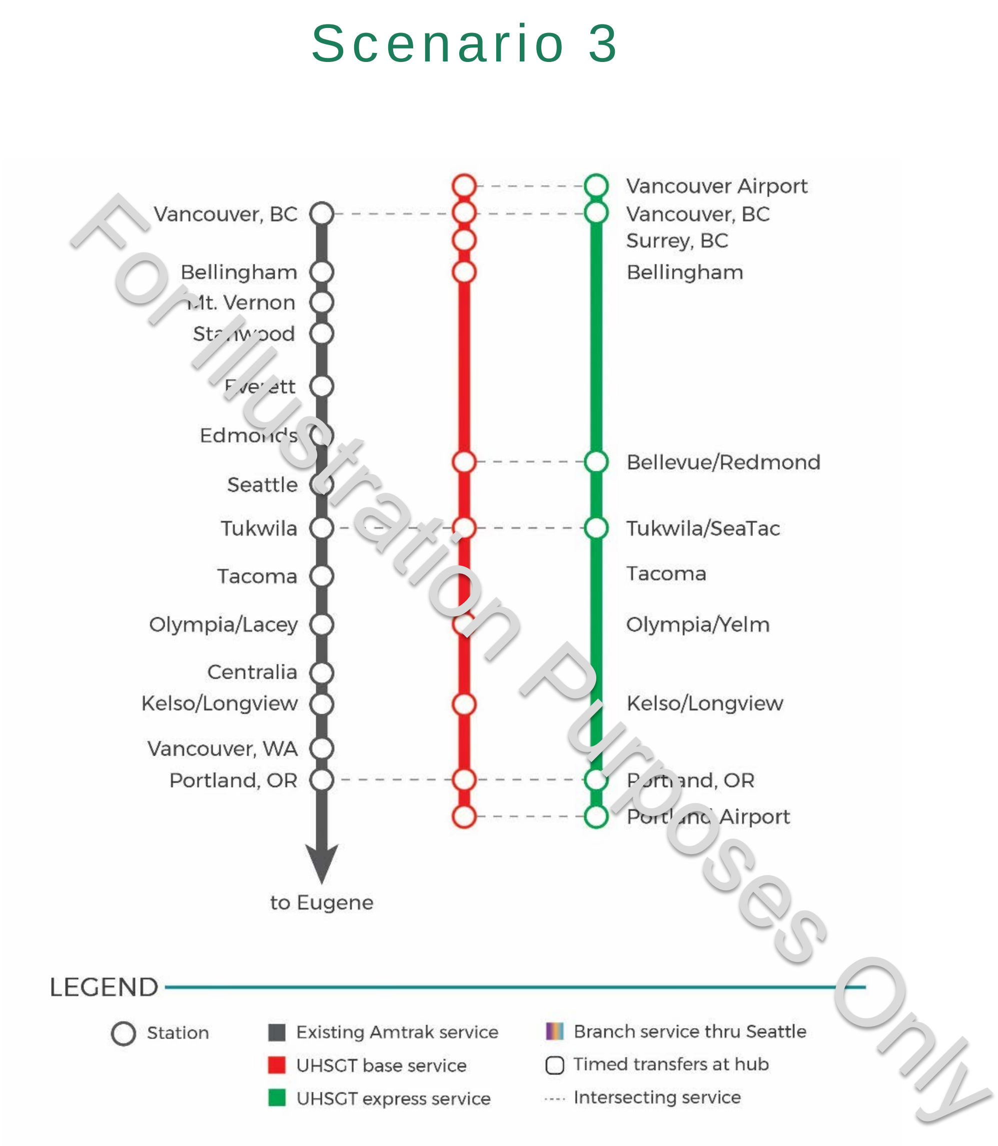


Figure 41: Service Diagram – Express and Base Services Scenario 3

24.5 Service Planning Metrics by Scenario Variation

Table 5 presents service planning metrics and outputs for the nine scenario variations that can be used to compare the scenario variations with another given similar levels of service. Two levels of service (21 roundtrips and 30 roundtrips) were investigated based on the results of early ridership model runs.

Columns A-E describe the service planning metrics for each scenario. These include:

A: Scenario number

B: Number of stations

C: Station names

D: Length of the route end-to-end

E: Estimated end-to-end travel time for local and express trains based on train performance calculations using a 220 mph/350 kph design vehicle along a hypothetical route

For each service level the following outputs were calculated:

F: Daily train trips by service type

G: Number of in-service miles that trains travel per year - a train-mile is the movement of a train the distance of one mile.

Annual train miles are a central determinant of operating costs. Annual train miles (Column G) are highest for Scenarios 1B and 2B because of the additional service between Bellingham and Olympia and in the Puget Sound region. The Vancouver, BC - Portland scenarios (1A, 1C, 2A and 2C) have comparable train miles. Scenario IE and 2D have fewer train miles due to the Surrey, BC terminus and Scenario 3 train miles are higher due to the airport extensions on each end of the line. Train miles were calculated for trips on the UHSGT spine; they were not calculated for trips along the branches.

Higher frequencies/higher level of service were anticipated to attract more ridership on the corridor. However, any gains in ridership would be weighed against the associated increase in train miles and operating costs.

VANCOUVER - Everett - SEATTLE - Tacoma - Olympia-Downtown - PORTLAND

SOUTHBOUND
Filter Trains from scenario: 'S1B v1'.
Validity daily
Time windo 5:00 - 23:00

	Train type		Branch 1	BASE	Branch 1	Branch 2	EXP	Branch 2	Branch 1	BASE	Branch 1	Branch 2	EXP	Branch 2	Branch 1	BASE	Branch 1	Branch 2	EXP	Branch 2	Branch 1	BASE
	Train number		301	1	301	401	101	401	303	3	303	403	103	403	305	5	305	405	105	405	307	7
	Remarks																					
mi		From:																				
0	VANCOUVER			6:01			6:40			7:01			7:40			8:01			8:40			9:01
13	Surrey			6:10			|			7:10			|			8:10			|			9:10
53	Bellingham			6:26		6:53	|			7:26		7:53	|			8:26		8:53	|			9:26
Branch	Everett		6:38	|		|	|		7:38	|		|	|		8:38	|		|	|		9:38	|
145	SEATTLE KING ST	o	6:55	6:58	↴	7:25	7:28	↴	7:55	7:58	↴	8:25	8:28	↴	8:55	8:58	↴	9:25	9:28	↴	9:55	9:58
	SEATTLE KING ST		↳	7:00	7:03	↳	7:30	7:33	↳	8:00	8:03	↳	8:30	8:33	↳	9:00	9:03	↳	9:30	9:33	↳	10:00
Branch	Tacoma	o		|	7:29		|	|		|	8:29		|	|		|	9:29		|	|		|
Branch	Olympia-Downtown	o		|			|	8:07		|			|	9:07		|			|	10:07		|
199	Olympia-Yelm			|			|			|			|			|			|			|
261	Longview			7:39			|			8:39			|			9:39			|			10:39
309	PORTLAND	o		8:02			8:28			9:02			9:28			10:02			10:28			11:02
		To:																				

Figure 42: Conceptual Timetable, Scenario 1B, Southbound AM Peak Service

Table 60: Projected Service Planning Metrics and Outputs by UHSGT Scenario Variation

					21 Roundtrips		30 Roundtrips	
A	B	C	D	E	F	G	F	G
Scenario	Number of Stations	Stations	Length of Route (Miles)	End-to-End Travel Time (Minutes)	Train Trips per Direction per Day	Annual Train Miles	Train Trips per Direction per Day	Annual Train Miles
1A	7	Vancouver, BC; Surrey, BC Bellingham; Seattle Olympia/Yelm; Longview/Kelso Portland	306	126 Local 107 Express	12 Local 9 Express	4,690,980	17 Local 13 Express	6,701,400
1B	6	Vancouver, BC; Surrey, BC Bellingham; Seattle Longview/Kelso; Portland	306	121 Local 107 Express	15 Local 6 Express	6,749,580	17 Local 13 Express	9,617,750
	3	Bellingham; Seattle Olympia Downtown	164	N/A	12		17	
	3	Everett; Seattle Tacoma	71	N/A	12		17	
1C	3	Vancouver, BC; Seattle Portland	306	107	21	4,690,980	30	6,701,400
1D	9	Vancouver, BC; Surrey, BC Bellingham; Everett Seattle; Tacoma Olympia Downtown; Longview/Kelso Portland	322	135 Local 107 Express	12 Local 9 Express	4,936,260	17 Local 13 Express	7,051,800
1E	8	Surrey, BC; Bellingham Everett; Seattle Tacoma; Olympia Downtown Longview/Kelso; Portland	292	118 Local 99 Express	12 Local 9 Express	4,476,360	17 Local 13 Express	6,394,800
2A	8	Vancouver, BC; Surrey, BC Bellingham; Bellevue/Redmond Tukwila/SeaTac; Olympia/Yelm Longview/Kelso; Portland	300	129 Local 106 Express	12 Local 9 Express	4,599,000	17 Local 13 Express	6,570,000
2B	7	Vancouver, BC; Surrey, BC Bellingham; Bellevue/Redmond Tukwila/SeaTac; Longview/Kelso Portland	300	124 Local 106 Express	12 Local 9 Express	6,911,640	17 Local 13 Express	9,846,240
	4	Bellingham; Bellevue/Redmond Tukwila/SeaTac; Olympia Downtown	159	N/A	12		17	
	4	Everett; Bellevue/Redmond Tukwila/SeaTac; Tacoma	65	N/A	12		17	
	5	Seattle; Tukwila Kent; Auburn Tacoma	40	N/A	12		17	
2C	3	Surrey, BC; Bellevue/Redmond Portland	286	106	21	4,384,380	30	6,263,400

					21 Roundtrips		30 Roundtrips	
A	B	C	D	E	F	G	F	G
Scenario	Number of Stations	Stations	Length of Route (Miles)	End-to-End Travel Time (Minutes)	Train Trips per Direction per Day	Annual Train Miles	Train Trips per Direction per Day	Annual Train Miles
3	10	Vancouver, BC Airport Surrey, BC Bellevue/Redmond Olympia/Yelm Portland Vancouver, BC Bellingham Tukwila/SeaTac Airport Longview/Kelso Portland Airport	318	158 Local 135 Express	12 Local 9 Express	4,874,940	17 Local 13 Express	6,964,200

25 Capital and Operating Costs

25.1 Capital Cost Projections

The 2019 Business Case did not include the conceptual engineering of a proposed alignment. For reference, the capital cost estimates from the 2017-2018 Feasibility Study range from $24 billion to $42 billion (2017 dollars).

The costs associated with the construction of a fixed guideway system, including stations, is highly dependent upon the specific location and geography of the proposed alignment. Sections that would require underground stations and tunnels are significantly more expensive to construct than at-grade sections or areas that require an aerial viaduct. Right-of-way (ROW) acquisition costs can also differ significantly depending on location and the requirements for ROW differ between the construction types. A capital cost estimate for Scenario 1E, for example, could be approximately 5-8% less than a capital cost estimate for Scenario 1A due to the reduced route length, one less station, and the reduced cost of construction and property acquisition in Surrey, BC that would be required as compared to construction and property acquisition in downtown Vancouver, BC.

25.2

25.3 Operating and Maintenance Cost Projections

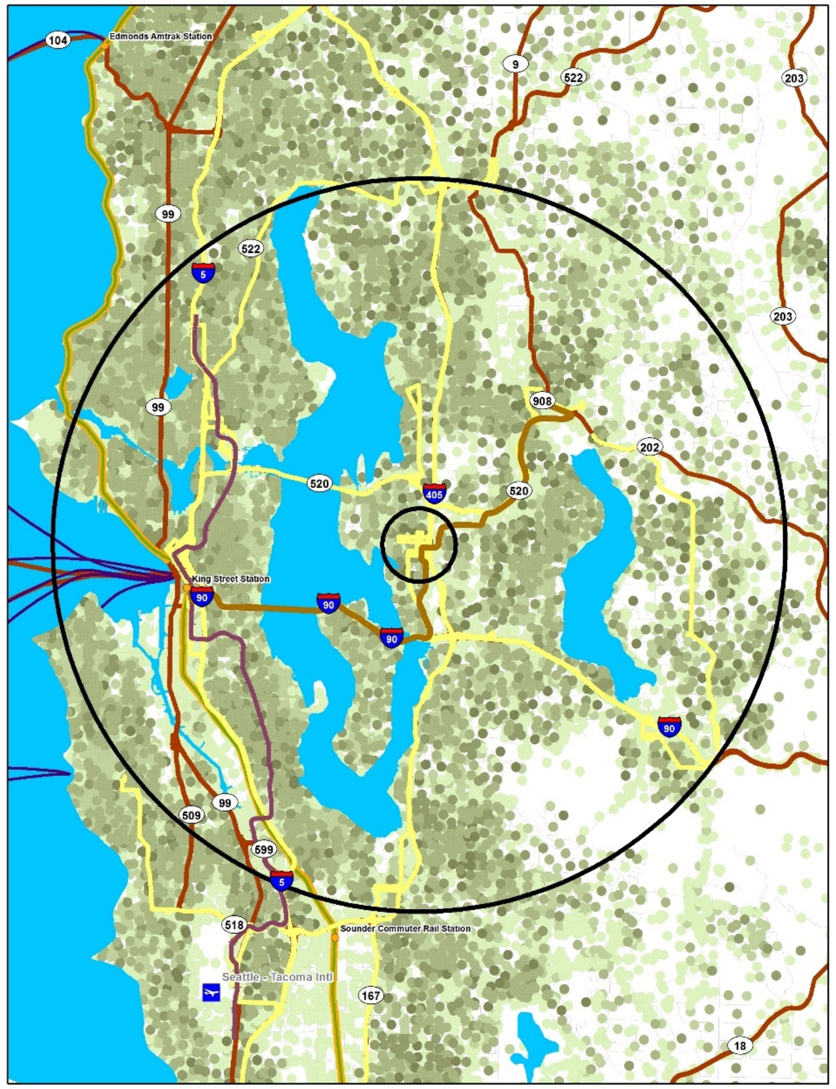
Anticipated farebox revenue discussed in the *Ridership and Revenue Forecasts Report* would be used to offset the operating and maintenance (O&M) costs required to run the UHSGT system. O&M costs are linked to recurring costs for train operations, infrastructure maintenance, station operations, control center and field operations, staff, and insurance. A unit cost approach was used to assess Scenario 1D as a representative scenario with 21 roundtrips per day on a route length of 306 miles. Unit cost assumptions were developed based on a review of other similar existing and planned systems in the US, Europe, and Japan.

The operating costs for train operations per roundtrip were estimated to be lower in the 2019 Business Case as compared to the 2017-2018 Study. Similarly, the station operating costs were also estimated to be lower per station. However, the 2019 Business Case assumed 9 more roundtrips and an additional station as compared to the highest ridership alternative in the 2017-2018 Study. Insurance costs were also added to Scenario 1D in the 2019 Business Case. Thus, the annual operating costs are anticipated to be about 13-14% higher than in the earlier study.

However, the higher ridership volumes forecast in the 2019 Business Case would result in higher revenues, which allow for operating and maintenance costs to be covered by fare revenue by 2055 – a finding similar in magnitude to the 2017-2018 Study. An increase in ridership of about 10% or decreases in operating costs of about the same magnitude and/or the additional of ancillary revenues (advertising, station space leases, food service, etc.) could result in a full offset of O&M costs by revenue in 2040.

Exhibit A Station Area Assessments for Three Selected Candidate Locations

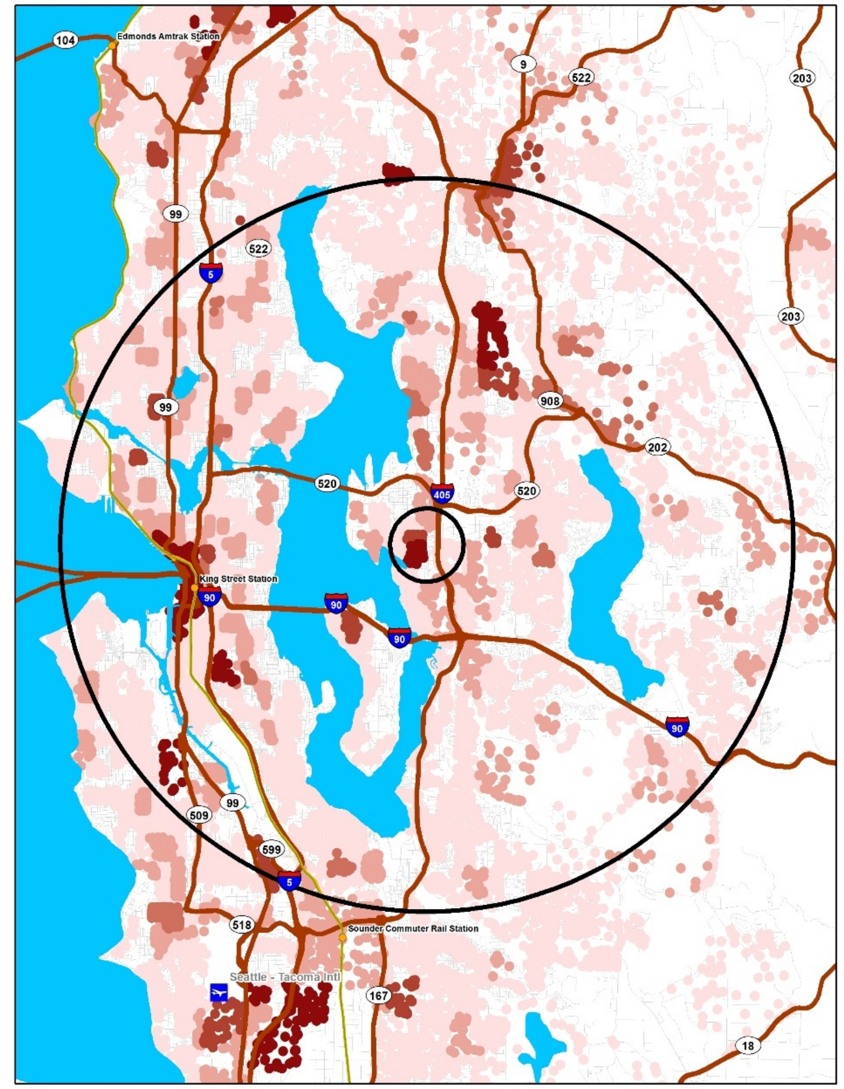
- Bellevue/Redmond, WA
- Tacoma, WA
- Portland, OR



Bellevue/Redmond, WA Population

Legend
- Airports
- Amtrak Cascades Station
- Ferry Routes
- EastLink
- Link Light Rail
- ST Express Bus
- Sounder
- Amtrak Cascades RailLine

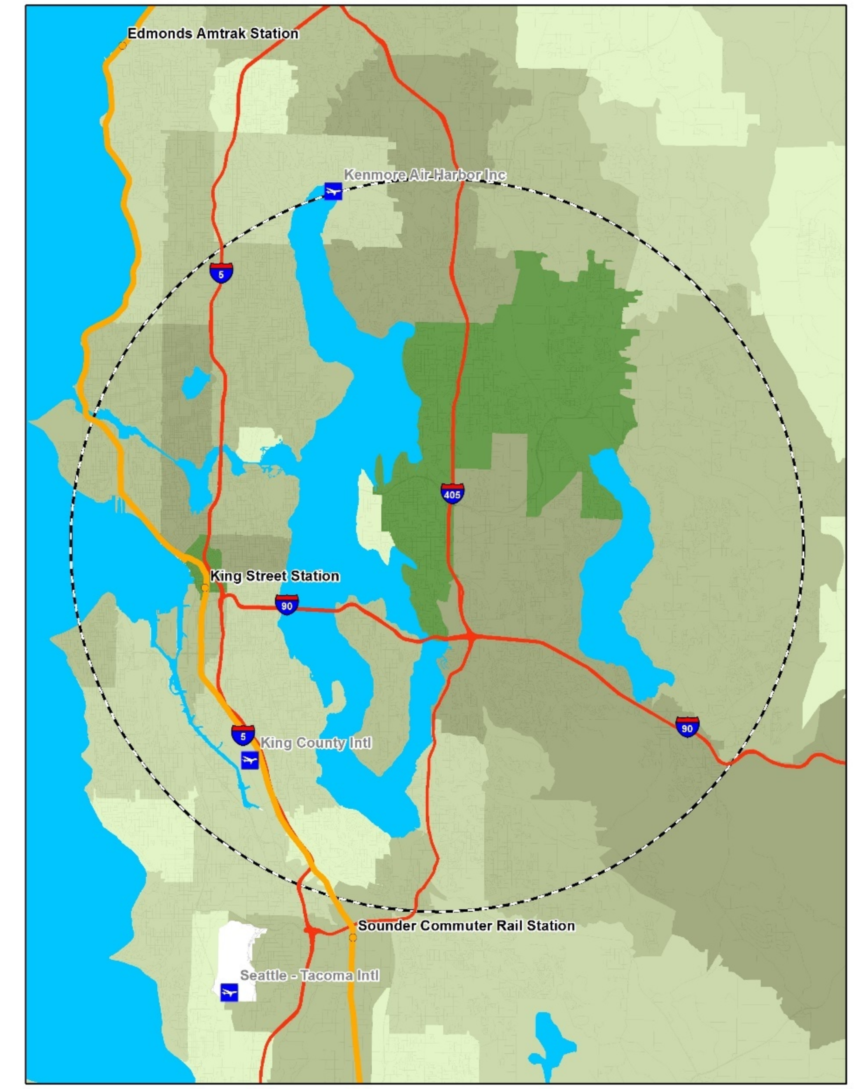
Total Population
- 0 - 24
- 25 - 81
- 82 - 186
- 187 - 411
- 412 - 1034



Bellevue/Redmond, WA Employment

Legend
- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

Total Employment
- 0 - 50
- 51 - 250
- 251 - 500
- 501 - 1000
- 1001 - 5942

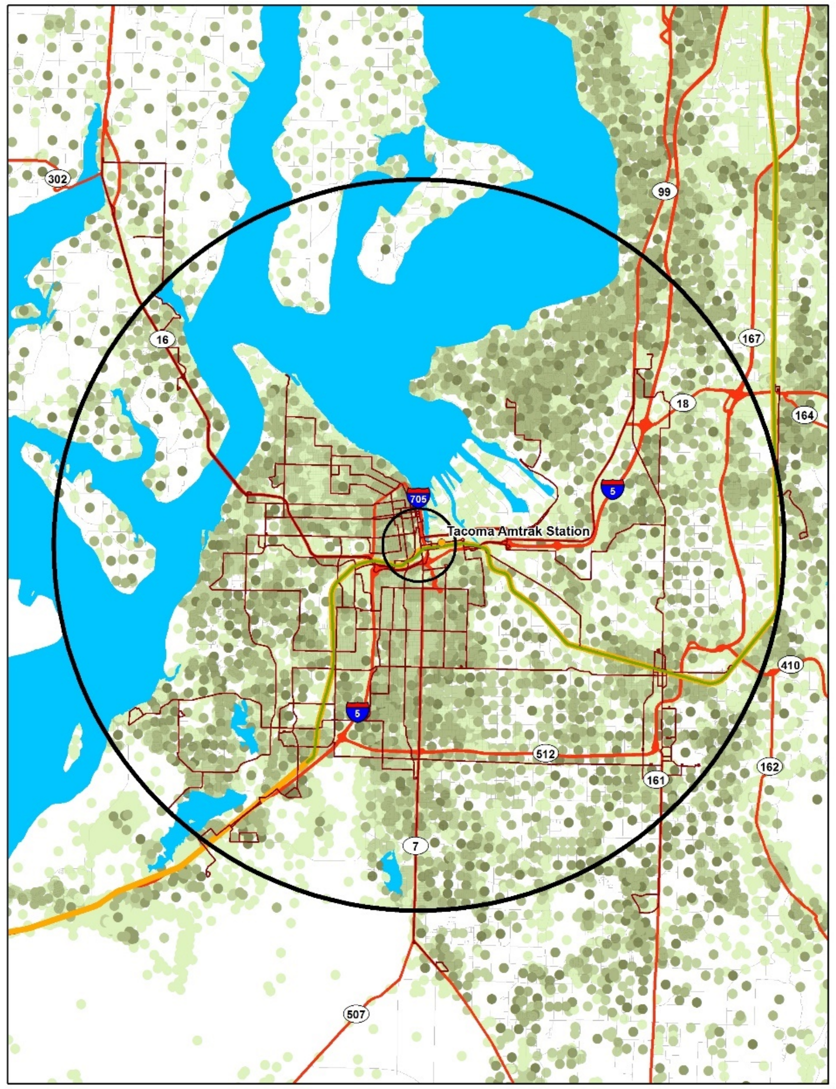


Bellevue/Redmond, WA Information Technology

Legend
- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

IT Establishments
- 1 - 10
- 11 - 27
- 28 - 59
- 60 - 126
- 127 - 321

Bellevue/Redmond, Washington



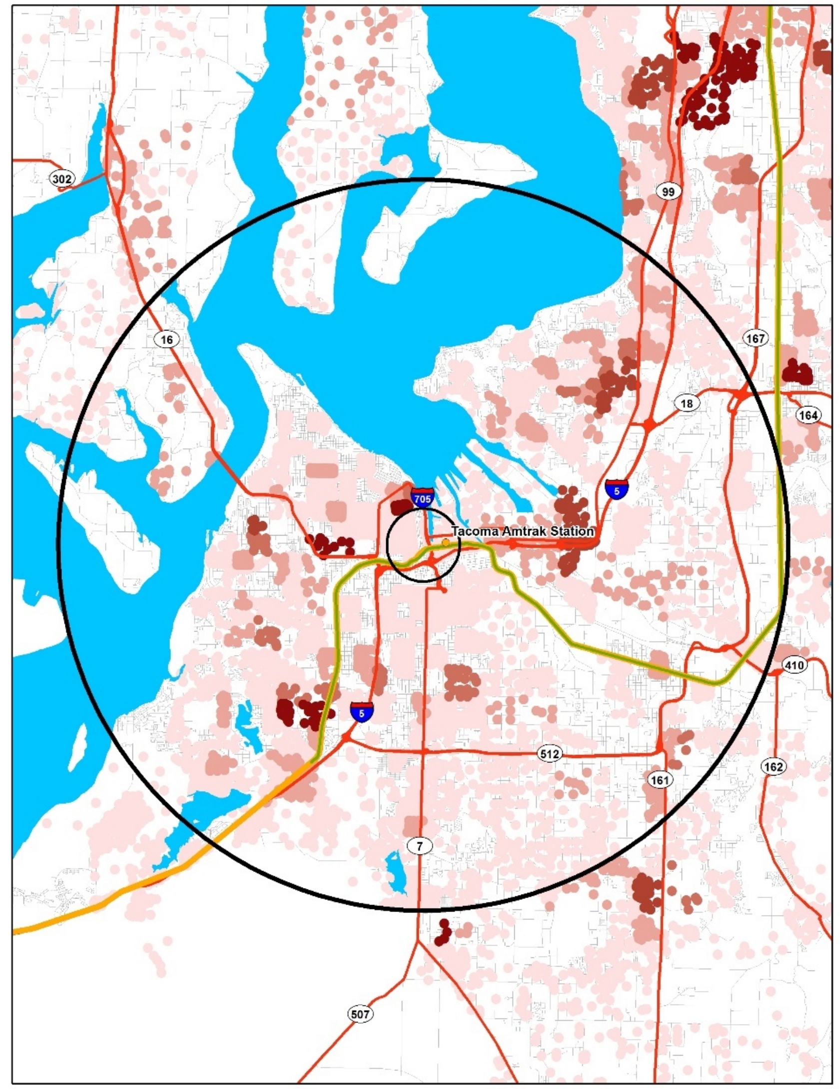
Tacoma, WA Population

Legend

- Airports
- Amtrak Cascades Station
- Ferry Routes
- EastLink
- Link Light Rail
- ST Express Bus
- Sounder
- Amtrak Cascades RailLine

Total Population

- 0 - 24
- 25 - 81
- 82 - 186
- 187 - 411
- 412 - 1034



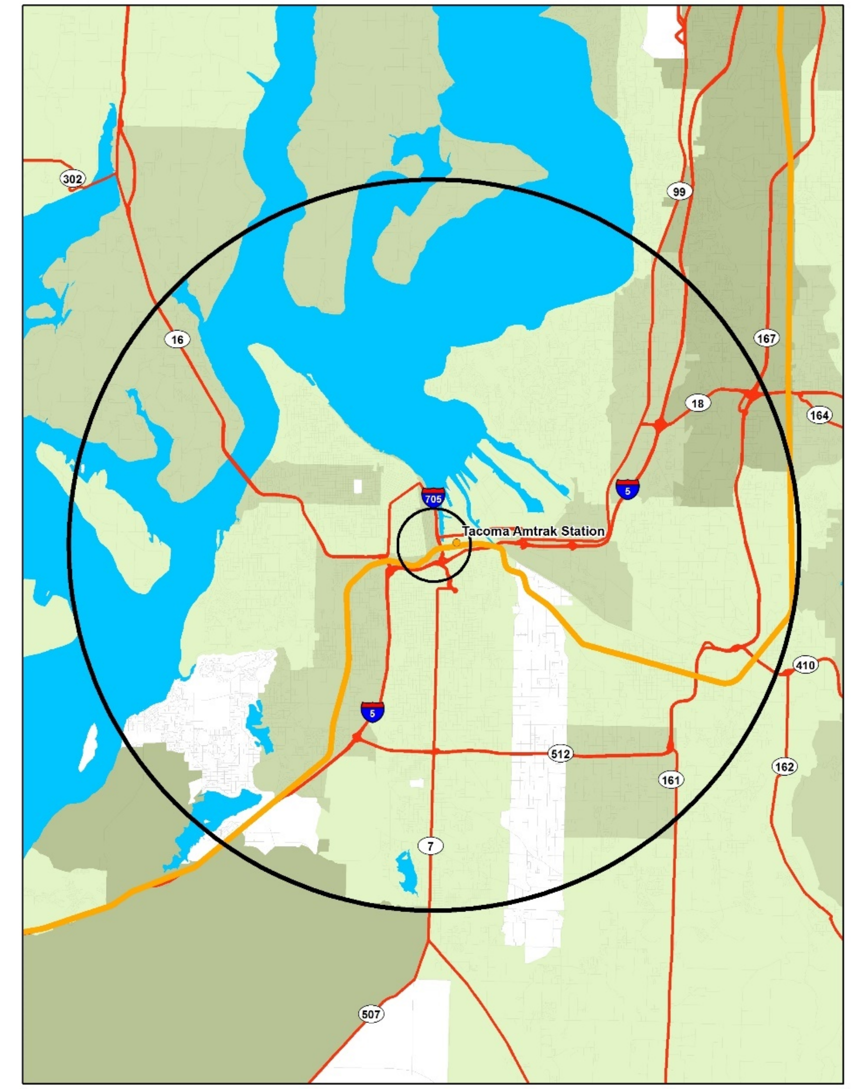
Tacoma, WA Employment

Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

Total Employment

- 0 - 50
- 51 - 250
- 251 - 500
- 501 - 1000
- 1001 - 5942



Tacoma, WA Information Technology

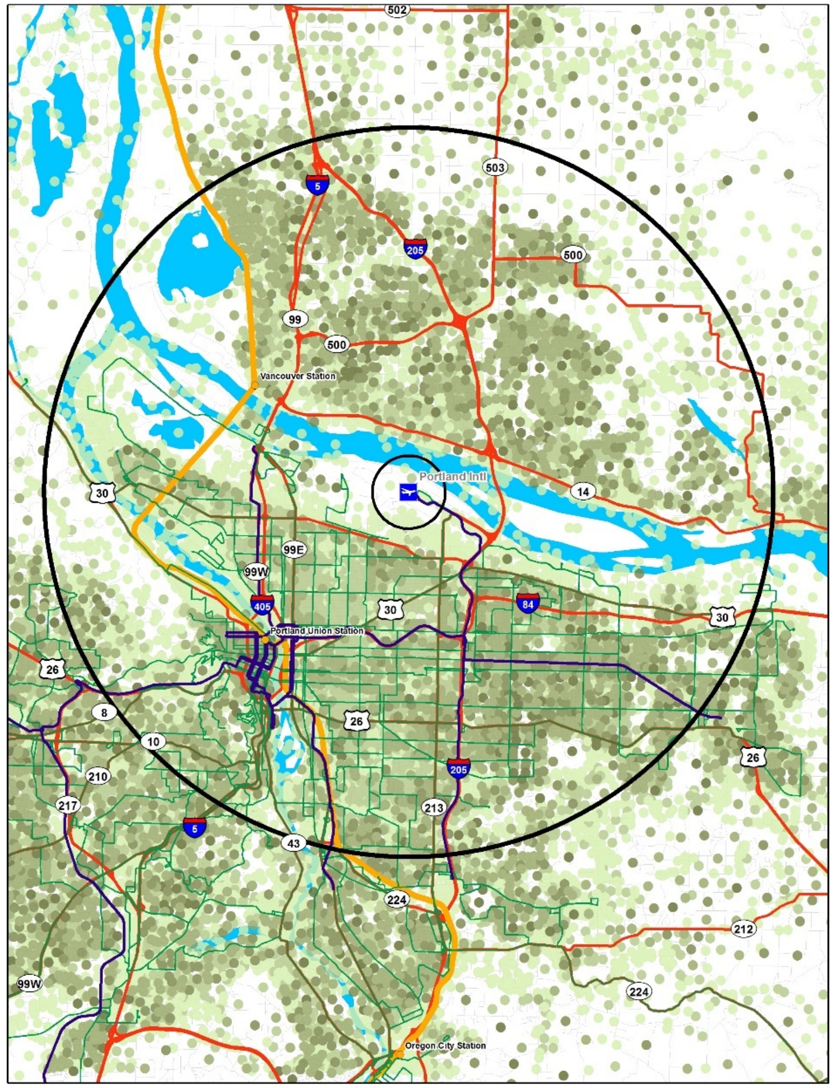
Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

IT Establishments

- 1 - 10
- 11 - 27
- 28 - 59
- 60 - 126
- 127 - 321

Tacoma, Washington



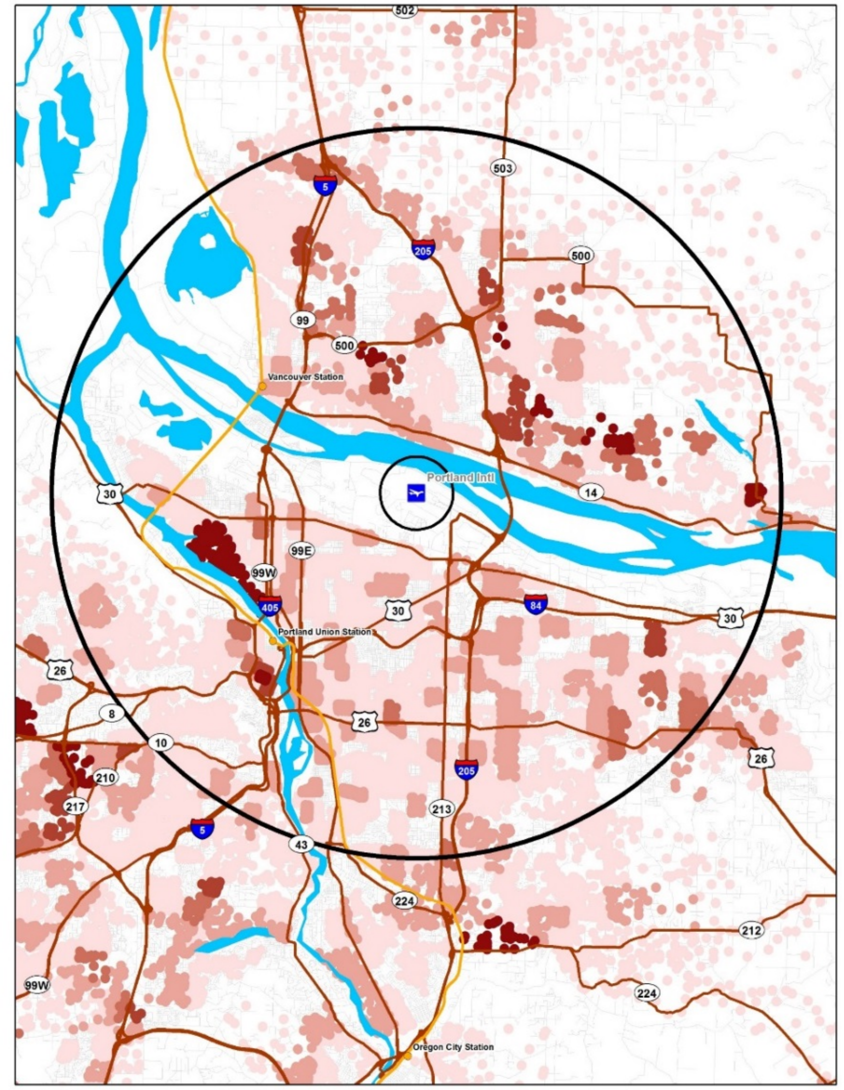
Portland, OR Population

Legend

- Airports
- Amtrak Cascades Station
- TriMet Rail System
- Bus Routes
- Amtrak Cascades RailLine

Total Population

- 0 - 24
- 25 - 81
- 82 - 186
- 187 - 411
- 412 - 1034



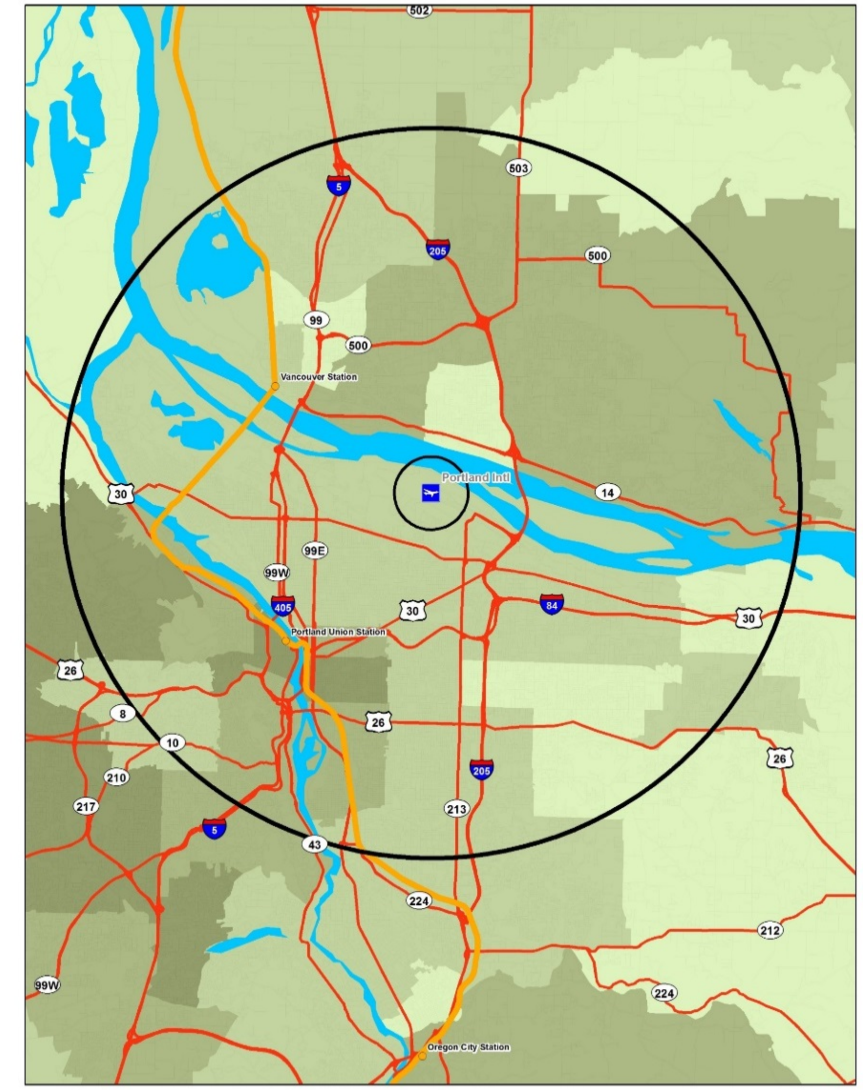
Portland, OR Employment

Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

Total Employment

- 0 - 50
- 51 - 250
- 251 - 500
- 501 - 1000
- 1001 - 5942



Portland, OR Information Technology

Legend

- Airports
- Amtrak Cascades Station
- Amtrak Cascades RailLine

IT Establishments

- 1 - 10
- 11 - 27
- 28 - 59
- 60 - 126
- 127 - 321

Portland, Oregon

Exhibit B Station Area Fact Sheets for Eight Potential Candidate Locations

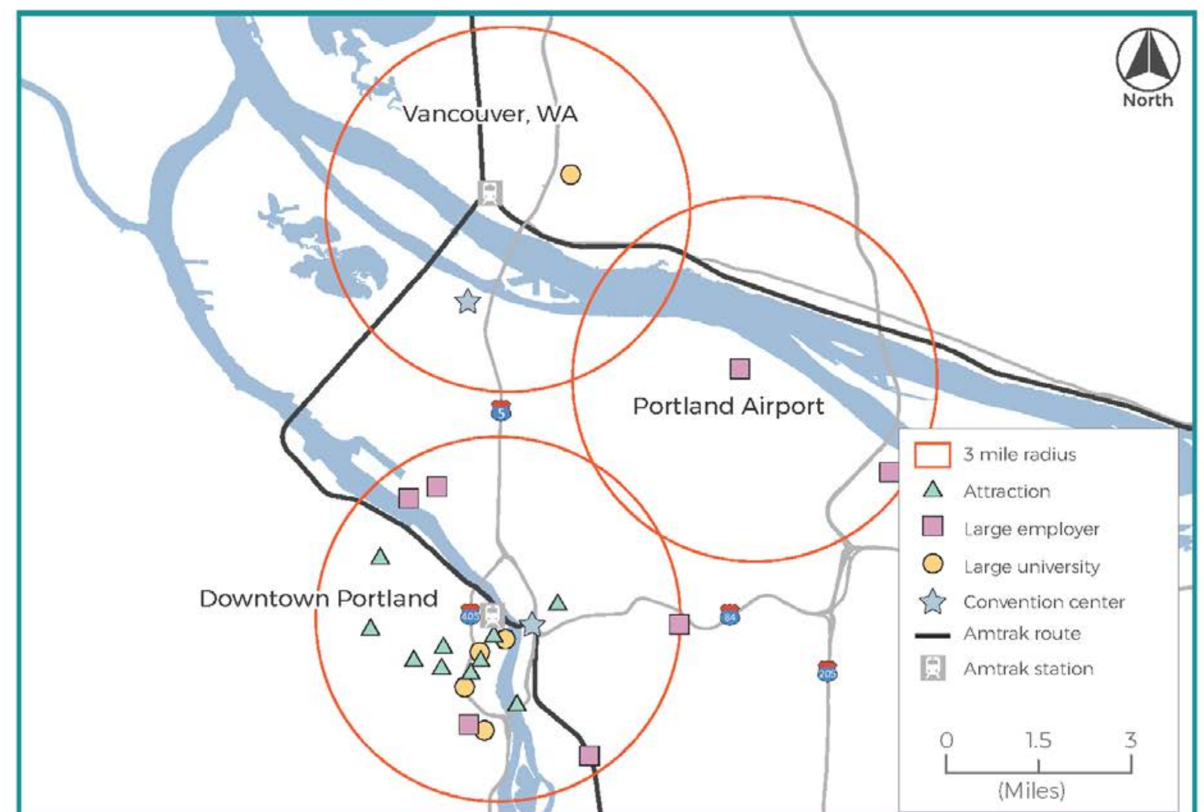
Greater Portland, Oregon

Ultra High-Speed Ground Transportation Study
Station Screening Criteria

GREATER PORTLAND — **Market Capture Potential**

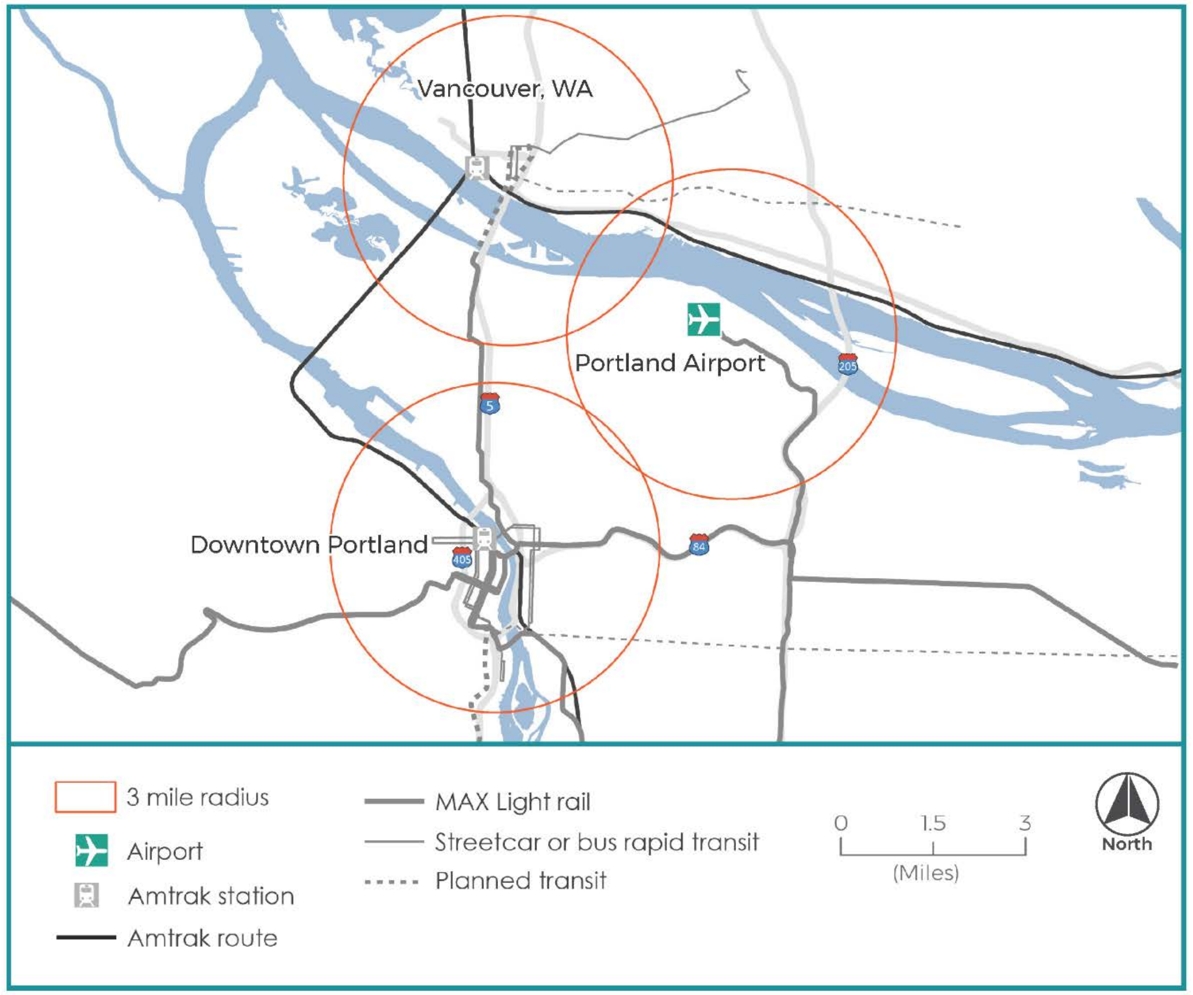
	Downtown Portland	Vancouver, WA	Portland Airport
Large universities/ colleges*	4	1	0
Hotel rooms	8,000+	2,500+	1,500+
Attractions**	10	0	0
Large employers/ High-tech companies***	5 / 8	0 / 3	2 / 2
Convention centers	1	1	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.
**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*
***Per TripAdvisor's top 10 tourist attractions for the region.*
****Largest private companies within 3 mile radius as determined by Greater Portland Inc. Specific employment numbers not available. High-tech companies determined using existing resources tracking the technology industry.*



Ultra High-Speed Ground Transportation Study
Station Screening Criteria
GREATER PORTLAND — Multi-modal Interconnectivity

	Downtown Portland	Vancouver, WA	Portland Airport
Rail transit (existing/additional planned)	5 / 1	0 / 1	1 / 0
BRT and streetcar (existing/additional planned)	3 / 1	1 / 0	0 / 0
Intercity connections (Ferry/Bus/Rail)	0 / 5 / 3	0 / 0 / 1	0 / 0 / 0
Bus lines	32	15	0



Ultra High-Speed Ground Transportation Study
Station Screening Criteria
GREATER PORTLAND — Land Use Plans and Policies

Population and Employment

	Downtown Portland	Vancouver, WA	Portland Airport
Existing population (2015)	253,841	87,199	96,024
Future population (2040)	372,553	118,884	115,934
Population growth (2015 - 2040)	47%	36%	21%
Existing jobs (2015)	296,446	64,139	60,841
Future jobs (2040)	365,154	90,937	80,231
Job growth (2015 - 2040)	23%	42%	32%

Source: Data from Oregon Metro transportation analysis zones. Households and employment are within 3 mile buffers of station locations.
Note: TAZ data on existing and future population and employment in the Portland Metro Region is based on households, not population.

Plans and policies

Regional
Oregon Metro 2040 Growth Concept (2014)
Clark County Comprehensive Plan (2016)

City
Vancouver Comprehensive Plan (2011)
Portland Comprehensive Plan (2014)

Downtown Portland
N/NE Quadrant Plan (2012)
Albina Vision (2017)
Central City 2035 (2018)

Vancouver, WA
Vancouver City Center Vision & Sub-area Plan (2007)

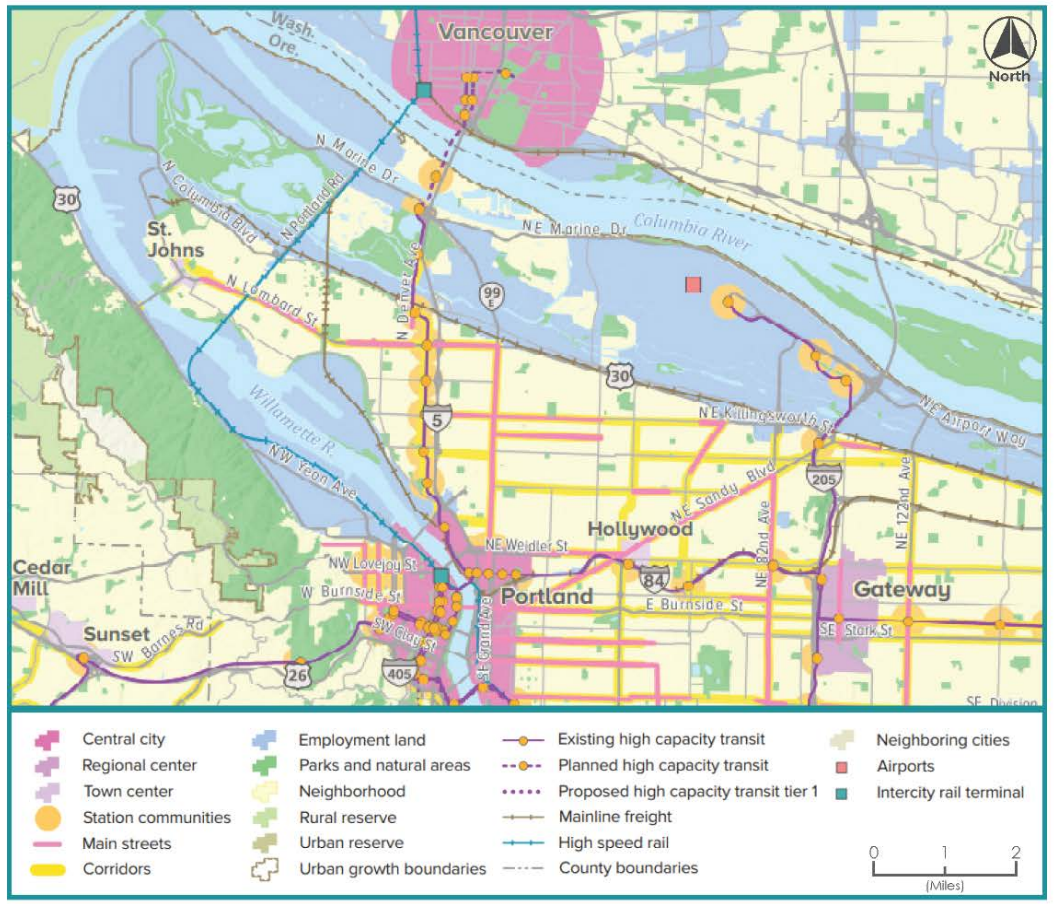
Portland Airport
Portland International Airport Master Plan (2008)

The seven-county region is expected to grow by 0.6 million people between 2015 and 2040 (2.4 to 3.0 million) and by 0.3 million jobs (from 1.1 to 1.4 million).

Source: Metro 2018 Urban Growth Report Discussion Draft July 3, 2018, Appendix 1 – 2018 Regional Economic Forecast

Ultra High-Speed Ground Transportation Study
Station Screening Criteria

GREATER PORTLAND — **Value Capture Potential**



Planned future land use with higher density multi-use areas have potential to equate to higher value capture. *Source: Oregon Metro 2040 Growth Concept*

Downtown Portland

The station is located in the Portland Metro "central city," which serves as the principal business, employment, cultural and entertainment location for the region.

Vancouver, WA

The station is located in downtown Vancouver, WA, which is designated as a "central city," that exists north of Portland in Washington state.

Portland Airport

The station is located in an "employment land" designation, which is defined by Oregon Metro as regionally significant industrial areas or employment areas that include a mix of employment uses.

Ultra High-Speed Ground Transportation Study
Station Screening Criteria

GREATER PORTLAND — **Equity Considerations**

Area Median Income *County average AMI calculated by averaging AMI of all census tracts in the respective county.*

Minority populations

Tacoma, Washington

Ultra High-Speed Ground Transportation Study

Station Selection Criteria

TACOMA **Market Capture Potential**

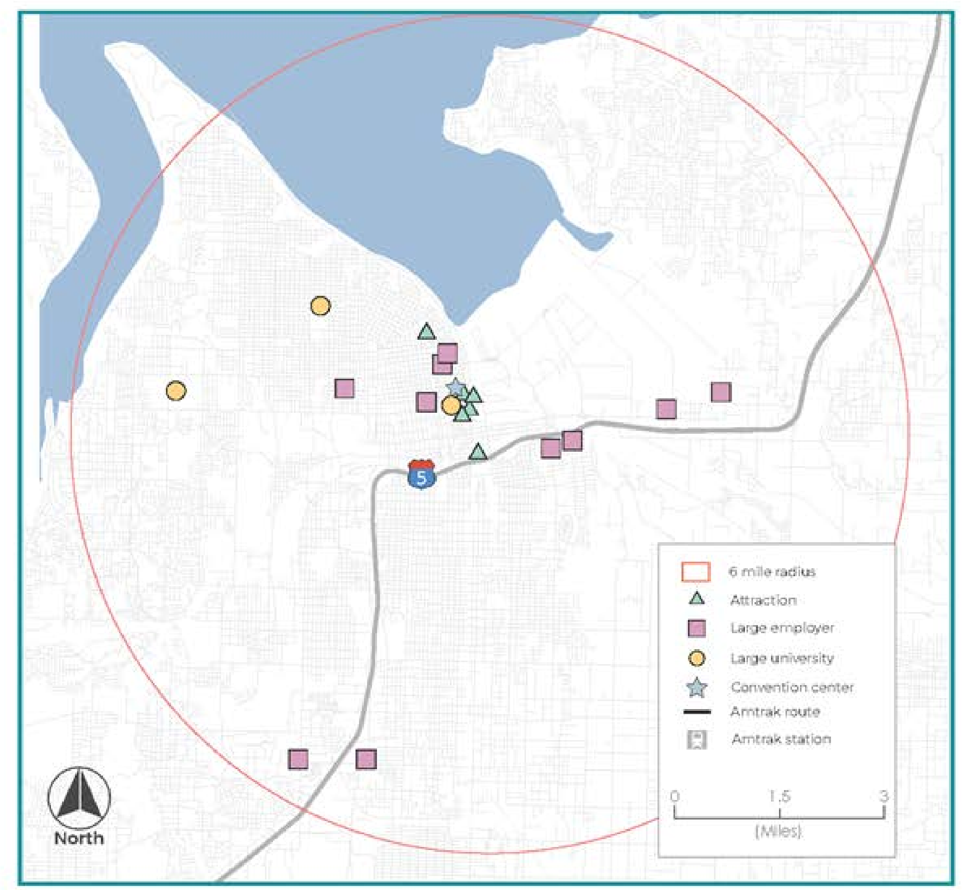
	Tacoma
Major universities/colleges*	3
Hotel rooms	5,500+
Attractions**	6
Large employers/High-tech companies***	10/1
Convention centers	1

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

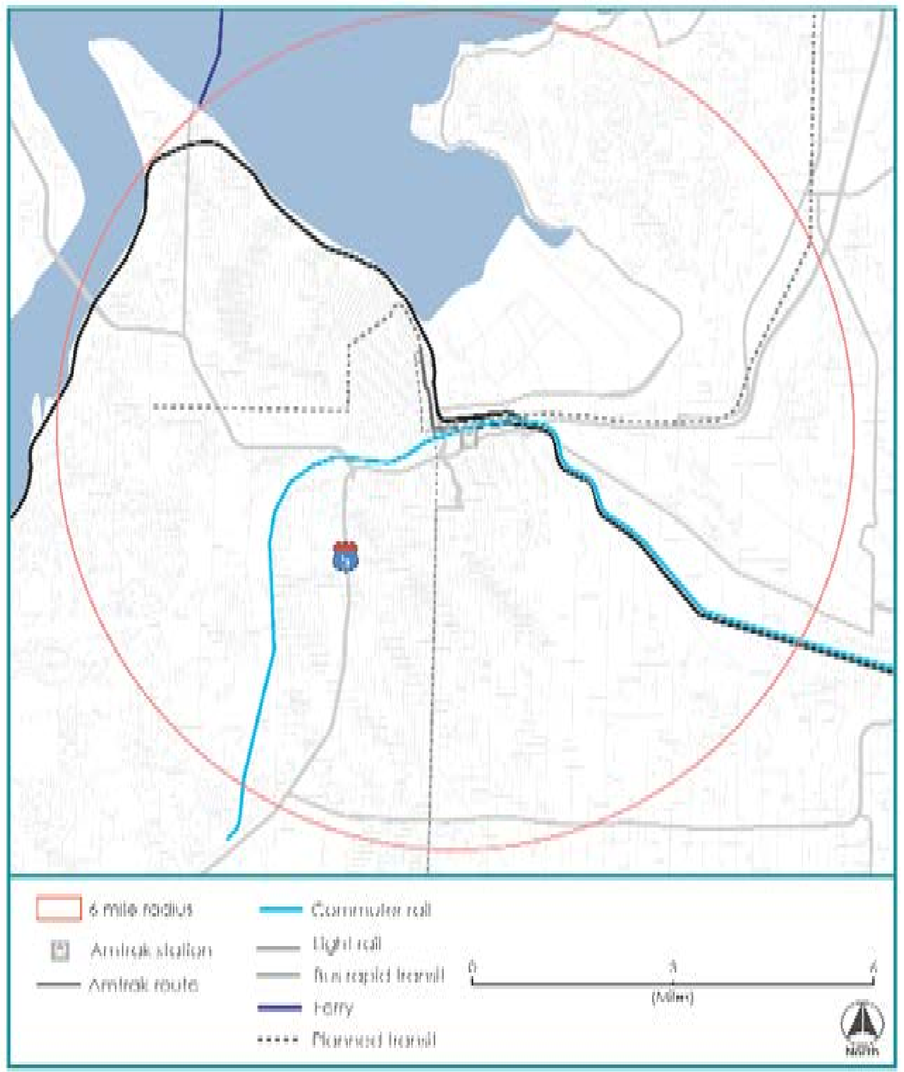
***Per TripAdvisor's top tourist attractions within 6 mile radius of station.*

****Companies with 1,000+ full time eployees per City of Tacoma Community and Economic Development Department.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
TACOMA — Multi-modal Interconnectivity

	Tacoma
Rail transit (existing/additional planned)	2 / 2
BRT and streetcar (existing/additional planned)	0 / 1
Intercity Connections (Ferry/Bus/Rail)	0 / 2 / 2
Bus lines	6



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
TACOMA — Land Use Plans and Policies

Population and Employment

	City of Tacoma
Existing population (2015)	203,992
Future population (2035)	284,457
Population growth (2015 - 2035)	39%
Existing jobs (2015)	112,568
Future jobs (2035)	158,977
Job growth (2015 - 2035)	41%

Source: PSRC regional growth forecast per VISION 2040.

Plans and policies

Regional
Vision 2040 (2009)
Transportation 2040 (2010)
Growing Transit Communities (2013)
Vision 2050 (2020 planned adoption)

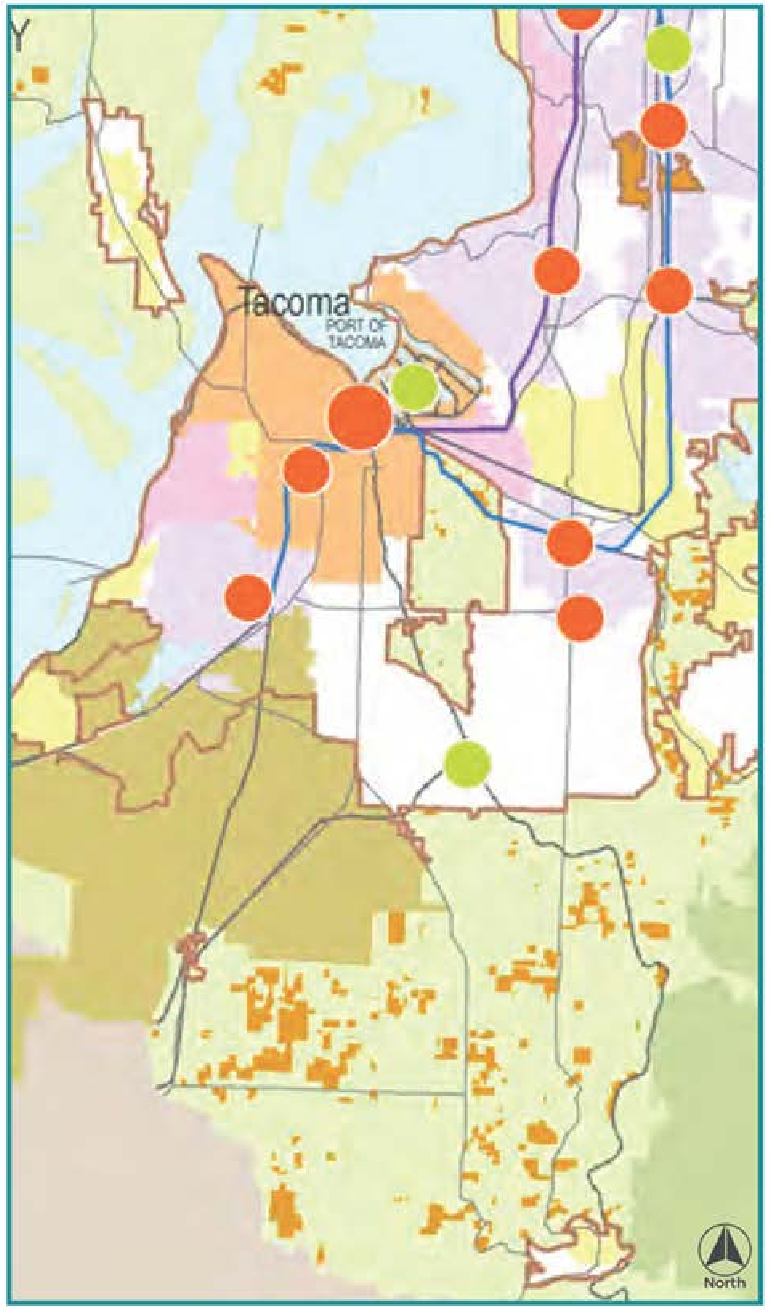
City
South Downtown Subarea Plan (2013)
Tacoma 2025 (2015)

The four-county region is expected to grow by 1.0 million people between 2016 and 2040 (4.0 to 5.0 million) and by 0.9 million jobs (from 2.2 to 3.1 million).

Source: Puget Sound Regional Council Vision 2040, December 2009

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

TACOMA — **Value Capture Potential**



Source: PSRC Vision 2040 — *Planned future land use with higher density multi-use areas have potential to equate to higher value capture.*

Tacoma

The station is located in one of five "regional growth centers," in the Puget Sound Region which serves as a primary location for the arts, civic activity, commerce and recreation. Regional growth centers are envisioned as major focal points of higher density population and employment, served with efficient multimodal transportation infrastructure and services.

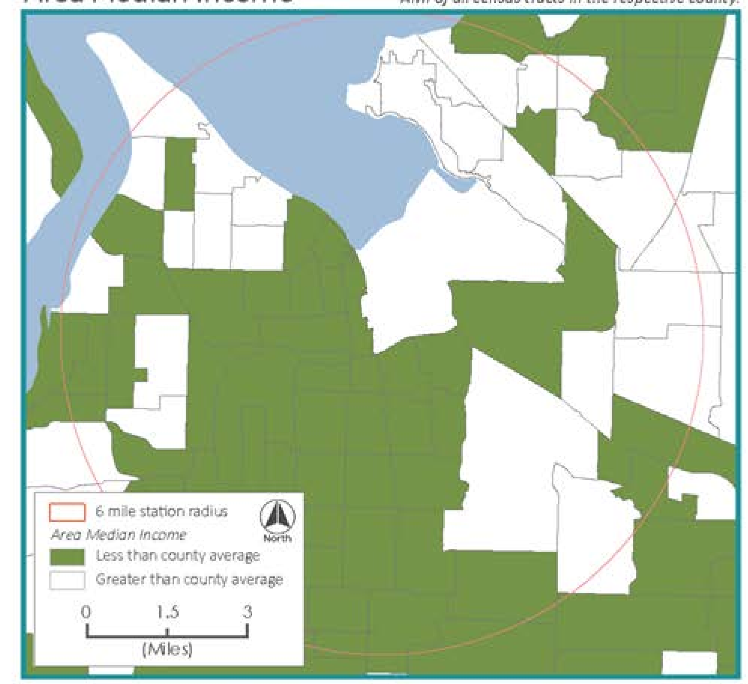
Source: Puget Sound Regional Council Vision 2040 (2009)

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

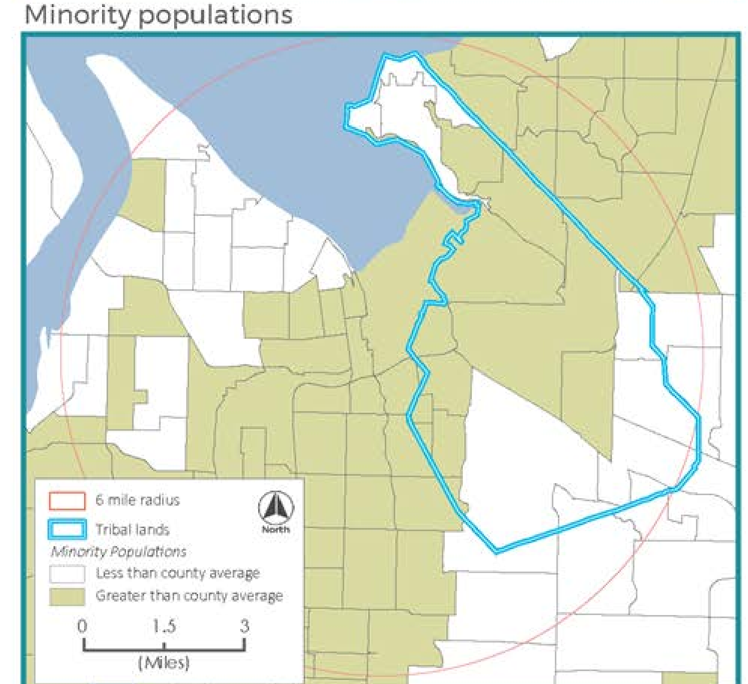
TACOMA — **Equity Considerations**

Area Median Income

County average AMI calculated by averaging AMI of all census tracts in the respective county.



Minority populations



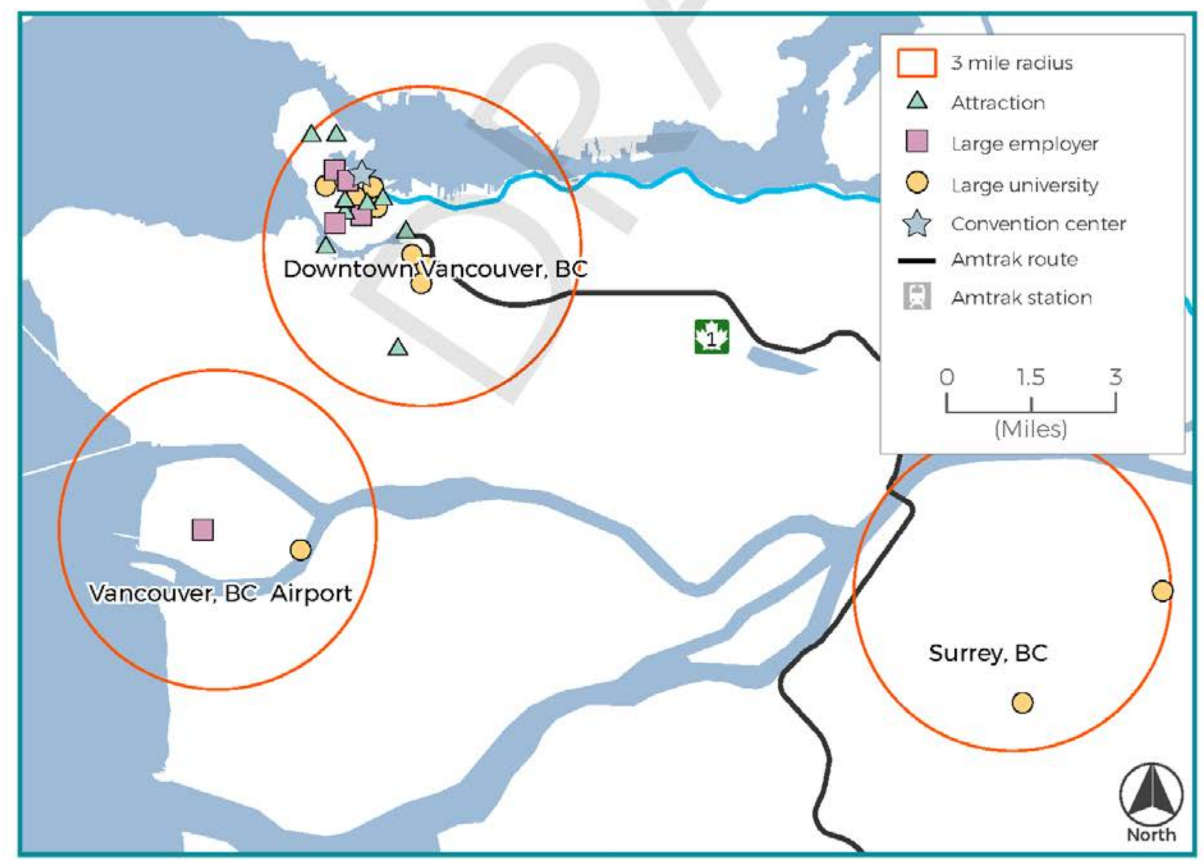
Greater Vancouver, British Columbia

Ultra High Speed Ground Transportation Study
Station Selection Criteria

VANCOUVER, BC — **Market Capture Potential**

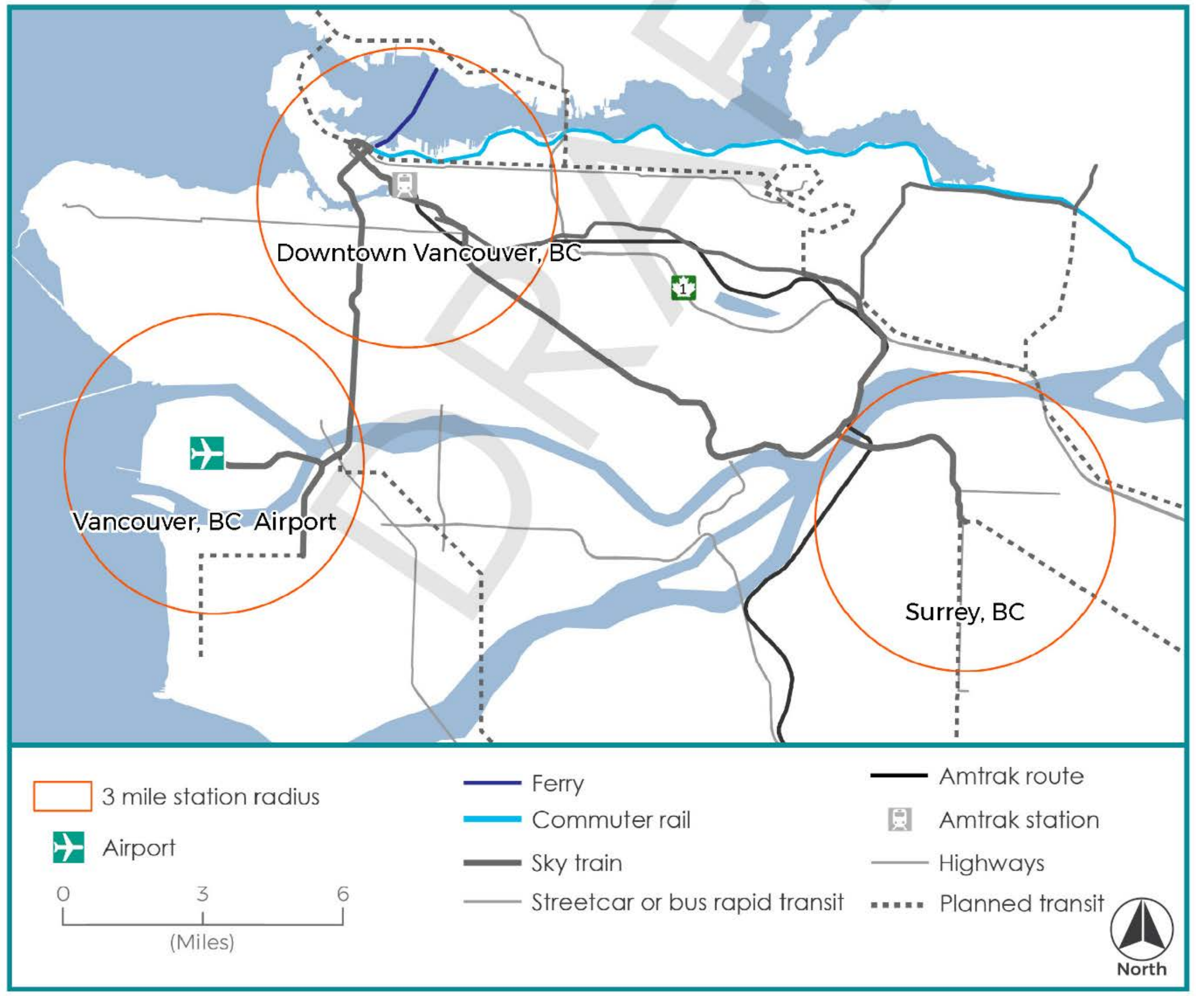
	Downtown Vancouver, BC	Surrey	Vancouver, BC Airport
Large universities/ colleges*	7	2	1
Hotel rooms	8,000+	2,500+	Data not available
Attractions**	9	0	0
Large employers/ High-tech companies***	4 / 8	0 / 3	1 / 2
Convention centers	1	0	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.
**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*
***Per TripAdvisor's top 10 tourist attractions for the region.*
**** Top public and private employers within 3 miles of radius as determined by Business Council of British Columbia. High-tech companies determined using existing resources tracking the technology industry.*



Ultra High Speed Ground Transportation Study
Station Selection Criteria
VANCOUVER, BC — Multi-modal Interconnectivity

	Downtown Vancouver, BC	Surrey	Vancouver Airport
Rail transit (existing/additional planned)	4 / 2	1 / 2	2 / 2
BRT and streetcar (existing/additional planned)	2 / 0	1 / 0	0 / 0
Intercity Connections (Ferry/Bus/Rail)	1 / 3 / 2	0 / 0 / 0	0 / 0 / 0
Bus lines	7	8	1



Ultra High Speed Ground Transportation Study
Station Selection Criteria
VANCOUVER, BC — Land Use Plans and Policies

Population and Employment

	Downtown Vancouver, BC	Surrey	Vancouver Airport
Existing population (2016)	464,835	255,134	172,721
Future population (2035)	547,772	347,192	234,402
Population growth (2016 - 2035)	18%	36%	36%
Existing jobs (2016)	394,733	115,435	99,922
Future jobs (2035)	438,445	154,506	119,892
Job growth (2016 - 2035)	11%	34%	20%

Source: Data from TransLink transportation analysis zones. Population and employment are within 3 mile buffers of station locations.

Plans and policies

Regional
Metro Vancouver 2040 (2011)

Downtown Vancouver, BC
Transportation 2040 (2012)
Vancouver Tourism Master Plan (2013)
Greenest City Action Plan (2015)

Surrey
Surrey Transportation Strategic Plan (2008)
Surrey Official Community Plan (2014)

Vancouver Airport
Richmond Official Community Plan (2012)
Richmond City Centre Area Plan (2012)

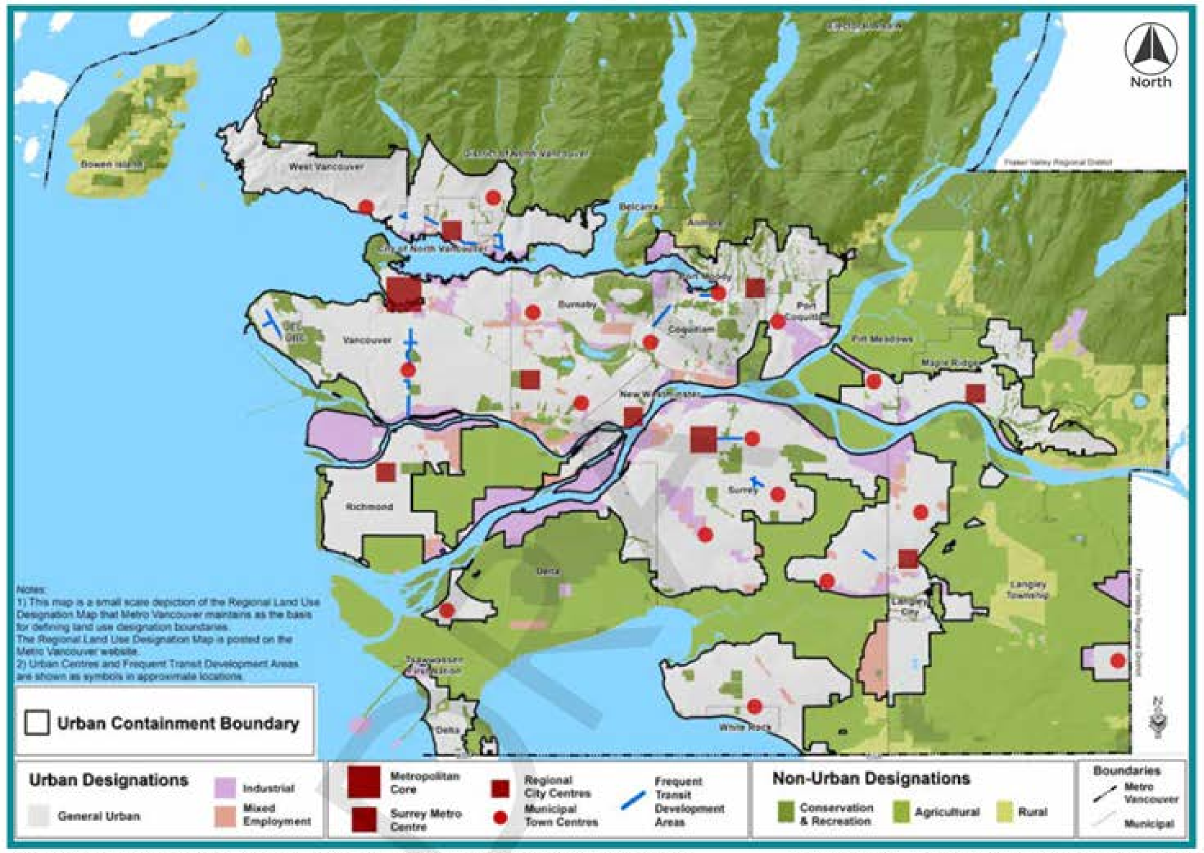
The regional district is expected to grow by 1.1 million people between 2011 and 2041 (2.36 to 3.44 million) and by 0.6 million jobs (from 1.2 to 1.8 million).

Source: Metro Vancouver 2040 Shaping Our Future Adopted by the Greater Vancouver Regional District Board on July 29, 2011 Updated to July 28, 2017

Ultra High Speed Ground Transportation Study

Station Selection Criteria

VANCOUVER, BC — Value Capture Potential



Planned future land use with higher density multi-use areas have potential to equate to higher value capture.

Source: Metro Vancouver 2040 Shaping Our Future

Downtown Vancouver, BC

The station is located in the "metropolitan core," which serves as the principal business, employment, cultural and entertainment location for the region. Growth targets include:

- 57,000 jobs, 10% growth from 2006 to 2041
- 31,000 units, 5% growth from 2006 to 2041

Surrey

The station is located in the "Surrey metro centre," a major activity area for the subregion. Growth targets include:

- 31,000 jobs, 5% growth from 2006 to 2041
- 34,700 units, 6% growth from 2006 - 2041

Vancouver, BC Airport

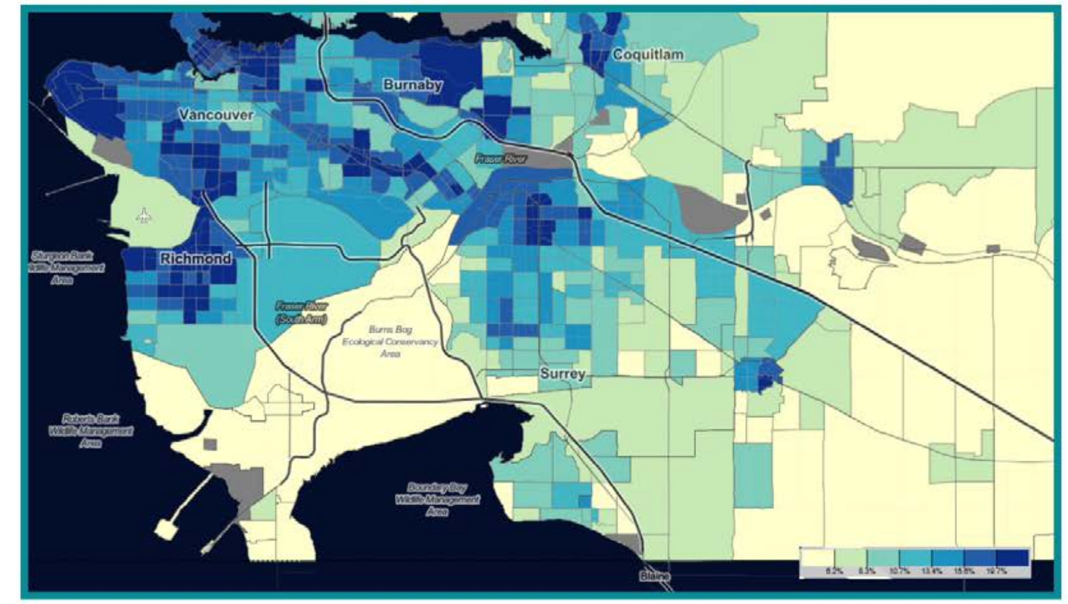
The station is located in the "industrial" urban designation, intended for heavy and light industrial activities and limited commercial uses and not intended for residential uses.

Ultra High Speed Ground Transportation Study

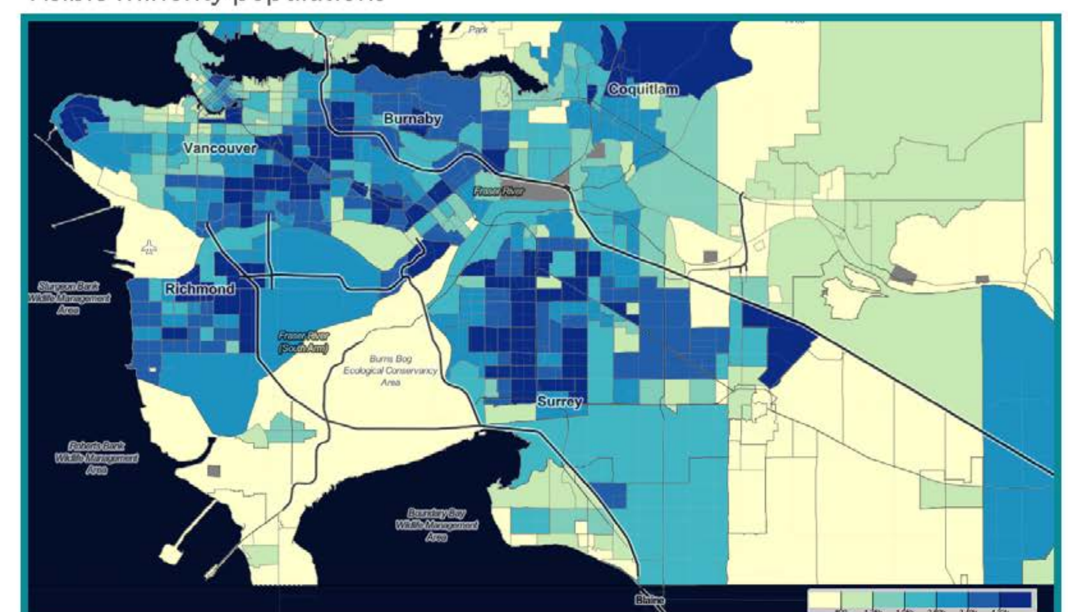
Station Selection Criteria

VANCOUVER, BC — Equity Considerations

Low Income populations



Visible minority populations

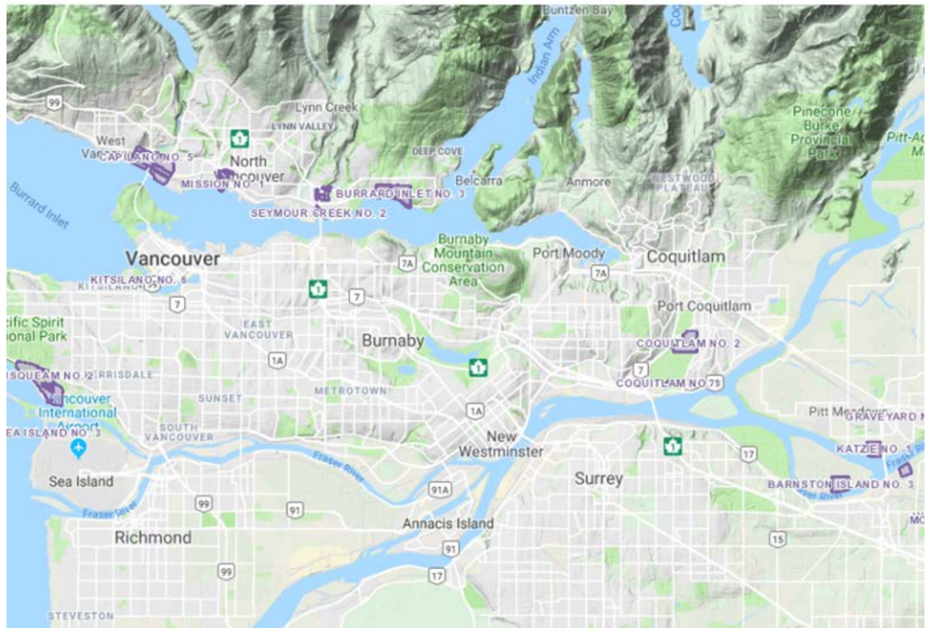


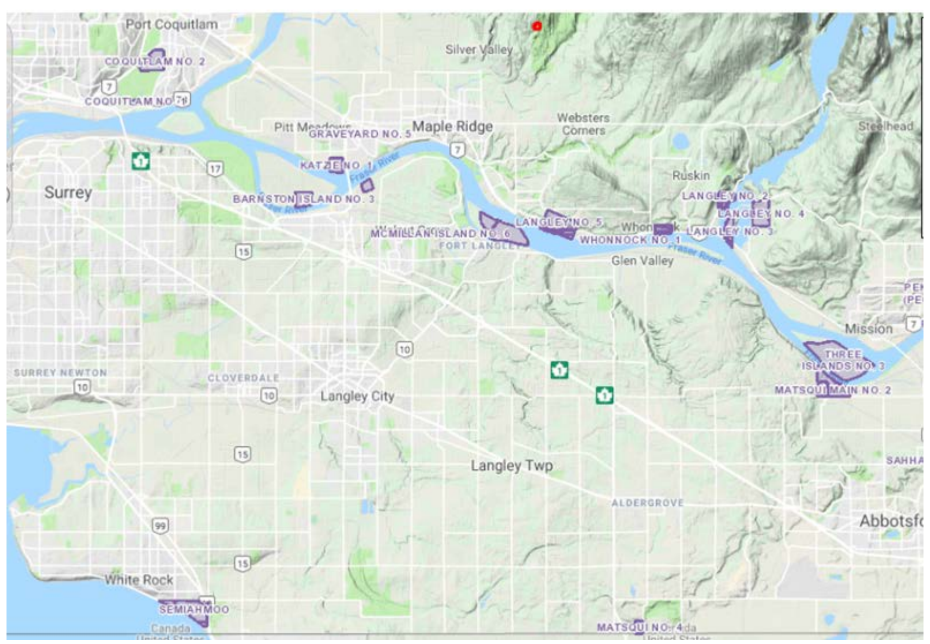
Source: Censusmapper.ca. Data fromCanada Census 2016.

Ultra High Speed Ground Transportation Study
Station Selection Criteria

VANCOUVER, BC **Equity Considerations**

First Nation Reserves in Greater Vancouver, BC Area.





Source: First Nation Profiles Interactive Map https://geo.aadnc-aandc.gc.ca/cippn-fnpim/index-eng.html

Kelso/Longview, Washington

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

KELSO/LONGVIEW — **Market Capture Potential**

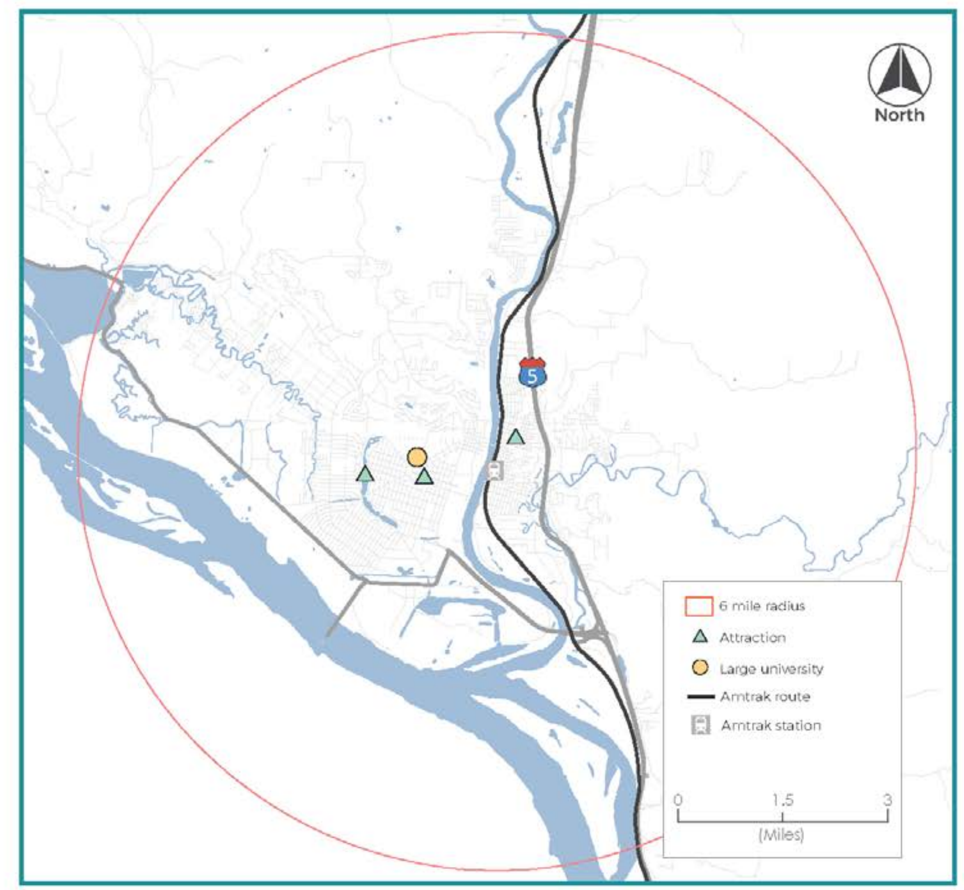
	Kelso/Longview
Large universities/colleges*	1
Hotel rooms	500+
Attractions**	3
Convention centers	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

***Per TripAdvisor's top 10 tourist attractions for the region within 6 mile radius of sample station.*

****Companies with 200+ full time employees.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
KELSO/LONGVIEW — Multi-modal Interconnectivity

	Kelso/Longview
Rail transit (existing/additional planned)	0 / 0
BRT and streetcar (existing/additional planned)	0 / 0
Intercity connections (Ferry/Bus/Rail)	0 / 2 / 2
Bus lines	4

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
KELSO/LONGVIEW — Land Use Plans and Policies

Population and Employment

	City of Kelso	Cowlitz County
Existing population (2015)	11,940	104,280
Future population (2035)	Data not available	116,485
Population growth (2015 - 2035)	Data not available	12%
Existing jobs (2015)	Data not available	Data not available
Future jobs (2035)	Data not available	Data not available
Job growth (2015 - 2035)	Data not available	Data not available

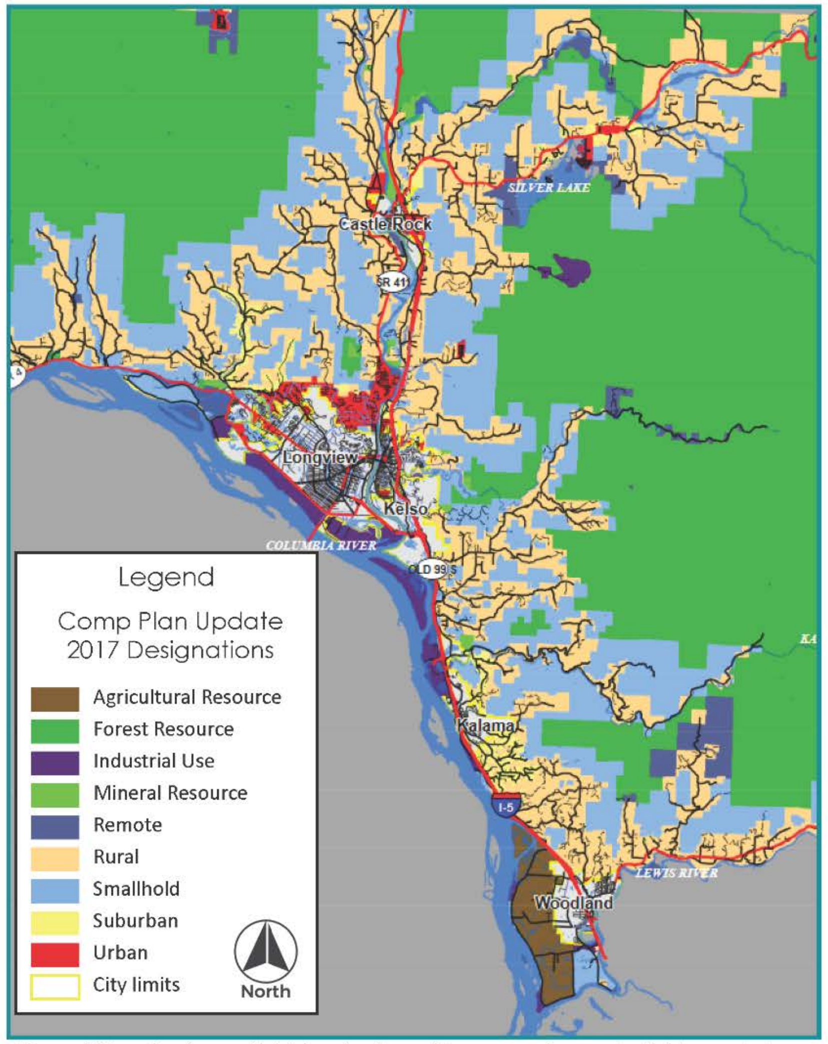
Source: Cowlitz County Comprehensive Plan (2017), City of Kelso Comprehensive Plan (2017).

Plans and policies

Regional
Cowlitz County Comprehensive Plan (2017)

City
City of Kelso Parks and Recreation Comprehensive Plan (2014)
Environmental Protection Agency, Using Smart Growth Strategies to Foster Economic Development: A Kelso, Washington, Case Study (2015)
City of Kelso Comprehensive Plan (2017)

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
KELSO/LONGVIEW — Value Capture Potential



Planned future land use with higher density multi-use areas have potential to equate to higher value capture.

Kelso/Longview

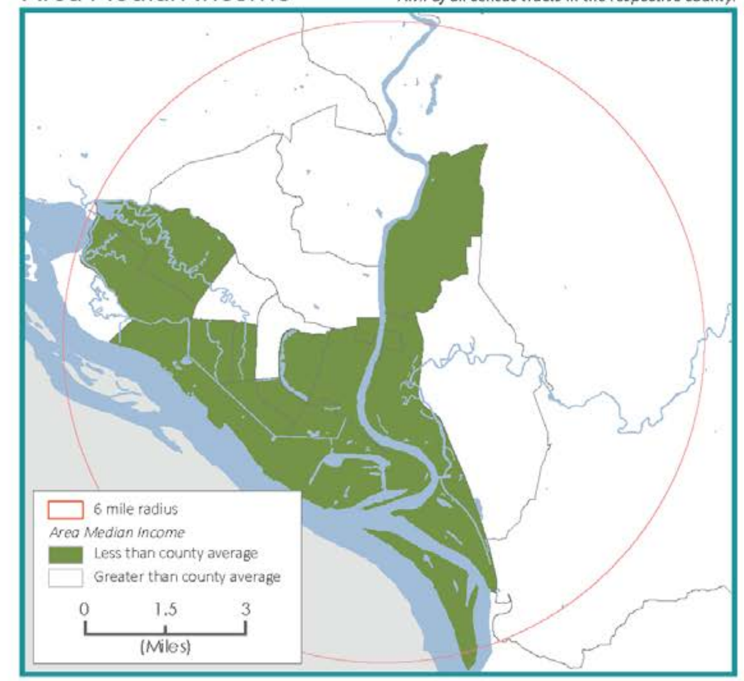
The Cowlitz County Future Land Use Map locates the Kelso Amtrak station in the "commercial" zone which encourages mixed-use residential development, and improves multi-modal access to commercial areas. Economic Development Policy #4 encourages labor-intensive business development.

Source: Cowlitz County Comprehensive Plan (2017)

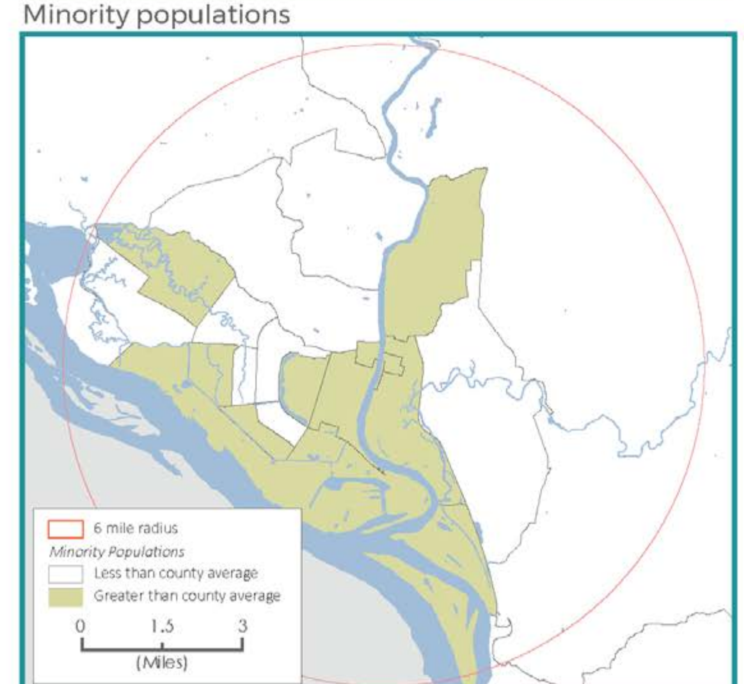
Ultra High-Speed Ground Transportation Study
Station Selection Criteria
KELSO/LONGVIEW — Equity Considerations

Area Median Income

County average AMI calculated by averaging AMI of all census tracts in the respective county.



Minority populations



Olympia/Lacey, Washington

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

OLYMPIA/LACEY — **Market Capture Potential**

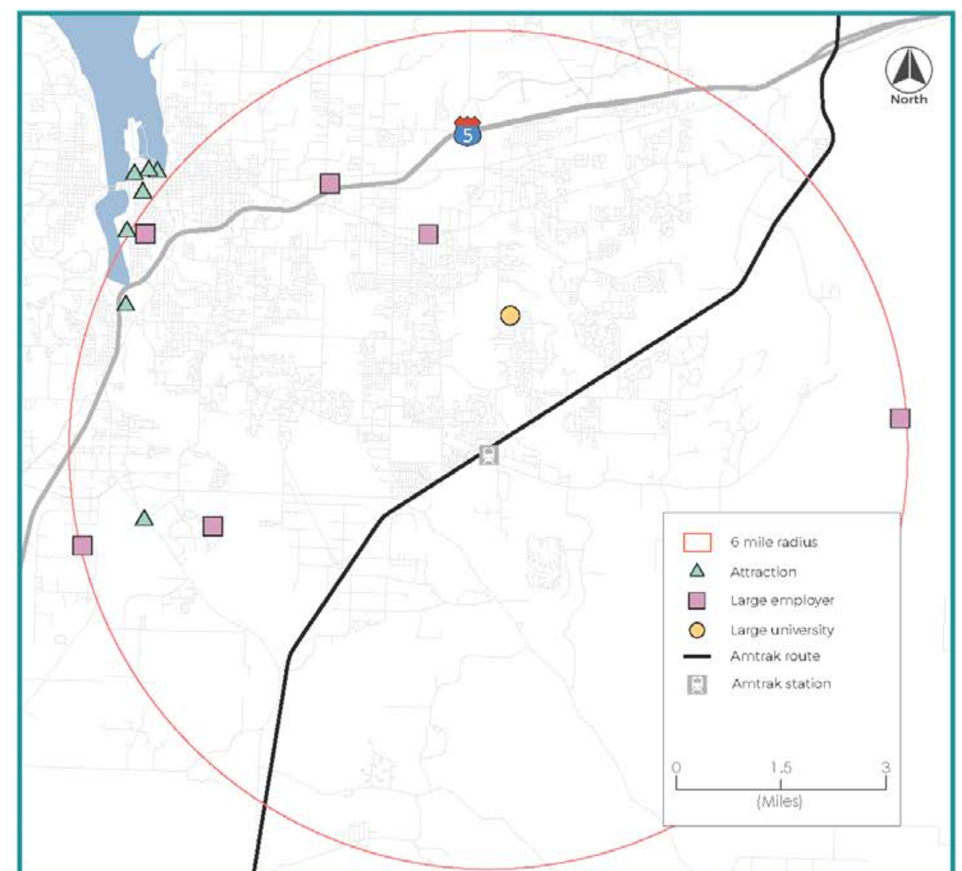
	Olympia/Lacey
Large universities/colleges*	1
Hotel rooms	Data not available
Attractions**	7
Large employers/High-tech employers***	6/1
Convention centers	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

***Per TripAdvisor's top tourist attractions within 6 mile radius or in downtown Olympia, WA.*

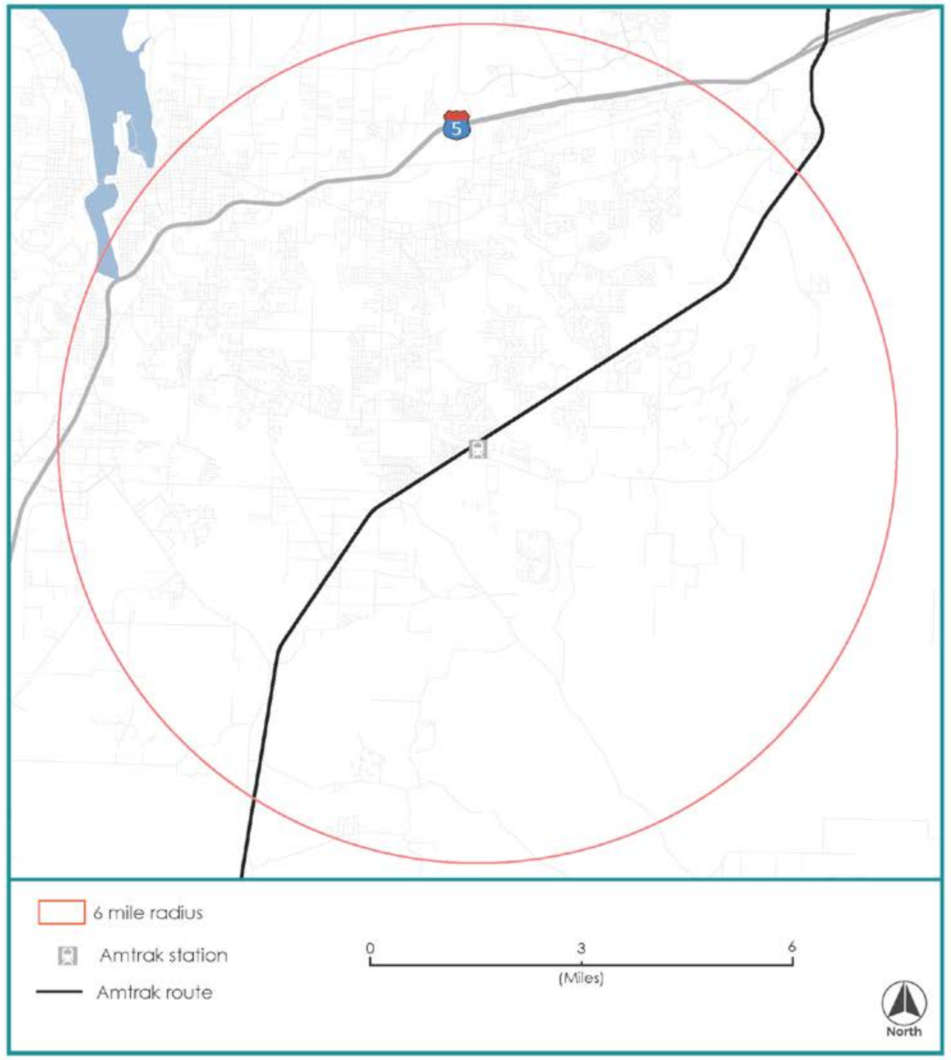
****Companies with 200+ full time employees. Does not include state employees.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria

OLYMPIA/LACEY — Multi-modal Interconnectivity

	Olympia/Lacey
Rail transit (exising/additional planned)	0 / 0
BRT and streetcar (exising/additional planned)	0 / 0
Intercity connections (Ferry/Bus/Rail)	0 / 1 / 2
Bus lines	2



Ultra High-Speed Ground Transportation Study
Station Selection Criteria

OLYMPIA/LACEY — Land Use Plans and Policies

Population and Employment

	Thurston County
Existing population (2015)	267,410
Future population (2035)	354,400
Population growth (2015 - 2035)	33%
Existing jobs (2015)	140,775
Future jobs (2035)	184,500
Job growth (2015 - 2035)	31%

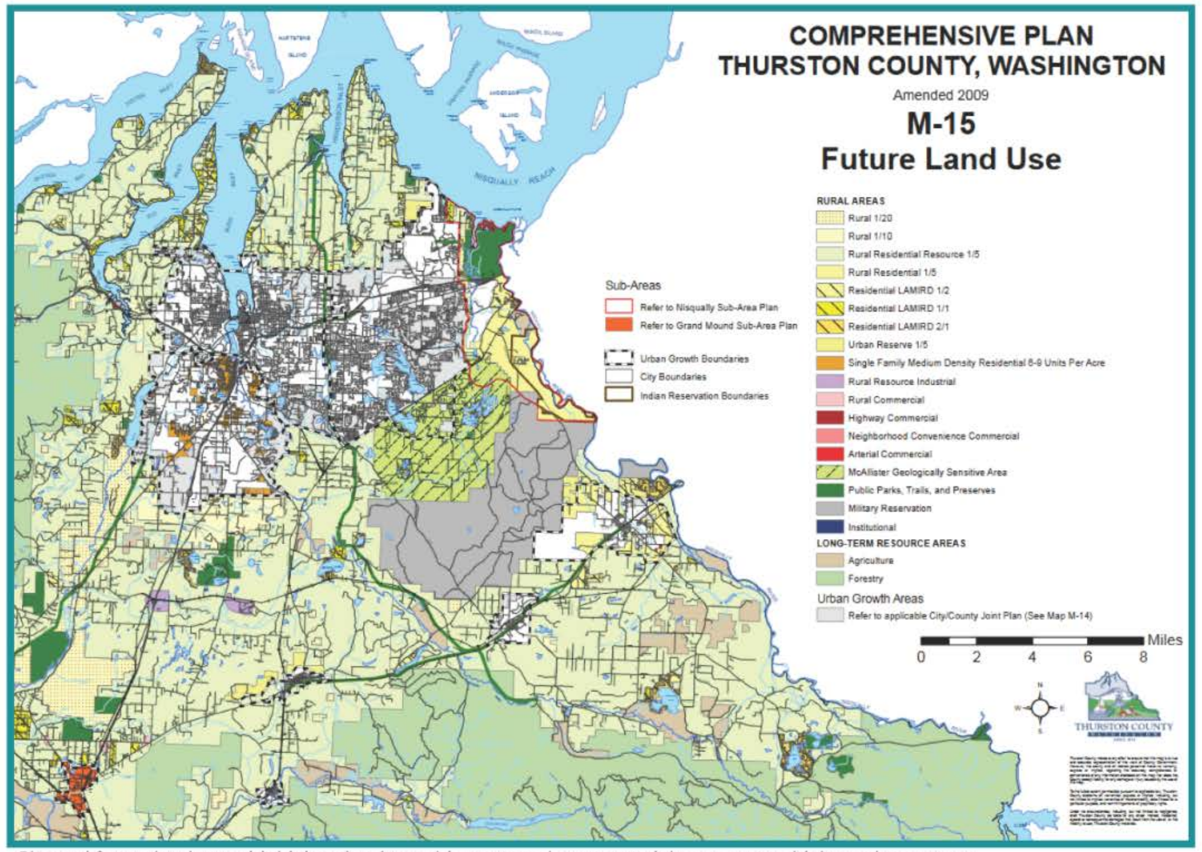
Source: Thurston Regional Planning Council Countywide Employment and Commute Forecast, 2015.

Plans and policies

Regional
Thurston County Comprehensive Plan (2015)
2040 Regional Transportation Plan (2017)

City
Olympia Comprehensive Plan (2014)
Lacey Comprehensive Plan (2016)

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
OLYMPIA/LACEY — Value Capture Potential



Planned future land use with higher density multi-use areas have potential to equate to higher value capture.

Thurston County

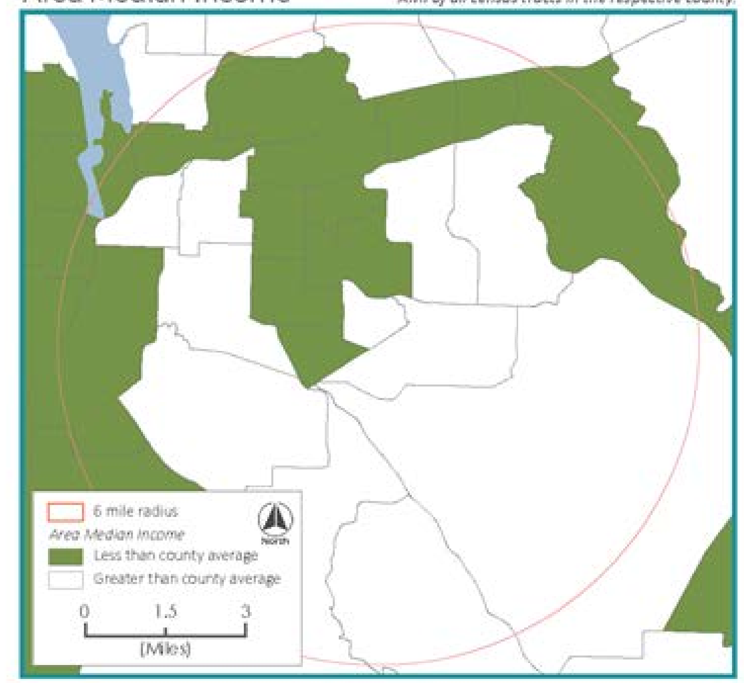
The most densely built areas of the County are, by design, the urban growth are as and cities. In new subdivisions the cities achieved an average net residential density of over 7.6 dwelling units per acre, where the unincorporated urban growth areas achieved 6.0 dwelling units per acre (between the years 2000 and 2004).

Source: Thurston County Comprehensive Plan (2015)

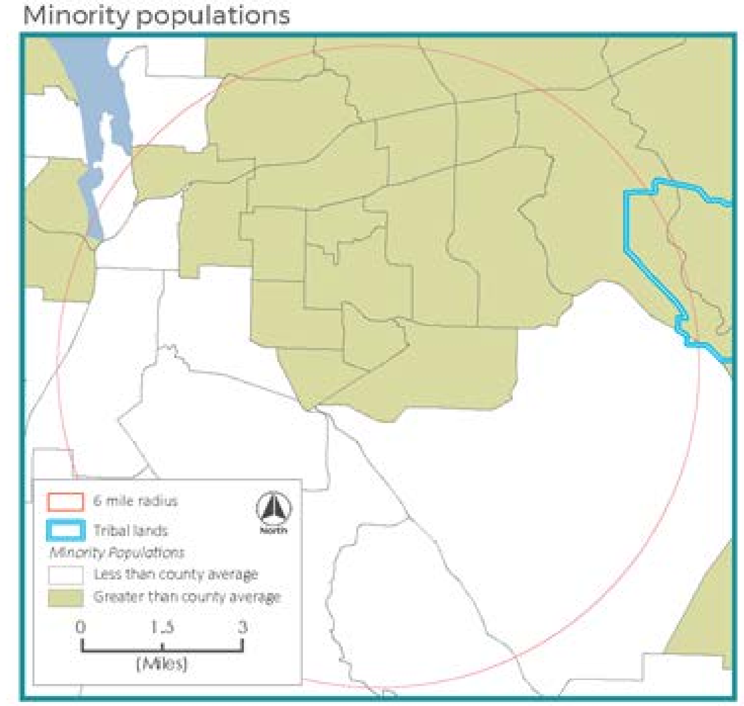
Ultra High-Speed Ground Transportation Study
Station Selection Criteria
OLYMPIA/LACEY — Equity Considerations

Area Median Income

County average AMI calculated by averaging AMI of all census tracts in the respective county.



Minority populations



Seattle, Washington

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

SEATTLE — **Market Capture Potential**

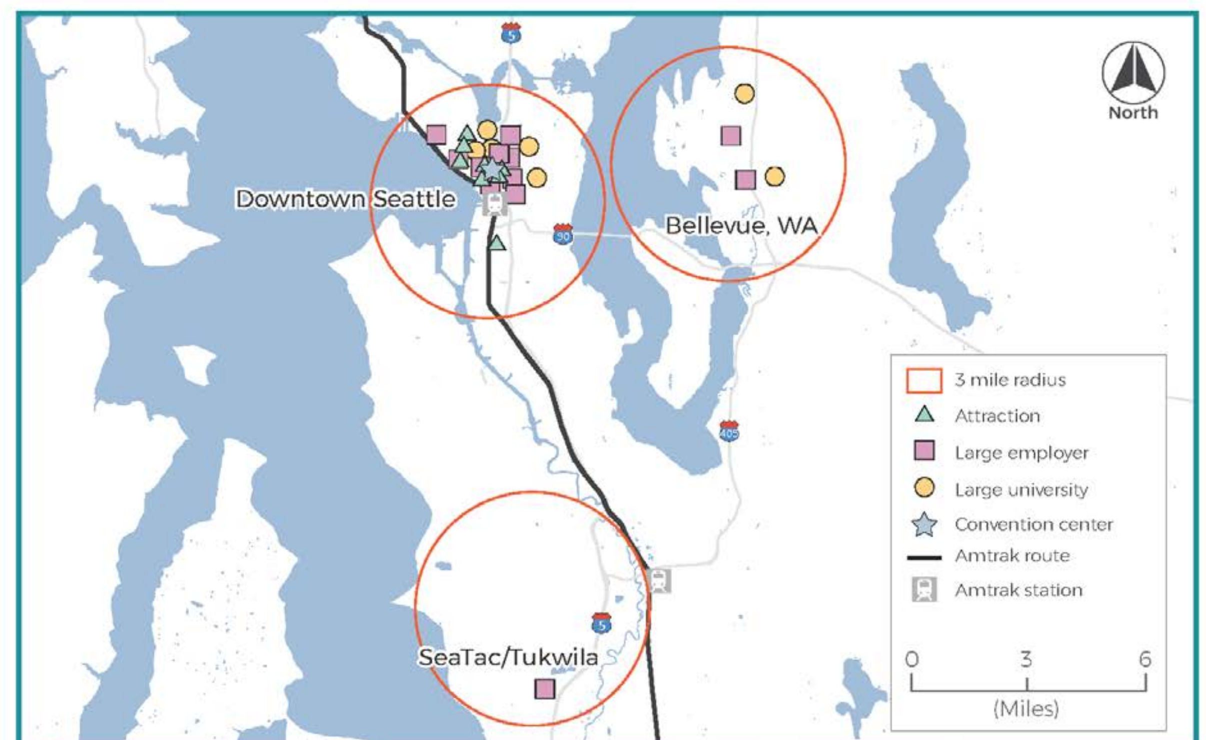
	Downtown Seattle	Bellevue	SeaTac/Tukwila
Major universities/ colleges*	5	2	0
Hotel rooms	14,250+	5,200+	8,000+
Attractions**	8	0	0
Large employers/ High-tech companies***	9 / 12	2 / 10	1 / 1
Convention centers	1	0	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

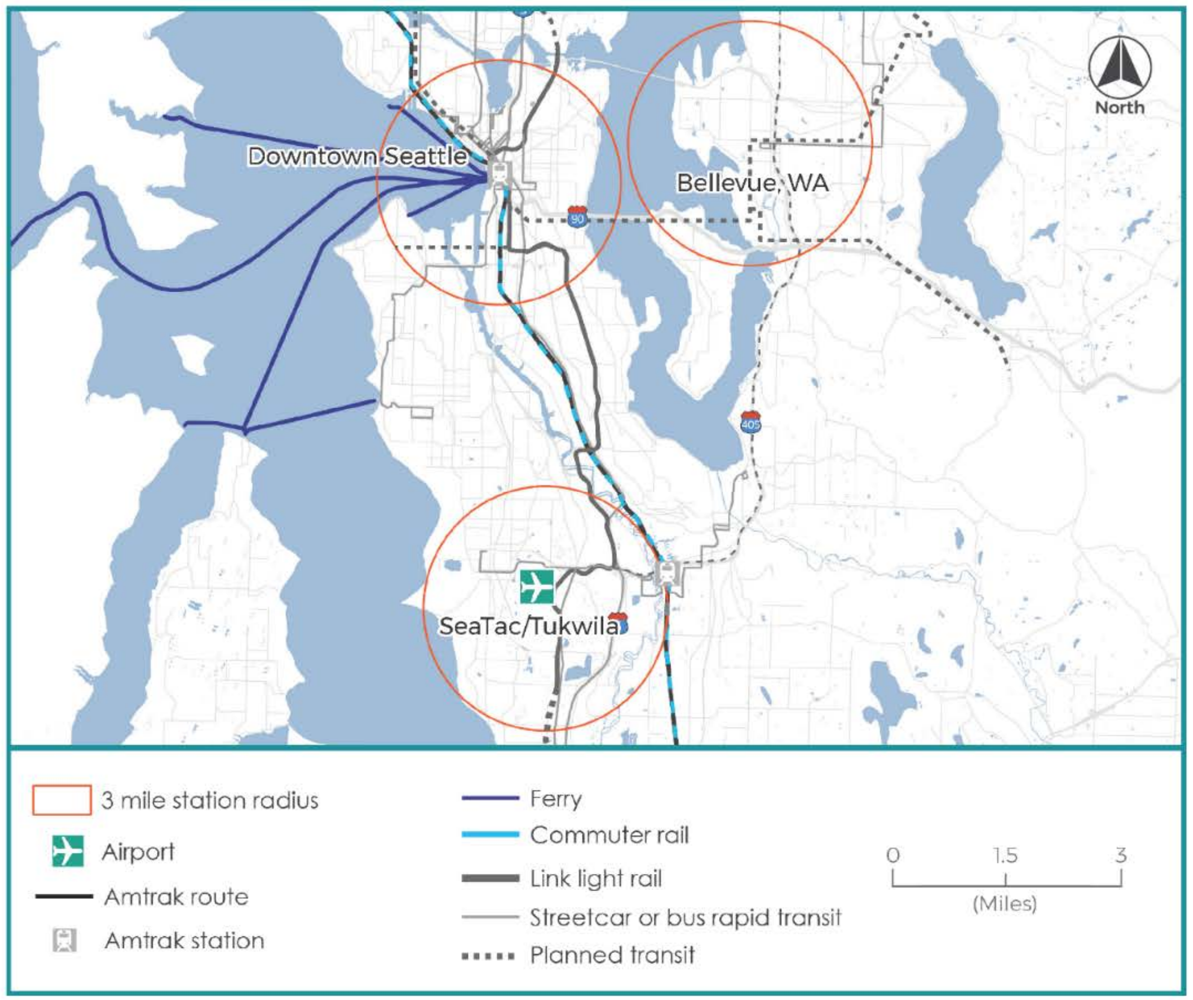
***Per TripAdvisor's top 10 tourist attractions for the region.*

****Top 20 companies within 3 miles of radius as determined by Economic Development Council of Seattle and King County. High-tech companies determined using existing resources tracking the technology industry.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
SEATTLE — Multi-modal Interconnectivity

	Downtown Seattle	Bellevue	SeaTac/Tukwila
Rail transit (existing/additional planned)	2 / 6	0 / 2	2 / 1
BRT and streetcar (existing/additional planned)	6 / 3	0 / 1	2 / 1
Intercity Connections (Ferry/Bus/Rail)	5 / 1 / 3	0 / 0 / 0	0 / 0 / 0
Bus lines	55	8	7



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
SEATTLE — Land Use Plans and Policies

Population and Employment

	Downtown Seattle	Bellevue	SeaTac/Tukwila
Existing population (2016)	366,457	249,775	187,723
Future population (2035)	441,992	298,895	222,926
Population growth (2016 - 2035)	21%	20%	19%
Existing jobs (2016)	430,828	258,744	191,737
Future jobs (2035)	506,362	316,671	250,054
Job growth (2016 - 2035)	18%	22%	30%

Source: Data from PSRC forecast analysis zones. Population and employment are within 3 mile buffers of station locations.

Plans and policies

Regional
Vision 2040 (2009)
Transportation 2040 (2010)
Growing Transit Communities (2013)
Vision 2050 (planned to be adopted in 2020)

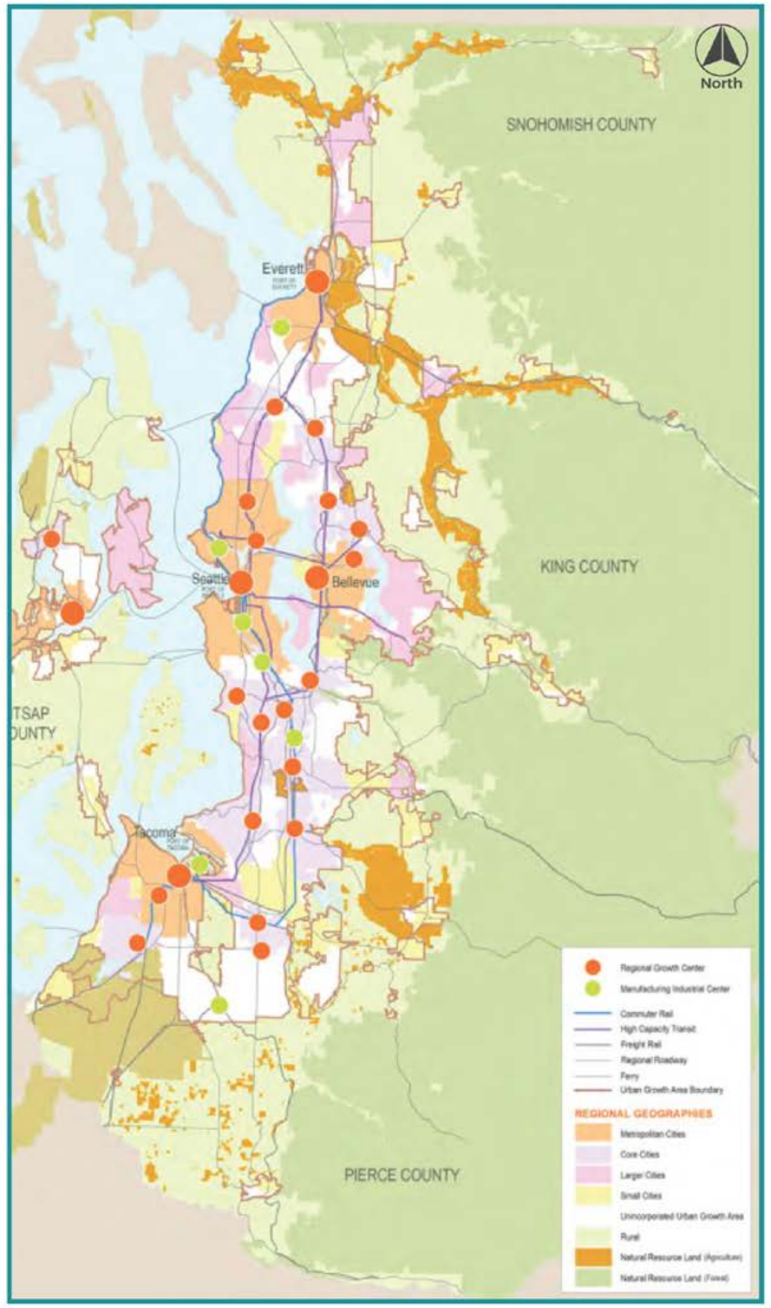
Downtown Seattle
Seattle Comprehensive Plan
Downtown Transportation Plan (2015)

Bellevue
Bellevue Comprehensive Plan (2015)

SeaTac/Tukwila
SeaTac Comprehensive Plan (2017)

> *The four-county region is expected to grow by 1.0 million people between 2016 and 2040 (4.0 to 5.0 million) and by 0.9 million jobs (from 2.2 to 3.1 million).*
>
> *Source: Puget Sound Regional Council Vision 2040, December 2009*

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
SEATTLE — Value Capture Potential



Source: PSRC Vision 2040 *Planned future land use with higher density multi-use areas have potential to equate to higher value capture.*

Downtown Seattle

The station is located in one of five "regional growth centers," in the Puget Sound Region which serves as a primary location for the arts, civic activity, commerce and recreation. Regional growth centers are envisioned as major focal points of higher density population and employment, served with efficient multimodal transportation infrastructure and services.

Bellevue

The station is located in one of five "regional growth centers," in the Puget Sound Region which serves as a primary location for the arts, civic activity, commerce and recreation.

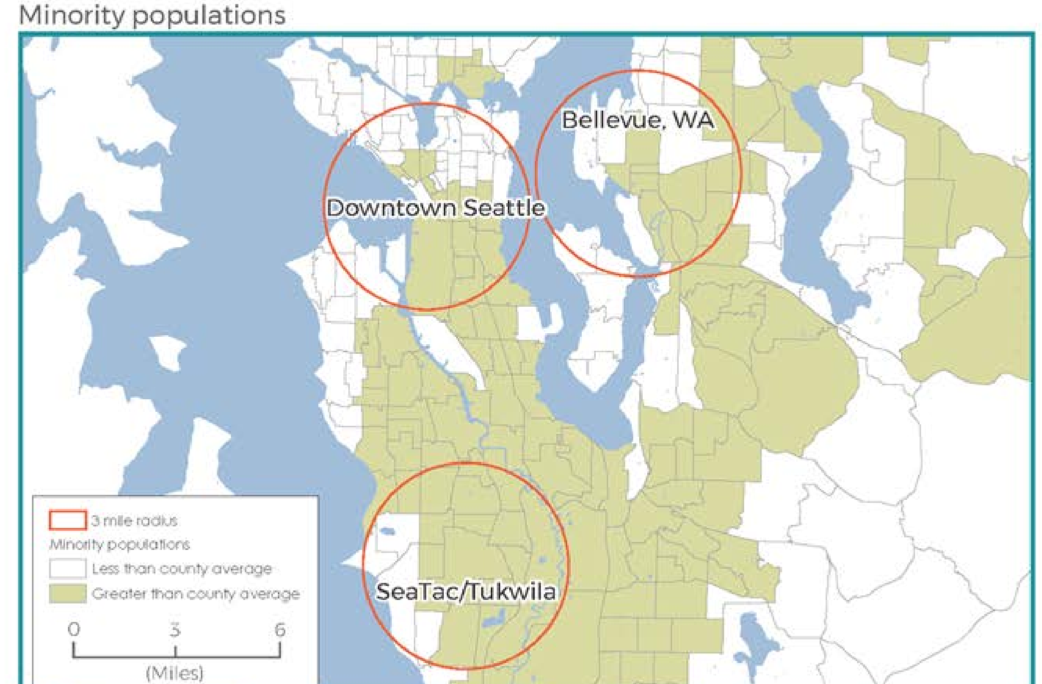
SeaTac/Tukwila

The station is located in the "core cities" regional geography, with three "regional growth centers" located within the 3-mile buffer. SeaTac is one of the region's 13 core cities, which serve as major civic, cultural and employment centers within their counties. Core cities also contain key hubs for the region's long-range multimodal transportation system.

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
SEATTLE — Equity Considerations

Area Median Income *County average AMI calculated by averaging AMI of all census tracts in the respective county.*

Minority populations



Everett, Washington

Ultra High-Speed Ground Transportation Study
Station Selection Criteria

EVERETT **Market Capture Potential**

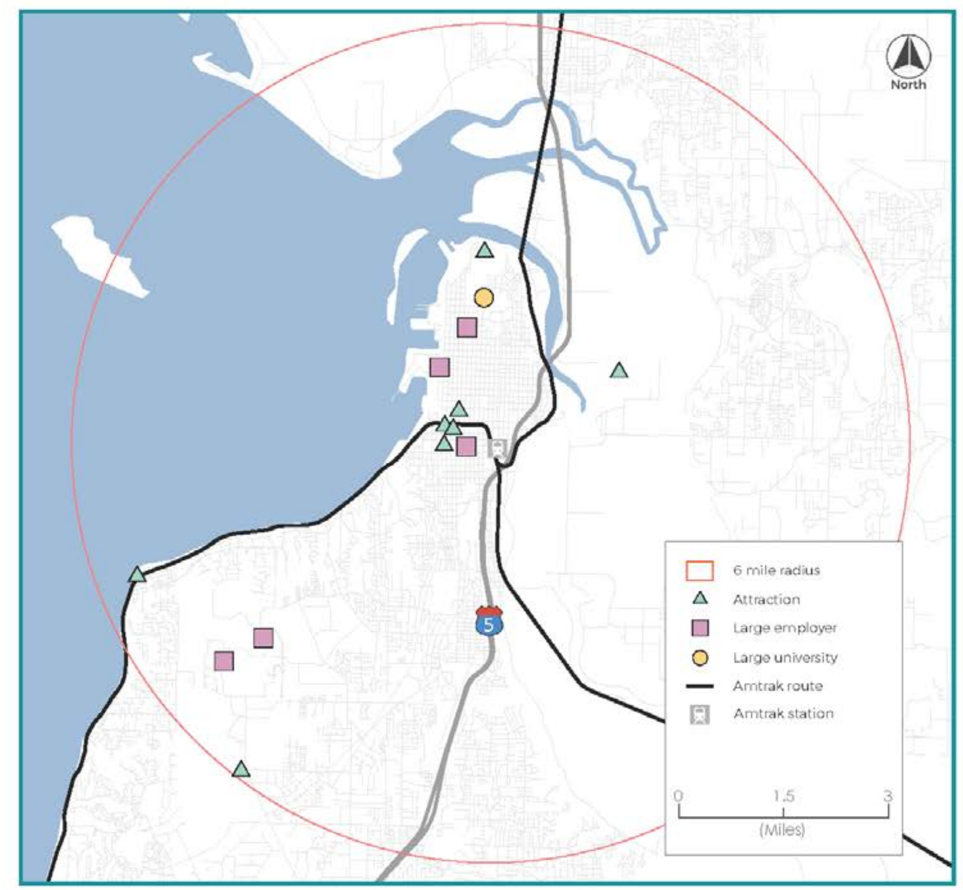
	Everett
Large universities/colleges*	1
Hotel rooms	6,000+
Attractions**	8
Large employers/High-tech companies***	5/0
Convention centers	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

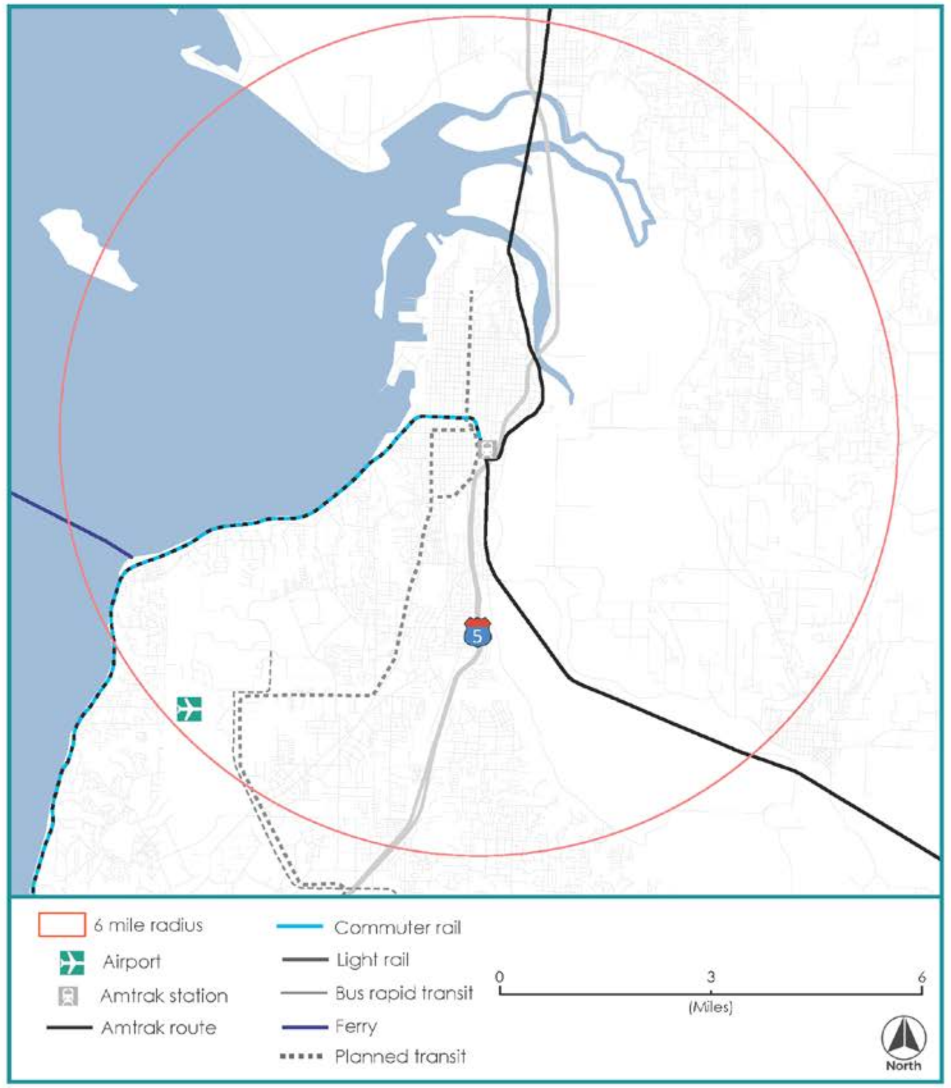
***Per TripAdvisor's top tourist attractions within 6 mile radius of station.*

**** Companies with 1000+ full time employees per the Economic Alliance of Snohomish County.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
EVERETT — Multi-modal Interconnectivity

	Everett
Rail transit (existing/additional planned)	1 / 1
BRT and streetcar (existing/additional planned)	1 / 0
Intercity Connections (Ferry/Bus/Rail)	1 / 3 / 2
Bus lines	16



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
EVERETT — Land Use Plans and Policies

Population and Employment

	City of Everett
Existing population (2015)	125,266
Future population (2035)	180,497
Population growth (2015 - 2035)	44%
Existing jobs (2015)	109,916
Future jobs (2035)	148,155
Job growth (2015 - 2035)	35%

Source: PSRC regional growth forecast per VISION 2040.

Plans and policies

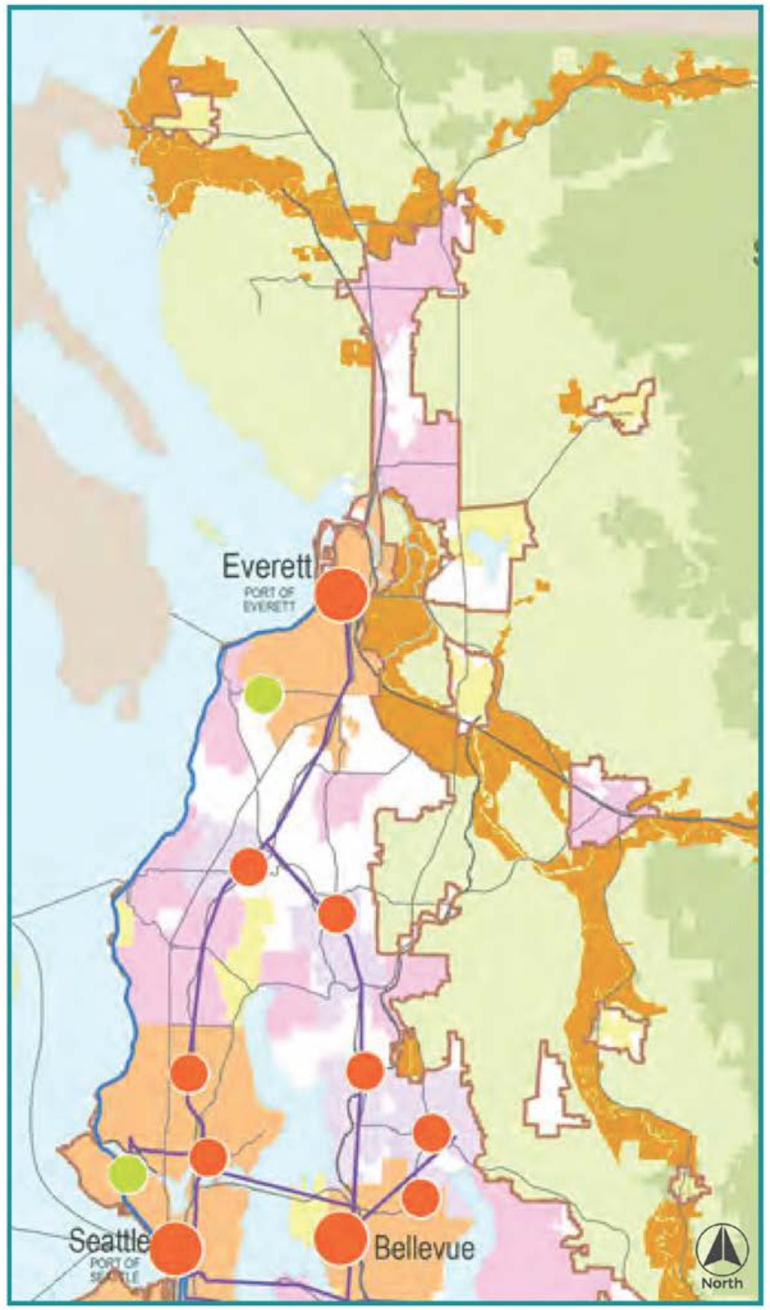
Regional
Vision 2040 (2009)
Transportation 2040 (2010)
Growing Transit Communities (2013)
Vision 2050 (2020 planned adoption)

City
Everett Downtown Plan (2006)
Everett Station Area Plan (2014)
Everett Comprehensive Plan (2017)
Metro Everett Subarea Plan (2018)

The four-county region is expected to grow by 1.0 million people between 2016 and 2040 (4.0 to 5.0 million) and by 0.9 million jobs (from 2.2 to 3.1 million).

Source: Puget Sound Regional Council Vision 2040, December 2009

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
EVERETT — Value Capture Potential



Source: PSRC Vision 2040 *Planned future land use with higher density multi-use areas have potential to equate to higher value capture.*

Everett

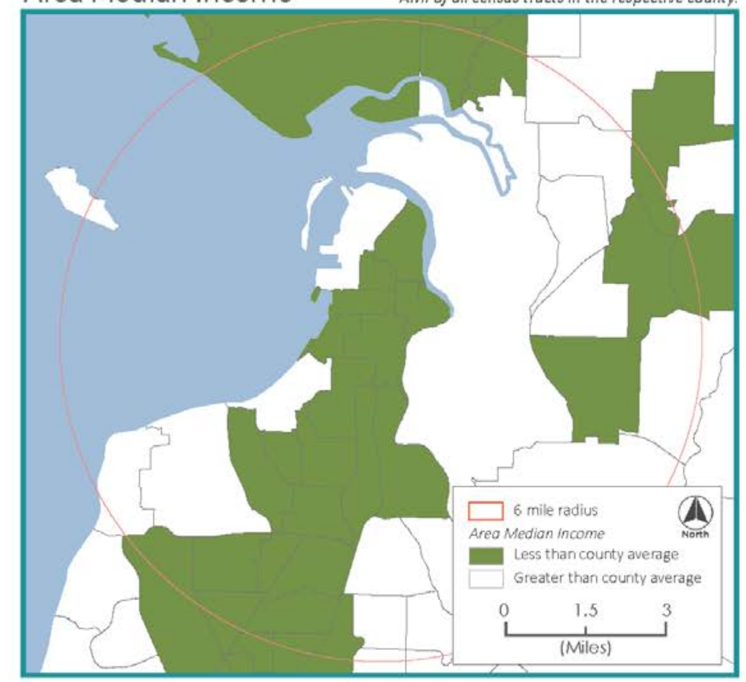
The station is located in one of five "regional growth centers," in the Puget Sound Region which serves as a primary location for the arts, civic activity, commerce and recreation. Regional growth centers are envisioned as major focal points of higher density population and employment, served with efficient multimodal transportation infrastructure and services.

Source: Puget Sound Regional Council Vision 2040 (2009)

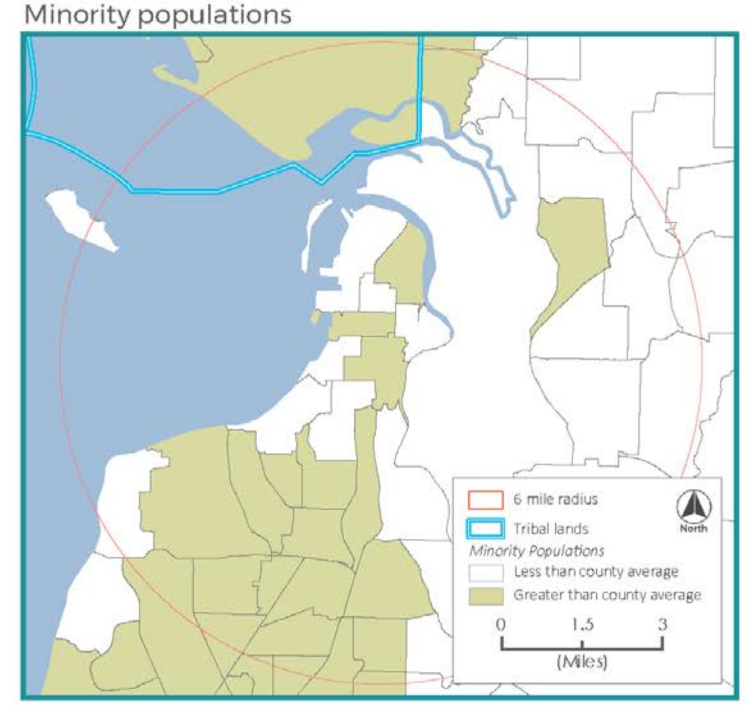
Ultra High-Speed Ground Transportation Study
Station Selection Criteria
EVERETT — Equity Considerations

Area Median Income

County average AMI calculated by averaging AMI of all census tracts in the respective county.



Minority populations



Bellingham, Washington

Ultra High-Speed Ground Transportation Study

Station Selection Criteria

BELLINGHAM

Market Capture Potential

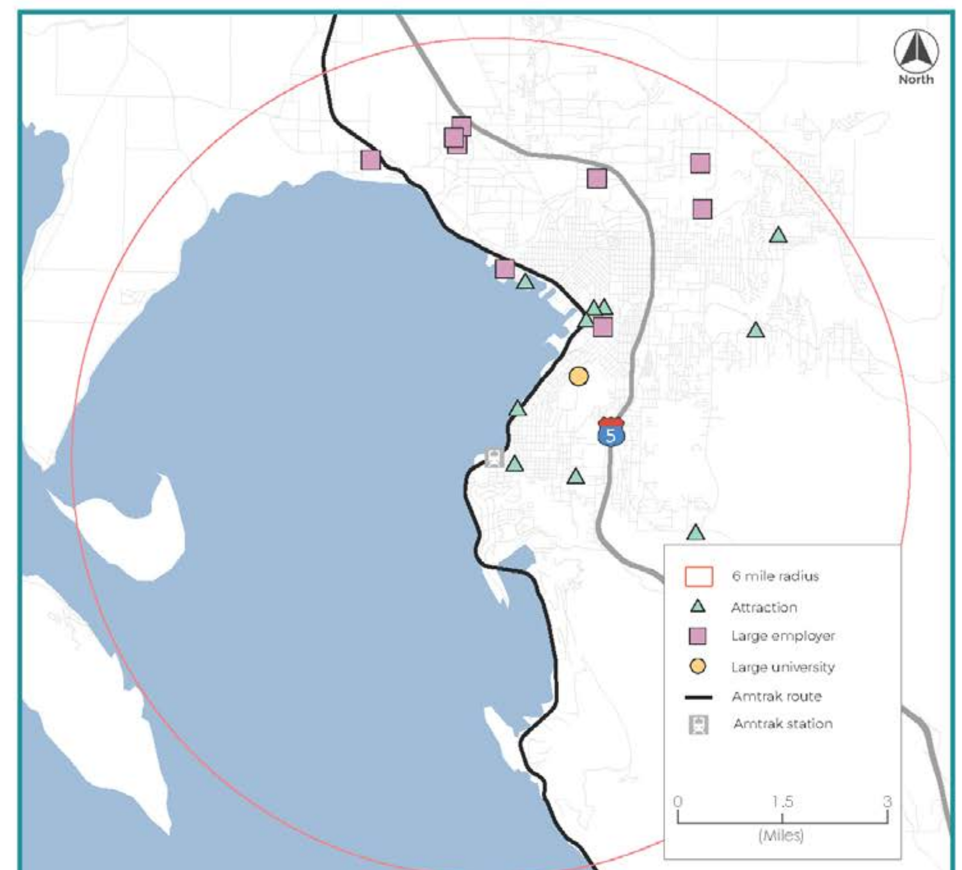
	Bellingham
Large universities/colleges*	1
Hotel rooms	2,000+
Attractions**	10
Large employers/High-tech companies***	9/2
Convention centers	0

Comparative statistics compiled from a variety of available data sources to be as consistent as practical among the cities in Oregon, Washington, and British Columbia. Figures for large employers and high-tech companies are representative of their location/occurrence in station areas. Please see methodology documentation for details.

**More than 2,000 students enrolled or a satellite campus of a university with more than 2,000 students enrolled.*

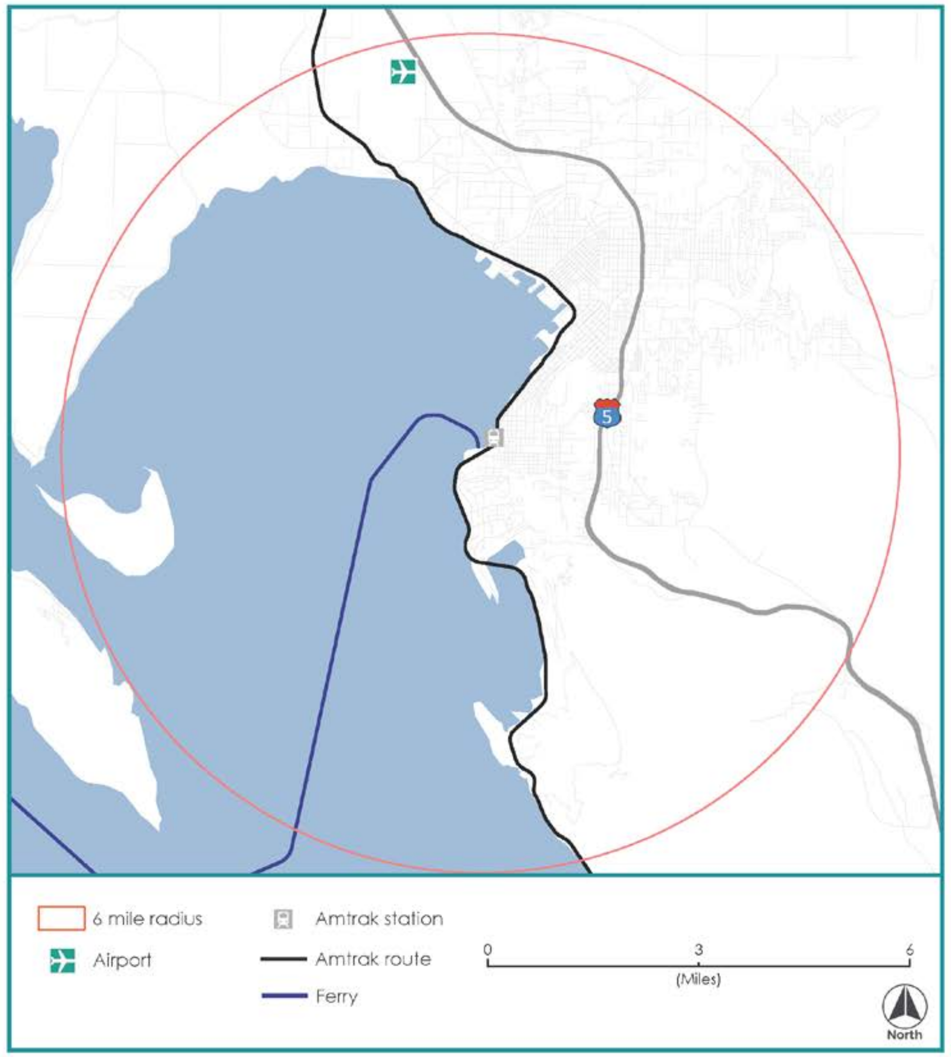
***Per TripAdvisor's top tourist attractions within 6 mile radius of station.*

****Companies with 200+ full time employees.*



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
BELLINGHAM — Multi-modal Interconnectivity

	Bellingham
Rail transit (existing/additional planned)	0 / 0
BRT and streetcar (existing/additional planned)	0 / 0
Intercity Connections (Ferry/Bus/Rail)	1 / 2 / 2
Bus lines	3



Ultra High-Speed Ground Transportation Study
Station Selection Criteria
BELLINGHAM — Land Use Plans and Policies

Population and Employment

	Whatcom County	Bellingham Urban Growth Area
Existing population (2015)	205,800	92,660
Future population (2035)	273,911	123,710
Population growth (2015 - 2035)	33%	34%
Existing jobs (2015)	83,232	52,359
Future jobs (2035)	120,284	75,000
Job growth (2015 - 2035)	45%	43%

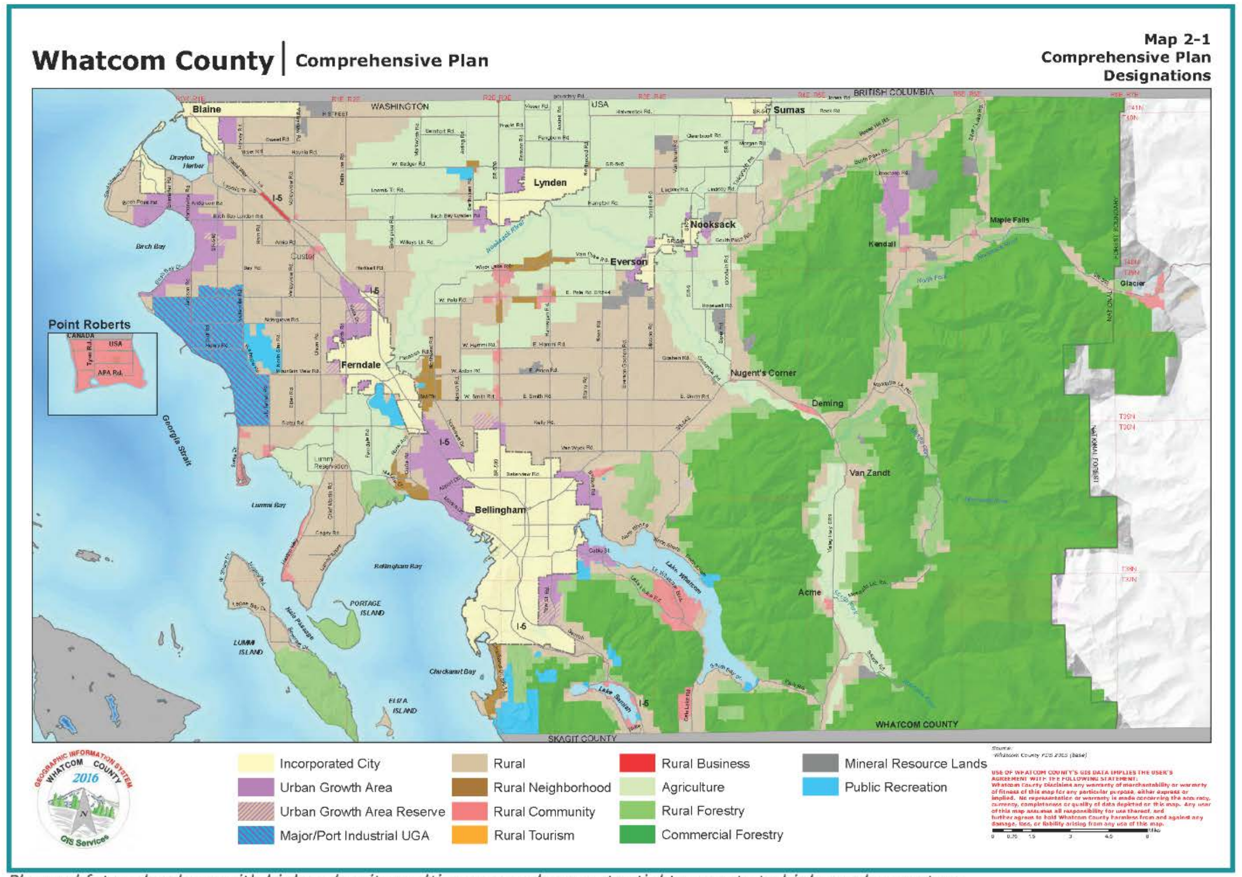
Source: Whatcom County Comprehensive Plan (tables 3, 4, and 5), 2016.

Plans and policies

Regional
Whatcom County Comprehensive Plan (2016)
Whatcom Mobility 2040 (2017)

City
Downtown Bellingham Plan (2014)
Bellingham Comprehensive Plan (2016)

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
BELLINGHAM — Value Capture Potential



Planned future land use with higher density multi-use areas have potential to equate to higher value capture.

Whatcom County

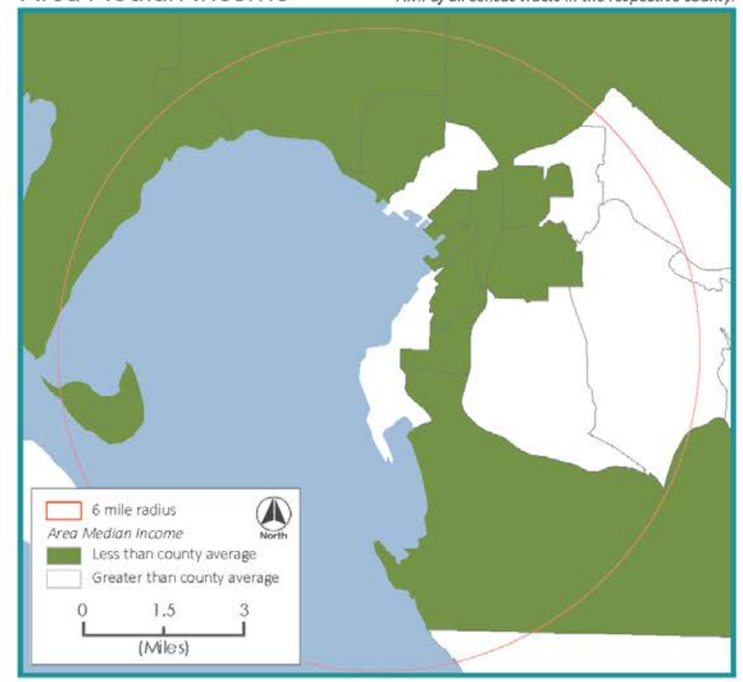
Whatcom County, through Goal 2P, encourages development within its respective cities to densify as a way to increase vitality, reduce the cost of services, manage outward growth, and protect the environment. The County encourages cities to approve new residential developments at an increased density from current standards. For Bellingham, this amounts to an increase from 6 units/net acre to 24 units/net acre.

Source: Whatcom County Comprehensive Plan (2016)

Ultra High-Speed Ground Transportation Study
Station Selection Criteria
BELLINGHAM — Equity Considerations

Area Median Income

County average AMI calculated by averaging AMI of all census tracts in the respective county.



Minority populations

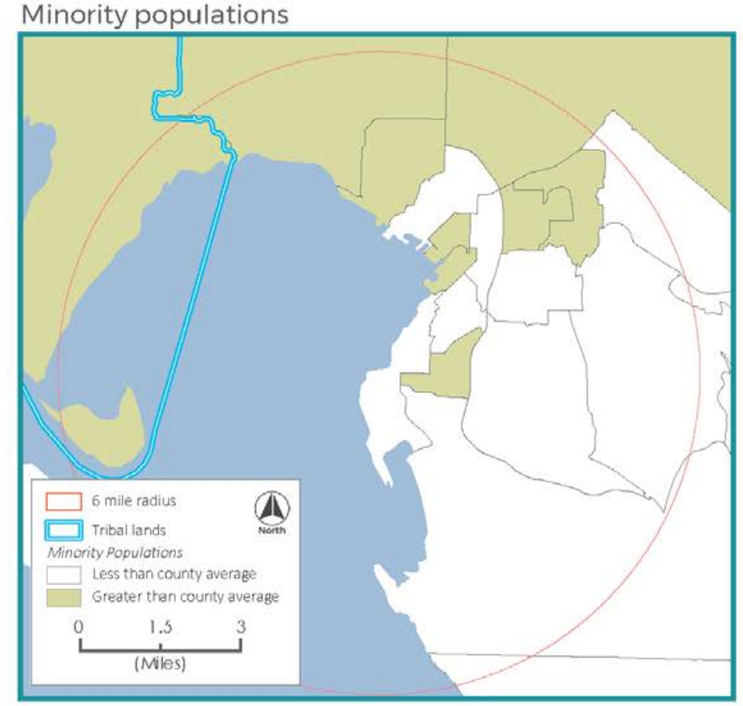


Exhibit C Memorandum on "Green Field" Stations

This appendix presents a synopsis of opportunities to stimulate development, specifically including tech hubs, around greenfield station locations. WSDOT requested this discussion as part of the corridor planning scope.

Greenfield station areas, which are undeveloped land on the urban periphery or in rural areas, offer an opportunity to spur economic activity at a lower cost than central city locations. Nevertheless, research on tech hub locations indicates that the most desirable locations are in the central city. The following are examples of central city station locations for innovation and technology.

Central City Tech Hub Examples

- **Diridon Station, San Jose, California**: In 2018 Google purchased land around Diridon Station from the city of San Jose to develop offices, retail, and housing with up to 20,000 jobs. Diridon is an existing commuter rail and Amtrak station and is planned station on the California High-Speed Rail line.
- **Cortex Station, St. Louis, Missouri**: In June 2018 MetroLink opened a new station in the200-acre Cortex innovation hub and technology district just outside of downtown St. Louis. The master plan calls for 4.5 million square feet of mixed-use development and 13,000 tech jobs.
- **Station F, Paris, France**: Station F, the world's largest startup facility, opened in 2017 in a former railway station known as la Halle Freyssinet. It includes over 350 thousand square feet, 1,000 desks and 26 international startup firms.
- **Michigan Central Station, Detroit, Michigan:** Ford Motor Company purchased the former train station and will renovate it and nearby buildings on 45 acres of vacant land. It will be the base for 2,500 employees working on innovative mobility projects.

An example of a peripheral greenfield station area is the Peña station

Peripheral Tech Hub Examples

- **Smart City, Denver Airport, Colorado**: a 400-acre greenfield is being developed into a smart city with high-tech infrastructure, including Panasonic's enterprise solutions division. Transportation features include the accessibility provided by its location near the Denver Airport and along a regional rail line to downtown Denver.

Peripheral Stations

In some cases, it might not be practical to place stations in city center's due to cost, alignment, or other constraints. Stations, particularly those that are between major cities, are sometimes located outside the center of those more moderately-sized cities. Operating into the center of these intermediate cities might require out-of-direction travel off the fastest route between two major cities. Also, the additional capital cost to route the line through the city center might be too high in relation to the ridership generated in moderately sized intermediate cities. Therefore, the station could be located on the periphery of the more densely-developed urban areas. An example on the present Amtrak Cascades is the Olympia/Lacey station.

Peripheral stations outside urban areas require transit connections with the city center and other large trip generators. Connecting service should ideally be timed for short passenger connections with high-speed rail trains.

These greenfield station locations offer opportunities to create new mixed use, high density communities with sustainability elements, district-scale infrastructure, smart technologies, and multimodal accessibility. Key to achieving this vision, in addition to a healthy real estate market, are a master plan that limits sprawl around the station and a focus on non-automobile travel modes within the station area. Experience to date shows limited success of sustainable development and transportation around peripheral high-speed rail stations.

Peripheral Examples

- **Stazione Reggio Emilia, Italy:** the only stop on the high-speed train service between Milan and Bologna opened in 2013. The station is connected to the center of Reggio Emilia, about two miles away, by a regional rail line. The infrastructure is part of an urban renewal project incorporating the northern part of Reggio Emilia.
- **Guadalajara-Yebes, Spain**: the station opened in 2003. It is 20 minutes from Madrid on the Madrid – Barcelona high-speed rail line. The area around the station is planned for over than 9,000 housing units around the station, and 30,000 new residents [59] Development has not met planned expectations, resulting in low ridership at the station.[60]
- **Avignon TGV, France:** Completed in 2001, Avignon TGV is three miles from the city center. Most passengers access the station by car and most land in the station area is surface parking. Since 2013, a rail line provides a five-minute ride between Avignon TGV station and the historic downtown rail station, Avignon Centre.[61] The Avignon TGV station was intended to accommodate more growth and economic activity because there are limited development opportunities around Avignon Centre. More than a decade after construction of Avignon TGV, however, there is little development around the station.

[59] Peripheral High-Speed Rail Stations in Spain, Carmen Bellet, Department of Geography and Sociology, University of Lleida, Spain, The Open Transportation Journal, Volume 13, 2019
[60] Territorial Implications of High Speed Rail: A Spanish Perspective, 1st Edition Edited by José M. de Ureña

[61] Reflections on French and German High Speed Rail Stations: California's Struggling Central Cities as both Blessing and Curse, Eric Eidlin, German Marshall Fund, March 3, 2014

Exhibit D Summary of WSDOT 201-2018 Ultra-High-Speed Ground Transportation Study, Corridor Analysis

Conclusions

Economic Impact	Found no fatal flaws, confirmed feasibility, and identified significant economic potential
Engineering:	Challenges are not insurmountable
Ridership:	Seattle-Portland market is the driver for the corridor (based on current trends) UHSGT has the potential to shift significant intercity travel market to rail
Revenue/Cost:	Operating costs could be covered by 2055 Stations costs are a small portion of overall price tag and fewer stations = lower ridership
Service:	Twelve roundtrips is the sweet spot Higher speed (Maglev vs. HSR) did not significantly change ridership

Methodology

Develop mix of corridor concepts to demonstrate effects of urban vs suburban locations and number of station stops

Threshold Criteria

- Average Operating Speed of at least 250 mph
- Dedicated ROW
- Minimum turn radii
- Population of cities near proposed station
- Opportunity for multi-modal connections

Screening Criteria

Public benefits:

- Seven guiding public benefits objectives
- Station accessibility
- Ridership
- Route length

Engineering Feasibility:

- Minimize ROW/ real estate impacts
- Support 250 mph speeds
- Tunnels/Bridge/Aerial construction
- Geographic features
- Impacts on existing structures

Environmental Considerations

- Areas of Concern

Operations and Infrastructure

- Revenue/Operating Cost
- Capital Cost
- Travel Time
- Mode Shift

Concept Corridors

Three representative corridors were selected: Key attributes:

1A: Seven stations in urban core and periphery: Vancouver International Airport, Seattle, Portland, Bellingham, Everett, Tacoma, Olympia
2: Four major stations in largest cities: Vancouver, Seattle, Portland Airport, Tacoma
4: Three stations in urban periphery: Vancouver (King George SkyTrain), Tukwila (Link LRT and Sounder Commuter Rail), and Expo Center (MAX LRT).

Evaluation was undertaken using Federal Railroad Administration's (FRA) CONNECT (Conceptual Network Connections Tool) to estimate ridership, revenue, operating and capital costs for each corridor concept.

Core Based Statistical Area (CBSA) population data were used to estimate order-of-magnitude ridership, cost, revenue among the alternatives. CONNECT does not account for multiple stations within a CBSA, location of stations within a CBSA, or trips less than 50 miles long.

Applied model on iterative basis for 2035 and 2055 forecast years for a variety of service frequencies.

Exhibit E Summary of WSDOT 1992 High-Speed Ground Transportation Study, Corridor Concepts

Ridership:

1. 2020 Ridership = 5.1M annual trips at 185 mph (HSR); 5.8M annual trips at 300 mph (Maglev); approx. 90% from auto, 3% from air and 7% induced
2. Average peak hour/peak direction passenger loadings are at least two-thirds of seats occupied.
3. Marginal ridership gain from Maglev (14%) does not justify increased capital cost (37%).
4. Assume fares are 50-70% of airfare.

Operations:

1. Annual operating costs $156.5M (185 mph-HSR) and $195.0M (300 mph-Maglev) in 1992$.
2. Twelve round trips per day; hourly for six hours/day, 120-minutes for 12 hours/day.
3. Travel times, distances, and speeds:

Segment	Miles		Travel time (min)*		Speed (mph)	
	HSR	Mag Lev	HSR	Mag Lev	HSR	Mag Lev
Portland-King County	179.3	179.3	111.6	92.0	96	117
Portland-Vancouver	336.8	336.8	208.1	167.1	97	121

*Includes 24 minutes of dwell- 3 minutes each at eight stations

Capital/Alignment:

1. Capital costs for HSR, including vehicles, design and 30% estimating allowance range from $9.03B to $11.95B (1992$) or $22.1B to $29.3B (2.45 inflation factor- 26 years at 3.5%/year). Maglev costs are $12.13 to $16.15B in 1992$.
2. Assume 100-foot ROW.
3. Mileage and unit cost assumptions:

ROW Category	Miles		Cost/Mile ($ Millions) *	
	HSR	Mag Lev	HSR	Mag Lev
Existing track	32.6	0		
At grade	88.9	116.5	$8-15	$20-30
Structure (aerial/retained cut)	180.0	185.0	$20-30	$2-40
Tunnel	32.8	32.8	$60-120	$65-125
Total	334.3	334.3		

Cost/Mile does not include stations, maintenance base, design/management, estimating allowance

4. Capital cost estimates:

HSR at 185 mph Speed	Cost (in $M)	
	Low	High
ROW	599	715
Existing track	134	222
At grade	364	605
Structure (aerial/retained cut)	2916	3726
Tunnel	1722	2299
Stations ($12M ea.)	120	170
Maintenance Facility	55	70
30% Allowance	1553	2061
23% Design. Mgmt.	1548	2054
10 trains, 20% spare $15M ea.	150	250
TOTAL	9.03B	11.95B

Cost range for 300 mph HSR is $12.13 to $16.14B

Proposed Alignment from Portland to US-Canada Border:

Portland Union Station, I-84, I-205, I-5 to Napavine, cross country to BNSF south of Tenino, through Yelm, McKenna and east side of Fort Lewis, turn northeast, follow powerlines to Southeast of Puyallup, turn north of Sumner to BNSF, continue along BNSF past Auburn and Kent to I-405, I-405 to SeaTac, I-405 to east of Renton, along power transmission line through King and Snohomish Counites into Skagit County, join BNSF near Whatcom/Skagit county line east of Anderson Mountain, follow BNSF to border. Alignment from border to downtown Vancouver was not considered.

25.3.1.1 Stations:

1. Portland, OR downtown
2. Portland International Airport
3. Clark County, WA
4. Thurston County, WA
5. SeaTac
6. King County, WA
7. Snohomish County, WA
8. Whatcom County, WA
9. Whalley/Surrey, BC
10. Vancouver, BC downtown

Alternatives to Serve Downtown Seattle

A: From SeaTac follow SR 518 and I-405 to BNSF, King Street station, existing tunnel under downtown, Ship Canal drawbridge, existing alignment along coast to powerline north of Arlington (12.5 miles south of Marysville). SeaTac-Snohomish travel time: 56 min.

B: From SeaTac follow SR 518 and I-405 to BNSF, King Street station, new tunnel under downtown, and ship canal to power transmission line ROW in north King County, turn northeast, into tunnel cross into Snohomish and under I-405. SeaTac-Snohomish travel time: 25 min.

Ridership forecast is higher for Bellevue than for downtown Seattle station location (5.1M vs. 4.5M).

Outline of the 1992 Study Methodology

- Evaluated tilt-train, HSR and Maglev technologies.
- Evaluated corridor for physical attributes: key challenges: grade separations between Everett-Tacoma, crossing Lake Washington Ship Canal in Seattle, and crossing Columbia River in Portland.
- Developed generic corridors using 1:100,000 topo maps, subjectively estimating ROW types.
- Conducted travel surveys at airports and on highways.
- Socio-economic, population and employment forecasts from regional agencies, forecast year 2020.
- Developed demand model based on user preference surveys. Tested scenarios and sensitivities to input variables.

Exhibit F Summary of WSDOT 2006 Long-Range Plan for Amtrak Cascades

2033 Service Goals	Frequency Portland – Seattle: 13 trains each direction (4 now); Seattle – Vancouver: 4 trains each direction (2 now) Will require 13 trainsets, including 3 spare sets Travel Time Vancouver – Portland: 5:22 (322 min vs. 450 now) Seattle – Vancouver: 2:37 (157 min vs. 210 now) Portland – Seattle: 2:30 (150 min vs. 240 now) Increase maximum speed from 79 to 110 mph (after safety systems and track improvements)
Ridership	Approximately 3 Million in 2023 (811K in 2017); Station Volumes (Boardings + Alightings) Vancouver, BC: 711,000 (167,000 in 2017)) Seattle: 1.9 Million (480,000 in 2017) Portland: 1.4 M (412,000 in 2017) 13 stations between Portland and Vancouver (11 in WA, 1 in OR, 1 in BC)
Operating Revenue	$82 million by 2023; Net operating revenue (subsidies): -$1 million ($29.6M in 2017)
Farebox Recovery	99% by 2023
Operating Cost	$83 Million by 2023 (in 2006 dollars); 2006 cost was approximately $20 Million
Construction and Equipment Cost	Exceed $6.5 billion in 2006 dollars (approx. $8.1 billion in today's dollars)
Improved tracks and facilities	• Additional mainline tracks – Exclusive for Cascades - 185 miles of a 3rd ML track and 46 miles of a 4th ML track – All traffic- 24 miles of 3rd ML track and 2 miles of 4th and 5th ML track • New and extended sidings, Crossovers and turnouts, Bypass Tracks • Additional yard storage and running tracks, larger maintenance facilities
Vancouver Terminus Alternatives	• Additional trips to Pacific Central Station requires over $.5B capital investment (primarily for Fraser River bridge) • Scott Road (south of the Fraser, 10 miles from Pacific Central Station) would have 7.3% higher ridership than Pacific Central

Exhibit G WSDOT 2016 Station Policy for Amtrak Cascades Feasibility Assessment and Evaluation Criteria

1. **Consistency with Corridor and Agency Goals**
   a. Is the proposal consistent with state/provincial transportation goals/policies and state rail plans for WA and OR?

2. **Customer Demand**
   a. How many riders can be expected to use the station stop?
   b. How will the stop affect total ridership in the corridor?

3. **Operational Feasibility**
   a. Are changes consistent with commitments outline in the applicable agreements?
   b. How do the changes affect other trains/users of the system?

4. **Station Suitability**
   a. Is the proposal consistent with applicable land use polices and plans?
   b. What site changes would be needed to serve Amtrak Cascades safely and efficiently?

5. **Interconnectivity**
   a. In what ways would the proposal improve multimodal connectivity for passengers?
   b. How will the proposal contribute to or reduce transportation-related societal benefits (net positive or net detriment)?

6. **Fiscal Viability**
   a. Based on anticipated costs and revenue, is the effect of the proposal positive, neutral, or negative?

Exhibit H Amtrak Cascades 2017 Origin-Destination Matrix

Rows are Origins, Columns are Destinations

	VAC	BEL	MVW	STW	EVR	EDM	SEA	TUK	TAC	OLW	CTL	KEL	VAN	PDX	Total
VAC	--	1%	--	--	1%	1%	9%	--	--	--	--	--	--	1%	12%
BEL	1%	--	--	--	--	--	1%	--	--	--	--	--	--	1%	4%
MVW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1%
STW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EVR	1%	--	--	--	--	--	--	--	--	--	--	--	--	--	2%
EDM	1%	--	--	--	--	--	--	--	--	--	--	--	--	--	2%
SEA	9%	1%	--	--	--	--	--	--	1%	1%	1%	1%	3%	17%	33%
TUK	--	--	--	--	--	--	--	--	--	--	--	--	--	1%	2%
TAC	--	--	--	--	--	--	--	--	--	--	--	--	1%	4%	6%
OLW	--	--	--	--	--	--	1%	--	--	--	--	--	--	1%	4%
CTL	--	--	--	--	--	--	1%	--	--	--	--	--	--	--	2%
KEL	--	--	--	--	--	--	1%	--	--	--	--	--	--	--	2%
VAN	--	--	--	--	--	--	3%	--	1%	--	--	--	--	--	5%
PDX	1%	1%	--	--	--	--	17%	1%	4%	1%	--	--	--	--	25%
Total	12%	4%	1%	--	2%	2%	33%	2%	6%	4%	2%	2%	5%	25%	100%

Seattle-Portland	34%
Seattle-Vancouver, BC	18%
Tacoma-Portland	7%
Seattle-Vancouver, WA	6%
Seattle-Bellingham	3%
Portland-Vancouver, BC	2%

Source: WSDOT

Exhibit I Summary of Relevant Plans and Policies in the Cascadia Region

This section presents an overview of selected long-range land use, transportation, growth management and economic development plans in the corridor. It also includes notable planned transportation projects in each station city that could affect intermodal connectivity between UHSGT and other modes of transportation.

Central Puget Sound Region

The Central Puget Sound Region, comprised of Pierce, King, Kitsap, and Snohomish Counties, is situated between the Olympic Mountains to the west and Cascade mountains to the east. Economically, the region has strong and growing industries in aerospace, information and communication technology, business services, and tourism.[62] City, regional, and State planning efforts in the region focus on sustainable, stable growth. The Puget Sound Regional Council (PSRC) develops policies and coordinates decisions about regional growth, transportation, and economic development.

Plans and policies include:

- State of Washington Growth Management Act: Enacted in 1990, requires jurisdictions with more than 50,000 residents or growth rates above 20% per decade to define and implement a land use policy framework. The Act supports compact development and multimodal transportation by requiring policy frameworks that minimize sprawl and low-density development in the urban fringe.[63]
- Vision 2040: Adopted by the PSRC in 2008, the plan is a long-range vision that supplies implementation actions and identifies target growth areas.[64] PSRC is preparing VISION 2050 and anticipates adopting it in 2020 to provide a guide for sustaining a healthy environment, thriving communities, and a strong economy.
- Amazing Place: The PSRC's economic development strategy identifies three goals for the Central Puget Sound Region: open economic opportunities to everyone, compete globally, and sustain a high quality of life.[65]
- Seattle 2035: The City's Comprehensive Plan, Seattle 2035 was amended in 2017 and will help the City manage growth and make decisions over the next twenty years.[66]
- Bellevue Comprehensive Plan: Adopted in 2015, most growth will be through redevelopment in downtown or other mixed use centers.[67]

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[62] Puget Sound Region Council. "Amazing Place." 2017. Pg. 3.
[63] Washington State Legislature. Chapter 36.70A.
[64] Puget Sound Regional Council. "Vision 2040
[65] "Amazing Place."
[66] City of Seattle. "Seattle 2035 Comprehensive Plan."
[67] City of Bellevue, "Bellevue Comprehensive Plan

Key transportation projects in the central Puget Sound:

- ST2 includes extension of light rail from University of Washington to Northgate (2021) and Lynwood (2024); from Central Seattle east to Bellevue and Redmond Technology Park (2023), and south from Angle Lake to Federal Way (2024).
- ST3 includes extension of light rail from Northgate to Everett (2036), Redmond Technology Station to Downtown Redmond (2024), a new line between Issaquah and Kirkland (2041), and from Federal Way to Tacoma (2030). Sounder would extend from Lakewood to DuPont (2036), and Sounder South will have capacity increases (longer trains and station platforms, track and signal upgrades). Bus Rapid Transit (BRT) along I-405 will be added between Lynnwood and Burien Transit Center via Bellevue (2024). Planning studies for a future commuter rail connection from Orting to Sounder in Sumner.

Greater Portland

Greater Portland, comprised of five Oregon counties and two Washington counties, is a fast-growing region known for its environmental sustainability and world-class transit system. Portland is surrounded by natural landscapes, with the Columbia River forming the boundary between Washington and Oregon, the Columbia River Gorge National Scenic Area to the east, Oregon Coast Range to the west, and the agricultural Willamette Valley to the south. Six key economic sectors, identified by the regional economic development organization Greater Portland, are clean technology, computer and electronics, software and media, metals and machinery, athletic and outdoor, health science and technology, and emerging industries.[68]

Plans and policies that guide Portland's growth include:

- Oregon Statewide Planning Goals: The statewide planning goals, enacted in 1973, express Oregon's policies on land use and related topics. Goal 12: Transportation says that transportation plans shall consider all modes of transportation, avoid dependence on a single mode of transportation, and conserve energy, among other elements.
- Region 2040 Growth Concept: The 50-year plan, adopted by the Metro Regional Council in 1995, and updated in 2014, lays out strategies to focus growth in corridors and centers that can be well-served by transit service, bicycle, and pedestrian facilities and to accommodate industrial growth.[69]

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[68] Greater Portland. "Industries Overview."
[69] Metro. "2040 Growth Concept Map." 2014.

- Portland 2035 Comprehensive Plan: Adopted in 2016, prepares for and manages how Portland will increase population and employment densities to accommodate a large share the region's population and employment growth.[70]

Key transportation projects in Greater Portland include:

- Southwest Corridor Light Rail Transit Plan: designing and pursuing funding for extending light to the southwest of downtown (2027).
- I-5 Columbia River Bridge Oregon and Washington officials are discussing options for a new bridge.

Vancouver, BC Region

The Vancouver, BC Region is an international metropolitan area surrounded by ocean harbors to the east and west and mountain peaks to the north. Vancouver, BC is the densest and ethnically diverse city in Canada. The Vancouver Economic Commission, the economic development agency of the City of Vancouver, identifies the focus sectors as technology, digital entertainment and interactive, green economy and Asia pacific.[71]

Plans and policies that support transportation and growth in the Vancouver, BC Region include:

- Metro Vancouver 2040 Regional plan: sets out goals, strategies, and policies to guide growth and provides the land use framework
- Transportation 2040: The long-term plan provides a strategic vision for the city that will help guide transportation and land use decisions, and public investments for the years ahead.[72]
- Greenest City Action Plan: The plan aims to prepare Vancouver for the potential impacts of climate change, while building a vibrant community and supporting alternative modes of transport, among other strategies.[73]

Key transportation projects in the Vancouver, BC region:

- Millennium Line Broadway Extension: SkyTrain extension along Broadway.
- South of Fraser Rapid Transit: Study of transit improvements including SkyTrain extension from King George station along the Fraser Highway corridor.

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[70] City of Portland, Planning and Sustainability. "2035 Comprehensive Plan."
[71] Vancouver Economic Commission. "Our Focus
[72] City of Vancouver. "Transportation 2040 Plan."
[73] Vancouver Economic Commission. "Greenest City Action Plan."

Intermediate Station Cities

The intermediate station cities' land use planning is guided by Washington State's Growth Management Act.

- Tacoma and Everett are in the Puget Sound Regional Council guided by Vision 2040, alongside the Seattle region.
- Olympia's regional planning is led by Thurston County. Relevant plans include the 2040 Regional Transportation Plan (2017) and Comprehensive Plan (2015).
- Kelso, with regional planning led by Cowlitz County, is guided by the County's Comprehensive Plan (2017).
- Bellingham's growth and change is guided by the Whatcom County Comprehensive Plan (2016) and Whatcom Mobility 2040 (2017).

Washington State Department of Transportation

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix D

Ridership and Revenue Forecasts

July 2019

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Disclaimer

Executive Summary

In July 2018, the Washington State Department of Transportation (WSDOT) commissioned a team led by WSP, of which Steer is a member, to produce a Business Case Analysis of Ultra-High-Speed Ground Transportation (UHSGT) in the Cascadia megaregion. The proposed UHSGT corridor spans approximately 310 miles (499 kilometers) between Portland, Oregon, Seattle, Washington, and Vancouver, British Columbia (BC). It would connect the key urban areas in one of the most dynamic, fastest growing economic megaregions in North America (including but not limited to the main three identified above).

This report forms the Ridership and Revenue Report deliverable, assessing the potential ridership and revenue for various alternative scenarios of UHSGT service. This work seeks to build upon the previous study of UHSGT in the Cascadia corridor, completed in December 2017, that utilized the Federal Railroad Administration's CONNECT model to project ridership in the corridor.

Forecasting Approach

The approach to forecasting ridership and revenue for the proposed UHSGT service builds upon a modeling framework (based on discrete choice models) that is widely accepted throughout the transportation industry and commonly used to estimate potential demand across modes for both new and existing services. This focused on identifying or estimating:

- The current and future size of the "in-scope" market – the subset of trips made in the Cascadia megaregion by travelers for whom the proposed UHSGT service would be a viable travel option;
- How much of this market UHSGT can capture at a given fare; and
- How much additional travel might be "induced" by the presence of the UHSGT service itself.

This work included conducting a behavioral travel survey of over 3,000 current travelers, seeking information on their origins / destinations, travel purposes and potential response to alternative UHSGT service scenarios.

Ridership and Revenue Forecasts

In total, nine service scenarios were evaluated, each featuring variations of station locations, stopping patterns and frequencies, travel times, and/or operating hours to test and analyze their ridership and revenue potential.

In 2035, when the UHSGT system is assumed to open, there are forecast to be between 0.8 and 1.4 million one-way UHSGT trips throughout the entire system, generating between $70 and $115 million in fare revenues[74] (depending on the service scenario).

By 2040, UHSGT ridership is forecast to grow to between 1.7 and 3.1 million one-way trips per year, an average annual growth rate of over 16.5% (between 2017 and 2040). Similarly,

[74] All revenues are presented in 2019 prices.

fare revenue is forecast to grow to between $155 and $250 million. This significant growth is largely due to ramp-up assumptions in the early years (as people get used to the new travel options introduced by UHSGT).

By 2055, UHSGT ridership is forecast to grow to between 2.1 and 3.7 million one-way trips per year, an average annual growth rate of 1.2% (between 2040 and 2055). Fare revenues are forecast to grow to between $190 and $300 million.

When compared to the previous study of UHSGT that utilized the Federal Railroad Administration's CONNECT model, the forecasts presented from this current study are broadly comparable (on average 3% higher in 2035) for demand between the 3 major cities (Portland, Seattle and Vancouver, BC). However, the forecasts from this current study are significantly higher (by an average of 29% in 2035) when including potential ridership from intermediate stops (i.e. stops outside of the 3 major cities, such as Surrey, Bellingham, Everett, Tacoma and Olympia).

The sensitivity of the ridership and revenue projections to incremental changes in each of the key input variables was tested, highlighting the relative importance of individual forecasting assumptions. Many of the tests undertaken have a relatively limited impact (less than 5%) on forecasts and therefore demonstrate the resilience of the forecasts across a range of areas of uncertainty. However, there are some key risk areas – including UHSGT fares, journey times and frequencies, as well as auto journey times, model value of time and market growth – where the impact on the ridership and revenue projections is more material. Further, shifting the Canadian terminus from Vancouver, BC to Surrey, BC would also be expected to have a significant impact of between 9% and 16% (depending on the service scenario).

Potential Future Analysis

The projections of ridership and revenue presented in this report represent what are reasonable estimates on the basis of the analysis undertaken, and thereby a provide a reasonable basis on which to compare across the various scenarios considered.

However, it is acknowledged that there are a number of areas that may not be fully represented within these forecasts, including:

- Future investment in local transportation systems: There may be future enhancements to the local transportation systems in each urban area that are not fully captured in the analysis presented in this report.
- Future investment in other connecting services: In addition to local services, there are enhancements being considered to other connecting services (for example, rail services connecting Portland with Eugene) that are not fully captured.
- Induced demand resulting from enhanced economic activity: In addition to captured demand, additional trips are projected to be made by UHSGT that otherwise would not have been made by any mode if UHSGT were not available. This additional demand is called "Induced" demand. The induced trips highlighted in the projections account for additional trips projected to be made as a result of the improved travel options now

available in the corridor. This does not, however, include all potential induced trips. In particular, induced trips as a result of enhanced economic activity brought about by UHSGT are not accounted for within the numbers presented.

- Connecting air passengers: It may be possible to capture a portion of connecting air passengers (for example, someone going from New York – Seattle – Portland via air) if appropriate commercial agreements with airlines could be reached.
- Other local markets: The research undertaken as part of this work focused primarily on the potential to attract longer-distance intercity travelers onto UHSGT; it may under-represent shorter distance movements where the service may also be viable.

Each of these areas represent possible items that may increase of decrease projected ridership and revenue relative to the projections outlined in this report. Depending on the priorities for the development of UHSGT moving forward, it may be appropriate to consider additional analysis to more fully understand the potential scale of each of these items, and therefore their potential impacts on the case for investment in UHSGT.

26 Introduction

In July 2018, the Washington State Department of Transportation (WSDOT) commissioned a team led by WSP, of which Steer is a member, to produce a Business Case Analysis of Ultra-High-Speed Ground Transportation (UHSGT) in the Cascadia megaregion. The proposed UHSGT corridor spans approximately 310 miles (499 kilometers) between Portland, Oregon, Seattle, Washington, and Vancouver, British Columbia (BC). It would connect the key urban areas in one of the most dynamic, fastest growing economic megaregions in North America (including but not limited to the main three identified above).

This report forms the Ridership and Revenue Report deliverable, assessing the potential ridership and revenue for various alternative scenarios of UHSGT service. This work seeks to build upon the previous study of UHSGT in the Cascadia corridor, completed in December 2017, that utilized the Federal Railroad Administration's CONNECT model to project ridership in the corridor.

The CONNECT model is a sketch planning tool that estimates the overall performance of user-defined intercity rail corridors and networks. CONNECT was developed to provide an analytic basis for the decision-making process in the early stages of intercity rail network planning. However, it is not a substitute for detailed corridor and network planning, as all estimates are intended to be "order-of-magnitude" only. A key objective of this study is to take the prior study's preliminary ridership analysis to the next step, thereby developing an enhanced understanding of the potential ridership and revenue associated with UHSGT.

Other elements of the overall project feasibility, including project-related and wider economic impacts, capital and operating costs, and technology options, are addressed in the overall business case document and other relevant appendices.

27 The Market

The proposed UHSGT service will serve the Cascadia megaregion, anchored by the three key metropolitan areas of Portland, Seattle, and Vancouver, BC. A summary of the characteristics of this Megaregion—including demographic conditions, economic trends, and the currently available modes of travel—are described below.

27.1 Overview of the Cascadia Megaregion

Cascadia is a fast-growing, dynamic megaregion, covering much of the Pacific Northwest of the United States, in addition to southwestern British Columbia in Canada. As mentioned above, the megaregion is anchored by three major metropolitan statistical areas (MSAs)[75]: Seattle-Tacoma-Bellevue, WA; Portland-Vancouver-Hillsboro, OR-WA; and Vancouver-Surrey-Burnaby, BC. Beyond these "big three" metropolitan areas, several other urban areas play key roles in the broader regional economy.

Table 1 presents an overview of population and employment for Cascadia MSAs located along the proposed UHSGT corridor. Further demographic information on population and employment trends are included in the separate Potential Economic Gains in the Cascadia Megaregion report.

Table 61: Population and employment for key metropolitan areas in Cascadia, 2016/2017

Metropolitan Area	Population (2016)	Employment (2017)
Seattle-Tacoma-Bellevue, WA	3,802,660	1,896,045
Vancouver-Surrey-Burnaby, BC	2,463,431	1,359,200
Portland-Vancouver-Hillsboro, OR-WA	2,423,102	1,147,337
Olympia-Tumwater, WA	273,923	113,437
Bellingham, WA	216,274	81,653
Mount Vernon-Anacortes, WA	123,390	47,278
Longview, WA	104,756	36,141

Sources: US Census Bureau 2016 Population Estimates; US Census Bureau Quarterly Workforce Indicators, 2017; Canada Census Program, 2016; Canada Labour Force Survey, 2017

The Cascadia megaregion is home to a diverse range of industries and businesses. In particular, the information technology and related industries (e.g. analytical instruments, small electric goods, and video production and distribution) have relatively high concentrations in Cascadia compared to other areas of the US, with companies such as Amazon and Microsoft headquartered in Seattle. Other areas of economic strength for the megaregion include aerospace and defense contractors (with Boeing based near Seattle) and footwear (Nike near Portland) [76]. In addition to these knowledge-based, high-value

[75] The Canadian equivalent of an MSA is a census metropolitan area (CMA); all future references to MSAs in this report include Canadian CMAs where applicable.
[76] Additional details on the industrial composition and economic strengths of the megaregion are provided in the Megaregion Report.

industries contributing to a strong regional economy, individual companies have both headquarters and satellite offices within the megaregion, thereby driving a degree of intercity travel.

In addition to a strong economy, Cascadia boasts a strong tourism industry, with its vibrant cities, beautiful natural landscapes, and exciting array of outdoor activities drawing visitors from across the US and Canada and around the world. As the focal point of the megaregion, Seattle has seen year-over-year growth in visitor numbers for eight consecutive years leading up to 2017, topping out at 39.9 million that year.[77] The Seattle-Tacoma International Airport (Sea-Tac) has seen similar trends, with an emphasis on international growth, both in terms of number of passengers handled and destinations served. While not as large tourism hubs as Seattle, Portland and Vancouver, BC have each experienced similarly positive visitor growth over the past decade.

The strong economy and flourishing tourism industry across the megaregion create a strong market for travel, parts of which UHSGT is well positioned to capture (details on the scale of this market that UHSGT might be able to capture are provided in Section 5.2.1). As Figure 1 illustrates, the scope of the proposed service covers all major urban areas in the megaregion.

[77] Source: Visit Seattle

Figure 43: Potential stations to be served by UHSGT under various service scenarios

27.2 Existing Travel Options

Intercity travelers in the Cascadia megaregion currently have four primary modes to choose from: automobile, air, intercity rail, and intercity bus. In addition, there are various local transportation systems that help to connect and serve these primary modes. The following subsections provide a high-level overview of the service characteristics for each mode in turn.

27.2.1 Air

The Cascadia megaregion is served by four major airports: Portland (PDX), Seattle (SEA), Bellingham (BLI), and Vancouver, BC (YVR), with Alaska Airlines, Delta Airlines, and Air Canada as key airline operators in the area. Table 2 presents key service characteristics for Cascadia airport pairs that have nonstop service.

Table 62: Air service characteristics for Cascadia airport pairs with nonstop service78

Airport Pair	Daily Frequency	Daily Seats[79]	Average Travel Time (min)
SEA – PDX	24	2,100	55
SEA – BLI	5	375	50
SEA – YVR	17	1,350	60
PDX – YVR	5	375	70

Sources: Google Flights, April 2019; Bureau of Transportation Statistics T-100 International Air Carrier Statistics, 2017

Trips in the corridor by air are estimated to account for approximately 19% of the in-scope trips (see Sections 4.2 and 5.2.1 for further details).

In addition to these major airports, there are a number of regional airports providing service throughout the corridor, including Boeing Field, Paine Field and South Lake Union (seaplanes). These airports comprise a relatively small amount of demand relative to the major airports above, and also generally serve more local needs. Accordingly, these airports are not included in the ridership analysis.

27.2.2 Rail

Amtrak is the exclusive operator of intercity rail services between Portland and Vancouver, BC, operating two types of service along the route: Cascades, a regional service exclusively within Cascadia, and the Coast Starlight, a long-distance service that begins in Seattle and continues south beyond Portland to Los Angeles. Table 3 below presents service characteristics for major station pairs in the rail corridor.

[78] All service characteristics are for one-way travel and represent an average of travel in both directions.
[79] Daily seat count is estimated based on frequency by aircraft type: Bombardier Q400 and Embraer E175 aircraft are assumed to have 75 seats per aircraft, and Boeing 737 and Airbus A320 series aircraft are assumed to have 150 seats per aircraft.

Table 63: Rail service characteristics for major station pairs in Cascadia[80]

Station Pair	Daily Frequency	Average Travel Time (hh:mm)[1]
Seattle – Portland	6	3:40
Seattle – Vancouver	2	4:15
Portland – Vancouver	1	8:15

Sources: Amtrak schedules and 2017 ridership data
[1] Trans-border travel times include time spent for immigration and customs formalities at the border.

Trips in the corridor by rail are estimated to account for approximately 6% of the in-scope trips (see Sections 4.2 and 5.2.1 for further details).

27.2.3 Auto

The primary mode for north-south intercity travelers in the Cascadia megaregion is private car using Interstate 5 (I-5), which runs the length of the UHSGT corridor from Portland through Seattle to the Canadian border. From the border to Vancouver, BC it is known as Highway 99. Alternate routes for portions of the corridor include US Route 30 from Portland to Longview, Interstate 405 through Bellevue and Tukwila, and Washington State Route 9 from Seattle to the Canadian border, running east of I-5. Free-flow travel times on I-5 are approximately 2 hours 55 minutes between Portland and Seattle, and 2 hours 30 minutes between Seattle and Vancouver (excluding customs formalities).

Trips in the corridor by auto are estimated to account for approximately 64% of the in-scope trips (see Sections 4.2 and 5.2.1 for further details).

27.2.4 Intercity Bus

A variety of intercity bus operators provide service between the downtown areas of major cities in the Cascadia Megaregion, including Greyhound, Bolt Bus, and Quick Shuttle. Table 4 presents service characteristics for major city pairs in the area.

Table 64: Bus service characteristics for major city pairs in Cascadia[81]

City Pair	Daily Frequency	Average Travel Time (hh:mm)[1]
Seattle – Portland	11	3:40
Seattle – Bellingham	11	2:00
Seattle – Vancouver	12	4:10
Portland – Vancouver	5	8:15
Bellingham – Vancouver	11	2:05

Sources: Various bus operators, December 2018
[1] Trans-border travel times include time spent for immigration and customs formalities at the border.

[80] All service characteristics are for one-way travel and represent an average of travel in both directions.
[81] All service characteristics are for one-way travel and represent an average of travel in both directions.

Trips in the corridor by bus are estimated to account for approximately 11% of the in-scope trips (see Sections 4.2 and 5.2.1 for further details).

27.2.5 Local Transportation Systems

Many UHSGT passengers will begin or end their trips beyond walking distance of stations, making transit connections important, particularly in station areas with managed parking.

Each of the urban centers in the corridor include local transit connections, be that fixed-rail systems (such as those operated by Translink in British Columbia) or bus services. Connections to each of these services are considered through use of the local RTPO/MPO models throughout the corridor (see Section 4 for further details).

It is important to note, however, that there may be future enhancements to these local transportation systems that are not fully captured in the analysis presented in this report. These enhancements could include services specifically designed to complement the UHSGT system, or those that are independently developed for the local needs of each area. It is important that the potential business case for UHSGT is not predicated on other investments that are not currently committed[82]. With this in mind, the analysis explicitly only considered local connection options that are either in place today, or that were committed at the time that the outputs from each RTPO/MPO model were provided to us (see Section 4 for details of when models were provided to us)[83].

Some of these enhancements are likely to provide an upside in terms of projected UHSGT ridership (for example, where a new/improved transit connection makes it easier for people to access the UHSGT system), however some are likely to provide a downside (for example, if congestion pricing were to be introduced in/around an UHSGT station location, making it more expensive for people to access via auto). Currently the proposed service alternatives (see Section 3) do not assume specific station locations, but rather general areas that stations are likely to be located. This level of detail is appropriate for this study, enabling us to compare across scenarios, but does not allow detailed analysis in relation to local connections. Accordingly, further analysis of the impact of such local connections may be warranted as part of future detailed analysis once further progress has been made regarding the likely location of stations in each urban area.

[82] Otherwise such investments would need to be explicitly included in any benefit-cost analysis undertaken.
[83] In some case, the local RTPO/MPO models may not have been updated since a project became committed, thereby meaning that project would also be excluded from the analysis.

28 UHSGT Service

In this section, the proposed Ultra-High-Speed Ground Transportation (UHSGT) project, the various service scenarios under evaluation, and proposed station locations are summarized.

28.1 The UHSGT Project

The proposed UHSGT corridor spans approximately 310 miles (499 kilometers) between Portland, Seattle, and Vancouver, BC. It would connect the key urban areas in one of the most dynamic, fastest growing economic megaregions in North America (including but not limited to the main three identified above). UHSGT service would enhance existing travel options along the corridor as identified in the previous section.

Depending on the stations ultimately served and various governance and operational decisions, there is also the potential for UHSGT to offer seamless, interline connections to other scheduled modes of travel. For example, some service scenarios include stations at Vancouver and Portland airports, potentially allowing travelers to cover the shorter, intra-regional leg of their trip on UHSGT while traveling the long-haul leg by air. Similarly, stops at existing rail stations in Portland or Seattle can facilitate connections to and from existing Amtrak long-distance services to points south and east of the Cascadia megaregion.

28.2 CONNECT Scenarios

This work seeks to build upon the previous study of UHSGT in the Cascadia corridor, completed in December 2017, that utilized the Federal Railroad Administration's CONNECT model to project ridership in the corridor.

The CONNECT model is a sketch planning tool that estimates the overall performance of user-defined intercity rail corridors and networks. Three different scenarios were presented:

- Scenario 1A: Assuming seven stations in Vancouver, BC, Bellingham, Everett, Seattle, Tacoma, Olympia/Lacey and Portland;
- Scenario 2: Assuming four stations in Vancouver, BC, Seattle, Tacoma and Portland; and
- Scenario 4: Assuming three stations in Surrey, BC, Tukwila and Portland.

None of these scenarios (or station locations) align precisely with the scenarios presented in this report (in spite of some of the similar naming conventions used). Accordingly, a degree of caution needs to be taken when comparing these forecasts.

Although none of the scenarios entirely align, a cross-walk of scenarios which are considered to provide a reasonable comparison is provided below:

- Broadly comparable to CONNECT Scenario 4: 1C and 2C;
- Broadly comparable to CONNECT Scenario 1A: 1A, 1B, 1D, 1E, 2A, 2B and 3.

Further details on each of these scenarios is provided below.

28.3 Proposed Service Scenarios

The UHSGT service is intended at this stage to be technology neutral – rather it is characterized by the desire to serve key markets throughout the corridor with a fast and reliable intercity service. However, when developing the service scenarios, these were assumed to be on the basis of a high-speed rail service in all cases in order to allow a like-for-like comparison across different scenarios. From a ridership perspective, the key differences to other technologies (for example Maglev or Hyperloop) are likely to relate to possible journey times and frequencies. Sensitivity tests related to each of these parameters are provided in Section 6.

In total, nine service scenarios were evaluated, each featuring variations of station locations, stopping patterns and frequencies, travel times, and/or operating hours to test and analyze their ridership and revenue potential:

- Scenario 1A: Serving Vancouver, BC, Surrey, BC, Bellingham, Seattle, Olympia-Yelm, Longview and Portland
- Scenario 1B: Same as 1A, but adding branches to Downtown Olympia, Tacoma and Everett
- Scenario 1C: Serving only Vancouver, BC, Seattle and Portland
- Scenario 1D: Same as 1A, but adding stops at Tacoma, Everett and Downtown Olympia[84] on the spine
- Scenario 1E: Same as 1A, but removing the stop in Vancouver, BC (thereby terminating in Surrey, BC)
- Scenario 2A: Serving Vancouver, BC, Surrey, BC, Bellingham, Bellevue, Tukwila, Olympia-Yelm, Longview and Portland
- Scenario 2B: Same as 2A, but adding branches to Seattle, Downtown Olympia, Tacoma and Everett[85]
- Scenario 2C: Serving only Surrey, BC, Bellevue and Portland
- Scenario 3: Same as Scenario 2A, but with extensions to airports in Vancouver, BC and Portland

The following subsections provide a brief overview of each scenario in turn.

28.3.1 Scenario 1A

Scenario 1A features a single trunk line, known as the spine, that runs through the "big three" central cities of Portland, Seattle, and Vancouver, BC. Beyond the big three urban areas, this scenario also features stations in Surrey, Bellingham, Olympia-Yelm, and Longview. An express service directly connects the "big three" with nine trains distributed

[84] The Olympia-Yelm stop is replaced by the Downtown Olympia stop.
[85] There are also intermediate stops at Kent and Auburn. These are not included in the service diagram for Scenario 2B to avoid the diagrams becoming overly cluttered. These stops would be served as part of the branch line linking Seattle with Downtown Olympia.

from approximately 6:00 am to 8:00 pm, alongside a base service that serves all station stops with 12 trains over slightly expanded hours, from 5:00 am to 11:00 pm.

Table 5 outlines the service characteristics by service type, and Figure 3.1 illustrates the different service types and stations served.

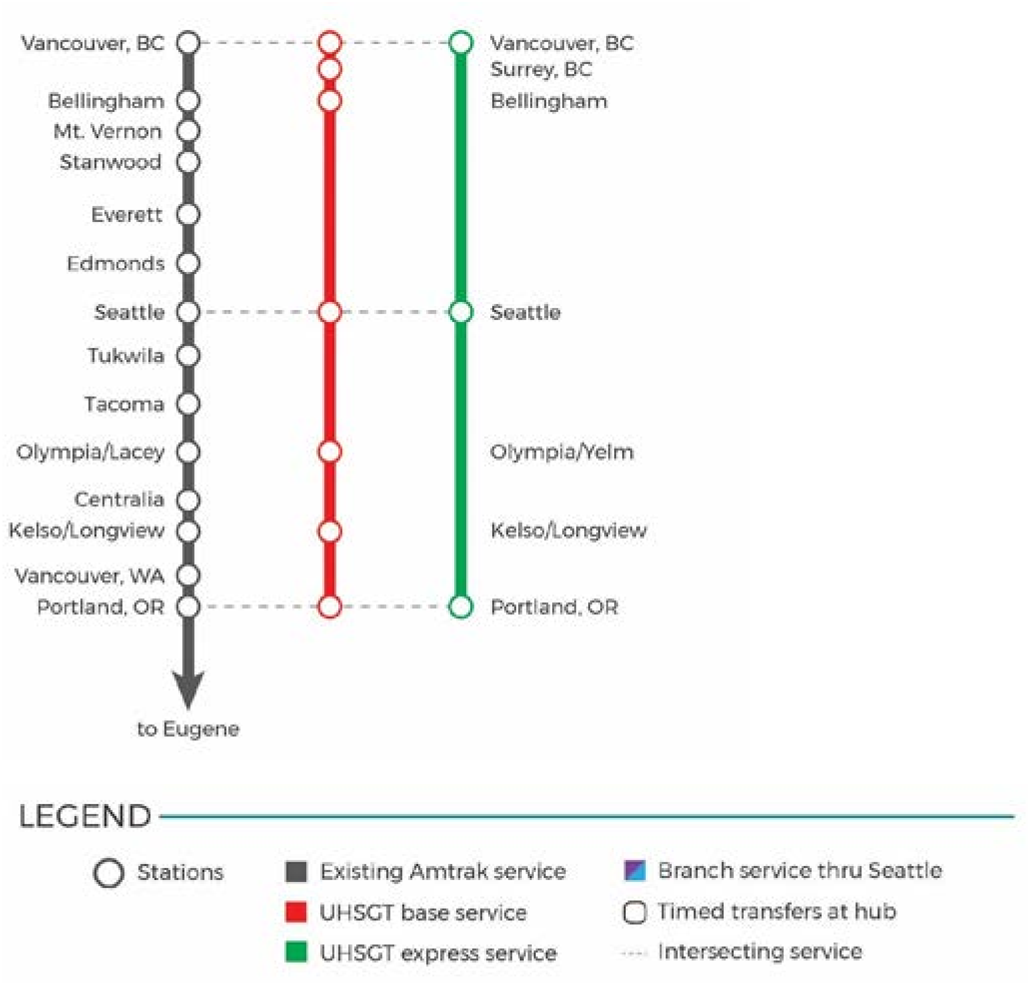
The travel time columns in Table 5 and subsequent tables can be interpreted as follows: the value in a given row represents the travel time between the corresponding station for that row and the next station served by the corresponding service type. For example, under Scenario 1A, an express train would take 47 minutes to travel between Vancouver, BC and Seattle; whereas a trip from Vancouver, BC to Surrey would take 8 minutes.

The frequency in Table 5 and subsequent tables represents the number of daily services in each direction. The total number of daily services is therefore the sum across each of the service types. For example, under Scenario 1A, there are 9 express services and 12 base services, resulting in a total of 21 services in each direction per day.

Table 65: UHSGT service characteristics for Scenario 1A

	Express Service		Base Service	
Station	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC	X	47	X	8
Surrey, BC			X	16
Bellingham			X	32
Seattle	X	58	X	20
Olympia/Yelm			X	24
Kelso/Longview			X	24
Portland	X		X	
Hours of operation	6:00 am – 8:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12	

Figure 44: Service concept diagram for Scenario 1A



Source: WSP scenario planning analysis

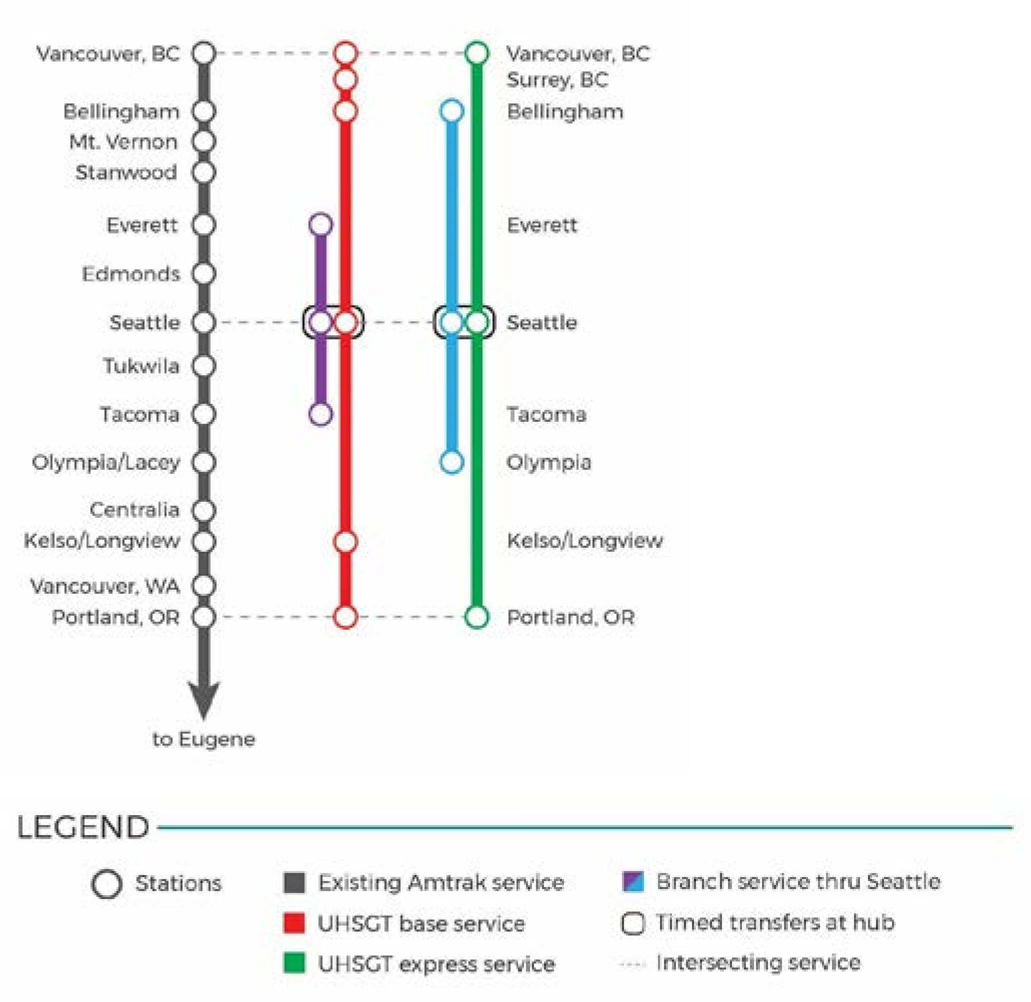
28.3.2 Scenario 1B

Scenario 1B adopts the same spine as Scenario 1A and adds two branches: one serving Everett and Tacoma, and another serving downtown Olympia, replacing the previous Olympia/Yelm stop on the spine. These two branches serve as feeders to the spine, with timed transfers scheduled in Seattle between the two main services (express and base) and the two branches. Table 6 outlines service characteristics by service type, and Figure 3 illustrates the different service types and stations served.

Table 66: UHSGT service characteristics for Scenario 1B

Station	Express Service		Base Service		Branch 1		Branch 2	
	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC	X	47	X	8				
Surrey, BC			X	16				
Bellingham			X	32			X	32
Everett					X	16		
Seattle	X	58	X	39	X	31	X	34
Tacoma					X			
Olympia							X	
Kelso/Longview			X	24				
Portland	X		X					
Hours of operation	6:00 am – 6:00 pm		5:00 am – 10:00 pm		6:00 am – 9:00 pm		6:00 am – 10:00 pm	
Frequency (in each direction, per day)	9		12		12		12	

Figure 45: Service concept diagram for Scenario 1B



Source: WSP scenario planning analysis

28.3.3 Scenario 1C

Like Scenario 1B, Scenario 1C features the same spine as Scenario 1A, but it only includes 21 express trains per day serving the "big three" stations of Portland, Seattle, and Vancouver, BC (no intermediate stops are served). The service runs between the approximate hours of 5:00 am and 10:00 pm, with similar travel times and stopping patterns as the express services in Scenarios 1A and 1B.

Table 67: UHSGT service characteristics for Scenario 1C

Station	Express Service	
	Stop Served	Travel Time (min)
Vancouver, BC	X	48
Seattle	X	58
Portland	X	
Hours of operation	5:00 am – 10:00 pm	
Frequency (in each direction, per day)	21	

Figure 46: Service concept diagram for Scenario 1C

Source: WSP scenario planning analysis

28.3.4 Scenario 1D

Scenario 1D slightly alters the common spine alignment used in Scenarios 1A through 1C, with a routing that serves the downtown areas of Everett, Tacoma, and Olympia directly with base service (rather than as branch services as in Scenario 1B). The service types—express and base—and their service hours and frequencies remain the same as Scenario 1A. Table 8 outlines service characteristics by service type, and Figure 5 illustrates the different service types and stations served.

Table 68: UHSGT service characteristics for Scenario 1D

Station	Express Service		Base Service	
	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC	X	47	X	8
Surrey, BC			X	16
Bellingham			X	24
Everett			X	12
Seattle	X	58	X	15
Tacoma			X	10
Olympia			X	24
Kelso/Longview			X	24
Portland	X		X	
Hours of operation	6:00 am – 8:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12	

Figure 47: Service concept diagram for Scenario 1D

Source: WSP scenario planning analysis

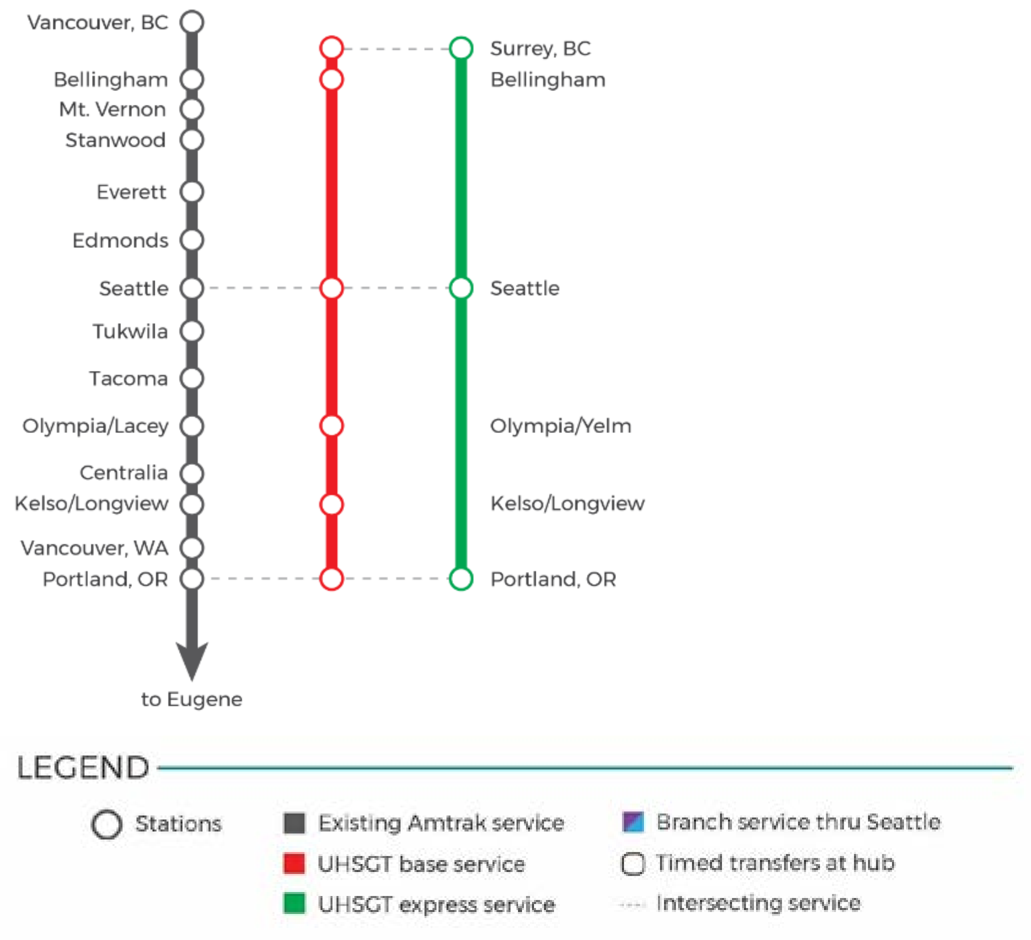
28.3.5 Scenario 1E

Scenario 1E provides the same service as in Scenario 1A but assumes that the northern end of the line terminates in Surrey, BC, rather than continuing into Vancouver, BC.

Table 69: UHSGT service characteristics for Scenario 1E

	Express Service		Base Service	
Station	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Surrey, BC	X	39	X	16
Bellingham			X	32
Seattle	X	58	X	20
Olympia/Yelm			X	24
Kelso/Longview			X	24
Portland	X		X	
Hours of operation	6:00 am – 8:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12	

Figure 48: Service concept diagram for Scenario 1E



Source: WSP scenario planning analysis

28.3.6 Scenario 2A

Scenario 2A is based on a revised spine alignment that does not serve downtown Seattle and instead includes stations at Bellevue/Redmond and Tukwila, on an alignment that runs along the eastern side of Lake Washington. The terminals of Portland and Vancouver, BC remain the same, and intermediate stops include Longview, Olympia/Yelm, Bellingham, and Surrey. Nine express trains per day connect the primary four stations (Portland, Tukwila, Bellevue, and Vancouver, BC) from 5:00 am to 10:00 pm, while 12 base trains per day serve all station stops with nearly similar operating hours as those found in Scenario 1A. Table 10 outlines service characteristics by service type, and Figure 7 illustrates the different service types and stations served.

Table 70: UHSGT service characteristics for Scenario 2A

	Express Service		Base Service	
Station	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC	X	47	X	8
Surrey, BC			X	17
Bellingham			X	30
Bellevue/Redmond	X	7	X	7
Tukwila	X	55	X	16
Olympia/Yelm			X	24
Kelso/Longview			X	24
Portland	X		X	
Hours of Operation	5:00 am – 10:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12	

Figure 49: Service concept diagram for Scenario 2A

Source: WSP scenario planning analysis

28.3.7 Scenario 2B

Scenario 2B builds off the service provided in Scenario 2A and adds three branch services through the Seattle core, serving the following stations from south to north:

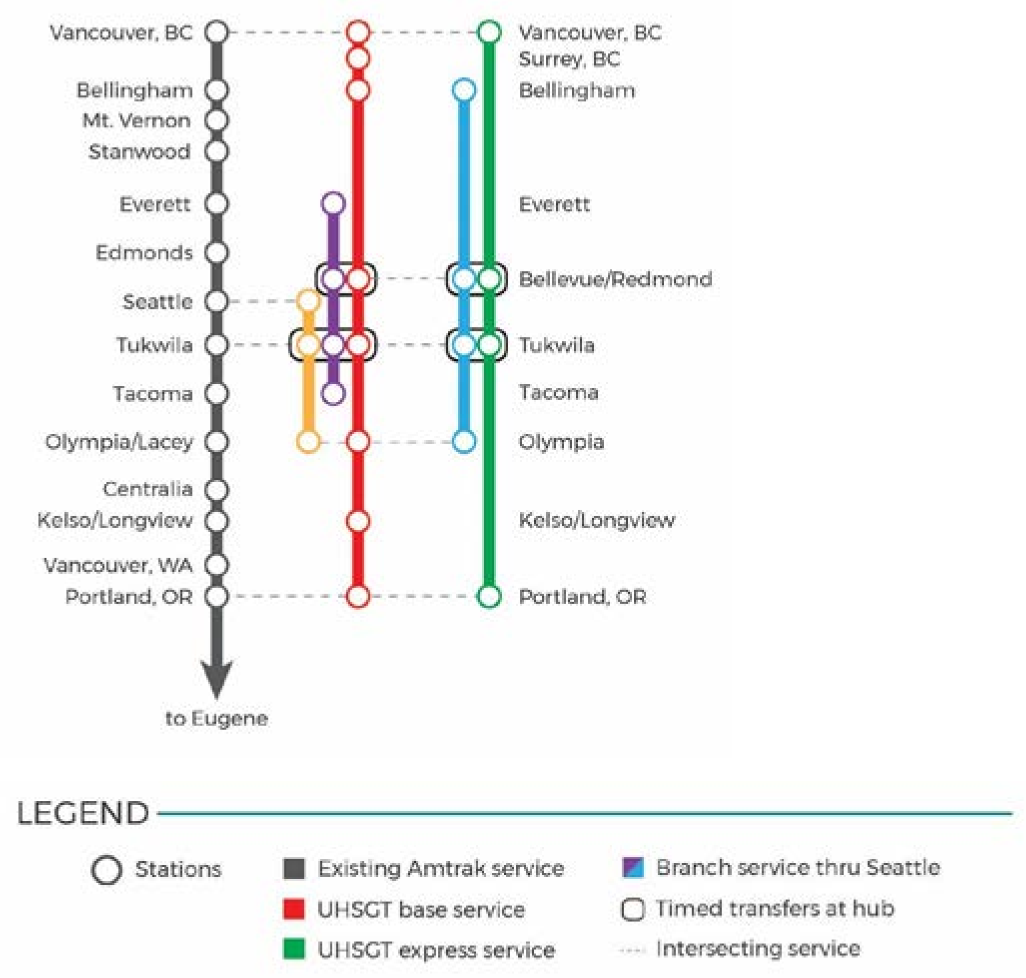
2. Tacoma, Tukwila, Bellevue, and Everett
3. Downtown Olympia, Tukwila, and Downtown Seattle
4. Downtown Olympia, Tukwila, Bellevue, and Bellingham

Like Scenario 1B, these branches are scheduled with timed connections around a transfer hub in Tukwila and/or Bellevue, affording travelers the opportunity to transfer seamlessly to/from express and base services along the spine. Specifically, branches 1 and 2 are timed to connect with base service, while branch 3 is timed to connect with express service. Table 11 outlines service characteristics by service type, and Figure 8 illustrates the different service types and stations served.

Table 71: UHSGT service characteristics for Scenario 2B

Station	Express Service		Base Service		Branch 1		Branch 2		Branch 3	
	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC	X	46	X	8						
Surrey, BC			X	17						
Bellingham			X	30					X	29
Everett					X	15				
Seattle							X	7		
Bellevue/Redmond	X	58	X	7	X	7			X	7
Tukwila			X	35	X	24	X	30	X	30
Tacoma					X					
Olympia							X		X	
Kelso/Longview			X	24						
Portland	X		X							
Hours of operation	5:00 am – 10:00 pm		5:00 am – 11:00 pm		6:00 am – 11:00 pm		5:00 am – 11:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12		12		12		12	

Figure 50: Service concept diagram for Scenario 2B[86]



Source: WSP scenario planning analysis

[86] The Kent and Auburn stops are not included in the service diagram for Scenario 2B to avoid the diagrams becoming overly cluttered. These stops would be served as part of the branch line linking Seattle with Downtown Olympia.

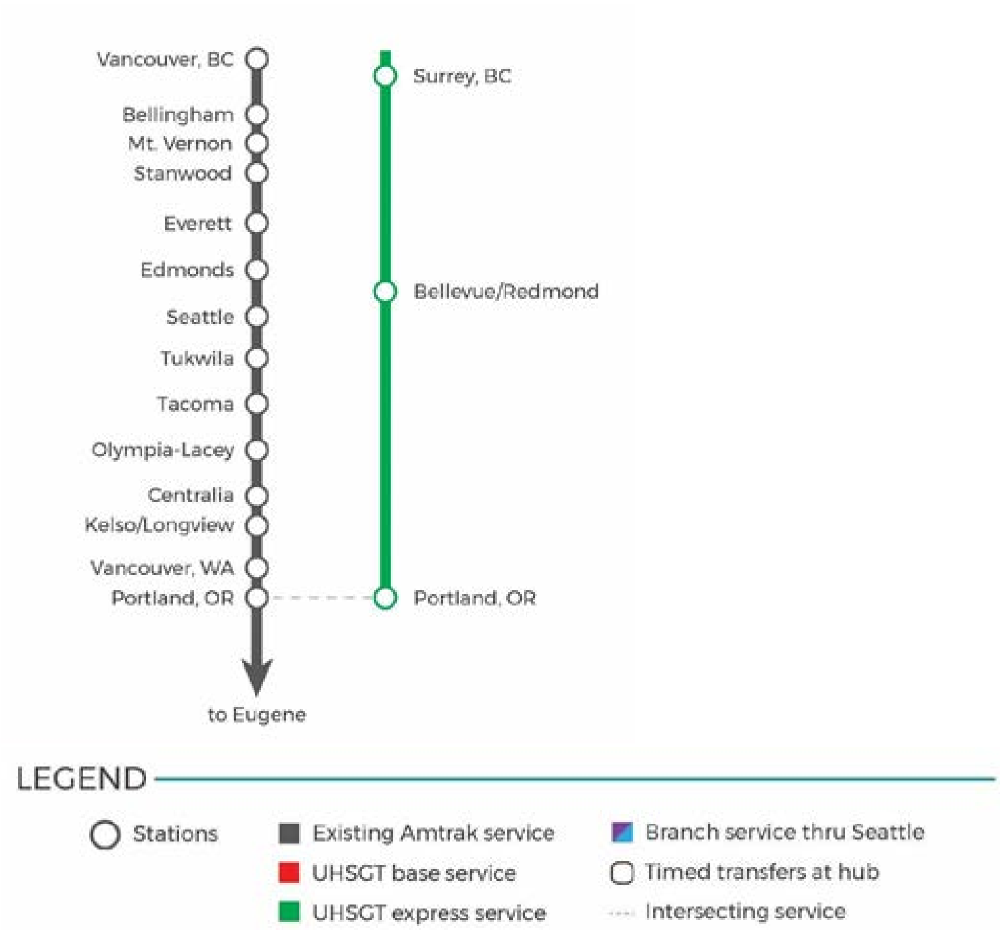
28.3.8 Scenario 2C

Scenario 2C features the same spine as Scenario 2A, but it only includes 21 express trains per day serving the "big three" stations of Portland, Bellevue, and Surrey, BC (no intermediate stops are served with base service). The service runs between the approximate hours of 5:00 am and 10:00 pm, with similar travel times and stopping patterns as the express services in Scenarios 2A and 2B, albeit with Vancouver, BC replaced by Surrey, BC.

Table 72: UHSGT service characteristics for Scenario 2C

Station	Express Service	
	Stop Served	Travel Time (min)
Surrey, BC	X	46
Bellevue/Redmond	X	58
Portland	X	
Hours of operation	5:00 am – 10:00 pm	
Frequency (in each direction, per day)	21	

Figure 51: Service concept diagram for Scenario 2C



Source: WSP scenario planning analysis

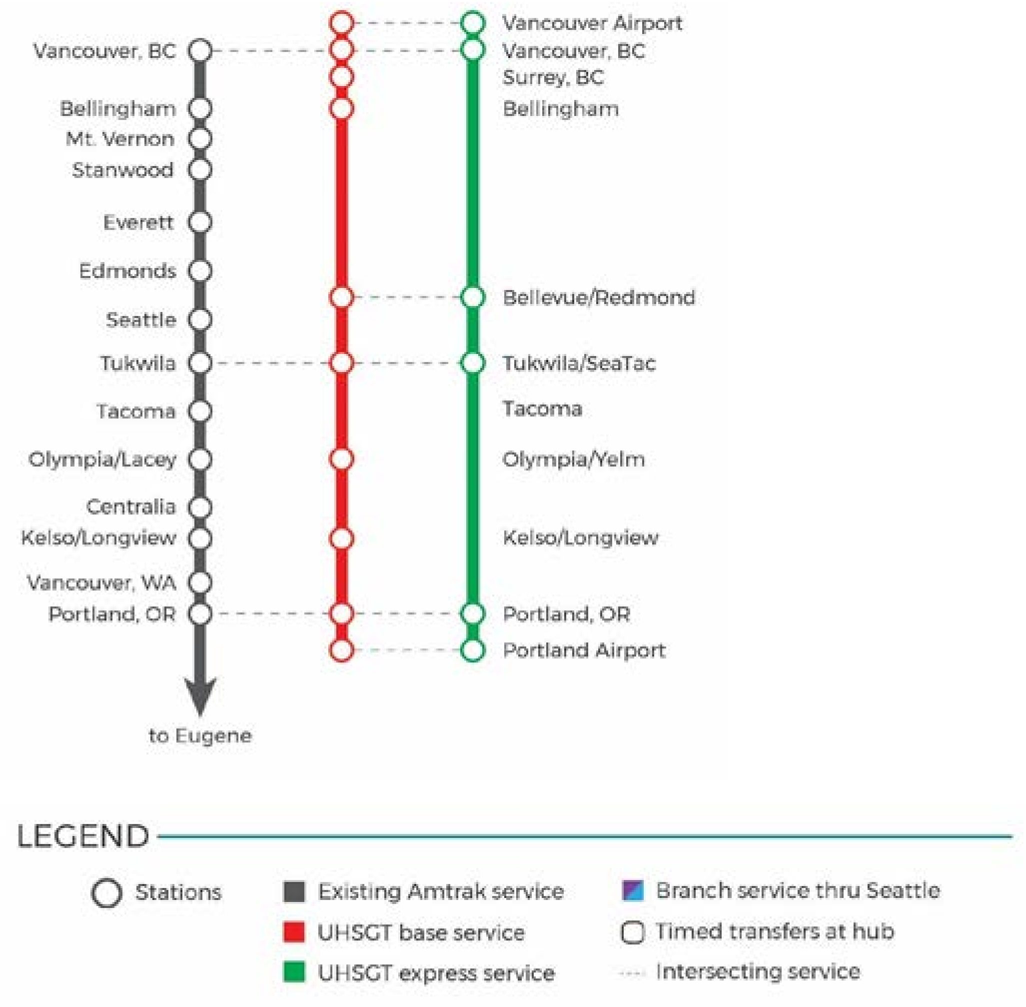
28.3.9 Scenario 3

Scenario 3 features a similar spine alignment as Scenario 2A, with extensions to serve both the Portland and Vancouver, BC airports. The station in Tukwila provides a close connection to Sea-Tac airport, as well. Service types, operating frequencies, and travel times remain the same as Scenario 2A. Table 13 outlines service characteristics by service type, and Figure 10 illustrates the different service types and stations served.

Table 73: UHSGT service characteristics for Scenario 3

Station	Express Service		Base Service	
	Stop Served	Travel Time (min)	Stop Served	Travel Time (min)
Vancouver, BC Airport	X	12	X	12
Vancouver, BC	X	47	X	8
Surrey, BC			X	17
Bellingham			X	30
Bellevue/Redmond	X	7	X	7
Tukwila	X	55	X	16
Olympia/Yelm			X	24
Kelso/Longview			X	24
Portland	X	12	X	12
Portland Airport	X		X	
Hours of operation	5:00 am – 10:00 pm		5:00 am – 11:00 pm	
Frequency (in each direction, per day)	9		12	

Figure 52: Service concept diagram for Scenario 2B



Source: WSP scenario planning analysis

29 Forecasting Approach

The approach to forecasting ridership and revenue for the proposed UHSGT service builds upon a modeling framework widely accepted throughout the transportation industry and commonly used to estimate potential demand across modes for both new and existing services. The following subsections detail the various steps in the approach.

29.1 Approach Summary

29.1.1 Basis of Modeling Approach

The forecasting approach uses discrete choice models to estimate mode choice. Discrete choice models describe, explain, and predict choices between two or more discrete alternatives, such as choosing between modes of transport. Discrete choice models consider choices made by people among a finite set of alternatives and estimate the probability that a person chooses a particular alternative.

Discrete choice models can be derived from utility theory. The utility is the net benefit or well-being that a person obtains from choosing an alternative. The behavior of the person is assumed to be utility-maximizing: a person chooses the alternative that provides the highest utility.

A discrete mode choice model specifies the probability that a person chooses a particular alternative with the probability expressed as a function of observed variables that relate to the alternatives (such as time and cost) and the person (such as income). The generalized cost is the sum of the monetary and non-monetary costs of a journey.

Monetary costs might include a fare, or the costs of fuel, parking charge, and any toll on a car journey. Non-monetary costs refer to the time spent undertaking the journey. Time is converted to a money value using a value of time figure, which usually varies according to the traveler's income and the purpose of the trip. The “generalized costs” is a representation of all aspects of time and cost for traveling by a given mode. If the generalized costs of two alternative modes are equal, the model allocates half the travelers to each mode. If they differ, it allocates more travelers to the mode with the lower generalized cost. The greater the cost difference, the more it allocates to the “cheaper” mode. This is a more realistic approach than assuming “all or nothing” allocations, as it better reflects the range of individual circumstances, perceptions and preferences.

Discrete choice models are the predominant approach used to predict mode shares in transportation studies in the US and around the world. Application of discrete choice models in transportation began with the work of Daniel McFadden in the mid-1960s (work for which he received the Nobel Prize in economics in 2000). Standard texts used in graduate and professional transportation curriculum deal extensively or exclusively with discrete choice models[87]. Discrete choice models are used for mode choice prediction in

[87] Modeling Transport, Ortuzar and Willumsen; Transportation Systems Analysis, Cascetta; Discrete Choice Analysis, Ben-Akiva and Lerman; A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, prepared for USDOT by Koppelman and Bhat; and many others.

virtually all major US metropolitan transportation forecasting models and are strongly recommended by the US Federal Transit Administration for mode choice forecasts prepared as part of large fixed guide-way capital grant applications.

Diversion choice logit models, the type of model used for this project, are the application of discrete choice models to two-mode situations (e.g. auto and UHSGT) to predict the ridership captured by one mode (e.g. UHSGT) from users of another (e.g. auto).

Once a generalized cost has been calculated for each mode, the probabilities of choosing each mode are expressed as:

$$P_i = \frac{exp(\beta G_i)}{exp(\beta G_i) + exp(\beta G_j)} \; and \; P_j = \frac{exp(\beta G_j)}{exp(\beta G_i) + exp(\beta G_j)}$$

Where

$P_i \; and \; P_j =$ The probabilities of choosing to travel by modes i and j

$G_i \; and \; G_j =$ The generalized costs of travel by modes i and j

$\beta =$ A scaling parameter

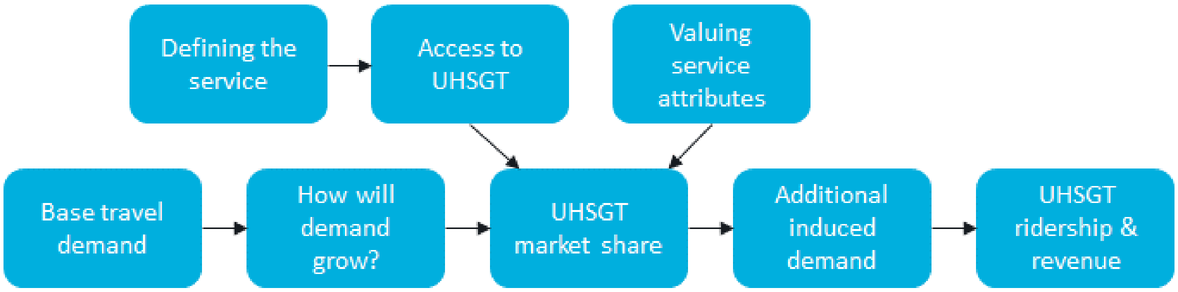
$exp =$ The exponential function

Steer has used this methodology on many major transportation studies, including in the US and internationally. A peer-reviewed description of the approach was published in 1992 in a journal edited by the US Transportation Research Board[88].

29.1.2 Overview of Modeling Methodology

The following figure provides an overview of the modeling methodology.

Figure 53: Overview of modeling methodology



For each existing travel option (auto, air, rail and bus), and for each travel market (split by geography and journey purpose), we:

- Establish the base travel demand;
- Forecast how this demand is anticipated to grow without the proposed UHSGT service;

[88] Forecasting High-Speed Rail Ridership", Brand, Parody, Hsu and Tierney, Transportation Research Record 1341.

- Define anticipated service attributes both for the existing mode and for the proposed UHSGT service;
- Determine how passengers might access the UHSGT service;
- Develop an understanding of how people value service attributes, and therefore how they choose between the two mode options;
- Forecast the UHSGT market share using each of the elements outlined above;
- Forecast the potential for additional induced traffic as a result of the proposed UHSGT service; and
- Produce overall forecasts of ridership and revenue.

The above core elements are discussed in further detail below.[89]

29.2 In-Scope Base Market

The "in-scope" base market represents current demand for travel along the project corridor from travelers who might consider traveling by UHSGT in the future. This section outlines the basis on which estimates of in-scope demand have been developed, including:

- Source data used;
- Geographic definitions used in analysis and reporting;
- The methodology used to develop estimates of base demand by mode; and
- The methodology used to develop estimates for future years.

The output scale of the in-scope demand from this analysis is provided in Section 5.2.1.

29.2.1 Source Data

Provided below is a list of each of the sources utilized in the development of the estimated base market:

- Travel Demand Models:
  - Translink Regional Transportation Model (RTM v3.2), provided by the South Coast British Columbia Transportation Authority ("Translink") on September 25, 2018;
  - RTC Travel Demand Model, provided by the Southwest Washington Regional Transportation Council ("RTC") on November 2, 2018;
  - WCOG Travel Demand Model, provided by the Whatcom Council of Governments ("WCOG") on October 29, 2018;
  - SCOG Travel Demand Model, provided by the Skagit Council of Governments ("SCOG") on November 6, 2018;
  - Portland Metro Trip-Based Demand Model, provided by Metro ("Portland Metro") on November 6, 2018;

[89] Service attributes for existing modes are covered in Section 2.2 (Existing Travel Options) and Appendix A (Assumptions Log), while service attributes for UHSGT are covered in Section 3.2 (Proposed Service Scenarios) and Appendix A (Assumptions Log).

  - PSRC Soundcast Model, provided by the Puget Sound Regional Council ("PSRC") on November 8, 2018; and
  - TRPC Travel Demand Model, provided by the Thurston Regional Planning Council ("TRPC") on November 9, 2018.
- CONceptual NEtwork Connections Tool ("CONNECT"), as utilized within the WSDOT 2017 Ultra-High-Speed Ground Transportation ("UHSGT") Study ("2017 Study"), provided by the Washington State Department of Transportation ("WSDOT") on October 31, 2018;
- Airsage OD travel demand matrices for February 2014, provided by the WSDOT on October 25, 2018;
- Air travel demand matrices through to Q1 2018 from the DB1B and T100 databases, provided by the Bureau of Transportation Statistics ("BTS") on September 28, 2018, via a request made by WSDOT;
- Amtrak Cascades historical ridership and revenue data for 2000-2018, provided by WSDOT on October 25, 2018;
- Population, labor force, and land area (square miles) data, collected by Steer via the "statcan"[90] and "US Census"[91] websites;
- Drive-distance (miles) data, collected by Steer via Google Maps[92]; and
- Bus schedule data, collected by Steer from various operator websites[93].

The dates that each RTPO/MPO travel demand model was provided is highlighted above. These models each reflect the existing and committed local transportation options as of the latest model updates available at that time. This therefore includes some significant committed enhancements to the local transportation network in future, such as Sound Transit 3 (ST3) (included within the PSRC model).

It is important to note, however, that there may be future enhancements to these local transportation systems that are not fully captured in these models. These enhancements could include services specifically designed to complement the UHSGT system, or those that are independently developed for the local needs of each area. It is important that the potential business case for UHSGT is not predicated on other investments that are not currently committed[94]. With this in mind, the model inputs have not been adjusted in any way, and thereby explicitly only consider local connection options that are either in place today, or that were committed at the time that the outputs from each RTPO/MPO model were provided[95].

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90 www.statcan.gc.ca
91 www.census.gov
92 www.google.com/maps
93 Bus schedules obtained for Greyhound (www.greyhound.com/north), BoltBus (www.boltbus.com), and QuickShuttle (www.quickcoach.com).
94 Otherwise such investments would need to be explicitly included in any benefit-cost analysis undertaken.
95 In some case, the local RTPO/MPO models may not have been updated since a project became committed, thereby meaning that project would also be excluded from the analysis.

29.2.2 Geographic Definitions

The source data utilize a range of different geographic definitions. There are three main definitions that are used in the development of the estimated base market:

- Metropolitan Statistical Areas ("MSAs");
- Intercity model zones ("IMZs"); and
- Transportation Analysis Zones ("TAZs").

Each of these are discussed in turn below.

29.2.2.1 Metropolitan Statistical Areas

MSAs are the largest of the three geographic definitions in use and are used within CONNECT when forecasting UHSGT ridership. Accordingly, this is the level of aggregation available within the 2017 Study.

CONNECT forecasts demand to/from up to 9 MSAs (depending on the forecast scenario). Of these, 5 are considered to be in-scope for the current study. The remaining 4 are considered to be out-of-scope, since they are located away from the UHSGT alignments being considered.

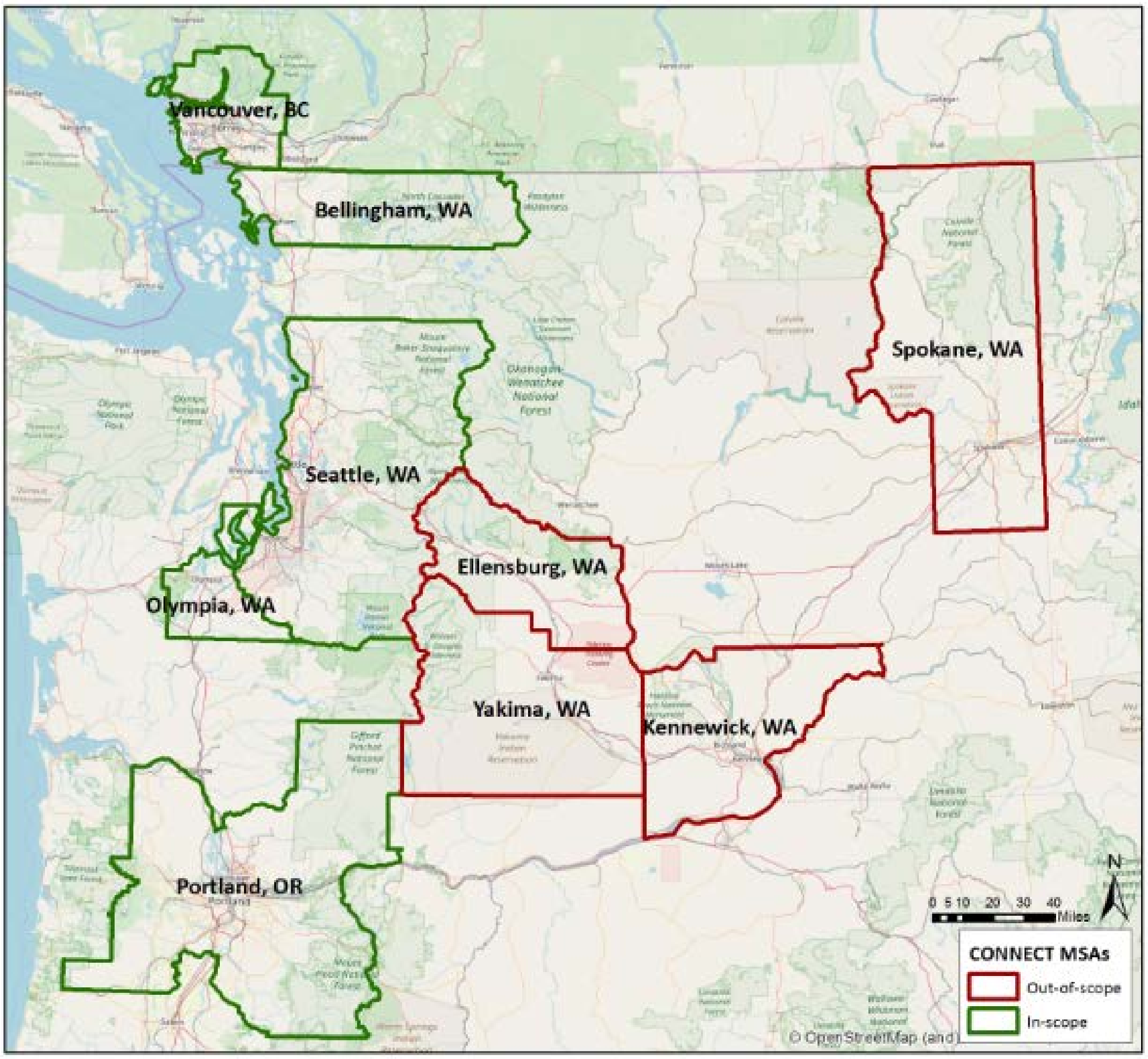
Table 74: In-scope and out-of-scope CONNECT MSAs

In-scope CONNECT MSAs	Out-of-scope CONNECT MSAs
Bellingham, WA	Ellensburg, WA
Olympia, WA	Kennewick, WA
Portland, OR	Spokane, WA
Seattle, WA	Yakima, WA
Vancouver, BC[1]	

[1] This area represents the Canadian Census Metropolitan Area (CMA).

The following figure provides a geographic representation of the scope of each of these MSAs.

Figure 54: In-scope and out-of-scope CONNECT MSA boundaries

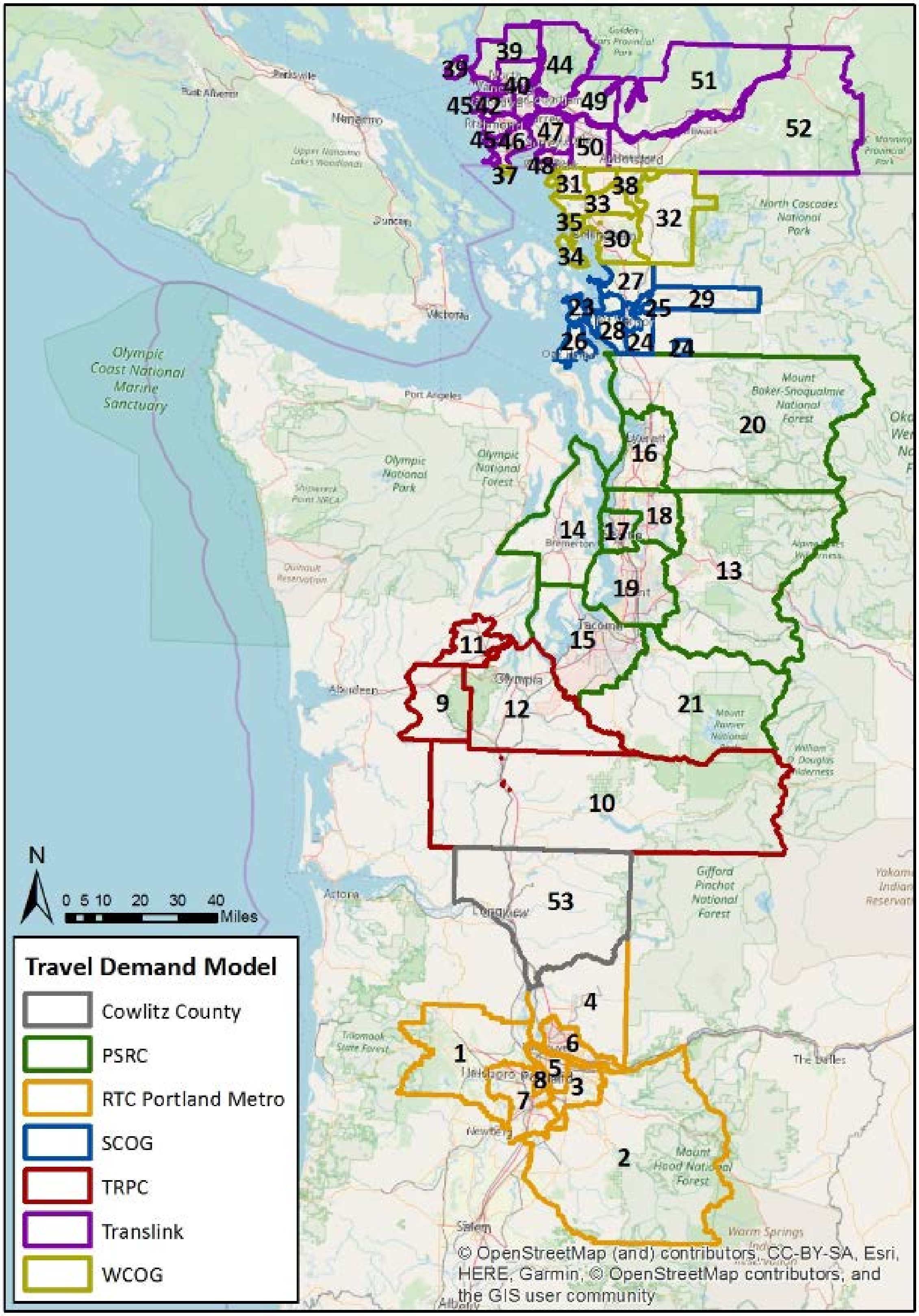


Note: When reporting at an "MSA" level subsequently in this document, there are two changes relative to the CONNECT zoning that are used:

1. The Olympia MSA is expanded to include the full scope of the TRPC model (i.e. including also zones 9, 10 and 11, as represented within Figure 13); and
2. An additional area is included that corresponds to the scope of the SCOG model (i.e. zones 30-38 within Figure 13), since this area is not covered by the CONNECT model zoning.

All other zones reported as "MSAs" are consistent with the scope outlined in Figure 12.

Figure 55: Intercity model zones Used in modeling framework



29.2.2.2 Development of Intercity Model Zones

Each of the travel demand models utilize aggregations of TAZs when reporting summary statistics. In many cases, county boundaries are used for this purpose, although this is not the case for every model[96]. These aggregations form the basis of the zone system used in the intercity ridership forecasting model, with the exception of select counties in the RTC, Portland Metro, and PSRC models that were further broken down to distinguish between urban, suburban, and rural areas, and in doing so provide more granular reporting detail. These groupings of zones are called intercity model zones ("IMZs"), since this is the zoning used within the intercity mode choice element of the ridership model.

The following figure provides a geographic representation of the scope of each of the IMZs.

29.2.2.3 Transportation Analysis Zones

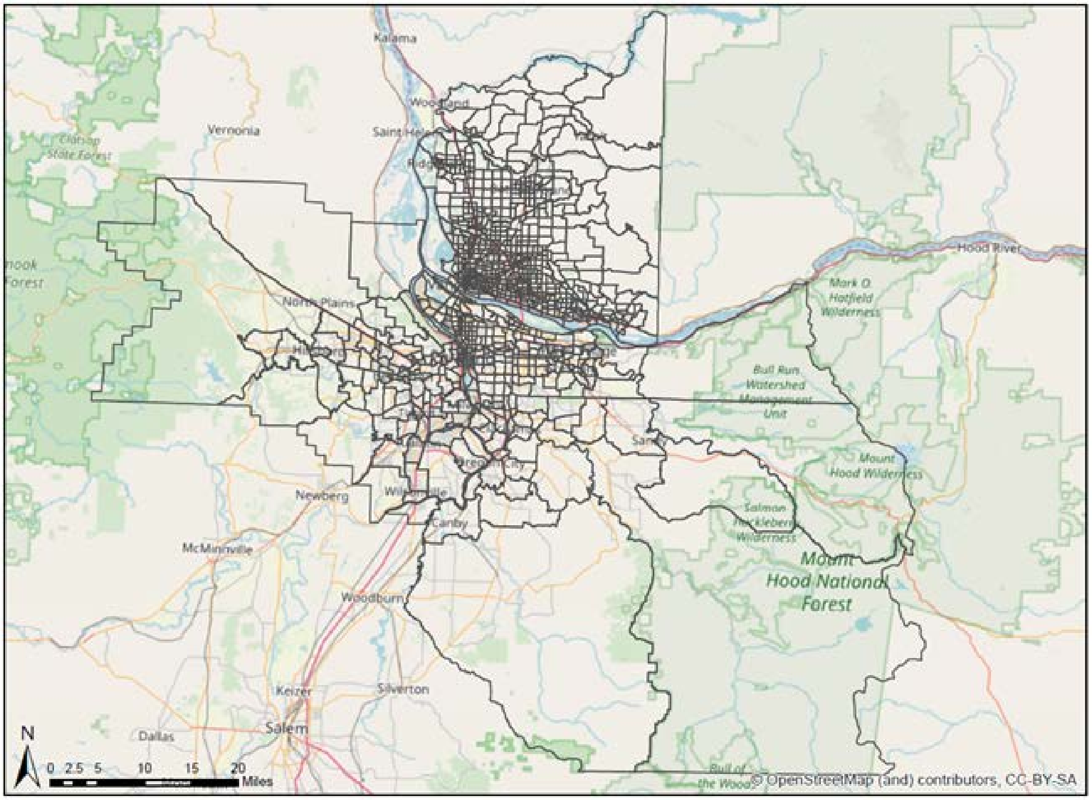
TAZs provide the highest level of detail within each Travel Demand Model and is the level at which data has been provided for each model.

The following figure provides a geographic representation of the scope of the TAZs within the RTC model[97].

[96] TAZs from the RTC, Portland Metro, PSRC, and TRPC models are aggregated to the county or sub-county (in the case that a given model covers parts of certain counties). TAZs from the remaining three models (SCOG, Translink, and WCOG) are aggregated using an agency-defined geography (SCOG: MCD, Translink: gy, and WCOG: Region).

[97] This model is used for demonstrative purposes – each model incorporates data at an equivalent level of detail.

Figure 56: TAZ boundaries for the RTC Travel Demand Model in the Greater Portland region



29.2.3 Methodology

Estimates of base demand have been developed for each of the following current modes:

- Air
- Rail
- Auto
- Bus

Each of these are discussed in turn below.

29.2.3.1 Air

Air origin-destination ("OD") matrices at an airport-airport level are developed directly from the air travel demand matrices provided by the BTS. 2017 is used as the base year for the data, since this is the latest full year of data available.

Provided below is a list of airports included within the analysis:

- SEA: Seattle Tacoma Intl
- BLI: Bellingham Intl
- PDX: Portland Intl;
- YVR: Vancouver Intl

Each airport is assigned to a MSA. Demand at the TAZ level is then assigned based on the following:

$$TAZD_{ij} = MSAD_i \times OW_{ij} \times DW_{ij}$$

$$OW_{ij} = OP_{ij} \div OP_i \times PF + OE_{ij} \div OE_i \times (1 - PF)$$

$$DW_{ij} = DP_{ij} \div DP_i \times PF + DE_{ij} \div DE_i \times (1 - PF)$$

Where

$TAZD_{ij}$ = *Demand for TAZ pair j within MSA pair i*[98]

$MSAD_i$ = *Demand for MSA pair i*

OW_{ij} = Origin w*eight for TAZ pair j within MSA pair i*

DW_{ij} = Destination w*eight for TAZ pair j within MSA pair i*

OP_{ij} = *Origin population for TAZ pair j within MSA pair i*

OP_i = *Origin population for MSA pair i*

PF = *Assumed population factor (50%)*

OE_{ij} = *Origin employment for TAZ pair j within MSA pair i*

OE_i = *Origin employment for MSA pair i*

DP_{ij} = *Destination population for TAZ pair j within MSA pair i*

DP_i = *Destination population for MSA pair i*

DE_{ij} = *Destination employment for TAZ pair j within MSA pair i*

DE_i = *Destination employment for MSA pair i*

On this basis, demand at the detailed TAZ level within an individual MSA is based on the relative population and employment within each TAZ.

29.2.3.2 Rail

Rail OD matrices at a station-station level are developed directly from the Amtrak Cascades historical ridership and revenue data provided by WSDOT. 2017 is used as the base year for the data, since this is the latest full year of data available.

Provided below is a list of stations included within the analysis[99]:

- BEL: Bellingham

[98] A TAZ pair represents two TAZs with one being the origin and one being the destination. Similarly, an MSA pair represents two MSAs with one being the origin and one being the destination. Accordingly, TAZ pair j within MSA pair i represents two TAZs, with the origin TAZ being within the origin MSA and the destination TAZ being within the destination MSA.

[99] Other stations on the Amtrak Cascades service are considered to be too far from potential UHSGT stations to be in-scope.

- CTL; Centralia
- EDM: Edmonds
- EVR: Everett
- MVW; Mount Vernon
- OLW: Olympia
- ORC: Oregon City
- PDX: Portland
- SEA: Seattle
- STW: Stanwood
- TAC: Tacoma
- TUK: Tukwila
- VAC: Vancouver, B.C.
- VAN: Vancouver, Wash

Each station is assigned to an IMZ based upon the IMZ that it is located within. Demand at the TAZ level is then assigned based on the same methodology as outlined for the air data but using the assigned IMZ in place of the assigned MSA.

29.2.3.3 Auto

Auto OD matrices at a MSA-MSA level are developed based on:

- Demand within CONNECT where an OD is in-scope (see Figure 12); and
- Projected demand where an OD is not in-scope within CONNECT, through application of a linear regression of the following form:

$$ln(MSAD_{ij}) = \beta_1 ln(P_i \times P_j) + \beta_2 ln(D_{ij}) + \beta_3 CB_{ij} + \beta_4 + \varepsilon_{ij}$$

Where:

$MSAD_{ij}$ = *Demand for MSA pair ij*

P_i = *Population for MSA i*

P_j = *Population for MSA j*

D_{ij} = *Distance between MSA i and MSA j*

CB_{ij} = *A binary indicator (1 or 0) identifying if MSAs i and j are in different countries*

β_{1-4} = *Model coefficients*

ε_{ij} = *Error term*

MSA-MSA auto demand for ODs that are not in-scope within CONNECT are therefore based upon the combined population of the two MSAs, the distance between the two MSAs, and whether the two MSAs are in different countries (thereby introducing potential barriers with regards to customs/immigration checks). The model was validated through comparing how it matches ODs that are in-scope within CONNECT.

Auto OD matrices at an IMZ-IMZ level are then developed based on:

- Demand within the Travel Demand Models where an OD is in-scope within any individual model (i.e. within the geographic coverage area of a single model, as set out in Figure 13); and
- Projected demand where an OD is not in-scope within any individual Travel Demand Model is based on the same methodology as outlined for the air data but using IMZs in place of TAZs.

Finally, demand at the TAZ level is then assigned based on the same methodology as outlined for the air data but using the assigned IMZ in place of the assigned MSA.

29.2.3.4 Bus

Bus OD matrices at a city-city level are developed based on the bus service data collected and an assumed average occupancy of 16. This average occupancy is based on OD demand that is in-scope within CONNECT, and the required average occupancy to match the total in-scope CONNECT demand given the input bus service data collected.

Each city is assigned to an IMZ. Demand at the TAZ level is then assigned based on the same methodology as outlined for the air data but using the assigned IMZ in place of the assigned MSA.

29.2.4 Future Market Growth

Baseline population and employment growth rates were obtained from the various MPO travel demand models and used to grow the base year (2017) travel demand to a projected future year (2040). Table 15 summarizes the population and employment compound annual growth rates (CAGRs) from the various travel demand models, expressed as averages over all TAZs in the respective model.

Table 75: Population and employment growth rates by MPO travel demand models, 2017 – 2040

Model	MSA	Compound Annual Growth Rate, 2017 – 2040	
		Population	Employment
RTC	Portland-Vancouver-Hillsboro, OR-WA	1.57%	1.97%
TRPC	Olympia-Tumwater, WA	1.57%	1.41%
PSRC	Seattle-Tacoma-Bellevue, WA	1.27%	1.49%
SCOG	Mount Vernon-Anacortes, WA	0.49%	Not available
WCOG	Bellingham, WA	0.96%	1.01%
Translink	Vancouver-Surrey-Burnaby, BC	1.43%	1.08%

To estimate market growth at an OD level, the population and employment growth rates for the origin and destination zones were averaged individually, and then averaged the two average rates to create a composite growth rate.

$$D_{2040} = D_{2017} * \left(\left(W_p * (0.5 * G_{Op} + 0.5 * G_{Dp}) \right) + \left((1 - W_p) * (0.5 * G_{Oe} + 0.5 * G_{De}) \right) \right)^{2040-2017}$$

Where:

D_{2040}, D_{2017} = *demand in 2040 and 2017, respectively, for a given OD zone pair*

W_p = *weight applied to population growth, between 0 and 1 (currently set at 0.5, with the corresponding weight applied to employment growth also equal to 0.5, indicating that population and employment growth are equally weighted)*

G_{Op} = *population (p, vs. e for employment) CAGR for origin zone (O, vs. D for destination zone)*

29.3 Projected Demand

29.3.1 UHSGT Capture

A series of forecasting models were constructed to estimate UHSGT's potential to capture market share, one for each of four existing modes of travel along the project corridor: auto, air, intercity rail, and intercity bus. The models contain:

- The number of in-scope travelers in 2017 and 2040, broken down into ten market segments by income quintiles and business/non-business trip purposes;
- Times and costs of travel by existing mode and by UHSGT;
- The generalized cost of each mode, which combines the individual times and costs for each element of the entire trip; and
- A mode choice "logit" function, which allocates future travelers between the two modes—existing mode and UHSGT—according to the differences in their generalized costs.

The principal elements of times and costs incorporated into the generalized costs are as follows[100]:

- For auto travelers:
  - Journey time;
  - Costs of fuel reflecting current and forecast fuel consumption and prices; and
  - Costs of other items, including depreciation, maintenance, and tires.
- For non-auto travelers:

[100] Details of the coefficients used for each element, and how these coefficients were estimated, are provided in Appendix B.

- Access and egress time to and from their origin and destination airport/station;
- Cost of driving to and parking at airport/station, or taxi/public transportation fare, as appropriate;
- Time spent in the vehicle, and at the departure and arrival airport/station; and
- Cost of the main mode fare.

To compute the generalized cost as a combination of the various time and cost elements listed above, various weights were used for each element. These weights were estimated from a behavioral survey, where respondents were presented with several scenarios for which they were asked to choose between using their current mode and UHSGT, based on various time and cost attributes for each mode. Their responses on stated chosen mode enabled the team to infer the weight they attached to time and cost elements.

The mode choice model or “logit” function is an established choice modeling technique that is used on several proposed transportation projects and is embedded in the demand forecasting model. If the generalized costs of two alternative modes are equal, the model allocates half the travelers to each mode. If they differ, it allocates more travelers to the mode with the lower generalized cost. The greater the difference between the costs, the more it allocates to the “cheaper” mode. It is through this method that key sensitivities within the model are calculated, such as the sensitivity to changes in service frequency, travel time, and future gas prices.

For each of the four available current modes, binary logit models were constructed, as described above, to estimate the probability that a given traveler will switch modes from their current mode to UHSGT. This probability is calculated by the following formula:

$$P_i = \frac{exp(\beta G_i)}{exp(\beta G_i) + exp(\beta G_j)} \text{ and } P_j = \frac{exp(\beta G_j)}{exp(\beta G_i) + exp(\beta G_j)}$$

Where:

$P_i, P_j =$ *probabilities of choosing to travel by modes i and j, respectively*

$G_i, G_j =$ *generalized cost of travel by modes i and j, respectively*

$\beta =$ *scaling parameter*

$exp =$ *exponential function*

Details of the coefficients underlying these calculations, and how these coefficients are estimated, are provided in Appendix B.

Applying this probability of switching to the entire base demand for a given mode results in a forecast of the number of travelers who will switch travel modes, or captured trips.

29.3.2 Induced Demand

In addition to capturing existing travelers using other modes, UHSGT has the potential to induce additional travel due to its attractiveness from a time and/or cost perspective.

Induced trips are new intercity trips that would not be made in the absence of the new UHSGT service but that occur as a result of the improved set of overall travel options provided by the proposed UHSGT service. The induced demand is then added to the forecast of diverted UHSGT trips to produce the total UHSGT ridership forecast.

The introduction of a new UHSGT service or the improvement of an existing service by itself will improve the overall level of service for travel within the corridor. For example, the addition of a new UHSGT service will increase the frequency of common carrier service; centralized location of stations will reduce the average time and cost required for terminal access/egress; and the new mode will provide comfort and other quality of service improvements for many travelers. These improvements will make conditions more favorable for travel and will decrease the disutility of travel relative to the benefits traveler's experience at their trip ends. Trips will therefore be made on UHSGT that would not otherwise have been made using any of the current modes (auto, bus, air, and existing rail). These new trips made on the new or improved mode, in addition to those diverted from the existing modes, are commonly referred to as induced trips. The total number of these trips can be defined as:

$$Induced\ Travel = Total\ Travel_{With\ new\ service} - Total\ Travel_{Without\ new\ service} \quad (1)$$

Induced travel for a new or improved service should be closely tied to the user benefits that make it attractive to users of existing modes. A new service that is able to capture 20 percent of an existing market is likely to induce additional trips not currently being made. On the other hand, if the service attracts only 1 percent of existing trips, it is unlikely that much, if any, induced demand can be expected. Because of this relationship between induced travel and diverted travel, the method of forecasting induced travel must be consistent with the method of predicting mode choice. To accomplish this, the model used to calculate induced demand incorporates the estimated travel utility functions from the market segment mode choice models.

One complication in forecasting induced demand that needs to be accounted for is that the level of service provided on the existing modes may also change with the introduction of the new service (for example, air frequencies may be reduced), so induced demand must be calculated using the net change in the level of transportation service that occurs with the introduction of the new service. This requires relating total travel on all modes to a composite generalized cost computed over all of the modes, as shown in the following equation:

$$T_{all\ m} = (SE)^a * GC_{composite}^q \quad (2)$$

where:

$T_{all\ m}$ = Total travel volume between O/D on all modes m;

SE = Socioeconomic factors for O and D;

$GC_{composite}$ = Utility of travel between O and D, negative of the generalized cost; and

a, q = estimation coefficients. (Note that default values of the parameter q are taken from the Volpe Commercial Feasibility Study (CFS) model[101], which uses a q equal to -0.355 for business trips and -0.222 for non-business trips[102] in the US.

The composite generalized cost $GC_{composite}$ is calculated as the logsum of the generalized costs of each of the modes, calculated using the utility estimates for each mode from the market segment mode choice models. Consequently, this can be written:

Total travel before (without new service): $T_B = (SE)^a * GC_{before}^q$ (4)

Total travel after (with new service): $T_A = (SE)^a * GC_{after}^q$ (5)

And the percent increase in total travel becomes:

Induced demand %: $\frac{T_A - T_B}{T_B} = \frac{GC_{after}^q - GC_{before}^q}{GC_{before}^q}$ (6)

For any given market segment, the percentage increase in travel is added to the number of trips diverted to the new or improved service, because the new or improved service represents the service improvement that has induced the additional travel.

Because binary diversion models are used, it is necessary to compute the GC for each sub-model:

$$GC_{mode,purpose}{}_{After} = ln(\exp(GC_{mode}) + \exp(GC_{UHSGT}))$$

$$GC_{mode,purpose}{}_{Before} = ln(\exp(GC_{mode})) = GC_{mode}$$

[101] Volpe CFS induced demand model is based on the induced demand formula developed by Charles River Associates as documented in Revised Induced Demand Formula, Memorandum CRA No. 434-01 to VNTSC, Charles River Associates, April 28, 1995.
[102] Evaluation of High-Speed Rail Options in the *Macon-Atlanta-Greenville-Charlotte Rail Corridor*, Appendices, Volpe National Transportation Systems Center Cambridge, Massachusetts, August 2008.

30 Ridership and Revenue Forecasts

This section presents the ridership and revenue forecasts for the various service scenarios outlined in Section 3. This section is structured as follows:

- Key Assumptions: Key information to be aware of when interpreting the values presented; and
- Comparison Across Scenarios: A comparison of ridership and revenue projections across each of the service scenarios.

30.1 Key Assumptions

Provided below are the key assumptions underpinning the ridership and revenue forecasts presented in this section:

- The forecasts present ridership and revenue potential on the proposed UHSGT system only; they do not include projected ridership and revenue associated with any other existing or planned rail services.
- The forecasts comprise two core components:
  - Captured trips: Trips that are currently being (or without UHSGT are projected to be) made by other modes and are projected to shift to using UHSGT in future; and
  - Induced trips: Trips that are not currently being made, but that are projected to be made in future once UHSGT is operational.
- The induced trips highlighted above account for additional trips projected to be made as a result of the improved travel options now available in the corridor. This does not, however, include all potential induced trips. In particular, induced trips as a result of enhanced economic activity brought about by UHSGT are not accounted for within the numbers presented.
- Where a single year is presented, values are presented for 2040 (unless otherwise stated). Underlying growth up to 2040 is based upon expectations of population and employment growth in the corridor from local RTPO/MPO models.
- All reported trips are one-way trips (i.e. a roundtrip from Portland to Vancouver, say, would be counted as two trips within the forecasts presented).
- All reported revenues are in 2019 US dollars (i.e. they do not account for inflation).
- Reported revenues are farebox revenues only (i.e. income from the fares that people pay); they do not include other potential revenues that the system might generate (such as from parking, food service or other commercial income).
- Reported ridership and revenue do not include any reductions for the following items:
  - Fare evasion;
  - Planned maintenance closures; and
  - Unplanned service disruptions.

Each of these items would typically be expected to reduce the potential ridership and revenue of the service.

A more comprehensive assumptions log is provided in Appendix A.

30.2 Comparison Across Scenarios

In total, eight (8) service scenarios were evaluated, each featuring variations of station locations, stopping patterns and frequencies, travel times, and/or operating hours:

- Scenario 1A: Serving Vancouver, BC, Surrey, BC, Bellingham, Seattle, Olympia-Yelm, Longview and Portland;
- Scenario 1B: Same as 1A, but adding branches to Downtown Olympia, Tacoma and Everett;
- Scenario 1C: Serving only Vancouver, BC, Seattle and Portland;
- Scenario 1D: Same as 1A, but adding stops at Tacoma, Everett and Downtown Olympia[103] on the spine;
- Scenario 1E: Same as 1A, but removing the stop in Vancouver, BC (thereby terminating in Surrey, BC)
- Scenario 2A: Serving Vancouver, BC, Surrey, BC, Bellingham, Bellevue, Tukwila, Olympia-Yelm, Longview and Portland;
- Scenario 2B: Same as 2A, but adding branches to Seattle, Downtown Olympia, Tacoma and Everett;
- Scenario 2C: Serving only Surrey, BC, Bellevue and Portland; and
- Scenario 3: Same as Scenario 2A, but with extensions to airports in Vancouver, BC and Portland.

30.2.1 In-Scope Market

The “in-scope” market represents current demand for travel along the project corridor between Vancouver, BC, and Portland, from those who might consider traveling by UHSGT in the future. This in-scope market is consistent across all of the scenarios.

Table 16 summarizes the size of the estimated in-scope market for the key metropolitan statistical area (MSA) pairs and current travel modes along the project corridor for key forecast horizon years.

[103] The Olympia-Yelm stop is replaced by the Downtown Olympia stop.

Table 76: In-scope demand by MSA pair and current travel mode

	One-Way Trips (millions)							
	2017	2020	2025	2030	2035	2040	2050	2055
MSA Pair (Both Directions)								
Portland – Seattle	3.8	4.0	4.3	4.7	5.0	5.4	6.1	6.4
Portland – Vancouver, BC	0.9	0.9	1.0	1.1	1.1	1.2	1.4	1.4
Seattle – Vancouver, BC	3.2	3.4	3.6	3.8	4.1	4.3	4.8	5.1
Other	2.8	3.0	3.2	3.4	3.6	3.8	4.3	4.6
Current Mode								
Auto	6.8	7.1	7.7	8.3	8.8	9.4	10.6	11.2
Air[1]	2.1	2.2	2.3	2.5	2.7	2.9	3.2	3.4
Air (OD)	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7
Air (connecting)	1.7	1.7	1.9	2.0	2.2	2.3	2.6	2.8
Rail	0.6	0.7	0.7	0.7	0.8	0.8	0.9	1.0
Bus	1.2	1.3	1.4	1.4	1.5	1.6	1.8	1.9
Total	10.7	11.2	12.1	13.0	13.8	14.7	16.6	17.6

[1] The total in-scope air market is comprised of Air (OD) – trips that are made entirely within the corridor, for example Seattle-Portland – and Air (Connecting) – trips that connect through the corridor, but include at least one leg outside of the corridor, for example Boston-Seattle-Portland.

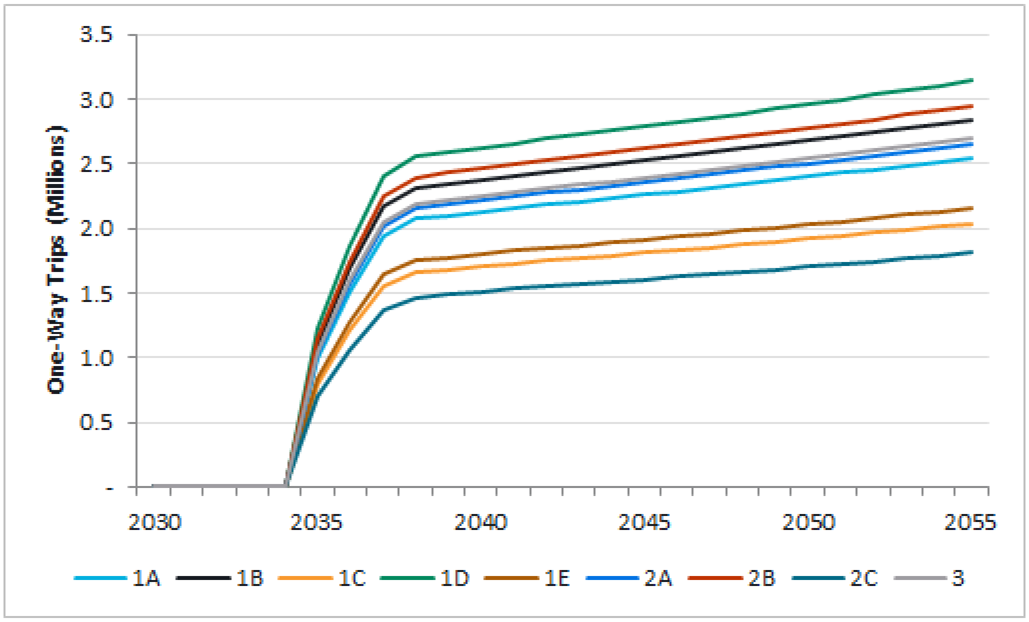
In 2017, the size of the in-scope market is estimated to be approximately 10.7 million one-way trips. Approximately 73% of those trips (7.8 million) are associated with travel between the three major MSA pairs along the project corridor (Portland, Seattle, and Vancouver, BC). Auto is estimated to be the dominant mode, accounting for 64% of trips, followed by air (19%, including OD and connecting trips), bus (11%) and rail (6%).

By 2040, the in-scope market is forecast to grow to 14.7 million one-way trips, an average annual growth rate of 1.4% (between 2017 and 2040). Finally, by 2055, the in-scope market is forecast to grow to 17.6 million one-way trips, an average annual growth rate of 1.2% (between 2040 and 2055).

30.2.2 Ridership

Figure 15 provides a summary of the projected captured ridership for each of the scenarios.

Figure 57: System-level captured ridership forecasts



Ridership is projected on the basis of the methodology set out in Section 4.

Throughout all years, the relative forecast level of capture between scenarios remains broadly consistent, with the lowest capture forecast for Scenario 2C (a capture rate of just over 10%), and the highest capture forecast for scenario 1D (a capture rate of just under 18%).

In 2035, when the UHSGT system is assumed to open, there are forecast to be between 0.7 and 1.2 million one-way UHSGT trips throughout the entire system diverted from existing modes (for scenarios 2C and 1D respectively).

By 2040, UHSGT captured ridership is forecast to grow to between 1.5 and 2.6 million one-way trips, an average annual growth rate of over 16.5% (between 2017 and 2040). This significant growth is largely as a result of ramp-up assumptions in the early years (see Appendix A).

By 2055, UHSGT captured ridership is forecast to grow to between 1.8 and 3.1 million one-way trips, an average annual growth rate of 1.2% (between 2040 and 2055).

30.2.2.1 Capture by Mode

As reported above, the UHSGT mode capture rate is forecasts to be between 10% and 18% depending on the scenario. Table 17 and Table 18 break down this capture rate for both the lowest and highest scenarios (2C and 1D respectively), along with the number of captured trips, by current mode.

Table 77: Capture rate and captured trips by original mode and model year (Scenario 2C)

Current Mode	Capture Rate		Captured Trips (millions)	
	2017	2040	2017	2040
Auto	7%	8%	0.5	0.8
Air	12%	16%	0.3	0.5
Air (OD)	64%	82%	0.3	0.5
Air (connecting)	-	-	-	-
Rail	28%	29%	0.2	0.2
Bus	1%	1%	0.0	0.0
Total	**9%**	**10%**	**0.9**	**1.5**

Table 78: Capture rate and captured trips by original mode and model year (Scenario 1D)

Current Mode	Capture Rate		Captured Trips (millions)	
	2017	2040	2017	2040
Auto	15%	16%	1.0	1.5
Air	16%	18%	0.3	0.5
Air (OD)	83%	94%	0.3	0.5
Air (connecting)	-	-	-	-
Rail	59%	59%	0.4	0.5
Bus	8%	8%	0.1	0.1
Total	**17%**	**18%**	**1.8**	**2.6**

The balance of capture from each mode is relatively consistent across each of the scenarios.

Rail has the highest percentage capture rate, at an average of 29% in Scenario 2C and 59% in Scenario 1D. Based on the size of the in-scope market, this translates to between 0.2 million and 0.5 million trips diverting from existing rail services in the corridor. UHSGT offers improved intercity travel times over traditional intercity rail, although at the cost of higher fares. The range between the lowest and highest capture is greatest for rail compared to any other mode, as this capture is highly dependent on the number of intermediate locations served by UHSGT. Nonetheless, there are various intermediate shorter-distance rail trips undertaken today which are not served by the assumed UHSGT service, irrespective of the scenario, resulting in a relatively large number of existing rail trips remaining on their current mode in future.

Air has the second highest percentage capture rate, at an average of 14% in Scenario 2C and 17% in Scenario 1D. Based on the size of the in-scope market, this translates to between 0.3 million and 0.5 million trips diverting from air in the corridor. Looking specifically at OD passengers, these capture rates increase to 73% and 89%, respectively. This is attributable to the fact that air and UHSGT tend to attract similar market segments—primarily business travelers with a high value of time—and for many key markets UHSGT offers lower intercity travel times and higher frequencies. However, the majority of air travelers within the corridor are connecting passengers as part of a broader trip (for example, New York-Seattle-Vancouver), whereby switching to UHSGT for the within-corridor leg of the trip (in this case, Seattle-Vancouver) is assumed to not be viable within the majority of the scenarios, since the UHSGT stations are generally not located at airports. The one exception to this is Scenario 3, which is discussed in further detail in Section 7.

Capture from auto is projected to be an average of 8% in Scenario 2C and 15% in Scenario 1D. Based on the size of the in-scope market, this translates to between 0.5 million and 1.5 million trips diverting from auto in the corridor – the largest absolute level of captured demand. The auto market includes a larger proportion of travelers from suburban or rural areas, necessitating the availability of a car for at least one leg of their trip. Accordingly, this results in lower UHSGT capture rates.

The lowest capture rate is from the bus market, at just 1% in Scenario 2C and 8% in Scenario 1D. Based on the size of the in-scope market, this translates to between 0.0 million and 0.1 million trips diverting from bus in the corridor. For the majority of intercity bus travelers, their mode choice decisions are likely primarily driven by travel cost. Given the significantly higher assumed UHSGT fare relative to current bus fares, few such travelers are forecast to switch modes.

30.2.2.2 Induced Demand

In addition to captured demand, additional trips are projected to be made by UHSGT that otherwise would not have been made by any mode if UHSGT were not available. This additional demand is called “Induced” demand.

The projected level of induced demand remains relatively constant across each of the scenarios, ranging from a low of 12% (Scenario 2C) to a high of 14% (Scenario 1D). This consistency arises since much of the induced demand is projected to be for the longer distance intercity markets between Portland, Seattle and Vancouver, BC, and the service to these three cities is largely consistent across each of the scenarios.

30.2.2.3 Market Composition

Figure 16 and Figure 17 provide a summary of the forecast market composition in 2040 both without and with UHSGT, in accordance with the forecast capture rates outlined above for Scenarios 2C and 1D respectively.

Figure 58: 2040 market composition by mode without and with UHSGT (referred to as "baseline" and "scenario", respectively) (Scenario 2C)

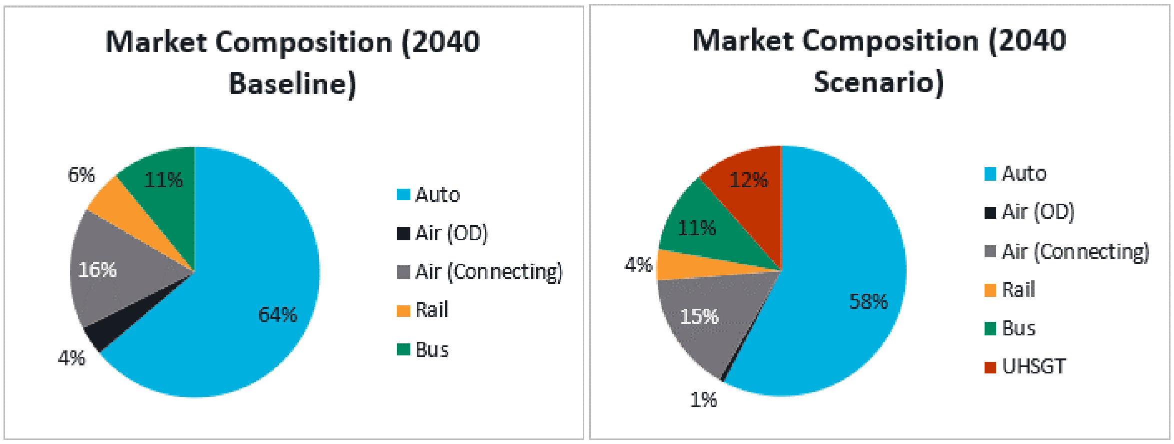
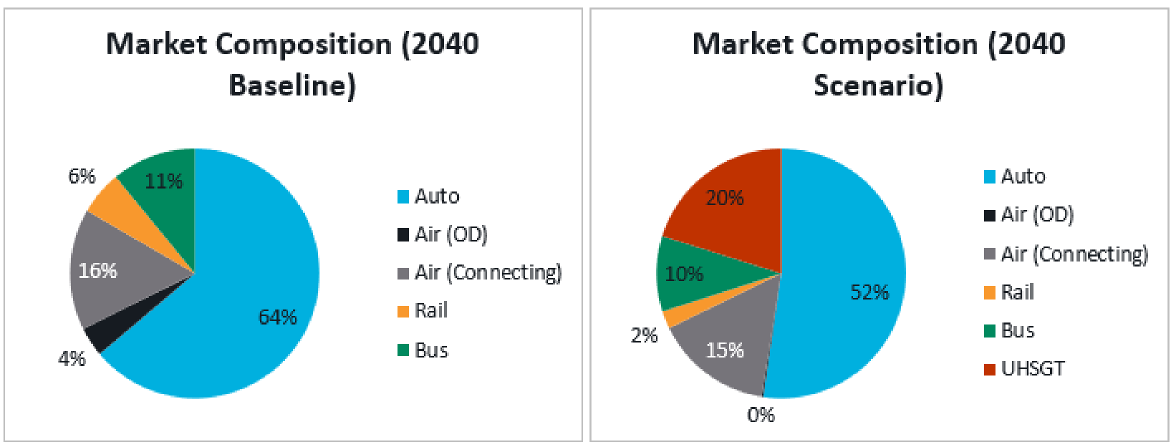


Figure 59: 2040 market composition by mode without and with UHSGT (referred to as "baseline" and "scenario", respectively) (Scenario 1D)



The baseline market composition remains the same in each case (since the in-scope market is unchanged across scenarios).

However, the scenario market composition does change, with the projected share of UHSGT ranging from 12% to 20%. Note, the UHSGT market share is higher than the forecast capture rate due to the inclusion of induced demand.

30.2.2.4 Capture by Geography

Table 19 and Table 20 provide a breakdown of forecast capture rates and the number of captured trips by MSA pair and model year for both the lowest and highest scenarios (2C and 1D respectively).

Table 79: Capture rate and captured trips by MSA pair and model year (Scenario 2C)

MSA Pair (Both Directions)	Capture Rate		Captured Trips (millions)	
	2017	2040	2017	2040
Portland – Seattle	16%	19%	0.6	1.0
Portland – Vancouver, BC	13%	15%	0.1	0.2
Seattle – Vancouver, BC	7%	8%	0.2	0.3
Other	-	-	-	-
Total	**9%**	**10%**	**0.9**	**1.5**

Table 80: Capture rate and captured trips by MSA pair and model year (Scenario 1D)

MSA Pair (Both Directions)	Capture Rate		Captured Trips (millions)	
	2017	2040	2017	2040
Portland – Seattle	22%	23%	0.8	1.2
Portland – Vancouver, BC	16%	17%	0.1	0.2
Seattle – Vancouver, BC	17%	16%	0.5	0.7
Other	12%	12%	0.3	0.5
Total	17%	18%	1.8	2.6

UHSGT's forecast capture rate is largest in the Portland – Seattle market, ranging from an average of 17% in Scenario 2C to an average of 22% in Scenario 1D. This translates to between 1.0 and 1.2 million captured trips by 2040.

Portland – Vancouver, BC, is the next highest market in terms of capture rate, at 14% in Scenario 2C and 17% in Scenario 1D. However, given the relative size of the in-scope market (see Table 16), the forecast ridership is just 0.1 million in 2017, rising to 0.2 million by 2040.

Seattle – Vancouver, BC, is projected to have the lowest capture rates among the primary markets – at 7% in Scenario 2C and 16% in Scenario 1D – however, given the size of this market it is forecast to contribute between 0.3 and 0.7 million trips by 2040.

Finally, "other" markets are projected to result in by far the lowest capture, with none at all in Scenario 2C (given that intermediate markets are not served in this scenario) and just 12% in Scenario 1D.

30.2.2.5 Ridership by Station

The stations included varies across each of the scenarios, making a like-for-like comparison difficult. Nonetheless, a comprehensive table including all stations across all scenarios, and the forecast number of projected boardings in 2040 is shown below.

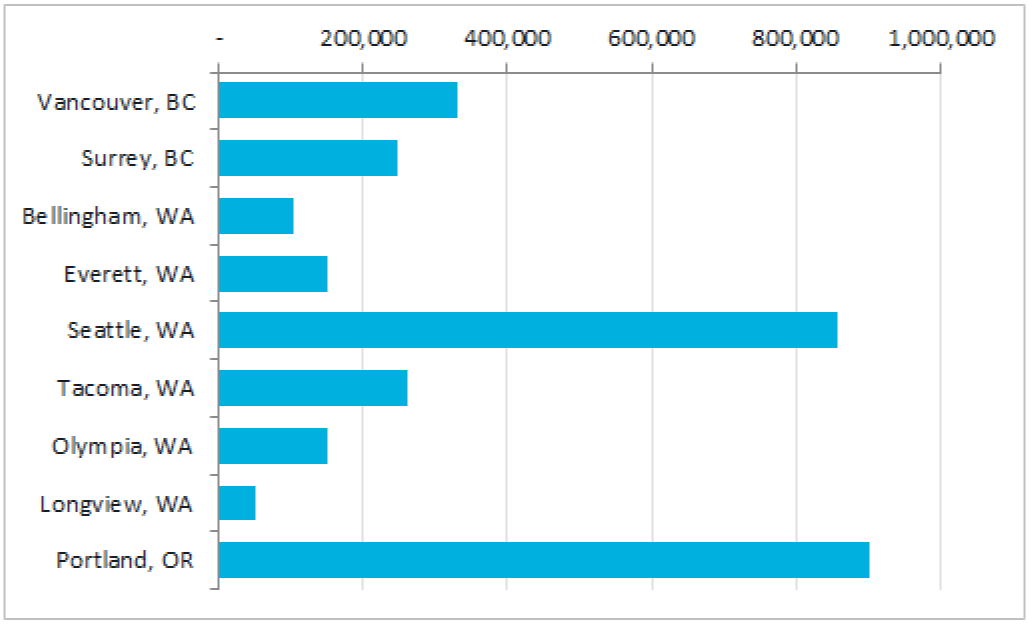
Table 81: 2040 boardings by station (millions)[104]

	1A	1B	1C	1D	1E	2A	2B	2C	3
Vancouver Airport, BC	-	-	-	-	-	-	-	-	0.0
Vancouver, BC	0.3	0.3	0.4	0.3	-	0.3	0.3	-	0.3
Surrey, BC	0.2	0.2	-	0.2	0.3	0.2	0.3	0.3	0.2
Bellingham, WA	0.1	0.1	-	0.1	0.1	0.1	0.1	-	0.1
Everett, WA	-	0.2	-	0.2	-	-	0.1	-	-
Bellevue/Redmond, WA	-	-	-	-	-	0.7	0.5	0.8	0.7
Seattle, WA	1.0	0.7	0.9	0.9	0.9	-	0.1	-	-
Tukwila, WA	-	-	-	-	-	0.4	0.2	-	0.4
Kent, WA	-	-	-	-	-	-	0.0	-	-
Auburn, WA	-	-	-	-	-	-	0.1	-	-
Tacoma, WA	-	0.2	-	0.3	-	-	0.2	-	-
Olympia-Downtown, WA	-	-	-	0.2	-	0.1	0.1	-	-
Olympia/Yelm, WA	0.1	0.1	-	-	0.1	-	0.0	-	0.1
Kelso/Longview, WA	0.0	0.0	-	0.1	0.0	0.0	0.0	-	0.0
Portland, OR	0.8	0.8	0.7	0.9	0.7	0.8	0.8	0.7	0.8
Portland Airport, OR	-	-	-	-	-	-	-	-	0.0

104 Trips to the airport, as well as some other locations, show 0.0 trips. These were rounded to millions and indicate less than 50,000 boardings per year from that location.

Figure 18 illustrates the number of boardings forecast at each station in 2040 for Scenario 1D (the scenario with the highest overall projected ridership).

Figure 60: 2040 ridership boardings by station



Ridership is forecast to be concentrated at the three major stations along the project corridor: Vancouver, BC; Seattle; and Portland.

Twenty-nine percent of passengers on the UHSGT system are forecast to use the Portland station, with Seattle being the second busiest station at 28%, and finally Vancouver, BC, with 11%. Overall, demand from at least one of these three stations is projected to account for 68% of all forecast trips in the corridor.

Surrey, BC, is forecast to account for 8% of passengers in the corridor. In the BC region, ridership is divided roughly 60%-40% between the Vancouver and Surrey stations respectively. Surrey is forecast to be an attractive station choice for the large population in the southeastern part of the region, allowing them to avoid backtracking north into downtown Vancouver to travel south on UHSGT.

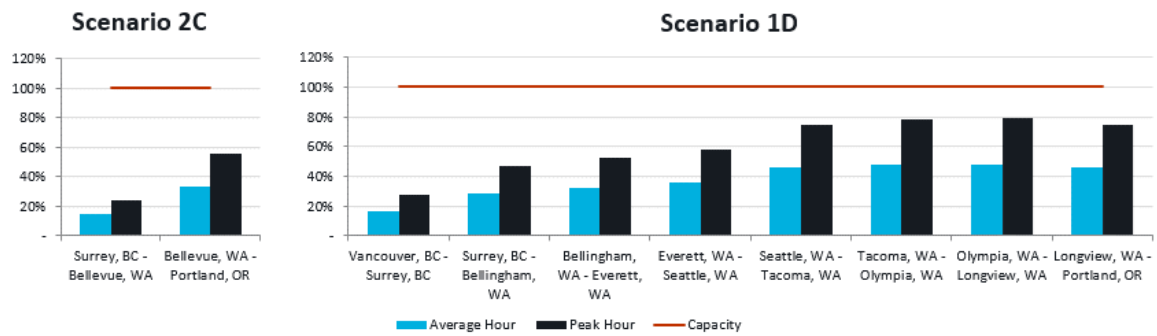
Tacoma, WA, and Everett, WA, are also projected to be heavily used stations, providing attractive access stations for a large population base of the region.

30.2.2.6 Line Loadings

Line loadings have been developed based on an assumed capacity of 260 seats per train (equivalent to the business class seating capacity of Amtrak's existing Acela fleet in the northeastern United States), with full services assumed to operate 365 days per year. These line loadings represent average loadings across the entire period of service. Peak loadings based on the observed maximum hourly demand currently in the corridor were also estimated.

On this basis, Figure 19 presents forecasted line loadings in both the southbound direction for the scenarios with the lowest (Scenario 2C) and highest (Scenario 1D) forecasted average loadings.

Figure 61: Projected line loadings (Scenario 2C)

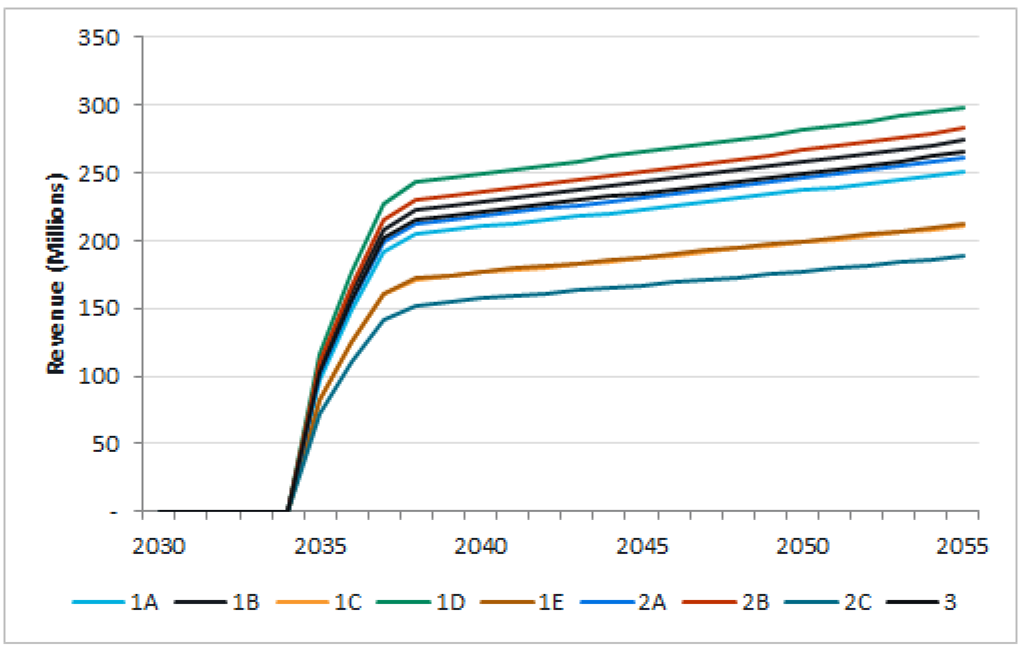


The highest average line loadings are projected between Seattle and Portland, at approximately 35% to 50% in an average hour, and approximately 55% to 80% in a peak hour[105].

30.2.3 Revenue

Figure 20 provides a summary of the projected farebox revenue for each of the scenarios.

Figure 62: System-level revenue forecasts (2019 prices)



[105] This compares to an average load factor of 50% reported across all of Amtrak's routes as of March 2019 (year-to-date results). For the Cascades service, the average reported load factor over the same period was 53%.

The projected revenue trends between scenarios are very similar to the projected ridership trends, with the lowest revenue forecast for Scenario 2C and the highest revenue forecast for scenario 1D.

All of the revenue forecasts have been developed on the basis of a $0.52 fare per mile across the entire system. Fares are assumed to remain constant in real terms throughout the forecast period (all years up to 2055). All revenues are based on the headline fare advertised to the customer expressed in 2019 US dollars.

In 2035, when the UHSGT system is assumed to open, the forecast indicates that there will be between $70 and $115 million in fare revenue (for scenarios 2C and 1D respectively).

By 2040, UHSGT fare revenue is forecast to grow to between $155 and $250 million, an average annual growth rate of over 16.5% (between 2017 and 2040), again driven largely as a result of ramp-up assumptions in the early years (see Appendix A).

By 2055, UHSGT fare revenue is forecast to grow to between $190 and $300 million, an average annual growth rate of 1.2% (between 2040 and 2055).

30.2.4 Comparison to CONNECT

As mentioned previously, the previous study of UHSGT completed in December 2017 utilized the FRA's CONNECT model to project ridership in the Cascadia corridor. Three different scenarios were presented:

- Scenario 1A: Assuming seven stations in Vancouver, BC, Bellingham, Everett, Seattle, Tacoma, Olympia/Lacey and Portland;
- Scenario 2: Assuming four stations in Vancouver, BC, Seattle, Tacoma and Portland; and
- Scenario 4: Assuming three stations in Surrey, BC, Tukwila and Portland.

None of these scenarios (or station locations) align precisely with the scenarios presented in this report (in spite of some of the similar naming conventions used). Accordingly, a degree of caution needs to be taken when comparing these forecasts.

Although none of the scenarios entirely align, a cross-walk of scenarios which are considered to provide a reasonable comparison is provided below:

- Broadly comparable to CONNECT Scenario 4: 1C and 2C;
- Broadly comparable to CONNECT Scenario 1A: 1A, 1B, 1D, 1E, 2A, 2B and 3.

IMPORTANT NOTE: The prior study only presented forecasts for 2035 and 2055, with no intermediate years. In order to produce the comparison presented below, the following steps were performed:

- Calculated the average annual growth rate in both demand and revenue between 2035 and 2055 from the CONNECT forecasts, and developed intermediate year forecasts by applying this average rate for each intermediate year; and

- Removed ramp-up assumptions from the projections, in order to be on a like-for-like basis with the CONNECT forecasts.

Figure 21 presents a comparison of forecast ridership between the forecasts in this report and the CONNECT Scenario 4 forecasts. Figure 22 then presents a comparison of forecast ridership between the forecasts in this report and the CONNECT Scenario 1A forecasts.

Figure 63: Comparison of forecast ridership between the 1C and 2C forecasts and CONNECT Scenario 4

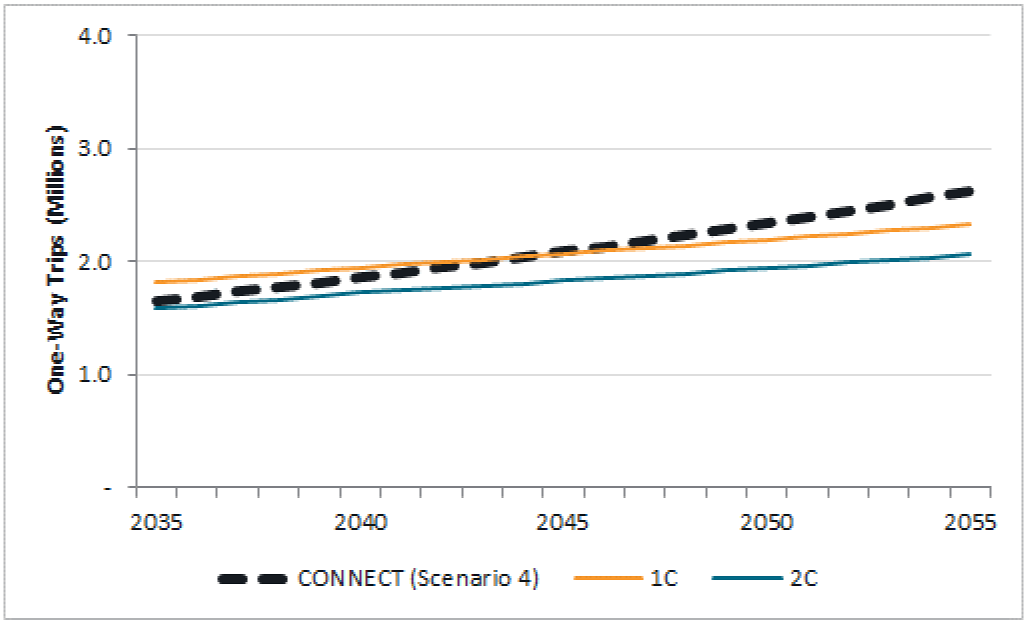
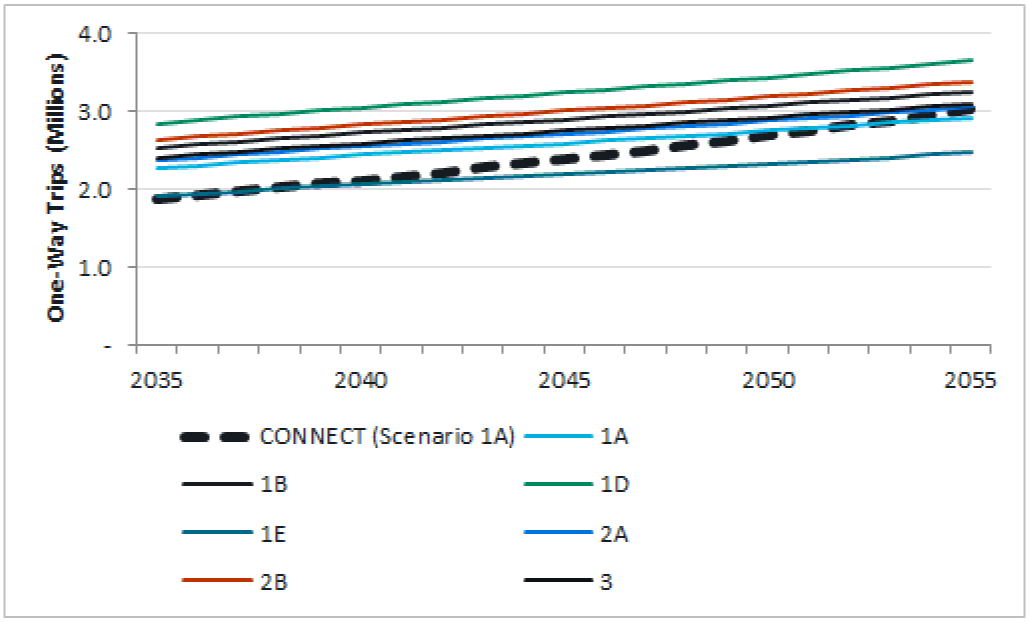


Figure 64: Comparison of forecast ridership between the 1A, 1B, 1D, 2A, 2B and 3 forecasts and CONNECT Scenario 1A



When compared to CONNECT Scenario 4 – that includes just 3 stations – the forecasts presented in this report are broadly comparable, in particular in 2035, where the forecasts are on average 3% higher than CONNECT. By 2055, the forecasts are 16% lower than the CONNECT forecasts as a result of lower projected growth in demand throughout the corridor within the forecasts developed for this study.

When compared to CONNECT Scenario 1A, however, the forecasts are significantly higher – by an average of 29% in 2035, and 3% by 2055. The reason for this difference is the projected ridership potential from intermediate stops (i.e. stops outside of the 3 major cities).

Overall, this comparison highlights that the projections for demand between the 3 major cities (Portland, Seattle and Vancouver, BC) are broadly comparable to the prior CONNECT forecasts, but the projections of demand to/from other intermediate stops (such as Surrey, Bellingham, Everett, Tacoma and Olympia) are higher than those within the prior CONNECT forecasts.

30.2.5 Comparison to other existing systems

As highlighted above, by 2040, when the UHSGT system is assumed to open and the impacts of ramp-up are assumed to be over, there are forecast to be between 1.5 and 2.6 million one-way trips on UHSGT (depending on the service scenario considered).

In order to undertake a more like-for-like comparison between these projections and existing rail ridership on other systems, projected ridership in 2017 must be considered, under the theoretical situation whereby UHSGT already existed at that point. On this basis, there are forecast to have been between 1.1 and 2.1 million one-way trips on UHSGT (thereby implying an average growth rate between 2017 and 2040 of between 1.6% and 2.1% per annum), and revenues of between $100 million and $170 million (2019 prices).

By comparison, in Amtrak FY17[106], the Amtrak Cascades service reported 0.8 million one-way trips, and gross ticket revenue of $32.5 million[107]. Accordingly, the projected ridership on UHSGT is between 32% and 160% higher than on the existing Cascades service, while the projected revenue on UHSGT is between 190% and 400% higher than on the existing Cascades service (accounting for inflation).

However, as highlighted above, some of the ridership projected for UHSGT is expected to come from existing rail users. Accordingly, the total projected ridership across both systems (i.e. Amtrak Cascades and UHSGT) is between 1.7 million and 2.4 million one-way trips.

[106] Year ending September 30, 2017.
[107] https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/monthlyperformancereports/2017/Amtrak-Monthly-Performance-Report-September-2017-Preliminary-Unaudited.pdf

The highest current ridership across any route operated by Amtrak is the Northeast Corridor (i.e. the combination of Acela and Regional services). In Amtrak FY17, just over 12 million one-way trips, generating over $1,200 million in gross ticket revenues, were reported on the Northeast Corridor. Thereafter, the next highest performing route was the Pacific Surfliner that reported almost 3.0 million one-way trips and almost $77 million in gross ticket revenue.

Accordingly, the projections of ridership for UHSGT are significantly below observed ridership already seen on existing routes in the US (both the Northeast Corridor and Pacific Surfliner). However, from a revenue perspective, UHSGT is projected to out-perform all existing routes other than the Northeast Corridor.

31 Sensitivity Analysis

The sensitivity of the ridership and revenue projections to incremental changes in each of the key input variables highlights the relative importance of individual forecasting assumptions and demonstrates the robustness of the results to a range of uncertainties and forecasting parameters.

Potential ridership and revenues will depend on a combination of variables. The characteristics offered by the UHSGT service will influence its competitive advantage and hence ridership. Journey times will be determined by the characteristics of the final technology, infrastructure and rolling stock. However, the service frequency and fares are largely within the control of the UHSGT operator, and so there is a degree of flexibility depending on the primary objectives – be it maximizing revenues, maximizing ridership or optimizing the overall business case and economic development potential for the service.

In addition, there are various external factors affecting the potential ridership and revenue on the service, including the attractiveness (costs, journey times, frequencies) of other modes and the underlying growth in the market.

Finally, the option of terminating each service scenario at Surrey, BC, rather than continuing up to Vancouver, BC, was also tested.

Each of these sensitivity tests impact the competitive position of UHSGT relative to other modes, therefore impacting the projected capture rate on UHSGT and in turn the project ridership, revenue and passenger miles. The sensitivity of forecasts to each of these factors is outlined below.

31.1 UHSGT Service Characteristics

Table 22 summarizes the effect on ridership, revenue and passenger miles in 2040 of a range of sensitivity tests related to the UHSGT service characteristics.

Table 82: Sensitivity tests: UHSGT service characteristics

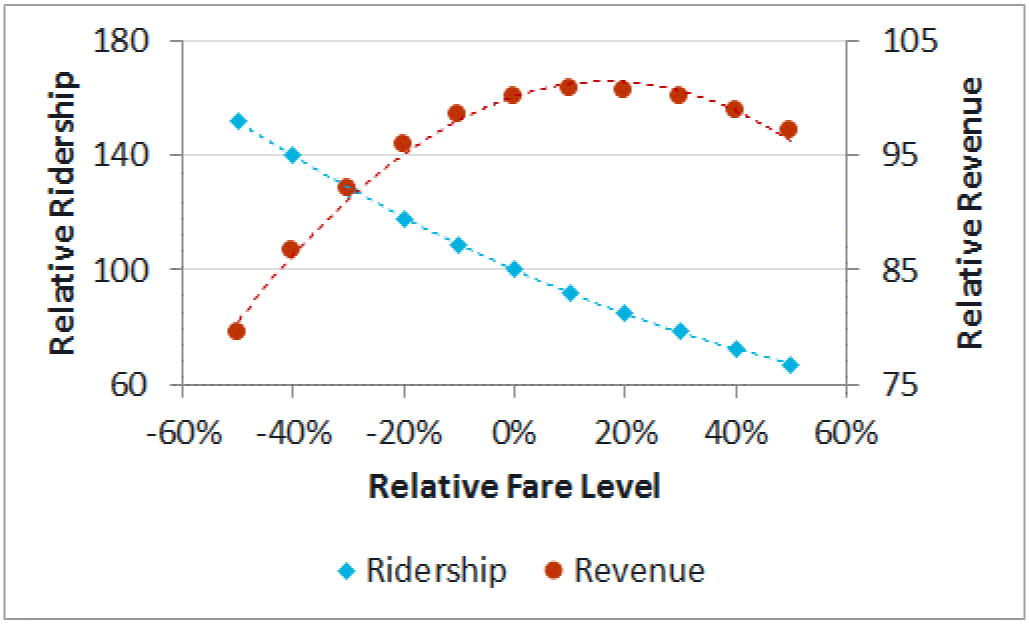
	Ridership	Revenue	Passenger Miles
UHSGT fares 50% higher	(32.9%)	(2.9%)	(35.3%)
UHSGT fares 40% higher	(27.4%)	(1.3%)	(29.5%)
UHSGT fares 30% higher	(21.4%)	(0.0%)	(23.1%)
UHSGT fares 20% higher	(14.9%)	0.6%	(16.1%)
UHSGT fares 10% higher	(7.8%)	0.7%	(8.5%)
UHSGT fares 10% lower	8.5%	(1.6%)	9.4%

	Ridership	Revenue	Passenger Miles
UHSGT fares 20% lower	17.9%	(4.2%)	19.8%
UHSGT fares 30% lower	28.3%	(8.0%)	31.4%
UHSGT fares 40% lower	39.7%	(13.3%)	44.5%
UHSGT fares 50% lower	52.1%	(20.6%)	58.9%
UHSGT journey times 25% higher	(7.5%)	(8.4%)	(8.4%)
UHSGT journey times 25% lower	7.9%	8.9%	8.9%
UHSGT frequency doubled	4.2%	4.1%	4.1%
UHSGT frequency halved	(7.0%)	(7.0%)	(7.0%)
UHSGT frequency halved (Constrained)	(14.7%)	(14.6%)	(14.6%)
UHSGT station parking charges doubled	(6.2%)	(6.1%)	(6.1%)
UHSGT station parking charges halved	3.2%	3.2%	3.2%

31.1.1 Fares

UHSGT fares within each of the scenarios presented in Section 3 have been set at $0.52 per mile – consistent with the fare levels assumed within the 2017 study. Increments to these fares of 10%, up to a maximum difference of 50% (resulting in fares ranging from $0.26-0.78 per mile) were tested. The impact on revenue and ridership of each of these tests is outlined below.

Figure 65: Sensitivity tests: impact of different UHSGT fares



The analysis demonstrates that it may be possible to achieve slightly higher fare revenues (approximately 1% higher) through charging higher fares. However, this in turn would be anticipated to have a more significant negative impact on ridership and passenger miles (approximately 10-15% lower), which in turn is likely to result in a less-favorable overall business case for the investment.

Conversely, it may be possible to increase ridership through charging lower fares – for example, reducing fares by 20% is projected to result in ridership that is almost 20% higher. However, this in turn would be expected to result in lower fare revenue – in this same example, fare revenue is projected to be almost 5% lower.

31.1.2 Journey Times

The base assumptions regarding journey times are presented in Section 3. The forecast increased journey times by 25% - for example, an express-train journey time between Portland and Vancouver of 2 hours 15 minutes in Scenario 1A (compared to a base assumption of 1 hour and 48 minutes) – resulting in a reduction in ridership, revenue and passenger miles of around 8%. Conversely, the impact of reducing journey times by 25% is forecast to attract a similar level of around 9% in increased passenger miles.

31.1.3 Service Frequency

If service frequencies are doubled relative to those assumed in the base scenarios (21 trains per day), it is forecast to result in a relatively minor increase in ridership and revenue of approximately 4%. This is because UHSGT frequencies in the base scenarios are sufficient to be attractive to most people. Accordingly, further frequency enhancements do not materially reduce average waiting times.

However, if service frequencies are reduced by half, ridership and revenue is forecast to drop by approximately 7% on an unconstrained basis, and by almost 15% on a constrained basis[108].

These impacts are for 2040. Accordingly, in future years the impact of capacity constraints would be expected to be more significant, resulting in potential material losses of ridership and revenue (although noting that some of the revenue impact may be able to be partially offset through yield management[109]).

31.1.4 Station Parking Charges

Two alternative scenarios where all UHSGT parking is halved (down to $5 per day) or all UHSGT parking is doubled (up to $20 per day) were tested.

The effect of halving all parking costs is to increase ridership, fare revenue and passenger miles by approximately 3%. Conversely the effect of doubling all parking charges is to reduce ridership, fare revenue and passenger miles by approximately 6%. However, in each case, this impact would likely be offset by reductions/increases in parking revenues respectively, assuming parking is controlled by the UHSGT system.

31.2 Other Factors

Table 23 summarizes the effect on ridership, revenue and passenger miles in 2040 of a range of sensitivity tests related to other factors.

Table 83: Sensitivity tests: other factors

	Ridership	Revenue	Passenger Miles
Gas price 25% higher	1.2%	1.4%	1.4%
Gas price 25% lower	(1.2%)	(1.4%)	(1.4%)
Other auto operating expenses 10% higher	0.7%	0.8%	0.8%
Other auto operating expenses 10% lower	(0.7%)	(0.8%)	(0.8%)
Auto journey times 10% higher	9.3%	9.4%	9.3%
Auto journey times 10% lower	(9.2%)	(9.1%)	(9.1%)
Air fares 25% higher	1.4%	1.5%	1.5%
Air fares 25% lower	(2.0%)	(2.1%)	(2.1%)
Air frequency 50% higher	(0.1%)	(0.1%)	(0.1%)
Air frequency 50% lower	0.3%	0.3%	0.3%
Model value of time 10% higher	5.3%	5.8%	5.8%
Model value of time 10% lower	(5.3%)	(5.8%)	(5.8%)

108 Unconstrained forecasts assume that there is no negative impact from crowding (i.e. it only reflects the impacts of the lower frequency in terms of the limited options on travel, not in terms of the higher chance of not being able to have access to a seat). Conversely, constrained forecasts seek to also take account of the impacts of crowding.
109 Whereby fare pricing can be used to manage demand.

Model mode constants 10% higher	(0.4%)	(0.4%)	(0.4%)
Model mode constants 10% lower	0.4%	0.4%	0.4%
Model mode constants 10% less favorable for UHSGT	(0.5%)	(0.5%)	(0.5%)
Population/employment growth 25% higher pa	8.4%	8.4%	8.4%
Population/employment growth 25% lower pa	(7.8%)	(7.8%)	(7.8%)

31.2.1 Auto Competition

Tests have been undertaken in relation to the relative cost (gas prices and other operating costs) and journey time of traveling by auto, and the effects of these changes in these factors on UHSGT ridership, revenue and passenger miles.

The largest impact is in relation to auto journey times, whereby a 10% change in journey times is projected to result in a 9% change in UHSGT ridership. This indicates that should highway delays increase significantly in future, there may be more demand for UHSGT, given the faster and more reliable journey times it could offer.

The tests undertaken in relation to auto cost indicate a relatively low level of sensitivity to these factors, with elasticities to gas price of approximately 0.05[110]. It is likely that sensitivity to auto costs may be more pronounced in extreme cases (for example, if gas prices were to double).

31.2.2 Air Competition

Four alternative sensitivities whereby average air fares are either increased or decreased by 25%, or air frequencies are either increased or decreased by 50% were tested. In each case, the impact on overall UHSGT ridership is relatively small (at most 2%). The core reason for this was that only 20% of UHSGT demand is projected to come from existing air travelers (with the rest coming from auto, existing rail, bus and induced demand).

Note that all forecasts are presented as unconstrained for all modes – this impact therefore could be larger in the reduced frequency case given potential capacity constraints at airports.

31.2.3 Model Parameters

A range of sensitivity tests have been undertaken related to model parameters within the forecasting model. The impacts of small changes (10%) in estimated mode constants is projected to be minor (at most 0.5%). The more significant parameter is the value of time.

Value of time (VOT) is typically measured in $/hour and provides an indication of how much people are willing to pay to save travel time. For example, a VOT of $20/hour indicates that

[110] The American Public Transportation Association (APTA) published a research paper in May 2012 that provides elasticities to gas prices from a number of US studies (http://www.apta.com/resources/reportsandpublications/Documents/Gas-Price-Impact-May-2012.pdf). These range between 0.05 and 0.4 with an average of approximately 0.2. The studies also indicate higher elasticities for larger changes in gas prices.

someone would be willing to spend an additional $20 in order to travel on a service that saves them one hour of travel time. The base value of time within the model is estimated based upon statistical analysis of the stated preference survey results (see Appendix B for further details).

If the value of time is assumed to be 10% higher than in the base assumptions, this is estimated to result in an increase in ridership, revenue and passenger miles of approximately 5-6%. Similarly, a 10% reduction in value of time is estimated to result in a decrease in revenue of approximately 5-6%. This test indicates the potential impact on ridership projections if the true VOT in the market differs from that estimated on the basis of the stated preference survey results.

31.2.4 Market Growth

The market growth assumptions used are based on population and employment projections from local RTPO/MPO models throughout the corridor.

If market growth differs from these expectations, it could have a material impact on projections. If market growth is 25% per annum higher than expected[111] this would result in ridership, revenue and passenger miles being approximately 8.4% higher. Conversely, if market growth is 25% per annum lower than expected[112] this would result in ridership, revenue and passenger miles being approximately 7.8% lower.

31.3 Surrey, BC Terminus

Within the nine (9) service scenarios described in Section 3, six (6) assume stations in both Vancouver, BC and Surrey, BC (Scenarios 1A, 1B, 1D, 2A, 2B and 3), one (1) assumes there is only a station in Vancouver, BC (Scenario 1C) and two (2) assumes there is only a station in Surrey, BC (Scenario 1E and 2C).

The potential impact on ridership, revenue and passenger miles of amending these scenarios such that each only has a station in Surrey, BC within Canada was considered:

- Scenario 1A, 1B, 1D, 2A, 2B and 3 would therefore all have one less station than in the base assumptions;
- Scenario 1C would have the same number of stations, but the Vancouver, BC station would be removed in favor of a Surrey, BC station; and
- There would be no impact on Scenario 1E and 2C.

Table 24 presents a summary of the projected impacts of this sensitivity test.

Table 84: Sensitivity tests: Surrey, BC terminus

	Ridership	Revenue	Passenger Miles

[111] For example, if base growth is 1.0% per annum, this test would assume growth is 1.25% per annum.
[112] For example, if base growth is 1.0% per annum, this test would assume growth is 0.75% per annum.

Scenarios 1A, 1B, 1D, 2A, 2B and 3	(14-16%)	(15-16%)	(12-14%)
Scenario 1C	(9%)	(9%)	(8%)
Scenario 1E and 2C	-	-	-

For Scenarios 1A, 1B, 1D, 2A, 2B and 3 ridership is projected to be approximately 14-16% lower with only a Surrey, BC station, compared to having stations in both Vancouver, BC and Surrey, BC.

For Scenario 1C, the impact is lower – just a 9% reduction – since rather than removing a station, this scenario assumes that the location of the station simply changes from Vancouver, BC to Surrey, BC.

Finally, for Scenarios 1E and 2C there is no impact since this scenario already assumes Surrey, BC is the location of the only station on the UHSGT line in Canada.

31.4 Summary

Many of the tests undertaken have a relatively limited impact (less than 5%) on forecasts and therefore demonstrate the resilience of the forecasts across a range of areas of uncertainty. However, there are some key risk areas – including UHSGT fares, journey times and frequencies, as well as auto journey times, model VOT and market growth – where the impact on the ridership and revenue projections is more material. Further, shifting the Canadian terminus from Vancouver, BC to Surrey, BC would also be expected to have a significant impact of between 9% and 16% (depending on the service scenario).

32 Potential Future Analysis

The projections of ridership and revenue presented in this report represent what are considered to be reasonable estimates on the basis of the analysis undertaken, and thereby a provide a reasonable basis on which to compare across the various scenarios considered.

However, it is acknowledged that there are a number of areas that may not be fully represented within these forecasts, including:

- **Future investment in local transportation systems**: As highlighted in Section 2 of this report, there may be future enhancements to the local transportation systems in each urban area that are not fully captured in the analysis presented in this report. These enhancements could include services specifically designed to complement the UHSGT system, or those that are independently developed for the local needs of each area. Some of these enhancements are likely to provide an upside in terms of projected UHSGT ridership (for example, where a new/improved transit connection makes it easier for people to access the UHSGT system), however some are likely to provide a downside (for example, if congestion pricing were to be introduced in/around an UHSGT station location, making it more expensive for people to access via auto).
- **Future investment in other connecting services**: In addition to local services, there are enhancements being considered to other connecting services (for example, rail services connecting Portland with Eugene). Enhancements to these services may increase the viability of a wider range of trips being made by UHSGT (for example, from Eugene to Seattle, with a transfer in Portland).
- **Induced demand resulting from enhanced economic activity:** In addition to captured demand, additional trips are projected to be made by UHSGT that otherwise would not have been made by any mode if UHSGT were not available. This additional demand is called “Induced” demand. The induced trips highlighted in the projections account for additional trips projected to be made as a result of the improved travel options now available in the corridor. This does not, however, include all potential induced trips. In particular, induced trips as a result of enhanced economic activity brought about by UHSGT are not accounted for within the numbers presented.
- **Connecting air passengers:** The total in-scope air market is comprised of Air (OD) – trips that are made entirely within the corridor, for example Seattle-Portland – and Air (Connecting) – trips that connect through the corridor, but include at least one leg outside of the corridor, for example Boston-Seattle-Portland. For most of the scenarios considered, capture from Air (Connecting) trips is assumed to be zero since switching to UHSGT for the within-corridor leg of the trip (in this case, Seattle-Portland) is assumed to not be viable since the UHSGT stations are not located at airports.

  The one exception to this is Scenario 3. In this case, the airports in Portland and Vancouver, BC, are assumed to be directly served (and there may also be the possibility of a connecting transit service for the Seattle airport). By 2040, there are projected to be approximately 2.3 million connecting air passengers in the corridor. It may be possible to capture some of this demand if appropriate commercial agreements with airlines could be reached[113]. This potential is not included within the projections for Scenario 3, since further work is required to determine the viability of such agreements.

- **Other local markets:** The research undertaken as part of this work focused primarily on the potential to attract longer-distance intercity travelers onto UHSGT. However, in certain scenarios (in particular scenarios 1B and 2B) providing more local connections in addition to services on the spine was envisioned. While this research should adequately represent the enhanced access/egress options this provides for longer distance travel, it may under-represent shorter distance movements where the service may also be viable.

Each of these areas represent possible items that may increase of decrease projected ridership and revenue relative to the projections outlined in this report. Depending on the priorities for the development of UHSGT moving forward, it may be appropriate to consider additional analysis to more fully understand the potential scale of each of these items, and therefore their potential impacts on the case for investment in UHSGT.

[113] If commercial agreements cannot be reached with airlines, the likely level of capture if very low, since airlines typically offer the shorter legs of trips at a large discount, since their commercial incentive is to attract people onto longer-distance legs through providing viable connecting options.

Appendices

A Assumptions Log

A summary of the key assumptions underpinning the ridership and revenue projections is provided below. A more comprehensive assumptions log is then also provided.

Summary of Key Assumptions

- The forecasts present ridership and revenue potential on the proposed UHSGT system only; they do not include projected ridership and revenue associated with any other existing or planned rail services.
- The forecasts comprise two core components:
  - Captured trips: Trips that are currently being made by other modes and are projected to shift to using UHSGT in future; and
  - Induced trips: Trips that are not currently being made, but that are projected to be made in future once UHSGT is operational.
- The induced trips highlighted above account for additional trips projected to be made as a result of the improved travel options now available in the corridor. This does not, however, include all potential induced trips. In particular, induced trips as a result of enhanced economic activity brought about by UHSGT are not accounted for within the numbers presented.
- Where a single year is presented, values are presented for 2040 (unless otherwise stated). Underlying growth up to 2040 is based upon expectations of population and employment growth in the corridor from local RTPO/MPO models.
- All reported trips are one-way trips (i.e. a roundtrip from Portland to Vancouver, say, would be counted as two trips within the forecasts presented).
- All reported revenues are in 2019 US dollars (i.e. they do not account for inflation).
- Reported revenues are farebox revenues only (i.e. income from the fares that people pay); they do not include other potential revenues that the system might generate (such as from parking, food service or other commercial income).
- Reported ridership and revenue do not include any reductions for the following items:
  - Fare evasion;
  - Planned maintenance closures; and
  - Unplanned service disruptions.

Each of these items would typically be expected to reduce the potential ridership and revenue of the service.

Assumptions Log

The following tables outline the core modeling assumptions and their respective sources, as used within the ridership and revenue forecasting framework.

Table A.1: General forecasting assumptions

Item	Description	Source
Base forecast year	2017	Steer modelling assumption
Price base year	2017	Steer modelling assumption
Future forecast year	2040	Steer modelling assumption
Range of years reported	2017 – 2055	Steer modelling assumption
Modelling year type	Calendar	Steer modelling assumption
CAD to USD conversion rate	1 CAD = 0.75 USD	XE Historical Exchange Rates, 2018
Tax	No specific assumptions on tax	Steer modelling assumption
Ramp-up	Ramp-up is applied in the first few years of system operation as follows: • First year of operation: 50% • Second year of operation: 75% • Third year of operation: 95% • Fourth year of operation: 100%	Steer modelling assumption based on estimated ramp-up observed on the Eurostar service

Table A.2: Base travel demand assumptions

Item	Description	Source
Market segmentation: current mode	Auto, air, intercity rail, scheduled bus	Steer modelling assumption
Market segmentation: origins and destinations	Intercity zone system includes 53 zones, distributed by MSA as follows: • 8 zones representing the Portland-Vancouver, WA-Beaverton MSA • 1 zone representing the Longview MSA • 4 zones representing the Olympia MSA • 9 zones representing the Seattle-Tacoma-Bellevue MSA • 8 zones representing the Mount Vernon-Anacortes MSA • 9 zones representing the Bellingham MSA • 14 zones representing the Vancouver, BC region A more detailed zone system is used for assessing access/egress to UHSGT stations, existing rail stations and airports. This zone system is based on the Traffic Analysis Zones (TAZs) within each MPO model collected for this study (see details below). In total, there are 8,848 TAZs used in the analysis.	Steer modelling assumption & MPO models
Market segmentation: trip purpose	Business and non-business	Steer behavioral survey
Market segmentation: household income	Income quintiles, defined based on MSA of residence	American Community Survey 5-Year Estimates, 2017
UHSGT in-scope market	In-scope markets include all pairs of MSAs in the origin-destination list above Note: When results are presented, intra-MSA movements (e.g. Olympia MSA – Olympia MSA) are often excluded. This is due to the very large number of small local movements made which would not be in-scope for switching to UHSGT. However, in some cases intra-MSA movements are still included in the UHSGT forecasts (for example, people traveling from Seattle-Everett on UHSGT) since these are potentially viable movements. This approach is used to ensure that all potential UHSGT demand is included, but that the large number of local trips does not render projected capture rates almost meaningless.	• Travel demand model demand matrices for each MPO/MSA jurisdiction: – RTC (Portland) – TRPC (Olympia) – PSRC (Seattle) – SCOG (Mount Vernon) – WCOG (Bellingham) – Translink (Vancouver, BC) • CONceptual Network Connections Tool (CONNECT) demand matrices • Airsage OD travel demand matrices for February 2014 • BTS DB1B and T-100 air demand matrices through Q1 2018

Item	Description	Source
		• Amtrak Cascades corridor historical ridership and revenue data through 2018 • American Community Survey 5-Year Estimates, 2017 • Canadian Census of Population, 2016 • Bus schedule data from various bus operators • Steer modeling assumptions
Bus market	Bus trips between zone pairs estimated using bus schedule data and an assumed average occupancy of 16, matching total in-scope CONNECT demand	• Bus schedule data as described above • CONceptual Network Connections Tool (CONNECT) demand matrices • Steer modeling assumption
Assignment of zones to stations and airports	Rail and bus stations assigned to a single model zone; airports assigned to a single MSA	Steer modeling assumption

Table A.3: Level of service assumptions

Item	Description	Source
Current driving costs: journey times	Intercity driving times collected for mid-week January 2019	Google Maps travel times
Current driving costs: fuel prices and consumption	Average gasoline prices and fleet fuel efficiency for model base year	Energy Information Administration (EIA)
Current driving costs: other costs	Maintenance, repair, and tires at 7.9 cents per mile in 2017 Mileage-based depreciation at 5.6 cents per mile in 2017	American Automobile Association (AAA)
Future driving costs: fuel prices and consumption	Gasoline price growth and changes in fleet fuel efficiency as forecast by the EIA	Energy Information Administration (EIA)
Current air costs: journey times and frequencies	Journey times and frequencies collected for mid-week January 2019	Google Flights
Current air costs: fares	2017 fares averaged by airport pair based on the BTS Airline Origin and Destination Survey (DB1B)	BTS DB1B, 2017
Current rail costs: journey times and frequencies	Journey times and frequencies from 2018 Amtrak Cascades corridor published schedule	Amtrak published schedules
Current rail costs: fares	Average fares by station pair calculated based on total ticket revenue and total ridership	Amtrak Cascades corridor historical ridership and revenue data, 2017
Current bus costs: journey times and frequencies	Journey times and frequencies collected for mid-week January 2019	Bus schedule data from Bolt Bus, Greyhound, and Quick Shuttle
Current bus costs: fares	Average fares by city pair collected for mid-week January 2019	Bus fare data from operators listed above
UHSGT service offer: system opening date	Note that no assumption is currently implemented in the modeling framework	Outstanding: To be agreed with client

Item	Description	Source
UHSGT service offer: operating times and days	365 days per year, times as dictated by scenario schedules (approximately 5:30 AM to 10:00 PM for Scenario 1A) Note that while these assumptions have been developed, no reduction in ridership is incorporated as a result of the lack of overnight service.	Steer modeling assumption Scenario schedules developed as part of corridor analysis
UHSGT service offer: journey times and frequencies	Based on scenario schedules	Scenario schedules developed as part of corridor analysis
UHSGT service offer: fares	Fixed-rate fare of 52 cents per mile	Steer modeling assumption
UHSGT service offer: other characteristics	• Reliability: very high, negligible service cancellations and delays • Fare evasion: no assumption is implemented in the modeling framework • Rolling stock capacity: Each train assumed to provide 260 seats	Steer modeling assumption
Other intercity costs: security and border crossing times	• Air: 45 minutes for domestic, 60 minutes for cross-border • Auto: 15 minutes for cross-border trips only • Rail, bus, and UHSGT: 30 minutes for cross-border trips only	Steer modeling assumption
Other intercity costs: average vehicle occupancy and split of costs	Auto: 2 passengers per vehicle	Steer behavioral survey
Access/egress costs: airport parking costs	Daily parking costs by airport: • YVR: $13.69 (converted to US dollars) • BLI: $12.00 • SEA: $26.00 • PDX: $18.00	YVR, BLI, SEA, and PDX airport ground transportation data
Access/egress costs: rail and UHSGT station parking costs	$10.00 per day	• Amtrak parking cost data • Various third-party-operated parking facilities, accessed through Amtrak • Steer modeling assumption

Item	Description	Source
Access/egress costs: bus parking costs	No parking costs, as majority of bus passengers assumed to be dropped off/picked up at bus station, or to access via modes not requiring parking costs to be incurred	Steer modeling assumption
Access/egress costs: share of people paying for parking	40% for all modes, including UHSGT	• Steer behavioral survey • Airport ground access/egress mode share information (SFO, PDX, BOS) – Steer modeling assumption
Access/egress costs: average parking duration	• Air: 4.6 days • Auto, rail, and bus: 3 days • UHSGT: assumed to be same as mode captured from	Steer behavioral survey
Access/egress costs: average vehicle occupancy and split of costs	• Air: 1.5 passengers per vehicle • Auto, rail, and bus: 2 passengers per vehicle UHSGT: assumed to be same as mode captured from	Steer behavioral survey
Access/egress costs: taxi and TNC costs	Taxi costs: • Fixed cost per trip: $2.67 • Cost per mile: $2.33 • Tip: 15% of total fare TNC costs: • Fixed cost per trip: $2.97 • Cost per mile: $1.14 • Cost per minute of delay: $0.22 Assumed 50-50 split of taxi and TNC modes for access/egress	• Taxi / TNC fare estimate sites, including – https://www.taxifarefinder.com/rates.php – http://uberestimate.com – http://www.alvia.com/uber-city/uber-vancouver/ – https://estimatefares.com • Airport ground access/egress mode share information (SFO, PDX, BOS) • Steer modeling assumption
Future travel costs	Unless explicitly mentioned above, journey times, frequencies, etc. are assumed to be unchanged from current/base year conditions, and prices and fares are constant in real terms	Steer modeling assumption

Table A.4: Behavioral assumptions

Item	Description	Source
Value of time	Segmented by trip purpose and income quintile (average of origin and destination MSA)	Steer behavioral survey

Table A.5: Forecasting assumptions

Item	Description	Source
Monthly demand profile	Proportion of in-scope demand by month: • January: 7.4% • February: 6.9% • March: 8.6% • April: 8.3% • May: 8.7% • June: 9.1% • July: 9.4% • August: 9.1% • September: 7.6% • October: 8.6% • November: 8.2% • December: 8.3%	BTS T-100, 2017
Hourly demand profile	Proportion of in-scope demand by hour: • 12:00 AM: 0.6% • 1:00 AM: 0.4% • 2:00 AM: 0.4% • 3:00 AM: 0.5% • 4:00 AM: 1.3% • 5:00 AM: 3.0% • 6:00 AM: 5.4% • 7:00 AM: 6.6% • 8:00 AM: 5.9% • 9:00 AM: 5.5% • 10:00 AM: 5.2% • 11:00 AM: 5.3% • 12:00 PM: 5.5% • 1:00 PM: 5.8% • 2:00 PM: 6.5% • 3:00 PM: 7.4% • 4:00 PM: 7.9% • 5:00 PM: 7.7% • 6:00 PM: 5.8% • 7:00 PM: 4.3% • 8:00 PM: 3.4% • 9:00 PM: 2.7% • 10:00 PM: 1.8% • 11:00 PM: 1.1% Note that while these assumptions have been developed, no reduction in ridership is incorporated as a result of the lack of overnight service.	WSDOT Traffic GeoPortal, 2018

B Stated Preference Survey Results

To better understand the Vancouver – Seattle – Portland travel market, and to estimate behavioral parameters specific to corridor travelers, Steer conducted a behavioral and stated preference (SP) survey of residents in the region. The behavioral survey was used to develop data and forecasting model inputs needed for the UHSGT ridership and revenue study.

This appendix covers the following:

- Survey goal, design, and implementation;
- Sample profile results, including socio-economic profiles, corridor travelers, users' behavioral characteristics, and trip frequencies and patterns; and
- Quantitative behavioral analysis of corridor travelers to derive the parameters (including values of time) to be used in the modelling of the combined airport choice and access mode choice, based on stated preferences from the survey and on observed (revealed) travel behavior.

Survey Design

Survey Goals

The behavioral survey was used to elicit qualitative and quantitative information from travelers who currently make trips along the Vancouver – Seattle – Portland corridor.

The specific goals of the behavioral survey included:

- Collecting trip pattern information to gain insight on the profiles of travelers;
- Developing a qualitative and quantitative understanding of how people make choices between using their car, or flying between cities based on attitudinal questions; and
- Collecting willingness to pay for travel time savings information based on stated preference scenarios.

The survey was designed to collect a wide range of contextual, attitudinal and choice data, as well as socioeconomic and demographic characteristics of current corridor travelers.

The socioeconomic and demographic data was important to identify characteristics of corridor travelers. Contextual data was gathered to identify the factors influencing people's current trip making characteristics (trip length, purpose, party size, etc.). Choice data was collected using Stated Preference (SP) techniques in order to understand people's travel preferences; and attitudinal data was collected to evaluate people's inherent biases and opinions toward the proposed ultra-high-speed ground transport (UHSGT) project.

Survey Design

The survey questionnaire collected revealed preference (RP) and stated preference (SP) data. The RP data informed current corridor travelers' behavior, based on respondents' most recent auto or air trip within the corridor. Travel times and other key information as well as attitudinal information such as attitude toward UHSGT systems were collected. Other information, including more detailed data on trip purpose, income categories and behavioral statements to allow further segmentation, was also collected.

The SP data asked respondents to make choices between hypothetical situations that involved (1) using a new UHSGT service, and (2) using their existing mode of transport (auto or air). The choice exercises were designed to assess the propensity to divert from the existing modes to the UHSGT and the willingness to pay for such a service.

- The questionnaire took no more than 15 minutes to complete for half the respondents, with about 50 questions for any given respondent, including screening questions and the mode choice exercise. The survey was structured as follows:
- Screening question: passengers who did not complete an intercity auto or air trip within the corridor were not retained
- Detailed questions about the current air trip including:
  - Trip purpose, time and day, and trip origin in the corridor area;
  - Mode of travel (air or auto), total travel time;
  - Travel costs and travel party size and luggage.
- An introduction to the UHSGT project, including questions about respondents' attitudes toward the project;
- A mode choice exercise consisting of trade-off questions asking the respondent to make a choice among (1) using the UHSGT service, and (2) using their existing mode of travel;
- Attitudinal questions about choices;
- Questions regarding a potential usage; and
- Socio-economic questions including respondents' income, occupational status, and age.

Survey Implementation

Steer developed the survey, hosted and administered it online, and performed analysis of the survey results. The main survey was completed between October 2018 and January 2019, and a total of more than 3,000 completed surveys were received from a sample of corridor travelers, exceeding the original target of 1,500 completes. The data was further cleaned and a sample of 2,430 completed surveys were retained for analysis.

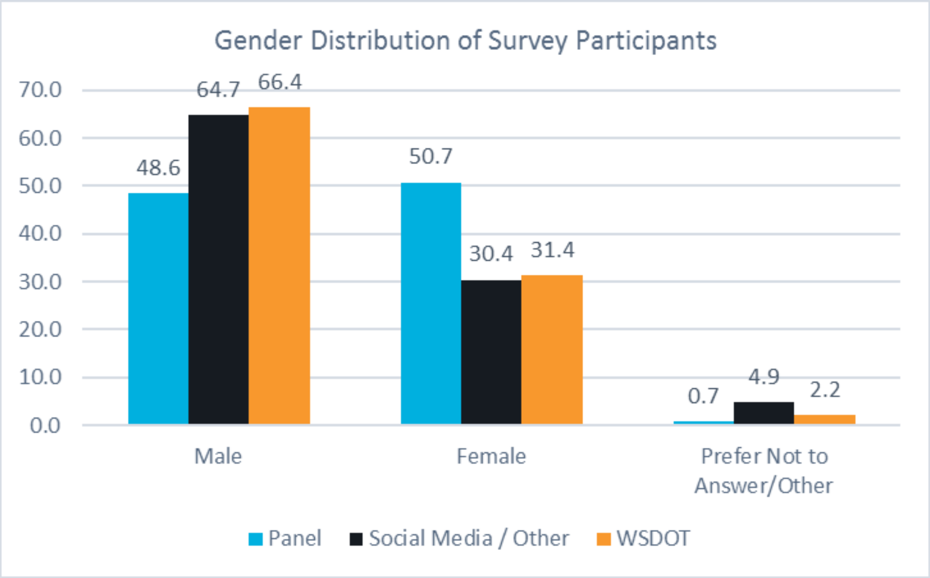
Survey Respondent Characteristics

This section presents a summary of the socio-economic and demographic characteristics of the respondents, their travel conditions, and their attitudinal and travel preferences. Unless indicated otherwise, results below are based on 2,430 responses: 970 from a panel of corridor resident ("panel"), 300 from a social media campaign ("social media"), and 1,160 from WSDOT's outreach effort ("WSDOT").

Demographic and Socioeconomic Characteristics

The panel participants were evenly represented by gender, but the social media and WSDOT respondents were roughly two-thirds male and one-third female. Figure B.24 shows the gender distribution of survey participants.

Figure B.66: Gender distribution of survey participants



The panel participants had an older average age compared to social media and WSDOT participants. The latter were mostly between the ages of 25-34 and 35-44, while the panel had a higher average age of 55-64. Figure B.25 shows the age distribution of participants.

Figure B.67: Age distribution of survey participants

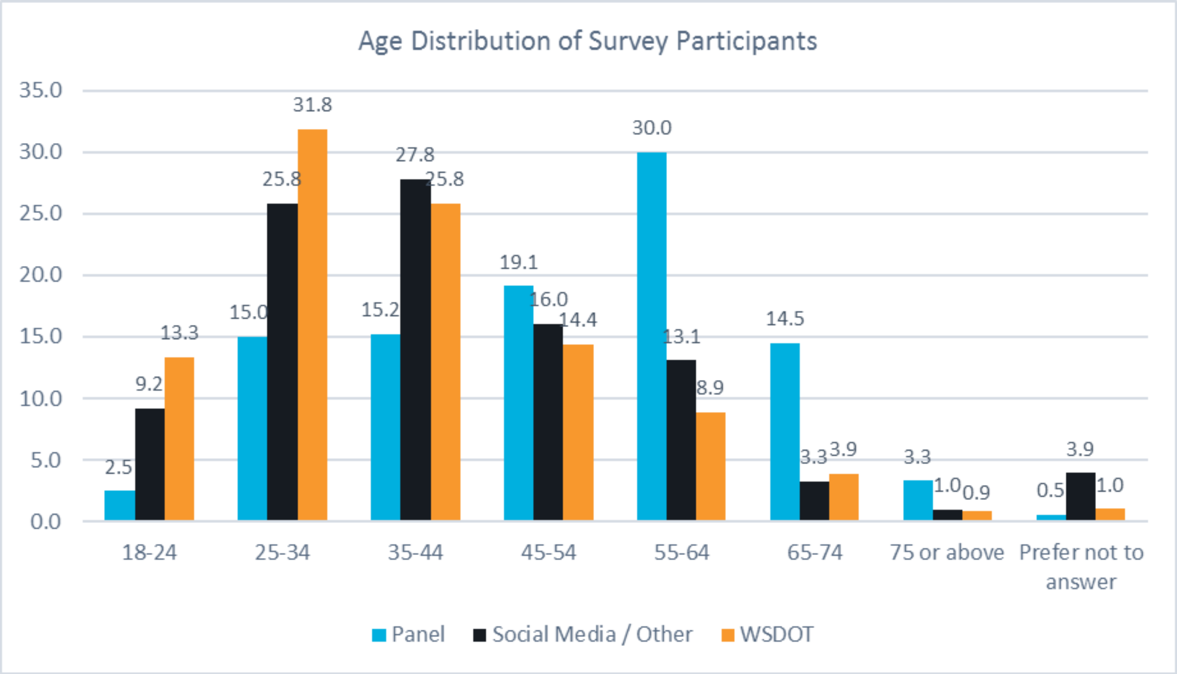
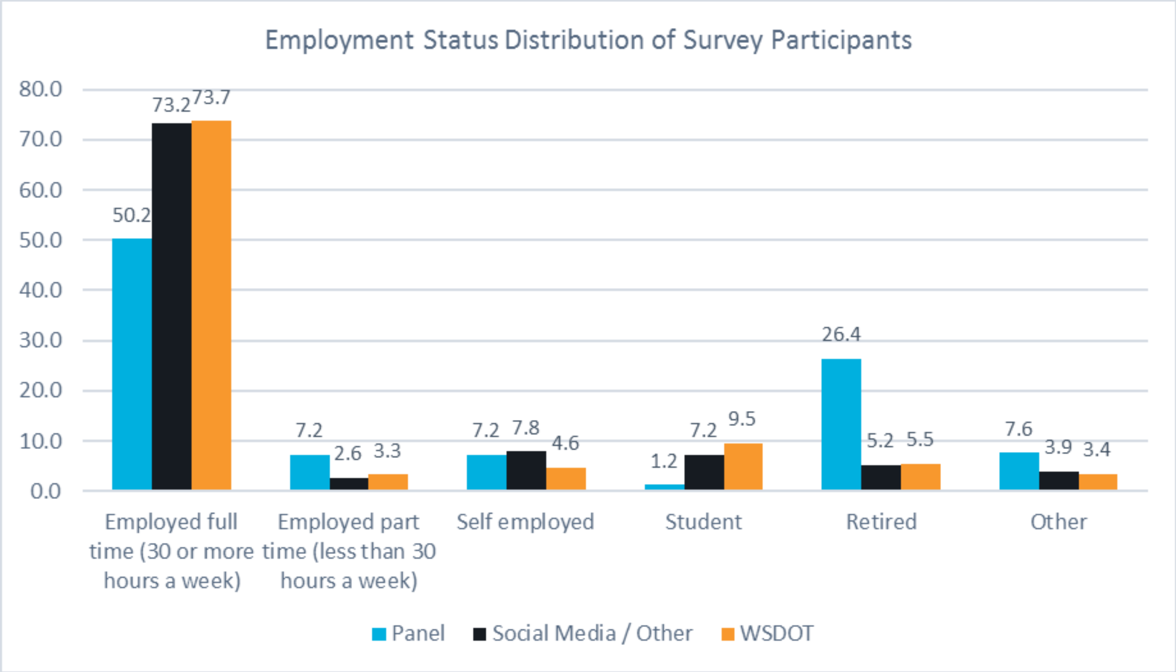


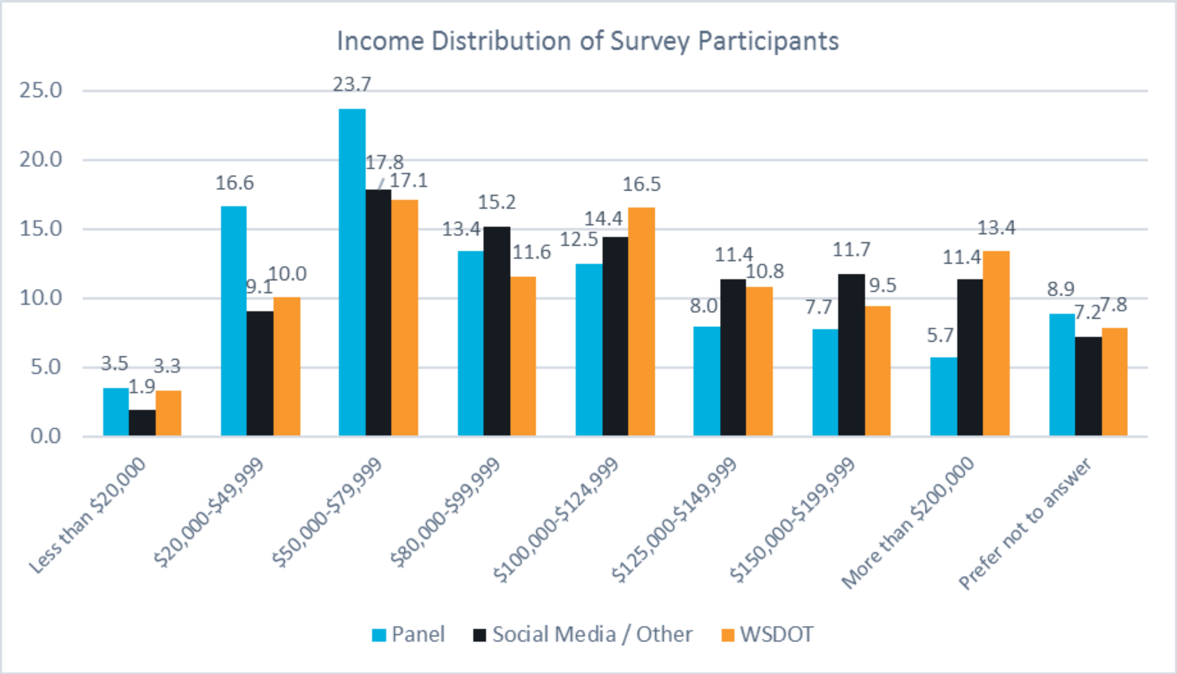
Figure B.26 shows participants' employment status. About half of the panel group was employed full time, a quarter retired, and the rest were a mix of students, unemployed, and other options. The panel group had a notable number of retired participants, whereas the distribution for the social media and WSDOT group were distributed pretty similarly with almost three-quarters of participants being employed full time and only 5% of the participants being retired.

Figure B.68: Employment status distribution of survey participants



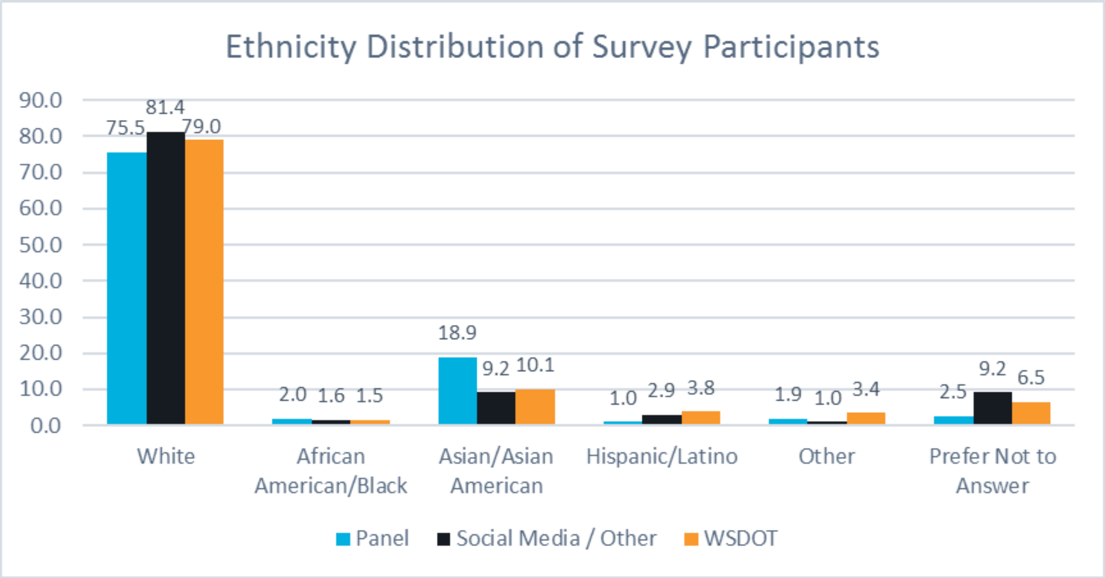
The panel data participants had a different income distribution than the social media and WSDOT survey participants. The income distribution of panel respondents was skewed toward the lower scale, with income buckets of $20,000-$49,000 and $50,000-$79,000 having a relatively larger share than for social media and WSDOT respondents. For the social media and WSDOT surveys, the income was distributed a bit more evenly across the categories, with $50,000-$79,000 being the most common, and $80,000-$99,000 and $100,000-$124,999 being the next most common ranges. Figure B.27 shows the income distribution.

Figure B.69: Income distribution of survey participants



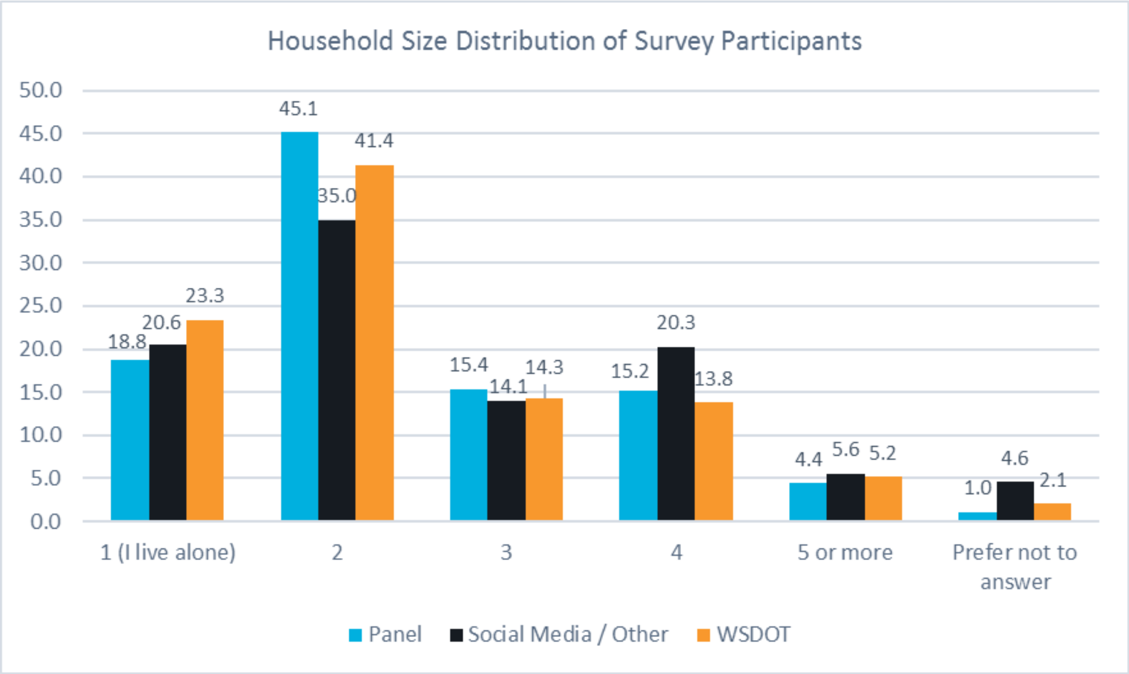
As Figure B.28 shows, the vast majority of survey respondents were white (between 75% and 82% of each survey group), while the second most common ethnicity being Asian/Asian American. The panel group had a smaller share of white respondents and a correspondingly larger share of Asian/Asian American respondents than the other groups, while the WSDOT group had the largest share of Hispanic/Latino respondents of the three groups.

Figure B.70: Ethnicity distribution of survey participants[114]



The most common household size across studies was two, with a household size of one being the second most common. Three- and four-person households were almost equally represented. See the household size distribution in Figure B.29.

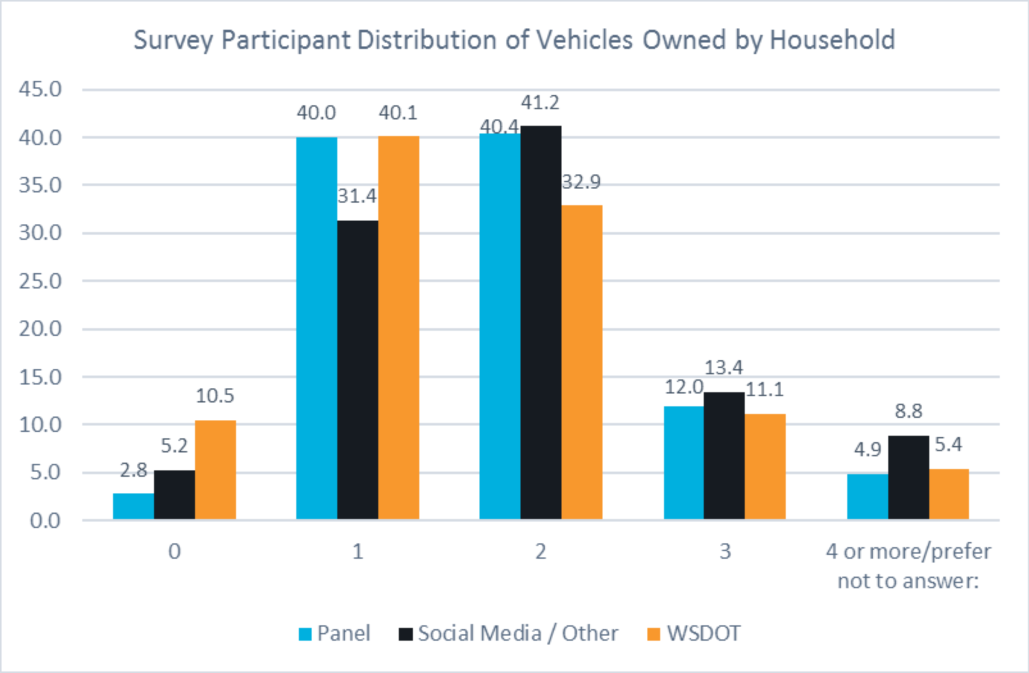
Figure B.71: Household size distribution of survey participants



[114] The percentages across survey groups add to slightly over 100% because the survey allowed multiple ethnicities to be selected.

Most households had either one or two cars, and WSDOT respondents were the group most likely to have zero cars in the household. Figure B.30 shows the distribution of the number of cars households owned.

Figure B.72: Survey participant distribution of vehicles owned by household

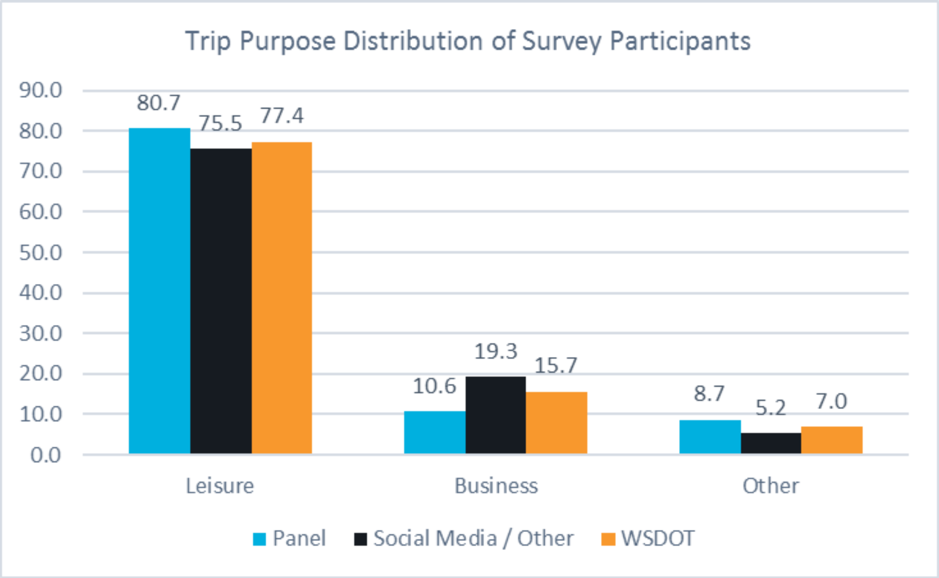


Trip Patterns

The survey collected revealed (observed) data on how travelers made travel decisions for intercity trips in the corridor, with the questions focusing on each respondents' most recent such trip.

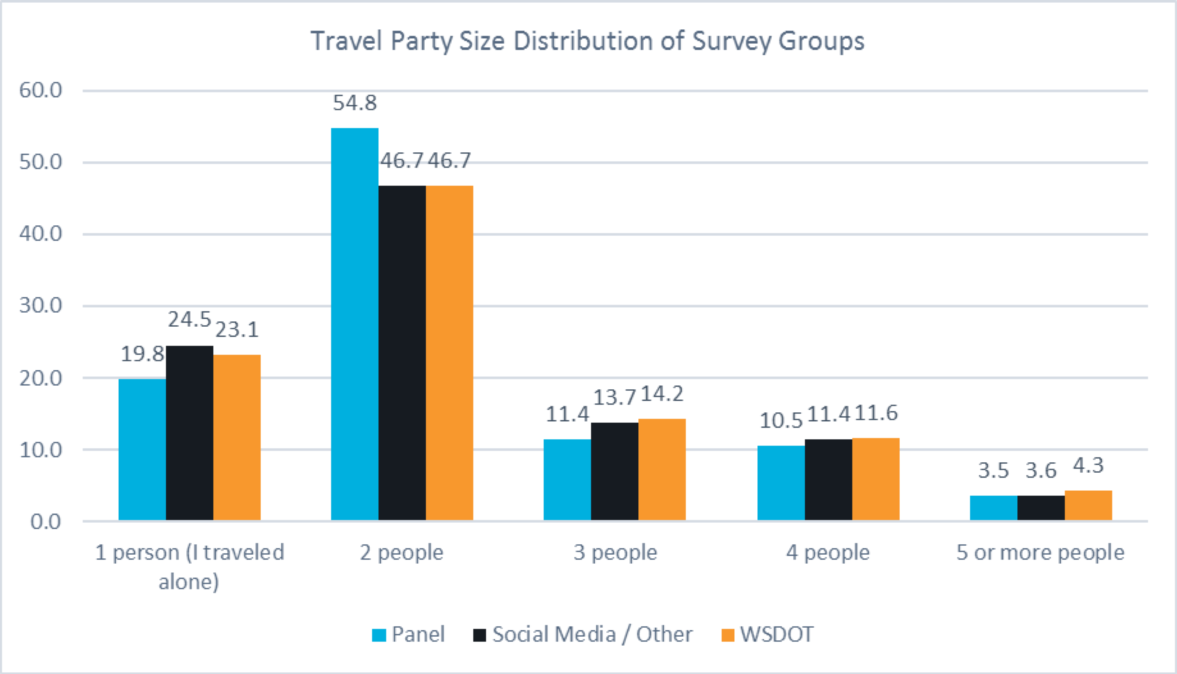
Leisure was the most cited reason for flying, and the different survey groups were similar in their trip purposes. The panel data had a noticeably lower share business travel than the other groups, but also had a higher share of retired participants. Figure B.31 shows the trip distribution of participants across groups.

Figure B.73: Trip purpose distribution of survey participants



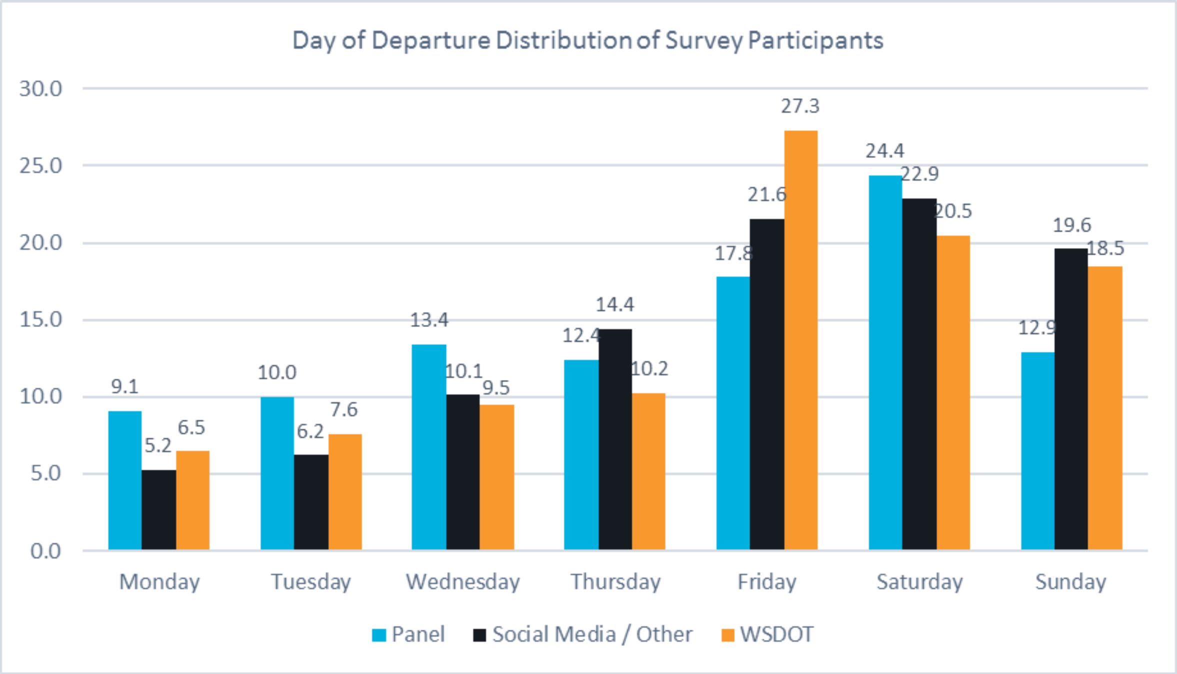
The typical travel party size was two people, with solo travelers being the second most common. Travel party size by survey group can be seen in Figure B.32.

Figure B.74: Travel party size distribution of survey groups



The weekend was the most popular time to leave for a trip, with the majority of participants leaving Friday, Saturday, or Sunday. Figure B.33 shows the distribution of departure day for survey participants.

Figure B.75: Day of departure distribution of survey participants



Trips tended to fall on the shorter side, as shown in Figure B.34. Most of the trips were between one day and four nights, with few participants going on trips that lasted longer than four nights across all three categories.

Figure B.76: Trip length distribution of survey participants

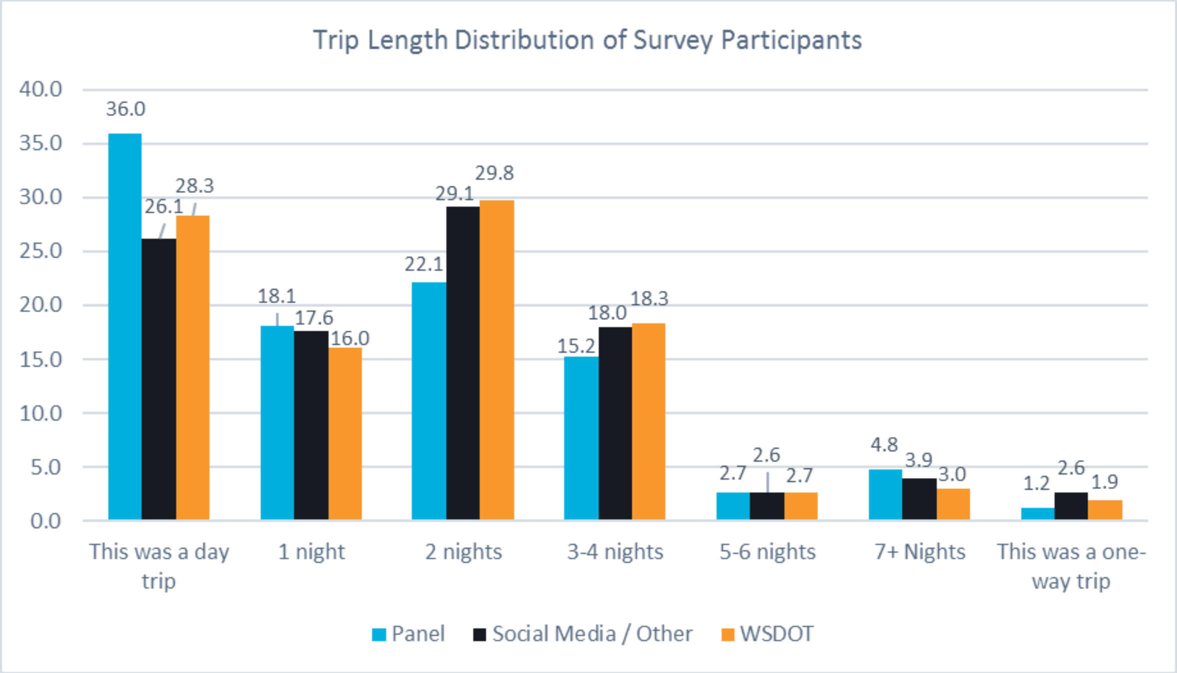


Figure B.35 shows the distribution of when respondents took their most recent trip, which is relatively varied across groups. Most notably, the largest share of social media respondents had not been on a trip in over 6 months.

Figure B.77: Survey participant distribution of most recent trip timing

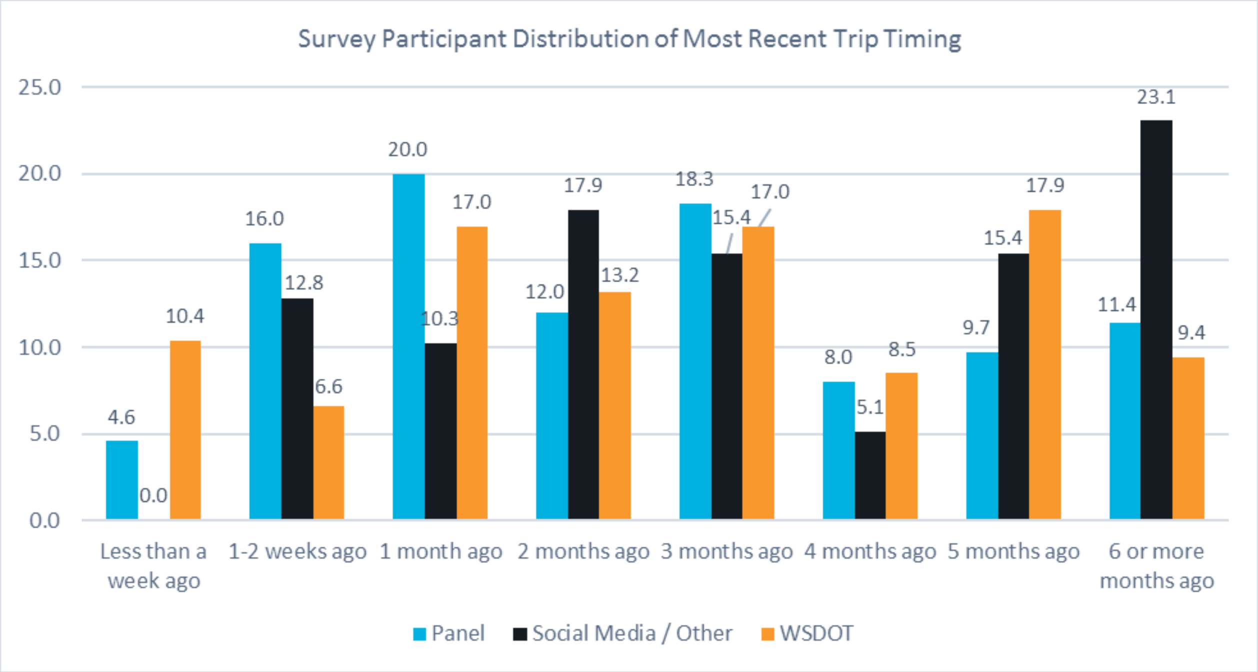
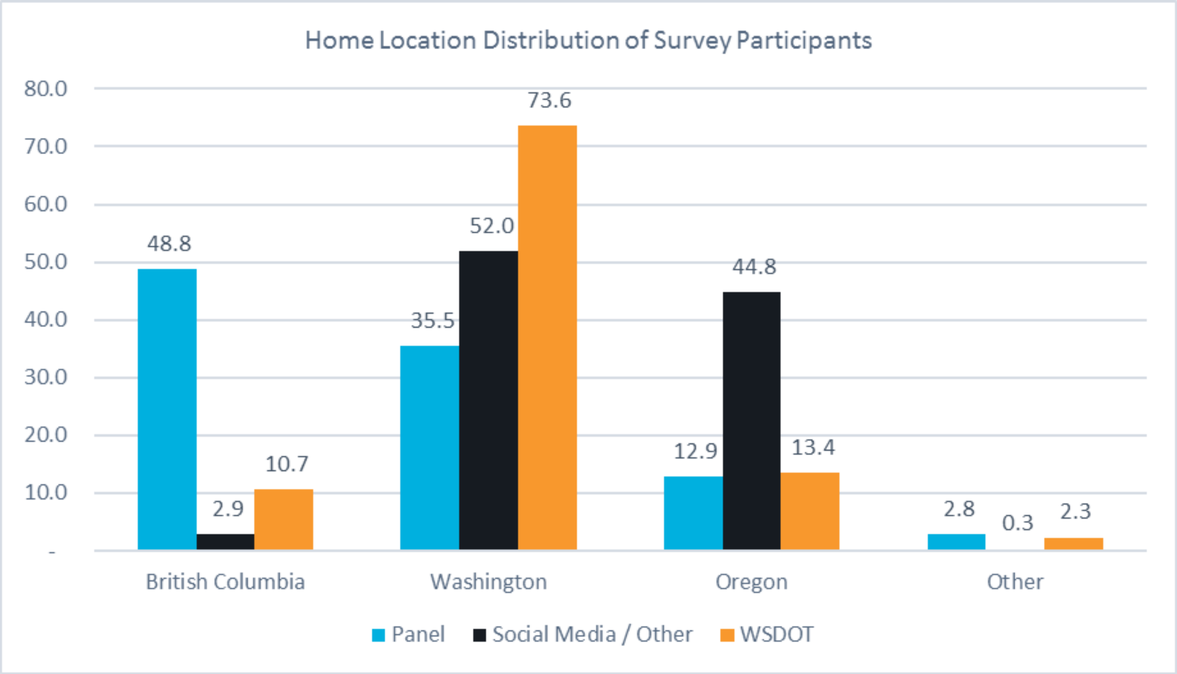


Figure B.36 shows that the three survey groups have different distributions of where respondents live, with the panel data having almost half of the respondents from British Columbia, while the other two survey groups had a much smaller number of Canadian participants. By comparison, almost 75% of WSDOT respondents live in Washington. The social media responses were split pretty equally between Washington and Oregon in the U.S., with a low percentage being from British Columbia.

Figure B.78: Home location distribution of survey participants



The majority of trips taken by survey respondents both originated and ended in the three main urban areas of Seattle, Vancouver, and Portland. Figure B.37 and Figure B.38 show the distribution of trip origins and destinations, respectively, of respondents from the different survey groups.

Figure B.79: Trip origin distribution of survey participants

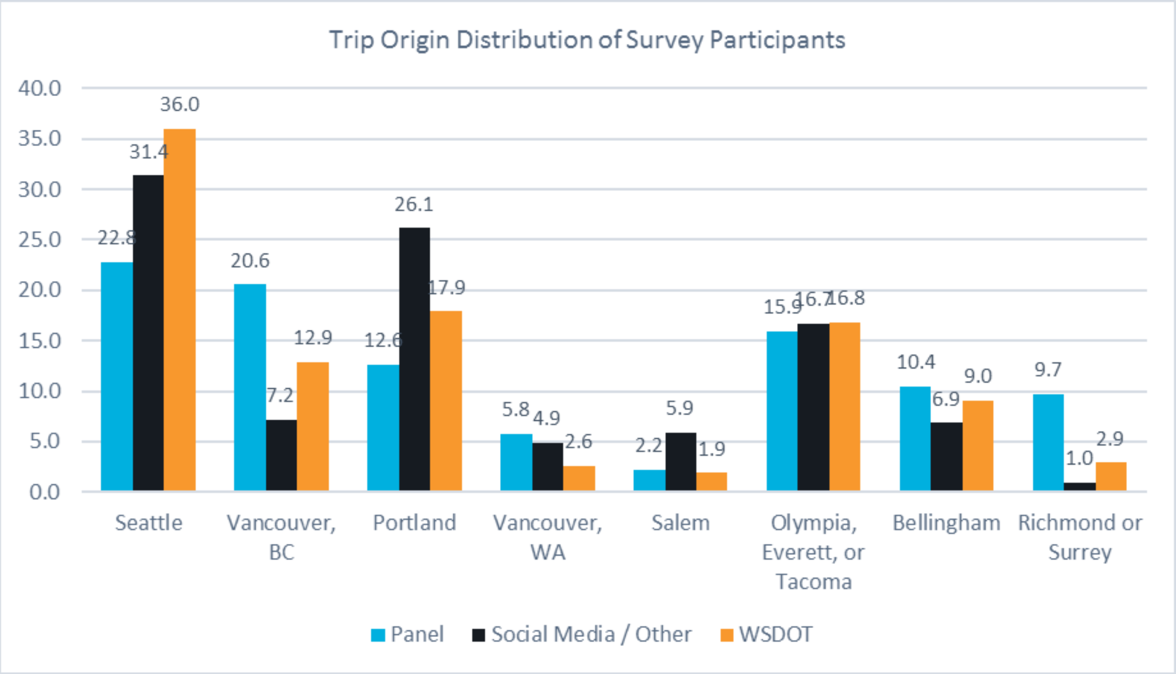


Figure B.80: Trip destination distribution of survey participants

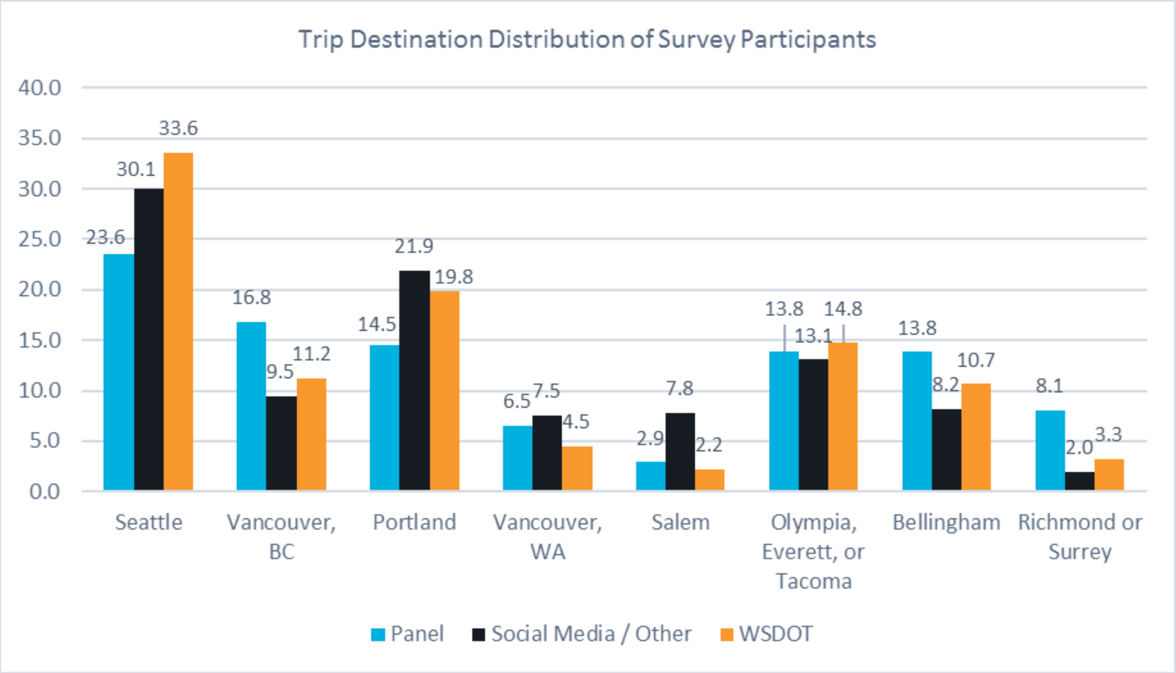


Figure B.39 shows that the number of trips that crossed the US – Canada border was quite different across survey groups. Only 20% of social media respondents and 30% of WSDOT respondents crossed the border, while 55% of panel respondents crossed the border.

Figure B.81: Cross-border trip distribution of survey participants

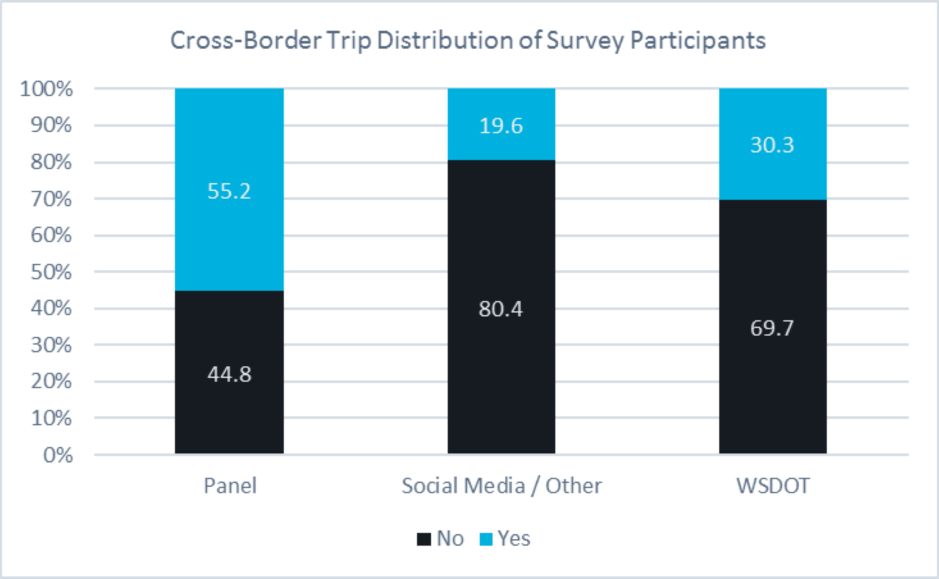
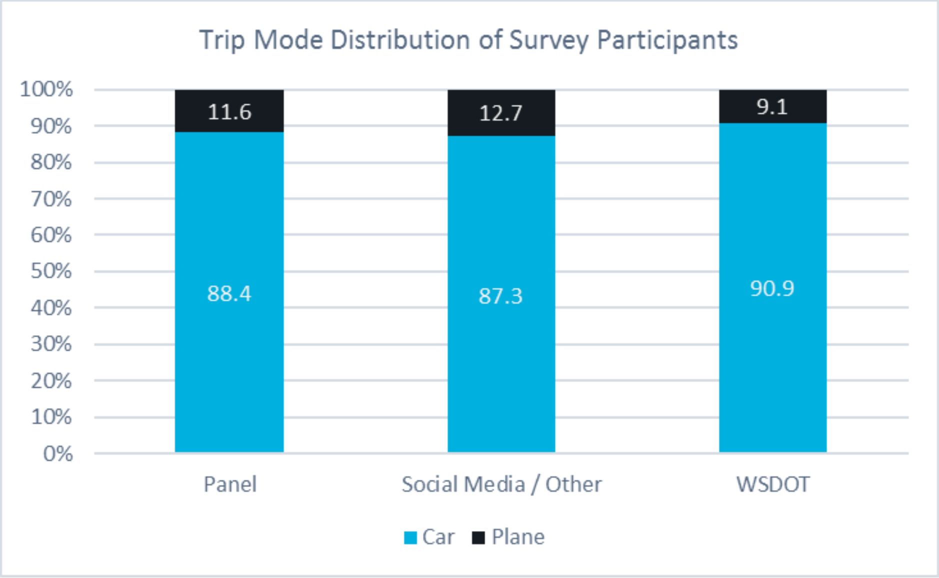


Figure B.40 shows that the majority of intercity trips were taken by car rather than plane, and that survey participants' trip modes did not vary significantly across the different survey groups.

Figure B.82: Trip mode distribution of survey participants



About half of the respondents who traveled by car made a stop on their most recent trip. Of these travelers who stopped, most tended to make only one stop, as Figure B.41 shows. Meanwhile, the longest amount of time spent at a stop is shown in Figure B.42. Most people across survey groups took shorter stops, falling between 15 minutes and an hour.

Figure B.83: Number of stops distribution of survey participants who traveled by car

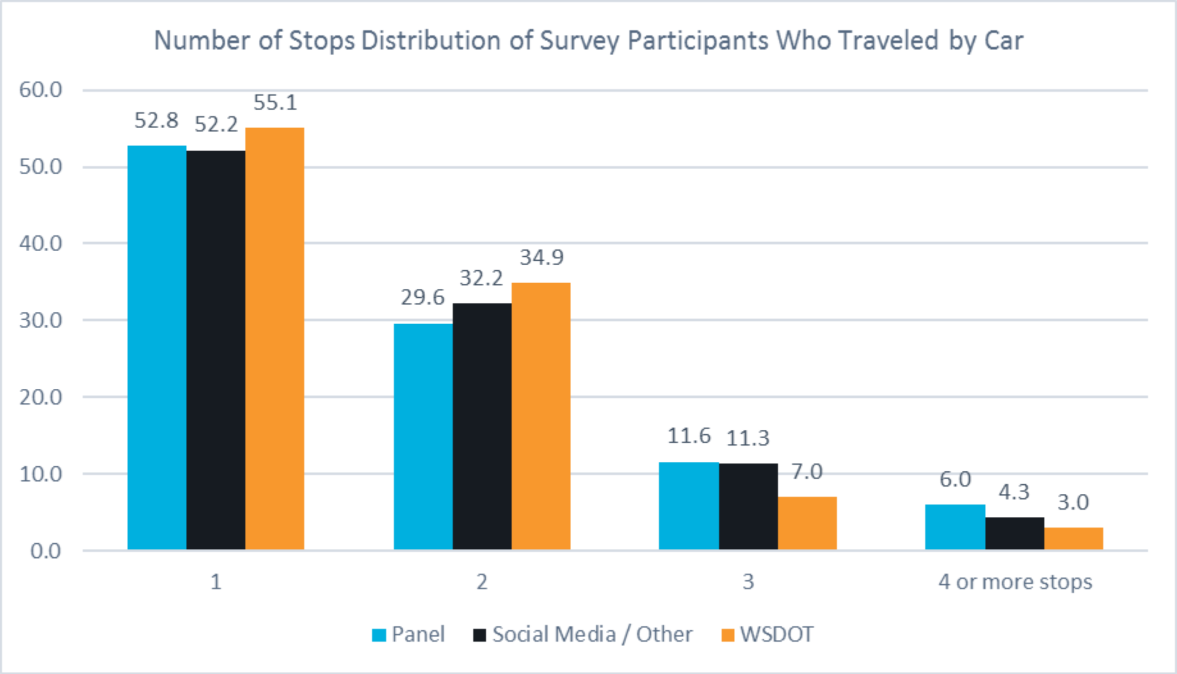
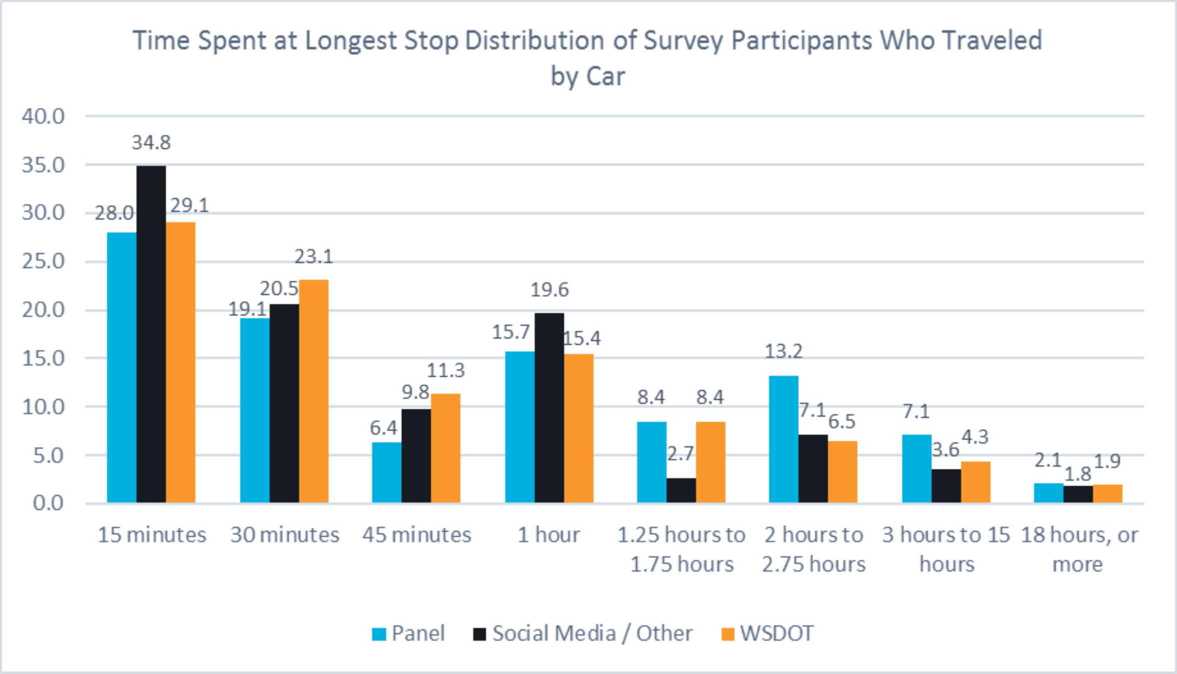
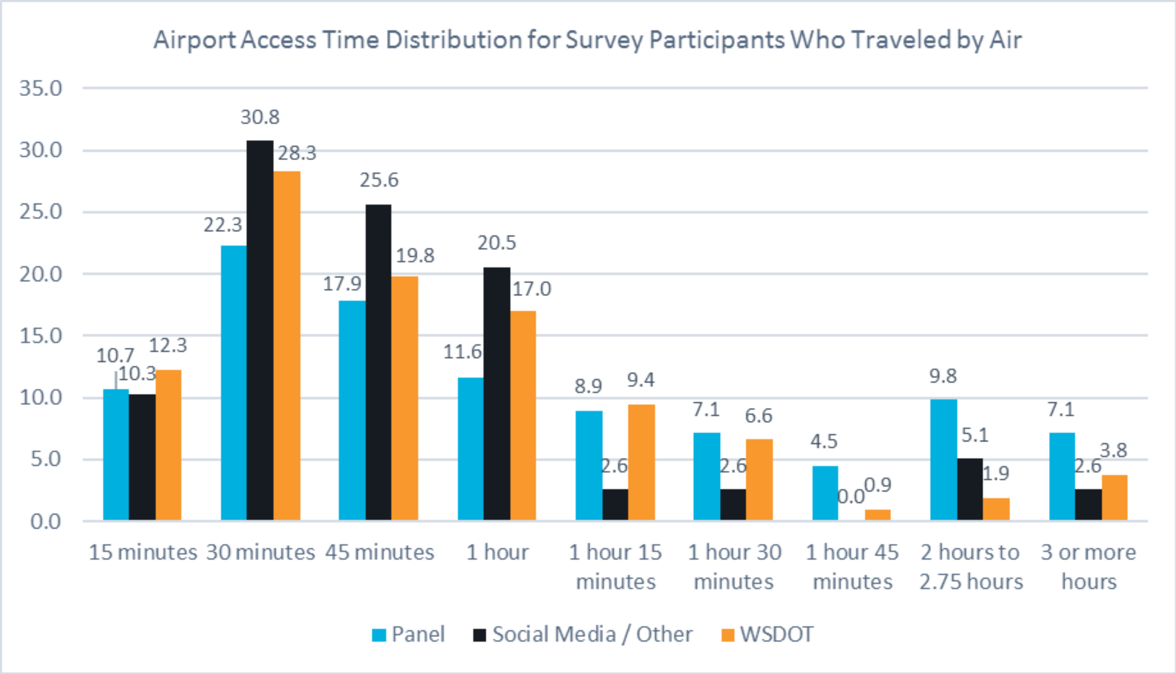


Figure B.84: Time spent at longest stop distribution of survey participants who traveled by car



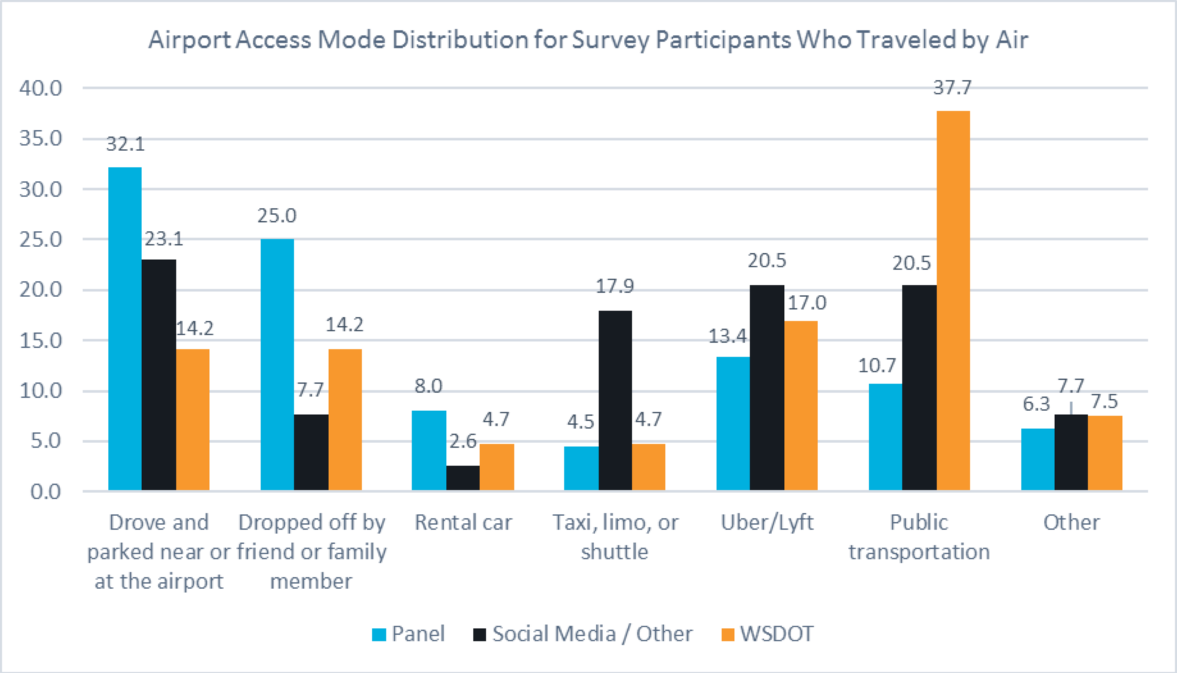
On the other hand, for air travelers, Figure B.43 shows the distribution of access time to the airport. Most access times fell within the half hour to hour range, with longer access times being not as common. The panel survey group tended to have higher access times compared to the other groups.

Figure B.85: Airport access time distribution for survey participants who traveled by air



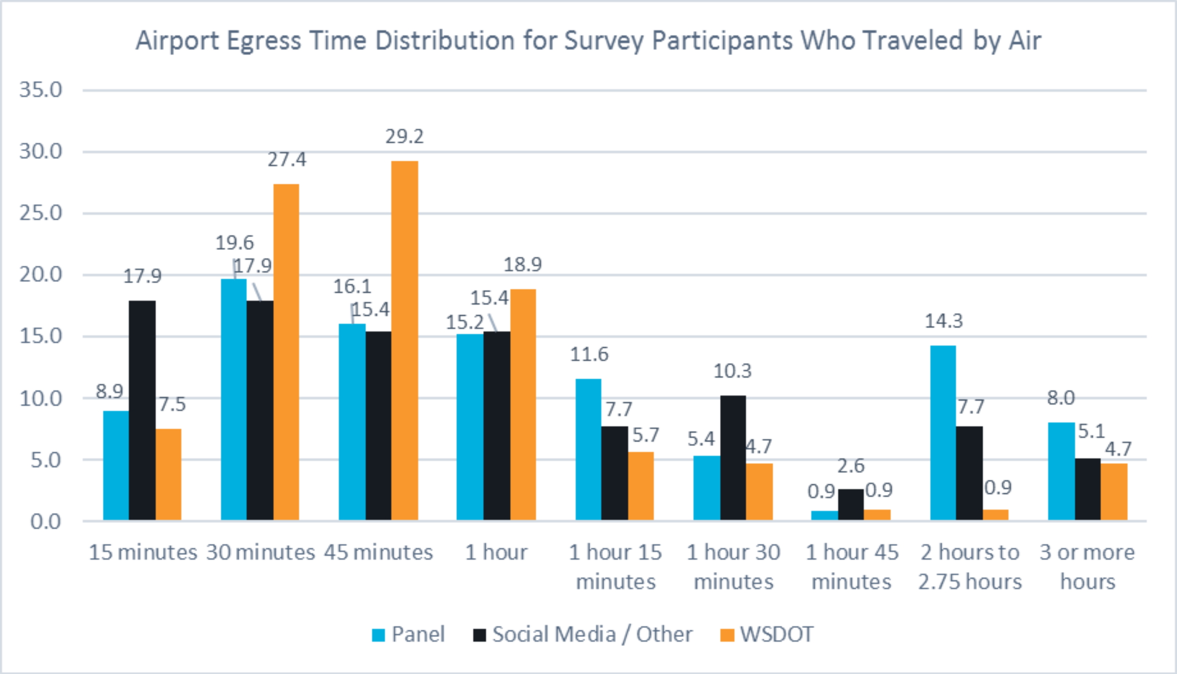
The mode used for airport access varied across the survey groups. The WSDOT survey group was more likely to reach the airport by public transportation, while the panel group was more likely than the others to reach the airport by car, either parking at the airport or being dropped off. The social media group was more likely to be dropped off by taxi, limo, shuttle, or Uber/Lyft than the other two groups. See Figure B.44 below.

Figure B.86: Airport access mode distribution for survey participants who traveled by air



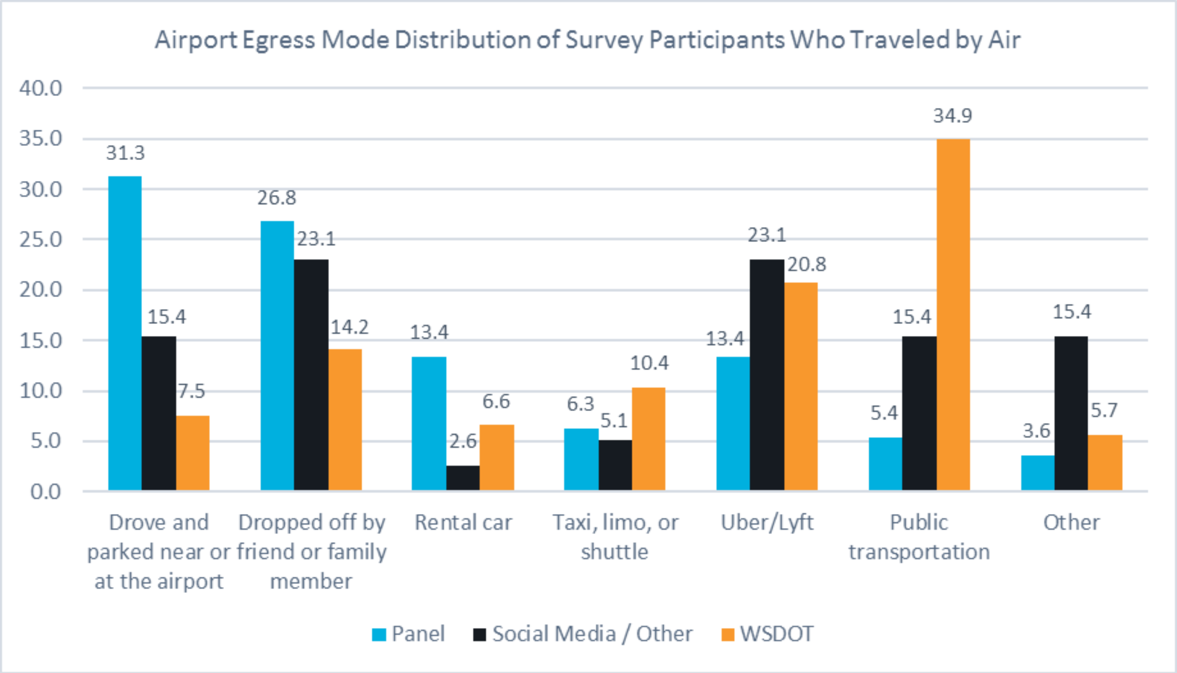
Conversely, travelers typically spent between 15 minutes and an hour to leave the airport and arrive at their travel destination, as Figure B.45 illustrates. The social media group had a much higher share in the 15-minute category than other groups, while the WSDOT group had a higher share in the 30- to 45-minute range than the other groups.

Figure B.87: Airport egress time distribution for survey participants who traveled by air



Similar to access mode, the mode used for airport egress varied across the survey groups. The WSDOT survey group was more likely to leave the airport by public transportation, and the panel group was more likely than the others to leave the airport by car, either from parking at the airport or being picked up. The social media group was more likely to be picked up by Uber/Lyft than the other two groups. See Figure B.46 below.

Figure B.88: Airport egress mode distribution of survey participants who traveled by air



Stated Preferences on UHSGT

Many respondents are aware of and/or familiar with high-speed rail (HSR) as a transportation concept similar to UHSGT, with around half of the social media and WSDOT groups and one third of the panel group reporting having experience with HSR in Europe (Figure B.47). Additionally, about one third of each group reported similar experience with HSR in Asia, as seen in Figure B.48.

Figure B.89: Distribution of survey participants' experience with HSR in Europe

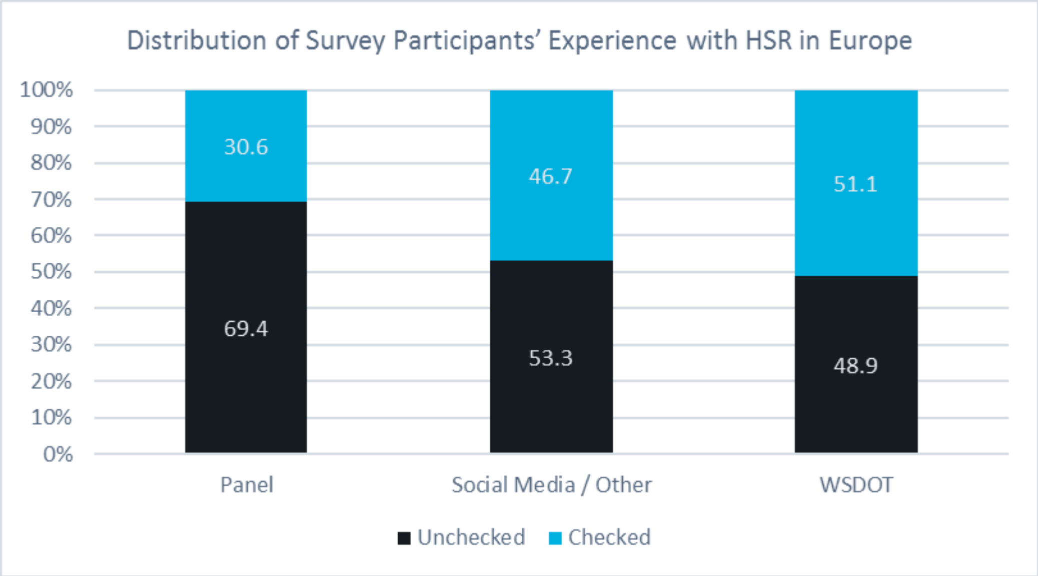
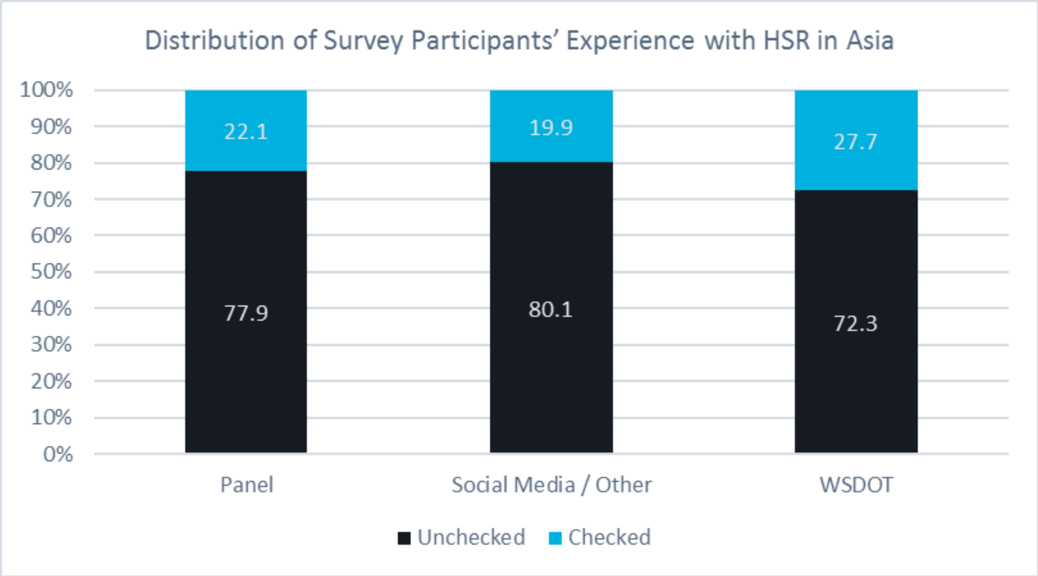
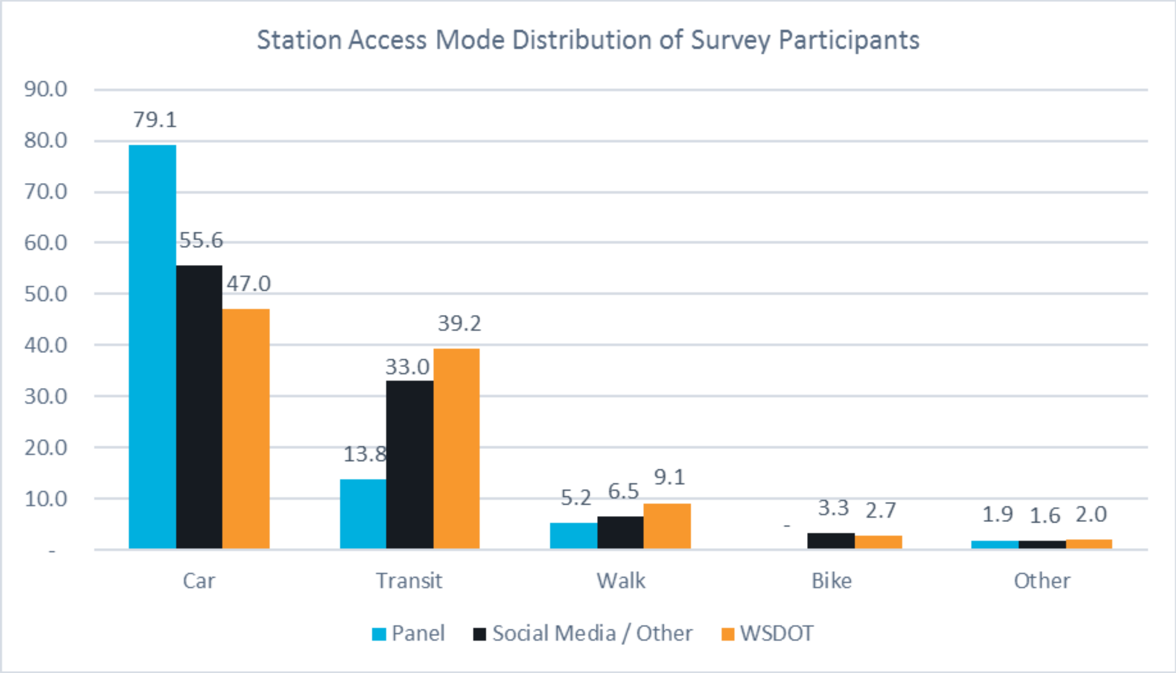


Figure B.90: Distribution of survey participants' experience with HSR in Asia



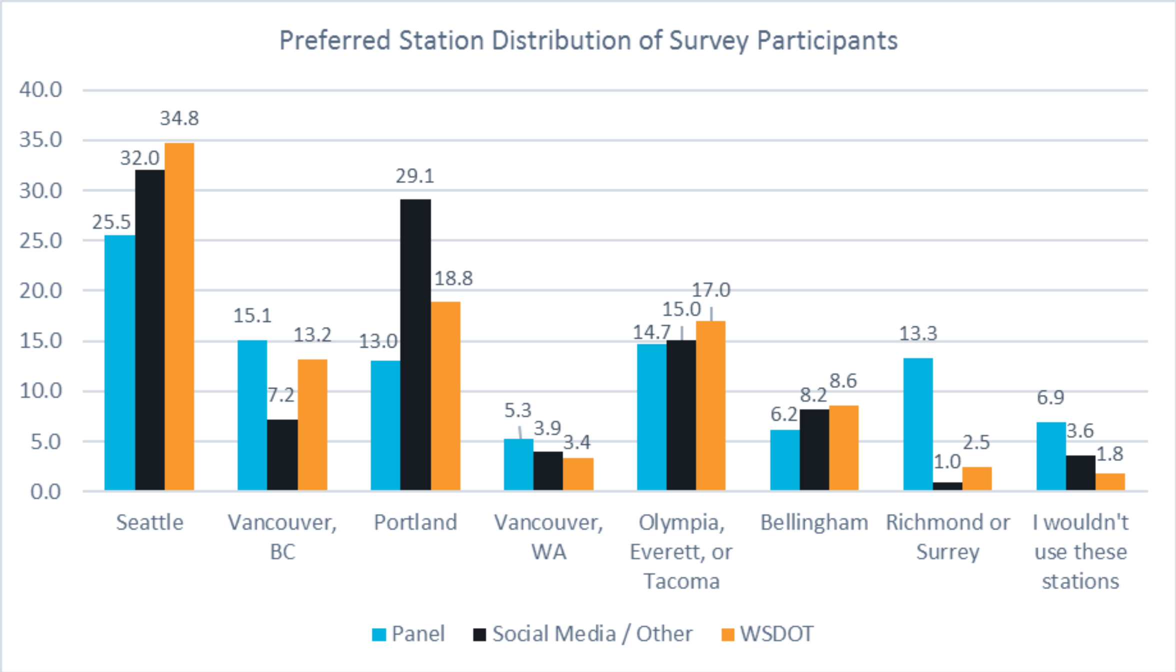
The survey results suggest that the majority of survey participants would prefer to access a hypothetical UHSGT station by car. Panel respondents were most likely to get there by car, while social media and WSDOT participants were more likely to get to the station by transit. Figure B.49 shows the mode preference distribution for traveling to the UHSGT station.

Figure B.91: Station access mode distribution of survey participants



The largest share of survey participants preferred to access a UHSGT station in Seattle, with Portland and Vancouver also being popular choices. Figure B.50 shows the preferred station distribution by survey group.

Figure B.92: Preferred station distribution of survey participants



Survey participants' stated interest in UHSGT is shown in Figure B.51 through Figure B.56, which show how they responded various statements about UHSGT. Overall, they were receptive to the improved level of service UHSGT can offer: Figure B.51 and Figure B.52 show that the majority of respondents across all groups strongly agreed with the potential for UHSGT to offer travel time savings and reduce the time spent in airport security lines, respectively. In addition, survey participants appeared to be excited about the idea of a new, improved mode of travel in the Cascadia Megaregion: again, the majority of respondents thought that UHSGT would be a fun way to travel (Figure B.55) and expressed interest in trying the new service (Figure B.56).

Figure B.93: Distribution of survey participant responses to "UHSGT would definitely be faster than taking a different mode"

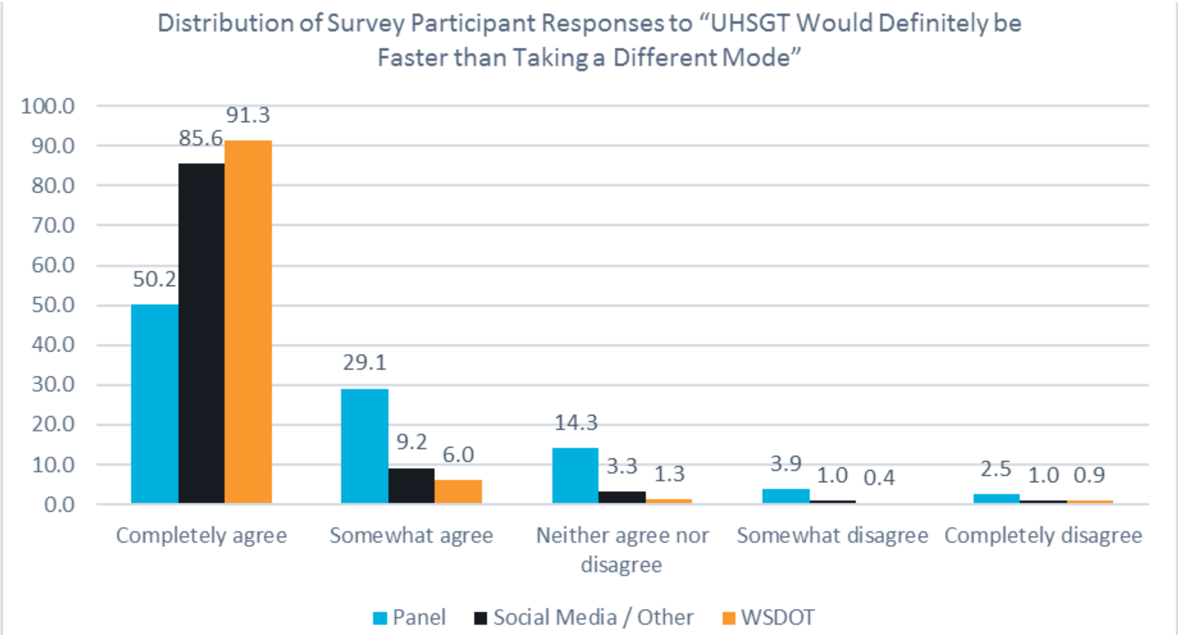


Figure B.94: Distribution of survey participant responses to "UHSGT means I will avoid the lines at the airport"

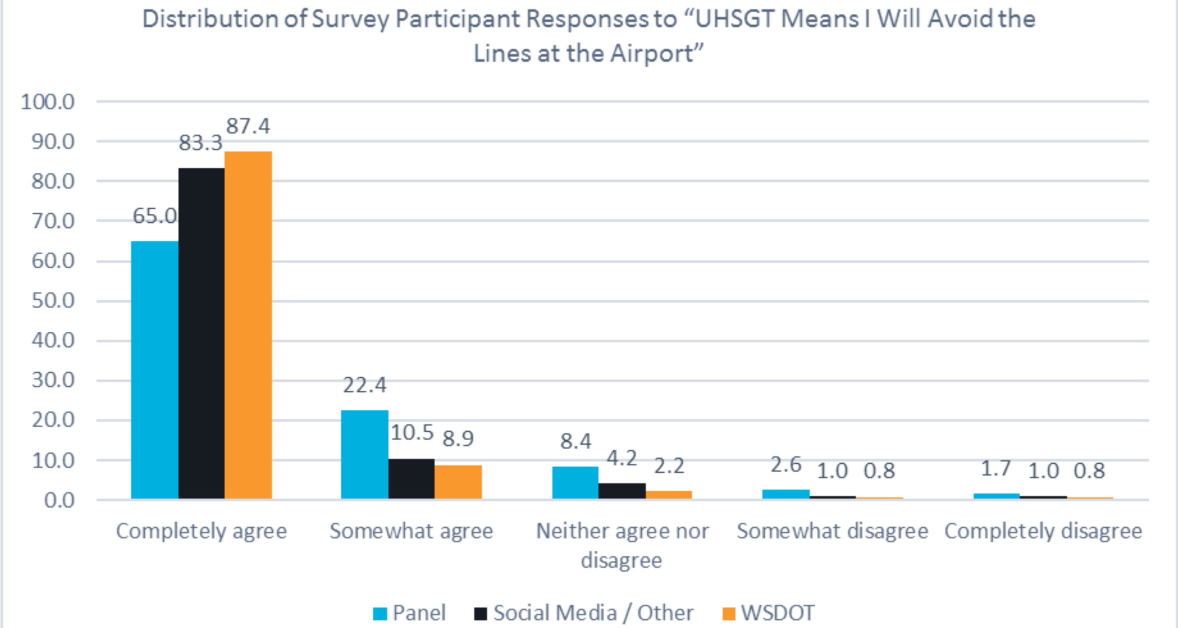


Figure B.95: Distribution of survey participant responses to "UHSGT sounds like a relaxing way to travel"

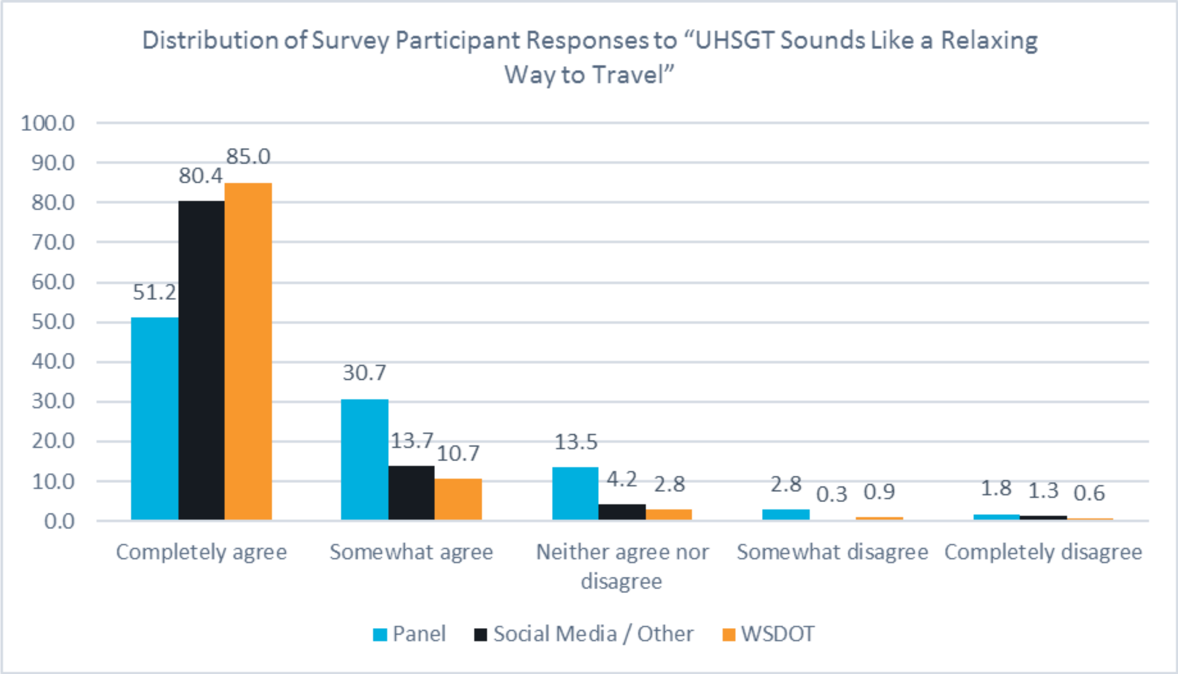


Figure B.96: Distribution of survey participant responses to “UHSGT will mean I can stay longer at my trip destination”

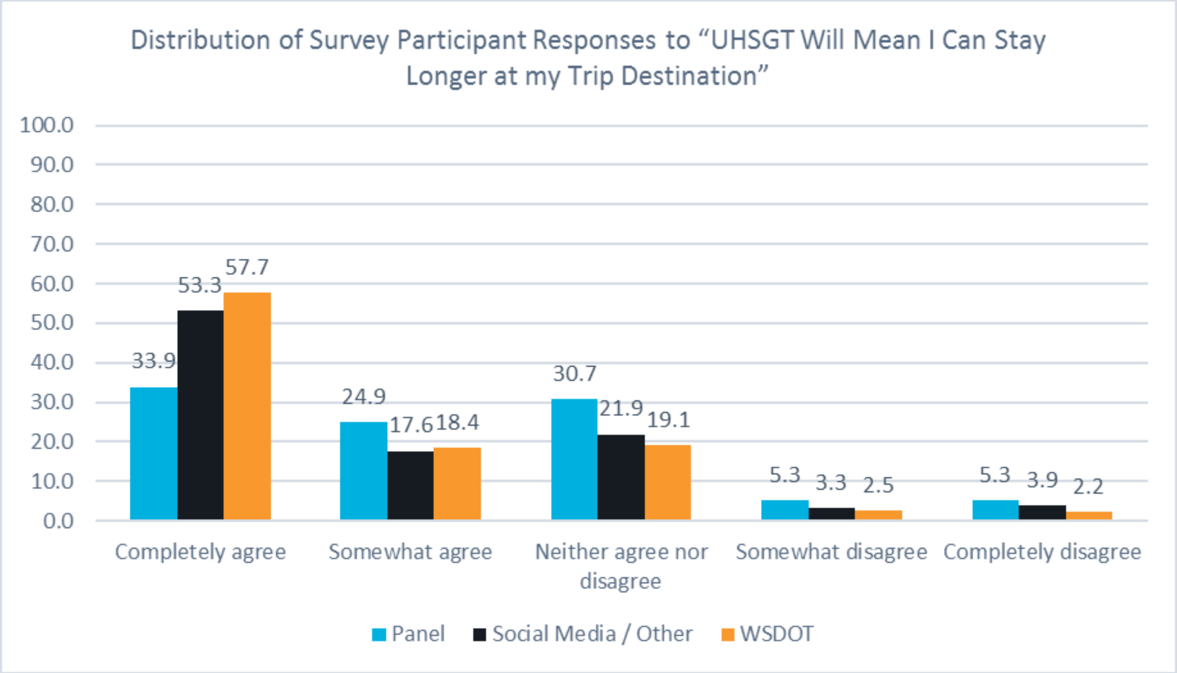


Figure B.97: Distribution of survey participant responses to “UHSGT sounds like fun”

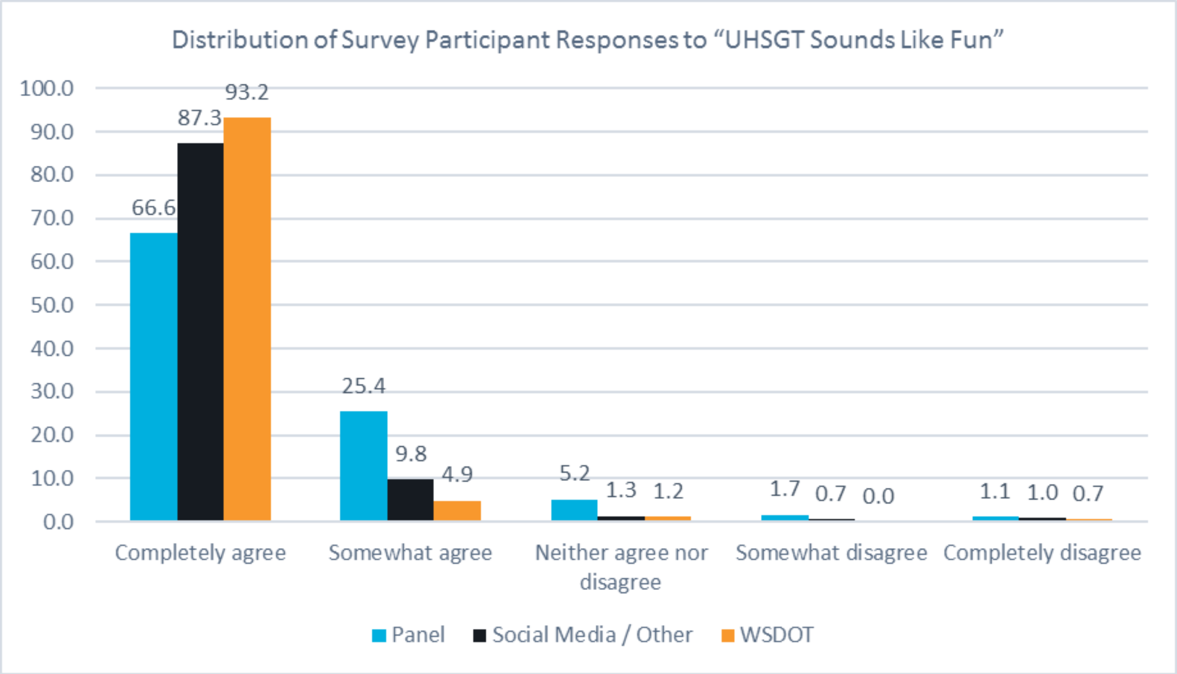
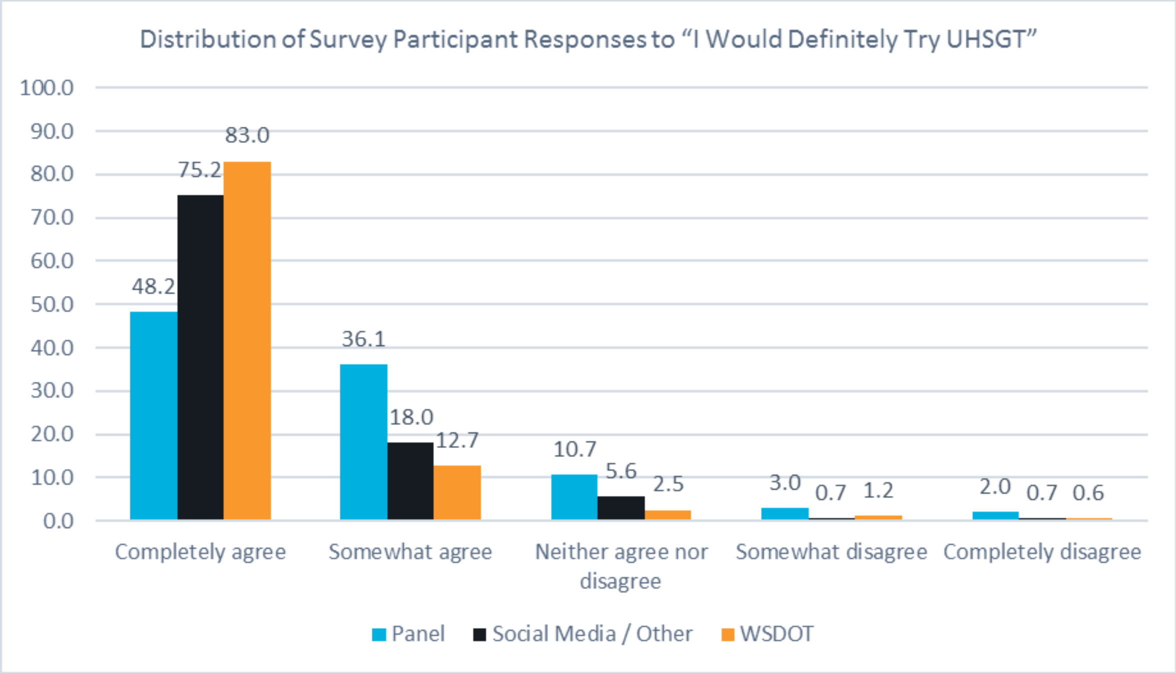


Figure B.98: Distribution of survey participant responses to "I would definitely try UHSGT"



Survey participants were asked to select one or more primary reasons they would choose to take UHSGT. The top reasons they selected include: shorter travel time (Figure B.57), higher travel speeds (Figure B.58), more frequent departures (Figure B.59) and reduced environmental impacts (Figure B.60).

Figure B.99: Distribution of survey participants who would take UHSGT because travel times are shorter

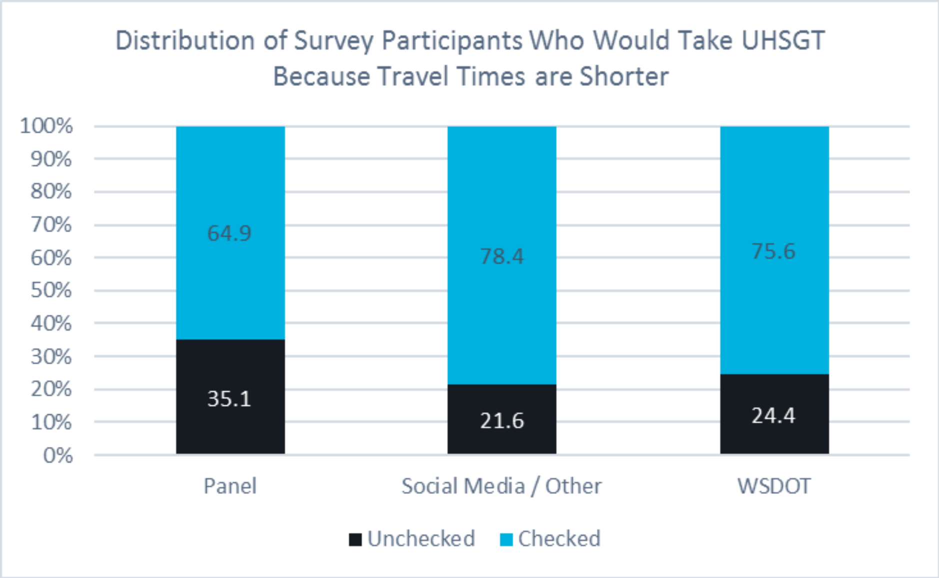


Figure B.100: Distribution of survey participants who would take UHSGT because travel speeds are faster

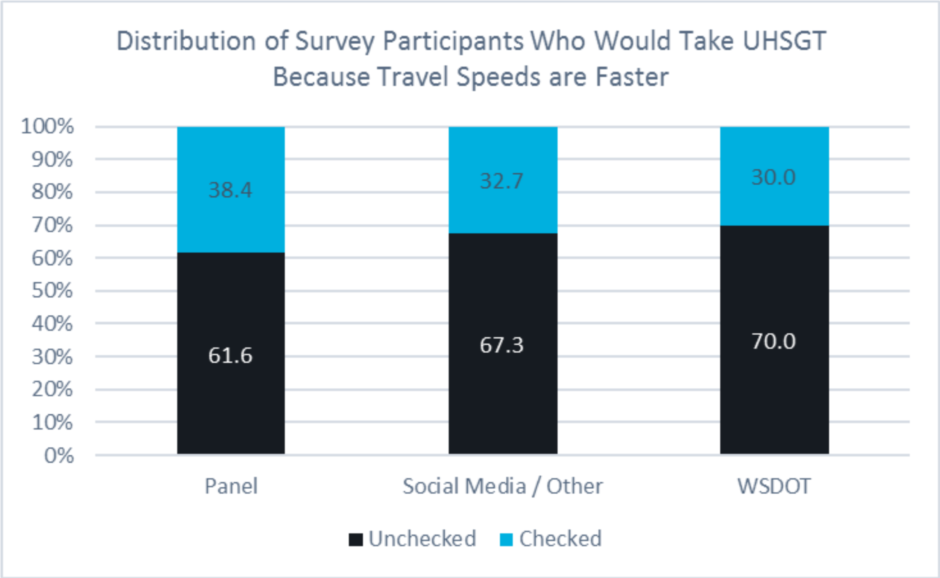


Figure B.101: Distribution of survey participants who would take UHSGT because of frequent departures

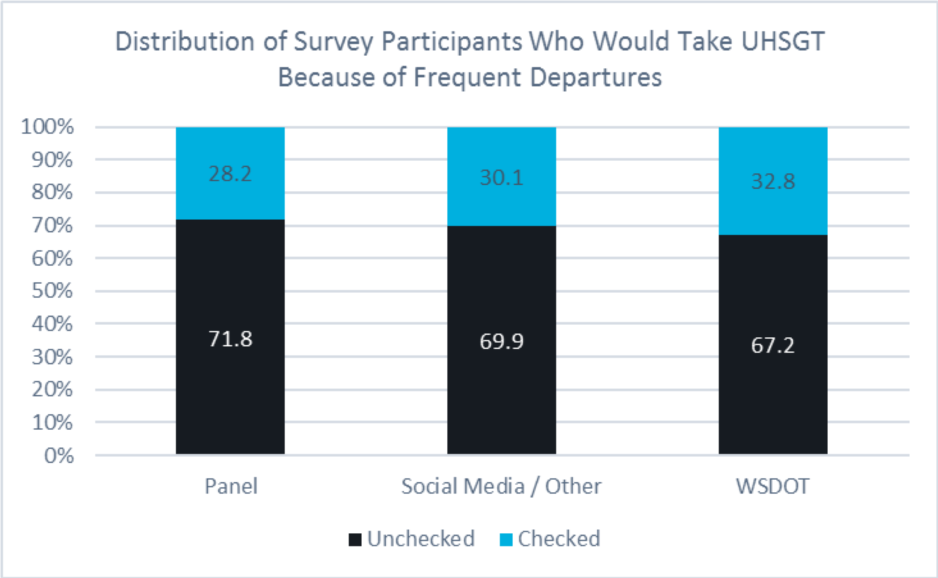
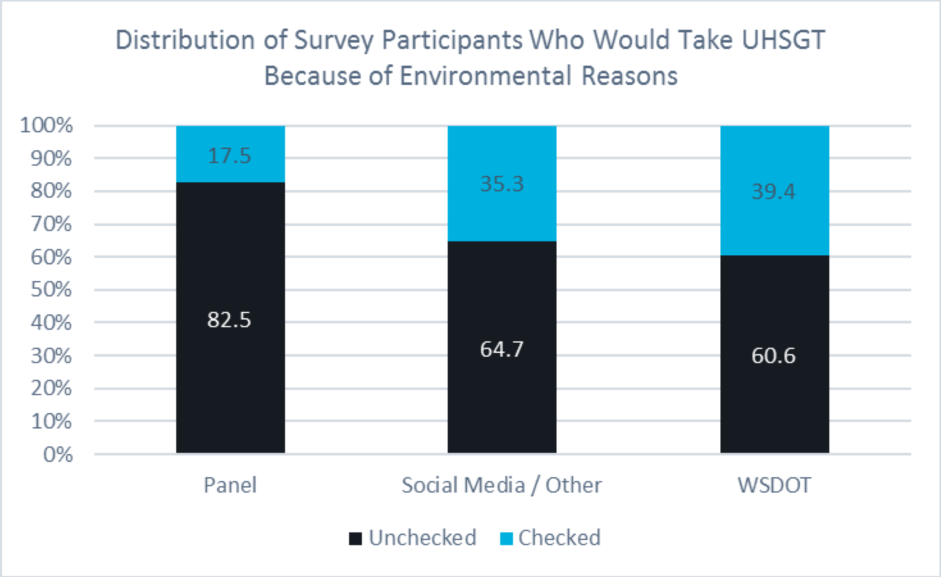


Figure B.102: Distribution of survey participants who would take UHSGT because of environmental reasons



Conversely, when asked the main reasons they would not take UHSGT, respondents overwhelmingly cited the potentially high price of a ticket (Figure B.61). Another stated key reason for not choosing UHSGT was the need for a car at the destination (Figure B.62).

Figure B.103: Distribution of survey participants who would not take UHSGT because of high ticket prices

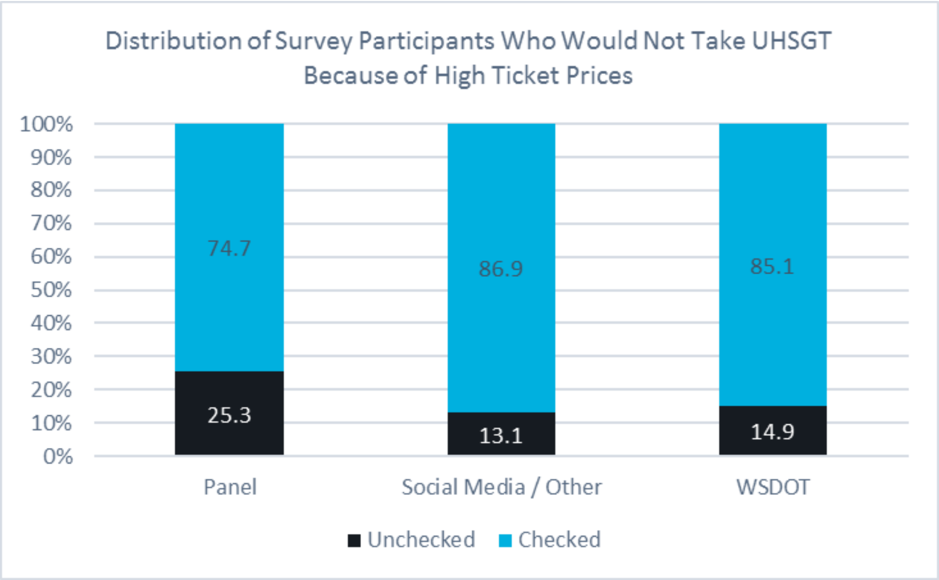
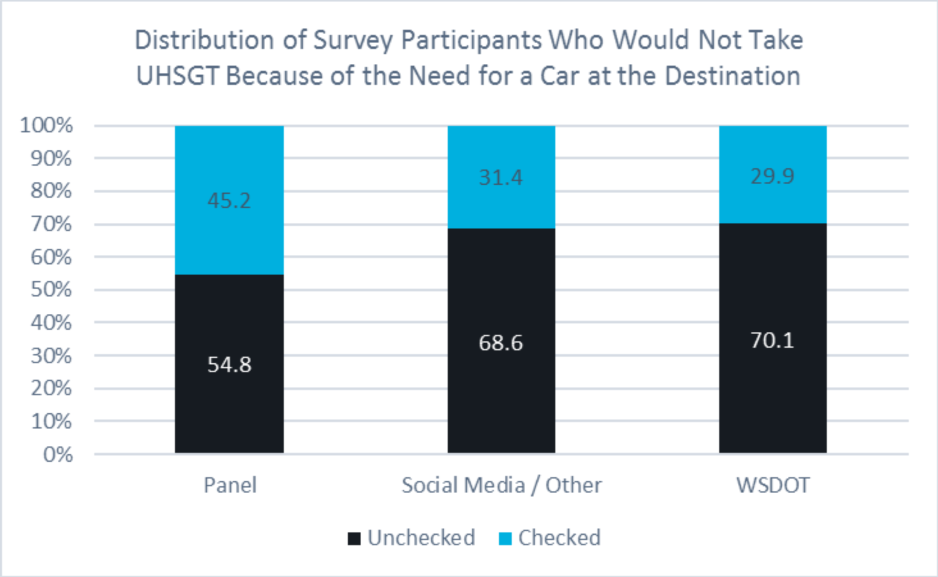


Figure B.104: Distribution of survey participants who would not take UHSGT because of the need for a car at the destination



Mode Choice Models

As described in Section 4, the model for forecasting UHSGT ridership and revenue implements a well-established three-stage process:

- In the first step, the base year demand and growth of the travel markets to the year of analysis is estimated.
- In the second step, the mode shares for all of the intercity travel modes (auto, air, bus and existing rail) and the new UHSGT mode are calculated using mode choice models developed as part of this study. The mode shares are applied to the travel market demand to obtain an estimate of the number of trips diverted to UHSGT.
- In the final step, the volume of induced ridership is estimated, and this is added to the forecast of diverted UHSGT trips to produce the total ridership forecast.

To predict shares for a new mode, where observations of travelers' actual choices are not available, mode choice models are developed using statistical analysis of the stated preference (SP) data collected from the online survey, which yielded 2,430 responses to be analyzed. This analysis was supplemented with results from intercity passenger rail studies around the world.

Two types of mode choice models were used:

- Intercity mode choice models, assessing travelers' preferences for their existing mode of transport (auto, air, bus, or rail) compared to UHSGT for the main, intercity leg of their journey; and

- Access and egress mode choice models, assessing travelers' preferences among available access and egress modes to and from the UHSGT station.

Intercity Mode Choice Models

Existing travel within the corridor is primarily made by auto and to a lesser extent air; as such, the focus of the work was in estimating the behavioral parameters affecting the diversion of auto and air travelers to the UHSGT mode, using binary logit models of travelers' choices between auto and UHSGT and between air and UHSGT. The probability of diversion to the new mode is directly given by the probability of choosing the UHSGT option, as provided by the binary logit model. As intercity travel by bus and rail is much less prominent in the corridor, binary logit models for these modes were asserted using best practice knowledge from other similar transportation systems, rather than estimated using SP survey data.

Auto and air mode choice models were estimated for application to two market segments, defined in terms of the purpose for which a trip is made: business (including commuting trips) and non-business. Several auto and air mode choice models were specified, estimated, and tested using the SP survey data. The attributes tested and retained in the final model include total travel cost (comprising access and egress costs, fares, gas cost and parking cost), in-vehicle time, access and egress time, wait time, service frequency, and modal constants. With the exception of some modal constants, the model coefficients were all directly estimated by applying standard statistical methods to the newly collected SP survey data; they did not need to be constrained or otherwise forced to reasonable values.

Table B.25 shows the variables and notation conventions used in model estimation.

Table B.85: Variables and notations used in model estimation

Description	Variable	Units	Range
Modes	i	Set of choices	$i = \{auto/plane, HSR, maglev, hyperloop\}$[115]
Mode-specific cost	c_i	USD	continuous
Mode-specific time	t_i^v	Minutes	continuous
Access time	t_i^a	Minutes	continuous
Frequency *Number of vehicles operating during business hours*	$freq_i$	Vehicles	$freq_i \in \mathbb{Z}^+$
Trip purpose	$\delta_{business}$	Binary	$\delta_{business} = \begin{cases} 1 & business\ trip \\ 0 & otherwise \end{cases}$
Household Income	$income_n$	10K USD	continuous

115 HSR, Maglev, and Hyperloop correspond to the various technology options being considered for UHSGT. Each mode was estimated separately due to potentially different values of various service attributes placed by customers.

Table B.26 shows the coefficients used in the final auto binary logit model.

Table B.86: Coefficients specified in auto model

Coefficient Name	Coefficient
Mode-specific Constants; Business and Non-business *$a_{auto,business}$ and $a_{auto,other}$ is set to 0 for estimation*	$\alpha_{i,business}$ and $\alpha_{i,other}$
Income-modified Cost Coefficient; Business and Non-business	$\beta_{cost,business}$ and $\beta_{cost,other}$
In-vehicle Time Coefficient; Business and Non-business	$\beta_{time,business}$ and $\beta_{time,other}$
Access Time Coefficient	β_{access}
Adjusted Frequency Coefficient $adjusted\ frequency = \ln(1 - e^{-0.08*freq_i})$ Where $freq_i$ is the number of vehicles operating in an 18-hour period, such that 18 corresponds to once per hour.	$\beta_{frequency}$
Stops Coefficient	β_{stops}

The structural utility for the binary auto diversion takes on the following form for individual n:

$$V_{auto} = \delta_{business}\left(\alpha_{auto,business} + \beta_{cost,business}\frac{c_{auto}}{\ln(income_n)} + \beta_{time,business}\, t^v_{auto}\right)$$

$$+(1-\delta_{business})\left(\alpha_{auto,other} + \beta_{cost,other}\frac{c_{auto}}{\ln(income_n)} + \beta_{time,other}\, t_{auto}\right)$$

$$U_{i\neq auto} = \delta_{business}\left(\sum_i \alpha_{i,business}\delta_i + \beta_{cost,business}\frac{c_i}{\ln(income_n)} + \beta_{time,business}\, t^v_i\right)$$

$$+(1-\delta_{business})\left(\sum_i \alpha_{i,other}\delta_i + \beta_{cost,other}\frac{c_i}{\ln(income)} + \beta_{time,other}\, t^v_i\right)$$

$$+\beta_{access}\, t^a_i + \beta_{frequency}\ln\left(1 - e^{-0.08*freq_i}\right)$$

The coefficients estimated for the auto models are shown in Table B.27.

Table B.87: Estimated coefficients in auto model

Coefficient	Value	Standard	p-Value
$\alpha_{auto,business}$	0	--	--
$\alpha_{auto,other}$	0	--	--
$\alpha_{HSR,business}$[116]	0	--	--
$\alpha_{HSR,other}$	-0.0836	0.0908	0.36
$\beta_{time,business}$	-0.0104	0.00168	0.00
$\beta_{time,other}$	-0.00757	0.000643	0.00
$\beta_{cost,business}$[117]	-0.0517	0.0109	0.00
$\beta_{cost,other}$*	-0.0556	0.00392	0.00
β_{access}	-0.0155	0.00133	0.00
$\beta_{frequency}$	0.311	0.0535	0.00

[116] Not statistically significant; set to 0.
[117] This and all subsequent cost coefficients are applied to the travel cost normalized for income by dividing by the natural logarithm of household income (in thousands of dollars).

Similarly, the coefficients defined for the air models are shown in Table B.28.

Table B.88: Coefficients specified in air model

Coefficient Name	Coefficient
Mode-specific Constants; Business and Non-business *$a_{auto,business}$ and $a_{auto,other}$ is set to 0 for estimation*	$\alpha_{i,business}$ and $\alpha_{i,other}$
Income-modified Cost Coefficient; Business and Non-business	$\beta_{cost,business}$ and $\beta_{cost,other}$
Time Coefficient; Business and Non-business	$\beta_{time,business}$ and $\beta_{time,other}$
Adjusted Frequency Coefficient	$\beta_{frequency}$

The structural utility for the binary air diversion takes on the following form for individual n:

$$
\begin{aligned}
V_{air} = +\delta_{business}\Bigg(&\alpha_{plane,business} + \beta_{cost,business}\frac{c_{plane}}{\ln(income_n)} \\
&+ \beta_{time,business}\left(t^v_{plane} + t^a_{plane}\right)\Bigg) \\
&+ (1-\delta_{business})\Bigg(\alpha_{plane,other} + \beta_{cost,other}\frac{c_{plane}}{\ln(income_n)} \\
&+ \beta_{time,other}\left(t^v_{plane} + t^a_{plane}\right)\Bigg)
\end{aligned}
$$

$$
\begin{aligned}
U_{i\neq air} = \sum_i\Bigg(\delta_{business}\Bigg(&\alpha_{i,business}\delta_i + \beta_{cost,business}\frac{c_{plane}}{\ln(income_n)} \\
&+ \beta_{time,business}\left(t^v_i + t^a_i\right)\Bigg) \\
&+ (1-\delta_{business})\Bigg(\alpha_{i,other}\delta_i + \beta_{cost,other}\frac{c_{plane}}{\ln(income_n)} \\
&+ \beta_{time,other}\left(t^v_i + t^a_i\right)\Bigg)\Bigg) + \beta_{frequency}\ln\left(1 - e^{-0.08*freq_i}\right)
\end{aligned}
$$

The estimated coefficients for the air model are shown in Table B.29**.**

Table B.89: Estimated coefficients in air model

Coefficient	Value	Standard Error	p-Value
α_{plane}	0	--	--
$\beta_{time,business}$	-0.0179	0.00278	0.00
$\beta_{time,other}$	-0.0105	0.00154	0.00
$\beta_{cost,business}$	-0.0800	0.0131	0.00
$\beta_{cost,other}$	-0.0554	0.00694	0.00
$\beta_{frequency}$	0.145	0.141	0.30

As used in travel demand modeling, the value of time (VOT) represents the amount of money that a traveler would be willing to pay in order to save a unit of time. The value of travel time can be estimated from the logit model utility function, as it is the marginal rate of substitution between time and cost. In a linear utility function, this is the ratio of the time and cost coefficients. Separately, the value of travel time for business trips (time spent traveling in the course of work) can be related to prevailing wage rates.

Mode choice model coefficients are more readily interpreted when converted into time and monetary values. Table B.30 shows the corresponding non-business and business VOTs as calculated from the mode choice models. It also includes the values of the modal constants—terms included in modal utility functions to reflect the inherent attractiveness of a mode after its explicitly modeled attributes have been accounted for—in equivalent units of time. These constants represent the average contribution to a mode's utility of non-modeled attributes and can be expressed as an equivalent modal travel time penalty or bonus.

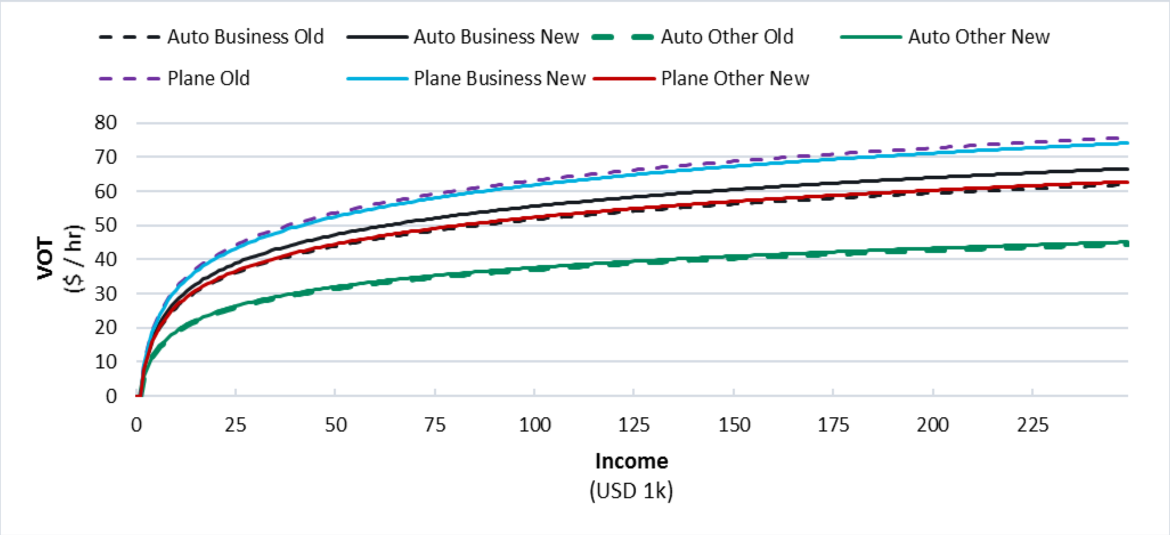
Table B.90: Auto and air values of time and values of modal constants (penalty)[118]

Value of Time (VOT) and Modal Constants	Auto Non-Business	Auto Business	Air Non-Business	Air Business
In-vehicle time VOT ($/hr)	$33.80	$49.90	$52.80	$57.30
Access time VOT ($/hr)	$69.10	$74.40	$79.20	$86.00
HSR penalty (min)	11	0	0	0

The auto and air options are assigned a reference modal constant value of zero. A positive time penalty for the UHSGT mode implies that, all else equal, travelers prefer their existing mode of travel to the UHSGT.

Values of time vary by income and by purpose. For a median annual income of $62,000, the VOT for auto travelers is $33.80 per hour for non-business trips and $49.90 per hour for business trips. These values of time are also within the ranges recommended by the 2016 USDOT guidance.[119] Figure B.63 provides a more detailed look at how VOT varies with income.

Figure B.105: VOTs as a function of income



[118] These values assume a median annual income of $62,000.
[119] "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis", US Department of Transportation, Office of the Secretary of Transportation, 2016. The USDOT publishes guidance on travel time valuation in the economic analysis of transportation projects. The latest memorandum recommends an array of values of time for different categories of travel, according to income, trip purpose, mode and distance. For surface modes, the guidance recommends VOTs for non-business inter-urban travel in a range from 60% to 90% of personal hourly income (annual household income divided by 2080 working hours/year).

A number of different functional forms were tested to represent the contribution of service frequency to utility, ranging from a linear specification, to inverse frequency (average headway), to a "damped" frequency. In intercity market models, the damped frequency specification has frequently been preferred as it captures well the diminishing effect of increasing service frequency.

As discussed previously, modal constants are added to the UHSGT utility value determined from time, cost and frequency to represent the relative attractiveness of UHSGT beyond the effects of the conventional level of service variables. Auto (or air) is taken as the reference mode with an implicit modal constant of zero. In representing the relative attractiveness of UHSGT, the modal constant takes account of the fact that some private vehicle travelers are harder to divert than others, and some are essentially impossible to divert.

With the modal constants estimated, the resulting ridership and revenue forecasts for various UHSGT alternatives that were tested were considered reasonable. The ridership and revenue forecasts with these constant values also responded appropriately and within expectations in detailed sensitivity analyses that were carried out.

On the other hand, the intercity bus and rail demand forecasting approaches are similar to the approaches for auto and air described above, with the exception that the model coefficients were asserted (and not estimated). The coefficients and modal constants were asserted based on the auto and air models estimated earlier and known differences between these modes, and they are consistent with Steer's previous US and international rail studies.

Table B.31 shows the bus and rail values of time for a median annual income of $62,000; and values of modal constants (penalty).

Table B.91: Bus and rail values of time and values of modal constants (penalty)

Value of Time (VOT) and Modal Constants	Bus Non-Business	Bus Business	Rail Non-Business	Rail Business
In-vehicle time VOT ($/hr)	$11.30	$16.60	$16.90	$25.00
Access time VOT ($/hr)	$16.90	$24.90	$25.30	$37.40
HSR penalty (min)	20	-20	20	-20

As for auto and air, the bus and rail options are assigned a reference modal constant value of zero. A positive time penalty for the UHSGT mode implies that, all else equal, travelers prefer their existing mode of travel to the UHSGT. A UHSGT modal constant equivalent to a 20-minute penalty was used for non-business HSR trips in the bus model, and a modal constant equivalent to a 20-minute advantage was used for business trips in the bus model. Intercity bus is perceived as less attractive than rail for business travelers, and business travelers are more likely to prefer rail over bus than their non-business counterparts. The corresponding value of time (VOT) of bus travelers is $11.30 per hour. Intercity bus and rail

VOTs are generally lower than auto VOTs, and the asserted VOTs for bus and existing rail follow this trend.

Access and Egress Mode Choice Models

To quantify accessibility to the UHSGT stations, a flexible method is used of exchanging the regional travel demand model mode choice logsums from the urban to the intercity models, making the intercity model sensitive to change in accessibility at the urban level. This is achieved through a logit averaging technique, explained below.

The urban mode choice models logsums offer a quantifiable measure of accessibility: the natural logarithm of the sum of the exponentiated utility for each mode measures the closeness of two zones. A logsum averaging technique was therefore used to pass-on the various MPO mode choice logsums to the larger intercity model.

The logsum for a particular TAZ pair k is the expected maximum utility:

$$E\big(Max(U_i, \forall\, i)\big) = \ln\Big(\sum_i \exp(U_i)\Big) = logsum_k$$

The set of logsums k can be seen as a set of Random Variables (RVs).

For a set of logsums, the “expected value of the maximum of the logsums” might be similarly obtained, using population and employment data within each TAZ to weight the logsum at the intercity zone level accordingly:

$$Logit\ Average = ln\Big(\sum share_k * exp[logsum_k] \Big)$$

The expected logsums obtained from the MPO models are converted into equivalent access time minutes and are added to the intercity UHSGT utility:

$$U_{UHSGT} = ASC_{rail} + \beta_{time} * IVT + \beta_{cost} * FARE + \beta_{freq} * Freq + \ \dots + \beta_{acclogsum} * \frac{logsum}{\beta_{time}}$$

If any mode of transport to access the UHSGT station is improved within the MPO model, then the expected logsum will be bigger and this will be reflected in the UHSGT utility.

Washington State Department of Transportation

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix E

Final Draft Funding and Financing Strategy Plan

July 2019

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WSP

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Contents

Tables

Executive Summary

The objective of this memorandum is to outline a proposed strategy for the Washington State Department of Transportation (WSDOT) and its partners to pursue funding for each stage of the proposed Ultra-High-Speed Ground Transportation (UHSGT) project (the project).

Proposed Strategy

This memorandum describes the proposed steps to pursue funding for each project stage, including discussion of the anticipated scope, timeframe, and strategy for pursuing funding.

The strategy is divided into three chronological stages: project initiation (near term), project development (intermediate term), and construction and operations and maintenance (O&M) (long term). The three stages are defined as follows:

- **Project Initiation**: This stage includes activities that should be accomplished within the first two to three years of the project delivery timeline. These activities may include, but are not limited to, creation of governance structure, planning and refined project definition, including purpose and need, preliminary consideration of environmental clearance, including U.S. National Environmental Policy Act (NEPA) clearance (Pre-NEPA), Canadian Environmental Assessment Act (CEAA) and state/provincial environmental policies, conceptual engineering that outlines alternative routes and station locations, governance, and stakeholder engagement/public consultation, including British Columbia's commitment to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).
- **Project Development**: This stage will begin after the project initiation stage is complete, occurring roughly three years from now. This stage should include, but is not limited to, achieving the following: final environmental clearance, including Tier 1 NEPA and Project NEPA for the initial operating segment, preliminary engineering/design, risk assessment, and establishing the project delivery approach.
- **Construction, Operations & Maintenance**: This stage is likely to begin six to eight years from now and will include land and right-of-way (ROW) acquisition, vehicle acquisition, final design, and construction, followed by the O&M period when service operation begins. The long-term strategy is contingent on effective planning and, most importantly, on securing a sustainable funding source in advance of the construction and O&M stages.

Each stage incorporates built-in decision points to evaluate advancement to the next stage and refine the project development approach to reflect the evolution of the project.

The proposed project funding/financing strategy must include multiple, parallel outreach efforts by the program to mobilize support that will lead to committed funding from federal, state/provincial, regional, private, and local funding sources.

The key milestones for project success include the following:

- Establish a workable governance structure and corporate organization or authority to act as the project lead
- Develop a coordinated stakeholder engagement approach
- Begin discussions with involved state/local/private stakeholders to mobilize support and secure funding contributions that are readily available to support the project initiation stage
- Simultaneously begin discussions with involved stakeholders that can champion substantial state/provincial and federal funding to support the project development stage
- Identify and secure a sustainable funding mechanism that will support the project's construction and O&M costs
- Perform a detailed analysis of potential long term revenue streams, including revenue potential, projection of market trends, and analysis of legislative requirements
- Consider financing needs to cover any funding shortfalls during the construction period

Table ES-1 provides a summary of the key elements and strategy involved to support the project in the short term, intermediate term, and long term.

Table ES-1: Summary of Project Stages Strategy

	Project Initiation	Project Development	Construction and O&M
Timeline	Present to 2-3 years	Approximately 3 years from present	Approximately 6-8 years from present, dependent on phasing
Length of Stage	≤3 years	5 years	Construction: 5-10 years O&M: Indefinitely following construction of initial phase
Scope	Governance Pre-Environmental Clearance Conceptual Engineering Stakeholder Engagement	Environmental Clearance Preliminary (NEPA/CEAA) Engineering/Design Risk Assessment Procurement	Land/ROW Acquisition Vehicles Final Design Construction O&M
Strategy	Rely on readily available funding streams to fund planning elements. Begin outreach to secure state/provincial/private/federal funding to support project development.	Support project development through federal and local funding. Begin proper technical, executive, and legislative outreach to line up construction and O&M funding streams well in advance.	Support construction and O&M through a sustainable, long-term funding stream tied to the economic benefit of the project; issue debt as needed to cover capital deficits during the construction stage.
Cost	<2% of overall program capital costs	5-10% of project costs	Capital/Construction Ongoing O&M costs

1 Introduction

This memorandum outlines a proposed strategy for WSDOT and its partners to pursue funding for each stage of the Ultra High-Speed Ground Transportation (UHSGT) project (the project). The project stages discussed in this memorandum include:

- **Project Initiation**: This stage includes activities that should be accomplished within the first two to three years of the project delivery timeline. These activities may include, but are not limited to, creation of governance structure, planning and refined project definition including purpose and need, preliminary consideration of environmental clearance, including U.S. National Environmental Policy Act (NEPA) clearance (Pre-NEPA), Canadian Environmental Assessment Act (CEAA) and state/provincial environmental policies, conceptual engineering that outlines alternative routes and station locations, and stakeholder engagement/public consultation, including British Columbia's commitment to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).
- **Project Development**: This stage will begin after the project initiation stage is complete, occurring roughly three years from now. This stage should include, but is not limited to, achieving the following: final environmental clearance, including Tier 1 NEPA and Project NEPA for initial operating segment, preliminary engineering/design, risk assessment, and establishing the project delivery approach.
- **Construction, Operation & Maintenance**: This stage is likely to begin six to eight years from now and will include land and ROW acquisition, vehicle acquisition, final design, and construction, followed by the O&M period when service operation begins. The long-term strategy is contingent on effective planning and, most importantly, on securing a sustainable funding source in advance of the construction and O&M stages.

Each stage incorporates built-in decision points to evaluate advancement to the next stage and refine the project development approach to reflect the evolution of the project.

The discussion of each project stage addresses the anticipated scope, timeframe, and strategy for pursuing funding. Overall stakeholder engagement, including public/community engagement, is covered in Section 4 of this memorandum.

At the beginning of the project initiation stage, WSDOT and its partner agencies will bear collective responsibility for initiating the project. Once a governance structure is defined, an authority, public agency, or other corporate body will presumably have responsibility for project development and delivery. This memorandum does not address governance; therefore, the general term "program" is used to indicate the entity responsible for development and delivery of the project, once established.

Many of the details of this strategy are contingent on decisions that have yet to be finalized. As the project becomes more defined, the strategy will need to be revised to reflect new details.

2 Strategy by Project Stage

This section proposes a strategy for pursuing project funding for three stages of project delivery: project initiation (near term), project development (intermediate term), and construction and O&M (long term).

2.3 Near Term: Project Initiation

This section defines the project initiation stage and describes the key steps for pursuit of project funding during this stage.

2.3.1 Scope, Schedule, and Costs

The project initiation stage includes activities that should be accomplished within the first two to three years of the project delivery timeline. This stage includes detailed project planning to set a strong foundation for the project to be successful. These activities may include, but are not limited to, establishing the governance structure, planning and refined project definition including purpose and need, preliminary consideration of environmental clearance, including U.S. National Environmental Policy Act (NEPA) clearance (Pre-NEPA), Canadian Environmental Assessment Act (CEAA) and state/provincial environmental policies, conceptual engineering that outlines alternative routes and station locations, and stakeholder engagement/public consultation, including British Columbia's commitment to implementing the UNDRIP. It is important that most, if not all, of the major stakeholders be involved in project initiation to provide transparency and establish consensus regarding key decisions. Stakeholder engagement can help to build interest in the project by underscoring the need for the project and demonstrating the benefits (economic, social, environmental) of the project. This effort would be supported by a new detailed study of broader economic impacts of the project. In addition, engaging with stakeholders will help define the most valuable project elements, as well as identify funding support that best addresses the needs of the project while achieving broad public, business, and political support.

Project initiation will be the least costly of the three project stages, with costs of less than two percent of overall program capital costs. These costs will be incurred over a two- to three-year period.

2.3.2 Secure Funding Commitments for Project Initiation

In order to pay for the estimated costs during the project initiation stage, WSDOT and its partners should identify funding sufficient to cover the cost of project initiation activities. Much of the funding would need to come from state/provincial appropriations, similar to Washington State's approach to funding the initial UHSGT project studies. These state/provincial appropriations may seek a match from corporate and philanthropic donors whose interests align with development of a high-speed ground transportation system. Engaging stakeholders early in the project initiation stage will help to earn their support well in advance of securing funds.

2.3.2.1 State/Provincial/Local

It is important during the project initiation stage to engage state/provincial and local legislators and other decision makers as early as possible to cultivate community support and endorsement. The key to mobilizing support among state/provincial and local decision makers will be to demonstrate the economic value of the project and its long-term benefits for the states/province and localities, including travel time savings, congestion mitigation, establishment of inclusive communities, environmental benefits, and economic development along the project alignment. Section 4 provides more detail on the strategy for engaging state/provincial and local decision makers.

Once buy-in is established, the program can further engage with legislators to understand the potential of state/provincial funds to support project initiation. Additionally, local and private funds could help fund project planning activities in the early years.

2.3.2.2 Private: Corporate and Philanthropic

The program should consider approaching the private sector, specifically corporate and philanthropic organizations. Potential state/provincial funds may seek a match from corporate and philanthropic donors whose interests align with development of a high-speed ground transportation system, including freight railroads and their customers. The program should approach such corporate and philanthropic organizations to provide potential donors with project information and establish project support and excitement. The program can foster private-sector interest by demonstrating the economic benefits as they relate to specific private-sector organizations and the communities they serve.

2.3.3 Secure Federal Funds for Initial Project Development

Simultaneously, as the program begins to secure funding for project initiation, outreach to the federal agencies (U.S. and Canadian) should also begin in order to line up funding for the intermediate project delivery stage: project development.

2.3.3.1 Federal

This section summarizes funding opportunities from U.S. and Canadian federal funding sources.

The Federal Railroad Administration’s (FRA) Consolidated Rail Infrastructure and Safety Improvements (CRISI) program is a promising U.S. federal funding source to support project development activities, as planning, project development, and environmental clearance are eligible uses of funds.

The CRISI program, administered by the FRA, provides funding for rail improvements that address safety, reliability, and efficiency. CRISI funding is also eligible for planning, project development, and environmental clearance, including NEPA clearance. The program may consider pursuing CRISI grant funding to fund project planning efforts.

To secure funding from the CRISI program, the program should meet with FRA staff to demonstrate the benefits of the project, focusing on the program objectives to promote reliability and efficiency. Additionally, discussions with FRA can inform how likely the project is to receive funding, what amount it might receive, and if any changes to the project elements and scope might allow the project to be more competitive for CRISI funding. The program should apply for a CRISI grant whenever a detailed scope for an eligible element of the project is ready to compete for funding.

In Canada, the Canadian Gas Tax Fund (GTF) provides lump sum funding to the provinces. In British Columbia, this funding is allocated by the Union of British Columbia Municipalities (UBCM) according to its prioritization methodology. To access these funds, proponent would need to make a strong case for the project to the UBCM and compete with other funding requests.

In order to make a compelling case to Infrastructure Canada, Transport Canada and the Canada Infrastructure Bank, the program should meet with leadership at these agencies to demonstrate the benefits of the project, focusing on the benefits of the project as they relate to the Investing in Canada Plan's objectives to promote long-term economic growth, support low carbon emissions, develop a green economy, and build inclusive communities. Discussions can inform how likely the project is to receive funding, what amount it might receive, and if any changes to the project elements and scope might allow the project to be more competitive for funding.

It is important to note that Canadian federal funding programs change over time and with different administrations. The project sponsor might consider administration changes as potential opportunities to help shape future infrastructure programs. A federal outreach strategy is outlined in the following section.

2.4 Intermediate Term: Project Development

This section defines the project development stage and describes the key steps for the program to consider during this stage.

2.4.1 Scope, Schedule, and Costs for Project Development

The project development stage will begin after the project initiation is complete, occurring roughly three years from now. This stage should include, but is not limited to, achieving final environmental clearance, including Tier 1 NEPA and Project NEPA for the initial operating segment, preliminary engineering/design, risk assessment, and establishing the project delivery approach.

Costs associated with project development are anticipated to range between 5 and 10 percent of the initial operating segment capital costs. This stage will last up to five years.

2.4.2 Develop Program Funding/Financing Framework and Secure Funding Commitments

A key aim of the project development stage is to secure a sustainable funding stream to support the project. The project is more likely to be delivered on schedule and within budget if the program proactively secures funding commitments in advance of each stage. Therefore, the program should engage in all necessary outreach and achieve buy-in from technical, federal, executive, and legislative decision makers in advance of construction and O&M, as described below. It may be difficult to secure sufficient funding all at once to support construction of the entire project; therefore, outreach efforts should consider a segmented approach where geographic sections of the project are sequentially constructed, or another logical phasing approach. A phased approach will allow the project to be constructed in manageable segments of independent utility that may enter service independent of other segments, and as funding is available.

2.4.2.1 Technical Outreach

The program will need to determine the extent to which existing funds may be available to support the program and the need for new funding streams. As the Funding and Financing Mechanisms Memorandum documented, existing state/provincial, regional, and local transportation funding available for high-speed rail is currently very limited; therefore, cultivation of new funding streams will be key to delivering this project.

Outreach to technical leads at departments of transportation (DOTs), metropolitan planning organizations (MPOs), and other agencies that manage allocations of existing funds is essential to understand the potential amount and timing of available funding, as well as application processes. This effort may yield only a small share of funding for the project—and funds identified may not be available until later years of the program—but it is essential for the program to know how to secure non-federal funding commitments.

In addition, this outreach will help to educate key staff within these agencies about the magnitude of the project funding requirements, including cash flows and the timing of specific funding needs. The program may share financial modeling results and funding research developed, or even work with funding partners to run their own funding and financing scenarios. This will help to build trust between the program and the technical leads at key agencies that agency leadership will rely upon to validate key assumptions and projections.

2.4.2.2 U.S. Federal Outreach

An effective federal funding strategy must do three things: (1) work energetically and cooperatively with other high-speed ground transportation proponents to demonstrate to the Congress and Administration that funding for high-speed rail should be prioritized in the next multi-year surface transportation bill; (2) work with the region's Congressional delegation to advocate for UHSGT as one of the best high-potential high-speed projects in the nation, and (3) ensure that the project is "shovel ready" upon enactment of the program, including the availability of a substantial local funding match.

At present, the prospect for near-term funding for high-speed rail is uncertain, but major activity to craft future legislation is already underway. As recently as a month ago, it appeared that the U.S. federal Administration agreed with Congressional leadership that they should work together to enact a broad-based multi-trillion-dollar infrastructure bill. However, only a few weeks later, President Trump appeared to abandon this goal. Simultaneously, the Administration withdrew its support for the California High-Speed Rail Program by announcing it was terminating an outstanding $900 million grant agreement, and contemplating seeking a return of $2 billion in already expended federal funds. Litigation over this action has been initiated by the California High-Speed Rail Authority.

Notwithstanding White House and United States Department of Transportation (USDOT) positions on infrastructure in general, and high-speed rail in particular, the Chairman of the House Transportation and Infrastructure Committee has announced he is working on a large infrastructure bill, including a reauthorization of the current surface transportation act (FAST Act) which expires in September 2020. Senate leadership has also indicated they are interested in working on FAST Act reauthorization. Leadership in both Chambers is anxious to undertake work on these bills this year in recognition of the fact that it is likely to be difficult to pass significant legislation in 2020, given the November 2020 election.

It has also been noted that the most urgent matter is for the Congress to lift the budget "caps" to enable Fiscal Year 2020 and 2021 appropriation spending levels to meet or exceed existing authorization levels. Some observers have suggested that this may be all that can be accomplished in 2019. However, the 2020 appropriation may contain substantial additional moneys for the existing CRISI program that would be a source of funding for undertaking PE, NEPA analysis, and other pre-development activities.

Various transportation advocacy associations are already working to advance their agendas on Capitol Hill. The American Public Transportation Association (APTA), one of the strongest voices for transit and passenger rail in Washington, DC, is in the course of finalizing its own reauthorization proposal. At its meeting in Toronto on June 26, APTA's Legislative Committee is expected to approve a final package of recommendations for adoption by APTA's Board, which is expected to include a request for a total of $31 billion in funding over a 6-year period for advanced passenger rail programs, creation of a new trust fund for rail projects (which have never benefitted from funding from the existing Highway Trust Fund), and other enhancements to existing financing programs and environmental rules.

A major infrastructure authorization must be supported by new revenue sources. There have been proposals already introduced to raise the federal gas tax to refill the Highway Trust Fund. However, unless a portion of the additional gas tax goes to a new Rail Trust Fund (which is opposed by APTA), new sources of revenue must be found for a robust high-speed and advanced intercity passenger rail program.

The project is advantaged by the leadership positions held by its Congressional delegation, including Rep. Peter DeFazio (D-4th, OR), Chair of the House Transportation & Infrastructure Committee; Rep. Earl Blumenauer (D-3rd, OR), the Ranking Member of Ways & Means; Rep. Rick Larsen (D-2nd, WA), Member of Transportation and Infrastructure; Senator Ron Wyden (OR), Ranking Member of the Finance Committee; and Senator Maria Cantwell (WA), Ranking Member of the Commerce Committee. These and other members of the Washington and Oregon delegations should be educated about the Business Case for UHSGT and its long-term funding requirements.

Chairman DeFazio and others have also hinted that "earmarks" may once again be used to allocate funding to projects of "national and regional significance," and strong efforts must be made with the region's representatives and senators in Washington, DC to include the UHSGT project in any such designations.

Armed with "lessons learned" from California, the nation's first project to actually enter construction after years of trial and error, public and private advocates must make the case that Cascadia's UHSGT can demonstrate to the nation how a project of such significant size and scope can be developed in far less time, attract a broader range of funding sources, and serve as a better investment than any transportation alternative.

Finally, regional representatives from both the public and private sector need to work closely with APTA and other advocacy organizations to make the case for a national high-speed rail program that will enhance the sustainable growth and global competitiveness of similar megaregions and strong city-pairs throughout the country.

2.4.2.3 State and Provincial Outreach

Executive-level outreach is required to state/provincial, regional, and local leaders who can help to shape future funding for the project. Initially, this will include high-level discussions with officials such as the Washington, Oregon, and British Columbia state secretaries of transportation/provincial minister of transportation, the executive directors of regional and local transportation authorities along the project alignment, and heads of other agencies in the region responsible for allocating transportation funding. The primary purpose of these meetings is to demonstrate the benefits of the program and ask officials what they can do to contribute to the project. These conversations are a necessary first step, but given the limited pool of funds available for a vast array of transportation needs throughout the region, these officials are not likely to be able to offer significant funding commitments.

Additional conversations will be necessary with officials at the highest levels of these organizations, up to and including each state's governor and the premier of British Columbia, and Transport Canada. To secure full funding for the project, these executives will need to serve as political champions for funding from their jurisdictions and other funding partners. This will likely involve complex negotiations with lawmakers, but ultimately, each state and province will need to develop its own legislative package to commit funds to the project.

The states and province will not likely offer a funding commitment to the project construction stage until the approximate Canadian and US federal funding share is known, but early conversations with existing leadership will help to position for the funding that is essential to completing the project. Funding options for consideration could include enhancement of traditional transportation funding sources, as well as exploring alternative funding sources.

To prepare for these meetings, WSDOT and its partner agencies should discuss which entity is best positioned to make the necessary outreach. For example, the program should consider if WSDOT and other stakeholders should meet with state DOT/provincial Ministry of Transportation and Infrastructure leadership individually or as a group. Further, the program should consider how to appropriately involve and intertwine the conversations with state/provincial leaders. The meetings should make clear the approximate level of funding expected from each party and the rationale, based in large part on federal funding commitments. Discussions should be held with the program's executive leadership regarding outreach strategy since it likely will bring together representatives of state DOTs and the British Columbia Ministry of Transportation and Infrastructure.

Involvement by U.S. Senators, British Columbia officials, and other federal (U.S. and Canadian) officials will also be important to the success of this outreach. This outreach will include demonstrating the long-term benefits the project to the Cascadia region, such as economic development, travel time savings, congestions mitigation, reduction in auto emissions, and economic international connectivity. Outreach efforts should focus on understanding the federal (U.S. and Canadian) goals for the project and incorporate them into the project objectives. Once federal support is established, the program can begin to lobby for additional federal funding streams.

2.4.2.4 Legislative Outreach

Legislative outreach will include engagement with state/provincial and local lawmakers, such as the state legislatures, Members of the British Columbia Legislative Assembly (MLAs), county boards, and city councils. The magnitude of funding required for the project will very likely require legislative action in Washington State, Oregon, and British Columbia to consider developing new funding streams. The Funding and Financing Mechanisms Memorandum highlighted multiple potential sustainable funding sources such as tax measures, or Land Value Recycle and Return (LVRR) support, all of which will require legislative enabling. Any legislative action will require a new round of outreach to members of each legislature. This outreach may be coordinated through program leadership, but each state and province will likely lead the educational outreach to legislators and the MLAs required to achieve passage of necessary legislation. The program should continue to provide support for these discussions, including background on the amount and timing of funding and demonstrations of funding scenarios. This again can help to build trust between the project and elected legislative leaders, whose support will be essential to developing necessary funding streams.

2.4.2.5 Funding Streams to Consider

The following sections describe potential funding streams for the program to consider for project development and future stages. Currently, there are no existing funding streams that would be able to sustain any phase of the project or the project in its entirety. However, the funding streams addressed in the following sections constitute the most promising options for a new funding stream which would be dedicated to supporting the project through construction and O&M. These potential new funding options warrant strong consideration, as they would provide revenue streams that are linked to the project benefits and are regionally palatable.

Typically, it can be politically challenging to move forward with any new funding stream which would lead to additional taxes or fees to the public; however, if the public is effectively engaged and aware of the project benefits, they can be persuaded that these benefits substantially outweigh the costs of incurring an additional tax or fee.

Tax Measures

While acknowledging it would be very challenging, measures to levy a gas tax, property tax, sales tax, business tax, , etc. constitute options to provide a long-term, sustainable revenue stream to support the program. Significant legislative work will be required to pass any such tax within Washington, Oregon, British Columbia statewide/provincewide or specifically in the Cascadia region. In order to compel state, provincial, and local legislators and voters to support a new tax, it will be important to demonstrate the long-term benefits of the project for each respective state/province/city, underscoring the potential for a large return on investment. Benefits include stimulating economic growth and innovation, efficient and sustainable mobility, and regional integration both within the state/province and within the greater Cascadia region.

Another key element to consider in evaluating the various tax measure options is the demographic and economic factors of the respective state/province/city. For example, a sales tax is a promising option if sales revenue in the region is growing; a property tax is promising if real estate values are growing; a fuel tax is promising if automobile use and fuel consumption is growing; a business tax is promising if development is growing;. It is important that the tax base has demonstrated growth in order to sustainably support the project long term, as costs are likely to grow with inflation.

It is also important to consider measures that have already demonstrated success and support in each geography:

- The Washington State Legislature has supported multiple transportation funding measures over the last 20 years and could consider supporting another measure formulated to fund intercity passenger rail. However, the funding package must take into account that the Washington State Constitution limits the use of gas tax revenue for highway purposes only.
- Business taxes have been successfully implemented in Seattle to support its new waterfront park; business taxes could presumably also be considered within Washington, Oregon, or British Columbia to support a rail project.
- Oregon recently passed a commuter tax statewide on all residents and non-residents who work in Oregon. However, it is important to note that the commuter tax is uncommon in Canada, as this is a form of taxation not typically allowed under provincial/territorial local government acts. Equity is another consideration that could make the commuter tax controversial.

Congestion Pricing

Congestion pricing is a direct user fee required for using congested roadways, including entry to designated city centers or use of highway lanes priced to provide free-flow traffic conditions. If used properly, congestion pricing can ease traffic, speed up travel times, reduce pollution, and provide funds for public transport and infrastructure investments. As congestion in the region— specifically along the I-5 corridor—is expected to continue growing, congestion pricing is a possible option to dis-incentivize automobile use while generating a revenue stream that can be reinvested in the corridor to provide an alternative transportation option that reduces travel time. Congestion pricing has been discussed in both Seattle and Metro Vancouver.

Highway Tolls

Similar to congestion pricing, highway tolls could be implemented along the I-5 corridor as a measure to mitigate congestion and automobile emissions and facilitate an alternative transportation option that saves time. Tolls generally support the tolled facility, but sometimes fund other transportation projects and services as well. If a toll facility were structured to fund complementary transportation services, the project could apply tolls as a revenue source. This would require significant work by the state/province, politically and procedurally. Using highway tolls to support the project incorporates an additional stakeholder, the tolling authority. However, both Oregon DOT (ODOT) and WSDOT act as the toll authority in their respective states, making highway tolling in those states a possible option to provide long-term funding for the project. Tolls are not an option in British Columbia.

Land Value Return and Recycle

LVRR is defined as returning publicly created land value to the public sector that created it and recycling it for infrastructure creation, operations and maintenance. LVRR assesses a fee based on the appraised land value—not on the value of structures or improvements to the property—to incentivize development of land proximate to or benefiting from transportation improvements.

There are limitations to this option, including its applicability only to station areas. Determining the servicing costs of development, known as Development Cost Charges (DCC) is required in British Columbia.

If the program is interested in pursuing an LVRR mechanism, the first step is to understand what LVRR mechanisms are already authorized within each city, county, and state/province by reaching out to the respective local/regional/state/provincial legislative authority of interest to learn what authority is already in place. For example, Oregon localities have the authority to impose a transportation utility fee on residents, which is considered a similar mechanism to LVRR. Outreach to the state legislature can lead to a better understanding of whether/how this authority can be expanded to support LVRR. If a LVRR mechanism is promising given unique characteristics of a particular area but does not have legal authorization, the program must work with the local and state/provincial officials to enact an LVRR program. Discussions with these decision makers may illuminate the most feasible opportunity to pass legislative authorization.

If legislative authorization already exists, the next step is to engage with the public early in project planning to educate them on the benefits of the project and underscore why the LVRR program is an appropriate funding mechanism.

Other Value Capture Mechanisms

The project has the potential to catalyze a significant amount of new development and redevelopment in the areas around the project corridor. Value capture mechanisms have the potential to generate significant revenue to fund the program, if structured properly. The timing and extent of future development are subject to a variety of factors, particularly the business cycle, the preferences of potential tenants, and the supply of competitive projects in the market. In addition, whether or not other taxing entities participate in any value capture can also have a significant impact on the amount of revenue that could be generated for the project.

Other potential value capture options specific to the project might include:

- Real estate development opportunities around potential station sites
- Deferring expansion of I-5 and reallocating the funding to the UHSGT project
- Leasing rail lines to freight railroads and/or third party utility companies (e.g., water or fiber optics).

Research regarding statutory authority and the preparation of projections of future land use values should be considered as next steps moving forward. These projections are always subject to the inherent volatility of real estate markets. Value capture strategies may also introduce political concerns related to the diversion of public revenue from general budgets to earmarked programs.

Additionally, following the formulation of a future development framework, it would be necessary to prepare a financial projection of the likely new development activity within the project station areas and the resultant local and state/provincial taxes. This information will allow a determination of the potential volume of debt financing that could be supported by these new revenues. In any value capture funding plan, coordination and approval from the local jurisdiction is needed. The next step would be to clarify the future development framework and begin to frame the master planning and provincial, state, and city input process.

Infrastructure monetization is also another potentially strong revenue stream. The next level of analysis could quantify the revenue opportunity for each asset type—for example, utility lease or data communication—so that such revenue can be factored against capital expenditure or toward operations of facility or infrastructure elements. The overall analysis would include technical feasibility and cost of adding a data/telecommunications conduit within the project corridor. Other high-speed transportation projects across the U.S. and Canada could serve as a business model to inform additional infrastructure monetization opportunities.

3.2.2.6 Financing

While funding is critical to ultimate delivery of the project, financing will likely be required to manage project cash flows. Financing refers to a variety of mechanisms where a lump sum amount of money is borrowed up front and paid back in smaller increments over time, with interest. Unlike funding, financing proceeds are borrowed, and must be paid back.

The most promising financing mechanisms include the U.S. Railroad Rehabilitation and Improvement Financing (RRIF) program, tax-exempt and taxable municipal debt, and public private partnership (P3) financing, as described in the appendix. In general, the program should be structured to enable debt issuance and/or receipt of debt proceeds from anticipated financing mechanisms.

The development of a detailed project financing plan should occur once funding commitments are secured. In the meantime, the project sponsor can develop a preliminary financing plan to illustrate to stakeholders how financing may leverage funding available for the project. After funding is secured, Transportation Infrastructure Finance and Innovation Act (TIFIA), RRIF, tax-exempt/taxable bonds, and P3 financing options all present viable options to project sponsors to support project finance needs. The program should plan ahead to consider which parties/entities are best suited to issue debt or enter into a P3 agreement on behalf of the project, as well as which funding streams are most appropriate for supporting a P3. Additionally, any P3 approach would need to be structured to ensure the public interest is preserved.

2.5 Long Term: Construction, Operations & Maintenance

This section defines the construction and O&M stage and describes the key steps for the program to consider during this stage.

2.5.1 Scope, Schedule, and Costs for Construction and O&M

The construction stage could begin as early as six to eight years from now and will be followed by the O&M period when service operation begins. The long-term strategy is contingent on effective planning and, most importantly, on securing a sustainable funding source in advance of the construction and O&M stages. If the project is constructed through a phased approach, there may be several distinct construction and O&M phases for each segment of the project. As a result, construction and O&M schedules will overlap between different segments.

The Construction/O&M stage will be the most expensive of the three project stages; construction will likely last 10 to 15 years depending on phasing. Construction costs include land and right-of-way (ROW) acquisition, vehicle acquisition, final design, and construction, including stations, systems, support and storage facilities, and contingency, as described in the Business Case Report.

2.5.2 Execute Project Funding/Financing Plan

The funding stream necessary to fund construction will have already been identified during the previous stage (Project Development). However, the program will likely still be considering all long-term funding streams available for O&M. In addition to fare revenues, which should cover a significant portion of the O&M costs, the program should consider technical, executive, and legislative outreach similar to the Project Development stage to develop funding stream(s) that can also contribute to O&M costs.

In addition, the program should develop a financial risk mitigation plan that entails back-up funding streams to consider as ways to fill gaps of previously assumed funding streams. The financial risk mitigation plan should be updated regularly to reflect changes in the program funding and economic outlook.

3. Stakeholder Engagement during Project Stages

The purpose of the stakeholder engagement plan is to outline the steps the program should take in order to establish stakeholder buy-in to support funding commitments for the project.

For the purposes of the project, a stakeholder is considered to be any group that benefits or is impacted by the project, either directly or indirectly. The stakeholder engagement plan seeks to identify stakeholders and categorize them based on how they are affected by the project. The four types of stakeholder categories are: Dedicated, Involved, Committed, and Aware stakeholders. This section will define each stakeholder category and describe a tailored strategy for engaging them.

The stakeholder engagement approach should be flexible and easily adjusted to meet the needs of the stakeholders. During the stakeholder engagement process, the program may need to update the project scope, mitigation measures, or benefits in order to ensure stakeholder buy-in.

3.3 Categorizing Stakeholders

The four stakeholder categories are defined as follows:

- **Dedicated Stakeholders** include those that will be involved in every aspect of the project and are likely involved in the program's governance structure. The project cannot be successful without the involvement and support of these stakeholders.
- **Involved Stakeholders** include those that hold a key role in one aspect of the project such as project development, funding, construction, or operations. While it is not required that these stakeholders are involved in every aspect of the project, it is important to keep them informed and give them opportunities to provide input on other aspects to support a holistic perspective of the project and maintain their cooperation and buy-in.
- **Committed Stakeholders** include those whose buy-in and commitment are essential for the project to be delivered successfully. These stakeholders are involved in activities that help move the project forward, such as securing standard permits. It is important to keep them involved well in advance of when their approval is needed to prevent project schedule delays.
- **Aware Stakeholders** include those who will be impacted by the project but will not be participating in any of the project activities. These stakeholders should be made aware of the project and updated on its progress.

Table 1 provides a matrix that identifies the key stakeholders involved in the project, including their stakeholder category and project role.

Table 92: Stakeholder Identification Matrix

Stakeholder	Category	Project Role
Program (public agency, authority, or other corporate entity)	Dedicated	Project Lead – The program will be the project champion involved in delivering all aspects of the project and its governance.
WSDOT	Dedicated	Project Sponsor – Current study sponsor leading business case development efforts. Providing state oversight and likely to be part of the program governance and to contribute funding.
ODOT	Dedicated	State Oversight – Providing state oversight; likely to be part of the program governance and to contribute funding.

Stakeholder	Category	Project Role
British Columbia Ministry of Transportation and Infrastructure	Dedicated	Provincial Oversight – Providing provincial oversight; likely to be part of the program governance.
US Department of Transportation: Federal Railroad Administration	Involved	Federal Oversight – The FRA will provide federal (U.S.) oversight and may contribute funding as well.
Transport Canada	Involved	Federal Oversight – Transport Canada will provide federal (Canadian) oversight .
Governors of Washington and Oregon, and Premier of British Columbia	Involved	State/Provincial Oversight – The governors will provide state/provincial oversight and are likely to act as champions of their respective segments of the project. Key advocates for project funding.
Cities/counties along the rail corridor (including mayors, county executives, council members, and city agencies, such as departments of transportation)	Involved	Local Oversight – This group of stakeholders will provide executive, legislative, and technical oversight to the project. As the project elements, ROW, and schedule become more defined, a more detailed and tailored stakeholder engagement plan should be developed separately for mayors, city councils, DOTs, and any other entities representing the interests of the affected municipalities. Note that these stakeholders may provide local funding to the project or have a role in approving enactment of value capture-based funding mechanisms.
Sound Transit	Involved	Transit operator in Seattle – may provide complementary service to the project.
King County Metro Transit	Involved	Transit operator in Seattle – may provide complementary service to the project.
Tri-County Metropolitan Transportation District of Oregon (TriMet)	Involved	Transit operator in Portland – may provide complementary service to the project.
TransLink	Involved	Transit operator in Vancouver – may provide complementary service to the project.
Other regional transit operators whose service area overlaps with that of the project	Involved	May provide complementary service to the project.
Metropolitan Planning Organizations (MPOs) in affected cities	Involved	Local Planning and Economic Oversight – MPOs can provide local oversight to help optimize the economic benefits to the affected municipalities.
Potential Rail Developers	Involved	Private Funding Partners – Potential to engage private developers who can provide funding to the project as a result of economic benefits along the project ROW.
Business Community	Involved	Private Funding Partner – Potential to engage the business community to provide private funding as a result of long-term economic benefits of the project (e.g., travel time savings, congestion relief, development).

Stakeholder	Category	Project Role
Utilities	Involved	Impacted Utilities – Technical coordination with utilities will be required where the project impacts utility infrastructure. Once the project ROW is defined, a detailed list of impacted utilities should be determined. There may be a case for certain utilities to relocate their infrastructure for the benefit of the project; therefore, utility coordination should begin as soon as possible so as not to cause any schedule delays.
U.S. House of Representatives Committee on Transportation and Infrastructure	Involved	Legislative Authority – Rep. Peter DeFazio of Oregon is the chairman of this committee and could act as a legislative champion for this project. If the committee takes interest in this project, this could open the door for legislative enabling for a new funding stream in support of the project.
Canadian Parliament	Involved	Legislative Authority – Potential legislative champions can be identified to promote legislative enabling of new Canadian federal funding streams.
Environmental	Involved	Community and public engagement will include experts to represent the following areas: earthquake resiliency, protection of wetlands, channeled growth, equity, greenhouse gas reduction, workforce housing availability, access to jobs, and health and educational opportunities.
Border/immigration services, including U.S. Customs and Border Protection (CBP) and Canadian Border Services Agency (CBSA)	Committed	Provide oversight to ensure safe, seamless, and legal border crossings.
U.S. Army Corps of Engineers, Canadian Military Engineers, U.S. Fish and Wildlife Service, State Department of Environmental Quality, State Historic Preservation Offices, etc.	Committed	Federal/state/provincial agencies with oversight over a portion of the project. This list should be updated as the project scope is refined to ensure all committed stakeholders are involved.
Indigenous Communities	Aware	Interested/Impacted Parties – should be educated on the project plans and schedule.
Community/Public	Aware/Involved	Interested/Impacted Parties – Local neighborhood groups and entities will want to ensure compliance with any mitigation measures proposed once a Record of Decision is issued. Additionally, these stakeholders may propose additional measures to benefit the community.

3.4 Outreach Action Items

An Outreach Action Plan outlines key activities that must be taken during the engagement process. The first step in the Outreach Action Plan is to coordinate internally within the program to establish common messaging and establish communication roles.

After internal coordination, Dedicated and Involved stakeholders must be engaged, using key messaging and outreach strategies to ensure their buy-in and commitment to the project.

In addition to the buy-in and commitment garnered in the prior step, funding partners will need to understand the benefits to them of providing funding or financing of the project through an understanding of how funding the project supports their own goals.

Concurrently, outreach can occur with Committed and Aware stakeholders to ensure they are getting relevant project information that conveys the benefits of the project and ensures appropriate expectations of the project's impact.

Table 2 summarizes the outreach action items for each stakeholder as well as the anticipated objectives and outcomes.

Table 93: Outreach Strategy

Action	Stakeholders	Objectives and Outcomes
Internal Outreach Coordination	Program	Review engagement plan internally and understand communication requirements of stakeholders as well as objectives for outreach action items. Materials including talking points, data to be shared, presentations, funding requests, and other materials to be presented to stakeholders should be reviewed and approved.
Meet with Dedicated stakeholders	• WSDOT • ODOT • British Columbia Ministry of Transportation and Infrastructure	Bring key stakeholders into the project, inform them of the project approach and schedule, and get buy-in and commitment to support the project.
Meet with Involved stakeholders	• U.S. Department of Transportation: FRA • Transport Canada • Governors of Washington and Oregon, and Premier of British Columbia • Cities/counties along the rail corridor (including mayors, county executives, council members, and city agencies, such as departments of transportation) • U.S. House of Representatives Committee on Transportation and Infrastructure • Canadian Parliament • Indigenous community • CBP/CBSA	Bring key stakeholders into the project, inform them of the project approach and schedule, and get buy-in and commitment to support the project.
Meet with other Involved stakeholders regarding technical issues	• City DOTs • City MPOs • Utilities • Environmental	Identify project impacts to stakeholders, communicate project schedule and coordination needs.
Outreach to federal funding/financing partners	• USDOT: FRA • Transport Canada • Infrastructure Canada	Determine the extent to which existing funds may be available to support the project.
Outreach to private funding partners	• Rail Developers • Business Community	Rail developers and/or the business community may provide funding to the extent that they benefit from the project.

Action	Stakeholders	Objectives and Outcomes
Technical outreach to state funding partners regarding funding availability	• WSDOT • ODOT • British Columbia Ministry of Transportation and Infrastructure	Determine the extent to which existing funds may be available to support the project. Educate key staff within these agencies about the magnitude of the funding requirements, including cash flows and the timing of specific funding needs.
State/provincial executive outreach regarding potential funding commitments	• The Governors of Washington and Oregon, and the Premier of British Columbia	Inform and request support from state/provincial leaders who can help to shape future funding for the project. Get officials onboard with the project. Recruit state/provincial executives to serve as political champions for additional funding.
Meet with Committed stakeholders	• U.S. Army Corps of Engineers, Canadian Military Engineers, U.S. Fish and Wildlife Service, State Department of Environmental Quality, State Historic Preservation Offices, etc.	Brief stakeholders of project plan and benefits, get buy-in and political support.
Meet with Aware stakeholders regarding local impacts	• Local Neighborhood Groups	Discuss project benefits, identify project impacts to stakeholders, communicate project schedule, and address concerns.

4. Conclusion

As documented in this plan, the project funding/financing strategy must include multiple, parallel outreach efforts by the program to successfully mobilize support that will lead to committed funding from federal, state/provincial, regional, private, and local funding sources.

The key milestones for project success include the following:

- Establish a workable governance structure and corporate organization or authority to act as the project lead
- Develop a coordinated stakeholder engagement approach
- Begin discussions with involved state/local/private stakeholders to mobilize support and secure funding contributions that are readily available to support the project initiation stage
- Simultaneously begin discussions with involved stakeholders that can champion substantial state/provincial and federal funding to support the project development stage
- Identify and secure a sustainable funding mechanism that will support the project's construction and O&M costs
- Perform a detailed analysis of potential long-term revenue streams, including revenue potential, projection of market trends, and analysis of legislative requirements

- Consider financing needs to cover any funding shortfalls during the construction period

Table 3 provides a summary of the key elements and strategies involved to support the project in the short term, intermediate term, and long term.

Table 94: Summary of Characteristics and Strategy of Each Project Stage

	Project Initiation	Project Development	Construction and O&M
Timeline	Present to 2 to 3 years	Approximately 3 years from present	Approximately 6 to 8 years from present, dependent on phasing
Length of Stage	≤3 years	5 years	Construction: 5-10 years O&M: Indefinitely following construction of initial phase
Scope	Governance Pre-Environmental Clearance Conceptual Engineering Stakeholder Engagement	Environmental Clearance Preliminary (NEPA/CEAA) Engineering/Design Risk Assessment Procurement	Land/ROW Acquisition Vehicles Final Design Construction O&M
Strategy	Rely on readily available, lighter funding streams to fund planning elements. Begin outreach to secure state/provincial/private/federal funding to support project development.	Support project development through federal and local funding. Begin proper technical, executive, and legislative outreach to line up construction and O&M funding streams well in advance.	Support construction and O&M through a sustainable, long-term funding stream tied to the economic benefit of the project; issue debt as needed to cover capital deficits during the construction stage.
Cost	<2% of overall program capital costs	5 to 10% of project costs	Capital/Construction Ongoing O&M costs

The general strategy outlined in this plan should be refined to assign responsibility to particular individuals to lead and support key tasks.

4.1

The following appendix includes the specific potential funding and financing sources discussed in this memorandum as sources to fund the various stages of the project.

Funding Options

CRISI

The CRISI program, administered by FRA, provides funding for rail improvements that address safety, reliability, and efficiency, with a specific set-aside to fund positive train control (PTC). CRISI funding is also eligible for planning, project development, and environmental clearance, including NEPA reviews. Project sponsors may consider pursuing CRISI grant funding for project planning efforts.

To secure funding from the CRISI program, WSDOT and other project sponsors should meet with FRA staff to demonstrate the benefits of the project, focusing on the program objectives to promote reliability and efficiency. Additionally, project sponsors should use discussions with FRA to better understand how likely the project is to receive funding, what amount it might receive, and if any changes to the project elements and scope might allow the project to be more competitive for CRISI funding. Project sponsors should apply for a CRISI grant whenever a detailed scope for an eligible element of the project is ready to compete for funding.

Investing in Canada Plan / GTF

Through the current Investing in Canada Plan, the Canadian federal government is making significant investments in Canadian infrastructure, with five main priorities: public transit, green, social, trade and transportation, and rural and northern communities. The Investing in Canada plan also supports the GTF, which is a source of semi-annual funding provided to provinces and territories, who in turn fund their municipalities to support local infrastructure priorities. However, given the total pool of funds available for projects province-wide, the program is likely to provide only a small contribution toward this project.

Previous Transportation Funding Measures in Washington State

The Washington State Legislature passed fuel tax and fee measures in 2003, 2005, and 2015; the purpose of each measure is summarized below:

- **2015 Gas Tax – Connecting Washington**: Connecting Washington funds various types of projects, including state highways and local roads, state highway maintenance, operations and preservation, non-highway projects (bike paths, walkways, rail and transit), ferries and terminals, and fish barriers.
- **2005 Gas Tax – Transportation Partnership Program (TPP)**: TPP funds at-risk structure projects, safety investment projects, choke points and congestion projects, multimodal improvement projects, environmental projects, and freight mobility and economic projects.

- **2003 Gas Tax – The "Nickel" Funding Package**: This revenue package funded highway improvement projects, highway preservation projects, Washington State Ferries projects, freight mobility and economic projects, and multimodal improvements over a 10-year period.

Projects for each of these funding packages have already been selected and, therefore, the UHSGT project is not eligible. However, if the Washington State Legislature were to enable a new funding package and select new projects to participate, this project could be eligible. The amount of funding for the project available from any new Washington state program would vary depending on the amount of funds appropriated, as well as the source of those funds.

Commuter Taxes

Commuter taxes are payroll income taxes or other fees paid by people employed in a given jurisdiction. Commuter taxes are very common in the U.S., but not in Canada. The commuter tax may be most appropriate if the project scope includes commuter rail service or other features of benefit to daily commuters.

To create a commuter tax, legislative approval is required through state/provincial and local governments. Initially, the tax will require enabling authority from the state/provincial government. The project sponsor will then work with local governments to advocate for the commuter tax, promoting the idea that it will drive development that may attract further businesses to the area. Once enabled, the entity responsible for levying the tax will typically host public meetings to engage affected stakeholders (including businesses and affected commuters) on project benefits, such as improved commuter transit services.

Oregon passed a commuter tax in July 2018 that requires Oregon residents, regardless of where they work, and non-residents who work in Oregon to pay one-tenth of one percent (0.001) of wages. Additionally, payers of annuities and other periodic payments also must withhold one-tenth of one percent (0.001) of these payments.

Commuter taxes are not common in Canada, as this is a form of taxation not typically allowed under provincial/territorial local government acts. Therefore, passing a commuter tax would be a significant challenge and would take more time to work with provincial legislators to enact legislation to support a commuter tax.

Business Taxes

Business taxes are direct taxes on businesses for improvements that will either directly or indirectly benefit them. Business taxes are common in the U.S. and Canada but can be challenging to enact.

The strategy to implement a business tax is similar to implementing a commuter tax. This includes engaging with state/provincial legislators to enable the tax, as well as the stakeholders to demonstrate that the benefits of the project justify the additional tax. The main difference is that the main stakeholder group will be businesses rather than commuters, so when explaining the benefits of the project, the emphasis will be on economic development in addition to commuter impacts.

Seattle has recently implemented a tax on nearby businesses and property owners to fund its new waterfront park. The state authorized the city to use a location-specific tax because businesses and residents within the boundaries of the development would see an increase in value once the park is complete. The project sponsor should engage with sponsors of the waterfront park to draw upon lessons learned.

Congestion Pricing

Metropolitan regions around the world are considering or implementing congestion or road pricing to reduce congestion, improve air quality, and raise revenue to fund more sustainable transportation options. Congestion pricing is a direct user fee required for using congested roadways, including entry to designated city centers or use of highway lanes priced to provide free-flow traffic conditions. If used properly, congestion pricing can ease traffic, speed travel times, reduce pollution, and provide funds for public transport and infrastructure investments.

Congestion pricing was recently approved by New York State for portions of New York City, marking the first time the mechanism is planned for North America. Currently, congestion pricing is under consideration for cities such as Seattle and Vancouver, demonstrating a supportive climate for congestion pricing in both the U.S. and Canada. The project sponsor can look to international examples in cities such as London and Singapore to derive lessons learned as to how to successfully educate and engage state/provincial and local officials who must provide approval, bearing in mind that the challenges in North America may differ due to differences in political, demographic, and institutional realities. The congestion pricing program in New York City is very new, but the project can also look to New York City as an example of how to implement congestion pricing in the U.S.

Highway Tolls

Highway tolls are a direct user fee for use of a highway. Tolls generally support the capital, operating, and debt service cost of the tolled facility, but sometimes fund other transportation projects and services as well. Although this is not a highway project, if a toll facility were structured to fund complementary transportation services, the project could apply tolls as a revenue source. Tolls are not an option in British Columbia.

Financing Options

Railroad Rehabilitation and Improvement Financing

The RRIF program is authorized to provide up to $35 billion in direct loans and loan guarantees to finance development of railroad infrastructure. The RRIF program aims to extend federal loans to rail projects of national significance by offering improved access to credit markets, flexible repayment terms, and potentially more favorable interest rates than can be found in private capital markets. The program prioritizes projects that provide public benefits, including benefits to public safety, the environment, and economic development, as well as those that improve railroad stations and passenger facilities and foster transit-oriented development.

In order to secure a RRIF loan from the USDOT Build America Bureau, the project sponsor should be prepared to discuss with the USDOT the terms of a potential loan once funding streams for the project are known. Engaging early with USDOT will help ensure that loan terms will adequately support the project. Additionally, these discussions should aim to educate USDOT on the needs of the project so that USDOT can best support the project. In addition, efforts are underway to enhance the RRIF program under a new federal surface transportation authorization bill, including appropriation of the credit risk premium that is required to be paid by borrowers.

Tax-exempt and Taxable Bonds

Municipal bonds are a fixed-income security issued by a state or local government, including public authorities, cities, and counties. Bonds are one of the lowest-cost methods of government borrowing and are the most common way of financing public works in the United States. Note that Canadian municipal bonds are always taxable, whereas U.S. municipal bonds can be tax-exempt.

U.S. federal statute permits municipal issuers to issue tax-exempt debt when any income derived from the project is exempt from federal tax. The interest earnings of tax-exempt debt are typically free of income tax to the bond holder, yielding a lower financing cost for the debt issuer.

The project is eligible for taxable and tax-exempt municipal bonds in Oregon and Washington. The project sponsor would need to consider which party is best suited to issue the municipal bonds: the state, local government, or a public authority. The project sponsor should consider which potential issuer is most likely to receive the best rating, as a higher rating will result in a lower interest rate and overall lower financing costs.

Public-Private Partnerships (P3) Financing

P3s have the potential to finance a significant share of project costs and could facilitate lower project costs as part of a comprehensive program delivery strategy to manage project risks. Elements of P3 financing may include equity—direct investment by the P3 concession—and private activity bonds (PABs), which are relatively low-cost bonds issued by private entities to support eligible public works infrastructure. Equity and PABs are frequently combined with RRIF or other direct federal loans to finance P3 projects in the U.S.

To pursue a P3, the project sponsor will need to conduct a competitive procurement that typically includes several stages, including a Request for Information (RFI), Request for Qualifications (RFQ), and Request for Proposals (RFP) from qualified teams. This typically occurs after the scope of the project is defined and refined. The project sponsor will communicate the benefits of the project to potential private partners to encourage competitive partnership opportunities. In advance of selecting a private partner, it will be very important for the project sponsor to consider how the contract will be structured to protect the interests of the public, the project (e.g., including contractual performance requirements), and the project sponsor in a way that is fair and beneficial to the private partner. The project sponsor should consider what type of payment structure would best suit the partnership and be prepared to negotiate with the private partner. Additionally, any P3 approach would need to be structured to ensure the public interest is preserved.

Additionally, the project sponsor should consider outreach to industries that might support a P3. For example, the California High-Speed Rail Authority released a Request for Expressions of Interest (RFEI) to better understand potential private partners' interest in the project and their recommendations to improve the preliminary project delivery strategy. Specifically, the RFEI included funding and financing questions for the respondents to address, such as issues raising the necessary funding and financing to deliver the project and the appropriateness of an availability payment mechanism. By incorporating interactive coordination with potential private partners, the project sponsor could increase the visibility of the project and attract partners by making them feel more involved in the project planning process.

The Regional Express Metro (REM) project is an example of a successful Canadian P3 transit project. REM is a new 40-mile integrated rail line linking downtown Montreal with the North, South, and West communities in the region, as well as the airport. The REM is expected to cost $5 billion and is financed in part through a P3 arrangement with CDPQ Infrastructure (which is comprised of public pension funds) that will recover its initial investment through long-term availability payments linked to achieving ridership and meeting performance targets both in the delivery of the capital works and operating performance measures.

Ultra-High-Speed Ground Transportation Business Case Analysis

Appendix F

Candidate Governance Structures Report

July 2019

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Contents

Executive Summary

This Report describes how the states of Oregon and Washington and the province of British Columbia can together create a joint governance entity endowed with powers and responsibility for overseeing the planning, design, construction and operation of the Ultra High-Speed Ground Transportation (UHSGT) project. It is acknowledged that the international border between these jurisdictions – with the associated security, customs, immigration and regulatory issues -- is a unique challenge. A joint governing entity may be the most appropriate structure to oversee the development of the UHSGT project, since it would address the needs of all three jurisdictions through a single decision- making process. Moreover, it would provide the mechanism to manage the financial contributions of the three governments; offer the ability to compete for federal funding from the United States and Canada; and attract private investments.

Existing Precedents. This report reviews several Canadian/US precedents involving development and/or operation of highway and bridge projects connecting Canada and the United States on the Saint Lawrence Seaway and the Great Lakes. These arrangements facilitate cooperation among multiple interested governmental entities through multi-party governing arrangements. Some also involve a separate development or operating entity. The most recent US/Canadian joint venture is developing the Gordie Howe Bridge connecting Detroit, Michigan and Windsor, Ontario across the Detroit River. The bridge is being financed entirely by Canada and the procurement is being undertaken by the Windsor-Detroit Bridge Authority, a Canadian Crown Corporation, but its major decisions must be approved by a joint Michigan/Canadian Authority.

This report also reviews the institutional arrangements employed for constructing, financing and operating large rail projects in Europe and elsewhere in Canada, including the Channel Tunnel, Crossrail (UK), the Tours—Bordeaux High Speed Rail line in France, and the REM Project in Montreal. Each of these projects established a separate delivery company to split responsibilities of policy/funding from delivery, in part to improve and streamline decision making processes.

Applicable State and Federal Law. A cross-border entity may only be organized in a manner that is authorized and consistent with applicable legal authorities in the participating states and province and their federal governments. The US Constitution prohibits individual states from entering into certain agreements with foreign countries without Congressional approval. However, it is possible for states to enter into cross-border agreements provided the arrangements do not encroach on sovereign powers of the state or the Federal government.

Oregon state law expressly permits a state agency to exercise authority jointly with an agency of another state or a foreign nation. The State of Washington has no comparable law except one that is limited to the joint exercise of powers with other states, but not foreign governments. Washington's Public-Private Partnership (P3) law does contemplate trans-border transportation public-private partnership projects, however these arrangements are subject to detailed requirements and approvals set forth in that statute.

While British Columbia does have authority to enter into a cross-border agreement, rail lines that operate between two provinces or beyond fall under the jurisdiction of the Canadian federal government.

Three other points to acknowledge that will affect governance:

1. British Columbia is committed to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and reviewing policies, programs and legislation in order to bring the principles of the Declaration into action;
2. Consultation with the municipal level of government is important; and
3. Interests of property owners and businesses along identified ROW alternatives will need to be addressed with sensitivity.

A Two-Step Approach. Reaching agreement on the form of a bi-national and bi-state entity will be a complex undertaking that may require additional legislative action. For that reason, it is recommended that the parties initiate the process through an informal arrangement under which they coordinate their individual efforts including pre-NEPA (National Environmental Protection Act) planning and community and business outreach, while developing recommendations for the final joint exercise of powers agreement, procurement and funding approach.

Suggested Attributes of Final Implementing Organization. Ultimately, the parties will need to determine the political, financial and operating structure necessary to bring the business case to fruition. This structure must be sufficiently strong to maintain public acceptance, withstand changes in political views, and be able to access governmental funding opportunities over the many years needed to plan, design and construct a project of this scope.

The key attributes of successful infrastructure organizations discussed in this Report include:

- **Common vision and goals** that will endure for the life of the project and that are developed through strong stakeholder engagement.
- **Governing Board** including representatives of the funding partners and other key stakeholders, including possibly participation by Transport Canada and USDOT, municipalities, business organizations, labor, and indigenous and other interest groups.
- **Allocation of decision-making authority** between the Board and officers. The creation of a separate delivery company that would separate responsibilities of policy/funding from delivery may improve the decision-making and delivery process,
- **Early agreement on overall cost allocation** to support adequate staffing and development costs, based on a frank and thorough assessment of risks.
- **Implementation powers** to finance, apply for Canadian and US federal grants and loans, impose fees and charges to help finance the capital costs of the project, acquire property, enter into contracts, adopt its own procurement rules, borrow money and issue bonds.
- **Adequate funding** for the organization to support its activities and undertakings.

- **Alternative funding and financing arrangements** to minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries**.**
- **Ability to implement value capture strategies** that will provide ancillary revenues to the project based on increased development potential of adjacent and other properties benefitting from the project.
- **Legislative authorization** that permits each party to enter into inter-state and international agreements without impairing state or federal sovereignty, as well as authorizing the use of a full array of funding, financing and development arrangements.

1 Background

As part of the Ultra High-Speed Ground Transportation (UHSGT) Business Case Analysis sponsored in 2018-2019 by the States of Washington, Oregon, the Province of British Columbia and Microsoft, WSP analyzed what type of governance institutions would be most feasible to implement an UHSGT project that includes the three jurisdictions. This governance entity would have responsibility for overseeing the planning, design, construction and operation of the UHSGT project.

This governance analysis builds on preliminary work conducted as part of the 2017 UHSGT Feasibility Study and is further supported by a Memorandum of Understanding (MOU) signed in October 2018 by Washington state Governor Jay Inslee and British Columbia Premier John Horgan. In the “Memorandum of Understanding on Advancing the Innovation Economy, Environmental Protection and Transportation Connectivity” of their two jurisdictions, the two leaders agreed to:

> *Continue support for the business case analysis of a new ultra high speed corridor between Portland, Seattle and Vancouver B.C., with speeds as high as 250 mph (400 km/h), and begin exploring the possibility of a new multi-jurisdictional Ultra High Speed Corridor authority that could lead the project in any agreed-upon subsequent phase(s).*

Previously, the States of Washington and Oregon had also agreed in a 2012 MOU to cooperate in the development of the “Pacific Northwest Rail Corridor” between Eugene, Oregon and Vancouver, British Columbia as one of the five high speed rail corridors originally designated by the Federal Railroad Administration as directed by the Intermodal Surface Transportation Act of 1991 (ISTEA).

In April 2019, the Washington State Legislature enacted a transportation appropriation bill, ESHB 1160 that provides funding to support continued analysis of the ultra high-speed ground transportation corridor with participation from Washington, Oregon, and British Columbia. The study funded by the Act is to include:

> “(i) development of proposed corridor governance, general powers, operating structure, legal instruments, and contracting requirements; (ii) an assessment of current laws in state and provincial jurisdictions and identification of any proposed changes to laws, regulations, and/or agreements that are needed to proceed with development; and (iii) development of general recommendations for the authorization needed to advance the development of the corridor.”[120]

[120] Section 222.

2 Existing US/Canadian Cross-Border Agreements

The Canadian/US precedents primarily involve highway bridge projects on the Saint Lawrence Seaway and the Great Lakes. Most of these involve cooperation among multiple entities, a multi-party governing arrangement and a separate development or operating entity.

2.1 Gordie Howe Bridge

The most recent US/Canadian joint venture is the Gordie Howe Bridge which will connect Detroit, Michigan and Windsor, Ontario across the Detroit River. The bridge is being financed entirely by Canada and the procurement is being undertaken by the Windsor-Detroit Bridge Authority, a Canadian Crown Corporation, but its major decisions must be approved by a joint Michigan/Canadian Authority.

In response to industry and border stakeholder concerns that the existing crossings would not support the anticipated increase in cross-border traffic, a cross-border traffic survey study to collect origin-destination patterns of cross-border trips was carried out in 2000 by the Ontario Ministry of Transportation (MOT), Transport Canada (TC), the Michigan Department of Transportation (MDOT) and the US Federal Highway Administration (FHWA). This survey information supported the development of baseline information for the subsequent Planning Need and Feasibility (PN/F) Study and in 2001, the creation of the Canada-U.S.-Ontario-Michigan Border Transportation Partnership.

The process to plan a new international crossing commenced in 2001 when TC, MDOT, the FHWA, and MTO, entered into an “Ontario-Michigan Border Transportation Partnership Framework.” [121] Each of the parties undertook various planning and preliminary design activities on their respective sides of the border, but ultimately came to an agreement on the final design solution. They also completed the environmental reviews under a single document used by both the Canadians and the Americans.

The Partnership Agreement stated that it was not intended to be binding. Rather it served to memorialize a consensus between the parties as to (1) the purpose of improving the safe and efficient movement of people, goods and services across the border; and (2) identifying infrastructure improvements that met stated objectives.

To implement the agreement, the parties established a Steering Committee composed of equal number of representatives of each Partner to:

- Seek appropriation of funds to implement various tasks;
- Direct, oversee and approve the development and implementation of an integrated planning and environmental process;
- Recommend legislation, regulations and strategies;
- Direct development and implementation of communications strategies;
- Coordinate with other public agencies, interested organizations and the public;
- Determine appropriate stages and mechanisms to foster public-private partnerships;

[121] https://www.state.gov/documents/organization/195002.pdf

- Oversee projects, studies and assignments, with MTO and MDOT leading consultant assignments and contracts; and
- Equally share the costs of a “Needs and Feasibility Study”.

The 13- member Steering Committee undertook these tasks through individual Working Groups and Task Forces.

In 2012, a formal “Crossing Agreement” was entered into by Canada and Michigan pursuant to which they created a joint “International Authority” under Michigan law with members from both jurisdictions with power to approve the design, financing and construction of the project that would be undertaken by a separate “Crossing Authority.”[122] All decisions of the International Authority had to be approved by both parties. Its jurisdiction included approving the form of RFPs and RFQs; approving acceptance of proposals; approving the requirements of any P3 agreement; and allocating costs. But its approval authority was generally circumscribed so that no one party could block the procurement because it did not like one individual element of it. The Crossing Agreement also expressly stated that no provision of the agreement could be construed as a waiver of governmental powers or sovereign immunity by Canada or Michigan, thereby avoiding the restrictions on international compacts contained in the US Constitution.

Since Canada had ultimately agreed to finance the toll bridge, a separate “Crossing Authority” was created as a Canadian Crown Corporation to implement the procurement. Construction of the project commenced in the Fall of 2018 with a 74-month construction schedule to complete the four components of the project, with opening planned for late 2024.

2.2 Seaway International Bridge

A second US/Canada precedent project is The Saint Lawrence Seaway International Bridge, an international crossing connecting New York State and the province of Ontario. It consists of the South and North Channel Bridges. The South Channel Bridge was opened in 1958 and spans the St. Lawrence Seaway. The North Channel Bridge, opened in 2014, connects the City of Cornwall to Cornwall Island. The bridge is among the busiest on the Canadian/US border, with about two million crossings a year. It is jointly owned by the Saint Lawrence Seaway Development Corporation, a US governmental agency created under federal law (33 USC 981 et seq.), and the Federal Bridge Corporation, created as an instrumentality of the Canadian federal government. These two mirror organizations allow the parties to work together without a single joint authority. The bridge is operated by the Seaway International Bridge Corporation (SIBC), which is under the control of the Canadian Federal Bridge Corporation. The SIBC bills each of the parties for their respective share of the costs of operating the bridge.

2.3Peace Bridge

A third, and much older precedent, is The Buffalo and Fort Erie Public Bridge Authority, an international entity which owns the Peace Bridge, a major international toll crossing spanning the Niagara River between Fort Erie, Ontario, and Buffalo, New York. It was created pursuant to a compact created in 1923 by the State of New York, with the consent

[122] https://www.michigan.gov/documents/buildthisbridge/Agreement_389284_7.pdf

of the United States Congress, and by the Government of Canada. The Authority is governed by a ten-member Board consisting of five members from New York State and five members from Canada. The chairmanship alternates annually between the United States and Canada.

Two of the five American Board Members are appointments of the Governor which are confirmed by the New York State Senate. The remaining three Members are the New York State Department of Transportation Commissioner, the Niagara Frontier Transportation Authority Chairman, and the New York State Attorney General – or their designees. The Canadian Board Members are appointed by the Governor-in-Council as recommended by the Minister of Transport.

2.4Gateway Development Commission

In 2016, the States of New York and New Jersey and Amtrak created a non-profit corporation, the Gateway Development Corporation (GDC), to plan, finance and develop a program of rail projects, including the replacement of a 100-year old passenger rail tunnel under the Hudson River connecting New York and New Jersey. It is now contemplated that the GDC will be replaced by a bi-state commission, the "Gateway Development Commission" to be authorized under mirror legislation currently pending before the legislatures of both New York and New Jersey.

The stated purposes of the Commission are to act as a coordinating agency, but with full powers to finance; apply for federal grants and loans; and impose fees and charges to help finance the capital costs of the project. The three commissioners of the Commission are to be appointed by agencies of the two states and Amtrak. The legislation also provides for state indemnification of the commissioners from each state. The Commission is also directed to adopt open meetings and open records procedures. The Commission's power will include those to acquire property; enter into contracts; make its own procurement rules; borrow money and issue bonds. As a matter of policy, its projects are to conform to local construction and other regulations, as well as fire and safety "to the extent practicable." While the Commission is subject to lawsuits, it is also subject to immunities granted to each of the States under state tort claims act and other statues. Named officials of each state are also authorized to exercise power of eminent domain for property to be transferred to the Commission.

The legislation also has language intended to avoid the Commission being subject to the US Constitution "Compact Clause" requirements, discussed below. A recital in the legislation states:

> [The] creation of a bi-state commission that shall be a body corporate and politic established by the State of New Jersey and the State of New York, acting in the public interest and exercising essential governmental functions, is an appropriate means to accomplish these very important goals and is not intended to impair, limit, diminish, or otherwise affect any right, power, or jurisdiction of the United States of America or any department, branch, agency, court, bureau, or other instrumentality thereof with respect to any matter, or grant or confer any right or power on such bi-state commission, or any officer or trustee thereof, to regulate commerce between the states.

2.5European and Canadian Authorities

A number of complex transportation projects have been delivered across Europe and Canada, some of which cross national borders. Due to the difficulties in delivering other similar projects using traditional governance approaches, this has led to the creation of new governance structures to more effectively develop, fund, construct and operate these investments, the most notable of which are outlined below:

- **Channel Tunnel**: This project, which links the United Kingdom (UK) with France, was conceived in the 1980s and completed in 1994. An international treaty was established to provide the right to construct, fund and operate/maintain the tunnel by a private company listed on London & Paris stock exchanges. The company was granted a 65-year operating concession (similar to a P3 structure) that allows it to recover its initial $6B investment through charges to users (including passenger and freight train companies, trucks, buses and private cars), retail revenues from its terminals and utility rights, which are primarily power and telecommunications. The tunnel is linked to existing public infrastructure (both rail and road) built in parallel to the tunnel. Independent public economic and safety regulations were established through the treaty to monitor the concession and protect the interests of users of the tunnel, competitors to the tunnel (primarily ferry companies) as well as the general public. The structure successfully delivered this transformational project and has continued to operate, maintain and develop services, including additional investments.
- **Crossrail (UK)**: When completed in 2020, Europe's largest infrastructure project (costing $20B) will provide a 73-mile (13 miles of new twin-bore tunnels) new cross-central London railway with 10 new stations (largely underground) and new transport links to London's key business districts. Crossrail's governance reflects lessons learned from the successful delivery of London Overground and the Channel Tunnel Rail Link in 2007. A separate delivery company was established, with clear output requirements set by the government client/sponsor (TfL & DfT) that were linked to sponsor's business case. While key decisions were agreed upon with the sponsor, the delivery company was empowered to deliver the project, including integrating civil, systems and operational works. The sponsor also employed an expert advisor team to provide impartial evidence of progress and impacts of any proposed changes. Crossrail was funded by a mix of government grants, surplus fare revenues and locally raised levies (business & land value capture fees).
- **Tours – Bordeaux HSR (France)**: In 2006, the case to extend the Paris to Tours HSR line to Bordeaux was agreed to increase capacity, reduce journey times and stimulate the regional economy. A P3 concession was signed with the private LISEA consortium in 2010, transferring responsibility against output requirements for design, construction, operation and maintenance for the 180-mile extension over a 50-year period. As with many other P3 concessions, responsibility for strategic, political and 50% of the funding was retained by the French government, with delivery, operation and other responsibilities (including delivery risk) transferred to LISEA. The private concession recovers its initial investment (50% of the $9B capital cost) through access charges, retail/property and availability payments for meeting contractual targets on completion of works, operating performance, etc. Independent regulation was established to ensure fair access to infrastructure. The line opened in 2017.

- **REM (Canada)**: Regional Express Metro (REM), is a new 40-mile integrated rail line linking downtown Montreal with communities across the region, as well as the airport. The project is being delivered by a separate company, CDPQ Infrastructure (made up of public pension funds), who are responsible for the design, procurement, construction, operation and maintenance. The scope for REM has been established by the Quebec provincial government linked to a business case. Unlike some other DBFOM/P3 projects, ownership is split between CDPQ and the Quebec provincial government. REM is expected to cost $5B and CDPQ will recover its initial investment through availability payments linked to achieving ridership and meeting performance targets (both in the delivery of the capital works and operating performance measures). Construction started in late 2018 and is planned to be completed in late 2023.

There are several common themes across many of these other projects, including:

1. A separate delivery company is established to split responsibilities of policy/funding from delivery, in part to improve decision making process.
2. Outcomes-based requirements are developed early in the development of the project to ensure clarity on project deliverables, linked to objectives.
3. There is private involvement in delivery (P3 in many cases) to incentivize robust and cost-effective project delivery through integration of design, procurement, construction and operational requirements (considering whole life-cycle costs).
4. Alternative funding tools are used to minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries.
5. There is an independent regulatory scheme to protect users and challenge performance.

3 Legislative Authorizations

Any governmental entity created to plan, finance, build and operate the UHSGT system must be authorized and comply with relevant statutory proscriptions, particularly those dealing with bi-state and bi-national organizations.

3.1 United States Constitution – Compact Clause

Article I, Section 10 of the United States Constitution governs the rights of states to enter into bi-state and international agreements. It provides:

> *No state shall enter into any treaty, alliance, or confederation…No state shall, without consent of Congress…enter into any agreement or compact with another state or with a foreign power.*

While this provision would appear to require Congressional consent to any international agreement or bi-state compact, it has been interpreted to mean that as long as the arrangement does not encroach on the supremacy of the United States government or any state, a bi-state or bi-national authority can be created without Congressional consent.[123] During their 74th and 88th sessions, Congress issued statements clarifying its stance on the issue of foreign agreements made by the states, holding that not all transborder interactions require their consent, and that they would generally allow states to enter into agreements so long as the states' actions did not threaten the centrality of the U.S. federal government. Congress interpreted the aforementioned constitutional clauses to imply that "the terms 'compact' and 'agreement' do not apply to every compact or agreement…but the prohibition is directed to the formation of any combination tending to the increase of political power in the States which may encroach upon or interfere with the just supremacy of the United States."[124] For example, legislation authorizing the Gateway Development Commission expressly states that it is "not intended to impair, limit, diminish, or otherwise affect any right, power, or jurisdiction of the United States of America…or grant or confer any right or power on such bi-state commission, or any officer or trustee thereof, to regulate commerce between the states." Likewise, the agreement setting up the "International Authority" created to oversee the development of the Gordie Howe Bridge provides:

> *Except as specifically provided to the contrary, nothing contained in this Agreement shall constitute or be construed or be deemed to constitute or be construed as a delegation by Canada of any of the powers, duties or functions of Canada to the Crossing Authority or a delegation by Michigan of any of its sovereign or constitutional powers to either of Canada or the Crossing Authority. (Section 7)*

3.2 Washington State Law

One Washington State statute, Revised Code of Washington (RCW) 39.34.030, authorizes the joint exercise of powers with other states, but does not include foreign jurisdictions:

[123] See "Constitutional and Legislative Authority for Intergovernmental Agreements Between U.S. States and Canadian Provinces, by Steven de Eyre, Canada-United States Law Institute.
[124] S. DOC. NO. 88-39, at 416-419 (1963).

***(1) Any power or powers, privileges or authority exercised or capable of exercise by a public agency of this state may be exercised and enjoyed…jointly with any public agency of any other state or of the United States to the extent that laws of such other state or of the United States permit such joint exercise or enjoyment. Any agency of the state government when acting jointly with any public agency may exercise and enjoy all of the powers, privileges and authority conferred by this chapter upon a public agency. ***

Washington's public-private partnership law (RCW 47.29.210) does permit the state to enter into agreements with other units of government or Canadian provinces for trans-border transportation projects. But such arrangements are subject to all the other specific requirements and approvals set forth in the P3 law.

3.3 Oregon State Law

Oregon's law, Oregon Revised Statutes (ORS) 190.485, is broader than Washington's joint powers act, RCW 39.34.030. Oregon's law permits a state agency to exercise authority jointly with another nation or agency of a foreign nation, subject to certain restrictions. The statute provides that the agreement must specify its duration, the organization, composition and nature of any separate legal or administrative entity created to exercise the functions agreed upon, the purpose of the agreement, the method of financing the joint or cooperative undertaking, the methods to be employed to terminate the agreement and "other necessary and proper matters."

A separate provision, ORS 109.420 authorizes bi-state (but not international) agreements. Such agreements, "must specify its duration, the organization, composition and nature of any separate legal or administrative entity created to exercise the functions agreed upon, the purpose of the agreement, the method of financing the joint or cooperative undertaking, the methods to be employed to terminate the agreement, and any other necessary and proper matters."

3.4 Province of British Columbia

The Province has the authority to enter into a cross-border agreement as well as some regulatory authority for railways. However, the Canadian federal government will have to be involved because. rail lines that operate between two provinces or beyond fall under the jurisdiction of the Canadian federal government.

3.5 Federal Government of Canada

Transport Canada (TC) and the Canadian Transportation Agency (CTA) both have jurisdiction over federally-regulated railways operating in Canada. Federally-regulated Railway Companies are those that meet one of the following conditions, as determined by the CTA:

- the railway work or undertaking connects or crosses provincial borders;
- a company operates a railway across international borders;
- the work is declared to be for the general advantage of Canada;

- the railway work is owned, controlled, leased or operated by a person who operates a railway within the legislative authority of Parliament; or
- it is an integral part of an existing federal undertaking.

These companies are required to obtain a Certificate of Fitness under section 91 of the Canada Transportation Act, S.C., 1996, c. 10.[1] (CTA Act), as well as a Railway Operating Certificate under section 17.1 of the Railway Safety Act, R.S.C., 1985, c 32[4] (RSA). For example, see Decision No. 391-R-1997 on the APPLICATION by National Railroad Passenger Corporation (Amtrak), pursuant to section 91 of the Canada Transportation Act, S.C., 1996, c. 10, for a certificate of fitness authorizing it to operate a railway in Canada as per agreements with the Canadian National Railway Company and the Burlington Northern and Santa Fe Railway Company.[3]

Construction of railways in Canada is also subject to the jurisdiction of the CTA (for approvals to construct railway lines under s.98 of the CTA Act) and of TC (under Part I of the RSA - Construction or Alteration of Railway Works).

Construction and operation of railways in Canada is also subject to the jurisdiction of TC under the Railway Safety Act, R.S.C., 1985, c 32[125].

Transport Canada played a significant role in the development of the Gordie Howe Bridge. In 2000, it participated in a cross-border traffic survey study to collect origin-destination patterns of cross-border trips. This led to execution of “Ontario-Michigan Border Transportation Partnership Framework” in 2001 by TC, the MDOT, the FHWA, and MOT, under which each of the parties undertook various planning and preliminary design activities on their respective sides of the border, but ultimately coming to an agreement on the final design solution. In 2012, the Minister of Transport was a party to the “Crossing Agreement” that authorized the creation of the “International Authority” with power to approve the design, financing and construction of the project. The International Authority included two members appointed by the Minister of Transport. There is also a Windsor-Detroit Bridge Authority, a 100% Canadian-owned Crown Corporation, that will deliver, procure and fund the project through a P3.

[125] https://laws-lois.justice.gc.ca/eng/acts/r-4.2/

4. Initial Partnership Agreement

Setting up a bi-national and bi-state entity will be a complex undertaking, and may require legislation, at least in the state of Washington. This will take time and considerable effort by the three jurisdictions to come to a final agreement on the membership, structure and powers of the entity.

While the structure and powers of a final implementing entity are being developed, as contemplated by the recent Washington enactment, the three jurisdictions may want to consider entering into an interim agreement to carry out other preliminary activities, such as further pre-NEPA planning. This should include a robust community engagement process to encourage public input while refining the alignment for communities and businesses relevant to the ultra high-speed corridor.

This kind of multi-jurisdictional cooperation could be implemented through an informal "partnership agreement" as was done in the early stages of the development of the Gordie Howe bridge. Such an agreement or MOU could authorize a steering committee or alliance comprised of representatives of each of the jurisdictions to carry out legal research, as well as other early-stage development tasks described above.

The parties might also want to consider whether such efforts could be supplemented by those of a separate non-profit corporation including public and private stakeholders. The organization could serve as a focus of public outreach and advocacy.

One model is the non-profit corporation created to advance the Gateway Project in its beginning stages. Initially its members included representatives of New Jersey Transit, the State of New York, Amtrak (a private corporation) and the US Department of Transportation (USDOT). The Gateway Development Corporation has developed financial plans; coordinated separate funding and financing applications for the first project; solicited input from the private sector on procurement and risk-sharing; and advocated for funding and financing by the federal government. Its website and press engagements also have served as a central source of information for the public. (As noted above, it is now contemplated that the Corporation will be succeeded by a Commission authorized by legislation in both states that will meet the qualifications for FTA Capital Investment Grant (CIG) funding.)

5. Key Governance Issues

In considering the structure of any international entity, the parties will need to consider and resolve a broad range of issues:

1. *What will be the stated purpose and goals of the organization?* The most important initial step for any project undertaken by different government entities is achieving a common vision for the project. The common vision and goals for the project should be expressly stated in the agreement establishing the governing authority. This should be a long-term and widely held vision that will endure for the life of the project. The means and methods for achieving the vision and goals may evolve over time, but the ultimate vision and goals must remain the guiding principles throughout the life of the project. Strong stakeholder engagement is critical to develop the vision and goals.

   What are the key goals that the project must achieve and reconcile? For example, how will the financial plan, that is dependent in part on maximizing project revenues, be modified to ensure that the project also provides important transportation benefits to underserved communities located at a distance from job centers.

2. *Who will be represented on the Governing Board, and how will their members be appointed?* Should the governing board be made up of only one appointee from each jurisdiction? Or should it be larger to include representatives of other stakeholders? Should representatives of USDOT and TC participate at the Board level? How should the private sector be included? Most multi-jurisdictional authorities require unanimous consent to any actions. What happens in the event of disagreement, or withdrawal of one or more parties? For this reason, the scope of the decision-making authority of the Board and that which can be delegated to its officers must be carefully considered.

3. *What should be the scope of decision-making authority of the Governing Board?* Most multi-jurisdictional authorities require unanimous consent to any actions. For this reason, the scope of the decision-making authority of the Board and that which can be delegated to its officers or implementing agencies must be carefully considered. For example, decisions of the Gordie Howe International Authority must be approved by both Canadian and American parties. Its jurisdiction includes approving the form of RFPs and RFQs; approving acceptance of proposals; approving the requirements of any P3 agreement; and allocating costs. But its approval authority is generally circumscribed so that no single party can block the procurement because it has issues with one detail of it.

4. *Should the project be delivered through a separate development company?* Several of the successful precedents. including the Gordie Howe Bridge. delivered the project through a separate delivery company established to split responsibilities of policy/funding from delivery, in part to improve the decision-making process. Older cross-border projects have used a separate operating company that bills the parties for their share of annual costs. A P3 entity could also fulfill this role.

5. *How will ongoing activities be staffed, procured and funded?* Long-term sustainable funding for the project will need to be provided by the member jurisdictions based on an agreed allocation, and subject to mutually-agreed conditions. A frank and thorough assessment of risks will be important on obtaining agreement on cost-sharing.

6. *How will the entity coordinate with other agencies and decision-making bodies at the local, regional, state and federal level?* Some members of the Governing Board may be appointed and thus directly represent the appointing agency, e.g. a state department of transportation. Should funding agencies be directly represented on the Board? In the case of the Gateway Development Corporation, the Trustee appointed by USDOT withdrew on the grounds that membership created a conflict of interest.
7. *What transparency rules should be adopted to govern meetings and availability of agency records and documents?* It is likely that each jurisdiction has somewhat different "open meetings" and "open records" laws that apply to their agencies. Should the rules of one state be selected or should the agency craft its own rules?
8. *What will be its role in pre-development activities?* These would include, among others, (a) defining station location and alignment options; (b) carrying out environmental reviews; (c) financial planning; (d) public outreach; and (e) industry outreach. What is the appropriate level of consideration needed for social responsibilities such as equity and emissions reduction in the implementation of pre-development activities and beyond?
9. *How will right-of-way acquisition be carried out?* Can rights of eminent domain be transferred to the entity or should each member agency be responsible for right-of-way acquisition in its own jurisdiction?
10. *What implementation powers should the entity have?* While one of the stated purposes of the authority would be to act as coordinating agency for the three jurisdictions, it should also have the ability to apply for Canadian and US federal grants and loans, as well as impose fees and charges to help finance the capital costs of the project. Alternatively, if a separate development corporation is created, financing can be implemented by that entity.
11. *What forms of procurements should the entity be empowered to use?* The governing authority should be empowered to enter into or approve the use of alternative funding and financing arrangements in order to access private financing. Alternative funding tools are used to minimize dependence on traditional government sources and spread obligations across a wider set of beneficiaries. Private involvement in delivery will incentivize robust and cost-effective project delivery through integration of design, procurement, construction and operational requirements by considering whole life-cycle costs.
12. *What kind of land development strategies can be exercised to capture some of the value of real estate projects benefitting from location near stations?* The authority's power should also include those needed to acquire right-of-way and other properties needed for stations and maintenance facilities. However, if the entity can be endowed with land development powers that go beyond providing for stations and immediate right-of-way, it can directly benefit from increased value of adjacent properties beyond tax increment financing.
13. *What legislation will be required in any of the jurisdictions to accomplish the foregoing?* For example, should the Washington State Legislature consider broadening RCW 39.34.030 to include international agreements apart from those carried out under RCW 47.29.210, or adopt legislation expressly authorizing an international and bi-state entity

to carry out the UHSGT project? Should each of the other jurisdictions adopt “mirror” legislation specifically tailored for the development entity? Would the project require legislative action by the federal government of Canada? Should the project be “earmarked” in upcoming US Surface Transportation Reauthorization legislation?

6. Conclusion

Creating a governing entity to undertake a major infrastructure project is always a challenging task. This is even truer when that entity must represent the interests of separate jurisdictions, including two sovereign states and separate nation joined by common borders. Happily, there are well thought-out precedents for large and complex infrastructure projects connecting the United States and Canada. There are also multi-party organizational structures that have successfully financed, built and operated major rail and transit projects in Europe and elsewhere. While there is no one “best” model, each of these precedents contains elements that might be adapted for the UHSGT project.

Initially, Oregon, Washington and British Columbia should consider coordinating their efforts to reach a final agreement on the structure of a new entity through an informal working group. This entity could also serve to advance such other ground-stage activities as: stakeholder and public outreach, preliminary alternatives analysis of corridor alignment and station locations, and developing a long-term financial plan for an UHSGT system linking Portland, Seattle and Greater Vancouver, BC.