

# Addendum Ultra-High-Speed Ground Transportation Study Initial Estimate of Economic Impacts

This memorandum supplements the Vancouver-Portland UHSGT analysis to assess the broader economic impacts of a potential future UHSGT project to the greater Vancouver and Seattle portion of the UHSGT study corridor as envisioned by government and private industry leaders from British Columbia and Washington at the 2016 Cascadia Innovation Corridor Conference. While the UHSGT study work on capital costing and ridership analysis examined many concepts; this supplemental memorandum assesses the economic impact of the HSR service under operating Concept Corridor 1A (12 round trips daily, 7 stations using the maglev technology). This memorandum is provided under separate cover as an addendum to the UHSGT Study because:

- it applied different analysis tools and parameters, including both CONNECT and TREDIS;
- it focused on a portion of the broader Vancouver-Portland study corridor; and
- it applied cost and performance outputs from one of multiple UHSGT concepts that emerged from the UHSGT Study.

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# Ultra-High-Speed Ground Transportation Study

## Initial Estimate of Economic Impacts

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### 1. Introduction

#### Project and Purpose

The Ultra-High-Speed Ground Transportation (UHSGT) Project (hereafter “the Project”) analyzed, at a high-level, the possibility of implementing ultra-high-speed passenger service between the urban areas of Portland, Oregon and Vancouver, British Columbia using either steel wheel or magnetic levitation (maglev) technology. The analysis performed to date looked at ridership, revenue, capital and operating costs, technology options, funding and financing, and institutional issues related to implementing this proposed service.

The work described in this technical memorandum builds on the prior analysis to assess the economic impacts of a potential future UHSGT project. Prior work on capital costing and ridership analysis examined many concepts; this analysis assesses the economic impact of the HSR service under operating Concept Corridor 1A (12 round trips daily, 7 stations using the maglev technology). This Concept Corridor is one of three which the study addressed, and had the highest ridership. In this memorandum, economic outcomes include the employment and labor income impacts that result from construction, operation of the service, as well as the wider economic effects as the market responds to the availability of this new service. This memorandum describes the assumptions and process used to analyze and quantify the economic effects of future UHSGT focused on the greater Vancouver, BC and Seattle/Puget Sound economic context, and reports the findings. As the Project is in the initial planning stages and to account for uncertainty, results are presented as a range.

#### Structure of Memorandum

The balance of this memorandum:

- Describes the economic context for the Project in Section 2
- Describes the Role of Economic Analysis in this Study in Section 3
- Describes the Economic Impact Analysis (EIA) in Section 4
- Outlines the methodology for the EIA including the data inputs and tools used in Section 5
- Quantifies the economic effects of the project for construction, operations and maintenance, and agglomeration in Section 6
- Quantifies the Greenhouse Gas (GHG) emissions reductions in Section 7
- Outlines the main takeaways of this preliminary economic assessment in Section 8

## 2. Economic Context

Seattle, Washington, Vancouver, B.C., and Portland, Oregon anchor the Cascadia megaregion, a uniquely positioned urban complex on the Pacific Coast of North America. A primary focus of government and industry leaders who attended the 2016 Cascadia Innovation Corridor Conference, the analysis examines the potential for UHSGT to leverage economic growth opportunities among the megaregion’s major urban economies—especially between Seattle and Vancouver— that are approximately 150 miles apart. In fact, the project would reduce travel times between Seattle and Vancouver from over 2.5 hours by car to less than one hour by rail. While the CONNECT tool (described later in this memo) assessed ridership impacts for the entire corridor between Portland and Vancouver, this memo focuses on the impacts to the 9-county corridor in Washington State and British Columbia because the TREDIS model, which is used for the Economic Impact Analysis (EIA), does not include the economic structure of Portland. As a result, the estimates for the economic impacts are conservative. The dominant economies within this study area are Seattle, Washington and Vancouver, B.C.

Bisected by the Canada-U.S. border, these two metropolitan areas still have similar economic histories—starting out as hubs for resource exports and gradually transitioning to high-tech knowledge economies. While a resource distribution economy emphasizes the efficient movement of goods, the evolution to a knowledge-based economy creates a greater need for labor accessibility and the efficient movement of people.<sup>1</sup>

The Seattle economy is anchored by global technology and commerce companies such as Boeing, Microsoft, and Amazon, among others. Many of these companies have begun to establish operations in Vancouver. Microsoft established a development center in Vancouver in 2007, and expanded its presence in the market with a downtown facility in June of 2016. Amazon.com selected a downtown Vancouver site in 2014 and Tableau Software, Inc., a smaller Seattle tech, firm began operating in Vancouver in 2015. All three cited Vancouver’s local pool of talent, as well as other factors in their site selection decision. In addition, Canada’s more predictable and favorable immigration policies relative to the U.S. at this time serve as another labor access factor for talent-hungry tech companies.<sup>2</sup>

This knowledge economy is dependent on the efficient movement of workers between the two metropolitan areas as workers respond to the needs of firms that create or work with new technologies. Movement is driven by the within-firm exchange of labor as well as collaboration among firms. The networks of firms that are developing new high-tech and bio-tech products increasingly span international borders and seek to draw from a pool of international talent. So, growth of the Cascadia region is fostered by investments that ease the movement of people between these two tech hubs and facilitate the integration of these economies.

In 2016, the population of metropolitan Seattle stood at about 3.8 million residents and metropolitan Vancouver stood at about 2.5 million<sup>3</sup>. Greater integration would effectively more than double the Vancouver labor market or increase the Seattle market by 66 percent. On its own, the Seattle metropolitan area ranks as the 15<sup>th</sup> largest in the U.S. The combined Seattle and Vancouver population of 6.3 million would put the area on par with the Washington, DC metropolitan area, the nation’s sixth largest. A Boston Consulting Group Study found that “[a]s the population in a region doubles, patents, wealth and total output all grow” and that such regions benefit “from increasing returns to scale. GDP,

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<sup>1</sup> The analysis assumes that border regulations will accommodate flows of people projected in the ridership model, and that the border will operate more as a sieve than a barrier. Investments to facilitate high-speed travel will be offset by immigration policies that close markets and deter movement between the two countries.

<sup>2</sup> Summarized from Richardson, Katherine. 2017. *Knowledge Borders, Temporary Labor Mobility and the Canada–US Border Region*. New York: Edward Elgar Publishing.

<sup>3</sup> Seattle estimate is for the Seattle-Tacoma-Bellevue Washington Metro area (U.S. Census, American Community Survey, 2016). The Vancouver estimate is for the Greater Vancouver Regional District (Statistics Canada, 2016).

R&D, and invention rates all increase ...”<sup>4</sup> Greater physical access and a one-hour trip time would allow Seattle and Vancouver access to a larger labor pool and to compete as a larger market than they do today, increasing their joint competitiveness.

Longer term, Cascadia is poised to serve as an important global gateway for both countries. One of the objectives of the North American Free Trade Agreement (NAFTA)<sup>5</sup> was to facilitate the integration of the North American economies, although some gains have been offset by post-9/11 security restrictions. Vancouver has developed strong human and economic ties with many of the strongest Asian economies including Hong Kong, Singapore, and Taiwan.

### 3. Role of Economic Analysis in this Study—What it Says at this Stage

Planning for UHSGT is at an early stage; as a result the economic analysis represents an early “first look” at the Project’s economic development potential with the understanding that the economic analysis will be refined as the Project develops. Two types of economic methodologies are used to assess infrastructure investments. Economic Impact Analysis (EIA) describes how the economy changes in response to the travel time savings and greater accessibility afforded by the Project. EIA does not tell us whether this is a good or bad investment; it describes how the economy changes in terms of jobs, earnings and productivity for example. Benefit Cost Analysis (BCA), by contrast, compares the net benefits to the net costs of the Project to determine whether it is a good investment. Given this early conceptual study stage, the study team advised WSDOT that it is premature to perform a BCA. A BCA could be misleading at this stage with the limited information developed and the potential of omitting large potential impacts of the investment. A BCA should be performed when the project information is further developed. This is consistent with the U.S. Federal Railroad Administration guidance which does not direct a BCA to be performed until much later in the project development process.

Because the planning for UHSGT is assessing the feasibility of the project, much of the planning information is understandably at a conceptual level. The EIA performed, with the limited information available, indicates the project has large economic development potential for the region and suggests there is good reason to continue project development. This analysis, to date, found no fatal flaws, confirms technical feasibility and through the EIA, identifies significant economic development potential for the broad U.S.-Canadian region.

### 4. Economic Impact Analysis

Economic Impact Analysis (EIA) compares the economic outcomes between two scenarios. The first scenario is the base case; it describes how the economy would perform across a variety of metrics in the absence of the candidate investment. The second scenario is the build case; it describes how the economy would perform across those same metrics with the candidate investment in place and operating. The economic impacts are the net changes in the metrics between the two scenarios.

Typical metrics include the jobs and earnings supported by construction and operations of the project. They can also describe the market response to the availability of the new asset. The impacts considered in an EIA may contain both quantifiable and non-quantifiable impacts, such as those summarized below:

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<sup>4</sup> *Better Together: The Cascadia Innovation Corridor Opportunity*. September 2016.

<sup>5</sup> Trade agreement between the United States, Canada, and Mexico that eliminated tariffs and most duties and quantitative restrictions on goods traded between the three countries.

- Construction impacts: The jobs and earnings created and sustained through the capital spending to build the transportation investment(s). These short-term construction impacts can include the direct, as well as the indirect and induced, impacts that last as long as the capital costs are expended<sup>6</sup>.
- Operations and maintenance impacts: The jobs and earnings created and sustained as a result of the operations and maintenance expenditures (including labor) associated with the transportation investment(s). These long-term operations and maintenance impacts can include the direct, indirect, and induced impacts that occur as long as the project is in operation.
- Wider economic benefits (agglomeration impacts): The term agglomeration refers to the concentration of economic activity within a region. Transportation investment that significantly reduces travel time between cities<sup>7</sup> or increases the ability to move large numbers of people in and out of an urban market improves accessibility—increasing the number of workers and suppliers of other goods and services accessible to a firm. As a result, the range of choices expands, and firms are able to select those workers and suppliers that represent the best match for their needs. When the match between workers and firms—or between suppliers and producers—improves, the productivity of the market increases because firms are using workers with the best skill set for their needs and suppliers are using specialized expertise that best fits their needs. This is the agglomeration benefit. Past theoretical and empirical evidence has confirmed that the level of agglomeration affects the productivity of firms and workers in an area, even after controlling for characteristics specific to firms and workers in that area, such as the mix of industries.

## 5. Methodology

The economic impacts associated with construction, operation and maintenance (O&M), and agglomeration are estimated using the Transportation Economic Development Impact System (TREDIS) economic model.<sup>8</sup> TREDIS uses regional multipliers that measure the total change (direct + indirect + induced effects) in business output, employment, and labor income that results from an incremental change to a particular industry. The TREDIS model uses IMPLAN multipliers.<sup>9</sup> This model was selected for the analysis as it has an additional feature that estimates the agglomeration impact, and the potential market response was a key question for this analysis. While construction and operations impacts are expenditure driven, the agglomeration impact describes how the market's productivity/competitiveness would change in the study area if the effective distance were reduced with project implementation.

The TREDIS model came in two components: one for Canada and one for Washington State. Three types of adjustments were required to report a unified result for the megaregion. These were: 1) Adjustments were made to eliminate overlapping impacts between the two models. 2) For currency, 2015 Canadian dollars were converted to 2015 U.S. dollars at an exchange rate of \$1 USD to 1.329 CAD.<sup>10</sup> All dollars

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<sup>6</sup> Using construction as an example, direct employment represents the actual jobs on the building site. Indirect jobs are supported by the purchase of materials for the Project. Induced employment represents the jobs supported across the economy through construction workers' spending their earnings from working on the Project. Indirect and induced job impacts are sometimes known as the multiplier effect.

<sup>7</sup> The project considers reducing travel times between Seattle and Vancouver from over 2.5 hours by car today to less than one hour by rail if the Project were constructed and in operation.

<sup>8</sup> TREDIS.net

<sup>9</sup> IMPLAN is one of the most commonly accepted models used for economic impact analysis. The IMPLAN model is an economic modeling, input-output based, social account matrix software. It is used to estimate the economic impacts to a defined region resulting from expenditures in an industry. A social account matrix reflects the economic interrelationships between the various industries (and commodities), households, and governments in an economy and measures the economic interdependency of each industry on others through multipliers. Multipliers are developed within IMPLAN from regional purchase coefficients, production functions, and socioeconomic data for each of the economic impact variables and are specific to each region.

<sup>10</sup> <https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates>, 2015 annual average

shown in this memorandum are 2015 U.S. dollars unless otherwise noted. 3) For distance, vehicle kilometers traveled (VKT) were converted to vehicle miles traveled (VMT).

## **Modeling**

Prior work developed and assessed multiple high-speed rail (HSR) Concept Corridors and two technologies: steel wheel and maglev. This analysis describes the expected economic outcomes that would occur with implementation of Conceptual Corridor “1A”, maglev, 12 round-trips daily, with high cost and medium ridership range outputs. The study team recommended this as the representative scenario based on this alternative having the highest ridership of the concepts tested. The CONNECT tool provided a range of ridership results for the alternative; the economic analysis applies the medium ridership and high cost (also provided from CONNECT) as many readers will compare the economic impacts to the costs. If the project’s economic impacts compare favorably with high costs, then they would also compare favorably with lower cost estimates.

The economic impact analysis relies on information developed through the prior analysis and additional assumptions. Cost and ridership information were drawn from the Federal Railroad Administration’s (FRA) CONNECT tool which was used in the prior analysis. CONNECT provided travel demand results by mode for 2035 and 2055. These inputs were applied in the TREDIS model to quantify the economic impacts of the changes in traveler behavior and market access. More information on each tool or model is provided below.

## **CONNECT**

CONNECT is a sketch planning tool that estimates ridership, revenue, and costs of high-speed and intercity passenger rail corridors and networks. Originally developed as part of the FRA National Planning Study, CONNECT is a CBSA-to-CBSA<sup>11</sup>-based planning tool based on ridership relationships and default input data from across the U.S., which can be refined to some degree for the specific corridor to be studied. It is intended for use at the outset of the study process, before detailed alignment and operational plans are developed. CONNECT outputs are not a substitute for more detailed ridership and revenue studies required for FRA Service Development Plans or for investment grade analysis of feasibility.

The user can build a desired HSR network and develop associated service plans, generate operational data, and bracket the financial and operational performance for the network with CONNECT. The analytical process is driven by user inputs, which include network configuration and capital and operating and maintenance (O&M) costs, as well as operational and infrastructure assumptions. Outputs include ridership, revenue, capital cost estimates, O&M estimates, and public benefit estimates for the user-defined network.

As CONNECT is a high-level, sketch-planning tool, there are specific limitations associated with the forecasts, and any additional analyses using CONNECT outputs, such as this EIA and BCA, have similar levels of uncertainty associated with them. Key limitations of CONNECT include the following:

- CONNECT uses generalized calculations that generate typical rather than corridor-specific outputs. CONNECT cannot be expected to reflect with accuracy the ridership, revenue, or costs of existing corridors, but the results are indicative and can be used to compare alternatives and determine general feasibility.
- Analyzing corridor and network performance only on a CBSA-to-CBSA basis limits CONNECT’s outputs in two primary ways:

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<sup>11</sup> A Core Based Statistical Area (CBSA) is a U.S. geographic area defined by the Office of Management and Budget. A CBSA consists of one or more counties (or equivalents) anchored by an urban center of at least 10,000 people plus adjacent counties. The counties are tied socioeconomically to the urban center by commuting.

- Stations are not modeled at a detailed level. Station location is not considered in the tool, and instead CONNECT looks at the CBSA centroids for all calculations. Multiple station stops in one CBSA will not alter the ridership results, but they will increase travel time, which impacts ridership results.
- CONNECT cannot account for trips less than 50 miles (80.5 km) or greater than 850 miles (1,368 km). This limitation generally eliminated intercity trips within the CBSA, as well as trips between close CBSA pairs, which could understate the ridership potential of the service.

Because of the limitations of the CONNECT tool, particularly its high-level nature and excluding short-distance trips, the resulting ridership and revenue forecasts may be substantially understated. As these are the starting basis for most of the travel demand inputs into TREDIS, the resulting EIA also has uncertainties and possibly understated results.

### ***Modeling Assumptions***

The economic analysis builds on the prior work to develop the Project including information from the CONNECT tool. Based on a number of assumptions, the CONNECT outputs were converted into regional trips served (vehicle trips annually), vehicle miles traveled (or vehicle kilometers traveled for the British Columbia model), and vehicle hours traveled annually. In addition, transit passenger trips, transit passenger miles (or kilometers), transit passenger hours, and out of vehicle passenger travel time were estimated from the CONNECT results. The current passenger rail mode and future HSR (maglev) modes also were further delineated by trip purposes: business, commute, and personal.

The TREDIS travel module requires inputs for at least two years and for the Base and Project alternatives. The travel demand model was run for three scenarios:

- 2035 Alternative 1A maglev
- 2055 Alternative 1A maglev
- 2055 Do Minimum

The Do Minimum scenario serves as the Base Case; the Alternative 1A maglev scenario serves as the Build Case. Because there was no 2035 Do Minimum scenario, those results were estimated outside of the model based on the three existing model results, considering induced trips and appropriately balancing mode shares between the Do Minimum and Alternative 1A maglev scenarios.

The primary inputs to TREDIS were the city-to-city travel demand model results from CONNECT for Do Minimum and Alternative 1A maglev and the number of trips for passenger rail (existing Amtrak service), auto, air, bus, and HSR (future maglev service) trips. Additional information not available from CONNECT was also required for the economic estimation. From the volume of trips, which were rounded, passenger miles and passenger hours traveled were estimated based on the following assumptions:

- Distance, in miles, between stations by mode, based on Google Maps
- Travel time, in hours, between stations by mode, based on Google Maps
- Air-to-auto distance ratio assumed to be 0.85

Vehicle occupancy assumptions by mode were used to convert person trips to vehicle trips:

- Passenger rail (*Cascades*): 300 persons per vehicle (train set)
- Passenger car: weighted average of business and non-business from CONNECT of 2.78 persons per vehicle
- Air: small to mid-sized planes used for intracorridor travel
- Passenger bus: 60 persons per bus based on industry averages

- HSR maglev: 500 passengers per vehicle (train set) from CONNECT

Mode split assumptions were benchmarked against similar new high-speed corridor services and estimated to be 18 percent business, 12 percent commuter, and 70 percent personal.

Out of vehicle time per trip was estimated for each mode and includes access, egress, and terminal time based on values used in CONNECT and professional judgement:

- Access/egress time for all modes: 40 minutes (included in times below)
- Passenger rail (*Cascades*): 65 minutes
- HSR maglev: 65 minutes
- Passenger bus: 55 minutes
- Air: 115 minutes

Using the assumptions described above, trip tables were developed and input into TREDIS for the Base and Project alternatives. The trip tables needed to be further apportioned into the two models (U.S. and Canada) in order to appropriately capture the changes in travel behavior, costs, and populations accessible to the two countries. This was done based on trip ends (origin or destination), where it was found that 38 percent of trips began or ended in Canada. Because this analysis is looking at trips, not trip ends (origins and destinations), the trip end percentage was divided by two; therefore, 19 percent of the trips are assigned to the Canadian model while the remaining 81 percent of trips are assigned to the U.S. model. Apportioning the trip tables to account for the Canadian trips means that those results were converted from vehicle miles traveled (VMT) into vehicle kilometers traveled (VKT) and passenger miles to passenger kilometers.

The travel demand model results were input into the TREDIS model for years 2035 and 2055 in the appropriate U.S. and Canada models.

### **TREDIS Model**

The TREDIS model builds on IMPLAN and was selected for this analysis due to its ability to estimate the wider economic benefits (agglomeration). It is widely used in practice and represents a best practice for this type of analysis.<sup>12</sup>

The TREDIS EIA model uses inputs including capital and operating costs, travel demand model outputs, and changes in population to estimate the impacts on a regional economy in terms of business output (sales), value added (or gross domestic product), job-years,<sup>13</sup> and labor income (earnings or wages). TREDIS provides these impacts by year and industry over the applicable analysis period. See **Figure 1** for the impacts estimated by TREDIS.<sup>14</sup> Note that value added is a component of business sales, and wages are a component of value added.

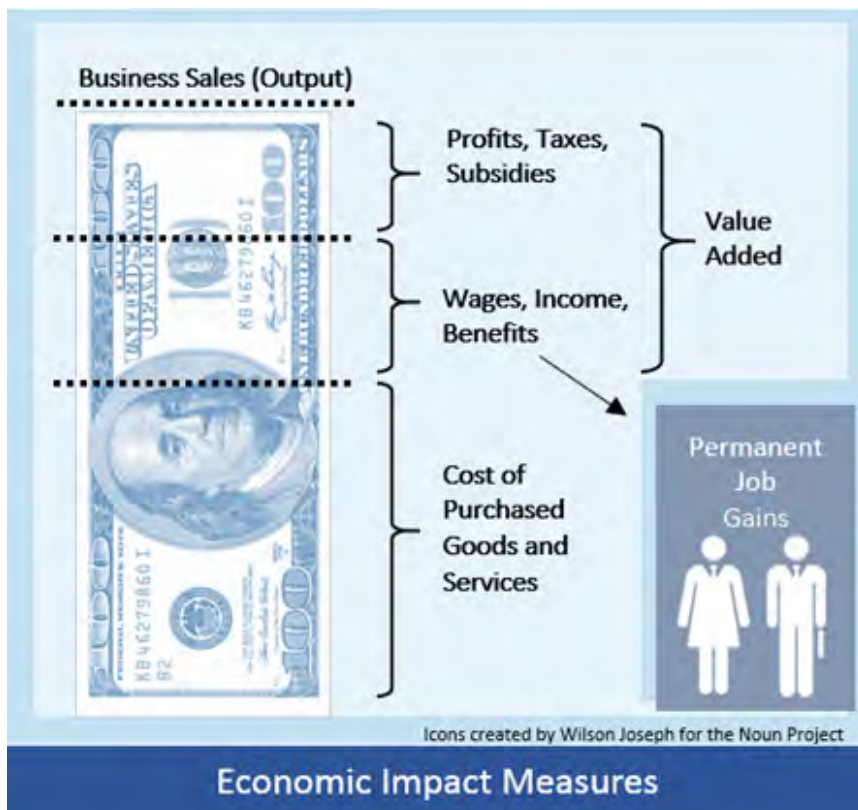
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<sup>12</sup> More information on the model, including the underlying economic theory, can be found from TREDIS documentation: see TREDIS Economic Adjustment Module, [https://500.tredis.net/user\\_resources/TREDIS%20500%20-%20Economic%20Adjustment%20Tech%20Doc.pdf](https://500.tredis.net/user_resources/TREDIS%20500%20-%20Economic%20Adjustment%20Tech%20Doc.pdf)

<sup>13</sup> A job year is one job for one person over one year; three job years is one job for each of three people over one year, or one job for one person over three years. The job-years are converted to average jobs per year by dividing by the number of years of construction (10 years for construction jobs) and operations (21 years for O&M, agglomeration, and operations).

<sup>14</sup> The TREDIS model used includes the IMPLAN I-O model for the multipliers. As part of that arrangement, TREDIS is prevented from breaking out the direct job impacts from the multiplier impacts (indirect and induced). Therefore, the analysts were unable to separate the indirect and induced impacts from the total impacts.





**Figure 1: Economic Impacts Estimated by TREDIS Model**

Source: TREDIS

In order to adequately capture the differing structures of the U.S. and Canadian economies, two models were developed for the purposes of this analysis: a Washington state model and a British Columbia provincial model. The following are module settings or inputs used in the TREDIS model setup process. The model was run using 0 percent inflation from the national perspective. Put another way, the analysis is in real terms.

- Analysis Type: The Vision Plan, which is most commonly used in TREDIS, was used for both the U.S. and Canada models.
- Modes: Passenger car, passenger bus, passenger rail, and aircraft modes were used. A new mode was added for HSR as a subset of passenger rail for the Project (Build) alternative.
- Timing: Construction spending was assumed over the 10-year period 2025-2034, while operations cover a 21-year period 2035-2055. Constant 2015 dollars were used to be consistent with CONNECT.
- Regions: The study area used for the Washington state model includes nine counties: Clark, Cowlitz, King, Lewis, Pierce, Skagit, Snohomish, Thurston, and Whatcom Counties. The study area for Canada is British Columbia. Note that Portland, Oregon is not included in the study area.
- Alternatives: Base (Do Minimum or No Build) and Project (Alternative 1A maglev or Build) alternatives were used.

- **Costs:** Costs were apportioned to the U.S. and Canadian models based on route-miles. Approximately 254 route-miles (409 km) of the Project (Vancouver to Portland) are in the U.S., and 29 miles (46 km) are in Canada. Costs were converted to Canadian dollars for the Canada model.<sup>15</sup>
- **Travel:** Travel demand model results were developed as described in the CONNECT tool section and applied for years 2035 and 2055 within both the U.S. and Canadian models.
- **Access:** The Market Access module of TREDIS quantifies the change in population accessible to the metropolitan areas by approximating the population within a 40-minute travel time of the central business district.<sup>16</sup>

The Base Local Market 40-minute travel time populations for Seattle and Vancouver were estimated by defining a separate model for each metropolitan area as the immediately adjacent counties for each. Note that Portland was not estimated because Oregon is not included in the model package for this project. The 40-minute travel time population is TREDIS's measure of a local market, within which the mechanisms of agglomeration show the greatest impacts.

The Base local market was defined for car and rail transit modes, and rail transit mode in the Project alternative.<sup>17</sup> In the Project alternative, the new HSR maglev service would allow for populations to travel farther within the same approximately 40-minute travel buffer, thereby providing additional accessibility for corridor populations. The Project alternative local market population was quantified using estimated travel times between stations, plus driving time within the 40-minute buffer. For example, the station of Bellingham, Washington is accessible from Vancouver within 14 minutes with HSR maglev service. As a result, the population of Bellingham and the surrounding towns with a 26-minute drive of Bellingham were added to the Vancouver Base population for the Project alternative. This pattern was continued up and down the corridor from Seattle and Vancouver; however, because Seattle's and Vancouver's accessible populations overlap in the Project alternative, half of the overlaps were assigned to each model. This split is to account for the fact that while populations will have access to both metropolitan areas within 40 minutes, people can only work in one at a time. This methodology was confirmed with TREDIS analysts. Sources of city and town populations came from the 2016 American Communities Survey (ACS) for the U.S. and Statistics Canada for Vancouver.

Finally, another market access scenario was estimated by adding the population within approximately 51 minutes, or the time it would take to travel by HSR maglev between Seattle and Vancouver. Again, the overlapping populations were divided equally between the Seattle and Vancouver models. Based on the 2016 ACS, the average commute in Seattle was 29 minutes, while 21 percent of commuters spent over 40 minutes traveling to work.

Because the Market Access module does not include the economic structure of Portland, Oregon, the estimates for these impacts are conservative.

## Costs

The project has two elements that contribute to the economic impacts assessment. The costs include the capital costs to construct the project and the O&M costs to run the services and maintain facilities.

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<sup>15</sup> CONNECT considered the corridor from Portland to Vancouver. The travel demand model estimates used in this study are drawn from CONNECT for consistency. The economic model considers Seattle to Vancouver; therefore the economic impacts are conservative.

<sup>16</sup> Same-Day Market (~180 minute employment size) and Average travel times to terminal were not used in this analysis as those metrics are freight-focused. This was confirmed with TREDIS analysts.

<sup>17</sup> Car mode in the Project alternative was not changed from the Base.

## Capital Costs

The capital costs for the project are based on costs utilized in CONNECT. The TREDIS model takes capital cost inputs for both the Base and Project alternatives. Under the Base alternative, the Do Minimum scenario from CONNECT was used for a cost of \$907 million.<sup>18</sup> The HSR maglev scenario from CONNECT was used for the Project alternative in TREDIS with a cost of \$40.5 billion.<sup>19</sup> Therefore the net capital costs are \$39.6 billion.

The capital costs are applied over a 10-year construction period estimated to begin in 2025 and ending in 2034, as is consistent with inputs to CONNECT. The costs are assumed to be spent equally over the construction period, and are apportioned to the U.S. and Canadian models based on route miles. The costs are shown in **Table 1**.

**Table 1: Summary of Capital Costs**

TREDIS Alternative	CONNECT	Capital Cost (2015 \$M USD)
Base	Do Minimum	\$900
Project	HSR Maglev	\$40,500
	Net Capital Cost	\$39,600

Note: figures are rounded

## Operating and Maintenance Costs

The project requires annual and periodic O&M costs to keep the track, stations, and the service operating efficiently. The O&M costs are provided on an annual basis consistent with CONNECT. Alternative 1A maglev operates 12 round trips per day and incurs \$28 million per year in O&M costs in under the Do Minimum scenario<sup>20</sup> and \$209 million per year under the HSR maglev scenario.<sup>21</sup> The net O&M costs are \$180 million annually, rounded.

The O&M costs are applied over the 21-year analysis period, 2035-2055. The costs are shown in **Table 2**.

**Table 2: Summary of Annual O&M Costs**

TREDIS Alternative	CONNECT	Annual O&M Cost (2015 \$M USD)
Base	Do Minimum	\$30
Project	HSR Maglev	\$210
	Net Annual O&M Costs	\$180

Note: figures are rounded

<sup>18</sup> Primary Corridor Emerging Stand-Alone Context – High, using the sum of the individual project components

<sup>19</sup> Primary Corridor Core Express Stand-Alone Context – High cost estimate for Alt 1A maglev, using the sum of the individual project components

<sup>20</sup> Primary Corridor Emerging Stand-Alone Context - High

<sup>21</sup> Primary Corridor Core Express Stand-Alone Context – High cost estimate for Alt 1A maglev

## 6. Economic Effects

Using the models and assumptions outlined above, the study team estimated the economic impacts from construction, operations and the market's response. The impacts are valued in terms of total job-years,<sup>22</sup> labor income, value added, and business output (sales).<sup>23</sup>

### Construction Impacts

The initial impacts of the HSR maglev investment are generated by the direct expenditures associated with building the new rail corridor, stations, and the maintenance facility. The construction of the modeled alternative will provide economic support for the surrounding corridor and the state or province as a whole. These are well paying jobs in the construction industry that support jobs across all sectors.

Construction spending increases the employment, earnings, and output for corridor communities for the duration of the construction process as building firms expand payrolls and purchase materials. The hiring associated with the project represents the direct effects of the corridor construction investment.

The earnings of these newly hired construction workers will translate into a proportional increase in consumer demand as these workers purchase goods and services in the region, generating additional jobs across a variety of industrial sectors and occupational categories as employers hire to meet this increase in local consumer demand. This latter hiring represents the indirect effect of the project. Purchases of supplies and materials for the project also translate into a proportional increase in employment in those industries that provide goods and services to the rail construction, as employers hire to meet this increase. This latter hiring represents the induced effect of the project. These are one-time benefits that last for the duration of the construction cycle.

The estimated construction impacts for years 2025-2034 as shown in **Table 3** are approximately 38,000 jobs per year and \$29 billion in labor income.

**Table 3: Summary of Construction Impacts**

	Construction Impacts (2025-2034)
Average Jobs per Year	38,000
Labor Income (2015 \$M USD)	\$29,000

Note: figures are rounded

### Operating and Maintenance (O&M) Impacts

Once the HSR maglev project is constructed and moves into operation, additional jobs are generated by the direct expenditures associated with operating the new rail corridor, stations, and the maintenance facility. In a similar sequence of spending and re-spending (the multiplier effect) to the construction impacts, the spending for O&M workers and supplies supports the economy. The O&M of the service will provide economic support for the surrounding corridor and the state as a whole. These are well paying jobs in transportation operations and maintenance that support jobs across all sectors.

Unlike construction jobs, jobs related to O&M are recurring and last for the duration of the HSR system's operation.

The estimated O&M impacts for 2035-2055, as shown in **Table 4**, are 3,000 jobs per year in total and \$5 billion in labor income.

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<sup>22</sup> This report converts the total job-years reported by TREDIS to average jobs per year by dividing the job-years by the number of years of construction (10 years for construction jobs) and operations (21 years for O&M, agglomeration, and operations).

<sup>23</sup> The TREDIS model includes the IMPLAN I-O model for the multipliers. As part of that arrangement, TREDIS is prevented from breaking out the direct job impacts from the multiplier impacts (indirect and induced). Therefore, the analysts were unable to separate the indirect and induced impacts from the total impacts.

**Table 4: Summary of Operating and Maintenance Impacts**

	O&M Impacts (2035-2055)
Average Jobs per Year	3,000
Labor Income (2015 \$M USD)	\$5,000

Note: figures are rounded

### Agglomeration Impacts

Urban areas such as those found in the corridor are focal points for commercial transactions and generate agglomeration impacts through internal connections as well as by facilitating connections to other cities. By collecting producers, suppliers, and consumers in urban centers, communication, transport, distribution, and production activities are less costly. Retailers, for example, benefit from a concentration of consumers in a relatively small geography. Consumers also benefit as their search costs are reduced and their choices are expanded.

Businesses also benefit from being in an urban area because they have a greater range of suppliers and access to specialized goods and services that make their own production more cost efficient. Urban areas provide access to large pools of labor, generally frequent and relatively inexpensive air transport, specialized technical and professional services, and a large client base. In an increasingly global economy, large metropolitan areas remain the gateway to the global economy. These so-called agglomeration economies diminish the cost of transactions and make the urban corridor's firms more productive and competitive.

The large reduction in travel times associated with implementation of HSR will foster greater accessibility for workers and employers. Business productivity benefits from employers' access to a broader and more diverse labor market with a better fit of workers, skills, and access to a wider customer market. The increase in effective economic density (or clustering) of economic activities supported by the HSR's operation and stations will enhance the productivity of the economy through firms' or workers' ability to access a wider range of offices, retail, entertainment centers, and other land uses within the same travel time. Such accessibility improvements provide increased efficiency through reduced labor costs, improved communication, lower infrastructure costs, and increased interaction with similar businesses. The concentration of economic activity and mobility to access various parts of the corridor provided by the HSR service provides an opportunity for more face-to-face contact and for access to specialized labor, which result in higher productivity and more economic growth. The reliability and mobility of the service improves the overall quality of life, and the attraction of both businesses and employees to the region supports additional growth and development, resulting in agglomeration economies.

These agglomeration economies collectively make the corridor economies more competitive than they would be in the absence of the Project. The biggest driver for economic impacts in the corridor is the increased market access from the reduction in travel time between cities. The improved travel efficiency attracts users to the HSR, and the diversions in turn free up valuable capacity on the interstate highways, allowing cars and trucks to travel faster, reducing congestion, saving transportation costs, and reducing accidents. These transportation savings are redirected by households through discretionary spending and other more productive uses, thereby driving economic growth. In addition, the improved transportation network allows for a wider reach and more diverse pool of employees to match with skillsets needed by businesses. This improved access to employees in turn also drives productivity and can attract businesses to the area that were not there before the project was constructed.

The estimated economic impacts from agglomeration include:

- The agglomeration impact supports between 2.4 million and 3.4 million in total additional job years of employment over the 2035 to 2055 period. This increase equates to approximately 116,000 to

160,000 additional jobs per year over the 21-year analysis period,<sup>24</sup> representing about 3 to 4 percent of the total labor market for the Seattle and Vancouver metropolitan areas in 2016.<sup>25</sup>

- The labor income associated with this employment is between \$208 billion and \$282 billion, for an average of \$84,500 per job. Labor income is a component of value added and business output.
- Business Output, or sales, over the analysis period (2035-2055) total \$532 billion to \$738 billion. Business output is made up of profits, taxes, subsidies, wages, income, benefits, and the costs of purchased goods and services.
- Value Added, or GDP, increases by \$264 billion to \$355 billion over the analysis period. Value added includes profits, taxes, subsidies, wages, income, and benefits. Value added is a component of business output.

## Total Impacts

The total impact of the project is the sum of the construction, O&M, agglomeration, and the effects of improved travel options for users, denoted as operational. Two travel sheds are shown in

**Table 5** in order to provide a range of impacts. In this analysis, travel time to access stations is used as the measure for travel shed. Larger travel sheds generate larger impacts. As shown, the impacts of the 51-minute travel shed, or the approximate travel time between Seattle and Vancouver with the project, are greater than the 40-minute travel shed due to the greater market access (agglomeration) benefits.

**Table 5: Summary of Total Impacts**

	Construction	O&M	Market Access	Operational	Total Impacts
Average Jobs per Year					
40-min	38,000	3,000	116,000	200	<b>157,200</b>
51-min	38,000	3,000	160,000	200	<b>201,200</b>
Labor Income (2015 \$M USD)					
40-min	\$29,000	\$5,000	\$208,000	\$300	<b>\$242,300</b>
51-min	\$29,000	\$5,000	\$282,000	\$300	<b>\$316,300</b>
Business Output (sales) (2015 \$M USD)					
40-min	\$79,000	\$9,000	\$532,000	\$1,000	<b>\$621,000</b>
51-min	\$79,000	\$9,000	\$738,000	\$1,000	<b>\$827,000</b>
Value Added (GDP) (2015 \$M USD)					
40-min	\$39,000	\$4,000	\$264,000	\$500	<b>\$307,500</b>
51-min	\$39,000	\$4,000	\$355,000	\$500	<b>\$398,500</b>

Note: figures are rounded

The total impacts over the 10-year construction and 21-year operating periods include:

- 157,200 to 201,200 average jobs per year
- \$242 billion to \$316 billion in labor income
- \$621 billion to \$827 billion in business output
- \$308 billion to \$399 billion in value added

<sup>24</sup> Job years for agglomeration are converted to average jobs per year by dividing the job-years by the operating period of 21 years.

<sup>25</sup> Vancouver data for 2016 from British Columbia Labour Market Statistics, <https://www2.gov.bc.ca/gov/content/data/statistics/employment-labour/labour-market-statistics>, accessed 1/11/18 and Seattle 2016 data from BEA table CA30 Economic Profile, accessed 1/11/18

## 7. Greenhouse Gas Emissions Reduction Analysis

The greenhouse gas (GHG) emissions reduction analysis was conducted using the Federal Transit Administration’s (FTA) calculation spreadsheet for New Starts projects under the Capital Investment Grants Program.<sup>26</sup> This spreadsheet uses the travel demand forecast by mode to estimate the environmental benefits of the project, among other evaluation metrics. This analysis will focus solely on the environmental benefits, specifically GHG reduction.

One limitation of the spreadsheet is that it does not include air travel as a mode. Reductions in GHG emissions for air travel would require air service to decrease by entire planeloads; this is a difficult factor to estimate and would require a significant amount of air passengers to switch to rail to impact the air service. Since GHG reductions associated with travelers switching from air are not included, the GHG reduction estimate below is conservative.

This analysis was conducted for four scenarios:

- Low Ridership
  - 2035 Maglev Scenario 1A
  - 2055 Maglev Scenario 1A
- High Ridership
  - 2035 Maglev Scenario 1A
  - 2055 Maglev Scenario 1A

The inputs required for calculating the reduction in GHG attributed to the project includes the VMT by each mode (auto, intercity bus, and intercity rail) for the No Build and Build scenarios (which are estimated as described in the Economic Impact Analysis section). As this spreadsheet is typically used to evaluate regional transit projects, air travel is not included in the analysis, which would increase the environmental benefit of the project. As this scenario is using the Maglev technology, it is assumed that there are no emissions associated with the project, and conventional rail usage is assumed to maintain a similar level of usage, therefore there is no increase or reduction in emissions due to rail. The emissions factors by fuel type come directly from the FTA New Starts spreadsheet, and are calculated differently for the two horizon years (2035 and 2055).

**Table 6** and **Table 7** provide the detailed calculations for the GHG reduction by mode due to travelers switching to the project. For the year 2035, emissions are reduced by approximately 28,000 to 30,000 metric tons per year, while the year 2055 reduction ranges from 36,000 to 39,000 metric tons per year. This reduction is primarily driven by auto trips switching over to using the project, and the associated reduction in auto VMT.

**Table 6: Annual GHG Reduction – 2035**

Mode	2035 Conversion Factor: Emissions (ton) / VMT	Low Ridership		High Ridership	
		VMT Decrease (Increase)	Emissions Decrease (Increase) (tons)	VMT Decrease (Increase)	Emissions Decrease (Increase) (tons)
Automobile	0.000532	50,376,000	26,800.03	54,475,000	28,980.78
Intercity Bus	0.003319	368,000	1,221.39	369,000	1,225.82
<b>TOTAL CHANGE</b>	---	<b>50,744,000</b>	<b>28,021.42</b>	<b>54,844,000</b>	<b>30,206.60</b>

<sup>26</sup> <https://www.transit.dot.gov/funding/grant-programs/capital-investments/capital-investment-grants-program>, accessed 1/5/18

**Table 7: Annual GHG Reduction – 2055**

Mode	2055 Conversion Factor: Emissions (ton) / VMT	Low Ridership		High Ridership	
		VMT Decrease (Increase)	Emissions Decrease (Increase) (tons)	VMT Decrease (Increase)	Emissions Decrease (Increase) (tons)
Automobile	0.000397	87,256,000	34,640.63	94,295,000	37,435.19
Intercity Bus	0.002721	627,000	1,706.07	627,000	1,706.66
<b>TOTAL CHANGE</b>	---	<b>87,883,000</b>	<b>36,346.70</b>	<b>94,922,000</b>	<b>39,141.85</b>

## 8. Main Takeaways of this Preliminary Economic Assessment

The analysis presented in this memorandum represents a first look at the Project’s economic impact to understand its economic development potential. While it is anticipated that many results will be revised as the Project is developed further, the analysis provides some initial findings.

- On an average annual basis, the Project would support between approximately 116,000 and 160,000 jobs across the combined U.S.- Canada study area. This employment base would grow gradually over the 21-year analysis period with the adoption of the new maglev service. These estimates represent about 1.9 to 2.7 percent of the study area in the opening year of the service and about 1.4 to 2.0 percent by 2055 when the economy has grown. It is anticipated that most of this impact would be in the metro areas.
- The baseline projections from Moody’s Analytics are trend projections that assume 21 years of growth between 2025 and 2055. In reality, there will be economic cycles (downturns) during this time that reduce the region’s growth and temper the realization of the Project’s economic potential.
- The greater accessibility afforded by the maglev connection expands the effective labor markets in Seattle and Vancouver in a meaningful way, helping existing employers to grow and allowing the region to compete for larger companies that seek a larger labor pool.
- The projections provided in this analysis represent the economic potential; many factors must come in to play in order to realize these gains. Chief among these is the free flow of labor across the border. To the degree that border enforcement requirements increase travel times or make trip times less reliable, the projected economic gains would be reduced.
- In addition to the Project’s economic outcomes, it supports an improved environment by reducing between 36,000 and 39,000 tons of GHG annually by 2055.
- While these economic results are based on preliminary modeling results for the Project, they highlight that even at the lower end of the estimated range, the Project would have a meaningful positive impact on the study area economy. Without becoming tied to the exact estimate, the findings suggest that there is merit to the Project and would be worth taking to the next step in project development.