

# Burnaby Mountain Gondola Transit – Feasibility Study

*Prepared for*  
TransLink



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# Executive Summary

In 2009, an initial feasibility study commissioned by Simon Fraser University (SFU) Community Trust, the authority developing the UniverCity community, indicated that a gondola as a transit alternative to diesel bus service could improve travel time, service frequency, reliability, and reduce greenhouse gas (GHG) emissions.

On the basis of that finding, in 2011, the South Coast British Columbia Transportation Authority (TransLink) commissioned CH2M HILL Canada Limited (CH2M) to conduct a full business case, assessing alternative transit technologies, route options, costs, and benefits. The 2011 business case identified a preferred solution: a 2.7-kilometre (km) alignment from Production Way-University SkyTrain Station to the SFU Town Square and transit loop on Burnaby Mountain, using 3S gondola technology.

In 2011, the Burnaby Mountain Gondola Transit (BMGT) project was estimated to cost \$114 million to build and \$3 to \$3.5 million per year to operate. It was demonstrated that the benefits of the gondola clearly outweighed the costs. However, due to constrained capacity for new capital spending on regional transit, no further action was taken.

In 2017, TransLink retained CH2M to conduct a feasibility study to confirm whether the findings of the 2011 business case remained valid, and to assess an alternative alignment. This updated 2017 assessment finds that there is still a compelling case for replacing current diesel bus service with a gondola transit alternative.

## Changing Circumstances

### Continued Growth and Persistent Challenges

Reliable transit service to Burnaby Mountain remains a significant challenge. With a daytime SFU population of 20,000 students, faculty and staff, and a UniverCity population that has increased from 3,000 in 2011 to 5,000 in 2017 (projected to be 9,000+ within the next 5 years), the transit system generates more than 25,000 trips each day. Peak-hour travelers report that as many as four full buses pass them by before they can board – which results in a 15-minute bus journey becoming a more than 30-minute trip. The diesel buses have difficulties operating a vertical climb of nearly 300 metres, and emit an estimated 1,700 tonnes of GHGs per year, including a range of Criteria Air Contaminants (CACs). Additionally, winter snowstorms halt the service altogether for an average of 10 days per year, not only disrupting classes, exams and research at SFU, but also stranding UniverCity community members at considerable inconvenience and expense. These challenges will only grow over the coming decade as SFU enrollment rises to an estimated 30,000 students and the full 10,000 resident community of UniverCity is established.

### An Updated Planning Regime

In the 10-Year Vision from 2014, the Mayors' Council on Regional Transportation noted the growing transit demand on Burnaby Mountain. It was identified that a high-capacity connection linking Burnaby Mountain to a nearby SkyTrain station may be required (subject to the business case, public and stakeholder consultation, funding, partner contributions, and achievement of other initiatives contained in the 10-Year Vision). Through partnership between Federal, Provincial, and local levels of government, in 2016, funding for Phase One of the 10-Year Vision was approved. The approval included direction to update the 2011 business case for a high-capacity transit connection between Burnaby Mountain and SkyTrain which would establish whether the business case supports the inclusion of the BMGT project in a future investment plan.

## Trans Mountain Pipeline and Tank Farm Risk Avoidance

SFU and the SFU Community Trust are concerned about the risk to safety and security posed by the Federal approval in 2016 of the Trans Mountain Expansion Project (TMEP) (a twining of the pipeline from Edmonton to Burnaby) and the related tripling of capacity at the Trans Mountain Pipeline ULC (Trans Mountain) tank farm on Burnaby Mountain. In response, SFU engaged RWDI Consulting Engineers and Scientists Inc. to review Trans Mountain's plans, and their study found that if an incident at the tank farm cut off access to Gaglardi Way and Burnaby Mountain Parkway a gondola could provide a safe evacuation option for Burnaby Mountain students, staff, and residents.

## Updated Assessment: Key Findings

### Technology and Alignment

The 2011 business case considered a number of ground-based and aerial transit options, and settled on the 3S gondola technology as the preferred solution to connect Burnaby Mountain to SkyTrain. Benefits of a 3S gondola system include the ability to operate in high wind conditions, provide sufficient capacity, and utilize less energy, which results in lower operating costs. For the 2017 update, two aerial ropeway suppliers were consulted to determine if there had been any advancement in technology that should be considered, and they confirmed that 3S technology remains the best option.

As to the alignment, the 2011 business case considered several options, including straight-line service from various SkyTrain stations, but settled on Production Way-University Station as the closest and the most convenient for the largest number of potential users.

For the 2017 update, public concern regarding service travelling over the residential neighbourhood of Forest Grove was addressed. Two aerial ropeway suppliers were asked to provide cost estimates for both a direct route and a "kinked" alignment that would dog-leg around the homes. The "kinked" alignment would prove to be longer (3.4 km as opposed to 2.7 km for the straight route), slower (9 minutes as opposed to 6 minutes), more expensive to build (up to \$255 million compared to \$197), and more expensive to operate (\$5.3 million compared to \$4.1). Given this, the direct route remains the preferred alignment.

### Ridership Forecasts and Design Capacity

TransLink has implemented improvements to its forecasting tools since the 2011 business case, and the new models indicate future ridership potential of approximately 2,600 passengers per hour per direction (pphpd). The models also predict that a gondola has the potential to increase ridership when compared to the continuation of diesel bus service.

Aerial ropeway suppliers suggested that capacity requirements would best be met using 33-passenger cabins travelling with gaps of less than 1 minute and taking 6 to 7 minutes to complete a trip that today takes 15 minutes by bus. While a target capacity of 3,000 pphpd might be adequate through 2045, it may be prudent to design tower foundations and size the key gondola components, such as the cables and the drive-train motor, to a standard that would accommodate up to 4,000 pphpd, if needed beyond 2045. While this would add cost in the immediate term, it would be prohibitively expensive to try to rebuild or move towers and upgrade the gondola system in the future if travel demand were to outpace forecasts.

### Capital and Operating Costs

Estimates of capital and operating costs have increased since the 2011 business case. General inflation is one reason, but the largest factor is estimated property costs, which have grown substantially over the past several years. The estimated cost of civil works, such as the terminal buildings and tower foundations, have also increased based on a higher level of design requirements for these structures

provided by aerial ropeway suppliers. In all, the updated capital cost for 3S gondola technology on the direct route from Production Way-University Station to the SFU Town Square and transit loop, is now \$197 million in 2020 dollars (2020\$), up from \$114 million (in 2011 dollars [2011\$], or approximately \$136 million adjusted to 2020\$). The total annual operations and maintenance (O&M) are on par with the 2011 business case estimate of \$3 to \$3.5 million per year (in 2011\$, or \$3.6 to \$4.2 million adjusted to 2020\$) to an estimate of \$4.1 million per year (in 2020\$) for the direct route.

It is assumed that bus service from Production Way-University Station to Burnaby Mountain would be replaced by the gondola service, thereby providing some bus capital and operating cost savings to offset BMGT project costs. It is estimated that TransLink will be able to reclaim \$34.5 million in vehicle replacement expenses (from the buses removed from service) and a 25-year reduction of \$89.3 million in bus operations.

The capital cost, adjusted to \$193 million for an 18-month construction period, less the reclaimed transit capital cost value of \$34.5 million is \$158.5 million. The transit operating cost of the gondola is \$54.2 million less the bus operating costs of \$89.3 million without the gondola. Summing the capital and operating costs for a total of \$123.4 million.

## Consumer Benefits

This 2017 update estimated the monetary value of benefits which would accrue to transit users, the general public, and TransLink, if gondola service were put in place to connect Burnaby Mountain to SkyTrain. It is estimated that the value of consumer benefits would equal approximately \$225.3 million over a 25-year period. Most of these benefits would be related to travel-time savings, but savings related to vehicle operating costs, collision reductions, parking costs, and vehicle emissions could also be expected.

Comparing the cost of \$123.4 million for construction and 25 years of operation to a total benefit of \$225.3 million, reveals a benefit-cost ratio (BCR) of 1.8. This demonstrates that the overall benefits of the BMGT project would outweigh its costs.

## Conclusion

The 2017 feasibility study reveals that a gondola service from Production Way-University Station to the SFU Town Square and transit loop on Burnaby Mountain still has merit. Further work can be done to advance project planning and refine cost estimates, including work related to identifying and mitigating environmental and community impacts. Additional public and stakeholder engagement will be an important next step, as well as engaging senior levels of government and other possible funding partners.

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# Acronyms and Abbreviations

3S	three rope gondola system (also known as drei seil and Tricable Gondolas)
APC	automatic passenger counter
BAU	Business-As-Usual
<i>BC EAA</i>	<i>British Columbia Environmental Assessment Act</i>
BC EAO	British Columbia Environmental Assessment Office
BCR	benefit-cost ratio
BCSA	British Columbia Safety Authority
BMGT	Burnaby Mountain Gondola Transit
BMGT project	Burnaby Mountain Gondola Transit Project
BC MoTI	British Columbia Ministry of Transportation and Infrastructure
CAC	criteria area contaminant
CEA Agency	Canadian Environmental Assessment Agency
<i>CEAA 2012</i>	<i>Canadian Environmental Assessment Act 2012</i>
CH2M	CH2M HILL Canada Limited
EA	Environmental Assessment
GHG	greenhouse gas
km	kilometre(s)
km/h	kilometres per hour
Mayors' Council	Metro Vancouver Mayors' Council on Regional Transportation
MDG	monocable detachable gondola
NEB	National Energy Board
NPV	Net Present Value
O&M	Operations and Maintenance
PGL	PGL Environmental Consultants
pphpd	passenger(s) per hour per direction
RTM	Regional Transportation Model
SFU	Simon Fraser University
SoGR	state-of-good-repair
TMEP	Trans Mountain Expansion Project
TransLink	South Coast British Columbia Transportation Authority
Trans Mountain	Trans Mountain Pipeline ULC



# Introduction

## 1.1 Background

A 2009 feasibility study concluded that replacing diesel bus service to Burnaby Mountain with an aerial passenger ropeway (or aerial gondola) was a cost-effective means to improve travel time, service frequency, and reliability, and to reduce greenhouse gas (GHG) emissions. On that basis, in June 2010, the South Coast British Columbia Transportation Authority (TransLink) committed to further investigating the merits of aerial ropeway technologies and to developing a business case for improved transit service to Burnaby Mountain.

In 2011, TransLink published the *Burnaby Mountain Gondola Transit (BMGT) Business Case Report* and its companion document, the *BMGT Technology and Alignment Alternatives Assessment* (TransLink, 2011a; 2011b). Key findings of the 2011 studies were as follows:

- There was a clear need to investigate an alternative transit solution at Burnaby Mountain to deliver more reliable service to the growing Simon Fraser University (SFU) campus and UniverCity community, while reducing environmental impacts and managing future capital and operating costs.
- Aerial-ropeway technologies, particularly three-rope gondola systems (3S) and Funitel gondolas, showed the greatest potential to meet the Burnaby Mountain Gondola Transit (BMGT) project's (the BMGT project) multiple (transportation, financial, environmental, urban development, social and community, and deliverability) objectives and to minimize negative impacts.
- A direct route from Production Way-University SkyTrain Station to the SFU Town Square and transit loop emerged as the preferred option when considering the combined factors of system efficiency, residential impact, environmental impact, and affordability.
- The capital cost of a gondola system was estimated to be on the order of \$114 million (2011 dollars [2011\$]), which included a high-level cost allowance for property acquisition and risk. Annual operating costs were estimated to be approximately \$3 to \$3.5 million (2011\$).
- Over the 25-year evaluation period, the life-cycle costs were estimated to be approximately \$10 million (2011\$) higher than the estimated costs of maintaining and expanding the bus service to Burnaby Mountain. However, when considering travel time savings, avoided vehicle operating and collision costs, and environmental benefits, the BMGT project yielded a benefit-cost ratio (BCR) of 3.6.
- The BMGT project could be built cost-effectively using either Design-Build plus Operate-Maintain in a joint procurement, or Design, Build, Finance, Operate, and Maintain strategies. A traditional design-build procurement with TransLink assuming operations and maintenance (O&M) was also considered feasible.

The 2011 BMGT business case was developed at a time when funding sources (namely transit fares, property taxes, and vehicle fuel taxes) were constrained. This prevented any significant expansion of transit service to serve growing population and travel demands. At the same time, other regional rapid transit priorities emerged (including projects along the Broadway Corridor and in the South of Fraser). Therefore, despite the advantages, additional planning and design work for the BMGT project was put on hold.

## 1.2 Purpose

There have been a number of changes to the regional and local land-use and transportation context that directly and indirectly influence the business case for a gondola at Burnaby Mountain since the original business case was completed in 2011. These changes include, but are not limited to: new regional direction for future transportation investments, changes to the transit and transportation networks, improvements to the Regional Transportation Model (RTM), plans to expand the Trans Mountain Pipeline, and continued growth in the real estate market.

In response to these changes, TransLink retained CH2M HILL Canada Limited (CH2M) to conduct a feasibility study which would review assumptions and undertake the necessary technical analyses to update the 2011 report. The revised costs and benefits will enable TransLink to assess the merits of including the BMGT project in upcoming investment plans.

As part of this process, CH2M considered key themes from stakeholder and public feedback that were captured during the Burnaby Gondola Phase II Consultation and Communication Program in 2011. The feedback included:

- Resident concerns regarding privacy, safety, noise, and neighbourhood character
- Potential environmental impacts on trees and wildlife in the conservation areas
- Support for faster and more reliable transit service with reduced GHG emissions
- Safety and security concerns for riders
- BMGT project cost and its relationship to the Millennium Line-Evergreen Extension

### Stakeholder and Public Consultation (November 2010 to June 2011)

- Project Advisory Committee, chaired by TransLink, was established and comprises the BC Ministry of Transportation and Infrastructure (BC MoTI); City of Burnaby; SFU; and SFU Community Trust.
- Key stakeholder groups were engaged to provide general information on the BMGT project status and to garner initial feedback.
- Two open houses were held to raise awareness about the proposed project, provide information, and solicit participation and feedback from the community.

# Strategic Alignment and Priority

There have been a number of changes to the Regional and local land-use and transportation context surrounding the BMGT project since the original business case was completed in 2011.

## 2.1 Regional Context

### 2.1.1 Mayors' Council 10-Year Vision

In February 2014, the BC MoTI asked the Metro Vancouver Mayors' Council on Regional Transportation (Mayors' Council) to confirm its vision for transportation in the region. The Mayors' Council—with support from TransLink, Metro Vancouver, and member municipalities—developed *Regional Transportation Investments – a Vision for Metro Vancouver* (Mayors' Council, 2014). This 10-year Vision document established spending priorities, recommended new funding mechanisms, and outlined a phased implementation plan.

The 10-year Vision was structured around three key strategies:

1. Prioritizing the most urgent and effective infrastructure investments
2. Identifying a more consistent approach to pricing transit and roads as the most cost-effective way to reduce congestion and overcrowding
3. Partnering to ensure effective coordination of land-use plans and transportation investments

Figure 2-1 shows a map of priority projects, including critical upgrades to keep existing infrastructure in a state-of-good-repair (SoGR), as well as expansion of bus and rail rapid transit service, new bridge crossings, and improvements through the Major Road Network and Bicycle Minor Capital Program.

It was also noted that a high-capacity connection from Burnaby Mountain to a nearby SkyTrain station may be required, and that further investigation and consultation was needed. It was identified that the project could be advanced subject to the business case, funding, partner contributions and achievement of other initiatives contained in the 10-Year Vision.

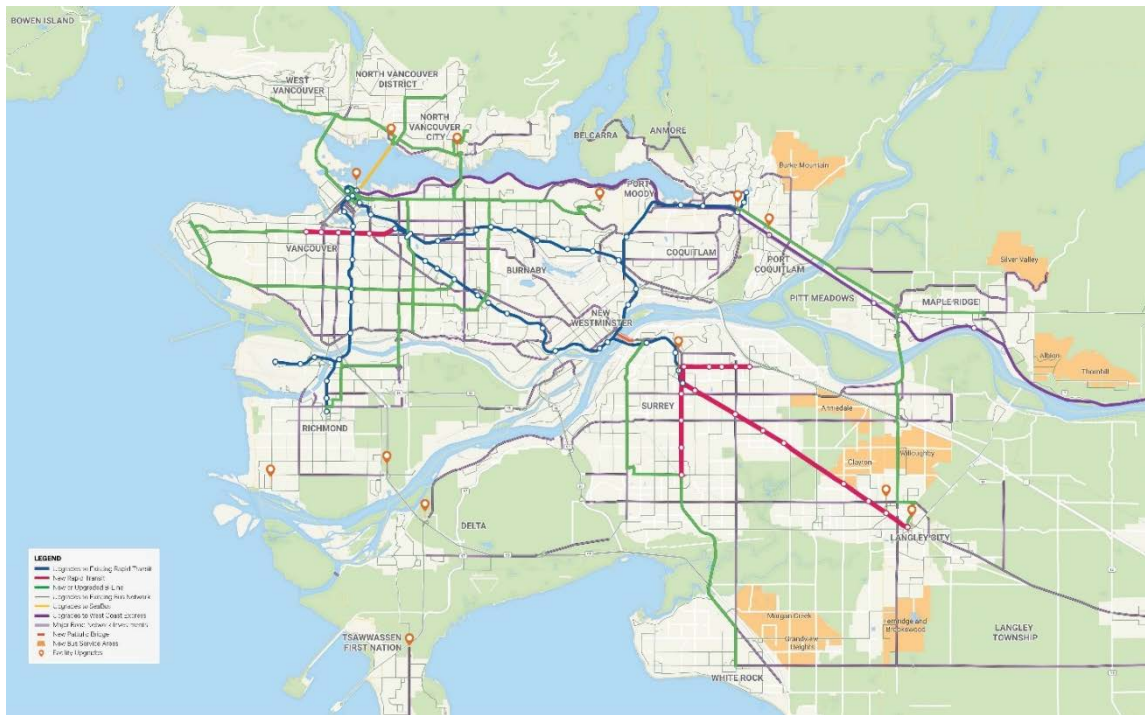


Figure 2-1. Map Illustrating Mayors' Council Vision  
 Provided by TransLink April 28, 2017

## 2.1.2 Phase One of the 10-year Vision: 2017-2026 Investment Plan

In June 2016, the three levels of government came together to announce “Phase One” funding for the Mayors’ Vision – \$741 million of capital funding<sup>1</sup> dedicated to priority public transit projects, including the following: SoGR initiatives, new vehicles, and business cases for rapid transit projects in Vancouver and Surrey. As part of that announcement, the Federal government committed to increase its share of capital funding for major projects to 50 percent, reducing the region’s share to 17 percent.

During public and stakeholder engagement (October 11 to 31, 2016), Metro Vancouver residents expressed broad support for the transit and transportation improvements in the Phase One Plan.

Delivering all of the transit and road improvements in the 10-Year Vision will require additional investment and planning. Over the coming years, additional investment plans are anticipated to be brought forward to the TransLink Board and the Mayors’ Council for consideration.

The Phase One Plan refers to updating the 2011 assessment of a high-capacity transit connection between SkyTrain and Burnaby Mountain campus, to establish whether the business case supports its inclusion in a future investment plan.

## 2.2 Local Context

At the local scale, there has been continued development atop Burnaby Mountain and around Production Way-University Station. This development is generally in keeping with SFU, SFU Community Trust, and City of Burnaby plans identified in the original 2011 business case report.

However, two key changes have emerged since 2011: approval of the Trans Mountain Expansion Project (TMEP), and opening of new transit services that alter travel patterns.

<sup>1</sup> Comprised of \$370 million Public Transit Infrastructure Fund Federal plus \$246 million Provincial plus \$125 million from TransLink

### 2.2.1 Trans Mountain Expansion Project

The Trans Mountain Pipeline, originally built in 1953, transports both crude oil and refined products. In December 2013, Trans Mountain Pipeline ULC (Trans Mountain) submitted an application to the National Energy Board (NEB) to construct and operate the Trans Mountain Expansion Project (TMEP). On May 19, 2016, the NEB, an independent economic regulatory agency, recommended the Federal Governor in Council to approve a 1,150-kilometre (km) expansion of the pipeline. It was approved for expansion by the Government of Canada on November 29, 2016. SFU is on the record as an intervenor in the NEB process (NEB, 2016).

The TMEP, would twin the existing pipeline between Edmonton and Burnaby, increasing the capacity from 300,000 barrels per day to 890,000 barrels per day (Kinder Morgan, 2017). The Kinder Morgan Burnaby Mountain Terminal, located adjacent to SFU Burnaby campus, has 13 storage tanks with a capacity of 1.7 million barrels. The expansion would add 14 new storage tanks, bringing the new capacity to 5.6 million barrels (City of Burnaby, 2014).

Due to the proximity of the Burnaby Mountain Terminal to SFU Burnaby campus, SFU retained PGL Environmental Consultants (PGL) to evaluate the risks arising from the TMEP (PGL, 2016). PGL concluded that there would be an increased risk to SFU due to the following factors:

- Significant increase in the volume of petroleum products being conveyed through the twinned pipelines and stored at the Burnaby Tank Farm;
- A higher proportion of heavy crudes (including diluted bitumen, which is more volatile than conventional crude products)<sup>2</sup>;
- Increased number and density of storage tanks at the Burnaby Tank Farm that present challenges to isolating potential fires; and
- Proposed tanks being located closer to the site boundary and the surrounding road network; the closest tanks are within 150 metres (m) of the key intersection of Gaglardi Way and Burnaby Mountain Parkway.

To further evaluate the risks of the new pipeline and tank farm expansion, SFU Community Trust retained RWDI Consulting Engineers and Scientists Inc. to prepare a letter of opinion on two proposed aerial gondola alignments. To this end, RWDI reviewed a Quantitative Risk Analysis conducted by Genesis Oil and Gas Consultants on behalf of Trans Mountain. The review found that either of the two proposed gondola routes would be acceptable, as both are far enough removed from the tank farm that the likelihood of catastrophic impact is less than one in 10 million. The Major Industrial Accidents Council of Canada's land-use planning criteria sets no restrictions to allowable land use or building construction in such an area (RWDI, 2017).

### 2.2.2 Transit Service Changes

Preliminary planning and design of the Evergreen Extension rapid transit project was underway during preparation of the 2011 business case. Although not directly serving SFU or Burnaby Mountain, the Evergreen Extension represented a significant shift in transit service to and from the Northeast Sector of the region. Therefore, recognizing the potential impact on BMGT, ridership estimates for the gondola were developed for two scenarios: with and without the Evergreen Extension in place.

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<sup>2</sup> As measured by flashpoint, the temperature at which an organic compound gives off sufficient vapour to ignite in air.

A number of relevant transit service changes have come into effect since 2011:

- Carvolth Transit Exchange and Park & Ride opened in December 2012, coinciding with the Port Mann Highway 1 project completion;
- Route 555 express bus service was implemented across the Port Mann Bridge in December 2012. Route 555, which originates at Carvolth Transit Exchange, connects the Township of Langley with Lougheed Town Centre Station; and
- The Millennium Line – Evergreen Extension went into service in December 2016 and brought about broader changes to SkyTrain operating patterns.

These changes, and the resulting impacts on gondola ridership, are reflected in the ridership forecasts presented in Section 4.

# Project Purpose and Goals

The purpose of proposed rapid transit to Burnaby Mountain is to improve travel time, frequency, and reliability compared to existing bus service, and to reduce environmental impacts. While these objectives have not changed since the development of the 2011 business case, it is important to revisit the purpose and goals in light of the current context for the BMGT project, presented in this section.

## 3.1 Transportation

The primary driver behind the initial alternatives assessment was high demand and poor bus service reliability for routes serving Burnaby Mountain, in particular Route 145. According to TransLink's 2015 *Transit Service Performance Review*, the issues with Route 145 have persisted, showing it to be among the worst (i.e. ranking in the bottom 10% of all bus routes) for the following metrics:

- Revenue Hours with Overcrowding (ranked 191 out of 214 routes): Overcrowding is measured by the extent to which average passenger loads for a bus route exceeds established crowding guidelines. The rank for this measure indicates that overcrowding on Route 145 is among the worst for all bus routes.
- On-time Performance (ranked 183 out of 208 routes): Buses are considered to be on-time if they arrive at a timing point along its route between one minute before and three minutes after the scheduled time. The rank for this measure indicates that on-time performance for Route 145 is among the worst of all bus routes.
- Bus Bunching (ranked 188 out of 208 routes): Bus bunching occurs when two or more buses, which were schedule to run evenly spaced along the same route, instead arrive in the same location at the same time or close to one another, then resulting in gaps in service and longer than anticipated wait times for customers. The rank for this measure indicates that bus bunching for Route 145 is among the worst of all bus routes.

This supports the anecdotal accounts of SFU transit users, who indicate that they are likely to be passed up by four or more buses during peak periods.

Bus service unreliability is exacerbated under winter conditions, with disruptions ranging from substitution of standard buses for articulated buses (resulting in a decrease in capacity) to a complete curtailment of transit service in the event of road closures.

The current travel time by bus from Production Way-University Station to SFU Bus Exchange, a distance of 8.0 km, is approximately 15 minutes. With a peak direction headway of 2 to 3 minutes, and sometimes up to four pass-ups, the total travel time can be almost 30 minutes when accounting for waiting time.

The current bus system can accommodate only two bicycles per trip, limiting the attractiveness for transit users to use their bicycles to commute to Burnaby Mountain, especially during peak periods. During off peak periods, there is high demand for bicycle rack space from recreational mountain bike use.

### 3.1.1 Transportation Project Objectives

- **Develop a rapid transit solution that offers improved reliability, frequency, and travel time relative to current bus service.** That transit service should be flexible enough to accommodate demand for longer operating hours and weekend service, to serve the evolving nature of SFU campus offerings and community and recreational opportunities atop Burnaby Mountain. Bus riders are currently being passed up by as many as four buses on Route 145.



- **Improve all-weather (snow, ice, and wind) reliability.** Snow and severe weather events coincide with the highest use times of campus (including exams and first week of spring semester). Severe weather impacts accessibility and safe transportation to Burnaby campus along roads under the control of SFU, the City of Burnaby, and the region. The “up to 10 days lost to snow and severe weather” condition remains from the last business case; however, it is important to understand the domino effect this can have on a student: missing exam due to University closure or transportation issues; re-scheduling exam, which needs to be coordinated with student, professor, and exam markers; and potential delays in writing, marking, and submitting grade, causing further delays to class registration or job applications.
- **Provide a safe and secure service that enhances accessibility.** With one common point of entry to Burnaby Mountain by road (intersection of Gaglardi Way and Burnaby Mountain Parkway) and an increasing population of residents, employees, students, and visitors, the need for a more reliable and redundant transportation network serving Burnaby Mountain grows. There is a lack of alternate safe transportation routes off-campus in the event of fires, earthquakes, or significant weather events, and according to SFU, an expanded Kinder Morgan tank farm on Burnaby Mountain will heighten these concerns.
- **Encourage a mode shift to transit, walking, and cycling.** Encouraging these modes is well aligned with regional goals and SFU and UniverCity plans to promote sustainable and active modes of transportation<sup>3</sup>. Enhanced transit access to Burnaby Mountain will not only support more sustainable modes for utilitarian trips, but also improved access to the Burnaby Mountain trail network would bring hiking and mountain biking opportunities within reach of a greater number of residents of Burnaby.
- **Reduce lifecycle energy usage associated with transportation.** A significant portion of TransLink’s bus fleet relies on fossil fuel energy, which is subject to price volatility.
- **Provide a connection from the existing rapid transit network to Burnaby Mountain that meets current and future travel demands.** SFU has expanded its non-peak evening and weekend offerings, including 24/7 dining, extended library hours, and more classes. Increased transit service frequency and hours of operation, would allow better access to these offerings.

## 3.2 Financial

It is important to understand whether the BMGT project is affordable, cost-effective, and represents a good use of public funds. Consideration should be given to both near-term and long-term financial impacts of the project.

### 3.2.1 Financial Project Objectives

- Establish whether a rapid transit connection linking the top of Burnaby Mountain to the existing rapid transit network would be cost-effective in meeting travel demands and reducing GHGs.
- Establish whether replacing the existing diesel bus fleet with an alternative transit technology would provide net savings in annual life-cycle capital and operations costs.
- Outline the lifecycle for construction and operation over a 25-year period.

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<sup>3</sup> <https://www.sfu.ca/sustainability/initiatives/transportation.html>



## 3.3 Environmental

There is renewed interest at the Federal level to address climate change commitments, especially when looking at carbon pricing as a key policy lever to effect change amongst industry. Additionally, aggressive Provincial and regional targets have been established for GHG and criteria area contaminant (CAC) air emissions, to fight climate change and air pollution. Replacement of diesel buses by innovative, electrically powered transit can contribute to achieving these targets.

A direct transit corridor from SkyTrain to SFU will cross the Burnaby Mountain and Burnaby 200 Conservation Areas and will need to limit and mitigate any disturbance to the natural environment. Consideration should also be given to noise, privacy, aesthetics, emissions, view, carbon footprint, and other issues identified through the public engagement process.

### 3.3.1 Environmental Project Objectives

- Reduce emissions of GHGs and CACs in the provision of transit service and by facilitating a mode shift away from single-occupancy vehicles.
- Reduce the carbon footprint and overall energy usage of transit to and from Burnaby Mountain.
- Minimize adverse effects to the Burnaby Mountain and Burnaby 200 Conservation Areas.
- Use sustainable methods and materials for the BMGT project.
- Develop an effective Environmental Assessment (EA) and public engagement process that addresses community concerns and meets regulatory requirements.

## 3.4 Urban Development

Current and expected urban development at the top of Burnaby Mountain is increasing transit demand. Improved transit service would serve SFU and support UniverCity’s aspirations to be a model sustainable community.

The remainder of the study area has a mixture of stable residential, commercial, and industrial lands, and there is potential for re-development near the SkyTrain station on Lougheed Highway.

### 3.4.1 Urban Development Project Objectives

- Support future land-use plans as contained in Metro Vancouver’s Regional Growth Strategy, the Burnaby Official Community Plan, and the SFU Official Community Plan.
- Provide rapid transit stations and infrastructure that are integrated into the urban fabric.
- Mitigate risk to urban developments.

## 3.5 Economic Development

Burnaby Mountain is home to Simon Fraser University and Fraser International College, which provides international students a direct pathway into year two of SFU undergraduate degrees. As the second largest post-secondary institution in the province, SFU’s education and research activities are key drivers of economic development in Metro Vancouver and beyond. The Burnaby campus is the university’s largest campus, accommodating more than 20,000 undergraduate and graduate students, faculty, and staff, and this population is expected to grow to over 30,000 by 2030. As noted previously, SFU is currently vulnerable to closures due to winter weather and roadway conditions, and these closures have a negative impact on SFU’s academic and economic development activities.

SFU campuses in Surrey and downtown Vancouver are also directly served by rapid transit. Students often attend classes at more than one campus or even at different post-secondary institutions. Improving the transportation connections among campuses is an important aspect of promoting academic exchange.

Long commute times are adding to Greater Vancouver’s difficulties in attracting high-end talent. A benchmark analysis by the Conference Board of Canada, Centre for Municipal Studies (Conference Board) (*Greater Vancouver Economic Scorecard 2016*) gives regional non-auto commute time a “C” grade (Conference Board, 2016). Failure to address deteriorating housing affordability and inadequate investment in transit and road infrastructure could keep talented people and business investment away. Continued attraction and retention of talent requires a commitment to invest in regional public transit and road infrastructure.

Investment in regional public transit and road infrastructure has been shown to influence private-sector competitiveness, especially if it reduces commute times for employees and improves goods movement.

In this regard, the Mayors’ Council 10-year Vision for Metro Vancouver, the Provincial government’s 2015 10-year plan, *B.C. on the Move* (Province, 2015), and the more recent Federal government commitment to fund up to 50 percent of urban transportation infrastructure projects all show that governments at every level are engaged on this issue.

### 3.5.1 Economic Development Project Objective

- Provide high-quality transit service that supports the SFU campus and the surrounding community, and contributes to regional economic good health.

## 3.6 Social and Community

SFU derives a distinct character from its mountain-top location. The UniverCity community character is also influenced by its location and its aspiration to serve as a model sustainable community. The study area also includes established residential communities and activity centres that could benefit from improvements to the transit services that connect Burnaby Mountain to the regional SkyTrain system.

SFU, the Burnaby Mountain Conservation Area, and the Burnaby 200 Conservation Area all serve as regional assets offering hiking and bicycling trails, scenic vistas, cultural institutions, and renowned architecture. Improved transit service would enhance access to these recreational and tourist opportunities.

### 3.6.1 Social and Community Project Objectives

- Maintain transit links to the study area residential communities, employment centres, and other activity centres.
- Minimize and mitigate adverse impacts to residential communities and the Burnaby Mountain and Burnaby 200 Conservation Areas.
- Foster active transportation and recreational opportunities with improved transit service and amenities.

## 3.7 Deliverability

Construction of rapid transit through or above the study area will require acquisition of rights-of-way or aerial easements in a developed urban environment. Residential, commercial, and industrial properties may be impacted, as may public streets, utility corridors, and the conservation areas. An EA and robust public and stakeholder engagement would be needed to deliver the BMGT project. Also, funding improvements to Burnaby Mountain transit service must be balanced against other regional priorities.

### 3.7.1 Deliverability Project Objectives

- Provide information on the BMGT project to the public, stakeholders, and all levels of government to support informed discussion and fact-based decisions.
- Develop a BMGT project scope that is deliverable and sustainable.

# Ridership Forecasts

## 4.1 Background

The RTM has undergone a major update with new assumptions, inputs, transit service changes, and revisions to the road network since 2011. The new model was validated against the 2011 Trip Diary and screenline surveys, travel times against bus schedules, automatic passenger counts and Compass Card fare data for ridership, and Google Maps for auto travel time. Overall, the new model compares well to observed metrics, providing confidence in its ability to estimate the impact of a new BMGT project on travel time and operating costs.

## 4.2 Model Scenarios

To understand ridership potential and estimate BMGT project benefits, the following three scenarios were modelled:

1. **Business-As-Usual (BAU)** – continuation of service for comparison against the two gondola alignment options;
2. **Option 1: Straight Alignment** – a direct route from Production Way-University SkyTrain Station to the SFU Town Square and transit loop; and
3. **Option 2: Kinked Alignment** – a “kinked” route that follows the lower portion of Gaglardi Way to avoid the Forest Grove residential area, with its Lower Terminal situated near Production Way and Commerce Court.

## 4.3 Future Year Ridership Projections

Updates to land-use projections and the transportation network have been incorporated into the RTM. Two horizon years were modelled to estimate BMGT project benefits: 2030 and 2045. For each horizon year, the three scenarios described in Section 4.2 were run: BAU, Option 1: Straight Alignment, and Option 2: Kinked Alignment.

### 4.3.1 Land-use Projections

Figure 4-1 summarizes future land-use assumptions for Burnaby Mountain. Overall, a significant increase in population and SFU enrollment is forecast by 2030; thereafter, modest growth is expected between 2030 and 2045.

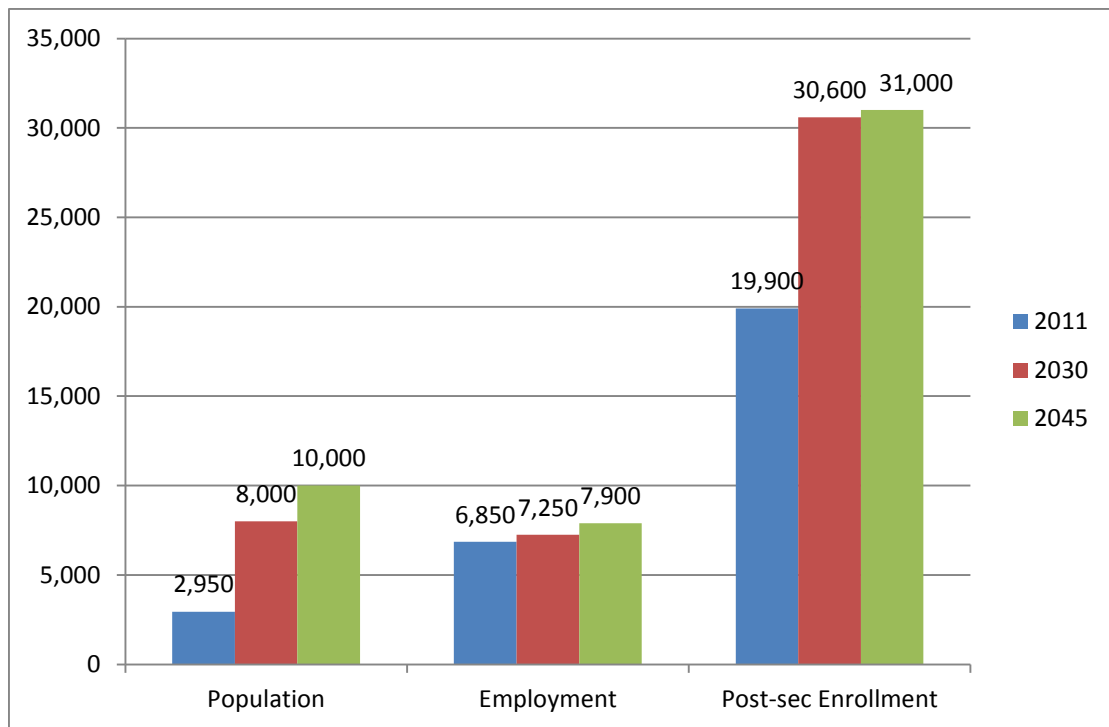


Figure 4-1. SFU and UniverCity Land Use Projections  
*Metro Vancouver's Regional Growth Estimates provided to TransLink in 2013/2014*

### 4.3.2 Network Changes

Major changes to the transportation network beyond 2011, and assumed in place for 2030 and 2045, include the following:

- Millennium Line - Evergreen Extension;
- Bus improvements in the Tri-Cities;
- SkyTrain operating pattern changes (that is, Expo Line stops at Production Way-University Station);
- Upgrades to Highway 1;
- Expanded capacity of the current George Massey Tunnel crossing<sup>4</sup>; and
- Bus from Burquitlam Station to SFU.

In modelling the Gondola scenarios, it was assumed that bus Route 145 is discontinued, and the remaining bus lines would not change.

### 4.3.3 Forecasts

Figure 4-2 shows in red the location of two screenlines, across which forecasts of transit demand to Burnaby Mountain were estimated:

- Screenline 1: crosses Gaglardi Way, and captures transit demand on the Routes 143 and 145.
- Screenline 2: crosses Burnaby Mountain Parkway, and captures transit demand on the Routes 135<sup>5</sup> and 144.

<sup>4</sup> In September 2017, the Province announced an independent technical review of the George Massey Tunnel Crossing, with a report including findings expected in spring 2018.

<sup>5</sup> In December 2016 Route 135 was replaced by Route 95.

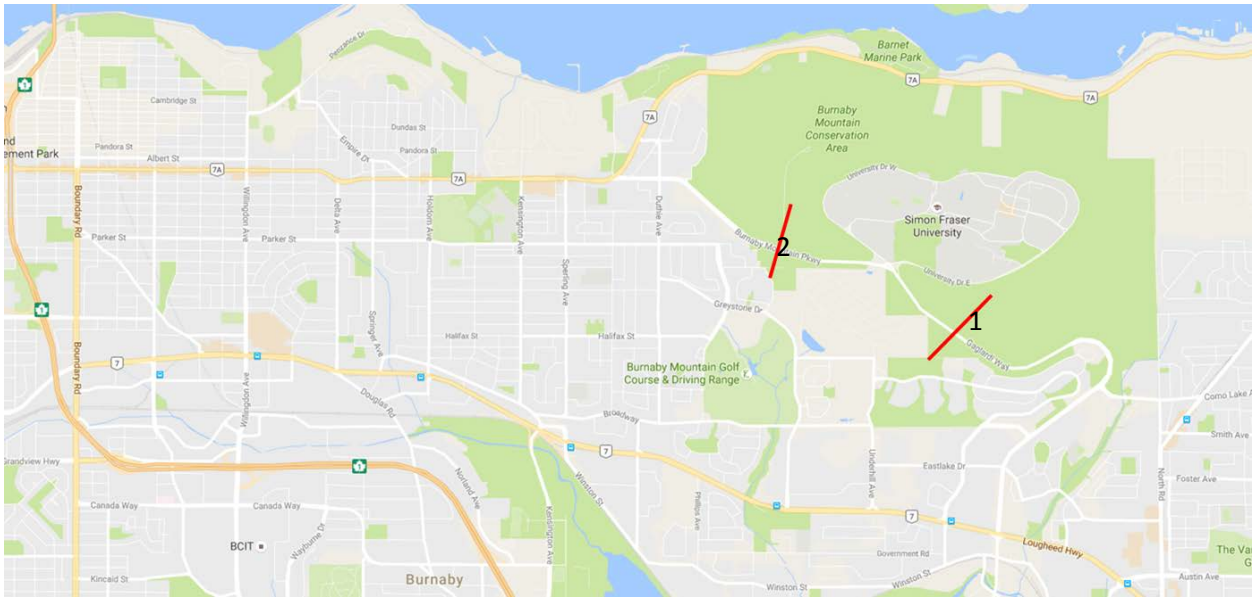


Figure 4-2. Transit Screenlines  
TransLink, 2017

Figure 4-3 presents AM peak hour ridership forecasts across Screenline 1 (Routes 143 and 145) and Screenline 2 (Routes 135 and 144) in 2030 and 2045 for the BAU and Gondola (Option 1 – Straight Alignment) scenarios.

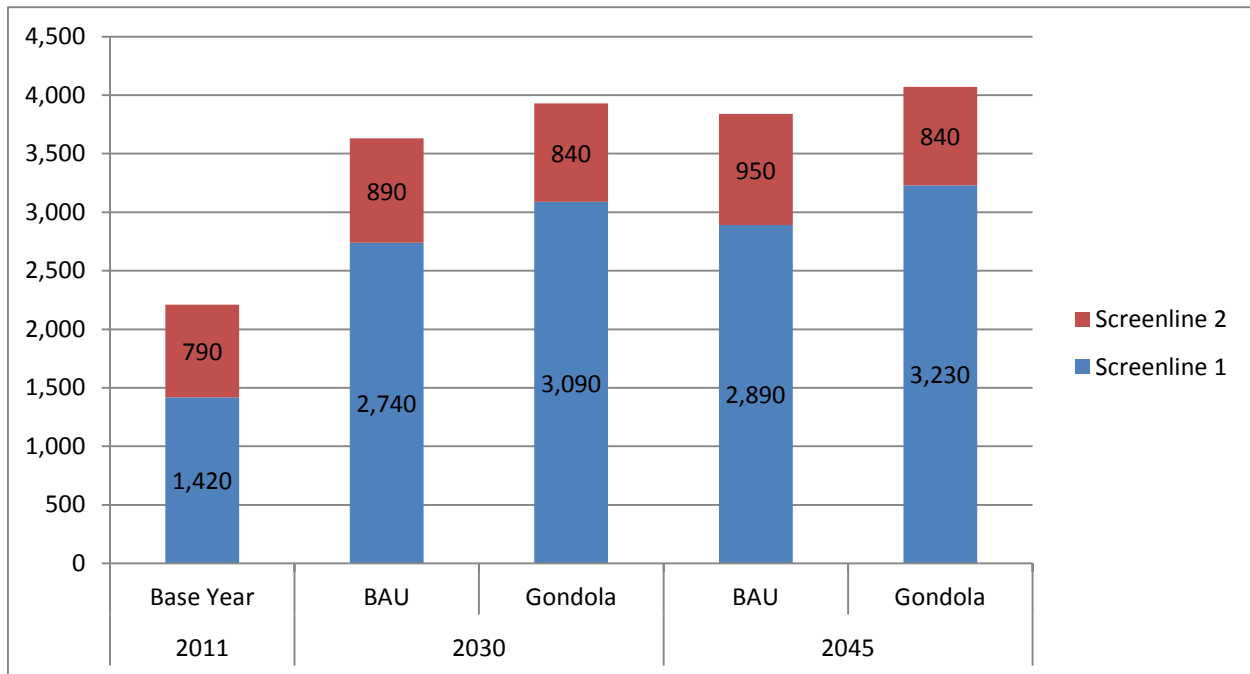


Figure 4-3. AM Peak Hour Ridership Forecasts across Screenlines 1 and 2  
TransLink, 2017

Overall, it is forecast that the BMGT project would support transit ridership increases of about 8 percent greater than BAU in 2030, and 6 percent greater than BAU in 2045.

Forecast mode shift from auto to transit due to the BMGT project is relatively modest. For example, in 2045 the total auto volumes on the screenlines are forecast to decline by only about 50 vehicles. This

result is not surprising, as more than 50 percent of post-secondary trips already occur by transit, rather than auto.

Table 4-1 shows the forecast ridership on the BMGT by direction.

**Table 4-1. Forecast Gondola Ridership (AM Peak Hour)**

Direction	2030			2045		
	BAU	Option 1	Option 2	BAU	Option 1	Option 2
To SFU	2,217	2,432	2,257	2,328	2,592	2,401
From SFU	75	288	214	82	348	235
Total	2,292	2,720	2,471	2,410	2,940	2,636

As seen in Table 4-1, the model also shows that by 2045 the gondola ridership for Option 1 alignment will be 12 percent higher than if the Option 2 alignment were constructed.

## 4.4 Ridership Forecast Conclusion

Ridership forecast estimates that the BMGT project needs to accommodate approximately 2,600 passengers per hour per direction (pphpd) in 2045, signalling that a system designed for 3,000 pphpd should be sufficient to meet long-term needs for travel to and from Burnaby Mountain via the Production Way-University SkyTrain Station.



# Alternative Alignment Assessment

While the 2011 business case identified a straight route from the Production Way-University SkyTrain Station to the SFU Town Square and transit loop as the preferred gondola alignment, given the concerns raised by residents of the Forest Grove neighbourhood, located under the preferred alignment, an alternative “kinked” alignment that avoids those properties was investigated for the 2017 update to the business case.

Of note, other straight-line alignments from adjacent SkyTrain stations – that is, Lake City Station and Burquitlam Station – were previously assessed and not recommended in the 2011 business case.

## 5.1 Alignment Evaluation

Figure 5-1 shows the general alignment of two options under consideration.

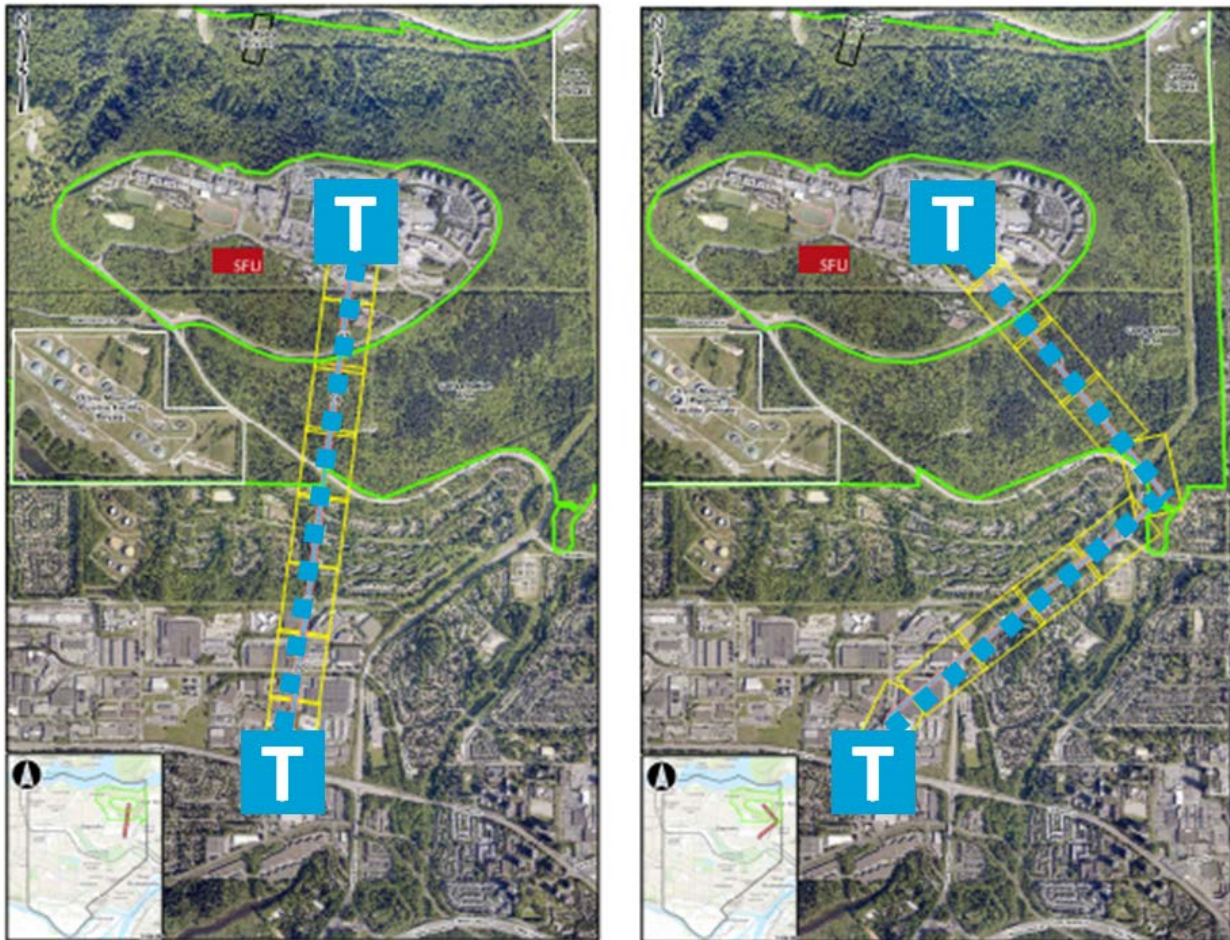


Figure 5-1. Alternative Alignments: Option 1 (left) and Option 2 (right)  
CH2M, 2017

The Option 1 alignment is 0.7 km (20 percent) shorter and 3-minutes-per-trip faster. The Option 1 alignment traverses over approximately 0.5 km of the Burnaby Mountain Conservation Area compared to approximately 1.2 km for Option 2 leading to a greater impact for Option 2 from an environmental and approval standpoint. Option 2 also runs adjacent to more residential properties creating a greater impact on privacy and aesthetics for residents.



















Option 2 does not integrate as well with transit, partly because of the longer travel time, but also because the Lower Terminal would be positioned further away from the Production Way-University SkyTrain station, requiring an overpass walkway and a longer pedestrian connection. The SFU Campus and UniverCity integration is also lower for Option 2, because it cuts across the East Parking Lot, limiting future development options for this property.

About half of Option 2 parallels Gagliardi Way, and avoids going through or over many commercial and residential properties. This limits the cost and risk for property acquisition, because the tower locations would be on or closer to transportation or utility corridors. Option 2 also has a minor safety advantage, because it is located further from the Kinder Morgan Burnaby Mountain Terminal and the risks associated with it (as discussed in Section 2.2.1).

Under the cost category, capital and operating cost estimates for Option 1 are lower (and are further discussed in Section 7.0), which can be explained by its relatively shorter and more direct routing.

Table 5-1 shows the summary evaluation for the two route options.

Table 5-1. Alignment Evaluation Summary

Criteria	Route Option 1	Route Option 2
Length (km)	2.7	3.4
Conservation Area Impact		
Residential Impact		
Transit Integration		
SFU Campus and UniverCity Integration		
Property Acquisition Risk		
Safety and Approvals		
Cost, including Property		
Overall		

**Legend:**



## 5.2 Alignment Conclusion

While avoiding the Forest Grove neighbourhood, and having slight advantages with regards to property acquisition and a potential safety advantage, Option 2: Kinked Alignment would undermine the stated objective to minimize travel time, be less supportive of encouraging more transit use, have a larger surface footprint, and cost more to build and operate.

Given this, Option 1: Straight Alignment remains the preferred option, however this could be confirmed through further stakeholder and public engagement.

# Alternative Technology Assessment

The updated ridership forecasts were shared with the same two aerial gondola suppliers who provided direction and indicative costing for the 2011 business case. The suppliers were asked to re-assess their technology and design recommendations to meet the opening-day and ultimate transit capacity needs that were identified (as discussed in Section 4.0).

























## 6.1 Technology Evaluation

A design for a 10-person monocable detachable gondola (MDG) was modelled for comparison purposes. It was identified that such a system could provide sufficient capacity, however it needs to slow in winds above 50 kilometres per hour (km/h) and is likely to shut down at 70 km/h. It also requires additional towers and has a lower cable profile, two factors that increase land-use impacts. Accordingly, this technology option was not considered further.

Funitel systems perform well in high-wind conditions, but are more energy intensive and therefore more expensive to operate and maintain than 3S systems. Therefore, funitel systems are not recommended in urban areas with long operating hours. Additionally, longer spans between towers are more readily achievable with the 3S technology.

Supplier feedback suggests that the technology evaluation prepared for the 2011 business case is still valid. An excerpt of the technology evaluation from the 2011 business case is reproduced in Table 6-1.

Table 6-1. Alternative Technology Evaluation Summary

Evaluation Criteria	Diesel Bus	MDG	3S/Funitel <sup>a</sup>
Financial			
Transportation			
Environment			
Urban Development			
Economic Development			
Social and Community			
Deliverability			
Overall			

**Legend:**



## 6.2 Operations and Maintenance

Suppliers were asked to estimate costs associated with operating the BMGT from 6:00 AM to 1:00 AM the next day, 7 days per week – consistent with operating hours for TransLink's overall rapid transit network.

Suppliers were also asked to comment on whether regular maintenance and cleaning could be performed within a shorter timeframe (that is, between 2:00 AM and 5:00 AM). The suppliers indicated that further study and data from in-service installations would be required to answer this question. Most current urban ropeway systems operate for only 17 hours per day and use MDG technology, which requires more line and tower servicing than 3S technology.

### 6.3 Safety, Security and Privacy

Cabin lighting and (one-way) communications systems are included in the base cost estimate. Two-way communications would add approximately \$6,000 to \$8,500 per cabin.

Cabin enhancements to address privacy concerns of residents living below the gondola route have not been included in the base cost estimate. Switchable smart glass (such as, Vario Smart Privacy Glass) or switchable window films (such as, Smart Tint) could be employed to frost the windows during critical segments of the ride. Other options include gradient window films or windows with built-in blinds, which allow riders to see straight out but obscure the view down to homes below the ropeway.

### 6.4 Technology Conclusion

The technology evaluation finds that 3S technology remains the preferred solution for the BMGT project. Further research is required to confirm upper limits for operating hours of a gondola system, and additional consideration may be given to communications and window technologies for cabins to provide enhanced safety and address privacy concerns.

# Updated Cost Estimates

Updated cost estimates for the BMGT project were developed to ensure future planning is based on a current understanding of estimated project costs, which may have changed since the 2011 business case. This involved updating cost estimates related to building and operating the BMGT project, including costs related to property acquisition.

## 7.1 Capital Costs

Capital cost estimates of the BMGT project were developed to account for all TransLink and contractor costs, including the following:

- Project management
- Preliminary investigations and engineering
- Environmental mitigation costs
- Private land purchases
- 3S gondola costs
- Terminal, tower, and alignment costs
- Transit integration costs
- Permits
- System start-up costs
- Interest during construction
- Premiums for project risks and contingencies

Estimated accuracy range is based on Class 4 (minus 30 percent to plus 50 percent) in accordance with Association for the Advancement of Cost Engineering Cost Estimate Classification System.

### 7.1.1 Aerial Ropeway System

Project parameters, including operating characteristics and geometric constraints, were provided to two aerial ropeway suppliers who then provided capital and operating costs estimates for the electromechanical systems and towers required to support a 3S gondola system capable of accommodating 3,000 pphpd.

### 7.1.2 Civil Works

Based on drawings provided by the suppliers, CH2M developed updated cost estimates for the civil works, including the Upper and Lower Terminal buildings and tower foundations, as well as site preparation and access to these sites.

Additionally, the cost estimates for Option 2 include a pedestrian overpass crossing Commerce Court to connect passengers from SkyTrain and buses at Production Way - University Station to the Lower Terminal. The cost estimates do not account for road works along Gaglardi Way that would be required to accommodate the towers for the Option 2 alignment.

### 7.1.3 Reclaimed Transit Capital Cost

With consideration to forecast population growth, historical growth in transit service, and future plans for bus service expansion outlined in the Mayors' Council 10-Year Vision, TransLink developed bus service assumptions for BAU and Gondola scenarios to estimate annual bus operating costs and associated transit vehicle replacement savings. These assumptions are summarized in Table 7-1 and 7-2.

Table 7-1. Bus Operations and Peak Fleet Savings

Year	Peak Bus Fleet		
	BAU	Gondola	Bus Fleet Savings
2021 – Standard Bus	14	14	0
2021 – Articulated Bus	51	31	20
<b>2021 – Total</b>	<b>65</b>	<b>45</b>	<b>20</b>
2045 – Standard Bus	17	16	1
2045 – Articulated Bus	62	37	25
<b>2045 – Total</b>	<b>79</b>	<b>53</b>	<b>26</b>

Table 7-2. Bus Service Assumptions (Annual Service Hours)

Route	Route Name	BAU			Gondola		
		2021	2030	2045	2021	2030	2045
95	Burrard Stn - SFU B-Line	101,400	126,700	151,500	101,400	126,700	151,500
143	Burquitlam Stn - SFU	15,100	18,900	22,600	15,100	15,100	15,100
144	Metrotown Stn - SFU	51,900	64,800	77,500	51,900	51,900	62,100
145	Production Way Stn - SFU	31,300	39,100	46,800	3,300	3,300	3,300
<b>Total Annual Service Hours</b>		<b>199,800</b>	<b>249,500</b>	<b>298,400</b>	<b>171,700</b>	<b>197,000</b>	<b>232,000</b>
<b>Annual Service Hour Savings</b>					<b>28,000</b>	<b>52,500</b>	<b>66,400</b>

*Note: The BAU scenario includes assumptions based on historical growth in bus service for how bus service is expected to grow and meet future demand, however funding to support the BAU scenario is not confirmed and would need to be secured through future investment plans.*

TransLink will reclaim transit capital costs from the buses removed from service with the introduction of the gondola system. The reclaimed transit capital cost value is determined in two parts. The first is the value claimed in 2021 with 20 articulated buses at \$1,609,524 totalling \$34,160,794 (present value of \$32,227,165 in 2020 dollars [2020\$] with 6 percent discount rate). The second is the value claimed in 2045 with one standard bus at \$1,157,143 and five articulated buses at \$1,609,524 totalling \$9,768,168 (present value of \$2,275,970). The total negative transit capital cost value is \$34,503,135.

### 7.1.4 Private Land Purchases

TransLink's Real Estate team and White Land and Consulting Services Ltd. estimated real estate costs based on: tower locations and vertical profile requirements provided by the aerial ropeway suppliers; and on the private-property impacts within the gondola right-of-way. An operating height of 30 to 35 m was assumed, which is sufficient to keep gondola cabins at least 2.4 m above the tree line for both options. This would be supported by towers that would have a 20 m by 20 m footprint and be placed in locations where there are currently no buildings. Based on these assumptions, real estate costs were estimated at \$70 million in 2020 dollars (net of recovery).

Table 7-3 outlines capital costs in year-of-expenditure dollars for 3,000 pphpd.

Table 7-3. Capital and Operating Cost Estimates (2020\$, millions)

	<b>Option 1: Straight Alignment</b>	<b>Option 2: Kinked Alignment</b>
Capital Costs	\$196.7	\$215-255
Reclaimed Transit Capital Cost	\$34.5	\$34.5
O&M Costs (Annual)	\$4.1	\$5.29

Note: Capital cost estimate shown includes cost of Civil Works and Private Land Purchases.

## 7.2 Operations and Maintenance Costs

The operations period is assumed to be 25 years. The total annual O&M costs, including direct TransLink costs such as policing and risk adjustments, are estimated at \$4.1 million per year for Option 1 and \$5.29 million per year for Option 2 (Table 7-3) including periodic rehabilitation. The annual O&M costs are summed over the 25-year period in the BMGT Life Cycle Costs (Table 7-4).

The replacement schedule for the major maintenance items for rehabilitation is outlined in Table 7-4. Each of the item costs are applied to their scheduled years and summed over the 25-year period in the BMGT Life Cycle Costs (Table 7-5).

Table 7-4. List of Major Maintenance Items for Rehabilitation

<b>Item</b>	<b>Cost (2020\$ – including FOB Burnaby, BC and spare parts)</b>	<b>Replacement Schedule</b>
Track ropes	\$2,250,000	30 years
Haul rope	\$450,000	20,000 hours or 3 years
Track rope slipping	\$170,000	6 years
Cabins and hangers	\$4,500,000	30 years
Saddle profiles	\$230,000	20 years
Bullwheel bearings	\$340,000	15 years
Alternating Current (AC) motors	\$340,000	20 years
Gearbox	\$560,000	20 years
Control systems and hydraulics	\$560,000	20 years
Sheave liners, sheave bearings, and slack carriers		Ongoing
Major inspection	\$230,000	5 years

Notes:

FOB = Free on Board (including or assuming delivery without charge to the buyer's named destination)

### 7.2.1 Asset Renewal Costs

Asset renewal/life-cycle profile and costs were updated for the 2017 assessment. The expected life of track ropes and cabins is 20 to 40 years, with 30 years as the assumed mid-point, so neither the track ropes nor the cabins are assumed to be replaced during the 25-year project term. All other components are assumed to require rehabilitation on the schedule estimated in Table 7-4.

Generally, ropeway systems are replaced near the end of their life expectancy due to age and technical obsolescence. Foundations and steel structures are sometimes modified or upgraded to reinforce for higher design loads and/or to meet newer standards.

As it is difficult to change urban tower locations to increase capacity, it is optimal to fully examine and design the system for the final pphpd requirements. Minimal changes in the rope catenaries (sags) can be accommodated with similar tower heights and locations. However, if there are large changes in the rope catenaries, then changes to tower heights and even locations (or additional towers) might be necessary.

With regard to these considerations, the suppliers have shown that capacity increases from 3,000 pphpd to 4,000 pphpd can be accommodated with the tower heights and locations specified in the plans they submitted. A consideration would be whether the civil works (such as, tower foundations) should be designed and constructed for the higher capacity and heavier loads associated with larger ropes and more cabins, but used at the lower initial capacity.

## 7.2.2 Bus Operations and Maintenance

A key consideration for the BMGT project is the potential for operating and capital cost savings that might result from shifting transit service provision from diesel buses to aerial gondola transit.

The annual bus costs are estimated by comparing the hours of operation and the peak bus fleet for the BAU scenario with that required for implementation of the BMGT project (Table 7-1). Implementation of the BMGT project results in operating 20 fewer buses on opening day with another 6 fewer buses in 2045. This results in a reduction of \$89.3 million in bus operations costs.

The reduction serves a dual purpose: buses can be reallocated to other areas of the network, and purchase of replacement buses can be delayed.

## 7.3 Agency Lifecycle Project Costs

Table 7-5 estimates BMGT capital and operating costs over a 25-year operations period, with capital expenditures assumed in the first year. Thereafter, annual O&M costs are assumed at \$4.1 million, plus periodic major rehabilitation expenses for key gondola components. Industry experts informed these rehabilitation costs and the assumed timing shown in Table 7-4. The present value of the total lifecycle project costs—including initial capital costs, O&M, and periodic rehabilitation—is estimated to be \$123.4 million.

Table 7-5. Burnaby Mountain Gondola Transit Life Cycle Costs (2020\$)

Year	Direct Project Costs			Total costs	
	Initial Costs	Subsequent Costs		Constant Dollars (2020\$)	Present Value
	Capital Expenditures	O&M	Rehabilitation		
<b>Construction Begins</b>					
0	\$196,680,083			\$196,680,083	\$192,969,138
<b>Project Opens</b>					
1		\$4,085,424		\$4,085,424	\$3,854,174
2		\$4,085,424		\$4,085,424	\$3,636,013
3		\$4,085,424		\$4,085,424	\$3,430,201
4		\$4,085,424		\$4,085,424	\$3,236,038

Table 7-5. Burnaby Mountain Gondola Transit Life Cycle Costs (2020\$)

Year	Direct Project Costs			Total costs	
	Initial Costs	Subsequent Costs		Constant Dollars (2020\$)	Present Value
	Capital Expenditures	O&M	Rehabilitation		
5		\$4,085,424	\$450,465	\$4,535,889	\$3,389,480
6		\$4,085,424	\$168,924	\$4,254,348	\$2,999,148
7		\$4,085,424		\$4,085,424	\$2,717,040
8		\$4,085,424		\$4,085,424	\$2,563,246
9		\$4,085,424		\$4,085,424	\$2,418,156
10		\$4,085,424	\$450,465	\$4,535,889	\$2,532,817
11		\$4,085,424		\$4,085,424	\$2,152,150
12		\$4,085,424	\$168,924	\$4,254,348	\$2,114,281
13		\$4,085,424		\$4,085,424	\$1,915,406
14		\$4,085,424		\$4,085,424	\$1,806,987
15		\$4,085,424	\$788,314	\$4,873,738	\$2,033,640
16		\$4,085,424		\$4,085,424	\$1,608,212
17		\$4,085,424		\$4,085,424	\$1,517,181
18		\$4,085,424	\$168,924	\$4,254,348	\$1,490,485
19		\$4,085,424		\$4,085,424	\$1,350,286
20		\$4,085,424	\$2,139,709	\$6,225,133	\$1,941,026
21		\$4,085,424		\$4,085,424	\$1,201,750
22		\$4,085,424		\$4,085,424	\$1,133,726
23		\$4,085,424		\$4,085,424	\$1,069,553
24		\$4,085,424	\$168,924	\$4,254,348	\$1,050,733
25		\$4,085,424	\$450,465	\$4,535,889	\$1,056,856
<b>Total</b>	<b>\$196,680,083</b>	<b>\$102,135,599</b>	<b>\$4,955,115</b>	<b>\$303,770,796</b>	<b>\$247,187,720</b>



# Updated Quantification of Benefits

This section provides an overview of the methodology and results related to estimating benefits from the BMGT project that would accrue to transit users and the general public, as well as TransLink, over a 25-year period. An explanation is also provided of expected benefits that could not be quantified, but should be considered when assessing the overall value of the BMGT project.

## 8.1 Consumer Benefits

Consumer benefits – that is, benefits for transit users and the general public – were calculated based largely on BC MoTI’s latest Benefit Cost Analysis Guidebook<sup>6</sup>. Following this guidance, estimates were developed for the following accounts:

1. Travel Time Savings
2. Vehicle Operating Costs Savings
3. Collision Reductions
4. Parking Cost Savings
5. Reduction in GHG Emissions

### 8.1.1 Assumptions

Table 8-1 shows assumptions used in the calculation of consumer benefits.

**Table 8-1. Consumer Benefits Key Assumptions**

Assumption	Value	Source
Dollar Year	2017	--
Vehicle Operation Cost	\$0.18/km	BC Automobile Association
Value of Time (VOT)	\$17.20/hr	BC MoTI
Annualization	300	--
Discount Rate	6%*	BC MoTI
Benefits Start Year	2021	TransLink
Benefits Duration	25 years	BC MoTI

Note: Value of Time (VOT) from BC MoTI is \$15.90 per hour in 2012 dollars; factored to 2017 dollars using Statistics Canada Consumer Price Index data.

Note: 6 percent discount rate is a standard assumption.

### 8.1.2 Consumer Benefits Calculation

Table 8-2 presents the results of the consumer benefits calculation. The total Net Present Value (NPV) of consumer benefits is approximately \$225.3 million. Most of the benefits are derived from transit user travel time savings, which is in line with the modest shift from auto to transit that is forecasted by the RTM.

<sup>6</sup> <https://www.th.gov.bc.ca/publications/planning/Guidelines/BenefitCostAnalysisGuidebook.pdf>

Travel time savings from the gondola would accrue to transit customers using the gondola service during all times of the day and days of the week. Travel time savings would be derived from shorter in-vehicle travel times between Production Way-University Station and SFU Square, as well as shorter wait times. This applies to peak period travel, but also importantly to travel during off-peak times when the frequency of bus service is lower and wait times for passengers is therefore longer.

Table 8-2. Consumer Benefits Estimate (2020\$, millions)

Benefit Type	Benefit Estimate	Total Benefit
Travel Time Savings	\$207	\$225.3
Vehicle Operating Cost Savings	\$11	
Collision Reductions	\$6.6	
Parking Cost Savings	\$0.5	
Vehicle Emissions Reductions	\$0.2	

## 8.2 Agency Benefits

### 8.2.1 Delayed or Avoided Capital Investments

A potential benefit could arise if the BMGT project enabled TransLink to reduce the number of buses in its fleet, thereby extending the life of existing O&M facilities. The 2013 study, *An Operations and Maintenance Facilities Plan for TransLink's Operating Entities* (CH2M, 2013), concluded that the earliest requirement for the opening of an O&M facility is 2025 under a High Growth scenario of 2.25 percent annual growth in service. For the BAU scenario (0.33 percent annual growth), a new O&M facility would not be required until sometime after 2045. Under a midpoint growth rate (1.3 percent per year) a new O&M facility will be required in 2032. Under all growth scenarios, buses and possibly other vehicles and equipment would need to be re-allocated between the O&M facilities as individual facility capacities are exceeded.

The largest demand for new O&M capacity will be in the central part of the Metro Vancouver region, therefore the next new O&M facility site would likely be required in the Vancouver or Burnaby sub-areas.

It is assumed that the BMGT service would replace Route 145, freeing up 25 articulated buses and one standard bus by 2045. Those buses could be re-allocated to other routes, reducing the need to purchase new buses and delaying growth of the fleet and demand on the O&M facilities. Applying the midpoint growth rate of 1.3 percent per year on the fleet of 230-plus articulated buses, would reduce the need for more buses by approximately 8 years, delaying the need to upgrade O&M facilities from 2032 to 2040.

## 8.3 Qualitative Benefits

The following sections summarize some of the BMGT benefits that would be realized by riders, TransLink, SFU, and the community at large. These benefits are described qualitatively and are not quantified, monetized, or included in the economic benefit-cost analysis.

### 8.3.1 Transportation Reliability

Changes in transportation reliability are increasingly examined in analysis of transportation projects and programs. Reliability problems associated with congestion are generally identified as “recurring” or “non-recurring.” Recurring reliability issues include, for example, traffic bottlenecks that consistently

cause delay. Non-recurring reliability issues include weather events or traffic collisions that affect travel reliability. Burnaby Mountain suffers problems in both categories.

Recurring reliability problems include bus “pass-ups” that occur during peak travel times, when buses are full and cannot take on additional riders. Pass-ups are frustrating for riders, causing travel delay and forcing them to set aside more travel time to ensure they reach their destination on time.

Pass-ups, and the underlying overcrowding, also indicate that a system is operating beyond its capacity. Compared to the current conditions, the BMGT could fully accommodate travel demand, with capacity to spare even at the end of the planning period. This would eliminate or reduce bus crowding on remaining bus routes and reduce or eliminate pass-ups.

Non-recurring reliability is also a problem, as regular snow storms make it difficult or impossible for buses and cars to reach the top of Burnaby Mountain, keeping students and staff from SFU, trapping residents of the UniverCity neighbourhood, and causing economic harm to retailers who lose business on inclement days. The BMGT, which can operate reliably in all weather, would solve this issue.

Although gondola operations may still experience queuing and wait times for available cabins, with a continuous stream of cabins, the perception of delay may not be as negative as a full bus pass-up. Detailed modelling of pedestrian activity will help better understand demand and anticipate the amount of queuing and delays that would be expected.

### 8.3.2 Recreation and Tourism

Burnaby Mountain is an important regional destination with recreation opportunities including hiking, cycling, and developed park facilities. The BMGT would improve access for all users, while also serving as a tourism draw itself. The novel nature of gondola transport, coupled with existing recreation amenities, could attract visitors (as the aerial tram in Portland, Oregon does today).

### 8.3.3 Land Use

The Burnaby Mountain SFU campus is extremely space constrained; the campus has few options for lateral expansion due to presence of the Burnaby Mountain Conversation Area and a strong desire to maintain the natural setting of the school and the mountain itself. SFU’s master plan (Endall Elliot, 2010) notes that the university is approaching full “buildout,” meaning that modest expansion foreseen under the campus master plan would fully utilize available land. By enhancing transit – improving reliability and reducing travel times – the BMGT could reduce demand for parking on campus, reducing the need for costly structured parking and making existing surface parking lots available for development.

Additionally, the BMGT could facilitate SFU expansion near the Lower Terminal at the Production Way-University Station. With frequent service and shorter travel times as compared to bus service, the connection between the hilltop SFU campus and Production Way would be more convenient. The Oregon Health Sciences University campus is similarly space-constrained on top of Marquam Hill in Portland, and the frequent, reliable, and quick connection provided by the Portland Aerial Tram has allowed the university to expand its campus adjacent to the lower tram terminus on Portland’s riverfront.

# Benefit Cost Summary

## 9.1 Timing Assumptions

For the purposes of the financial analysis, the key timing assumptions approximate a notional schedule for the BMGT project. This schedule was developed solely to estimate costs and cash flows. An accurate schedule would be developed if and when the proposed project is approved. Testing and commissioning are assumed to occur during the construction phase. These assumptions are consistent across all financial and procurement options and are summarized in Table 9-1.

**Table 9-1. Notional Timing Assumptions**

Key Milestones	Date
Start of construction	January 1, 2020
Construction length (months)	18
End of construction	June 30, 2021
Start of operations	July 1, 2021
Operation period (years)	25
End of operating contract	June 30, 2046

The updated BMGT project costs, shown in Table 9-2, summarize the detailed costs shown in Table 7-5 (with further breakdowns in Tables 7-3).

**Table 9-2. Project Costs (2020\$, millions)**

Category	Total Benefit (NPV millions)
Initial Capital Expenditures	\$193
Reclaimed Transit Capital Cost	(\$34.5)
O&M and Rehabilitation Costs	\$54.2
Bus Operations Reduction	(\$89.3)
Total	\$123.4

Initial Capital Expenditures is adjusted to present value for an 18-month construction period from \$196.68 million to \$192.97 million.

The updated consumer benefits, shown in Table 9-3, summarize the detailed benefits shown in Table 8-2.

**Table 9-3. Project Benefits (2020\$, millions)**

<b>Category</b>	<b>Discount</b>	<b>Benefit Estimate (NPV millions)</b>	<b>Total Benefit (NPV millions)</b>
Consumer Benefits	RTM Output (includes Travel Time Savings, Vehicle Operating Cost Savings, Collision Reductions, Vehicle Emissions Reductions)	\$224.8	\$225.3
	Parking Cost Savings	\$0.5	

The evaluation of the BMGT project costs to benefits provide a new BCR of 1.8, as shown in Table 9-4. A BCR greater than 1.0 indicates that the project benefits surpass the project costs.

**Table 9-4. New Benefit Cost Ratio**

<b>Category</b>	<b>Estimate (2020\$, millions)</b>
NPV Benefits	\$225.3
Present Value Capital and O&M Costs	\$123.4
BCR	1.8

# Updated Regulatory Requirements

## 10.1 Environmental Requirements

The following section has been updated to reflect changes to regulations since the 2011 business case was prepared. Current Federal and Provincial EA legislation was reviewed to determine if Provincial or Federal EAs, or both, would likely be required for the BMGT project.

The BC Environmental Assessment Office (BC EAO) coordinates Provincial EAs required under the *BC Environmental Assessment Act (BC EAA)*. The Reviewable Projects Regulation defines which projects are reviewable by the BC EAO. If the project is not reviewable, the Minister of Environment can direct the project to be reviewed, or a proponent can request that a project be designated as reviewable. The project, as described in this report, is not listed as reviewable under the Reviewable Projects Regulation and would likely not be subject to a Provincial review under the *BC EAA*.

The Canadian Environmental Assessment Agency (CEA Agency) is the main body that coordinates Federal EAs required under the *Canadian Environmental Assessment Act 2012 (CEAA 2012)*. *CEAA 2012* has changed substantially since the previous version of this report was prepared. The CEA Agency no longer has “triggers” that would make a project subject to a Federal review under *CEAA 2012*. Under *CEAA 2012*, the types of projects that require Federal review are listed under the Regulations Designating Physical Activities. The BMGT project, as described in this report, is not listed as reviewable under the Regulations Designating Physical Activities. Projects that receive Federal funding and are located on Federal land or outside of Canada are subject to review under Sections 67 and 68 of *CEAA 2012*. While the BMGT project may receive Federal funding, it is not proposed on Federal land and will not be located outside of Canada; as such, a review under these sections of *CEAA 2012* would not be required.

TransLink should contact the Provincial BC EAO and Federal CEA Agency regarding the BMGT project to confirm that no Federal or Provincial review would be required.

If the BMGT project is not subject to Provincial or Federal review, TransLink has three options for how to proceed:

1. Proceed with the BMGT project without a formal EA.
2. Conduct an internal EA process.
3. Request that the BC EAO designate the BMGT project as reviewable under *BC EAA*.

Table 10-1 lists advantages and disadvantages of each of these options.

**Table 10-1. Analysis of Environmental Assessment Options**  
*Burnaby Mountain Gondola Transit – Business Case Update*

Environmental Assessment Method	Advantages	Disadvantages	Best Suited For
No EA process	<ul style="list-style-type: none"> <li>• Reduced project timelines and costs</li> </ul>	<ul style="list-style-type: none"> <li>• May cause stakeholder and First Nation concerns</li> <li>• Could affect reputation if project perceived as causing significant social and environmental issues</li> </ul>	<ul style="list-style-type: none"> <li>• Small scale projects</li> <li>• Well-known and easily mitigated social and environmental effects</li> <li>• Few social and environmental concerns identified during consultation</li> </ul>

**Table 10-1. Analysis of Environmental Assessment Options**  
*Burnaby Mountain Gondola Transit – Business Case Update*

<b>Environmental Assessment Method</b>	<b>Advantages</b>	<b>Disadvantages</b>	<b>Best Suited For</b>
Internal EA process	<ul style="list-style-type: none"> <li>• Flexible</li> <li>• Can be customized to suit project</li> <li>• Can focus on issues raised during consultation or that have potential to be significant</li> <li>• Potential to reduce project timelines</li> <li>• Improved project design</li> </ul>	<ul style="list-style-type: none"> <li>• No third-party oversight (though could establish an independent committee to review or by an independent consultant)</li> <li>• May not meet stakeholder and First Nation expectations</li> <li>• Timelines and methodologies are not legislated</li> </ul>	<ul style="list-style-type: none"> <li>• Larger scale projects</li> <li>• Proponent has good reputation</li> <li>• Proponent has capability to conduct assessment</li> <li>• Several social and environmental concerns identified, but potential effects are not complex</li> <li>• Proponent has capability of adequately addressing concerns</li> </ul>
Opt into BC EAO process	<ul style="list-style-type: none"> <li>• Coordinated by a separate body</li> <li>• Standardized process with regulated steps and timelines</li> <li>• Review and input from many government agencies, stakeholders, and First Nations</li> <li>• Improved project design</li> </ul>	<ul style="list-style-type: none"> <li>• More rigid process</li> <li>• Could be more time consuming and costly than other options</li> <li>• Less control over process</li> <li>• Recent trend in public mistrust of government EA processes</li> </ul>	<ul style="list-style-type: none"> <li>• Larger scale projects</li> <li>• Controversial projects</li> <li>• Government review is expected by stakeholders and First Nations</li> <li>• Several social and environmental concerns identified</li> <li>• Project is more complicated or may cause significant adverse effects</li> </ul>

Table 10-2 contains a preliminary list of permits that may be required before construction. This list can be confirmed with regulatory agencies once the BMGT project route is defined. Permitting can run concurrently with an EA to reduce BMGT project timelines.

Table 10-2. List of Applicable Permits

Regulatory Agency or Stakeholder	Permit/Approval/Notification	Relevant Legislation	Timeline to Prepare Application	Timeline for Approval	Target Submission Phase	Action(s) and Deliverables	Project Component and Location	Notes
Fisheries and Oceans Canada (DFO)	<i>Fisheries Act</i> Authorization	Section 35 (2) of the <i>Fisheries Act</i>	1 to 2 months	6 to 9 months	Early in Detailed Design	Self-Assessment by Qualified Environmental Professional to determine if potential for serious harm to fish and fish habitat Request for review by DFO, including an Aquatic Effects Assessment, if potential for serious harm Offset Plan (if authorization is required) Monitoring Plan (if authorization is required) Consultation with First Nations	Towers; lay down/staging areas	Self-Assessment is required if project footprint is within riparian area or within the stream bed of a fish-bearing watercourse. Authorization is only required if potential for serious harm to fish. This governs the design of the intake (mitigation to reduce effects to fish and fish habitat) and potential adverse effects on environmental flows.
BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (MFLNRORD)	Changes in and about a stream	<i>Water Sustainability Act</i>	1 to 2 months	3 to 6 months	During detailed design	Detailed description of proposed works including maps and drawings Detailed effects assessment and mitigation measures to reduce effects Consultation with First Nations and stakeholders	Towers; lay down/staging areas	Approval for “changes in and about a stream” may be required for activities that take place within a stream bed.
	Crown Land Permit and subsequent Tenure	<i>Land Act</i>	2 to 4 months	3 to 6 months	During detailed design	Prepare permit application Detailed effects assessment and mitigation measures to reduce effects Consultation with First Nations and stakeholders	Towers; lay down/staging areas	Permission to occupy crown land during construction is required, followed by a tenure over Crown land.
	Cutting Permit	<i>Forest Act</i>	1 to 2 months	2 to 4 months	During detailed design	Prepare Licence to Cut application Complete timber cruise Scale timber and pay stumpage	Towers; lay down/staging areas	Permission to cut Crown timber is required.
	General Wildlife Permit	<i>Wildlife Act</i>	1 month	2 to 3 months	During detailed design	Prepare permit application Use baseline information collected for EA process	Towers; lay down/staging areas	This is required for wildlife salvage and removal during construction.
	Heritage Investigation Permit (Section 14)	<i>Heritage Conservation Act</i>	1 to 2 months	3 to 6 months	During Project Definition Phase	Desktop review Archaeological surveys Prepare permit application Permission from and coordination with First Nations	Towers; lay down/staging areas	Heritage Investigation Permit is only required if field work is required or for archaeological monitoring during construction. Field work is only required if desktop assessment identifies potential for archaeological sites within the project footprint.
	Site Alteration Permit (Section 12)	<i>Heritage Conservation Act</i>	1 to 2 months	3 to 6 months	During detailed design	Prepare permit application Permission from and coordination with First Nations Collect and inventory artifacts	Any archaeological site that would be modified or destroyed by the proposed project	Site Alteration Permit is only required if a site protected under the <i>Heritage Conservation Act</i> would be disturbed or destroyed.
City of Burnaby (local approving authority)	Rezoning Development Permit Conservation Permit Tree Cutting Permit Road use Permit Building Permits	<i>Local Government Act</i> <i>Building Act</i>	2 to 3 months	3 to 6 months	During detailed design	Prepare permit applications Detailed effects assessment and mitigation measures to reduce effects Riparian Areas Regulation Assessment Consult with stakeholders	Towers; lay down/staging areas	Permit and rezoning requirements depend on location of proposed facilities and project design.
First Nations	Heritage/Archaeology Permits	First Nations Government	1 to 2 months	2 to 4 months	During detailed design	Prepare permit application Permission from and coordination with First Nations Collect and inventory artifacts	Any archaeological site that would be modified or destroyed by the proposed project	This is only required if a site protected under the <i>Heritage Conservation Act</i> would be disturbed or destroyed.



### 10.1.1 Follow-up Activities

It is assumed that during design and EA, TransLink would log environmental and public concerns and identify mitigation strategies to respond to these concerns. Committees may be formed to engage directly with affected parties, including local businesses, residents, and environmental groups. Given potential safety issues and the evacuation capacity that an aerial ropeway would add to Burnaby Mountain, TransLink may also form an Emergency Responders Committee, including first responders, who could develop and implement safety training and response protocols in coordination with systems operators.

## 10.2 Safety Requirements

### 10.2.1 Standards and Regulations

As part of the British Columbia Safety Authority (BCSA), the Provincial Safety Manager and Safety Officers oversee the safety of all passenger ropeways in the province, ensuring that ropeway owners and licenced contractors comply with the regulatory requirements for installation, operation, and maintenance of equipment for public use.

The *Safety Standards Act* and the Safety Standards General Regulation applies to everyone who installs, alters, maintains, or operates a passenger ropeway system. Operators and contractors must also adhere to the Elevating Devices Safety Regulation.

Passenger ropeways are also subject to the 2014 CSA Z98 standards, national codes published by the CSA Group (formerly Canadian Standards Association), a not-for-profit standards organization accredited by the Standards Council of Canada. The standards govern design, manufacture, construction, modifications, operation, inspection, testing, and maintenance of passenger ropeways and passenger conveyors (including gondolas with fixed or detachable grips).

Approvals for designs and products are provided by independent professional engineers with knowledge in the industry and must adhere to the design standards set out by CSA Z98.

### 10.2.2 Permits, Licencing, and Certification

A BCSA installation permit is required for any new installation – with consideration of the proximity to road crossings and nearby structures. A completed system must pass an acceptance inspection by a BCSA Safety Officer before acquiring an operating permit and beginning service.

All contractors and companies that operate, install, maintain, test, and alter passenger ropeways must be licenced by BCSA in a classification applicable to their ropeway system.

Trainers who train passenger ropeway operators and attendants require a certificate of qualification through a BCSA Train the Trainer program.

## 10.3 Customer Requirements

TransLink's *Transit Passenger Facility Design Guidelines* (TransLink, 2011c) serve as a comprehensive resource for producing consistently excellent transit passenger facilities through a systematized and integrated design process. They are intended to supplement, rather than replace, existing design, engineering, and environmental standards and requirements.

In designing the BMGT project, the layout for decision and circulation spaces within the station terminals will need to be reconciled with the expected peak ridership.

There will be opportunity spaces, which are those areas of the terminal buildings not dedicated to decision-making or circulation. Consultation with stakeholder groups will inform the types of amenities that could occupy those spaces.

# Recommendations and Next Steps

This 2017 assessment of the BMGT project is based on a high-level analysis, incorporating many assumptions. As such, there may be need for future updates as new information emerges and as conditions and assumptions change.

## 11.1 Remaining Uncertainties and Additional Technical Work

### 11.1.1 Ridership Forecast Refinement

In 2016 and 2017, the Tri-Cities area has seen significant changes to the transit network serving these communities with the introduction of the Millennium Line-Evergreen Extension and related changes to the bus network. It will be important to monitor ridership data to see how these changes may influence travel patterns and mode choice, particularly for travel to and from Burnaby Mountain.

### 11.1.2 Geotechnical Assessment and Foundation Refinement

A geotechnical investigation at terminal and tower locations would reduce uncertainty about underlying soil conditions, confirming the suitability of locations and refining assumed foundation costs.

The current civil works estimate assumes piled foundations. The tower foundations are crude, with a solid mass of concrete based on an assumed tower footprint. The number and depth of piled foundations could be refined with additional information, and the tower foundations could be optimized based on loading at the tower base (to be provided by suppliers in future design phases).

### 11.1.3 Design and Costing Refinements

BMGT project cost estimates could be refined to incorporate urban integration of the Upper and Lower Terminal buildings. The focus would be for sustainable development to improve the economic, physical, social, and environmental conditions through design and planning of the facility and amenities.

The aesthetics of the system and the interaction with the surrounding urban fabric must also be considered. This could be applied to the tower designs, particularly if there is a desire to incorporate visual or aesthetic treatments. For example, the Emirates Air Line, a cable car link across the River Thames in London, has an open spiral design for the towers. The Portland Aerial Tram Tower has a public art component, with lighting that reflects seasonal changes in the Portland sky, generally responding to lunar and solstice cycles.

### 11.1.4 Utilities

The area around overhead BC Hydro lines was identified as a 'no go' zone and the suppliers respected that constraint in their designs. But BC Hydro may impose additional conditions, especially during construction. These need to be clarified. There also may be minor underground structures and utilities at the terminal building and tower sites, which will require identification and potential mitigation.

### 11.1.5 Visual Impact Assessment

Public engagement related to the 2011 business case identified significant concern from Forest Grove residents about potential visual impact. A preliminary analysis, based on a Google SketchUp model developed to support the 2011 Burnaby Mountain Gondola Transit Business Case Report, could be updated with 3-dimensional visual software and drone flights, following the cabin travel paths and flagging any privacy concerns.

## 11.2 Next Steps

1. Inputs for the ridership forecast can be updated based on the new usage of the transit system and service changes, including the opening of the Millennium Line - Evergreen Extension and the effects on mode choice and travel patterns.
2. The civil works estimate (including the Upper and Lower Terminal buildings; tower foundations; and site preparation and access for construction and maintenance) was based on a conceptual design that provides an accuracy range of approximately minus 30 percent to plus 50 percent. Progressing the development of the preferred option will help to improve the accuracy of the cost estimate. Further design development could include the following:
  - Geotechnical investigation to provide more detailed information about underlying soil conditions to inform the design of foundations for the towers and terminal buildings;
  - Refinement of the tower designs and their urban integration to mitigate impacts;
  - Identification of other major constraints, such as underground utilities that may need relocation;
  - Identification of overhead ‘no go’ zones to propose and price mitigation measures; and
  - Further assessment for visual impact on the surrounding neighbourhood and privacy of residents, with proposed mitigation measures.
3. Further investigation is required to determine how environmental impacts to the Burnaby Mountain Conservation Area can be minimized through construction and operations. This will be important to assuaging concerns from environmental groups regarding trees that may need to be cleared for the gondola right-of-way. Construction and operation of other gondolas can provide evidence and documented examples of how this has been done elsewhere and can show how it can be replicated.
4. Based on a target start-of-construction date of January 1, 2020, an indicative design development schedule should be prepared to take the BMGT project from its current stage to the award of the contract. As the design progresses, in parallel with further site investigations to refine the design, the degree of accuracy and confidence in the cost estimation will improve from the current minus 30 percent to plus 50 percent accuracy at this conceptual stage to approximately minus 10 percent to plus 15 percent at the tender ready documentation stage.

The accuracy of cost estimates at different project phases or stages is shown in Table 11-1.

Table 11-1. Association for the Advancement of Cost Engineering Cost Estimate Classification Matrix for Process Industries

Estimate Class	Maturity Level of Project Definition Deliverables	End Usage	Expected Accuracy Range Typical Variation in Low and High Ranges
Class 5	0% to 2%	Concept screening	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	L: -3% to -10% H: +3% to +15%

5. Pedestrian modelling (using Legion, Paramics, or Vissim/Viswalk) on the final design will help visualize pedestrian movements to identify areas of concern or congestion and queuing impacts through the BMGT system and the connections from the Upper and Lower Terminals to SkyTrain and SFU Campus. It can also assess issues that may arise during an emergency evacuation of the BMGT system. Furthermore, it is a useful tool for public engagement, providing video-clip visualizations of station and gondola operation.
6. While no substantial growth in SFU enrollment or development on Burnaby Mountain is anticipated beyond 2045, work with SFU to better understand how travel demand may change over time as students from other parts of Metro Vancouver choose to attend courses at SFU Burnaby Mountain.
7. Perform a stress test and logic check of the future transit services, based on model outputs and route performance. RTM forecasting does not account for overcrowding on transit services, which means transit services may not accommodate the projected ridership as expected. Verifying the routes, headways, and capacities against ridership will help to identify limits of the transit system and flag any areas for adjustment. The RTM should also be updated based on the opening of the Millennium Line - Evergreen Extension and associated changes in travel patterns.
8. Milestones can be programmed for engagement with the public and key stakeholders to maintain transparency with the process and progress.
9. The procurement method can be reviewed to investigate whether the BMGT project follows the more traditional Design-Bid-Build route or the Design-Build-Operate route.
10. Funding options should be assessed to see whether the BMGT project will qualify for “special” funding outside of the Public Transit Infrastructure Fund, including federal green infrastructure funding.

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