



TransLink

2019 Late Night Service Report

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1.0 Introduction

1.1 Existing Late-Night Service

TransLink provides a significant amount of service late at night. Currently TransLink operates 40% of its daytime services past midnight. SkyTrain, SeaBus, and most bus services terminate service at approximately 1AM.

After 2AM the NightBus network provides overnight service on key corridors, with service radiating from the Granville entertainment district, as presented in the figure below:

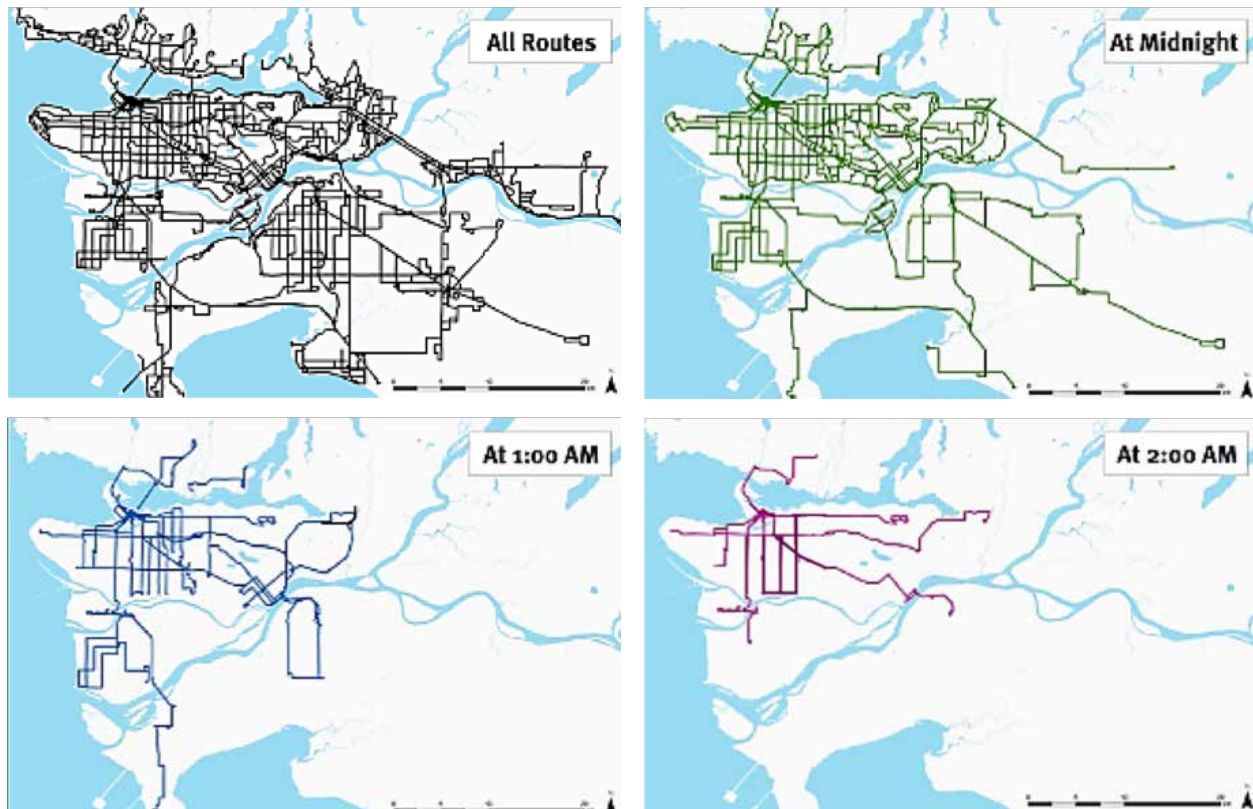


Figure 1: Network coverage by time of day

NightBus service runs every 30 minutes on most lines. Some services resemble day time routings, but other lines have routings that are only operated at night.

In all cases, the entertainment district (Granville Street in Vancouver) is a focal point that provides customers with an opportunity to transfer between bus services late at night.

Customers have communicated that existing services are not meeting their needs. Customers have many transit opportunities and modes including SkyTrain to reach their destinations during the day and into the evening, but they have limited options for their return trips late at night.

Different stakeholders have also communicated that current service offerings are not meeting their needs late at night. These include entertainment trips, shift workers, YVR, and more.

1.2 Existing Late-Night Ridership

Late-night transit demand is low. Looking at any transit mode or day of week, the transit system experiences significant ridership reductions after 11PM when SkyTrain and regular bus services are in operation. This is associated with an overall reduction in activity across the region and across transportation modes.

Late-night boardings between midnight and 4AM represent approximately 1% of total daily boardings. This includes the last hour of SkyTrain operation (midnight to 1AM).

Late-night demand is higher on Friday and Saturday nights than other nights of the week. This trend is observed on buses and during the last hour of SkyTrain operation.

The following is a summary of late-night ridership (past midnight):

- NightBus lines experience an average of 1,900 boardings from Sunday to Thursday
- Average NightBus boardings are 2,600 on Friday and 3,700 on Saturday
- SkyTrain experiences 3,600 boardings from Sunday to Thursday,
- On Friday and Saturday, SkyTrain experiences approximately 9,500 boardings

Detailed figures and time periods are presented in Figure 2 below:

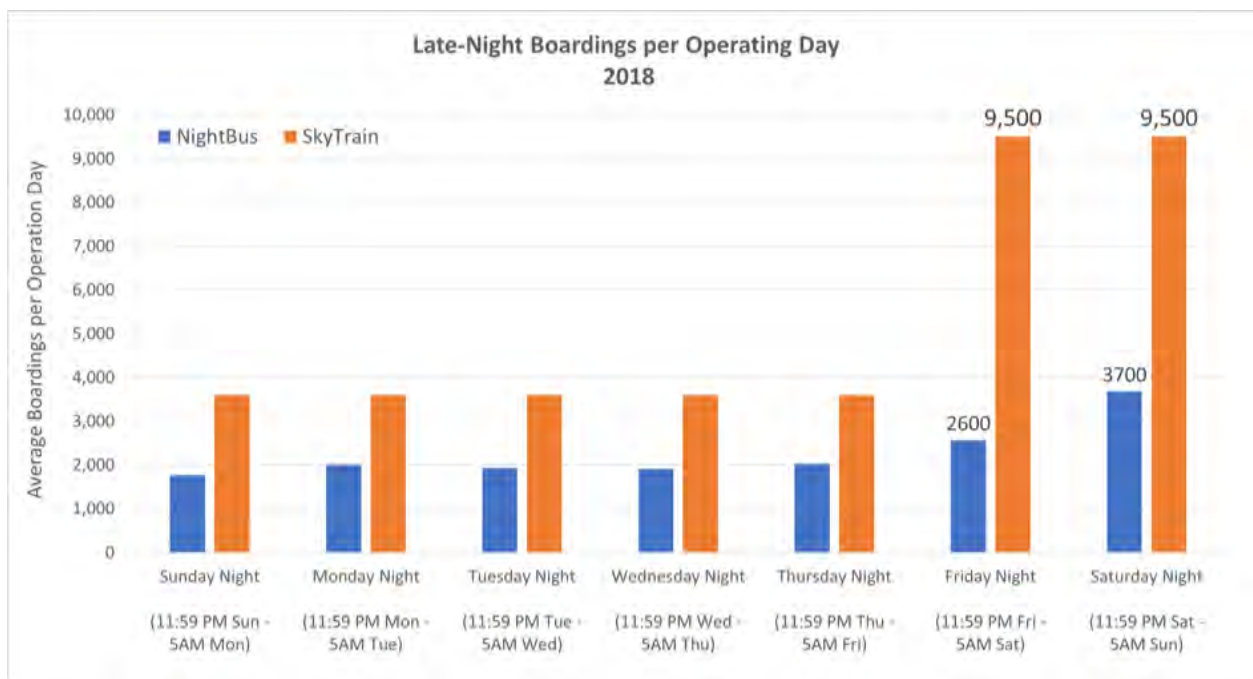


Figure 2. Late-night ridership by transit mode

For the purposes of this study, ‘Operating Day’ is different from calendar day. For instance, a ‘Saturday NightBus Operating Day’ takes place between 11:59PM on Saturday and 5AM on Sunday.

1.3 Background and Need for the Study

At the request of elected officials and stakeholders in April 2018, TransLink launched a review of late-night services, including SkyTrain hours of operation, bus and other services focused around serving the Downtown Vancouver entertainment district. Through the study, TransLink made it clear that any increases to service hours must not come at the expense of vitally-important SkyTrain maintenance requirements.

An independent consultant was hired through public procurement process to complete a review of best practices around the world and a technical study of extended SkyTrain service. Reviews of bus and alternative modes of transportation were undertaken by TransLink planning.

TransLink also convened a group of key stakeholders consisting of city staff, safety and security officials, local businesses and others. The objective of the stakeholder group was to discuss the full range of impacts and options, including potential alternative means of improving safe transportation out of the downtown core late at night and travel to key destinations across the lower mainland. Three meetings were held to discuss the project and review the key stages of findings in April 2018, June 2018 and March 2019 respectively.

The Late Night Service Review included three streams of work, all of which will be discussed in greater detail herein:

STAKEHOLDER CONSULTATION

Form and engage a Late Night Stakeholder Committee to inform and discuss options with key stakeholders including business associations, students, municipal officials, police officials, and other agencies;

SKYTRAIN TECHNICAL STUDY

Commission a review by independent consultant of best practices around the world and a technical study of the potential system-wide impacts of extended SkyTrain service, including CanadaLine; and,

BUS SERVICE PLANNING

Review the current transit network and develop options for improving late night bus service.

This report is organized in sections that discuss work and findings from each workstream as follows.

2.0 Stakeholder Consultation

2.1 Community Stakeholder Group

As a part of the overarching study, TransLink convened a group of key stakeholders consisting of City of Vancouver Staff, safety and security officials, local businesses and others. Discussion with stakeholders included the full range of impacts and options, including potential alternative technology means to improve safe transportation out of the downtown Vancouver core late at night.

Late Night Services Review Stakeholder Group
CEO, Downtown Vancouver BIA
Hospitality Vancouver Association
YVR
BC Restaurant Association
City of Vancouver
Government of BC, Ministry of Transportation and Infrastructure
Metro Vancouver Transit Police (MVTP)
Vancouver Police Department (VPD)
Royal Canadian Mounted Police (RCMP)
Vancouver Taxi Association
The Alma Mater Society (AMS) of the University of British Columbia(UBC) Vancouver

Table 1: Late night Services Review Stakeholder Group

2.2 Additional final report engagement

In addition to briefings with the established community stakeholder group, prior to release of the final report, TransLink engaged with additional stakeholders in one-on-one meetings to receive feedback on the initial report findings.

The group of additional stakeholders include:

- Bar WatchVancouver Airport
- Ministry of Transportation and Infrastructure
- City of Vancouver
- Mayor of Coquitlam
- Downtown Vancouver Business Improvement Association Policy Committee

3.0 SkyTrain Technical Study

3.1 Overview

An independent consultant was hired through public bidding process to conduct a thorough review of the market, as well as analyze the feasibility of extending service on the SkyTrain network.

Under separate contract ProTrans, the independent operator of the Canada Line was commissioned to conduct a similar review of their network.

The study was broken into two phases, each with two containing stages (see Figure 3 below). This section summarizes key findings from all of the reports, which can be found in the associated appendix.

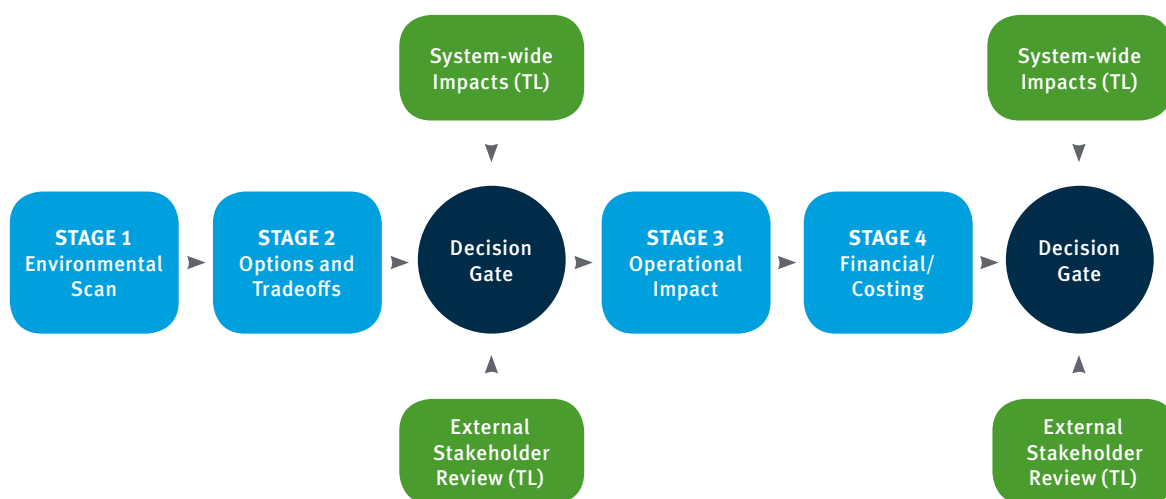


Figure 3: Late Night Services Study Stages

3.2 Phase 1 and 2: Environmental Scan and Late Night Options

Phase 1 and 2 of the extended service technical study was separated into two parts. The first part was an environmental scan to review hours of operation for other transit agencies around the world. Along with review of operating hours, various other factors were considered for comparative purposes, including but not limited to size of population serviced, age of infrastructure and type of infrastructure.

The second part looked at the technical feasibility of extended service based on the existing SkyTrain network.

The Phase 1 and 2 report titled 'Skytrain Extended Service Hours Feasibility Study' is included in Appendix A.

3.2.1 Environmental Scan

A total of 17 cities were reviewed in the environmental scan, including two Canadian cities (Toronto and Montreal), two North West cities which service similar population sizes (Seattle and Portland), six Asian cities and seven cities which either currently or previously have run late night rail service. A set of four peer cities were set for comparative purposes, the following table shows the Night time transit provision of these peer cities.

City	Toronto	Montreal	Seattle	Portland	Vancouver
Metro Area Population	6,418,000	4,099,000	3,799,000	2,425,000	2,463,000
Night-time Rail Service	No Subway line operates late night. Latest service is 02:13 on the Sheppard Line.	No Metro line operates late night. No plans to start night service due to maintenance requirements.	Sound Transit Link operates limited services during special events.	MAX does not operate late night.	SkyTrain does not operate late night.
Night-time bus Service	Blue Night buses	Night buses	Night Owl buses	No service due to financial constraints	NightBus
Night Time Headway	30 mins or less	Minimum of 45 minutes. 15 mins. along Rene Levesque	60 minutes	N/A	30 mins. or less
Day of the Week	Everyday	Everyday	Everyday	N/A	Everyday
Start and End of Night-time Services	1:30 AM – 5:30 AM	1:00 AM – 5:30 AM	1:00 AM – 5:00 AM	N/A	1:00 AM – 5:00 AM

Table 2: Comparison of Population & Night Time Transit Provision

The study also found that no Asian cities run services overnight, but a select few either currently or previously have operated 24 hour passenger rail service including:

- Berlin, Germany
- Boston, USA,
- Chicago, USA,
- London, UK,
- New York, USA,
- Philadelphia, USA; and
- Sydney, Australia

Vancouver's SkyTrain and Kuala Lumpur LRT are the only unattended systems that were included in the benchmarking review and both occasionally operate extended night-time service to support special events. Overall it was found that SkyTrain's operating hours are consistent with peers and is in line with the benchmarking exercise.

3.3 Feasibility of Extended Service

3.3.1 Expo and Millennium Lines

The second primary deliverable of Phase 1 and 2 was for the independent consultant to determine if extended service hours were feasible on the Expo and Millennium lines. To support this evaluation four options were reviewed:

1. Extended service hours, Expo & Millennium Lines
2. Extended service hours, Millennium line Only
3. 24-Hour Service, Expo & Millennium Lines
4. 24-Hour Service, Millennium Line Only

The consultant's team interviewed key staff at SkyTrain, conducted ride-alongs during operations and non-operations hours and completed a thorough review of the SkyTrain capital program.

The complete multiple account evaluation and details on constraints and key challenges can be found in Appendix A.

3.3.1.1 Conclusion

Following internal review of findings from this stage of the technical study 24 – Hour a day 7 day a week service was ruled out due to impacts to existing ridership, the fact that this service would challenge 'State of Good Repair', and capital impacts. It was also noted that extending service by an hour or two as considered as part of options one and two would be inefficient, therefore a decision was taken to pursue a detailed technical analysis on a sub option 3: 24 – Hour a day 2 days a week service as potentially being feasible within our network.

3.3.2 Canada Line

As a part of the study, Protrans BC Operations Ltd. conducted an internal review of options for extending service as set out by TransLink. The options evaluated by Canada Line were:

1. 24-Hour Service, seven days a week
2. 24-Hour Service, on Friday and Saturday nights
3. One-Hour extension on Friday and Saturday nights
4. Two-Hour extension on Friday and Saturday nights
5. Limited stop service

The Canada Line team undertook the evaluation of the above options on six functional areas of the business: Service Delivery, Maintenance, Lifecycle Management, Staffing and Labour, Health Safety Security and Environment, as well as Business considerations

The Canada Line concluded that Option 1 (24-Hour service, seven days a week) would not be feasible on their network. It should be noted however that Canada Line utilizes a different propulsion technology than SkyTrain and is relatively new, as such their maintenance practices differ from that of SkyTrain. The majority of maintenance activities today happen from Sunday through Thursday on the Canada Line, increasing the ease of implementation for Option 2.

The full, detailed Canada Line Phase 1 assessment is available in Appendix B

3.4 Analysis of Extended Friday/Saturday Service (Phases 3 and 4)

Following the determination to pursue detailed investigation into feasibility of 24-Hour service Friday and Saturday nights (24/2 Service), the independent consultants undertook Phases 3 and 4 of work.

The study was conducted over approximately 6 months through the fall of 2018 and winter of 2019, and can be found in Appendix C.

3.4.1 Expo & Millennium Lines Detailed Operational Impact

For the Expo and Millennium lines, the purpose of these phases was to outline in detail SkyTrain's ability to operate 24/2 service on two time horizons, a medium term and long term. The remit of the project team was a detailed investigation into almost every element of how the SkyTrain is operated and maintained, resulting in a detailed study and a set of thorough recommendations.

3.4.1.1 Key Findings

Significant tradeoffs for operations, maintenance and capital projects needed to operate 24/2 service on the Expo and Millennium lines. The need to make up maintenance hours result in cancellation of last hour of Sunday to Thursday service and part-closures of SkyTrain during Statutory Holidays, which results in a net negative impact on ridership numbers.

The SkyTrain network is embarking upon a period of unprecedented growth, which puts further demands on the non-revenue hours. Fleet expansion and capital projects put further strain on the non-revenue hours for items like commissioning of new trains, replacing rail and upgrading stations.

As an automated network, SkyTrain operations and maintenance teams use the non-revenue hours of service to perform critical safety checks on the Automatic Train Control System, as well as other Fire Life Safety Systems such as tunnel ventilation. Given the possibility of impacting systems that are relied upon for passenger and worker safety creates a serious added risk that requires careful planning to effectively mitigate

3.4.1.1.1 Operations and Maintenance Impact

Using a two-month sample of data, the consultant group conducted a detailed analysis of maintenance activities that occur overnight on Friday and Saturday Nights, during what are called non-revenue, engineering, or maintenance hours. The result of the analysis showed that through improved efficiencies and work practices the work cannot fit into the non-revenue hours available in five nights a week. The need to make up maintenance hours results in decreasing service hours from Sunday to Thursday, as well as part closures of SkyTrain during low ridership periods to accommodate maintenance campaigns or capital works. A visual representation of this tradeoff is found in Figure 4.

Executive Summary – Operational Implications

- Loss of 9 maintenance hours
- Requirement to mitigate loss to the maintainer. Different approaches studied
- Proposal to reduce Sunday – Thursday revenue service by 60 minutes

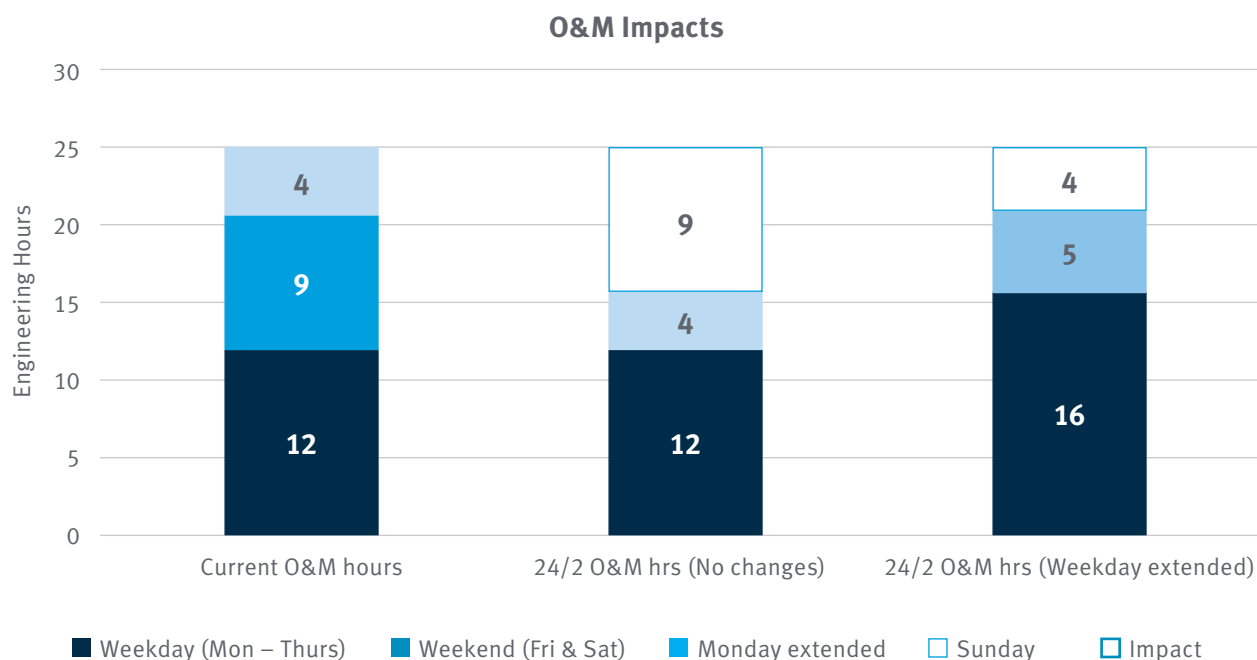


Figure 4: Proposed mitigations to compensate for the loss of maintenance hours in 24/2 operations

3.4.1.1.2 Ridership Impact

Due to the need to cancel last hour of service Sun-Thu to maintain the network, 24/2 service ridership would displace 'last hour' weekday passengers causing an estimated loss of 1,050,000 passengers annually in the long term. The projected gain from 24/2 service is 713,000 riders annually with 15min headways, resulting in a net loss of ridership of 337,000 riders.

The loss of ridership from Sun-Thu last hour is greater than the projected ridership gains on Fri-Sat nights from 1 to 5AM, as shown by the figure below.

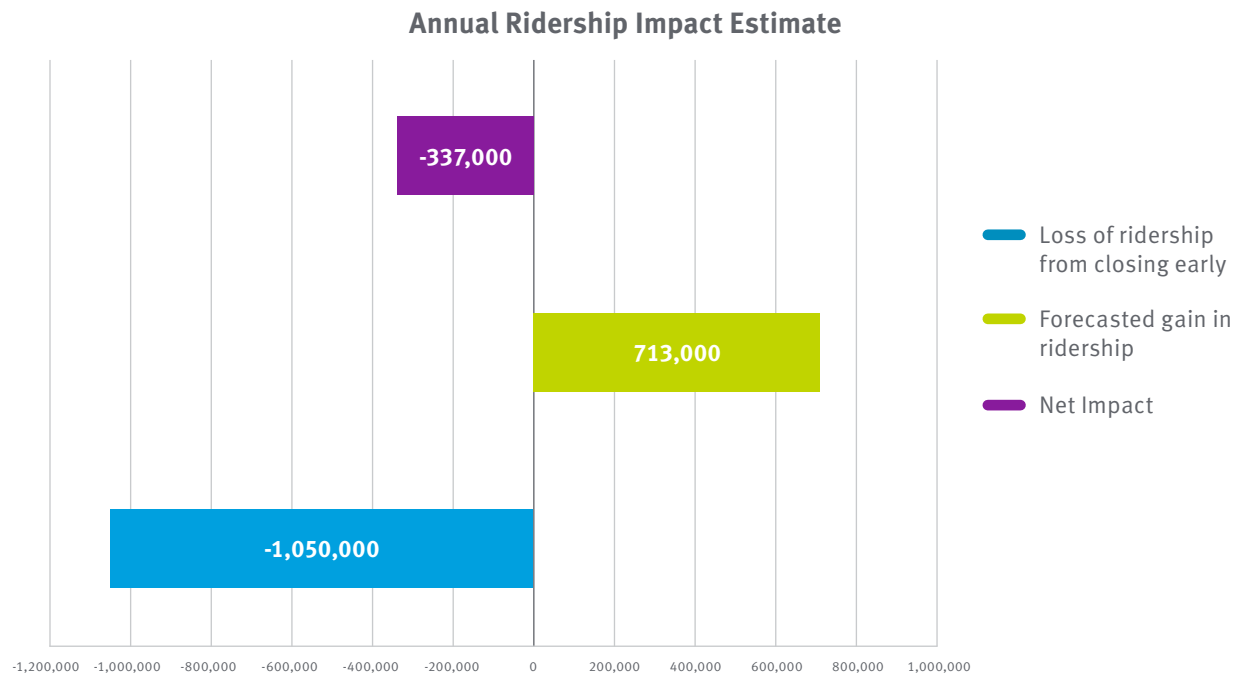


Figure 5: Long Term Estimated Ridership impact in 24/2 operations

3.4.2 Canada Line Detailed Operational Impact

Phase two of the Canada Line study focused on safety and service planning for the option of 24-Hour two day a week service.

The complete Canada Line report for phase 2 can be found in Appendix D

4.0 Bus Service Planning

4.1 Current NightBus service

TransLink operates 10 NightBus lines as presented in the figure below:



Figure 6: NightBus Network

NightBus services operate between 1 and 5AM; service runs every 30 minutes on most lines. Some services resemble day time routings, but other lines have routings that are only operated at night.

For all NightBus lines, the entertainment district (Granville Street in Vancouver) is a focal point that provides customers with an opportunity to transfer between bus services late at night.

4.2 Ongoing NightBus Investments

The Mayors' Vision identifies that NightBus service is a candidate for an 80% increase in service hours from 2016 service levels.

- As part of Phase 1 of the Vision, TransLink already implemented a 25% increase between 2016 and 2018
- As part of Phase 2 of the Vision, TransLink plans to implement an additional 58% increase between 2019 and 2020
- The above will result in full implementation of the NightBus 80% increase in the fourth year of the 10 Year Vision

The above increases include frequency, hours of service, and route extensions. These NightBus service changes are fully funded as part of the Mayors' 10-Year Vision and will provide several benefits:

- Frequency increases (shorter wait times)
- Service span increases (more hours of service to UBC and other destinations)
- Additional bi-directional services (more trips going to and from Vancouver)
- Service extensions (easier to get to existing and new destinations)

Figure 7 below presents the proposed restructuring and service extension of lines N10 and N15 to streamline service to Richmond and YVR. This service change was consulted on in April 2019 and is one example of several NightBus improvements being prepared for implementation.

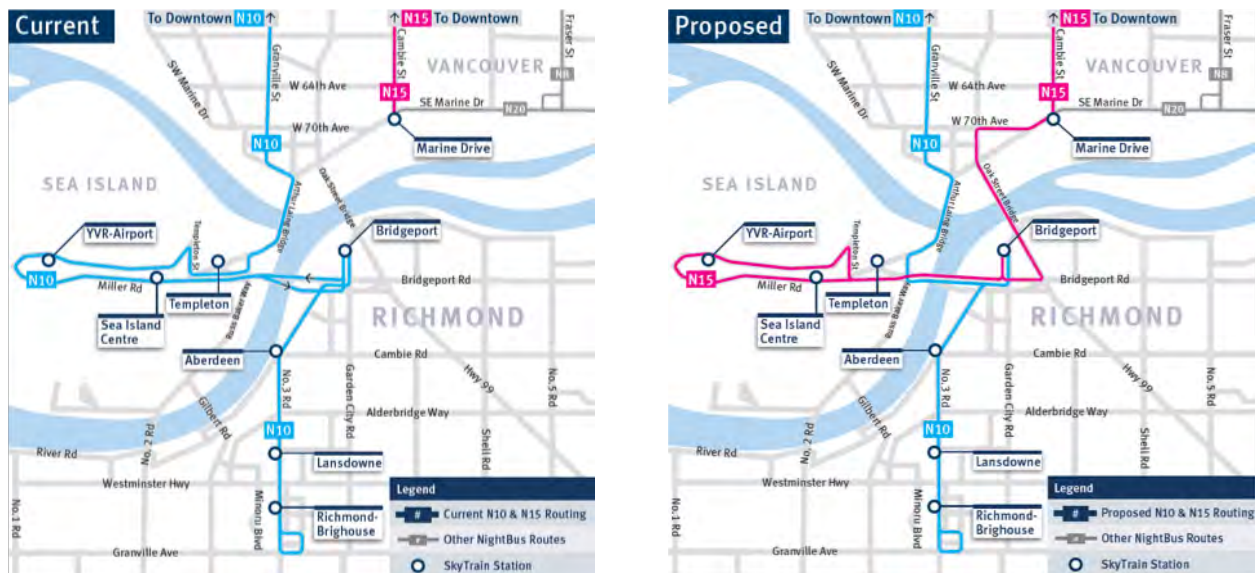


Figure 7: Proposed restructuring of N10 and extension of N15 to streamline Richmond-YVR service

TransLink received feedback from stakeholders indicating that several challenges would likely remain after the implementation of the above NightBus investments. To address these concerns, TransLink performed an investigation of late-night service gaps and challenges, as presented in the section below.

4.3 Transit Service Gaps and Challenges

Several challenges, including low operating speed, will likely remain after the implementation of the NightBus investments.

Regional accessibility, the number of destinations that can be reached by transit, is significantly reduced late at night. In addition, the operational speed of bus services is not competitive with the speed of SkyTrain.

To better understand gaps and challenges, this study reviewed complaints and comments received via TransLink's website and complemented those with the creation of isochrones. Isochrones are diagrams that illustrate how far a transit rider can travel by transit and walking within 15 to 60 minutes.

Figure 8 below presents two sample isochrones where the transit trip originates in Vancouver. It illustrates destinations that can be reached on weekdays at midnight, and at 2AM:



Figure 8: Transit accessibility late at night

These isochrones were created for different municipalities across the region (full set presented in Appendix E). Several key challenges were revealed as part of this analysis, including:

- Low bus speeds due to the absence of express or highway services late at night
- Need to review if additional bus services could expand hours of operation to increase regional coverage late at night

A number of transit options were developed to address the above challenges identified by TransLink and other challenges identified by stakeholders, including community impacts, maintenance, safety, operating costs, and deliverability. The transit options and evaluations are discussed below.

4.4 Bus Alternatives

TransLink investigated dozens of late-night bus options by creating a ‘strategy table’. A strategy table is a useful tool utilized by TransLink to support structured decision making. Strategy tables involve the identification of themes. In the case of late-night service, three key themes were identified:

- Reduce travel times by increasing bus speed,
- Provide service that is easy to understand, also referred to as service legibility
- Increase the number of destinations, also referred to as service coverage

A long list of 27 network options was developed by creating the strategy table below:

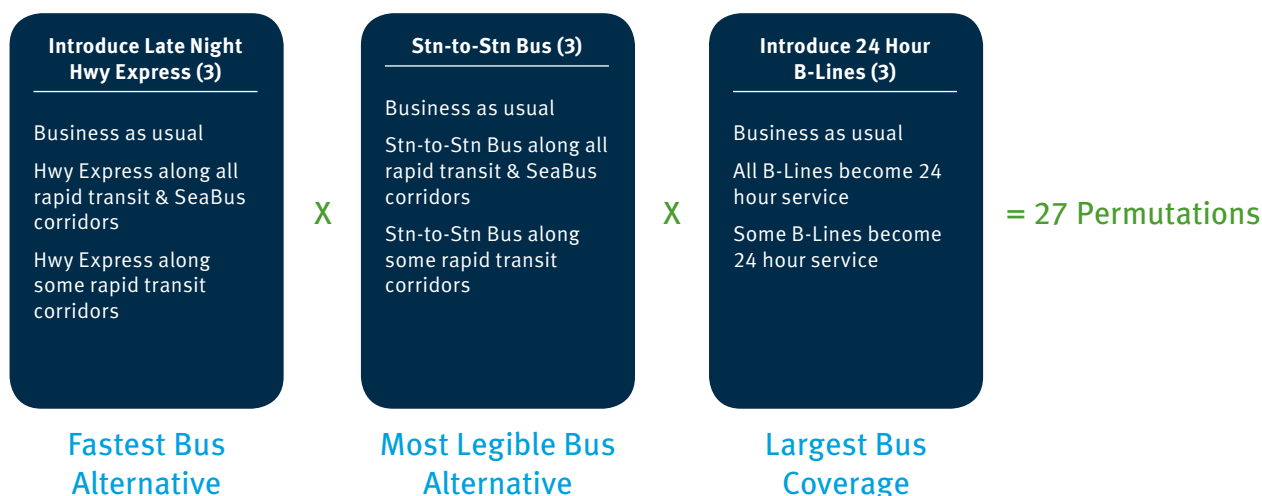


Table 3: Strategy table used to develop late-night bus options

A shortlist of the concepts was selected for further consideration. According to best practices in structured decision making, the shortlisted options need to be inherently different.

The long list of 27 permutations was discussed during several workshops with stakeholders, and the ‘bookend’ concept for each theme was selected for detailed evaluation. Bookends are alternatives that present ‘all-or-nothing’ options, the complete presence or complete absence of a particular service feature.

Figure 9 below illustrates the three shortlisted options that were selected for detailed evaluation. The options are organized in three themes: (1) fastest bus alternative, (2) most legible, and (3) largest coverage. In all three options, the underlying assumption is that local NightBus is maintained and that late-night service would be operated with 30 min frequency, seven nights a week, to benefit the travel markets previously discussed.

Fastest Bus Alternative

- Operates along highways
- Operates a limited-stop service
- Skips low-activity bus stops and SkyTrain stations and only serves the top 5 stations per line
- Lines resemble portions of SkyTrain but cannot be marketed as SkyTrain replacement services
- Main benefit is fast service to top SkyTrain destinations

Five Highway Express Lines



Most Legible Bus Alternative

- Operates along urban arterials
- Serves all SkyTrain stations overnight
- Lines resemble SkyTrain alignment and SeaBus termini
- Buses do not necessarily enter bus loops, but stop near all stations
- Main benefit is legibility (could be presented as a SkyTrain and SeaBus “Shadow network” replacement)

Six "Station-to-Station" Lines



Largest Bus Coverage

- Includes above ‘station-to-station’ lines, plus
- All B-Lines from the 10-Year Vision operate 30-minute service overnight (B-Line routings to be confirmed)
- Provides the benefits of ‘station-to-station’ lines, plus
- Increased late-night coverage across the region (increased number of destinations)

24hr B-Lines plus 'Stn-to-Stn'



Figure 9: Shortlisted ‘bookend’ options selected for detailed evaluation

4.5 Evaluation of Bus Alternatives

After meeting with stakeholders, six objectives were selected for the evaluation of the bus alternatives. The objectives were transformed into the following evaluation accounts:

1. Maximize usefulness to customers
2. Maximize attractive features such as speed and legibility
3. Minimize financial impacts
4. Minimize community impacts and increase perceived security
5. Implement in a reasonable timeframe
6. Maximize ridership

Appendix F presents detailed costs, ridership projections, and other metrics used to evaluate the above accounts. A summary of findings and conclusions is presented below.

4.6 Bus Findings and Conclusions

The evaluation found that highway express services would provide the highest operating speeds but would be difficult for users to use and understand (low legibility).

The analysis also found that having a network of 24 B-Lines would increase coverage and yield higher ridership increases, but at a high operating cost, and would likely experience implementation challenges.

After considering several trade-offs, the ‘station-to-station’ concept was identified as the top performing alternative since it provides higher speeds than NightBus, is legible, and can be implemented in phases. The concept could be scaled up or down, and potentially include some B-Lines depending on ridership and funding availability.

No funding has been identified for the ‘station-to-station’ lines. TransLink is gauging interest from various stakeholders to find partnership opportunities and understand general support for this concept.

5.0 Pilot Project – NightBus Hub

Increasing accessibility, awareness and promotion of TransLink’s NightBus service was a major focus of TransLink’s discussion with stakeholders. In response, TransLink launched the NightBus Hub Pilot Program at Granville and Georgia in summer 2018. An important objective of the initiative was to increase awareness and understanding of TransLink’s extensive Night Bus network, while also creating a more visible and user-friendly hub to aid in moving more customers in an efficient and safe way.

Because of TransLink’s efforts, and a number of other factors such as the economy and service increases, year-over-year NightBus ridership is up 20% from 2017.

Due to the success of the pilot, the downtown NightBus Hub is now a permanent part of TransLink’s regular service. TransLink will be conducting additional marketing of NightBus this summer to expand awareness of the service amongst downtown entertainment patrons.

See Appendix G for additional detail, including routes, marketing and ridership.

6.0 Ridehailing Considerations

The introduction of Ride Hailing as a transportation option is also a critical element of serving the needs late at night. Uber has presented the below data showing ridership requests over a 24 hour period. The most requests are received between 10pm and 3am.

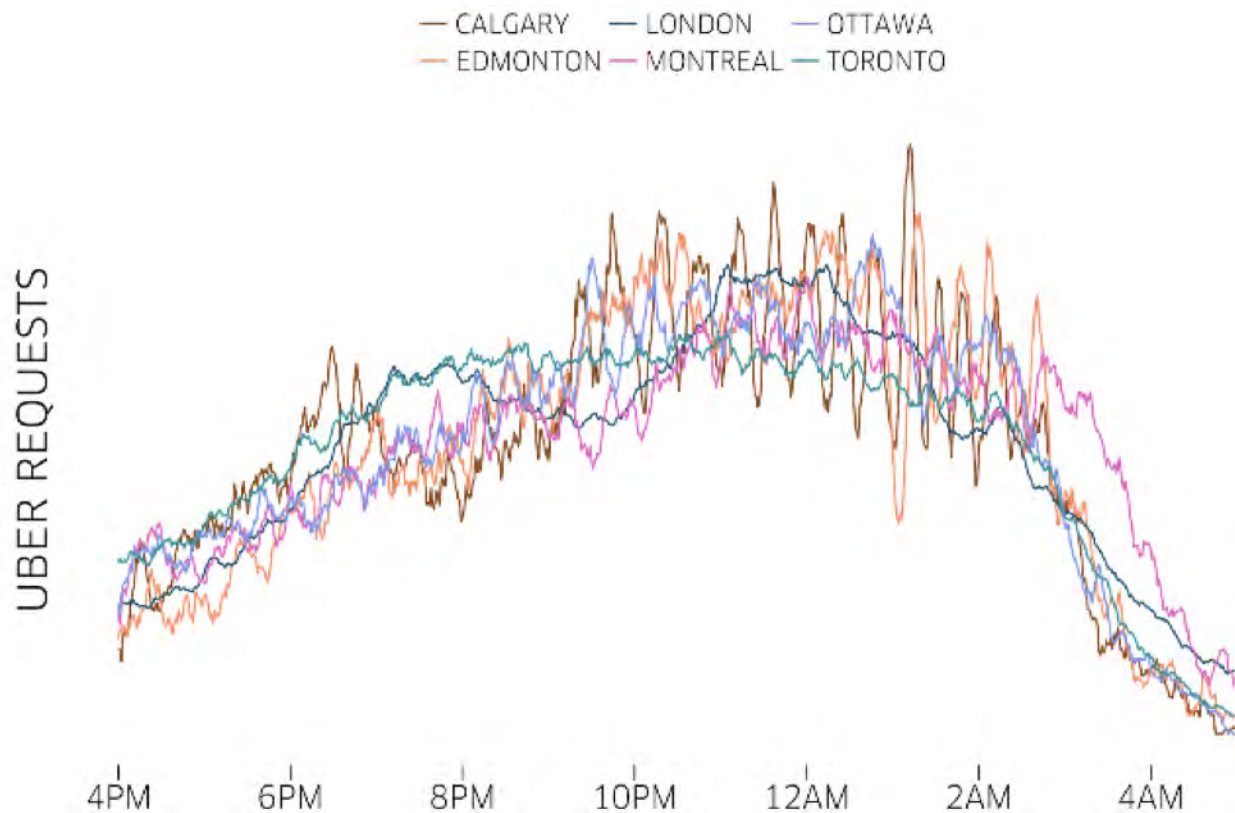


Figure 10: UBER Canadian City ridership by hour

In addition to ride hailing, TransLink is also exploring shared last mile transportation solutions (ie van pools) and has lobbied for additional Taxi licenses in the lower mainland. When considering the needs of the public all options should be considered as a whole, as a combination of solutions will better serve the diverse needs of our community.

7.0 Findings and Next Steps

The detailed and thorough technical investigation has led TransLink to the conclusion that at this time, the best way to service the need of passengers traveling out of the downtown core late at night is through expanded bus service. Primary drivers for this conclusion are noted below.

- Additional SkyTrain service on weekends affects weekday customers
- Late-night SkyTrain service would challenges ongoing maintenance and ‘state of good repair’
- Late-night SkyTrain service would require capital investments
- Limited ridership projections
- Cost effectiveness
- Bus service runs seven night a week
- Ease of implementation, bus service expansion can be actioned within 1-2 years, when funded

Throughout this detailed technical study, the feedback provided by stakeholders has been invaluable in TransLink’s planning and Feedback provided and great work done, TL will be pursuing the following three next steps

1. Maintain the NightBus hub as a permanent feature in service, as well as expand marketing and awareness campaigns through 2019
2. Implement the planned night bus expansion, which will see a 58% rise in bus service overnight from 2016-2020
3. Discuss “shadow bus” service with TransLink Board and policy makers, as part of conversations regarding next investment plan
4. Continue advocating for Ride Hailing and improved taxi service in the lower mainland
5. Continue to engage the Late Night Stakeholder committee on other future issues impacting the late-night economy

Updates on the Late Night Service will be available through regular TransLink Board update procedures.

Appendices

A – Expo & Millennium Line Phase 1

B – Canada Line Phase 1

C – Expo & Millennium Line Phase 2

D – Canada Line Phase 2

E – Transit Accessibility Isochrones

F – Evaluation of Bus Alternatives

G – Night Bus Hub



2019 Late Night Service Report

Appendix A

Expo & Millennium Line Phase 1



SkyTrain Extended Service Hours Feasibility Study

Stages 1 & 2

**SNC-Lavalin and Steer Davies Gleave
Draft Final Report**



7 April, 2018

NOTICE

This document contains the expression of the professional opinion of SNC-Lavalin Inc. (SNC-Lavalin) as to the matters set out herein, using its professional judgment and reasonable care. It is to be read in the context of the agreement dated March 12, 2018 (the "Agreement") between SNC-Lavalin and TransLink (the "Client"), and the methodology, procedures and techniques used, SNC-Lavalin's assumptions, and the circumstances and constraints under which its mandate was performed. This document is written solely for the purpose stated in the Agreement and for the sole and exclusive benefit of the Client, whose remedies are limited to those set out in the Agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

SNC-Lavalin has, in preparing any cost estimates, followed methodology and procedures, and exercised due care consistent with the intended level of accuracy, using its professional judgement and reasonable care, and is thus of the opinion that there is a high probability that actual costs will fall within the specified error margin. However, no warranty should be implied as to the accuracy of estimates. Unless expressly stated otherwise, assumptions, data and information supplied by, or gathered from other sources (including the Client, other consultants, testing laboratories and equipment suppliers, etc.) upon which SNC-Lavalin's opinion as set out herein is based has not been verified by SNC-Lavalin; SNC-Lavalin makes no representation as to its accuracy and disclaims all liability with respect thereto.

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1. Executive Summary

TransLink is in the process of developing their 10-year plan, which details the proposed service, network, infrastructure and station improvements proposed over the period. The plan is guided by TransLink's strategic plan and the Majors vision. A part of this update will consider future night service and any identified and planned improvements. Currently there are 10 NightBus routes that provide between 30 and 20-minute service frequencies. These include the N9 and N19, which run parallel to the Expo and Millennium Lines. The N9 and N19 provide overnight service along the SkyTrain lines during the systems none operating hours, but stop more frequently and have longer journey times. As these two routes effective replace SkyTrain service overnight, TransLink wishes to understand the feasibility of extending the operating hours of SkyTrain on a Friday and /or Saturday night. This also aligns with a public and stakeholder desire to see improved late-night transportation options.

TransLink engaged SNC-Lavalin and Steer Davies Gleave in March 2018, to conduct a study on the feasibility of extending SkyTrain service in the Metro Vancouver region on Friday and Saturday nights.

This study has looked at the late-night operating patterns for a selection of worldwide cities to provide a benchmarking review of their provision and comparison against Vancouver's service provision. A total of 17 cities were reviewed including:

- › Two Canadian cities (Toronto and Montreal)
- › Two West Coast cities in North America which have comparable population to Vancouver (Seattle and Portland)
- › Six Asian "World-Class" cities that have extensive rail network coverage (Shanghai, Tokyo, Seoul, Hong Kong, Singapore and Kuala Lumpur)
- › Seven cities which previously or currently operate night-time rail services (Berlin, Boston, Chicago, London, New York, Philadelphia, and Sydney).

In terms of night-time transit provisions, Vancouver provides a frequency of services that is comparable to its four "Peer" cities in North America that provide overnight service (Toronto, Montreal, Seattle and Portland). None of the "Peer" cities operate a late-night rail service and Portland does provide any overnight service. The Vancouver SkyTrain and the Kuala Lumpur LRT are the only two unattended systems that are included in the benchmarking review. Both occasionally operate an extended night-time service to support special events.

A diagram illustrating the current operating hours of Vancouver's SkyTrain system as compared to that of the cities reviewed is provided below:

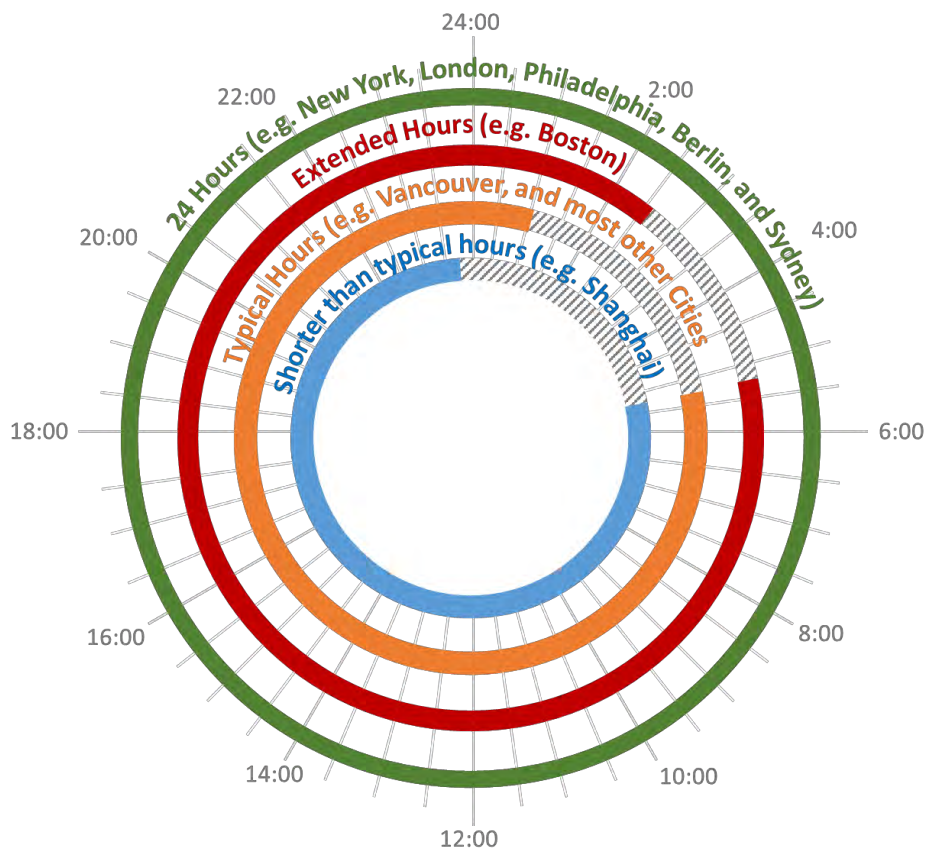


Figure 1: Operating Hours of Vancouver's SkyTrain as compared to Other Cities

Note: Cities are grouped together for presentation convenience. There are various distinctions at detailed levels; for example, New York operates as 24/7 whereas London operates as 24/2 but are both categorized in the 24 hours group.

The figure shows that the SkyTrain system provides comparable service span compared to peer cities, with only larger world cities providing 24-hour operation on Fridays and Saturdays or in the case of New York every day of the week. The cities that operate extended hours have more extensive rail based networks compared to SkyTrain, and operate extended service hours on only some of these lines.

This Study has looked further into how transit agencies of other cities have successfully introduced late-night service, and how TransLink could make the change without impacting crucial maintenance operations. The three selected transit agencies are:

- › Transport for London (London);
- › Massachusetts Bay Transportation Authority (Boston); and
- › South Eastern Pennsylvania Transportation Authority (Philadelphia).

One of the key lessons learned from these other transit agencies is that night-time passenger demand is a key factor for a city to decide whether a 24-hour transit service is required or not.

Transit agencies had more success implementing a 24-hour service if a night-time economy already existed, rather than using the service to kick-start a night-time economy. London Underground's Night Tube frequency of six trains per hour is the highest anywhere in the world.

Boston has undertaken a process of implementation, then removal of night-time rail operations, due to low ridership (2,460 boardings/weekend) and budget constraints. The Massachusetts Bay Transportation Authority in Boston is considering vendor-provided late night shuttle services between 01:00-04:15 in 2018.

Another key lesson learned from other transit agencies was that the decision to operate night-time rail services can be based both on the level of demand and/or more political or social desires to increase service provision. Political support for extended service hours was also considered important. Feedback from London Underground has suggested that a robust business case is required to implement 24/2 services. In Boston, after steady decline in night-time ridership and severe budgetary pressures, the operator had difficulties cancelling the service, due to it being highly valued by the public. In Philadelphia, SEPTA initially introduced late-night service only on a portion of the network and on a trial basis. However, stakeholder response soon led to it being extended to run on a permanent basis.

Project team has also conducted in-person interviews with key staff from TransLink, BCRTC and Transit Police. Informal operations-specific reviews had already been undertaken internally since 2011 after the success during the Winter Olympic Games.

A number of challenges and constraints have been identified in the SkyTrain system today that will need to be addressed in order to operate extended service hours. The majority of which are similar to those other cities have address to implement extended hours of operation. Some of these challenges could be overcome through changes in the approach to systems maintenance, maintenance procedures, track access procedures, and asset upgrades some of which are already being scheduled. An asset management system is currently being developed that could further improve the efficiency and coordination of maintenance and capital project works, which would help support extended hours of service.

Expanding the workforce with competent staff and proper renegotiation of the collective agreement is a key enabler that permits safe and reliable services during the extended service hours.

Through the adaption and the development of revised maintenance processes, procedures and scheduling, and greater coordination with capital projects scheduling SkyTrain could extended service hours.

In support of this initial high level evaluation four options have been considered in this study as follows:

- › Option 1 - Extended Service Hours, Expo & Millennium Lines
- › Option 2 - Extended Service Hours, Expo Line Only
- › Option 3 - 24-Hour Service, Expo & Millennium Lines
- › Option 4 - 24-Hour Service, Expo Line Only.

Other sub-options or permutations were also identified from these base options. A high-level estimate of the potential increased financial costs in implementing these four options are summarised below:

Table 1: Financial cost summary

 Financial	Option 1 Extended Hours Expo & Millennium	Option 2 Extended Hours Expo Only	Option 3 24-Hour Service Expo & Millennium	Option 4 24-Hour Service Expo Only
Operational and Maintenance Cost	\$2.3 M per year	\$1.4 M per year	\$6.3 M per year	\$3.9 M per year
Incremental Maintenance Cost	\$2.4 M per year	\$2.4 M per year	\$4.8 M per year	\$4.8 M per year
Capital Costs	\$5.0 – 7.5 M	\$5.5 – 8.0 M	\$5.0 – 7.5 M	\$5.5 – 8.0 M
Policing Costs	\$3.4 M per year	\$3.4 M per year	\$3.4 M per year	\$3.4 M per year

TransLink is undertaking System-Wide Impacts and External Stakeholder Reviews concurrently with this study. Findings from the System-Wide Impacts and External Stakeholder Reviews should be fed into the evaluation process of this study.

Project team has identified the following actionable items for TransLink's consideration as part of the next steps:

- › TransLink to host stakeholder sessions to communicate findings of this report and verify they are aligned with stakeholder and community needs.
- › TransLink to provide guidance and direction on:
 - Which of the four presented service hour extension options (and/or any sub-options) to proceed into detailed analysis, and
 - Which of the presented mitigation measures to be investigated.
- › Once a preferred service hour extension plan has been identified, the project team shall proceed with a series of detailed analyses to identify:
 - How the railway will be operated and maintained,
 - How the personnel requirements will change,
 - How safety and security will be maintained and enhanced,
 - How infrastructure and equipment requirements will change,
 - How other connected transit modes will need to change to render maximum benefit to users,
 - How the environment will be impacted, and
 - How extending the service hours will affect the energy consumption of the railway.
- › The Project team shall develop more detailed costs and revenues of operating extended service hours.

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2. Introduction

2.1 Study Objectives

In March 2018, TransLink engaged SNC-Lavalin and Steer Davies Gleave to conduct a feasibility study on the extension of operating hours for the Vancouver SkyTrain system.

The purpose of this feasibility study is to estimate the potential impacts and required system changes if operating hours of Expo/Millennium Line were to extend beyond the current schedule on Friday and Saturday nights.

Note: The term “SkyTrain” in this report refers to Expo Line and Millennium Line including the recent Evergreen Extension. SkyTrain currently operates beyond midnight on Fridays and Saturdays. The term “*Friday nights*” where the extended service hours of concern in this study actually refers to the time period between late night on Fridays and early morning on Saturdays; and the term “*Saturday nights*” refers to the period between late night on Saturdays and early morning on Sundays. For details on the current SkyTrain operating hours, please refer to Section 3.2.

2.2 Study Stages

This feasibility study is conducted according to the following four stages:

Stage 1 - Environmental Scan

Compare and contrast BCRTC (operator of SkyTrain), against other transit agencies that have implemented service hour extensions, and to understand how these were planned and executed by those agencies. To achieve this, a series of background reviews will be required, including of the current service operations of SkyTrain, how other transit agencies have evolved into their current operational model, industry best practices, methodology, Reliability Availability Maintainability and Safety (RAMS) including safety approval/certification implications, and an evaluation framework for extending service hours.

Stage 2 - Options and Trade-offs

Contemplating any change to service hours needs to involve a review of the implications and the pros and cons associated with the identified options. This will require thorough impact analyses that assess the cash flow considerations of each option, and the options to achieve the maintenance requirements.

Stage 3 - Detailed Operational Impact Plan

Once the “*what*” has been determined in the form of a preferred service hour extension plan, the next phase is the “*how*”. This will require a series of detailed analyses to identify: *how* the railway will be operated; *how* the railway will be maintained; *how* the personnel requirements will change; *how* safety and security will be maintained and enhanced; *how* the infrastructure and equipment requirements will change; *how* other connected transit modes will need to change to render the maximum benefit to users; *how* the environment will be impacted; and, *how* extending service hours will affect energy consumption of the railway.

Stage 4 - Financing/Costing

A change in service hours will bring about positives and negatives in relation to costs and revenues. To assess these impacts, a life cycle cost analysis of operating extended service hours, including relevant sensitivity analyses, and any ongoing/future planned projects will be required.

TransLink is also undertaking the System-Wide Impacts and External Stakeholder Reviews concurrently with this study. Findings from the System-Wide Impacts and External Stakeholder Reviews will be fed into the evaluation process of this study. Currently, TransLink has instructed the Project team to proceed with Stages 1 and 2 of this study. Stages 3 and 4 will be conducted once TransLink's senior management has reviewed the findings from Stages 1 and 2.

2.3 Purpose of this Report

This report summarizes the findings and analyses from Stages 1 and 2 and recommends the next steps for TransLink's consideration. Upon reviewing the findings and analyses from Stages 1 and 2, TransLink will decide whether they would still want to proceed with Stages 3 and 4.

The following tasks were conducted as part of Stages 1 and 2:

- › Request and assemble data from TransLink, BCRTC, and Transit Police that are relevant to this study;
- › Perform a thorough review of the data received from TransLink, BCRTC, and Transit Police to date;
- › Perform a thorough review of the current service operations and maintenance requirements of the SkyTrain system;
- › Conduct in-person interviews with key staff at TransLink, BCRTC, and Transit Police to understand the envisaged challenges and issues if extended service hours for the SkyTrain are to be implemented;
- › Perform a thorough review of current night-time transit provisions of other cities in North America and Asia;
- › Identify cities with current or previous night-time passenger rail service and perform an in-depth review of lessons learned;
- › Provide commentaries on SkyTrain's relative position to other transit agencies worldwide and assess the readiness of BCRTC in operating extended SkyTrain service hours;
- › Develop a list of options for TransLink's consideration in operating extended service hours for SkyTrain;
- › Evaluate pros and cons of each option and identify associated trade-offs; and
- › Recommend next steps for TransLink's considerations to proceed into a more detailed business case study (Stages 3 and 4).

2.4 Exclusions

Detailed ridership forecasts for late night demand have been excluded from this study. Instead, a high-level ridership potential is presented as a range between current NightBus demand and potential SkyTrain demand, should the SkyTrain operating hours be extended on Friday and Saturday nights.

This feasibility study reviews the implications of carrying out such a modification to SkyTrain operations, with respect to impacts on staffing, maintenance, operations, and potential costs. Complete implementation of such a change in operation would require a more detailed assessment in some areas but, in order to proceed to such a level of effort, an understanding of the impacts and magnitude of costs is first required.

This study did not look into running a 24/7 service for the SkyTrain as it means that a complete change of the maintenance model would be required which is outside the scope of this study.

Stages 1 and 2 of this study leverage lessons learned from other global transit agencies. The study will determine feasibility of the options and establish what elements may need to be implemented if TransLink/BCRTC considers the extension of SkyTrain operation hours as both practicable and desirable.

This study assumes the SeaBus, West Coast Express, and Night Bus service will operate as of today, i.e. no extended service hours, operations hours, nor cancellation of the SeaBus, West Coast Express, and Night Bus services, will be assumed in this study. There are also other external factors, such as the operation of Uber service or other alternatives which may affect the outcome of this study but are uncertain at the time when this study was conducted, which are not considered.

During the execution phase of this project, TransLink issued an additional RFP to conduct a study that evaluates potential sites to accommodate expanded vehicle storage and maintenance facilities for the future fleet of the Expo and Millennium Lines in the medium and long term. The future availability and locations of these vehicle storage and maintenance facilities may also affect the outcome of this study.

3. Current SkyTrain Operation and Maintenance

This section provides an overview of the operation and maintenance of the SkyTrain system. This provides the context against which extended service hours options are to be considered.

3.1 Overview of the SkyTrain System in Vancouver

Vancouver's SkyTrain system is one of the world's oldest and largest fully-automated rapid transit systems. Currently, the system has the Expo Line and Millennium Line (including the recent Evergreen Extension), spanning across multiple municipalities in Metro Vancouver. Table 1 below summarizes the operational characteristics of the SkyTrain network. The current SkyTrain network is also illustrated in Figure 2.

Table 2: Operational Characteristics of the Current SkyTrain Network

Line	Terminal Station		Number of Stations ¹	2017 Annual Boarding (million)	Approximate Travel Time (min)
Expo	Waterfront	King George	20	105	39
		Production Way-University	20		40
Millennium	VCC-Clark	Lafarge Lake - Douglas	17		34

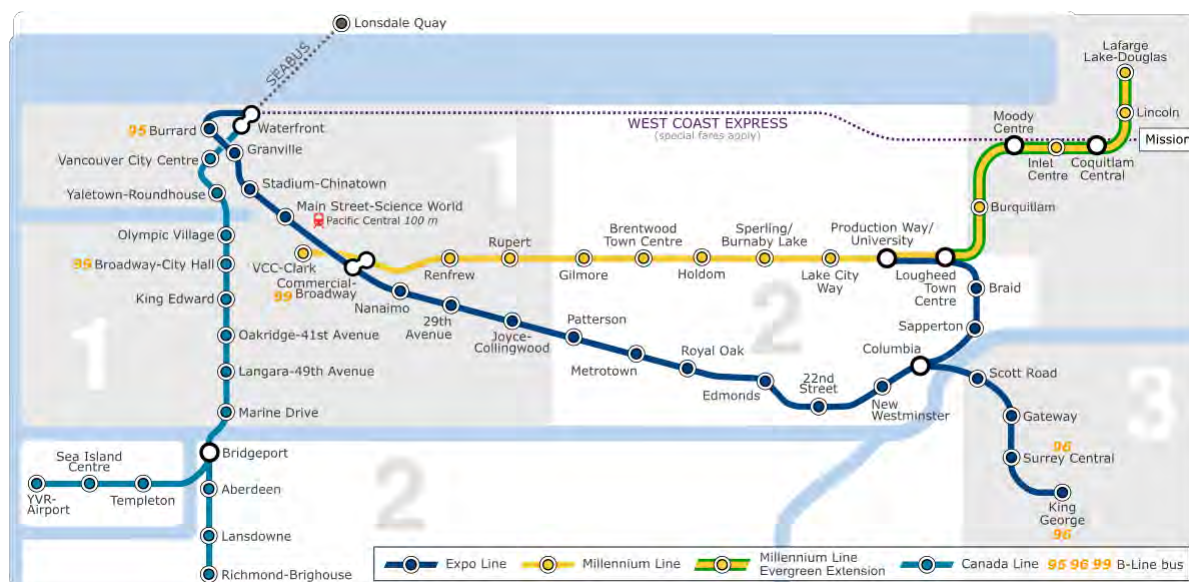


Figure 2: Existing SkyTrain Network in Vancouver

¹ TransLink, 2017 – A Record Year for Transit Ridership in Metro Vancouver, <http://buzzer.TransLink.ca/2018/02/2017-a-record-year-for-transit-ridership-in-metro-vancouver/>

3.2 Revenue Service

The operating pattern of revenue service varies depending on the day of the week. Generally, the period Monday through Friday has a longer revenue service window compared to the weekend. The current revenue service window for the SkyTrain lines are summarized in the tables below.

Table 3: First and Last Daily Revenue Train Services on Expo Line

Expo Line							
Direction of Travel	Branch	First Train			Last Train		
		Mon-Fri	Sat.	Sun.	Mon-Fri	Sat.	Sun.
Towards Waterfront	King George	5:08	6:08	7:08	12:38 1:28*		11:38 12:28*
	Production Way – University	5:10	6:11	7:11	12:30 1:26*		11:31 12:19*
Leaves Waterfront	King George	5:32 5:22**	6:48 6:16**	7:48 7:16**	1:16		12:16
	Production Way – University	5:37 5:13**	6:44 6:20**	7:44 7:20**	12:33 1:11***		11:33 12:11***

* Extra late trips to New Westminster Station only

** Extra early trips from Edmonds Station

*** From Waterfront to Lougheed Town Centre Station only

Table 4: First and Last Daily Revenue Train Services on Millennium Line

Millennium Line						
Direction of Travel	First Train			Last Train		
	Mon-Fri	Sat.	Sun.	Mon-Fri	Sat.	Sun.
Towards VCC-Clark	5:04 5:13*	6:05 6:20*	6:56 7:12*	12:58 1:39**		11:58 12:39**
	5:30 5:11***	6:30 6:08**	7:30 7:08**	1:21 1:29****		12:22 12:29****

* From Lougheed Town Centre Station to VCC-Clark

** From Lafarge Lake-Douglas to Lougheed Town Centre Station only

*** From Lougheed Town Centre Station to Lafarge Lake-Douglas

**** From VCC-Clark to Lougheed Town Centre only

3.3 Maintenance Window

Expo Line and Millennium Line have specific time windows for night-time guideway maintenance, depending on the geographical location. Each line has multiple area-defining boundaries set up by TransLink. The section enclosed by two boundaries can be considered one maintenance area, with each maintenance area having its unique maintenance entry and exit time. The area-defining boundaries are illustrated in the Figure below.



Figure 3: Area-defining Boundaries for Expo/Millennium Line Guideway Access

The maintenance entry and exit times by the different segments of the Expo and Millennium guideways are summarized in the Figures 3-6 pp 13-14). The current maintenance windows on “Friday nights” and “Saturday nights” are shaded in the Figures below.

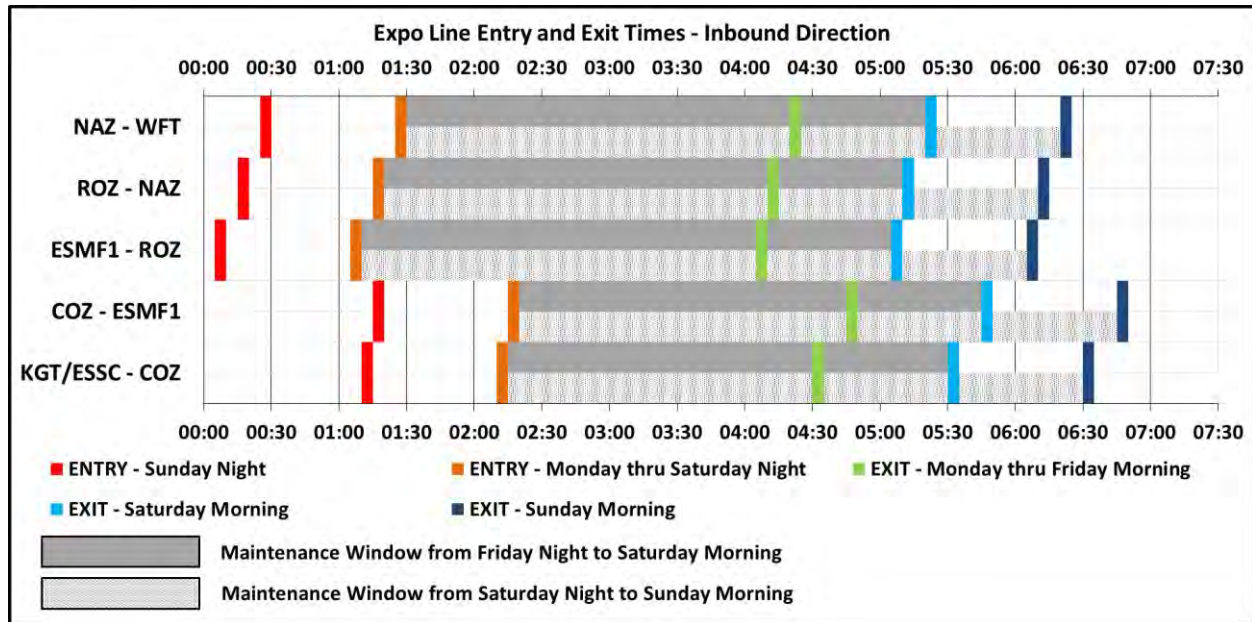


Figure 4: Expo Line Guideway Entry and Exit Times (Inbound)

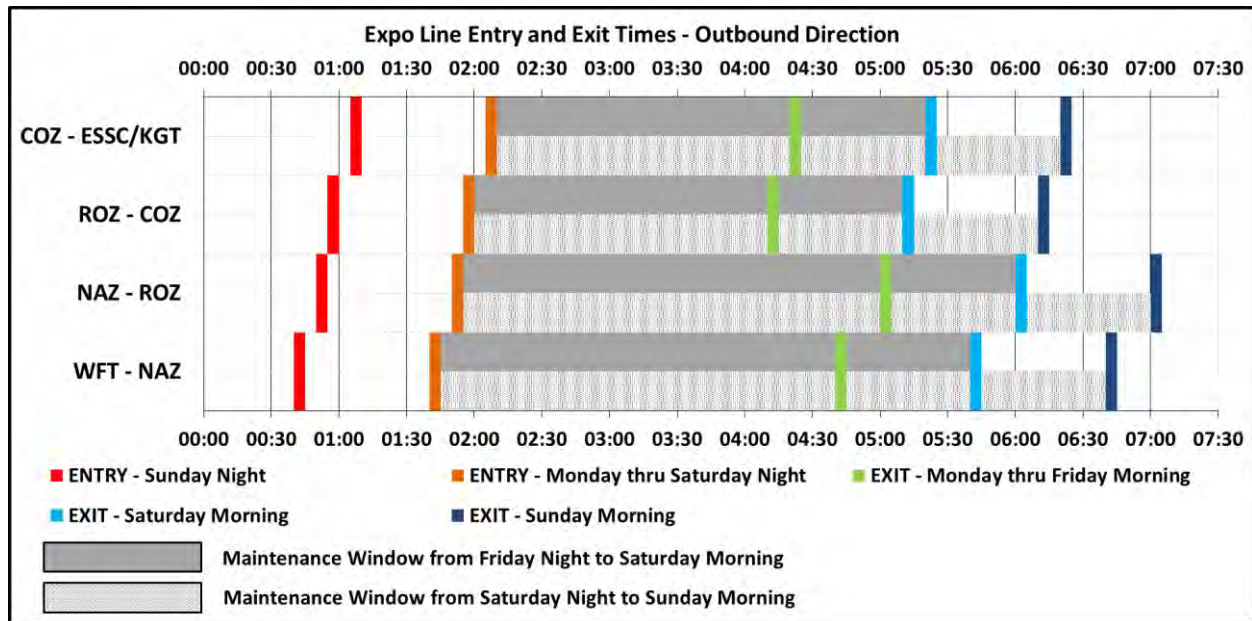


Figure 5: Expo Line Guideway Entry and Exit Times (Outbound)

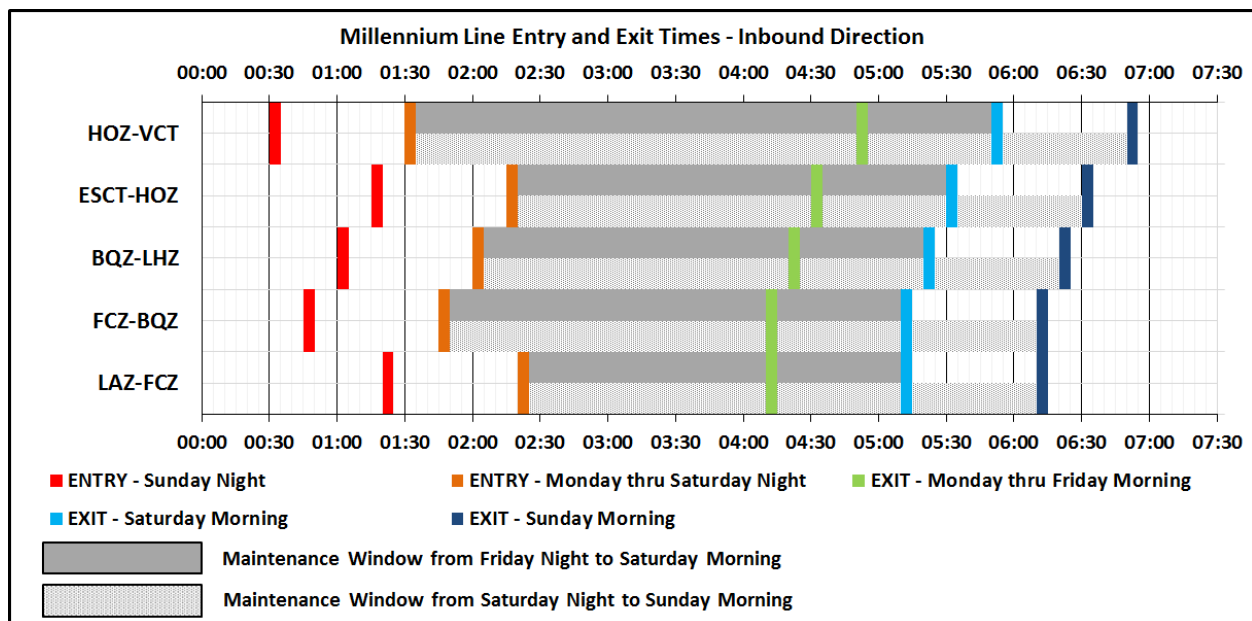


Figure 6: Millennium Line Guideway Entry and Exit Times (Inbound)

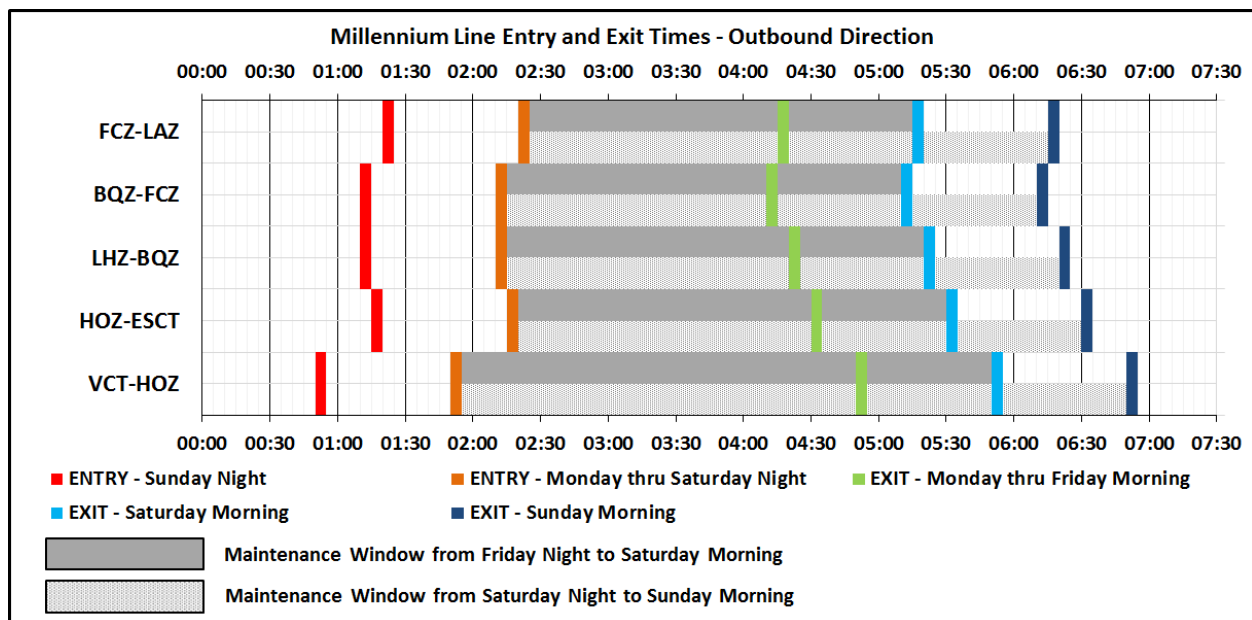


Figure 7: Millennium Line Guideway Entry and Exit Times (Outbound)

The available maintenance hours by each segment and by each day of the week are further summarised in Table 4 & Table 6 (pp. 19-20).

Table 5: Available Maintenance Hours by Segment and (Expo Line)

Segment	Mon. Night	Tues. Night	Wed. Night	Thurs. Night	Fri. Night	Sat. Night	Sun. Night	Weekly Total
WAF-NAZ	3:00	3:00	3:00	3:00	4:00	5:00	4:00	25:00
NAZ-ROZ	3:10	3:10	3:10	3:10	4:10	5:10	4:10	26:10
ROZ-COZ	2:15	2:15	2:15	2:15	3:15	4:15	3:15	19:45
COZ- KGT/ESS C	2:15	2:15	2:15	2:15	3:15	4:15	3:15	19:45
KGT/ESS C-COZ	2:20	2:20	2:20	2:20	3:20	4:20	3:20	20:20
COZ- ESMF1	2:30	2:30	2:30	2:30	3:30	4:30	3:30	21:30
ESMF1- ROZ	3:00	3:00	3:00	3:00	4:00	5:00	4:00	25:00
ROZ-NAZ	2:55	2:55	2:55	2:55	3:55	4:55	3:55	24:25
NAZ-WFT	2:55	2:55	2:55	2:55	3:55	4:55	3:55	24:25

Table 6: Available Maintenance Hours by Segment and (Millennium Line)

Segment	Mon. Night	Tues. Night	Wed. Night	Thurs. Night	Fri. Night	Sat. Night	Sun. Night	Weekly Total
VCT-HOZ	3:00	3:00	3:00	3:00	4:00	5:00	4:00	25:00
HOZ-ESCT	2:15	2:15	2:15	2:15	3:15	4:15	3:15	19:45
LHZ-BQZ	2:10	2:10	2:10	2:10	3:10	4:10	3:10	19:10
BQZ-FCZ	2:00	2:00	2:00	2:00	3:00	4:00	3:00	18:00
FCZ-LAZ	1:55	1:55	1:55	1:55	2:55	3:55	2:55	17:25
LAZ-FCZ	1:50	1:50	1:50	1:50	2:50	3:50	2:50	16:50
FCZ-BQZ	2:25	2:25	2:25	2:25	3:25	4:25	3:25	20:55
BQZ-LHZ	2:20	2:20	2:20	2:20	3:20	4:20	3:20	20:20
ESCT-HOZ	2:15	2:15	2:15	2:15	3:15	4:15	3:15	19:45
HOZ-VCT	3:20	3:20	3:20	3:20	4:20	5:20	4:20	27:20

3.4 Night-time Service

Currently, the SkyTrain system does not operate continuously overnight. For convenience, the gap in time between revenue services of two consecutive days is referred to as “night-time” in this report. During the night-time period, in the absence of SkyTrain, TransLink currently operates 10 NightBus routes which cover a wider network than the SkyTrain lines. The 10 NightBus routes connect downtown Vancouver with a selection of destinations. The routes are:

- › N8 – Downtown / Fraser
- › N9 – Downtown / Coquitlam Central Station
- › N10 – Downtown / Richmond
- › N15 – Downtown / Cambie
- › N17 – Downtown / UBC
- › N19 – Downtown / Surrey Central Station
- › N20 – Downtown / Victoria
- › N22 – Downtown / Dunbar
- › N24 – Downtown / Lynn Valley
- › N35 – Downtown / SFU.

The NightBus routes are shown in more geographical details in the Figure below.

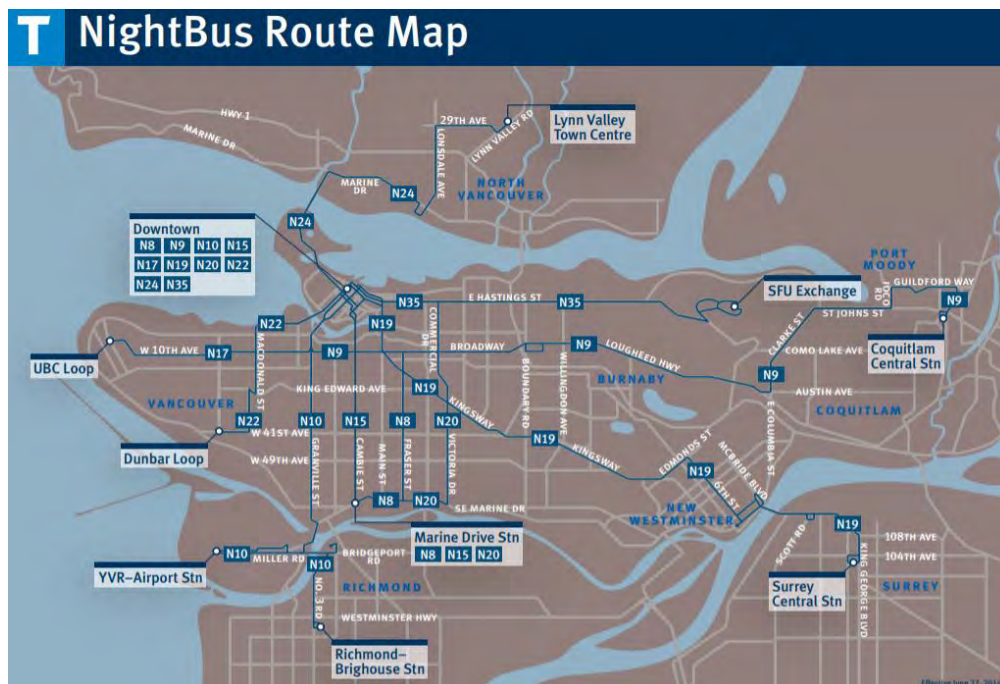


Figure 8: NightBus Route Map²

² TransLink, NightBus Route Map, http://infomaps.TransLink.ca/System_Maps/NightBus.pdf

Currently, NightBus operates 30 minutes or better, seven days a week. Some services operate from 1 a.m. to 3 a.m. and others from 1 a.m. to 5 a.m.

The routes of N19 and N9 respectively mirror significant portions of the Expo Line and Millennium Line. Therefore, these two NightBus routes are the primary focus where the options for the SkyTrain extended service hours operations will be evaluated against in this study. Their operations could be highly impacted by potential night-time SkyTrain services. If the SkyTrain system is to operate overnight, one logical assumption is that these two routes could potentially be re-purposed to avoid overlapping resources. This strategy of re-purposing an existing Bus Rapid Transit route with the introduction of SkyTrain service has been used in the past by TransLink, such as the 99B Line (UBC to Lougheed Station), 98B Line, and 97B Line.

Table 6 below details the provision for the N9 and N19 routes.

Table 7: Existing Service Headways and Journey Times of Routes N9 and N19

Service	Direction of Travel	Headway	Travel Time
N9 Downtown-Coquitlam Central	To Coquitlam	20 to 30 minutes	1 hour 20 mins.
	From Coquitlam	30 minutes To Lougheed only at 3:30, 4:05 and 4:35	1 hour 12 mins.
N19 Downtown-Surrey Central	To Surrey	20 to 30 minutes	1 hour 22 mins.
	From Surrey	Services at 12:48, 1:18 and 1:48 only	1 hour 20 mins.

Note that between two regular bus stops and between the hours of 9 p.m. and 5 a.m. passengers can request a stop. The bus driver will let the passenger off if he or she believes it is safe to do so. Note that passengers cannot request a stop along an express or limited-stop portion of a route.

3.5 Overnight Vehicle Stabling

The practice of stabling trains on the mainline is a useful strategy to ease yard congestion and provide more efficient morning service ramp up. It becomes particularly useful in the context of an ever-growing fleet. Therefore, it is important to understand the existing train storage and launch strategies when considering operation with extended service hours. Please refer to 6.1.3 Train Stabling for more information.

In the current conditions, multiple trains are being stabled overnight at multiple locations throughout the lines. Their stabling locations are shown in Figure 8 below.

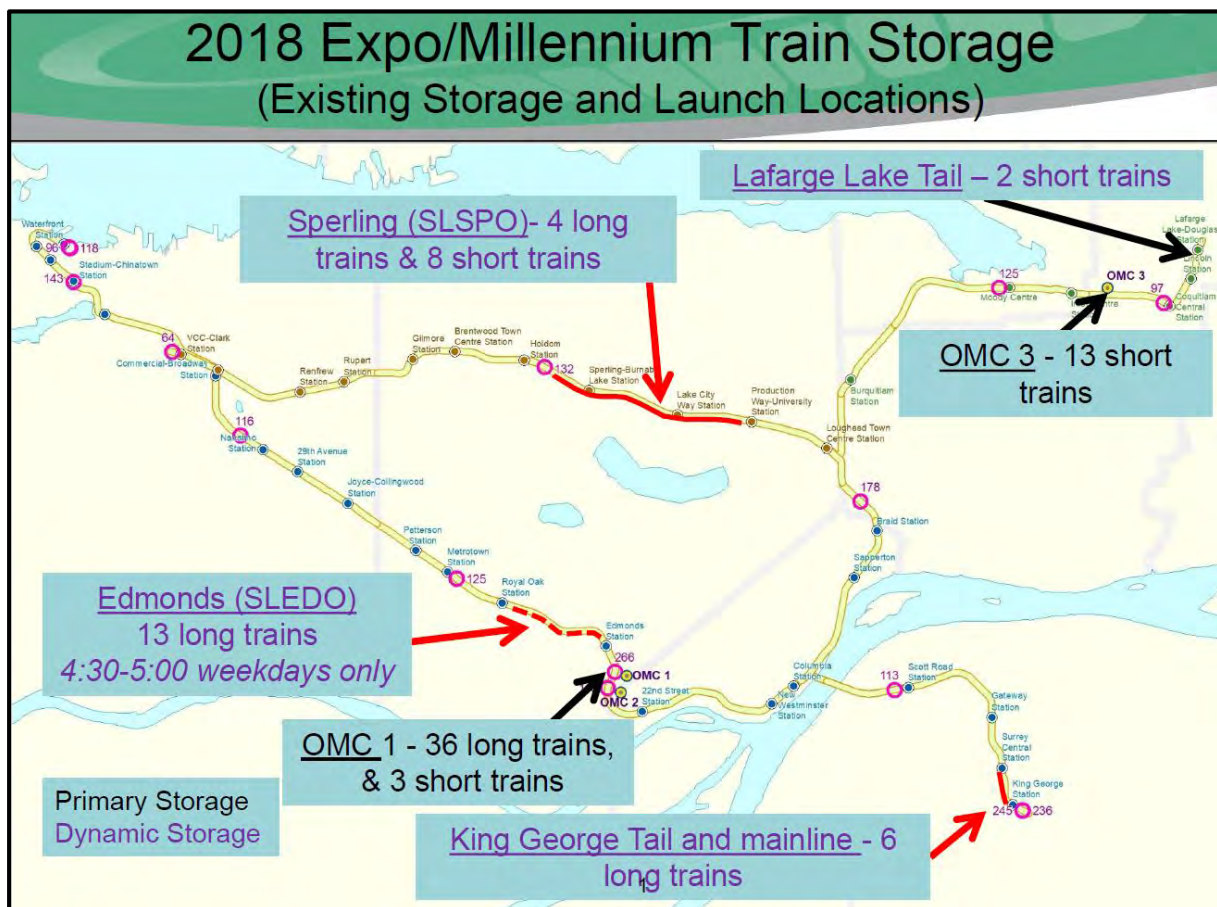


Figure 9: Expo/Millennium Line Existing Over-night Storage and Morning Launch Locations

3.6 Current Ridership

3.6.1 Expo and Millennium Lines

TransLink provided SkyTrain boardings and alightings for the February 2017 to March 2018 period.

Figures below show the system-wide daily profile of boardings and alightings by day of the week.

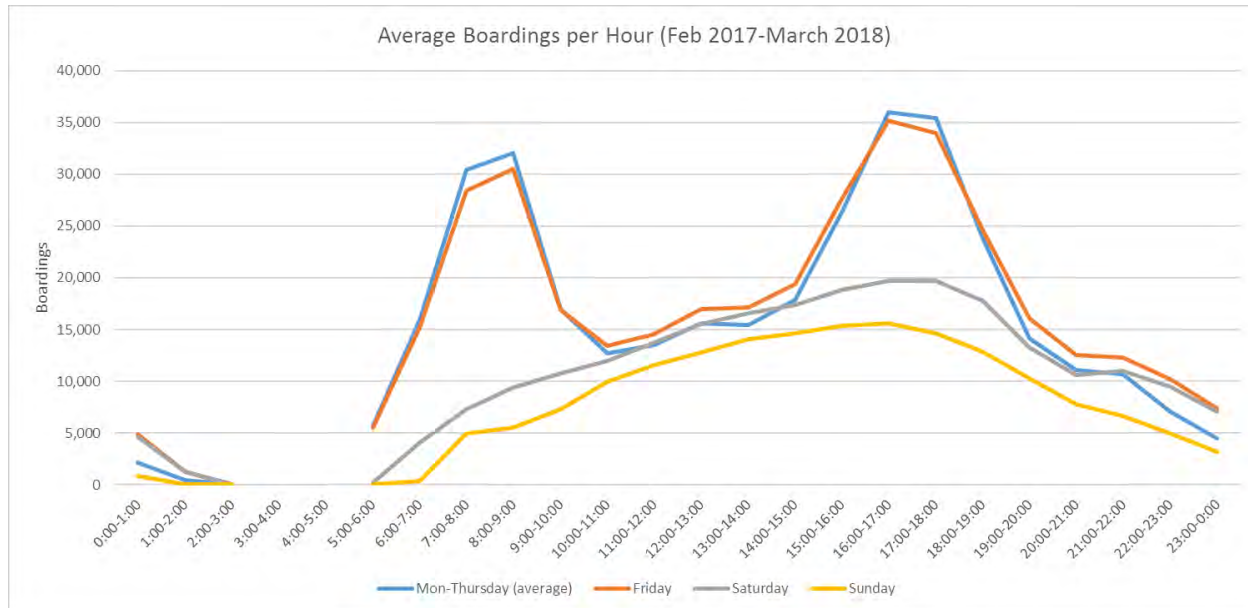


Figure 10: Average SkyTrain Boardings by Day of the Week

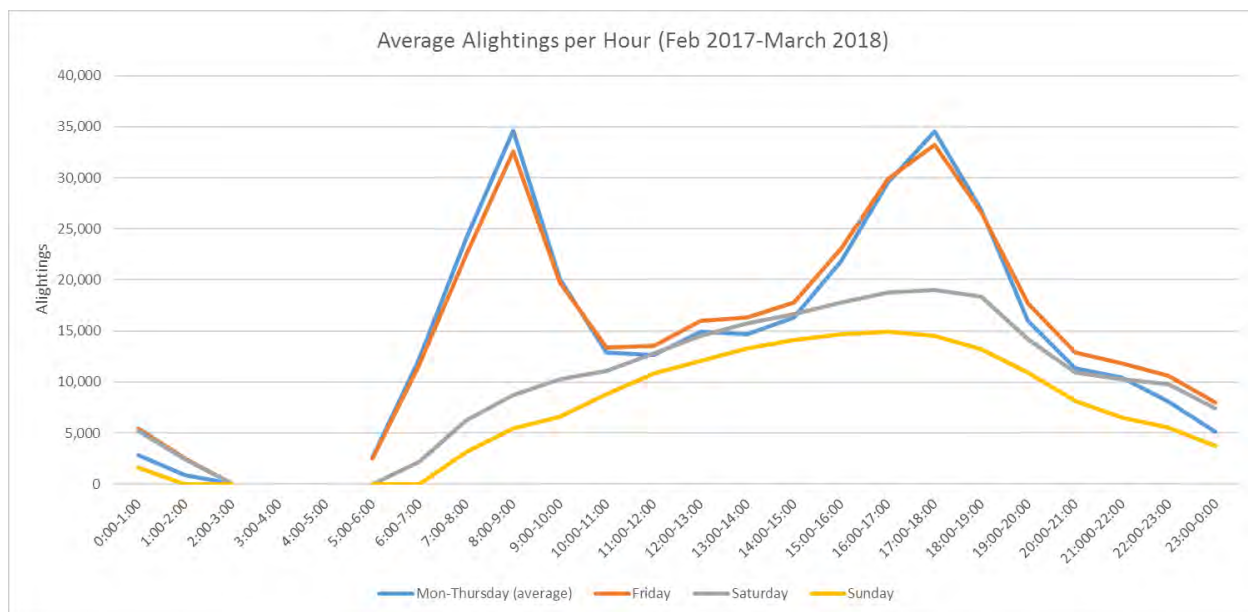


Figure 11: Average SkyTrain Alightings by Day of the Week

The figures show the following:

- › Low demand in some periods as limited/no services operating e.g. between 5:00am-6:00am on Saturdays and Sundays, between 1:00am-2:00am on Monday.
- › Clear AM and PM peaks for weekdays (Monday-Thursday and Friday)
- › The above charts confirm that Late Night Demand is higher during Friday and Saturday Nights, particularly after 10 p.m.
- › Millennium Line represents around 25% of total Expo and Millennium boardings and alightings
- › Demand on all transit modes is low late at night (defined as passenger taps between midnight and 4 a.m.):
 - Late night demand represents 0.7% of daily ridership Sunday to Thursdays, and
 - Demand is twice as high on Friday and Saturday Nights representing 1.4% of daily ridership

Expo Line accounts for over 75% of total late-night SkyTrain boardings. A review of boardings in the Waterfront to Metrotown stations during late nights on Fridays and Saturdays as well as during early mornings on Saturdays and Sundays are shown in the figures below. Demand levels on “Friday nights” and “Saturday nights” are similar and the majority of the boardings are split across the four downtown stations (Waterfront, Burrard, Granville, and Stadium).

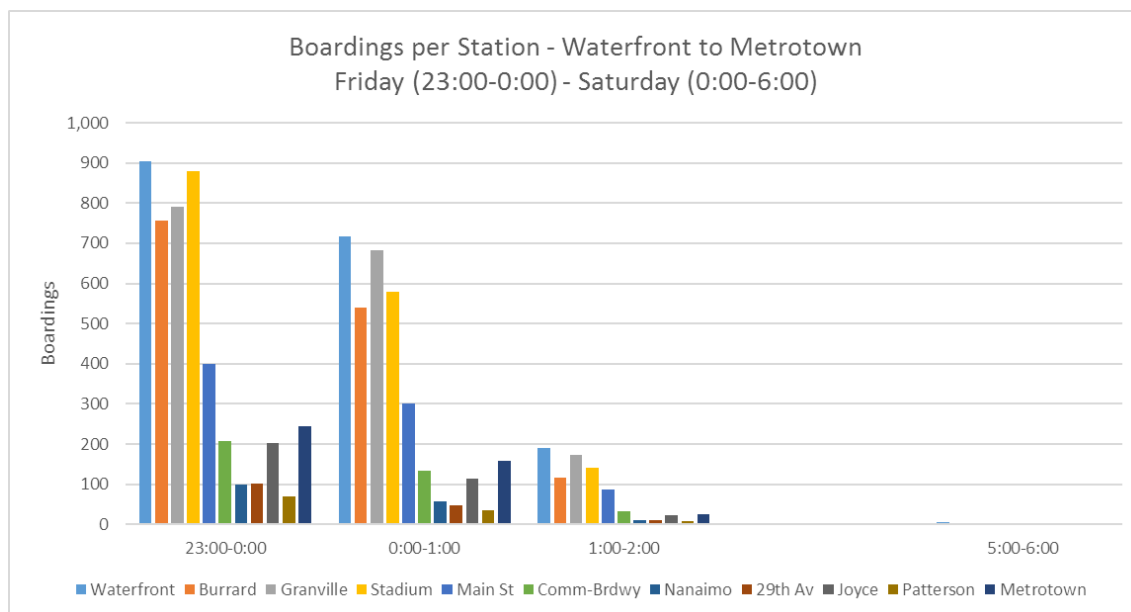


Figure 12: Waterfront to Metrotown Station Boardings by Time of Day - Friday Night and Saturday Morning

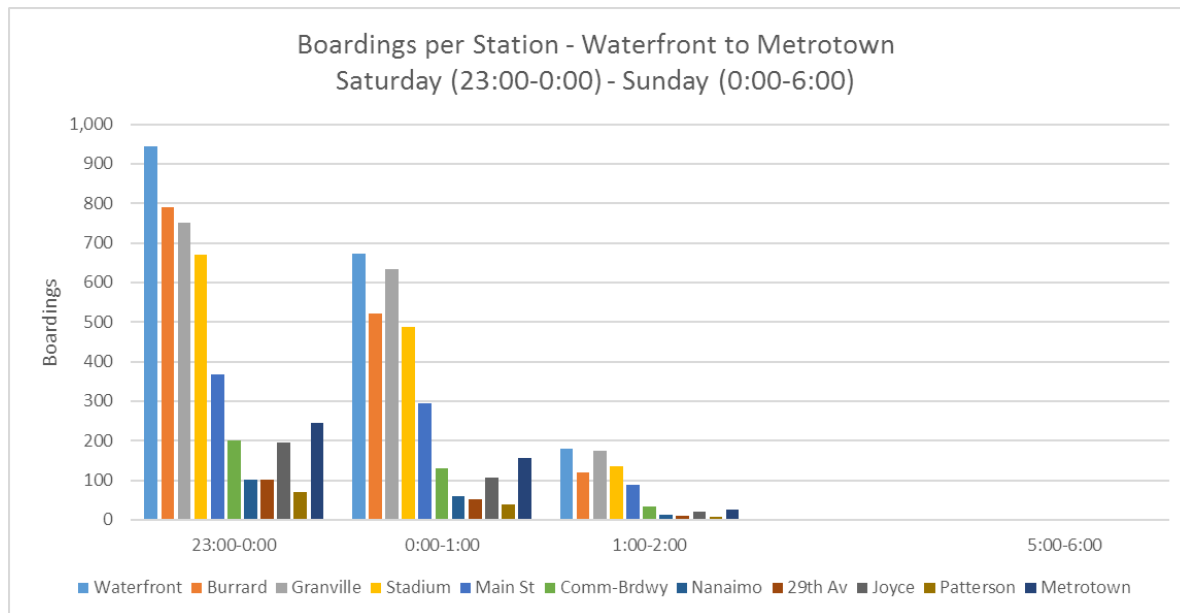


Figure 13: Waterfront to Metrotown Station Boardings by Time of Day - Saturday Night and Sunday Morning

The figures show a progressive reduction in demand after 23:00 and large reductions after 1:00 a.m. as some stations along the line are closing between 1:00 a.m.-2:00 a.m. Not all stations are accessible after 1:00 a.m.

A review of alightings in the Metrotown to Surrey and Lougheed “spur” (Braid and Sapperton stations) on Friday and Saturday nights is shown in figures below

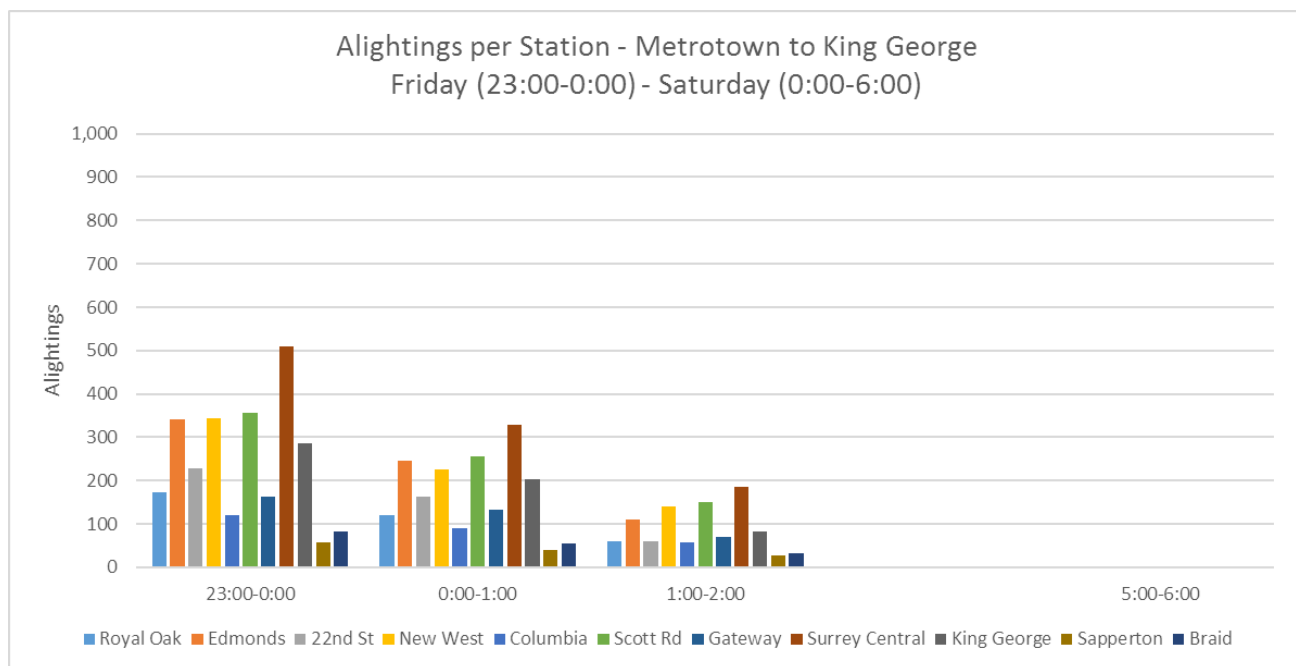


Figure 14: Metrotown to King George Station Alightings by Time of Day - Friday Night and Saturday Morning

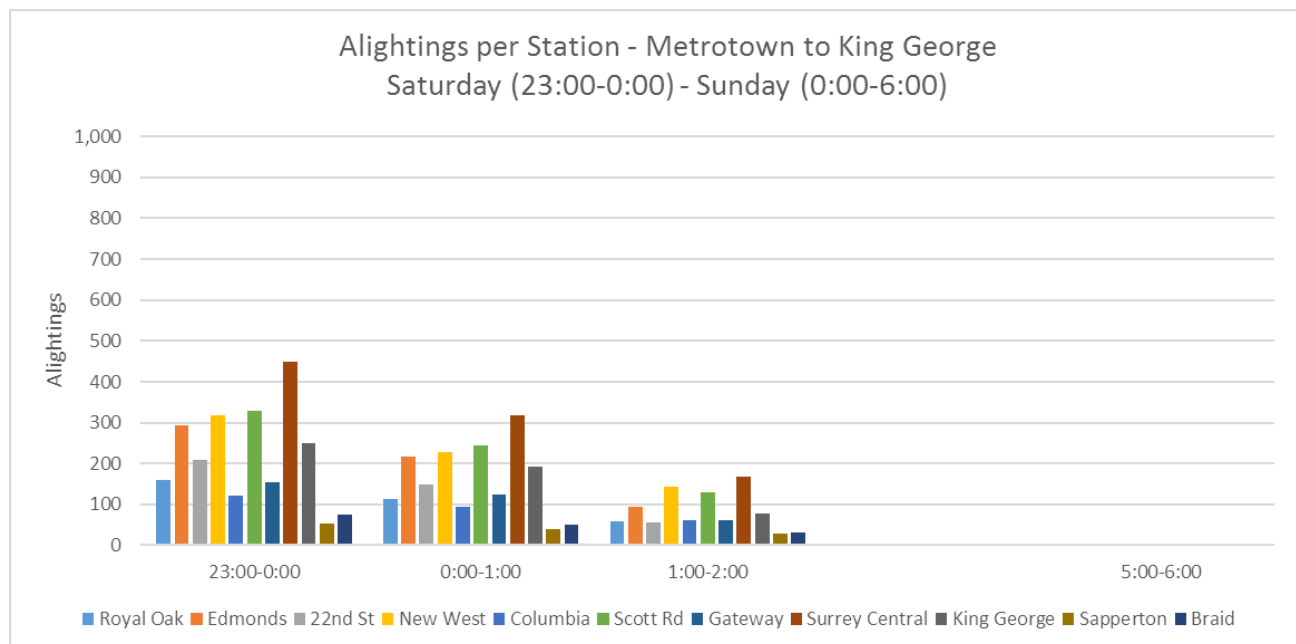


Figure 15: Metrotown to King George Station Alightings by Time of Day - Saturday Night and Sunday Morning

As per the boardings, demand levels on “Friday nights” and “Saturday nights” are similar with alightings relatively well spread out across the line with highest volume at Edmonds, New Westminster, Scott Road, and Surrey Central. It’s important to highlight that in the case of Expo Line, Waterfront and Surrey Central were found as two stations with high levels of activity; indicating activity at both ends of the Line and that short-turns (e.g. Granville to Surrey Central) are significantly less desirable than full length trips.

The charts above also indicate that the Sapperton-Braid branch of Expo Line has significantly low ridership, and these two locations are not considered as key destinations late at night.

The Saturday night station boardings and alightings for the Millennium Line are shown below. The figures below confirm that Millennium Line ridership is significantly lower than Expo Line. The highest passenger activity along Millennium Line is located at the main transfer stations (Commercial and Lougheed).

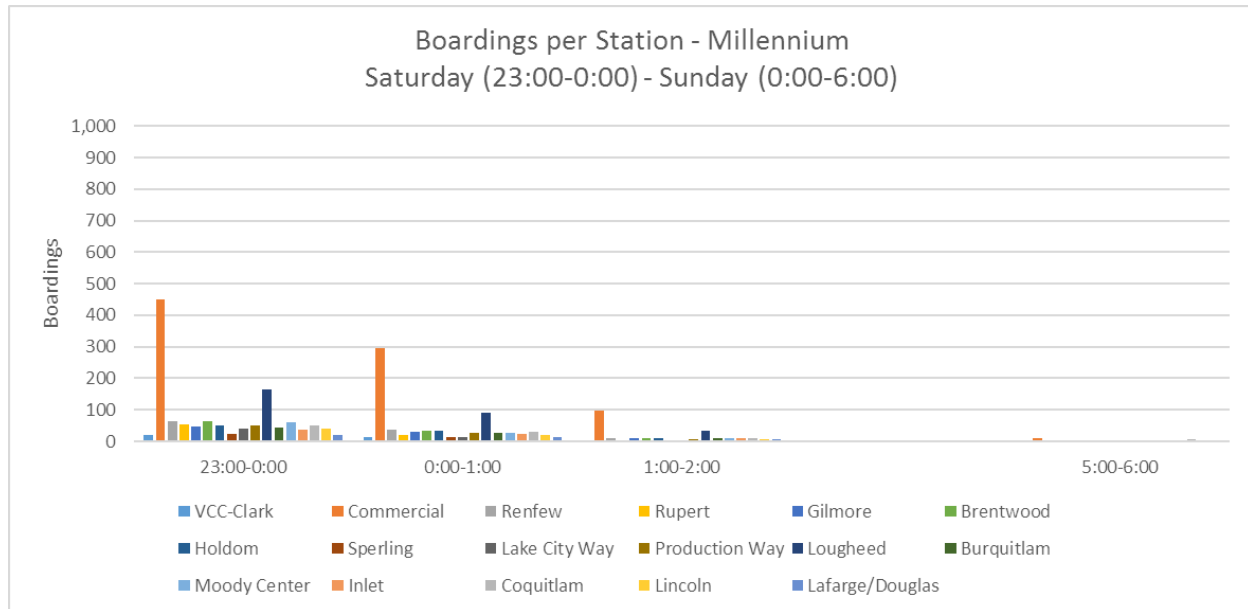


Figure 16: Millennium Line Station Boardings by Time of Day, Sat. Night and Sun. Morning

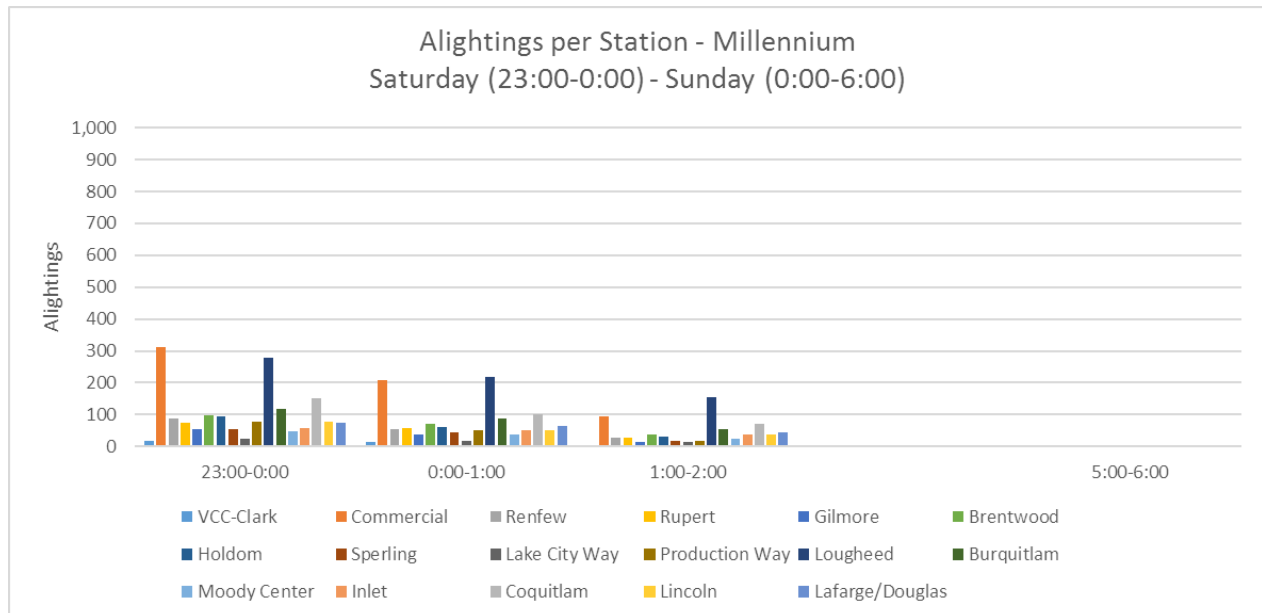


Figure 17: Millennium Line Station Alightings by Time of Day, Sat. Night and Sun. Morning

3.6.2 Busiest SkyTrain Stations

An analysis of 2017 compass data across all SkyTrain Lines indicates 20 specific SkyTrain stations represent 80% of all Entries and Exits:

Row Labels	AVG Taps between 12-4AM	Acum
WF - Waterfront Stn	436	10%
GV - Granville Stn	435	19%
BU - Burrard Stn	392	28%
ST - Stadium Stn	352	35%
VCS - Vancouver City Centre Stn	244	41%
CM - Commercial Drive Stn	228	46%
MN - Main Street Stn	195	50%
WTS - Waterfront Stn Can Line	193	54%
YTS - Yaletown-Roundhouse Stn	179	58%
YVR - YVR-Airport Stn	124	61%
NW - New Westminster Stn	103	63%
MT - Metrotown Stn	102	65%
BWS - Broadway-City Hall Stn	100	67%
BW - Broadway Stn Expo	96	69%
BPS - Bridgeport Stn	96	71%
TS - 22nd St Stn	83	73%
MDS - Marine Drive Stn	76	75%
KG - King George Stn	74	77%
JY - Joyce Stn	73	78%
LH - Lougheed Stn	65	80%

Figure 18: Late night average compass tap data (12 - 4 a.m.) (Source: TransLink)

3.6.3 NightBus

Project team has focused on the ridership analysis on N9 and N19 NightBus services as they follow the Millennium and Expo SkyTrain lines respectively. The average boardings per hour are shown in Figures 18-19 below.

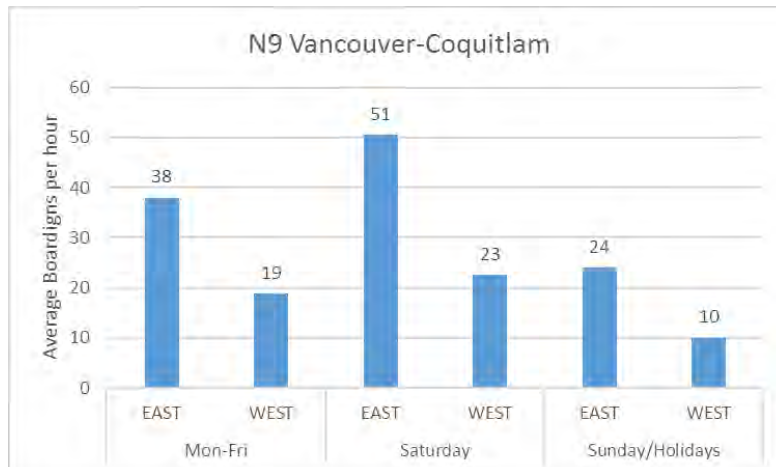


Figure 19: Average Hourly Boardings by Day of the Week for Route N9

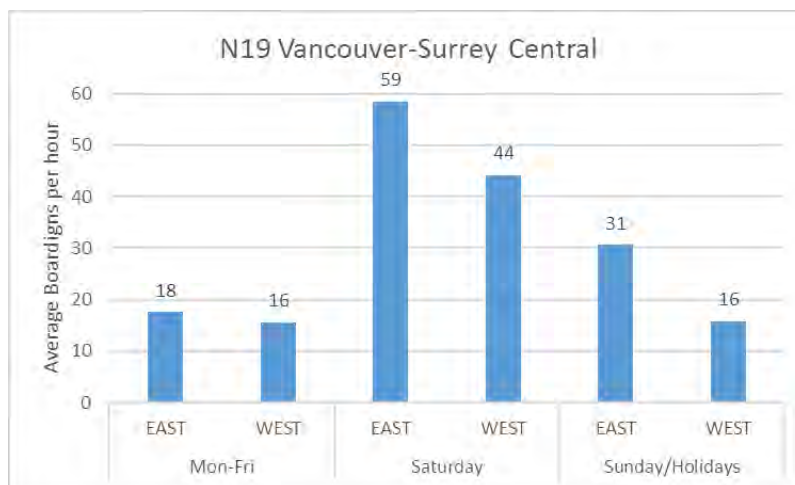


Figure 20: Average Hourly Boardings by Day of the Week for Route N19

The data shows the highest demand level for the N19 leaving Downtown on Saturday and TransLink data showing high peak load factors (up to 95%) on the 2:00 a.m. - 3:00 a.m. time period. However, in absolute values, the Night Bus demand levels are low, as the highest average boarding is 59 passengers per hour

The above analysis has a number of limitations, since Friday data was merged with the rest of the week. Another limitation is associated with low ridership levels is the fact that Night Bus service is significantly less frequent and slower than SkyTrain.

To bridge this gap, TransLink is currently reviewing NightBus service alternatives including frequency increases, express services, and route realignments among other options.

3.6.4 Weekly Variations

An analysis of 2017 compass data across all Transit modes confirms that both Friday and Saturday experience a 100% increase in late night demand (midnight to 4 a.m.) when compared to the rest of the week:

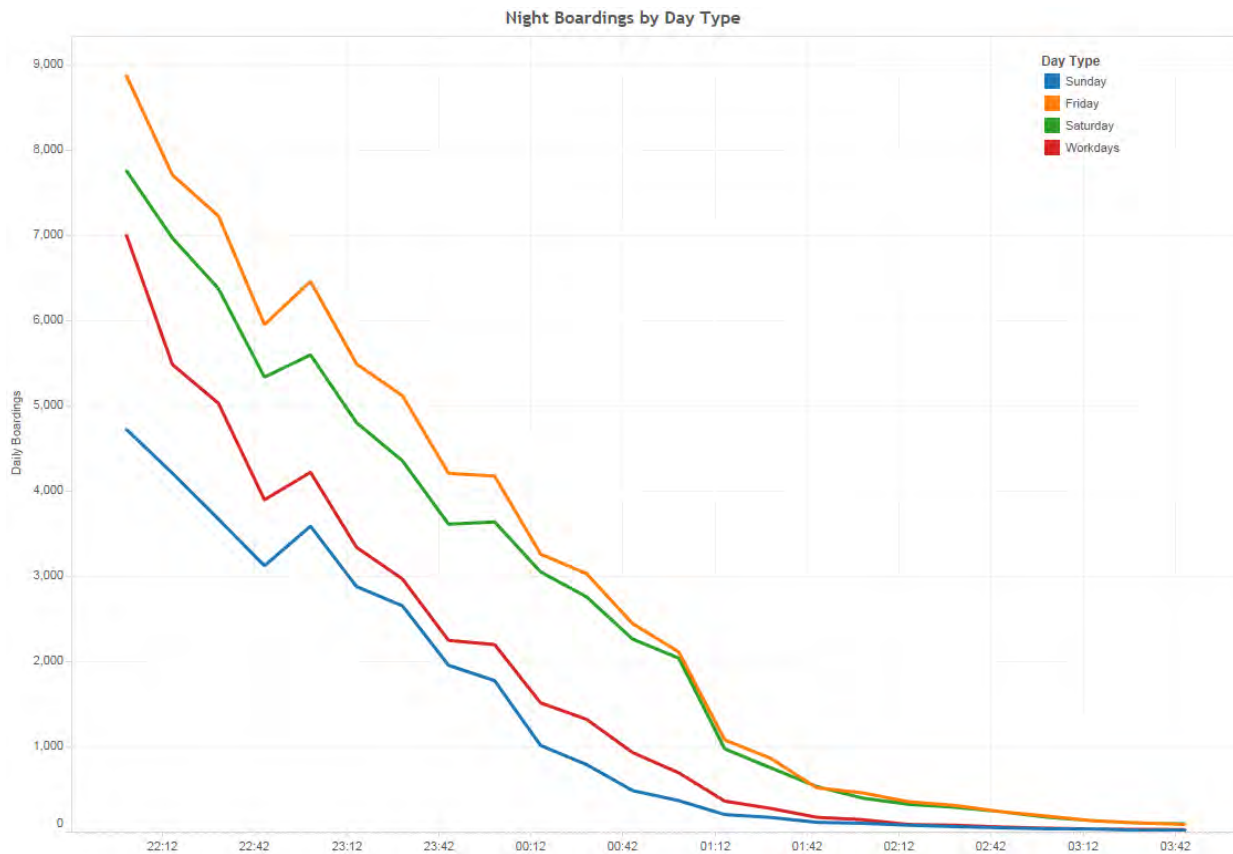


Figure 21: Night Time Boardings Trend (Source: TransLink)

The analysis confirms alternatives that only provide enhanced service one night a week (Friday or Saturday) are not attractive.

Service alternatives should include both nights (Friday and Saturday) if the intent is to better accommodate increased demand associated with Entertainment trips.

3.6.5 Seasonal Variations

Stakeholders have inquired TransLink whether a seasonal service increase could be considered to improve late night services. To address this inquiry TransLink analysed monthly Compass taps between 12 (midnight) and 4 a.m., across the bus and SkyTrain networks:

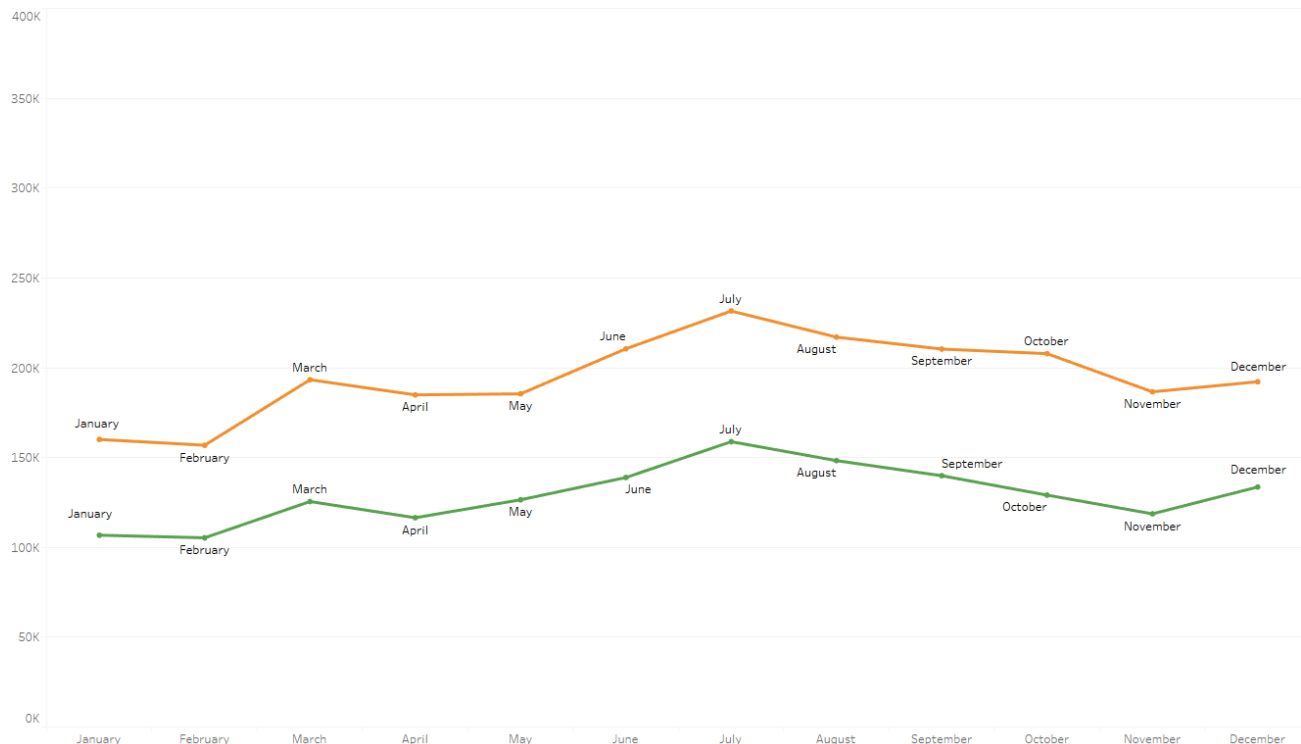


Figure 22: Seasonal Variation of Ridership (Source: TransLink)

The above figure confirms there are a few months with increased demand, however there is at least one “busy month” all four seasons:

- › March / Spring
- › July / Summer
- › October / Fall
- › December / Winter

The above finding indicates seasonal service changes would not be attractive for the customer, since late night demand is distributed throughout the year.

4. Night-time Transit Service Benchmarking

The Project team has reviewed the late-night operating patterns for a selection of worldwide cities to provide an overview of their provision and comparison against Vancouver's service described in the previous chapter.

This chapter reviews the operations of the following cities:

- › “Peer” cities – including two Canadian cities (Toronto and Montreal) and two US West Coast cities (Seattle and Portland). Canadian cities are the two largest in Canada and the US West Coast cities have the comparable population and cultural outlook
- › Asian cities – including Shanghai, Tokyo, Seoul, Hong Kong, Singapore and Kuala Lumpur. They represent a selection of Asian “World” cities with rail networks. In addition, Kuala Lumpur's Mass Rapid Transit system uses automated train control system that is very similar to the SkyTrain system.
- › Cities with night-time rail operations – including Berlin, Boston, Chicago, London, New York, Philadelphia, and Sydney. This includes Boston which has gone through a process of implementation and then removal of night-time rail operations.

4.1 Night-time Transit Service at Peer Cities

Toronto and Montreal are two of the most populated cities in Canada. Their subway systems provide valuable insights into the benchmark night-time operation conditions of major Canadian cities. Seattle and Portland are two cities on the west coast with comparable population sizes to Metro Vancouver.

Their night-time operation conditions are summarized in Table 7 below.

Table 8: Comparison of Population & Night-time Transit Provision - Vancouver vs. Peer Cities

City	Toronto	Montreal	Seattle	Portland	Vancouver
Metro Area Population	6,418,000	4,099,000	3,799,000	2,425,000	2,463,000
Night-time Rail Service	No Subway line operates late night. Latest service is 02:13 on the Sheppard Line.	No Metro line operates late night. No plans to start night service due to maintenance requirements.	Sound Transit Link operates limited services during special events.	MAX does not operate late night.	SkyTrain does not operate late night.
Night-time Bus Service	Blue Night buses	Night buses	Night Owl buses	No service due to financial constraints	NightBus
Night Time Headway	30 mins. or less	Minimum of 45 minutes. 15 mins. along Rene Levesque	60 minutes	n/a	30 mins. or less
Day of the week	Everyday	Everyday	Everyday	n/a	Everyday
Start and End of Night-time services	1:30a.m. – 5:30a.m.	1:00a.m. – 5:30a.m.	1:00a.m. – 5:00a.m.	n/a	1:00a.m. – 5:00a.m.

Analysis of Table 8: Comparison of Population & Night-time Transit Provision - Vancouver vs. Peer Cities shows that none of these “Peer” cities operate late-night rail services, with Portland additionally not operating Night buses. Service headways also differ, which suggest varying demands placed on transit operators. In terms of night-time transit provisions, Vancouver provides the most frequent service among these “Peer” cities.

4.2 Night-time Transit Service at Asian Cities

A literature review has been conducted for a number of major cities in Asia. The reviewed cities include Shanghai, Tokyo, Seoul, Hong Kong, Singapore, and Kuala Lumpur. The scale of the subway system in these cities are comparable to London and New York, which currently operate 24/2 and 24/7 respectively. The population density in these cities are also comparable, and in some cases, higher than London and New York. However, despite these similarities in scale and population density, none of the reviewed Asian cities currently operate 24-hours a day.

Except for Seoul, the other reviewed cities do not foresee 24-hour subway service as an immediate or future need. Unfortunately, very minimal accredited technical information was found regarding these cities' rationale for not operating 24-hour subway systems. However, there are a plethora of informal sources, including news articles and professional blogs, which provide logical speculations and concerns.

The key concerns from each Asian city are summarized in the table below. The primary concerns for not operating a 24-hour subway system include maintenance, lack of perceived demand (although the focus is primarily on weekdays), safety, and lack of financial support.

Most of these concerns are from the perspective of weekday night-time services, and therefore may not necessarily coincide with Vancouver's needs for weekend night-time services. However, it still provides insight for TransLink to consider operating extended service hours on SkyTrain. Tokyo has its own distinct concerns in addition to the common concerns of the other Asian cities.

Again, it is worth noting that most of these concerns are speculative in nature, rather than based on studies with evidence.

For clarity, the term "24-hour service" as presented in the table below refers to 24-hour service on the weekdays if it does not explicitly specifies Friday to Saturday. The term "24/7" refers to 24-hour service operating seven days a week while the term "24/2" refers to 24-hour service on Friday and Saturday nights.

Table 9: 24-hour Transit Services at Other Major Cities in Asia

City	Current “No-Service” Window	Concerns about Operating 24-hour Service	Relevance to Vancouver and TransLink
Shanghai, China	≈ 11:30 p.m. – 5:40 a.m.	<ul style="list-style-type: none"> › Maintenance - Maintenance and inspection of power, track, signal, etc. will require a “no-service” window³, which conflicts with night-time operation › Insufficient Demand – Hourly ridership data at major subway stations have shown that demand falls sharply past 10:30 pm during weekdays. Therefore, operating 24-hours is inefficient when the KPI is measured in terms of “per passenger carried” perspective (e.g. staff hour per passenger carried, power consumption per passenger carried) ⁴ › Safety concerns – Although not evidential by any statistics, the general beliefs are that crime rate is higher at night. Because of such perceived dangers, some consider taking a taxi to be a safer option than public transit at night 	TransLink could potentially face similar maintenance, demand, and safety concerns when developing a business case for night-time operation
Tokyo, Japan	≈ 1:30 a.m. – 5:00 a.m.	<ul style="list-style-type: none"> › Work hours – Japanese middle class has a well-known overtime working culture. Having the last train supports the curfew. In contrast, running a 24-hour subway service would encourage more overtime. Night buses are also rare, potentially for the same reason⁵ › There are relatively cheap options for people to stay overnight in downtown, during the “no-service” window 	SkyTrain’s night-time operation may impact City of Vancouver’s other internal planning and/or policy that addresses temporary overnight accommodation

³ Lei xi, *In most Chinese major cities, why are their subways not open 24 hours?*, Retrieved March 25, 2018 from <https://daily.zhihu.com/story/9632716>

⁴ Tuanzhishu (2016, June 27), *Response to “Why does Shanghai Subway not operate 24 hours?”*, retrieved March 25, 2018 from <https://www.zhihu.com/question/47836585>

⁵ Grace Buchele Mineta (2013, July 3), *Why Don’t Japanese Trains Run 24 Hours? Things I don’t understand about Japan*. retrieved March 25, 2018 from <http://howibecametexan.com/2013/07/03/why-dont-japanese-trains-run-24-hours-things-i-dont-understand-about-japan/>

City	Current “No-Service” Window	Concerns about Operating 24-hour Service	Relevance to Vancouver and TransLink
Seoul, South Korea	≈ 12:00 a.m. – 5:30 a.m.	<ul style="list-style-type: none"> › There is an ongoing feasibility study which analyses potential 24-hour service. Seoul Metropolitan Rapid Transit has plans to operate one subway line 24 hours from Friday to Saturday, noting that the fare during this period may be more expensive. The capital cost of hiring more staff and improving the facilities is estimated to be 2.6 billion won (3 million CAD)⁶ › Financial Deficit – there are concerns that running the subway system 24 hours would further increase the operating deficit › Labour Market – there are concerns there is a shortage of labor force in the subway system to support running 24-hour service. Also, running a 24-hour subway system may impact the taxi drivers⁷ 	TransLink could potentially face similar financial and labor market concerns when developing a business case for night-time operation

⁶ Korea Bizwire (2017, August 25), *Seoul Government Contemplates 24-hour Subway*, retrieved March 25, 2018 from <http://koreabizwire.com/seoul-in-talks-to-push-for-government-contemplates-24-hour-subway/92818>

⁷ HaB Korea (2017, August 11), *Seoul Subway will be Operated 24 Hours*, retrieved March 25, 2018 from <https://www.habkorea.net/seoul-subway-will-be-operated-24-hours/>

City	Current “No-Service” Window	Concerns about Operating 24-hour Service	Relevance to Vancouver and TransLink
Hong Kong	≈ 1:00 a.m. – 5:30 a.m.	<ul style="list-style-type: none"> › Maintenance⁸ - Maintenance and inspection of power, track, signal, etc. will require a “no-service” window, which conflicts with night-time operation › Insufficient demand – Hourly ridership data at major subway stations have shown that demand falls sharply past 10:30 pm during weekdays. Therefore, operating 24-hours is inefficient when the KPI is measured in terms of “per passenger carried” perspective (e.g. staff hour per passenger carried, power consumption per passenger carried) › Financial deficit – there are concerns that running the subway system 24 hours would further increase the operating deficit › Availability of other modes of transport for night-time services, such as night buses, mini-vans, and taxis. 	

⁸ South China Morning Post (2016, September 5), *Why Hong Kong is not Getting 24-hour MTR Service any Time Soon*, retrieved March 25, 2018 from <http://www.scmp.com/news/hong-kong/education-community/article/2013043/why-hong-kong-not-getting-24-hour-mtr-service-any>

City	Current “No-Service” Window	Concerns about Operating 24-hour Service	Relevance to Vancouver and TransLink
Singapore	≈ 12:30 a.m. – 5:30 a.m.	<ul style="list-style-type: none"> › Singapore Transport Minister stated the concerns that newer subway systems such as Singapore’s, were built at a time when land was significantly more expensive. Compared with older systems like London’s or New York’s, new subway systems have difficulty acquiring land to build sidings for bypassing. Not having enough bypass tracks make maintenance exceptionally difficult to do without a dedicated maintenance window⁹. › Lack of demand – See Shanghai for similar concerns › Maintenance – See Shanghai for similar concerns › Increasing cost of transportation – The increased costs due to maintenance and staffing is likely going to inflate the subway fares. This may not have public support, especially for those who only ride during the daytime. 	The authors note this may become an issue for 24/7 operation, however this isn’t an insurmountable constraint for 24/2 operation.

⁹ *Kenneth Cheng (2017, November 7), Design of S’pore’s oldest MRT lines not ideal and improvements will take time, says Khaw, retrieved March 25, 2018 from <https://www.todayonline.com/singapore/design-spores-oldest-mrt-lines-not-ideal-and-improvements-will-take-time-says-khaw>*

City	Current "No-Service" Window	Concerns about Operating 24-hour Service	Relevance to Vancouver and TransLink
Kuala Lumpur, Malaysia	≈ 12:00 a.m. – 6:00 a.m.	<p>Based on an informal discussion with RapidKL, operators for the Kuala Lumpur Light Rail Transit (LRT) and Mass Rail Transit (MRT) system, the following information was retrieved:</p> <ul style="list-style-type: none"> › RapidKL currently has no plan to extend the operating hours during night-time on a permanent basis. However, RapidKL does occasionally operate extended night-time services to support special events in downtown Kuala Lumpur. A fairly recent example is the Kuala Lumpur Marathon on April 8, 2018 › The cost of fare during night-time may be normally charged during public events (such as holidays) or charged to the event organizers during private events; the hours of extended services also depend on the event type › When extended service hours are implemented, maintenance works are carried on during the re-scheduled engineering hours. <p>In addition to the above findings, it should be noted that Kuala Lumpur operates interregional railways with Singapore. Some of these trains arrive or depart during night-time when there would be no MRT service. Therefore, it is speculated that the operating patterns in Kuala Lumpur and Singapore may be correlated or interdependent.</p>	The SkyTrain system uses an automated train control system that is very similar to that used in Kuala Lumpur Mass Rapid Transit

4.3 Other Cities with Current or Previous Night-time Passenger Rail Service

The Project team has identified cities around the globe that have been operating or have previously operated 24-hour passenger rail service on both weekends and weekdays. These cities include:

- › Berlin, Germany
- › Boston, USA
- › Chicago, USA
- › London, UK
- › New York, USA
- › Philadelphia, USA
- › Sydney, Australia.

Details of the population, length of the transit line, annual ridership, night-time headway, the date when the 24-hour service is started, and the service hours, etc. have been summarized in Table 10, p. 43.

While the Project team worked hard to capture Reliability, Availability, Maintainability and Safety data, success was only partially found with London. The publication of detailed reliability data was considered by some to be too revealing of overall system performance. Noting SkyTrain is a member of CoMET / Nova, an opportunity may arise to use this data in following Stages of this study.

Table 10: Cities with Current or Previous Night-time Passenger Rail Services

Transit Agency	The population of Metro Area	Transit Lines	Length of the line (km)	Annual ridership	Night-time Headway (minutes)	Date when night-time service started	Start and end of night-time services (times and days of the week)	Other Notes
Berliner Verkehrsbetriebe (Berlin)	6,004,857	S-Bahn-Linie Urban rail line	327.4	416,800,000	30	1990	01:30-04:30 Sat. & Sun.	
		U-Bahn-Linie Underground line	151.7	553,100,000	15	1990	01:00-04:00 Sat. & Sun.	
Massachusetts Bay Transportation Authority (Boston)	4,732,000	All subway and trolley lines Silver Line Nine key bus routes		13,000 / night (Dec 2015)	≤ 30	June 2015 (cancelled in March 2016)	00:30-2:00 Sat. & Sun.	
Chicago Transit Authority (Chicago)	9,512,999	Blue Line	43.3	68,180,540	15	Before 1994	01:00-05:00 Everyday	
		Red Line	37.7	91,911,745	15/30	Before 1994		

Transit Agency	The population of Metro Area	Transit Lines	Length of the line (km)	Annual ridership	Night-time Headway (minutes)	Date when night-time service started	Start and end of night-time services (times and days of the week)	Other Notes
Transport for London (London)	13,709,000	Night Tube consists of 5 Lines out of 11 lines operated Not all stations are served on Central, Northern and Piccadilly lines	156.2	876,021,000	10-20	Aug. 2016	00:30-06:00 Sat. & Sun.	1,965 permanent jobs created. 20-60 min. time savings by switching to night tube from bus. \$1:\$2.7 Cost: Benefit
Metropolitan Transportation Authority (New York)	20,200,000	All stations are served. 5 of 11 lines operated.	394	1,756,814,800	20	1904	01:00-06:00 Everyday	
South eastern Pennsylvania Transportation (Philadelphia)	6,069,875	Broad Street Line	20.1	6,477,087	20	June 2014	00:30-06:00 Sat. & Sun	
		Market-Frankford Line	20.8	9,774,134	20	June 2014		

Transit Agency	The population of Metro Area	Transit Lines	Length of the line (km)	Annual ridership	Night-time Headway (minutes)	Date when night-time service started	Start and end of night-time services (times and days of the week)	Other Notes
Transport for New South Wales (Sydney)	5,005,400	LRT	12.8	10,000,000	30		23:00-06:00 Sat. to Thur. 00:00-06:00 Fri.	From midnight to 4:30 am, when most trains stop running, NightRide buses replace train services on most lines.

4.4 Key Findings from the Benchmarking Studies

The key findings from the benchmarking studies are summarized as follows:

- › Seattle and Portland are two cities on the west coast that have comparable population sizes compared to Metro Vancouver. None of these “Peer” cities operates late-night rail services with Portland not even operating Night buses. In terms of night-time transit provisions, Vancouver provides the most frequent service among these “Peer” cities.
- › The Vancouver SkyTrain and the Kuala Lumpur LRT are the only two unattended systems that are included in the benchmarking review. Both occasionally operate extended night-time services to support special events but not on a permanent basis.
- › All passenger rail transit networks are currently operating with dedicated maintenance windows except for New York City’s subway system. Unlike all other networks, New York City has a unique grid-like a subway network with twin tracks and sidings that permits vehicles to go from one station to another using alternating routings.
- › None of the Asian cities included in the benchmarking review currently operate 24-hour passenger rail service, despite the fact that they have high population density and their transit operators have frequent daytime services. Most of the subway systems in these Asian cities are relatively new. Like Vancouver, because of the expensive land value, it was extremely difficult to acquire land to build sidings for bypassing when the subway was built. Not having enough bypass tracks makes maintenance exceptionally difficult to do without a dedicated maintenance window. While this is a major issue for 24/7 operation, this shouldn’t be an insurmountable constraint for SkyTrain from running 24/2 operation.
- › Overall, Vancouver’s SkyTrain system follows the typical operating hours as most other cities do.

5. Lessons Learnt from Selected Transit Agencies

Project team has further selected three transit agencies from the cities in Section 4 for a more in-depth review. The three selected transit agencies are:

- › Transport for London – TfL (London);
- › Massachusetts Bay Transportation Authority – MBTA (Boston); and
- › South Eastern Pennsylvania Transportation Authority – SEPTA (Philadelphia).

A summary of lessons learned from the selected transit agencies which include details on what changes these agencies have gone through is provided below. The following is a list of questions the Project team has addressed regarding Transport for London:

1. What were the biggest constraints to extending operating hours?
2. What changes to infrastructure maintenance were required to facilitate extended operating hours?
3. How long (from commencement to operation) did the exercise take?
4. How did the railway authority determine whether to extend service hours or operate 24 hours?
5. What changes were necessary to ensure safety & security was maintained throughout the operating window?
6. How were other operating modes considered in the context of extended operating hours?
7. What would the rail authority do differently in the planning & implementation phase?
8. How did the railway authority manage the issue of noise with stakeholders?
9. Were there political setbacks/pressure against extended operating hours?
10. Has the railway performed as predicted (reliability/passenger numbers/income generated)?
11. Was the railway required to update/vary operating procedures to enable extended service hours?
12. What were the financial implications to extended service hours for the authority? Practices and resources, as well as how the decision-making process is being formulated.

Due to time constraints, and lack of engagement from the pursued agencies, only literary studies were conducted for MBTA and SEPTA.

5.1 Transport for London (London)

As part of the best-practice review for this study, an examination of London's night-time subway service, known as the Night Tube, was conducted in April 2018. The review included a thorough inspection of the technical documents provided by Transport for London, as well as an in-person interview with the previous project director for Night Tube. The technical documents included the following:

- › Night Tube Business Case Narrative ver.4 (Transport for London, Sep. 2015)
- › Night Tube One Year On (Transport for London, Jan. 2018)
- › Developing, Delivering & Operating Night Tube (Transport Economists Group, April 2017).
- › The lessons learned from the in-depth review are summarized below.

Table 11: Summary of Lessons Learnt from Transport for London

Questions	Lessons-Learned From Transport for London
1. What were the biggest constraints to extending operating hours?	<p>Many constraints were identified, including maintenance window, noise, and vibration, litter, increased policing, increased staffing, and union resistance. Among these, two major constraints were:</p> <ul style="list-style-type: none"> › Maintenance - Prior to Night Tube, engineers and operators had the mindset that night-time should be dedicated to maintenance. To overcome this mindset, the Access Transformation Programme was established, which aimed to reduce wasted maintenance time and resource, remove inappropriate controls, and quicker possessions of the maintenance work. › Increased staffing and union resistance - It took significant planning to streamline the hiring of additional operators, scheduling, and training, prior to day 1
2. What changes to infrastructure maintenance were required to facilitate extended operating hours?	<p>Major infrastructure maintenance changes included:</p> <ul style="list-style-type: none"> › Access Transformation Programme was established (see Q1) › Signalling systems were changed on five lines to accommodate overnight operation and removing operational workarounds › Maintenance was concentrated on Sunday through Thursday nights › Modern technologies, primarily Computerised Track Access Control (CTAC), were used to support track maintenance › Upgrades were made to the Traincrew Scheduling System (TSS) and Computer Aided Railway Timetabling (CART) to accommodate overnight running › Track improvements, including localized measures to mitigate noise › Undertook asset renewal in advance of extended service hours operation

Questions	Lessons-Learned From Transport for London
3. How long (from commencement to operation) did the exercise take?	<ul style="list-style-type: none"> › Preliminary studies - approximately six months from late 2012 to summer 2013. The preliminary studies primarily focused on the high-level items of overnight operation. › Business case - approximately one year from summer 2013 to summer 2014. The business case was a detailed assessment of the options and alternatives of overnight operation. Five of LU's 11 lines were determined to have a positive business case. › Implementation – By September 2015 (initial launch date) all 5 lines were ready but launch was delayed by Union activity and Night Tube being linked with a concurrent programme of station closures. A re-work of the staffing arrangements led to a one year delay to the first day of operation in August 2016 on the first line. Others followed by the end of the same year.
4. How did the railway authority determine whether to extend service hours or 24 hours?	<p>In Summer 2013, during the project's feasibility phase, operating 24 hours or extended service hours were respectively identified as Option 1 and Option 2 for evaluation (Do nothing is the third Option). Ultimately, the feasibility phase demonstrated that operating 24 hours is the preferred option.</p> <p>Existing services operate on LU until as late as 01:30 (last train to depot) and first trains operate from as early 04:30 on weekdays (later at weekends). Once any extension to service hours was considered, the length of time remaining available for any maintenance to be undertaken is minimal. Demand was shown to hold up throughout the night, with different demand groups being represented at different times, from late night workers and social trips to lower paid workers and key workers in the early morning extended hours.</p>
5. What changes were necessary to ensure safety & security was maintained throughout the operating window?	<p>The major changes include:</p> <ul style="list-style-type: none"> › Additional policing during night-time › Additional permanent gates were constructed to close the parts of the stations not needed for night-time operation. Temporary gates were also used to support phased implementation › Transport for London undertook benchmarking to determine issues and mitigations around safety and security. The British Transport Police and London Underground found that crime was limited to platforms where passengers were experiencing extended headways. Original plan had been 15 minute headway, but a 10 minute frequency offered minimal operational cost impact and provided a mitigation to people waiting at stations.

Questions	Lessons-Learned From Transport for London
6. How were other operating modes considered in the context of extended operating hours?	<p>At the time of planning, the night bus network was already at capacity. There were more than 100 night bus routes on Friday/Saturday nights, many of which operate with 5-8 minutes headway. The busiest one, N29, operate with 3 minutes headway. The demand for night bus had almost tripled from 2000 to 2014. This growth rate was significantly higher than the growth rate (approximately 70% increase) for Tube after 10 pm or daytime buses during the same period.</p> <p>Therefore, night-time Tube operation was considered as the most sustainable and viable mode of transport at the time.</p>
7. What would the rail authority do differently in the planning & implementation phase?	<p>There was no major item for which Transport for London may have done differently. However, a number of lessons-learned was shared on those items that should be done earlier in the process:</p> <ul style="list-style-type: none"> › Communication with Trade Unions › Consultation with public and stakeholders › Identification of potential risks and prepare contingency funding for corrective actions <p>Lastly, the previous project director for Night Tube also advised that implementation should be based on the positive business case, and actions should be cautiously taken. Once implementation is done, it is very difficult to reverse the process. Transport for London has noted this phenomenon through their Benchmark Study.</p>
8. How did the railway authority manage the issue of noise with stakeholders?	<p>Noise and Vibration were handled with the following measures:</p> <ul style="list-style-type: none"> › An improved process was set up by London Underground to coordinate noise complaints and responses › Noise caused by trains and tracks were the greatest among the sources. Track renewals were made and mitigation measures were implemented such as rail grinding. (see Q3) › Noises caused within stations were within control and subject to past noise abatement orders › Noises caused by engineering works were mostly short-term and within control
9. Were there political setbacks/pressure against extended operating hours?	<p>There were no major political setbacks against night-time operation. In fact, it was strongly supported by political will, particularly as the Tube had already been operating extended service hours during the London 2012 Olympic Game.</p> <p>Whilst there was some concern by local authorities, mostly around noise and anti-social behaviour outside stations, LU also experienced pressure from other politicians to extend the service plan even before launch.</p>

Questions	Lessons-Learned From Transport for London
10. Has the railway performed as predicted (reliability / passenger numbers / income generated)?	<p>The following performance indicators were compared against their forecast after Night Tube's implementation:</p> <ul style="list-style-type: none"> › Demand – demand has exceeded forecast by almost twofold during the first quarter of implementation (August – December). From January 2017, the demand is fairly consistent with the forecast › Performance – over 99% of the trains have met their on-time performance targets › Fare Revenue – fare revenue is slightly lower than expected, due to a greater proportion of customers using season tickets rather than additional tickets. Those tickets are already valid for Night Tube – thus making the ticket greater value for money. Fares are the same through the night as other off peak periods.
11. Was the railway required to update/vary operating procedures to enable extended service hours?	<ul style="list-style-type: none"> › Generally, there was no major update to the operating procedures in terms of train operation. However, the operating procedures for some units who are not directly involved in train operation may have been updated. As examples, the procedure for handling noise complaints and responses have been updated. The litter cleaning process has also been updated to accommodate night-time service. › Access Transformation Programme was established (see Q1) › There were some one-off capital costs, including upgrades to ageing signal equipment to cope with additional load for the number of routes on a given day, but these were only on the Central Line. Coding changes to control software was required on the Victoria line to re-instate alerts in the control room for train movements that are normally turned off overnight (due to frequent engineers' trains causing trouble with the warnings).
12. What were the financial implications to extended service hours for the authority? Practices and resources, as well as how the decision-making process is being formulated.	<p>From the Benchmark Study, the trend that Transport for London observed was that night-time service is most successful in supporting existing night-time economy. The Benchmark Study also observed that night-time service may not be successful if the goal is to incentivize new night-time economy, as with the cases in Boston and Philadelphia.</p> <p>Transport for London quoted from a report released by London First and Ernst & Young that, the value of night-time economy in London contributes to 8% of London's GDP. London First and Ernst & Young predicted that Night Tube will add £138m to the city's economy annually for 30 years.</p>

One of the key findings from the Transport for London's lessons learned is that night-time passenger demand is a key factor for a city to decide whether a 24-hour transit service is required or not. Transit agencies had more success implementing a 24-hour service if there was already a night time economy, rather than using the service to kick-start a night time economy. London Underground's Night Tube frequency of six trains per hour is the highest anywhere in the world. London has a more vibrant nightlife and a much larger night-time economy than Vancouver.

5.2 Massachusetts Bay Transportation Authority (Boston)

The Massachusetts Bay Transportation Authority (MBTA) is the public agency responsible for operating most public transportation services in Greater Boston, Massachusetts. The MBTA is one of the few transit agencies that operate LRT, heavy rail, commuter rail, trolley buses and conventional buses.

From 2001 to 2005, the MBTA ran limited “NightOwl” bus services to 2:30 a.m. These were canceled due to low ridership (2,460 boardings/weekend) and budget constraints.

In March 2014, the MBTA launched the Late-Night Pilot Program in response to customer requests and in view of comparable services being offered by peer US transit agencies. The Program began with all rail lines and 14 bus routes operating from 00:30 to 02:30 on Friday and Saturday.

Initial findings from the Late-Night Pilot Program included:

- › A considerable increase in ridership between the NightOwl services and the Late-Night Pilot Program (2,500 boardings/weekend versus 27,000 boardings/weekend on the Program). However, the Late-Night Pilot Program provided a much more extensive service i.e. rail and buses.
- › Late-Night Pilot Program boardings comprised around 2% of the total weekend boardings from March 2014 to January 2015 and over a third of the late night demand was on one rail line (Green Line).
- › Initially estimated at an annual cost of US\$16M but revised to US\$12.9M due to scheduling efficiencies.
- › Low demand levels reflected a high net subsidy per passenger, i.e. the net subsidy per rail passenger is \$0.84, for the bus passenger is \$2.74 and for the Late-Night passenger it was estimated at \$7.68.
- › Ridership data showed the majority of late-night customers are monthly pass holders (59% of late-night fare transactions) with the busiest stations and bus routes those serving areas with large student populations.

Despite marketing efforts throughout 2014, ridership was greatest near the Program’s start and ridership decreased steadily as time went by. In June 2015, the Late-Night Program was cut back to 2 a.m. and service was eliminated on the five least-used bus routes.

Further review of Late Night operations recommended their cancellation in January 2016. This review found:

- › Continued low ridership compared to overall MBTA ridership
- › Extension of service for 2 hours on 2 days per week likely did not provide a transportation alternative for many third-shift workers
- › High cost of provision with per passenger subsidy increasing to \$13 (compared to \$1.43 during regular hours)
- › The net cost of providing late-night service estimated at \$14M per year and in the context of large, growing and unsustainable MBTA budget deficits
- › Private contributions to support late night service were time-limited and insufficient to meaningfully offset operating costs. Some of the anticipated contributions did not materialize.

- › Reduced access to tracks and right-of-way maintenance. Usual 5 hours reduced to 3 hours over the weekend and MBTA prioritizing system maintenance and upgrades.

The late-night services ceased operating in March 2016.

One of the issues raised by the cancellation has been how to consider any mitigation on the effects of the end of the service on minority and low-income riders. MBTA tried to avoid a federally required civil rights analysis before ending the service, but were later rebuked by federal officials for doing so and this has been an ongoing issue.

This raises one of the key lessons learned from the Boston experience. Even though the night-time ridership decreased steadily as time went by and there were severe budgetary pressures, the operator faced considerable pressure from the public regarding the service withdrawal.

In 2018 the MBTA is asking interested parties whether they would be willing to operate all night, rather than for just a few hours, and whether they prefer fixed routes or dispatching vehicles based on demand. That last approach raises the possibility that ride-hailing companies such as Uber and Lyft (which already work with the MBTA to offer paratransit service for riders with disabilities) may be attracted to provide overnight service.

5.3 South Eastern Pennsylvania Transportation Authority (Philadelphia)

The South East Pennsylvania Transportation Authority (SEPTA) operates the urban metro system in the city of Philadelphia. In response to a public petition, they operated a trial service on two of SEPTA's five lines starting on 15 June 2014. A service operated every ten to fifteen minutes, which reflected the parallel overnight bus service that was being operated. The trial was supposed to finish on US Labor Day weekend (which would have meant last trains on Sunday 31 August 2014) but was extended through to 2 November 2014 to allow further assessment during regular working weeks rather than over the summer holiday period. On 8 October 2014, the trial was extended indefinitely.

There is no report of a significant number of complaints from residents about noise from train movements or customers at night. The decision to operate night services was political, not operational. No significant increase in asset failures or maintenance costs came as a result of the 24-hour service. Crime during night service is not a significant issue for the operators or customers. The situation is no different from that in the late evening. SEPTA initially flooded their night service with staff and police officers but quickly realized this was unnecessary.

As noted from the case in Philadelphia, SEPTA initially introduced late-night service only on a part of the network and on a trial basis; however, stakeholder pressure soon led to it being extended to run on a permanent basis.

6. Summary of Interview Findings

A number of in-person interviews were conducted with key BCTRC & TransLink staff. This offered the opportunity to discuss running extended services and the perceived limitations of the existing configuration and means of operation.

The Project team conducted in-person interviews with the following staff from TransLink, BCRTC and Transit Police on March 20 and 27, 2018:

- › Richard Sykes, (former) Vice President, Maintenance, BCRTC
- › Richard Wong, Manager, AIO & Capital Support, BCRTC
- › Mike Richard, Vice President, Operations, BCRTC
- › Matt Doyle, Director, Railway Infrastructure, BCRTC
- › Chun Ho Lau, Director, Asset Management & Engineering, BCRTC
- › John Wollenzin, Director, Rail Operations, BCRTC
- › Mark Minson, Director, Engineering Project Delivery, TransLink
- › Doug LePard, Chief Officer, Transit Police
- › Sarah Ross, Director, System Planning, TransLink.

The Project team discovered informal operations-specific reviews had already been undertaken in 2011. The review made proposals for a six-month pilot programme, offering 24-hour running service starting early Friday morning, finishing around 00:30 Sunday morning.

The exercise also discussed SkyTrain specific limitations (such as preventative maintenance of the LIM rail) in addition to the geographic constraints such as the road network, should buses be required to offer shuttle services.

The interviews gave the Project team direct access to policymakers in the respective organizations, which gave an opportunity to discuss:

- › The perceived limitations of the existing infrastructure and the means of operation;
- › The decisions to be made in the event a determination was made to extend operating hours; and
- › What equipment/additional processes could be introduced to bring about greater likelihood of success in the extended service hours programme.

Interviews with the Key Staff revealed one common theme when running extended service hours; trade-offs need to be identified and effectively reviewed for their impact when determining the best course of action to take. This becomes especially important in the context of railway system maintenance and renewal, due to the potential for reduced maintenance hours every week.

The interviews helped shape the feasibility review by providing local context, feedback on the perceived constraints, and input on the state of processes employed by BCRTC.

6.1 Constraints in Operating Beyond the Current Timetable

The interviews identified a number of operational challenges when considering the possibility of extending operating hours. Some of the key issues found:

- › Overall network staffing, noting the contractual activities required for commissioning;
- › Managing the renewals activity around the network;
- › Effective asset management (and how this ties into maintenance;
- › Train stabling planning which met the needs of the railway system (e.g. supporting ramp-up for morning service, train wash schedules and maintenance schedules); and
- › Developing the first line response to meet the growing needs of the railway.

6.1.1 Staffing

The success of extended operating hours requires considerable effort when introducing necessary changes within the contractual agreements with staff representatives. The necessary changes form a near overhaul of the operating philosophy, which has been a source of contention for other operators evolving into 24-Hour Service operations.

Interviews with SkyTrain leadership found that ensuring employee safety was a key consideration when discussing the merit of extending service hours. SkyTrain leadership considered the requirement for Transit Police presence to ensure the safety of passengers and staff members. The interview panel discussed the issue of crime with the Transit Police Commissioner, who confirmed the likely increase in reported crime on transit network during extended service hours. This is further supported by the police crime data submitted to the interview panel.

Note: Study on London's Night Tube suggests a decline in overall reported incidents of crime after the implementation of 24/2 service. One key contributor is large crowds, which typically rush for the last train and being targeted by criminal activities. As a result of extend services, crowds are redistributed into smaller crowds over the extended service hours and thus lowering the odds of triggering incidents of crime. Noting that an adequate presence of Transit Police is still required, the extended service hours operation for SkyTrain system may not have higher policing requirement than regular operation.

First line response technical support is currently unavailable outside of core weekday hours. Therefore, addressing technical issues during the extended service hours is likely to become more challenging. Staffing levels may require expansion to facilitate necessary maintenance activities in reduced engineering hours throughout the week.

The issue of shift management was discussed with a number of the SkyTrain leadership. It has been identified that servicing the extended service hours with current staffing level is insufficient. The scheme of overtime work for occasional extended services (e.g., New Year's Eve, etc.) won't be sustainable for the extended service hours operation on a regular basis. Effective recruitment and training in the build-up to the extended service hours will form a key part of the success of this project. The collective agreement with unions will inevitably be renegotiated due to the change. Furthermore, seniority within the workforce plays a part of the priorities of shift assignment. As a result, it's possible that staff members with less experience will be assigned to the late night shifts. It will require a satisfactory level of competency being maintained for these staff members in order to respond to late night incidents.

During the staff interviews, it was noted that the recovery of a failed train required the nearest member of staff to board a nearby train and head in the direction of the failed train. This enabled the staff member to either manually drive the train or aid the diagnosis of the issue.

Reduced headways proposed for the extended hours will invariably result in longer Mean Time to Repair (MTTR) because the availability of trains for recovery purposes is reduced. This further builds the case for improved technician staffing throughout the network.

6.1.2 Asset Management

BCRTC is on the path to developing a comprehensive Asset Management System (AMS) that will assist the operators and maintainers to manage maintenance and asset upgrade schedules efficiently. This will enable the delivery of all necessary maintenance activities and scheduled capital projects with potentially fewer engineering hours required.

Data related to understanding assets and where they reside in their current lifecycle is in its early stages. The risks are unknown with regards to end of life of components and Asset Renewal plans. The risks will further increase when operating with extended service hours.

The interview panel found that the purchase of the Enterprise Asset Management system (EAM) is on hold at the moment. The deployment of AMS is a prerequisite to the successful implementation of extended service hours operation.

6.1.3 Train Stabling

Train stabling on the mainline guideway is a practice that aids the morning service ramp up and reduces congestion within the OMC yard. There are 23 long trains and 10 short trains being stabled on the Expo line and Millennium Line currently. Figure – 8 from Section 3 illustrates the current stabling locations during non-service hours. The need for stabling trains on the mainline tracks will further increase noting the fleet expansion is on the near horizon.

The train stabling strategy will need to be reconsidered depending on the operating model chosen. For example, operating with the Expo Line only allows trains to be stabled on the Millennium Line. This will put less pressure on the OMC yard and morning service ramp up, compared to operating on both Millennium Line and Expo Line during the extended service hours. In the event both Expo and Millennium Lines are operating an extended service, the track between Columbia and Lougheed will remain out of service, enabling both dynamic testing of new trains and stabling.

Some non-service terminal stations can also be used as new train stabling locations. For instance, the Waterfront station and King George Station can be used to store some trains if the extended service hours' service only operates from Granville Station to Surrey Central.

The morning service ramp-up strategy will be impacted significantly if the 24-hour service operation model is chosen. This will require careful planning and consideration in order to maintain safe, timely and efficient morning service.

6.2 Maintenance Challenges

Maintenance activities were found to be a challenge for operating extended service hours. Extended service hours on Friday and Saturday will greatly reduce the engineering hours for the maintenance team, particularly in the case of running 24-hour service for Friday and Saturday. This operating strategy will result in little to no maintenance window available for the entire weekend. This poses many challenges and issues for the maintenance (and Capital Projects) team as discussed in the following sections.

Interviews and follow-on discussions with the maintenance Director suggest, at a high-level, extended service hours is feasible when the overall number of weekly maintenance hours are preserved (i.e. increasing maintenance hours mid-week to balance the loss of hours at the weekend). Any corresponding reduction in overall maintenance hours would require careful planning, budgeting and consideration at a detailed level prior to acceptance and migration to extended service hours. This section of the report goes into some detail on the impact to effective maintenance.

It should be noted that when faced with the same issue, London Underground Engineers held the same view. The Access Transformation Programme proved better planning and efficient access to work sites meant squeezing the required maintenance was indeed feasible. This experience can be offered to TransLink at a detailed level in the follow-on stages to this project.

6.2.1 Losing the Longest Maintenance Window

The Saturday morning and Sunday morning maintenance windows are currently the longest non-service window that is considered to be more than one-third of the weekly maintenance hours available. (Refer to Section 3.3 for detail) The impact of maintenance activities over running into the morning service is also less critical during the weekend compared to weekdays. As a result, all large maintenance activities and capital projects are scheduled during the weekend maintenance window.

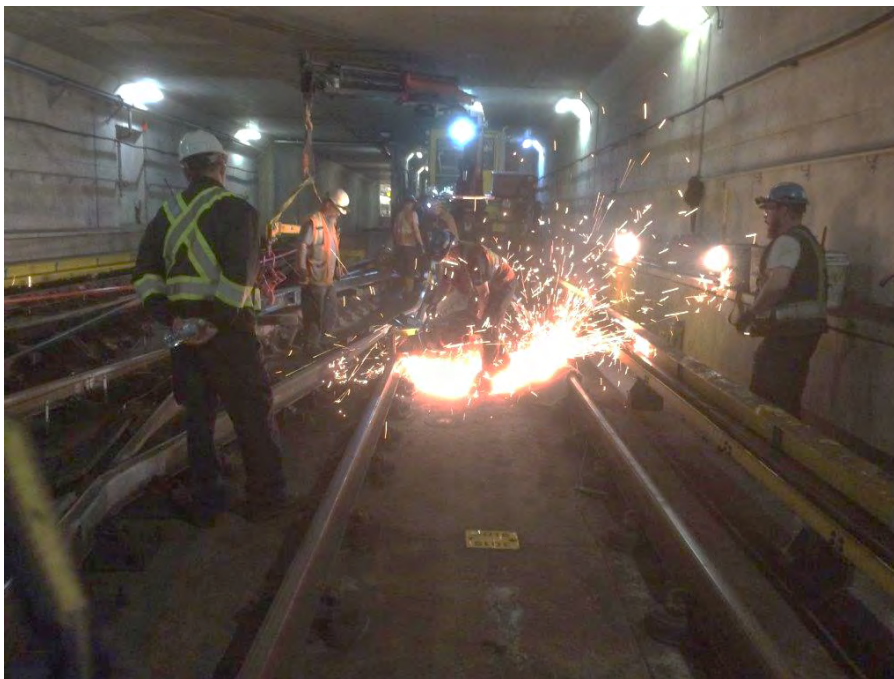


Figure 23: Maintenance Crew Working on Track

Reducing or removing these weekend maintenance windows will have strong impact to the maintenance plans and create new challenges. For example, the LIM rail inspection and maintenance is very resource heavy and time consuming. This activity will be hard to complete during a shortened maintenance window. Equipment upgrades and increasing staffing level are some mitigation methods that need to be evaluated when considering operation with extended service hours.

If the 24-Hour Service operation mode is chosen, the Monday morning (Sunday night) maintenance window will be used to carry out all outstanding maintenance activities incurred during the period of extended service hours.

6.2.2 Maintenance Efficiency

Improving maintenance efficiency is crucial to address required maintenance activities within shorter maintenance windows. Launching equipment from the OMC requires a significant amount of time. Transporting equipment and maintenance crew to work sites is time-consuming. All this “build-up” time ahead and after maintenance activities consume a significant portion of the non-service time window. Therefore, when the maintenance window is reduced beyond the “breaking point”, no meaningful maintenance activity can be accomplished.

Note: Reduction of this “build-up” time had been identified as a core part of the Access Transformation Programme at London Underground in advance of implementing the 24/2 Night Tube service. Many changes to the operation and maintenance procedures were created/updated to reduce wasted time, resource, removing inappropriate controls and quicker possessions, to allow more time to work on site.

This can be improved by having more storage locations for maintenance equipment. Employing de-commissioned MK1 trains is another efficiency improving method that can be used to transport maintenance crews and equipment to the maintenance site faster. Similarly, equipping maintenance vehicles with ATC will improve the effectiveness of maintenance works.

The Asset Management System (AMS) currently under development by BCRTC should be instrumental to improving maintenance efficiency and productivity. The deployment of AMS will help to improve the effectiveness of maintenance activity planning and scheduling so that the required maintenance activities can be accomplished within a shorter maintenance window.

6.2.3 Equipment Self-tests

Many equipment self-tests are currently scheduled during engineering hours. For example, GIDs self-tests is scheduled at 3 am daily and the VCC reset is scheduled during non-service hours on a monthly basis. These schedules will have to be revisited to coordinate with new service schedules. Software/hardware upgrade may be required for this activity.

6.2.4 Potential Trade-offs

Some trade-offs can be made in order to balance the loss of the engineering hours over the weekends. For example, reducing the service hours from Monday to Thursday could allow for longer maintenance windows during weekdays to complete some of the large ticket items. The acceptability to passengers will need to be considered. These trade-offs and mitigation candidates are further discussed in Section 8.6.

The Project team has considered the risk associated with this decision and note Transport for London has been able to balance the needs of the maintainer with the existing service provision.

6.2.5 Impact to Rolling Stock

The primary impact to rolling stock is the slight increase in annual KM travelled per annum. This translates to increased maintenance costs, as captured in the financial section of this report. The maintenance scheduling is not affected significantly with extended service hours. The current rolling stock maintenance schedule allows more than 30 trains being stabled on the mainline overnight. The operator can utilize the vehicles that are not being scheduled for maintenance to service the extended service hours. At this stage in the study, there appears to be no significant concern which would constrain extended service hours.

One SkyTrain benefit is the varying configurations of the current fleet. The MK I offers flexibility in train provision (owing to the ability to couple units to form longer consists) and would offer an energy-efficient means of maintaining service in times of less demand, against a MK IV. This feature is a marked improvement over other metros due to the flexibility.

Stabling of trains (particularly in the context of a growing fleet) warrants further consideration; full use of un-utilised track (e.g. south of Loughheed and platform areas at King George station) are noteworthy options. Assigning trains as 'hot standby' within the network will offer two benefits; aiding the network in the event of rolling stock failure and supporting the network to ramp up for the morning peak.

6.2.6 Monthly ATC Maintenance

Discussions with the BCRTC team have indicated the Thales SelTrac Automatic Train Control (ATC) system undergoes monthly shutdown to enable effective preventative maintenance. It is unknown at this stage how long such activities require (or what is required to be completed). However, Project team notes that London Underground operate two SelTrac lines (the Jubilee Line and the Northern Line) 24/2 in Loop configuration with Second Generation Vehicle Control Centres (2GVCC).

6.2.7 Testing and Commissioning of New Trains

While not strictly speaking a maintenance issue, the commissioning of new trains onto the system requires both dynamic testing together with "fault-free running" on the network outside of revenue service.

The Project team has considered this railway requirement and noted that even in 24/2 service on the Millennium and Expo Lines, there remains a section of track (south of Loughheed toward the OMC – Braid to Sapperton) which is not operating in revenue service, thereby enabling stabling of trains on one track, with limited dynamic testing on the remaining track.

6.3 Impact to Capital Projects

Aside from maintenance activities, operating with the extended service hours has the potential to impact scheduled capital projects. Capital projects generally require a long time to complete. Therefore, many capital projects that require guideway access are scheduled over the weekend during the long maintenance window. If the maintenance windows are reduced or removed, the schedule for capital projects will have to be revisited.

Capital projects normally have lower priority than maintenance activities. Therefore, capital projects can at times be pushed back by maintenance works. This can become more common if the effective maintenance window is reduced. Priority based scheduling between capital projects and maintenance activities can help coordinate capital the project's team and the maintenance team to utilize the limited engineering hours more effectively. This can be one of the key enablers to the extended service hours' operation. Furthermore, the AMS could act as the "one true source" of information ensuring effective scheduling and improved efficiency.

Capital projects are generally less flexible when compared to maintenance activities. This is mainly due to the availability of contractors and equipment. It will be a challenge to properly schedule the existing and upcoming capital projects with reduced engineering hours including the McNeil recommendations, etc. The prioritisation of access needs to be undertaken with an overall business view – some maintenance activities can be deferred to another evening (with alternative mitigations such as speed restrictions) if the costs of deferring pre-planned capital projects are detrimental to the business.

In discussion with the BCRTC & TransLink team, it became apparent that unlike other metro operators, SkyTrain doesn't often undertake renewals / maintenance works during blockades. At Christmas and Easter, numerous operators benefit from statutory holidays to close lines and undertake vital works – as the SkyTrain network continues to age (and with potential reduced engineering hours during the weekend) this option should be considered further for Vancouver.

Working with shorter maintenance windows can potentially cause safety risks to contractors depending on the model chosen for the operation. For example, the safety risk increases when having a crew working alongside running trains.

6.4 Demand Levels

The anticipated demand levels during the extended hours is a crucial indicator that can help identifying the required service level and operation strategy. TransLink has analyzed ridership data and COMS (customer complaints and communications), and found there are several markets: (1) Entertainment trips, (2) Shift-workers, (3) YVR trips, and (4) trips to town-centers /universities. It has been confirmed that the majority of the demand is associated with the entertainment district on Friday and Saturday Nights. Therefore, downtown SkyTrain Stations are the main hubs for boarding passengers. Twenty SkyTrain Stations represent 80% of the taps between midnight and 4 a.m. This is a key consideration to consider when developing service alternatives.

Single track operation can be considered if the demand is low to drive a long headway operation. This can allow certain maintenance activities to take place while providing revenue services. Another option is to provide limited service to only serving stations with relatively high demand, in conjunction with other bus services.

Ridership along NightBus is significantly lower than that of SkyTrain services. This is associated with the fact that NightBus service is infrequent, circuitous, and significantly slower than other transit services. TransLink is currently reviewing NightBus service alternatives including frequency increases, express services and route realignments among other options.

7. Findings from Stage 1 – Environmental Scan

This section will provide an assessment of BCRTC's relative position in relation to other transit agencies as well as the key constraints and readiness in operating extended service hours.

7.1 BCRTC's Relative Position

Vancouver's SkyTrain is a relatively young metro line compared to metro lines in other cities that provide night-time services. The population in the metro area is very small compared to large cities like New York City and London that offer 24-hour services. However, the ratio of annual ridership per kilometre to metro area population is very high in Vancouver comparing to the two cities that offer 24-hour services. The current number of non-service hours that the SkyTrain system has, is very similar to the MAX Light Rail from Portland and the MBTA Subway from Boston and the length of the track is the shortest comparatively (Refer to Section 4 for detailed analysis).

Table 12: Comparison of Vancouver's SkyTrain to Other Systems in the World

City	New York City	London (Night Tube)	Boston	Portland	Vancouver
Metro Area Population	20,200,000	13,709,000	4,732,000	2,425,000	2,463,000
Annual Ridership per km	1,282,346	4,943,204	3,174,603	414,078	1,319,095
Currently Providing Night Time Services	Yes	Yes	Canceled in March 2016	No	No
Age of Line	114 Years	155 Years	118 years	32 Years	33 Years
Non-Service Hours Available (Weekly)	Operate 24-hour services	Operate 24-hour services	About 29 Hours	About 30 Hours	About 30 Hours
System Length	394 km	230 km	126 km	96.6 km	79.6 km

Massachusetts Bay Transportation Authority (Boston) is one good example that Vancouver can compare to in terms of network, length, and population. MBTA launched extended services over weekends in 2014. This program was canceled in 2016 due to low ridership and budget constraints. (Refer to Section 5.2) Therefore, it is important to consider the potential level of ridership during the extended service hours for Vancouver's SkyTrain before implementing the regime.

Maintaining asset to the "State of Good Repair" is another challenge that many transit authorities face when considering running an extended services hours operation. For instance, the New York City subway system has been offering 24-hour services since 1904 and has since become an essential part of the city that never sleeps. The subway ridership rose steadily year after year. From 1991 to 2016, the annual ridership had increased 77 percent. However, the maintenance spending was lacking and the on-time performance has been dropping dramatically to -26 percent according to the National Transit Database.¹⁰

Many assets of the network are very old and require upgrades and much-needed maintenance work which has been pushed back and delayed due to lack of maintenance windows and budget constraints. Therefore, effective planning and resource management are crucial to the success of implementing extended service hours operation for Vancouver's SkyTrain system. The maintenance and capital project schedules will require careful consideration and optimization to ensure the system maintains availability and reliability.

Noting the different challenges and upcoming asset maintenance and upgrade plans, a number of key constraints are identified at BCRTC that require consideration before implementing the extended services.

¹⁰ National Transit Database <https://www.transit.dot.gov/ntd/ntd-data>

Brian M. Rosenthal, Emma G. Fitzsimmons and Michael LaForgia (Nov. 18, 2017), How Politics and Bad Decisions Starved New York's Subways. From <https://www.nytimes.com/2017/11/18/nyregion/new-york-subway-system-failure-delays.html>

7.2 Key Constraints Identified at BCRTC Today

Many limitations at BCRTC have been identified through the environmental scan that pose challenges to the operation of extended service hours. The following sections discuss some of the key constraints today and how they impact the implementation of the service extension.

7.2.1 Human Resources

When comparing the staffing level of BCRTC to other railway operators offering extended service hours, it becomes clear that the current level of workforce cannot support the extra night shifts on a regular basis. The environmental scan covering extended service hours with overtime shifts is neither sustainable nor in the interests of the railway system. As a result, BCRTC will be required to hire more staff to accommodate the service extension. The number of additional staff required varies depending on the level of service being provided during the extended service hours and the model of operation. (E.g. service all stations, limited stops, etc.)

In addition to expanding the workforce to support the extra shifts during the extended service hours, it is equally important to ensure an adequate level of competency for new hires. The existing strategy for a competency management system may require a modification/update. The current shift management plan will also need to be revised noting the additional shifts required.

Union involvement also plays an important role in the process. The collective agreement between BCRTC and the unions will have to be revisited to account for the changes in work shifts, hours, etc.

7.2.2 Transit Police

The presence of Transit Police was found to be crucial in the successful delivery of extended service operation for comparable cities. For example, the reported crime incident data from New York City Police Department suggests that the number of reported crime incidents during late night and early morning operation (12 a.m. to 6 a.m.) accounts for close to 21 percent of the total criminal incidents reported, as illustrated in the figure below:

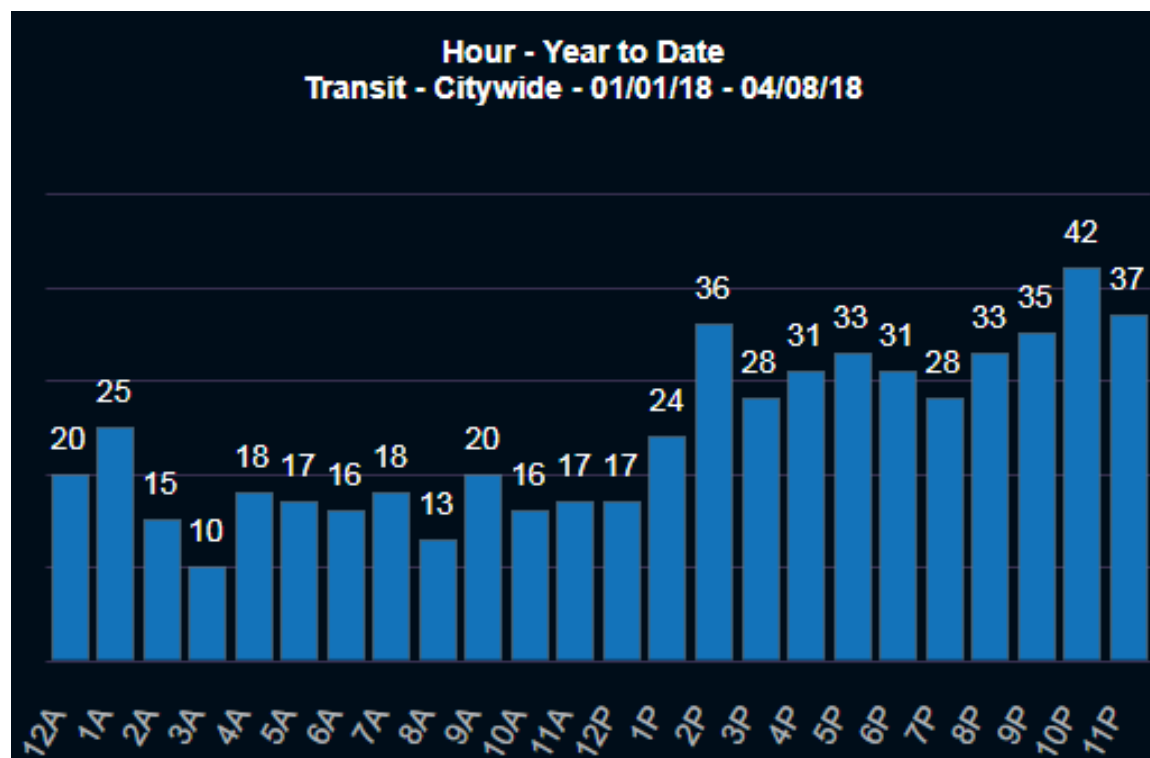


Figure 24: New York City Transit Crime Data from NYPD CompStat 2.0

The violent crimes data gathered from the Transit Police suggests a high number of incidents are being observed on Friday evenings (9 p.m.-1 a.m. Saturday) and Saturday evenings (9 p.m.-1 a.m. Sunday) as illustrated in the Figure below.

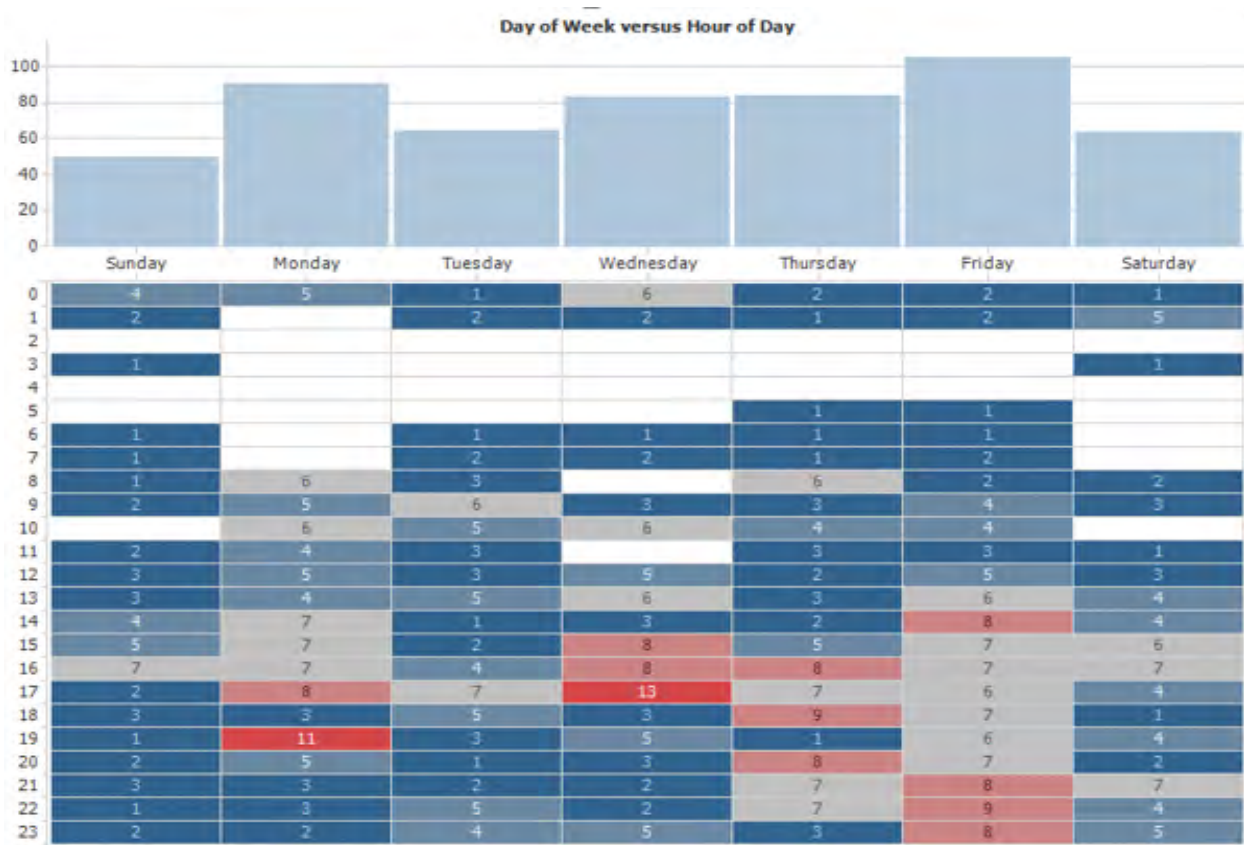


Figure 25: Violent Crimes Data from Vancouver Transit Police – the Year 2017

The total number of reported incidents for Transit Police is expected to increase when SkyTrain starts operating with extended service hours. As a result, the presence of transit police at stations offers perceived safety to the public and staff members during the extended service hours.

7.2.3 Capital Projects

Maintaining the condition of our transit infrastructure is an issue of great importance. Many capital projects have been planned for the next few years to ensure that SkyTrain is maintained in a “State of Good Repair” to provide efficient, reliable, and safe service.

New York City’s subway system has operated 24/7 since 1904. In efforts to raise New York transit reliability, the President of New York City Transit has publicly raised the possibility of closing lines to carry out vital network maintenance.¹¹ These efforts highlight the result of poor renewal planning and ineffective maintenance.

The capital projects are constrained by the availability of equipment and contractors. Capital projects are usually “resource heavy” and requires a long maintenance window to complete. The 2017 January to September total non-revenue hours recorded for capital projects is shown in the table below:

Table 13: Total Non-Revenue Hours Recorded for Capital Projects in 2017 Jan-Sep

Total Non-Revenue Hours									
Type of Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monitor (AIO Monitor, GWY SP and GWY Tech)	748	1407	1893	1485	1348	1141	1076	1143	1004
P-Tech and P-Service person	41	54	101	121	42	71	13	127	28
E-Tech	58	71	184	140	65	145	52	218	82
V-Tech	20	7	5	22	5	8	13	17	6

Different asset upgrade projects are being developed including projects from the McNeil recommendations to mobilize the Mayor’s vision for the infrastructure system of the city in the years to come. Many of these capital projects will require guideway access during the long maintenance windows currently available on Fridays and Saturdays.

While the pressure of conducting renewals / Capital Projects isn’t new, the service extension on Fridays and Saturdays poses a significant challenge to the current and future works. This has been taken into account with mitigation candidates presented in Section 8.

Furthermore, coordinating capital projects with maintenance activities is very challenging. Maintenance activities have higher priority in general, that may cause capital projects to be delayed. The asset management process which is being developed at BCRTC, as part of the McNeil recommendations, will significantly improve the scheduling efficiency and optimize the coordination between capital projects and maintenance. This tool will be one of the key enablers to the successful implementation of extended service hours.

¹¹ Jason Ransom (Dec 5, 2017) New York’s Next Subway Chief Will Mull Closing Lines for Repairs from <https://www.nytimes.com/2017/12/15/nyregion/new-york-subway-chief-closing-lines.html>

7.2.4 Maintenance Windows

The current non-service window of Vancouver's SkyTrain system is found to be similar to other cities with transit networks of similar age and size. (Refer to Section 4 for detail).

It is understood that a weekly average of 17 to 27 hours of maintenance window can be used depending on the areas of maintenance activities scheduled. (Refer to Section 3.3)

Engineering hours for Fridays and Saturdays are valued greatly as they are the largest maintenance windows of the week. Many "big ticket" maintenance activities and capital projects are scheduled on these two days. Operating extended service hours over weekends will significantly reduce the effective maintenance time for the maintenance team and impact the schedules for both the maintenance and capital project teams.

Effective asset management system and task priority system are critical for both the maintenance team and capital projects team. The AMS is currently under development by BCRTC. This system can assist the operator and maintainer in schedule optimization and ensure that SkyTrain is maintained in a "State of Good Repair".

Moving maintenance equipment and crew from the MSF to the maintenance site is another constraint that consumes valuable maintenance hours. One of the mitigation methods is utilizing decommissioned vehicles to transport the maintenance crew to site with line speed ATO. This will improve the efficiency and safety of the maintenance crew.

Limited storage facility along the mainline for maintenance equipment is another constraint that limits the maintenance efficiency. The current maintenance regime can be further improved by building and utilizing more storage facilities along the mainline to reduce the maintenance build up time and provide more effective maintenance hours within a shorter timeframe.

Furthermore, the maintenance plan on Sundays (Monday morning) will also be impacted to fix/address the outstanding items carried over the weekend due to the extended service. Currently, the maintenance activity can, on the rare occasion, overrun into the morning service of Sundays. This can have a critical impact if the maintenance activities overrun and disrupt Monday morning service.

7.2.5 Operational Flexibility

Unlike New York Transit, the SkyTrain track configuration was not designed to operate over extended periods of time. New York's configuration (in excess of two tracks per line) enables the operator extended flexibility to operate. As a result, New York is able to operate 24/7. This is unique among worldwide metros.

Should TransLink pursue 24/2 services, SkyTrain would be the first unmanned 24/2 operation in the world. The unattended functionality offers numerous benefits over their staffed equivalents. These include:

- › No need to provide staff facilities at terminus stations
- › Rapid reaction of standby vehicles
- › No driver scheduling concerns
- › Schedule redetermination without need to consider staffing levels

In a lessons learned from London's Night Tube, trade union discussions enabling extended operation caused over twelve months delay to the overall program. This highlights the sensitivity around extended hours, but also the fact that as an unattended operation, SkyTrain finds itself uniquely positioned in this discussion.

7.2.6 Noise Impact

One of the major environmental impacts for SkyTrain is noise. Many condo buildings are built around SkyTrain lines and it is important to consider the noise impact to the residents in these areas.

TransLink received 466 noise complaints in 2017, up from 344 in 2014, as illustrated in the figure below. These complaints range from station upgrade construction and after-hours rail grinding to station announcements and wheel noise. Most of the noise complaints are on the Expo Line, which began operation in late 1985 and is the oldest part of the SkyTrain network.

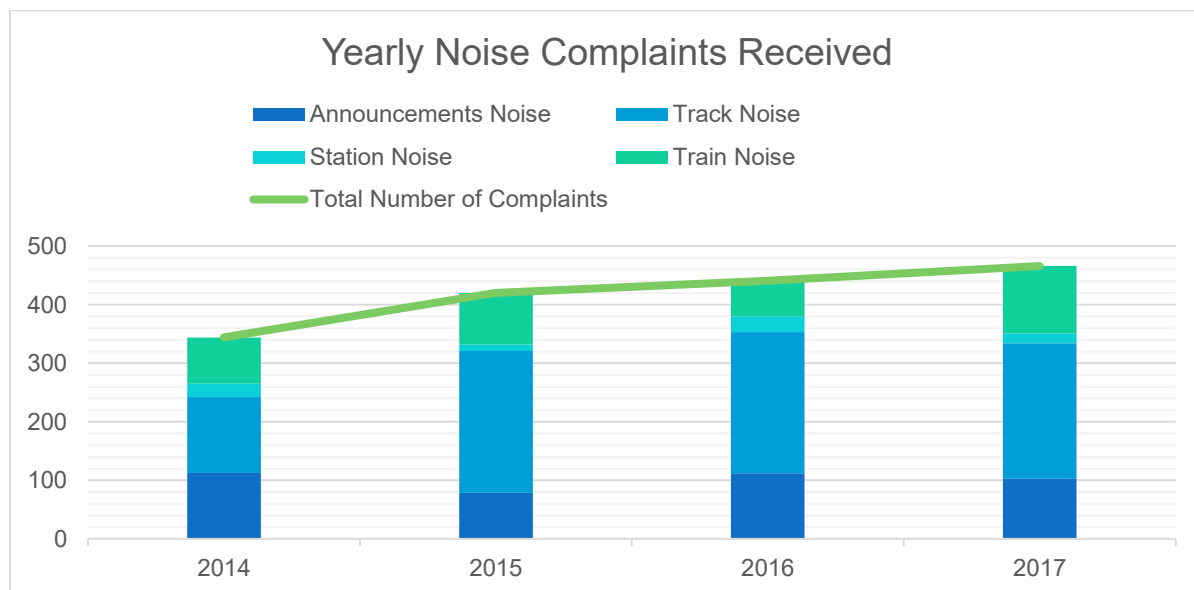


Figure 26: Yearly Noise Complaints Received 2014 - 2017

The number of complaints is anticipated to increase further with extended service hours.

Limited night-time operation with reduced speed can be implemented to reduce some of the noise induced by SkyTrain. Upgrading tracks and vehicles with noise reduction mechanisms is another option that can potentially reduce the noise generated during extended service hours.

TransLink and BCRTC have started a separate noise assessment study to address this issue in detail.

7.3 Readiness in Operating Extended Service Hours

Many challenges and constraints have been identified in the SkyTrain system today that will need to be addressed in order to operate extended service hours. Some of these challenges can be overcome through asset upgrades that are already being scheduled. An asset management system is currently being developed that can further improve the efficiency of maintenance and capital project works.

Expanding the workforce with competent staff and proper renegotiation of the collective agreement is a key enabler that permits safe and reliable services during the extended service hours.

Through adapting a robust maintenance and capital projects scheduling scheme and optimized operation planning, SkyTrain can achieve extended service hours operation.

8. Stage 2 – Option Evaluation

8.1 Introduction

This section describes the option development process that has been carried out by the Project team. It also describes the high-level evaluation of extending the service hours of the SkyTrain network by reviewing the potential costs and benefits for each option developed.

8.2 Option Development

A number of service characteristics have been reviewed to develop potential options. These include:

- › Independent Operation or Combination of Line(s)
- › Terminal Options
- › Service Patterns
- › Headways
- › Days of week
- › Service Hours
- › Track Utilizations

The variations under each service characteristic are summarized in Figure 27, p.76:

Independent Operation or Combination of Line(s)		Terminal Options		Service Patterns		Headway		Days of the Week		Service Hours		Track Utilizations
<ul style="list-style-type: none"> › Expo Line › Millennium Line 	X	<ul style="list-style-type: none"> › Waterfront › Granville › Vancouver City Centre › Surrey Central › King George › VCC-Clark › Commercial-Broadway › Lafarge Lake › Lougheed Town Centre 	X	<ul style="list-style-type: none"> › 2-way stops at all stations in between the terminal options › 2-way limited stops in between the terminal options › Outbound stops only in between the terminal options 	X	<ul style="list-style-type: none"> › 15 minutes › 20 minutes › 30 minutes 	X	<ul style="list-style-type: none"> › Fridays and Saturdays › Fridays only › Saturdays only 	X	<ul style="list-style-type: none"> › 24-hour operation › Extended service hours to or beyond 3:30 am › Extended service hours to or beyond 3:30 am and with service ending earlier on the subsequent days 	X	<ul style="list-style-type: none"> › Both inbound and outbound tracks › Single track only › Hybrid (i.e. Partially two tracks and partially single track operation)

Figure 27: Variations by each service characteristic

The diagram above highlights a large number of options that could be considered. To reduce the number of options reviewed and ensure a set of feasible and robust options are evaluated, the following assumptions have been applied:

- › Late night Friday and Saturday ridership is similar and therefore we propose operating services both days.
- › Expo Line will be operating between Waterfront and Surrey Central as Waterfront and Surrey Central were two stations with high levels of activity; indicating there is activity at both ends of the Line and that short-turns (e.g., Granville to Surrey Central) are significantly less desirable than full length trips.
- › King George, Braid and Sapperton stations on the Expo Line will not be served. These 3 stations have low alighting volumes in the 23:00-2:00 period for the entire Expo Line on weekday and weekends (Refer to Figures 13 and 14).
- › Millennium Line will start operations at Commercial-Broadway rather than VCC-Clark. VCC-Clark station has the lowest total boardings and alightings in the 23:00-2:00 period for the entire Millennium Line on Saturdays (Refer to Figure 15 and 16).
- › As discussed in Section 3.6.1, Expo Line accounts for over 75% of the total late-night SkyTrain boardings. As a result, we consider operating the Expo and Millennium Lines or the Expo Line only. The two options are shown in Figures 24 and 25 in addition to the N9 and N19 NightBus routes.
- › In line with other cities providing late-night rail service, we propose to run a “full” service serving all stations in both directions. This avoids passenger confusion and ensures a consistent service is provided at all times (note station terminal changes discussed above).
- › A 15-minute headway (approximately) is assumed to be operated. While a 30-minute headway could be warranted due to demand levels, a more important consideration will be the wait times and safety and security issues arising from crowding on platforms of late night passengers. Note that 14 of the 18 late night rail services reviewed have a headway under 30 minutes (Refer to Table 9).
- › Single track operation is not able to achieve 15-minute headway.

An important consideration will be the service hours to operate i.e. whether extending the service hours only or running 24-hour services on Fridays and Saturdays. Extending the service to meet the 3 a.m. closure time for bars on Granville Street means the last train would have to leave downtown at 3:30 a.m. Some consideration of extending this might be needed to ensure bar workers that will finish later can also use the service. Given the late start on weekends, some engineering hours could be maintained depending on the exact extended service hours and operation scheme. With the reduced maintenance window, some of the engineering inspection work and minor maintenance could still be done. With a robust maintenance plan, this window could help address more critical issues. Moreover, over-running into Sunday morning operation is not as critical as on Monday morning due to the much higher demand on early morning weekdays.

Running a 24-hour service on Fridays and Saturdays means the earliest train would need to start launching to the main line at around 04:30 Friday morning and the last train would continue running until 00:30 Monday morning. The routine maintenance plan on Monday morning will be impacted to fix/address the outstanding items carried over the weekend due to the extended service.



Figure 28: Proposed Late Night SkyTrain Service Options with Expo and Millennium Lines

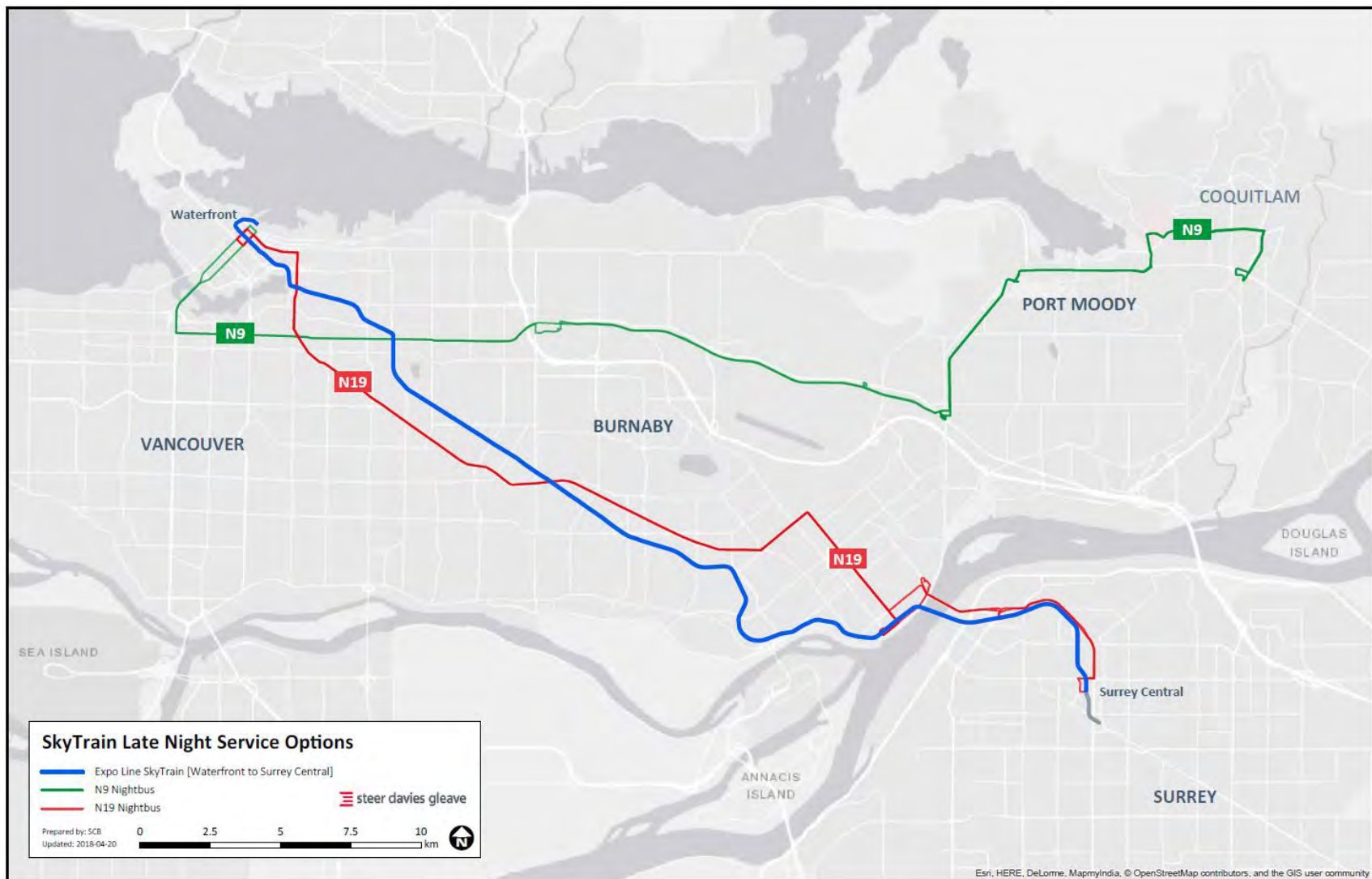


Figure 29: Proposed Late Night SkyTrain Service Options with Expo Line Only

Based on the analysis and assumptions above, four options have been identified. The four base options are:

- › Option 1 - Extended Service Hours, Expo & Millennium Lines
- › Option 2 - Extended Service Hours, Expo Line Only
- › Option 3 - 24-Hour Service, Expo & Millennium Lines
- › Option 4 - 24-Hour Service, Expo Line Only

The four options proposed could include a number of service characteristics presented above which are considered sub-options or permutations. These sub-options can be considered in the later phases of the project as required based on the outcome of this stage of the evaluation.

Details of these base options and the potential sub-options/permutations are detailed in the tables below.

Table 14: Option 1 - Extended Service Hours, Expo & Millennium Lines

Service Characteristics	Base	Sub-Options/Permutations
Lines Operated	Expo & Millennium	n/a
Terminal Options	Waterfront to Surrey Central Commercial-Broadway to Lafarge Lake	Granville to Surrey Central Commercial-Broadway to Lougheed
Service Patterns	2-way stops at all stations in between the terminal options	2-way stops at limited stations in between the terminal options
Headway	15 mins.	30 minutes or adjusted to optimize the number of operating vehicles
Days of Week	Friday & Saturday	Friday only Saturday Only
Service Hours	Extended Service Hours to or beyond 3:30 am	n/a
Track Utilization	Both inbound and outbound tracks	Single-track only (requires 30-minute headway) Hybrid (i.e. Partially two tracks and partially single-track operation)

Table 15: Option 2 - Extended Service Hours, Expo Line Only

Service Characteristics	Base	Sub-Options/Permutations
Lines Operated	Expo	n/a
Terminal Options	Waterfront to Surrey Central	Granville to Surrey Central
Service Patterns	2-way stops at all stations in between the terminal options	2-way stops at limited stations in between the terminal options
Headway	15 minutes.	30 minutes or adjusted to optimize the number of operating vehicles
Days of Week	Friday & Saturday	Friday only Saturday Only
Service Hours	Extended Service Hours to or beyond 3:30 am	n/a
Track Utilization	Both inbound and outbound tracks	Single-track only (requires 30-minute headway) Hybrid (i.e. Partially two tracks and partially single-track operation)

Table 16: Option 3 – 24-Hour Service, Expo & Millennium Lines

Service Characteristics	Base	Sub-Options/Permutations
Lines Operated	Expo & Millennium	n/a
Terminal Options	Waterfront to Surrey Central Commercial-Broadway to Lafarge Lake	Granville to Surrey Central Commercial-Broadway to Lougheed
Service Patterns	2-way stops at all stations in between the terminal options	2-way stops at limited stations in between the terminal options
Headway	15 minutes.	30 minutes or adjusted to optimize the number of operating vehicles
Days of Week	Friday & Saturday	Friday only Saturday Only
Service Hours	24-Hour Service	n/a
Track Utilization	Both inbound and outbound tracks	Single-track only (requires 30-minute headway) Hybrid (i.e. Partially two tracks and partially single-track operation)

Table 17: Option 4 – 24-Hour Service, Expo Line Only

Service Characteristics	Base	Sub-Options/Permutations
Lines Operated	Expo	n/a
Terminal Options	Waterfront to Surrey Central	Granville to Surrey Central
Service Patterns	2-way stops at all stations in between the terminal options	2-way stops at limited stations in between the terminal options
Headway	15 min.	30 minutes or adjusted to optimize the number of operating vehicles
Days of Week	Friday & Saturday	Friday only Saturday Only
Service Hours	24-hour Service	n/a
Track Utilization	Both inbound and outbound tracks	Single-track only (requires 30-minute headway) Hybrid (i.e. Partially two tracks and partially single-track operation)

The stations that are considered popular during night-time are shown in the table below.

Table 18: Popular stations for extended service hours

Service	Stations
Waterfront to Surrey Central	Waterfront, Burrard, Granville, Broadway/ Commercial, Joyce Collingwood, Metrotown, New Westminster, Surrey City Centre
Commercial-Broadway to Lafarge Lake	Commercial-Broadway, Brentwood, Lougheed Town Centre, Coquitlam Centre, Lafarge Lake-Douglas







8.3 Multiple Account Evaluation Framework

8.3.1 Overview of Accounts, Criteria, and Approach to Scoring

A Multiple Account Evaluation (MAE) framework consistent with TransLink's standard MAE framework is used. Criteria have been identified that will help differentiate the evaluation between the different rapid transit options evaluated, and also where possible, to provide a comparison against alternative approaches that are being considered parallel to this scope of work. Accounts and criteria are therefore included that may not be appropriate within this evaluation but are included for consistency. These are marked as not appropriate (N/A).

The proposed accounts and associated criteria are detailed in the table below.

Table 19: Options evaluation criteria

 Transportation	 Financial	 Environment	 Social, Community and Safety	 Urban Development	 Economic Development
Ridership Potential	Operational Cost	Noise	Safety	N/A	Supportive of employment (Shift Work)
Effect on System Maintenance	Maintenance Costs	Power Consumption	Emergencies		Supportive of 24-hour economy
Effect on the delivery of Capital Projects	Capital Costs (see note 1 below)				
Journey time	Policing Costs				
Service Frequency					
Service Coverage					

*1 Costs associated with any capital improvements or equipment costs

The MAE is both a quantitative and a qualitative evaluation with the options compared to the operation and maintenance of the system today.

Qualitative Scoring

Table 20: Scoring criteria

Score	Value
+2	Very Good / High Benefit
+1	Good / Benefit
0	Neutral
-1	Poor / Dis-benefit
-2	Very Poor / Large Dis-benefit

The evaluation will compare the options against the operation and maintenance of the system today, the so-called Business As Usual (BAU). We assume that the BAU will include:

- › N9 (Downtown-Coquitlam) and N19 (Downtown-Surrey Central) Night buses at current headways, travel times, and ridership levels.
- › Assumed annual operating costs of \$310,000 for N9 and \$555,000 for N19 (from 2016 Transit Service Performance Review).
- › The evaluation also considers each option alongside the other options to ensure a comparison is provided both against the BAU and comparison between the options.

8.3.2 Transportation Account

Ridership Potential

There is no forecasting tool available for late night demand. Ridership potential is presented as the range between current NightBus demand and potential SkyTrain demand between 1:00 am - 5:00 am on average Friday and Saturday nights as follows:

- › 1:00am-2:00am and 2:00am-3:00am based on the demand reduction observed on SkyTrain between 11:00pm and 1:00am i.e. assume a progressive reduction in demand as the night progresses; and
- › 3:00am-4:00am and 4:00am-5:00am based on the NightBus demand profile for those hours.

The ridership potential estimates for NightBus and SkyTrain are summarized below.

Table 21: Ridership estimate for SkyTrain and NightBuses

	1:00 a.m.-3:30 a.m.	1:00 a.m.-5:00 a.m.
N9 (Downtown-Coquitlam)	172	231
N19 (Downtown-Surrey)	271	376
Expo Line	3,563	4,221
Millennium Line	4,120	4,901

Effect on System Maintenance

This criterion considers the potential impact on the current maintenance of the system, which could include assumptions on how maintenance practices are changed to help mitigate any potential impacts or issues.

Effect on Delivery of Capital Projects

A number of longer term capital improvement to stations and facilities are ongoing and will continue to be undertaken on the corridors, the majority of which relate to the Expo Line. The extended hours of operation is considered and its potential impacts on the ability to deliver these works in a similar timescale to the BAU. Any proposed mitigation measures could be identified and included in the evaluation.

Journey time

Considers the end-to-end journey time for customers compared to the current Night Bus service.

Service Frequency

Considers the benefit from any increase in service frequency compared to that of the current Night Bus service.

Service Coverage

Considers the area covered by the proposed service as compared to the existing Night Bus.

8.3.3 Financial Account

Operational and Maintenance Cost

The cost of operations and maintenance is assumed to increase based on the costs associated with the extension of the opening hours, the service provided, and the number of stations served.

Costs associated with operating the service will depend on the frequency of the service provided, the length of the trains, and the hours the additional service is provided. The trains are assumed to be either 6 car Mark 1 or 4 car Mark 3 trains on the Expo line, and 2 car Mark 2 trains on the Millennium line.

The station facilities will need to include operational ticketing, lighting, escalators, elevators, and a station attendant complete with appropriate support and supervision. The increase in operations also results in greater use of trains and infrastructure with a corresponding increase in necessary maintenance.

Order of magnitude operating and maintenance costs have been developed for each of the options based on the different criteria. The costs have been developed using 2015 SkyTrain costs inflated to 2018. The costs are for a single year of extended operation.

Incremental Maintenance Costs

The maintenance costs for the system are assumed to increase due to the increased utilization of the system, facilities, and trains. These costs are included above. Incremental maintenance costs over and above the cost above could be incurred. These could be due to the timing of maintenance activities such as changes to alternative nights of the week, which could require the number of maintenance personnel to be increased based upon the current maintenance staff levels and limited shift cover to undertake the same work in a more compressed timescale. The increased utilization of the system could also require additional maintenance team cover, to provide an increased ability to respond quickly to any system faults that may occur.

As above, an order of magnitude incremental maintenance cost has been developed based on the characteristics of the different options considered, and the 2015 SkyTrain cost information.

Capital Costs

Capital costs are any costs related to work or equipment required due to the extension of service hours. An example is the installation of shutters at Broadway and Commercial between Expo and Millennium lines if only the Expo line was to operate late.

In advance of extending service hours, a number of the systems reviewed undertook advance renewals or enhancements to the system to improve operability, reliability, and maintainability. These costs would be considered a capital cost. The project team has not considered this within the current phase of work.

In addition, specialist tools and equipment might be required to facilitate the maintenance of the system more effectively within a more limited number of overnight closures. These costs are also considered.

As above, an order of magnitude cost has been identified.

Policing Costs

The system is not currently policed when closed. A police presence would be required in the form of an additional overnight shift pattern. TransLink's Chief of Transit Police identified a need for 16 officers, support staff, and equipment for the additional overnight cover. Each shift is 10

hours in length. Thus, in addition to the costs incurred directly by the increased hours, there would be additional police presence at other times of the day, which would be an additional benefit that should be considered.

Order of magnitude costs for additional policing are based on 2017 information.

8.3.4 Environmental Account

Noise

Any increase in noise due to the extended service hours of operation is considered based on the noise measurement data recorded from the trains. Increased noise on weekday nights from a revised maintenance regime is also considered.

Power Consumption

The increase in power consumption due to the extended service hours of operation is considered, although, with Hydro generation, the effect remains carbon neutral.

8.3.5 Social, Community and Safety

Safety

The safety of customers is considered under this criterion, which considers the time passengers wait at stations, the time between stations, and any other safety concerns identified with an option being considered. The advocates for downtown businesses, including BarWatch and the DVBA have also pointed out that the violence on the Granville entertainment district can be partly attributed to the lack of late night SkyTrain services. This information has not been substantiated.

The benefit of additional police resources is also considered.

Emergencies

This criterion considers emergency response and potential issues. An example would be stopping the train at a closed station and the ability and time for staff and emergency services to gain access to the location.

8.3.6 Urban Development

The urban development account is retained for consistency with TransLink's MAE process but is not applicable to this work as there will be very limited to no increase in development along the transit corridors being considered, due to the provision of extended hours service.

8.3.7 Economic Development

Supportive of employment (Shift Work)

This considers if an option is of value to shift workers by improving travel times and accessibility for Downtown Vancouver workers who live further out of the area.

Supportive of 24-hour economy

This considers if an option is supportive of a 24-hour economy by improving access and transit travel times for a range of leisure activities including entertainment (concerts, events, theaters) and night life (pubs, clubs, restaurants).

8.4 Option Description

8.4.1 Option 1 - Extended Service Hours, Expo & Millennium Lines

Operations

The following are assumed:

- › Two additional hours of operation on Friday and Saturday
- › 15-minute service headway inbound and outbound
- › 18 Expo Line stations open
- › 15 Millennium Line stations open
- › 6-car Mark 1 or 4-car Mark 3 trains on the Expo line
- › 2-car Mark 2 trains on the Millennium line.

Maintenance

The following are assumed:

- › Additional electronics maintenance cover, beyond current day shifts
- › Additional power maintenance cover, beyond current day shifts
- › Additional guideway maintenance teams would be required to undertake work in remaining overnight maintenance hours. This could include guideway techs, guideway service persons, and guideway laborers.

Police

The following are assumed:

- › All additional police shifts would be allocated to the extended service hours operations on Friday and Saturday.

Capital Costs

The following are assumed:

- › ATC upgrades
- › Additional station gating requirements
- › Reprogramming of the Compass fare system
- › Additional guideway maintenance equipment such as speeder, and crew speeder with flat cart.

8.4.2 Option 2 - Extended Service Hours, Expo Line Only

Operations

The following are assumed:

- › Two additional hours of operation on Friday and Saturday
- › 15-minute service headway inbound and outbound
- › 18 Expo Line stations open
- › 6-car Mark 1 or 4-car Mark 3 trains.
- › Maintenance
- › The following are assumed:
 - › Additional electronics maintenance cover, beyond current day shifts
 - › Additional power maintenance cover, beyond current day shifts
 - › Additional guideway maintenance teams would be required to undertake work in remaining overnight maintenance hours. This could include guideway techs, guideway service persons, and guideway laborers.

Police

The following are assumed:

- › Two of the four additional police shifts would be allocated to the extended service hours operations on Friday and Saturday
- › The remaining shift and hours would provide a benefit of additional policing during normal operating hours.

Capital Costs

The following are assumed:

- › ATC upgrades
- › Additional station gating requirements
- › Shutter installation at Broadway and Commercial between Expo and Millennium Lines
- › Reprogramming of the Compass fare system
- › Additional guideway maintenance equipment such as a speeder, and crew speeder with flat cart.

8.4.3 Option 3 - 24-Hour Service, Expo & Millennium Lines

Operations

The following are assumed:

- › 5.5 additional hours of operation on Friday
- › 6.5 additional hours of operation on Saturday
- › 15-minute service headway inbound and outbound
- › 18 Expo Line stations open
- › 15 Millennium Line stations open
- › 6-car Mark 1 or 4-car Mark 3 trains on the Expo line
- › 2-car Mark 2 trains on the Millennium line.

Maintenance

The following are assumed:

- › Additional electronics maintenance cover, beyond current day shifts
- › Additional power maintenance cover, beyond current day shifts
- › Additional guideway maintenance teams would be required to undertake work in remaining overnight maintenance hours. This could include guideway techs, guideway service persons, and guideway laborers.

Police

The following is assumed:

- › All additional police shifts would be allocated to the 24-hour operations on Friday and Saturday.

Capital Costs

The following are assumed:

- › ATC upgrades
- › Additional station gating requirements
- › Reprogramming of the Compass fare system
- › Additional guideway maintenance equipment such as a speeder, and crew speeder with flat cart.

8.4.4 Option 4 - 24-Hour Service, Expo Line Only

Operations

The following are assumed:

- › 5.5 additional hours of operation on Friday
- › 6.5 additional hours of operation on Saturday
- › 15-minute service headway inbound and outbound
- › 18 Expo Line stations open
- › 6-car Mark 1 or 4-car Mark 3 trains.

Maintenance

The following are assumed:

- › Additional electronics maintenance cover, beyond current day shifts
- › Additional power maintenance cover, beyond current day shifts
- › Additional guideway maintenance teams would be required to undertake work in remaining overnight maintenance hours. This could include guideway techs, guideway service persons, and guideway laborers.

Police

The following are assumed:

- › Two of the four additional police shifts would be allocated to the 24-hour operations on Friday and Saturday
- › The remaining shift would provide a benefit of additional policing during normal operating hours.




Capital Costs




The following are assumed:

- › ATC upgrades
- › Additional station gating requirements
- › Shutter installation at Broadway and Commercial between Expo and Millennium Lines
- › Reprogramming of the Compass fare system
- › Additional guideway maintenance equipment such as a speeder, and crew speeder with flat cart.

8.5 Evaluation of Options

Summary of the evaluation scores for each option is provided below. Details of the evaluation can be found in Appendix B, p.101.

	Scoring			
 Transportation	Option 1 Extended Hours Expo & Millennium	Option 2 Extended Hours Expo Only	Option 3 24-Hour Service Expo & Millennium	Option 4 24-Hour Service Expo Only
Ridership Potential	+1	+1	+2	+1
Journey time	+1	+1	+1	+1
Service frequency	+1	+1	+1	+1
Service Coverage	0	0	0	0
Effect on System Maintenance	-1	-1	-2	-2
Effect on the delivery of Capital Projects	-1	-1	-1	-1
 Financial				
Operational and Maintenance Cost	-1	-1	-2	-1
Incremental Maintenance Cost	-1	-1	-2	-2
Capital Costs	-2	-2	-2	-2
Policing Costs	-1	-1	-1	-1
 Environment				
Noise	-2	-1	-2	-1
Power Consumption	0	0	0	0

 Social, Community, and Safety				
Safety	0	+1	0	+1
Emergencies	0	0	0	0
 Urban Development				
N/A	0	0	0	0
 Economic Development				
Supportive of employment (Shift Work)	+1	+1	+1	+1
Supportive of 24-hour economy	+1	+1	+2	+2

8.6 Implementation Risk and Potential Mitigation Strategies for Short-listed Options

The project team undertook an exercise to identify high-level implementation risks should TransLink execute any plan to extend the operating hours of the SkyTrain network. These risks have been identified following the near-completion of this study, and aims to promote concept-level risks for consideration by TransLink and BCRTC.

The following table presents a number of multi-discipline risks, together with mitigation candidates.

Table 22: Potential Risks of Implementing Extended Service Hours

	Issue Description	Most Affected	Mitigation Candidates	Comment
R1	Reduced maintenance window as a result of extended operation hours.	Maintenance	<ul style="list-style-type: none"> › Shorter operating hours Mon-Thurs to extend mid-week maintenance window › Friday only or Saturday only extended service › Utilize decommissioned vehicles to store, transport crew and equipment to work site › Purchase new maintenance equipment to improve efficiency of maintenance work › Investigate possibility of fitting maintenance vehicles with ATC to enable maintenance vehicle movements during service hours 	<p>The severity and mitigation for this issue depends largely on the option selected by TransLink.</p> <p>These mitigations have been highlighted without consideration for costs, at this stage of the project.</p>
R2	Extended service hours result in insufficient stabling on mainline.	Operations	<ul style="list-style-type: none"> › Study required to re-evaluate solution to stable the fleet in a manner that meets the needs of operators 	<p>The procurement of new trains requires more stabling, which will put the existing stabling plan under pressure.</p>

	Issue Description	Most Affected	Mitigation Candidates	Comment
R3	Perceived risk of poor behaviour on rail vehicle and causes delay.	Operations	<ul style="list-style-type: none"> Study required to consider what presence is necessary on board trains and at stations to prevent/react to poor behaviour on the system 	There is likely to be a “bedding in” period for the railway and the public. London found the crime rate and risk of anti-social behaviour was less than anticipated.
R4	Lack of first line tech support. This results in extended mean time to repair.	Operations & Maintenance	<ul style="list-style-type: none"> Recruit technical staff to meet the needs of the expanded service 	It appears the current provision of technical staff is insufficient to meet the needs of the extended service.
R5	Perceived safety risk to station staff.	Operations	<ul style="list-style-type: none"> Increased Transit Police presence Frequent trains Increased staffing (no lone working) 	Frequent trains result in reduced wait times for passengers under the influence.
R6	Insufficient staffing provision and shift scheduling to permit new timetable (with extended service hours).	Operations & TransLink	<ul style="list-style-type: none"> Limited stops for extended hours Recruit technical and operational staff to meet the needs of the expanded service 	Limited stops would have a significant impact to other aspects of the rail service. Recruitment needs ongoing integration with contract negotiations.
R7	Incompatible / insufficient transit provision for the “Last Mile”.	TransLink	<ul style="list-style-type: none"> Study required to determine needs at high profile interchange stations e.g., Surrey 	This issue is likely to require more work if some stations are closed for extended hours.

	Issue Description	Most Affected	Mitigation Candidates	Comment
R8	Passenger numbers during extended service hours provision insufficient to sustain service (e.g., alternative travel mode like UBER).	TransLink	<ul style="list-style-type: none"> › Clear success criteria agreed with stakeholders (not limited to passenger access or on-time performance) › Strong external communications 	This has been observed at other cities – the business case requires thorough analysis.
R9	At this stage, insufficient detail available to quantify the level of necessary capital spending.	TransLink	<ul style="list-style-type: none"> › Further study required on the technical and operational impact of extended hours on the railway system 	This has been outlined in Stages 3, 4 and 5 of RFP No. Doc1236451632.
R10	Negative publicity induced / experienced as a result of increased noise pollution.	TransLink & BCRTC	<ul style="list-style-type: none"> › Technical analysis of root cause, with mitigation candidates › Speed restrictions during extended hours › Additional track noise limitations › Noise barriers › New trains with robust specification on noise › Plant vegetation where possible 	<p>This issue appears to be under study. Listed for completeness and to suggest further mitigations.</p> <p>It should be noted that a reduction in train speeds will have a corresponding impact on journey times, thereby reducing operational flexibility. This may result in the need for more trains to support the new timetable.</p>

	Issue Description	Most Affected	Mitigation Candidates	Comment
R11	Union resistance to a new collective contract agreement.	TransLink & BCRTC	<ul style="list-style-type: none"> Review lessons learned from London at detailed level Commence review of potential remuneration options for night shift 	This is naturally a sensitive issue and requires careful planning and acceptance of working unsocial hours.
R12	Difficult to revert back to normal service hours (internal)	TransLink & BCRTC	<ul style="list-style-type: none"> Review lessons learned from other transit systems who have been required to “migrate back” to normal operating hours 	The railway will be required to update processes, plans, timetables etc. Reversion would bring about further costs. (e.g., shift variations, staff reduction costs, public relation costs etc.)
R13	Costs of extended service hours increase daytime user cost and causes public outcry.	TransLink	<ul style="list-style-type: none"> Investigate funding from businesses who seek the extended service Investigate pricing for late night fares 	There are unique revenue streams which may be worth considering in future (e.g., NYE service for London is sponsored and free to all passengers).
R14	System reliability and availability is impacted following the implementation of extended service hours’ operation.	TransLink & BCRTC	<ul style="list-style-type: none"> Ensure positive system demonstration months prior to opening to public (closed to passengers) Review asset condition regularly and bring forward any necessary maintenance to take advantage of longer weekend engineering hours 	It should be noted that few (if any) SkyTrain systems in revenue service were specified for 24-hour running. As a result, there needs to be an expectation of variation to Systems to facilitate extended hours operation.

	Issue Description	Most Affected	Mitigation Candidates	Comment
R15	Insufficient time and resource for capital projects to access the railway.	TransLink & BCRTC	<ul style="list-style-type: none"> Continued development of Asset Management System (AMS) Development of track access planning system which permits stakeholder access to the system 	A planning tool with stakeholder access was key to enabling London meet their maintenance activities.
R16	Cost increases for future and existing projects without support for extended service hours in their existing contracts.	TransLink	<ul style="list-style-type: none"> Seek ways to de-risk and optimise works which require access to the railway 	TransLink should consider the impact to their existing projects.
R17	Current cleaning regime may not be sufficient for anticipated demands of the extended service.	BCRTC	<ul style="list-style-type: none"> Review current cleaning regime for suitability on extended service hours. 	Late-night passengers are more likely to cause undesirable waste on board trains. Review of operational impact to these events.

9. Next Steps

The objective of the feasibility study was to review and investigate BCRTC and TransLink Security Management Limited's (TSML) current service operations along with a review of other transit agencies worldwide to identify the challenges and constraints for the extended service operation. The study produced concept options and trade-offs that have been guided by research and interviews with key staff members, feedback from other operators, and the experience of the team members. The information contained within this report can be used to assist decision making in enabling the SkyTrain system to operate with extended service hours.

The Project team has identified the following actionable items for TransLink's consideration as part of the next steps:

- › TransLink to host stakeholder sessions to communicate findings of this report and verify they are aligned with stakeholder and community needs.
- › TransLink to provide guidance and direction on:
 - Which of the four presented service hour extension options (and/or any sub-options) should proceed into detailed analysis, and
 - Which of the presented mitigation measures should be investigated.
- › Once a preferred service hour extension plan has been identified, the project team shall proceed with a series of detailed analyses to identify:
 - How the railway will be operated,
 - How the railway will be maintained,
 - How the personnel requirements will change,
 - How safety and security will be maintained and enhanced,
 - How infrastructure and equipment requirements will change (e.g., ATC, Rolling Stock, etc.),
 - How other connected transit modes will need to change to render maximum benefit to users,
 - How the environment will be impacted, and
 - How extending the service hours will affect the energy consumption of the railway.
- › The Project team shall develop more detailed costs and revenues of operating extended service hours.
- › A number of potential external studies can be done as part of the next stage including but not limited to: legal and topographical surveys, environmental assessment (e.g., noise assessment), transportation impact assessment, and a detailed business case that determines the financial viability for operating with extended service hours and the potential of a 24-hour economy.


Appendix A: Data Received from TransLink



The following list of data was received from TransLink for Stages 1 and 2:




1. Compass Average Tap Ins (Entries) and Tap Outs (Exits) Records by day type, day of week, station and hour from February 1, 2017 to March 12, 2018
2. Spreadsheet with Daily Expo and Millennium Line Headways and Schedules as of January 2017
3. 2018 Expo/Millennium Train Storage Location Diagram
4. Expo Line Operations Map, Rev. 11 (DW-700400-001-D) dated July 24, 2002
5. Millennium Line Operations Map, Rev. 0 (MA-700400-002-D) dated March 3, 2017
6. Evergreen Line Operations Map, Rev. 0 dated June 11, 2015
7. Expo & Millennium Lines – First and Last Train Schedules as of January 2017
8. Expo & Millennium Lines – Location of Entry and Exit Time Boundaries
9. Expo & Millennium Lines – Entry and Exit Times for Guideway Maintenance Services
10. List of Existing Maintenance Equipment
11. 2018 Guideway Annual Maintenance Plan
12. SkyTrain Mark-I and Mark-II Vehicle Preventative Maintenance Program & Schedule Matrix, Rev. 1 (PP-922400-005-D) dated July 20, 2015
13. Previous proposal on a pilot project for Limited 24-Hour SkyTrain Service on Fridays and Saturdays, Rev. 2, October 11, 2011
14. Overview of 2010 Winter Olympic Operation Strategy
15. STA Staffing Counts During 2010 Winter Olympic
16. Expo and Millennium Lines Weekly Test Train Noise Data from June 15, 2017 to January 19, 2018
17. TransLink's 24-Hour Network Strategy, November 2008
18. TransLink's Late Night Transit Service Strategy, May 2015
19. Quarterly Overview of Customer Facing Facility Planning Activities, January 2018
20. McNeil Program Update, November 30, 2017
21. 2016 Night Bus Boarding by line, by direction and by average weekday, Saturday and Sunday
22. 2017 Night Bus Boarding and Alighting by stop
23. Night Bus Service Changes since 2010
24. BCRTC Organization Charts and Staff Number
25. 2017-18 Expo and Millennium Line Timetable Run Summaries
26. AIO Capital Project Resource Hours
27. Expo and Millennium Upgrade Program (EMUP) Schedule, March 2018
28. Command Accountability Review, 2016-2017 Service Extension Analysis
29. 2016 – 2017 Shift Strength vs Crime Volume by Hour of Day
30. Staffing and Infrastructure Requirements - Millennium Line Broadway Extension, Metro Vancouver Transit Police, August 2017
31. SkyTrain Operating Cost Information, BCRTC, 2015.

Appendix B: Evaluation of Options

Option 1 - Extended Service Hours, Expo & Millennium Lines


 Transportation	Evaluation	Scoring
Ridership Potential	880 to 8,440 passengers per weekend	+1
Journey time	<p>Journey time (considered here as door-to-door time) will be impacted by the following factors:</p> <ul style="list-style-type: none"> › SkyTrain has shorter station-to-station run time compared to NightBus. This saving is more significant the longer distance the passenger travels, and could be as much as a reduction from 82 mins. to 36 mins. from Granville Station to Surrey Central Station. › SkyTrain has longer walking time since passengers have to walk toward, and from the SkyTrain stations. In addition, passengers also spend longer time traversing within the station between the ground-level and platform-level as well as transferring at Commercial-Broadway station if taking the Millennium Line service; in comparison, NightBus has more stops and can stop on-demand based on passenger requests. This increase in journey time is irrespective of the distance the passenger travels. <p>Combining the above factors, the trend is that passengers who travel longer distance could experience major reduction in their travel time; passengers who travel only a few stations could experience longer travel time, particularly longer walking time. Therefore, at the feasibility stage, prior to conducting a detailed analysis on the centre of mass of journey pattern, there is insufficient evidence to conclude if there would be significant saving in journey time in terms of system-wide average performance.</p> <p>However, wait time is anticipated to be shorter compared to NightBus, as SkyTrain could operate at shorter headways than NightBus.</p>	+1
Service frequency	Based on the assumption that the SkyTrain night-time service will operate at 15 mins. headway, this represents a 25% reduction on Friday night (20 mins. headway for N9 and N19), and 50% reduction on Saturday night (30 mins. headway for N9 and N19) compared to an existing condition.	+1



Service Coverage	Overlapping with the coverage of N9 and N19 Night Bus services	0
Effect on System Maintenance	The weekly maintenance hours will be reduced by 5.5 hours for both Expo Line and Millennium Line on average (Roughly 25% reduction in weekly total maintenance hours) Major maintenance tasks and capital projects that are currently scheduled over the weekend maintenance windows will need to be rescheduled.	-1
Effect on the delivery of Capital Projects	Majority of the capital projects scheduled are on the Expo Line. Capital projects that require guideway access are impacted. Rescheduling is required.	-1
 Financial		
Operational and Maintenance Cost	\$2.3 M per year	-1
Incremental Maintenance Cost	\$2.4 M per year	-1
Capital Costs	\$5.0 – 7.5 M	-2
Policing Costs	\$3.4 M per year (all additional shifts required overnight to cover system). Need to hire a complete team regardless of the options, so the policing cost incurred is the same for all 4 options.	-1
 Environment		
Noise	Operating SkyTrain with increased operational hours increases noise in quieter hours. More noise complaints is anticipated from the residents around the SkyTrain lines.	-2




Power Consumption	<p>The expansion of service beyond the current provision will increase overall network power requirements. There are a number of factors which will feed into any power calculation – at the feasibility stage of this study, too many options remain available to model, however the following will feed into such a model:</p> <ul style="list-style-type: none"> › Size of fleet to provide service (e.g., x1 pair of MK I or a full-size MK IV) making up each consist › Frequency of service › Network coverage to be provided with extended service › Number of stations open › Planned time to commence ramp-up of AM service 	0
 <p>Social, Community, and Safety</p>		
Safety	No net benefit.	0
Emergencies	Stations through which the service/s operates would all be open to passengers and emergency services, therefore emergency access is not impeded.	0
 <p>Urban Development</p>		
N/A		0
 <p>Economic Development</p>		
Supportive of employment (Shift	Option will be supportive of weekend staff serving the entertainment industry but will	+1

Work)	provide limited benefits to permanent shift work staff.	
Supportive of 24-hour economy	Extended hours will support the entertainment industry by proving a travel alternative to bar closing demand.	+1

Option 2 - Extended Service Hours, Expo Line Only


 Transportation	Evaluation	Scoring
Ridership Potential	540 to 7,120 passengers per weekend	+1
Journey time	<p>Journey time (considered here as door-to-door time) will be impacted by the following factors:</p> <ul style="list-style-type: none"> › SkyTrain has shorter station-to-station run time compared to NightBus. This saving is more significant the longer distance the passenger travels, and could be as much as a reduction from 82 mins. to 36 mins. from Granville Station to Surrey Central Station. › SkyTrain has longer walking time since passengers have to walk toward, and from the SkyTrain stations. In addition, passengers also spend longer time traversing within the station between the ground-level and platform-level as well as transferring at Commercial-Broadway station if taking the Millennium Line service; in comparison, NightBus has more stops and can stop on-demand based on passenger requests. This increase in journey time is irrespective of the distance the passenger travels. <p>Combining the above factors, the trend is that passengers who travel longer distance could experience major reduction in their travel time; passengers who travel only a few stations could experience longer travel time, particularly longer walking time. Therefore, at the feasibility stage, prior to conducting a detailed analysis on the centre of mass of journey pattern, there is insufficient evidence to conclude if there would be significant saving in journey time in terms of system-wide average performance.</p> <p>However, wait time is anticipated to be shorter compared to NightBus, as SkyTrain could operate at shorter headways than NightBus.</p>	+1
Service frequency	Based on the assumption that the SkyTrain night-time service will operate at 15 mins. headway, this represents a 25% reduction on Friday night (20 mins. headway for N19), and 50% reduction on Saturday night (30 mins. headway for N19) compared to an existing condition.	+1


Service Coverage	Overlapping with the coverage of N19 Night Bus service. However, it does not cover the N9 service areas.	0
Effect on System Maintenance	<p>The weekly maintenance hours will be reduced by 5.5 hours for Expo Line on average. (Roughly 25% reduction in weekly total maintenance hours)</p> <p>Maintenance activities can be carried out as normal on Millennium Line.</p> <p>Major maintenance tasks and capital projects that are currently scheduled over the weekend maintenance windows will need to be rescheduled.</p>	-1
Effect on the delivery of Capital Projects	<p>Majority of the capital projects scheduled are on the Expo Line.</p> <p>Capital projects that require guideway access are impacted. Rescheduling is required.</p>	-1
 Financial		
Operational and Maintenance Cost	\$1.4 M per year	-1
Incremental Maintenance Cost	\$2.4 M per year	-1
Capital Costs	\$5.5 – 8.0 M	-2
Policing Costs	\$3.4 M per year (half of the additional shifts required overnight to cover system). Need to hire a complete team regardless of the options, so the policing cost incurred is the same for all 4 options. However, there is a benefit of extra policing on the system at the normal operating hours. This benefit is captured under the safety account.	-1
 Environment		




Noise	Operating SkyTrain with increased operational hours increases noise in quieter hours. More noise complaints is anticipated from the residents around the Expo Line.	-1
Power Consumption	<p>The expansion of service beyond the current provision will increase overall network power requirements. There are a number of factors which will feed into any power calculation – at the feasibility stage of this study, too many options remain available to model, however the following will feed into such a model:</p> <ul style="list-style-type: none"> › Size of fleet to provide service (e.g., x1 pair of MK I or a full-size MK IV) making up each consist › Frequency of service › Network coverage to be provided with extended service › Number of stations open <p>Planned time to commence ramp-up of AM service</p>	0
 Social, Community, and Safety		
Safety	The remaining shift would provide a benefit of additional policing during normal operating hours.	+1
Emergencies	Stations through which the service/s operates would all be open to passengers and emergency services, therefore emergency access is not impeded.	
 Urban Development		
N/A		0
		


Economic Development		
Supportive of employment (Shift Work)	Option will be supportive of weekend staff serving the entertainment industry but will provide limited benefits to permanent shift work staff.	+1
Supportive of 24-hour economy	Extended hours will support the entertainment industry by proving a travel alternative to bar closing demand.	+1

Option 3 - 24-hour Service, Expo & Millennium Lines


 Transportation	Evaluation	Scoring
Ridership Potential	1220 to 9,800 passengers per weekend	+2
Journey time	<p>Journey time (considered here as door-to-door time) will be impacted by the following factors:</p> <ul style="list-style-type: none"> › SkyTrain has shorter station-to-station run time compared to NightBus. This saving is more significant the longer distance the passenger travels, and could be as much as a reduction from 82 mins. to 36 mins. from Granville Station to Surrey Central Station. › SkyTrain has longer walking time since passengers have to walk toward, and from the SkyTrain stations. In addition, passengers also spend longer time traversing within the station between the ground-level and platform-level as well as transferring at Commercial-Broadway station if taking the Millennium Line service; in comparison, NightBus has more stops and can stop on-demand based on passenger requests. This increase in journey time is irrespective of the distance the passenger travels. <p>Combining the above factors, the trend is that passengers who travel longer distance could experience major reduction in their travel time; passengers who travel only a few stations could experience longer travel time, particularly longer walking time. Therefore, at the feasibility stage, prior to conducting a detailed analysis on the centre of mass of journey pattern, there is insufficient evidence to conclude if there would be significant saving in journey time in terms of system-wide average performance.</p> <p>However, wait time is anticipated to be shorter compared to NightBus, as SkyTrain could operate at shorter headways than NightBus.</p>	+1
Service frequency	Based on the assumption that the SkyTrain night-time service will operate at 15 mins. headway, this represents a 25% reduction on Friday night (20 mins. headway for N9 and N19), and 50% reduction on Saturday night (30 mins. headway for N9 and N19) compared to an existing condition.	+1


Service Coverage	Similar to the coverage of N9 and N19 Night Bus services	0
Effect on System Maintenance	<p>The weekly maintenance hours will be reduced by 9 hours for both the Expo Line and Millennium Line on average. (Roughly 36% reduction in weekly total maintenance hours)</p> <p>Major maintenance tasks and capital projects that are currently scheduled over the weekend maintenance windows will need to be rescheduled.</p>	-2
Effect on the delivery of Capital Projects	<p>Majority of the capital projects scheduled are on the Expo Line.</p> <p>Capital projects that require guideway access are impacted. Rescheduling is required.</p>	-1
 Financial		
Operational and Maintenance Cost	\$6.3 M per year	-2
Incremental Maintenance Cost	\$4.8 M per year. The additional maintenance cost associated with the increase in kilometres run has been included in the above operational cost. This additional maintenance cost is related to the additional maintenance staff that is required to provide more hours of cover to be able to react to faults under 24-hour operation. An extra maintenance team with the same number of personnel is required to undertake the works during the week regardless of running both lines or just running the Expo Line for 24-hours on Fridays and Saturdays.	-2
Capital Costs	\$5.0 – 7.5 M	-2
Policing Costs	\$3.4 M per year (all of the additional shifts required overnight to cover system). Need to hire a complete team regardless of the options, so the policing cost incurred is the same for all four options.	-1



 Environment		
Noise	Operating SkyTrain with increased operational hours increases noise in quieter hours. More noise complaints is anticipated from the residents around the SkyTrain lines.	-2
Power Consumption	<p>The expansion of service beyond the current provision will increase overall network power requirements. There are a number of factors which will feed into any power calculation – at the feasibility stage of this study, too many options remain available to model, however the following will feed into such a model:</p> <ul style="list-style-type: none"> › Size of fleet to provide service (e.g., x1 pair of MK I or a full-size MK IV) making up each consist › Frequency of service › Network coverage to be provided with extended service › Number of stations open <p>Planned time to commence ramp-up of AM service</p>	0
 Social, Community, and Safety		
Safety	No net benefit.	0
Emergencies	Stations through which the service/s operates would all be open to passengers and emergency services, therefore emergency access is not impeded.	0
 Urban Development		



N/A		0
 <p>Economic Development</p>		
Supportive of employment (Shift Work)	Option will be supportive of weekend staff serving the entertainment industry but will provide limited benefits to permanent shift work staff.	+1
Supportive of 24-hour economy	24-hour operation will support the entertainment industry by proving a travel alternative to the night time economy.	+2

Option 4 - 24-hour Service, Expo Line Only

 Transportation	Evaluation	Scoring
Ridership Potential	760 to 8,240 passengers per weekend	+1
Journey time	<p>Journey time (considered here as door-to-door time) will be impacted by the following factors:</p> <ul style="list-style-type: none"> › SkyTrain has shorter station-to-station run time compared to NightBus. This saving is more significant the longer distance the passenger travels, and could be as much as a reduction from 82 mins. to 36 mins. from Granville Station to Surrey Central Station. › SkyTrain has longer walking time since passengers have to walk toward, and from the SkyTrain stations. In addition, passengers also spend longer time traversing within the station between the ground-level and platform-level as well as transferring at Commercial-Broadway station if taking the Millennium Line service; in comparison, NightBus has more stops and can stop on-demand based on passenger requests. This increase in journey time is irrespective of the distance the passenger travels. <p>Combining the above factors, the trend is that passengers who travel longer distance could experience major reduction in their travel time; passengers who travel only a few stations could experience longer travel time, particularly longer walking time. Therefore, at the feasibility stage, prior to conducting a detailed analysis on the centre of mass of journey pattern, there is insufficient evidence to conclude if there would be significant saving in journey time in terms of system-wide average performance.</p> <p>However, wait time is anticipated to be shorter compared to NightBus, as SkyTrain could operate at shorter headways than NightBus.</p>	+1

Service frequency	Based on the assumption that the SkyTrain night-time service will operate at 15 mins. headway, this represents a 25% reduction on Friday night (20 mins. headway for N19), and 50% reduction on Saturday night (30 mins. headway for N19) compared to an existing condition.	+1
Service Coverage	Similar to the coverage of N19 Night Bus service. However, it does not cover the N9 service areas.	0
Effect on System Maintenance	<p>The weekly maintenance hours will be reduced by nine hours for Expo Line on average. (Roughly 36% reduction in weekly total maintenance hours)</p> <p>Maintenance activities can be carried out as normal on Millennium Line.</p> <p>Major maintenance tasks and capital projects that are currently scheduled over the weekend maintenance windows will need to be rescheduled.</p>	-2
Effect on the delivery of Capital Projects	<p>Majority of the capital projects scheduled are on the Expo Line.</p> <p>Capital projects that require guideway access are impacted. Rescheduling is required.</p>	-1
 Financial		
Operational and Maintenance Cost	\$3.9 M per year	-1
Incremental Maintenance Cost	\$4.8 M per year. The additional maintenance cost associated with the increase in kilometres run has been included in the above operational cost. This additional maintenance cost is related to the additional maintenance staff that is required to provide more hours of cover to be able to react to faults under 24-hour operation. An extra maintenance team with the same number of personnel is required to undertake the works during the week regardless of running both lines or just running the Expo Line for 24 hours on Fridays and Saturdays.	-2
Capital Costs	\$5.5 – 8.0 M	-2

Policing Costs	\$3.4 M per year (half of the additional shifts required overnight to cover system). Need to hire a complete team regardless of the options, so the policing cost incurred is the same for all four options. However, there is a benefit of extra policing on the system at the normal operating hours. This benefit is captured under the safety account.	-1
 Environment		
Noise	Operating SkyTrain with increased operational hours increases noise in quieter hours. More noise complaints is anticipated from the residents around the Expo Line.	-1
Power Consumption	<p>The expansion of service beyond the current provision will increase overall network power requirements. There are a number of factors which will feed into any power calculation – at the feasibility stage of this study, too many options remain available to model, however the following will feed into such a model:</p> <ul style="list-style-type: none"> › Size of fleet to provide service (e.g., x1 pair of MK I or a full-size MK IV) making up each consist › Frequency of service › Network coverage to be provided with extended service › Number of stations open <p>Planned time to commence ramp-up of AM service</p>	0
 Social, Community, and Safety		
Safety	The remaining shift would provide a benefit of additional policing during normal operating hours.	+1

Emergencies	Stations through which the service/s operates would all be open to passengers and emergency services, therefore emergency access is not impeded.	+2
 Urban Development		
N/A		0
 Economic Development		
Supportive of employment (Shift Work)	Option will be supportive of weekend staff serving the entertainment industry but will provide limited benefits to permanent shift work staff.	+1
Supportive of 24-hour economy	24-hour operation will support the entertainment industry by providing a travel alternative to the night time economy.	+1

AMENDMENT RECORD

Issue	Description	Distribution	Date
PA	Draft report for review	Tasia Balding	Apr. 23, 2018
PB	Draft report for review	Lois Breadner	Apr 24, 2018
PC	Draft report for review	Keith Foley Ian Sproul Rob Edgcumbe	Apr 26, 2018
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Approved by:	Rob Edgcumbe Director, Strategic Services, SNC-Lavalin	Date: Apr. 27, 2018

The background is a light blue gradient. It features numerous small, white, five-pointed stars of varying sizes scattered across the page. In the upper right corner, there is a large, stylized crescent moon in a light blue color. Inside the curve of the moon, there are three overlapping circles of different shades of blue, creating a layered effect.

2019 Late Night Service Report

Appendix B

Canada Line Phase 1



CANADA LINE EXTENDED SERVICE HOURS FEASIBILITY STUDY PROPOSAL

Stage 2 – Options and Tradeoffs

May 17th, 2018

Prepared by:		
Reviewed /Approved by:		
	Name, Title	Signature/Date
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CANADA LINE EXTENDED
SERVICE HOURS FEASIBILITY
STUDY PROPOSAL

REVISION LOG

Revision No.	Revision Date	Revision			Description of Revision
		Prepared	Reviewed	Approved	
0	April 27 th 2018				Early Draft
A	April 30 th 2018				First official Draft to TL and ITBC
1	May 17 th 2018				TransLink comments Minor updates

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1. Introduction


This feasibility study responds to the Stage Two scope of work from TransLink for the impact of the following scenarios to extend existing Canada Line Services.

1. Twenty-four hour service, seven days per week.
2. Twenty-four hour service on Friday and Saturday nights.
3. One-hour extension on Friday and Saturday nights.
4. Two-hour extension on Friday and Saturday nights.
5. Limited stops service

The study addresses the impact on the following functional areas:

- (a) Operational
- (b) Maintenance and Repair
- (c) Staffing/Labour
- (d) Safety and Security
- (e) Infrastructure
- (f) Financial
- (g) General requirements
- (h) Impacts on other related transit service modes (e.g. bus)
- (i) Environmental
- (j) Energy
- (k) Impact on key Sub-Suppliers
- (l) Impact on Concessionnaire activities
- (m) Impact on Concession Agreement

Several of the above functional areas have direct impacts on multiple disciplines within Protrans business unit.



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This study also includes Protrans recommendations for the extended service hours scenario and suggested service plans for its delivery. These both form part of the executive summary.

The Canada Line's current revenue service schedule is outlined in Section 7 of this document. Outside of revenue hours, extensive maintenance activities, most of which cannot be performed while trains are running, take place in Engineering Hours within a relatively small window. Specifically, most Guideway maintenance activities including walking inspections, rail profiling, switch maintenance etc. all fall into this category and must be performed either entirely during Engineering Hours or utilizing an extended window made available by late night single tracking when Engineering Hours alone is not sufficient for completion of the activity. Protrans currently focuses on major Guideway maintenance activities each week from Monday morning through to Friday morning, with less intrusive maintenance activities including Guideway inspections taking place on the remaining days.

2. Executive Summary

After assessing TransLink's proposed scenarios against the six evaluation criteria encompassed into the functional areas referenced in the scope of work, a summary of the evaluation is presented as follows:

2.1. Twenty-four hours seven days per week

The option for twenty-four hours service seven days per week is not recommended by Protrans with the current Canada Line infrastructure, as it will place significant risk on Protrans's ability to maintain the system [REDACTED]

[REDACTED] For these reasons it also would be non-complaint with the Concession Agreement's definition of an Acceptable Change as it would significantly

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affect Protrans's and the Concessionaire's ability to deliver their commercial O&M obligations [REDACTED]

Protrans does not recommend that TransLink continue to consider this option [REDACTED]

[REDACTED]

2.2. Twenty-four hours Friday and Saturday Nights

The option for twenty-four hour service on Friday and Saturday nights will also incur incremental O&M costs and would require Protrans to modify some current approaches to O&M activities. However given that it is only two nights per week and on nights where the Protrans currently performs lighter maintenance activities, the overall impact is much lower than seven days per week. In addition, as the maintenance window is already limited in terms of access to the guideway [REDACTED] it will essentially have the same effect on maintenance as extending service by one or two hours. All three scenarios involving extended hours on Friday and Saturday nights will result in the need to shift current maintenance activities to other nights of the week. A case could be made that it would be more efficient to provide service through the night rather than shutting the system down then reopening it an hour or under later.

This option would also require minimal changes to existing infrastructure if TransLink accepts Protrans' recommended service plan for extension of service. Protrans believes that this may be a viable option [REDACTED]

[REDACTED] In addition, the ridership data that Protrans has included in this study indicates that Friday and Saturday have a higher ridership after midnight than other nights of the week. Friday being the busiest after midnight with over 200% higher ridership compared to the same period on other week nights. This would indicate that potentially demand for an extended service during on other business days would attract a very low ridership.

[REDACTED]

2.3. One-hour Extension on Friday and Saturday Nights

This option presents the lowest impact on Protrans by far, as this service pattern is already operated once per year on New Year's Eve. As mentioned above, the shortened maintenance window already severely limits access to the guideway [REDACTED] with essentially the same effect on operations and maintenance as running all night service on Fridays and Saturdays.

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2.4. Two-hour Extension on Friday and Saturday Nights

Protrans viewed that there was no value in performing a detailed review of this option, due to the identical effect on operations and maintenance as running all night service on Fridays and Saturdays.

2.5. Limited Stop Service

Protrans viewed this as a sub-set of the options above in terms of possibly mitigating extended journey times due to the use of single tracking around maintenance areas during extended hours of operation. In pursuing this, a methodology of choosing the limited stop stations would need to be developed and justified to passengers and stakeholders such as the Cities of Richmond and Vancouver and Vancouver Airport Authority (YVRAA) if any of the non-stopping stations are to be within their respective areas of jurisdiction. Protrans expects a relatively high make-up of the ridership in any extended hours service to be multi-modal users transferring from or onto another mode of transport to complete their journey. This option could therefore focus on offering an express service connecting terminal stations and major bus loops Vancouver City Centre Station (VCS), Broadway Station (BWS), Marine Drive Station (MDS), Bridgeport Station (BPS) with fewer intermediate stops, reducing travel time and possibly reducing headway.

2.6. Service Plan Options



For a 24-hour service 7 days a week, the 30 minute service option would still be too restrictive on maintenance access. Protrans therefore proposes a headway of 60 minutes with a platoon of two trains departing Waterfront once per hour, thus allowing complete segregation of the Inbound and Outbound tracks aside from the three terminuses. Regular shutdowns of the terminuses will be required to facilitate maintenance from time to time,

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and complete shutdowns of the entire Canada Line will be required occasionally for wide-scale maintenance activities involving signaling and related electronic systems.

[REDACTED]

[REDACTED] Protrans suggests that a 15-minute service should be targeted to prevent passengers from waiting around for a lengthy duration on platforms, [REDACTED]

[REDACTED] It also will promote usage of the service as 30 minutes is a long time to wait late at night [REDACTED]

[REDACTED] With the 15 minute headway there are certain maintenance activities that Protrans will not be able to perform on those nights of 24-hour operation without disruption to the service. [REDACTED]

[REDACTED]

2.7. Safety and Security

It was evident in Protrans development of this feasibility study that safety and security of employees and passengers would be a key element in successfully implementing a 24-hour service on the Canada Line. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] a visible police presence will be required during any extended hours service to a sufficient level that does not compromise typical police responses that are provided at other times of the day.

2.8. Infrastructure Changes

On review of the extended hour's scenarios we have assumed that changing the infrastructure especially in the tunnels would be cost prohibitive given the fact that the

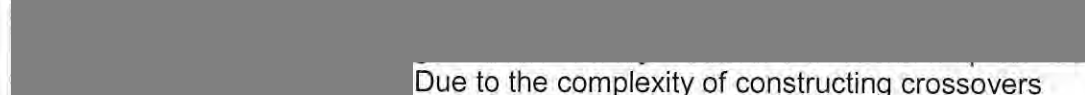
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additional revenue generated by ridership using this service may not support a business case for this capital expenditure. Note that this is based on our ridership data which suggest that ridership after midnight on the Canada Line is relatively low with a peak on Friday (see Section 5. Canada Line Late Night Ridership and Section 6. Canada Line Last Train Ridership). TransLink may have access to more detailed data such as ridership demand forecasts as Protrans currently have not carried out this type of analysis.



However, with more of a “blue sky” approach Protrans suggests the following for considerations:

- The addition of crossovers along the main line, for example near Yaletown and King Edward, would enable revenue trains to single-track around the adjacent sections and facilitate guideway maintenance activities on the opposite track. ■



■ Due to the complexity of constructing crossovers with the tunnel sections these changes are expected to be in the ■ dollar range

- In planning Capstan Way station construction there should be some consideration for additional switches as per the YVR branch to assist with single tracking
- Permanent staffing at Broadway station to be included any plan for extended hours

2.9. Other Considerations

Protrans and the Concessionaire are currently working on the Capacity Expansion program with the focus of delivering trains, infrastructure changes, and systems upgrades required increasing capacity on the Canada Line by the year 2020. Additional work is planned during engineering hours to implement infrastructure changes and system upgrades. Restricting work hours will likely increase risks and duration of the Capacity Expansion program. As a result, the Concessionaire and Protrans do not recommend implementation of the additional services until the full completion of the Capacity Expansion program.

3. Disclaimer



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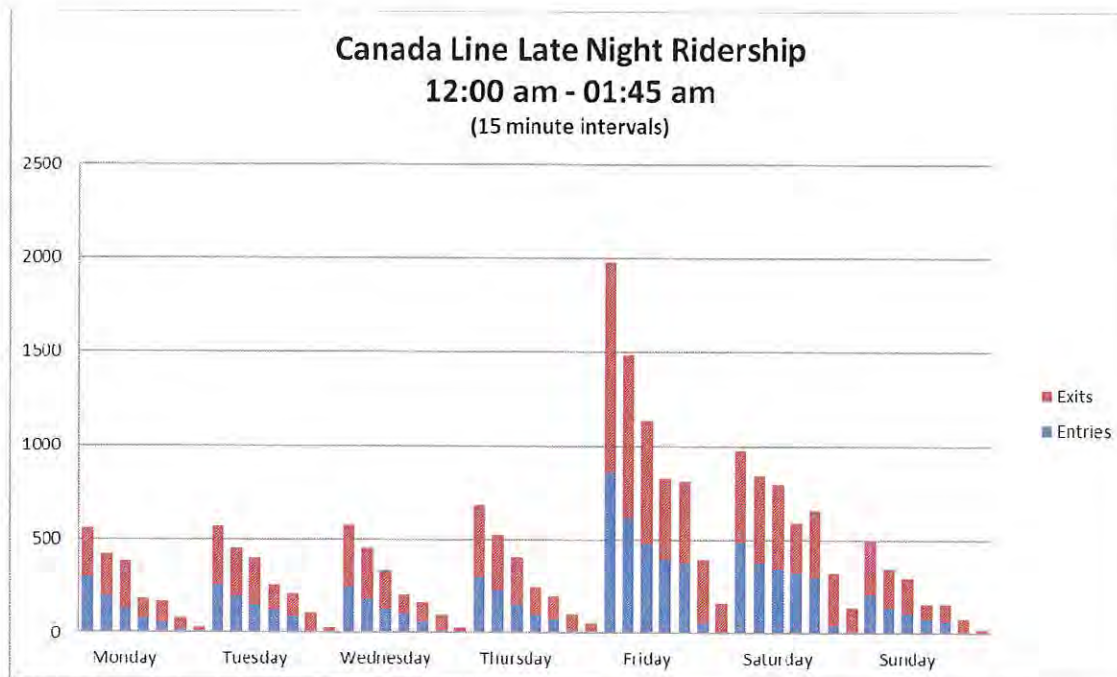


4. Non Disclosure



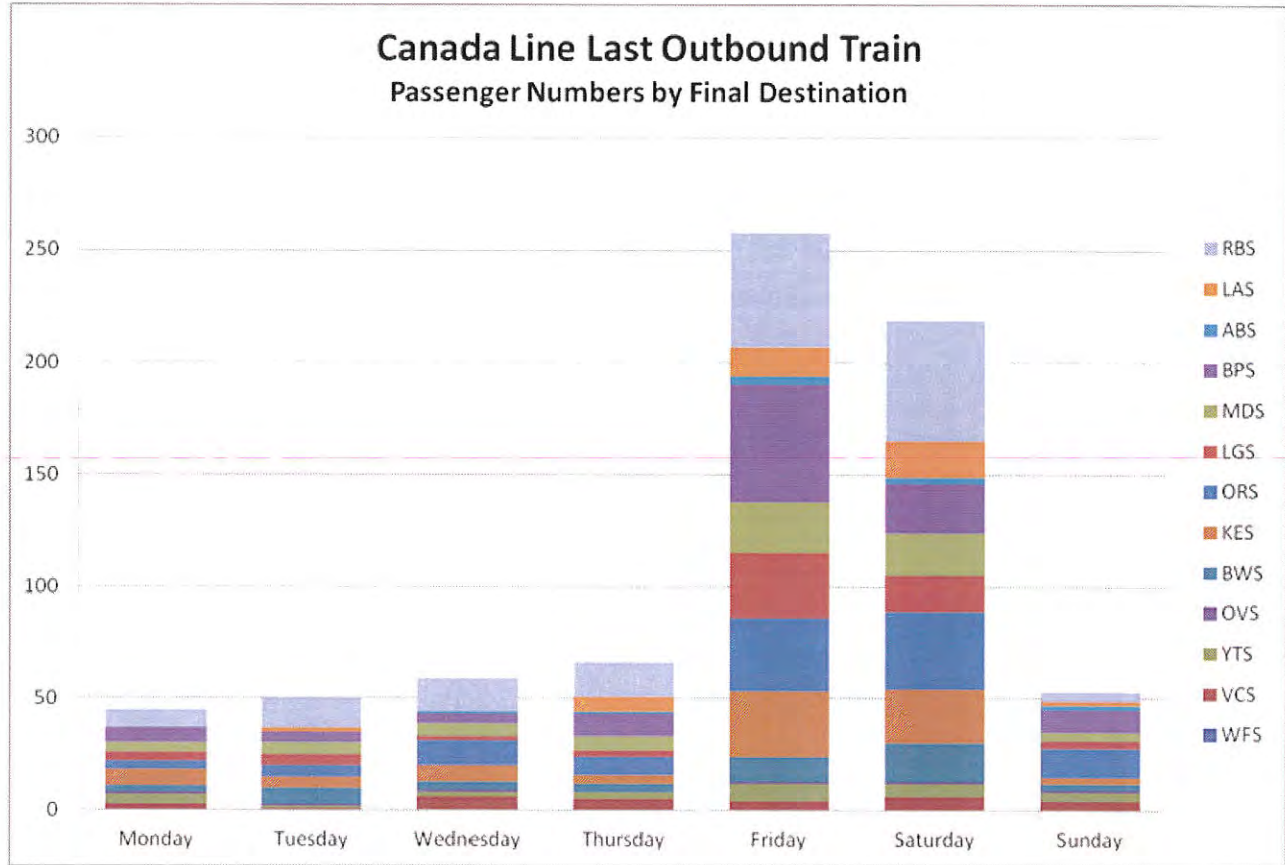
5. Canada Line Late Night Ridership

The following table is extracted from Compass ridership data for the Canada Line:



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6. Canada Line Last Train Ridership



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7. Canada Line Existing Service Hours

The current revenue service of the Canada Line is defined by the Concession Agreement as follows:

Weekdays	Saturdays	Sundays / Stat. Holidays
04:48 – 06:30 6:00 minute headway	04:48 – 09:00 6:00 minute headway	04:48 – 10:00 6:00 minute headway
06:30 – 09:30 3:08 minute headway	09:00 – 19:00 3:20 minute headway	10:00 – 19:00 3:20 minute headway
09:30 – 15:00 3:20 minute headway	19:00 – 23:00 6:00 minute headway	19:00 – 23:00 6:00 minute headway
15:00 – 19:00 3:08 minute headway	23:00– 01:41 10:00 minute headway	23:00– 01:41 10:00 minute headway
19:00 – 23:00 6:00 minute headway		
23:00– 01:41 10:00 minute headway		

This information is relevant to the one and two-hour extension options in relation to closing and opening the station at the end of the extended service.

8. Current Engineering Hours

The current available engineering window for the performance of track and system maintenance is somewhat dependant on the area in which the maintenance is to be performed and the speed and efficiency with which the system can be shut down and trains routed to the yard. As implied above, the window between the last and first revenue service trains is 01:41 to 04:48. Practically speaking, automatic trains are clear of the mainline track at 01:50 and launch begins at 04:15, leaving a 145 minute window for the performance of mainline track, guideway and system maintenance. It is important to note that travel time must also be included in this maintenance window, although it is occasionally possible to stage equipment or crews, or to schedule certain maintenance equipment movements concurrently with system shutdown.

For large scale maintenance tasks in appropriate areas, single tracking is employed, whereby a section of the mainline is closed early and trains are routed bi-directionally along the remaining

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open track. This imposes certain restrictions, the most notable of which being the minimum time between trains, which is constrained by the location of the specific crossover track switches which must be used to re-route the trains around the chosen maintenance area.

During the current Engineering Hours there are several tests/maintenance activities that would impact the service which would present a major challenge to be performed at any other time. These include:

- [REDACTED] automatic self-tests of the entire Guideway Intrusion Detection System [REDACTED]
- Preventative Maintenance to the Automatic Train Control System (ATC) central system [REDACTED]
- [REDACTED]

Other maintenance currently performed in engineering hours which is likely to be invasive to passengers at stations includes:

- Nightly routine cleaning and deep cleaning
- Re-lamping which can involve scaffolds
- Painting

9. Methodology and Approach

Protrans has reviewed each of the five extended hours scenarios and assessed the impact that these would have on existing O&M activities including the financial/cash flow impact on a rough order of magnitude level. Note in some cases the impacts on functional areas for a scenario is the same or not substantially different from another scenario as listed.

Protrans has also evaluated the risk profile of each scenario in the form of an aggregate risk rating in Appendix A – Extended Service Hours Scenario Comparison Matrix, using the following methodology [REDACTED]

9.1. Qualitative Risk Level

A qualitative risk level is determined for each proposed scenario, for each of the evaluation criteria. This is represented by a numerical value from 0 to 5 as outlined in the table below:

Risk Value	Qualitative Description
0	No impact / No risk
1	Minor risk
3	Moderate risk
5	Severe risk

This risk level is analogous to the probability of a significant negative impact or outcome for that evaluation criterion.

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9.2. Functional Area Weighting

Each of the evaluated criteria is assigned a weighting value from 1 to 10. This weighting is analogous to the overall impact or consequence of a negative impact or outcome pertaining to that function.

9.3. Aggregation

The overall risk level presented for each scenario is the weighted average of the qualitative risk levels of the 6 critical project factors, determined by multiplying each by the criteria weighting and dividing by the sum of all 6 weightings. The percentage listed is the percentage of the maximum mathematically possible level (5) that the overall risk level represents.

The overall qualitative risk levels for each of the critical project factors are also determined mathematically. In this case, each is the weighted average, calculated as above, of the determined risk level for each of the factor evaluation criteria.

10. Conclusion

Protrans conclusion from this feasibility study is that if TransLink intends to continue to consider extending service hours on the Canada Line, then extending on Friday and Saturday nights is the best and most achievable option. Furthermore, Protrans preference would be just to run services through the whole night on Friday and Saturday for the reasons that have been described with this feasibility study. Protrans also considers that this option will gain the best value in promotion of the usage of the extended services giving access to a regular and reliable service throughout the night.

11. Extended Hours Scenarios

11.1. Twenty-four hour service, 7 days per week

11.1.1. Assumptions

- Service Plan will provide trains departures from terminals on a clock face basis at 30 minute or 60 minute intervals
- Transit Police are allocated to police the Canada Line during extended service hours (details subject to further review).
- No substantial changes are made to existing infrastructure.
- These estimates hold for projected 2020 fleet size and service level expectations.

11.1.2. Service Delivery

Vehicle Availability

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Under 24-7 operations, any maintenance activity in ATC territory will require a modified service plan. Typically, this would be accomplished by employing single tracking around the affected area. Given current maintenance activity requirements, some degree of special accommodation would be required every night. [REDACTED]

In the event of an extended suspension of services between stations due to a failure Protrans typically will use bus bridges. It is unlikely that this will be possible to organise during an all-night service at short notice.

Vehicle Quality

The reduced availability of the trains for cleaning and vehicle quality maintenance purposes increases the risk of vehicle quality deductions. Alternatively, cycling trains to ensure adequate cleaning introduces added risk due to schedule complexity and manual train manipulations.

Station Availability

With all stations open 24-hours, non-revenue station maintenance requirements will necessitate occasional partial or complete station closures, resulting in lost availability credits. Additionally, modified and accelerated inspection and maintenance practices may result in increased risk of emergency partial or complete station closure.

Station Quality

24-hour operation will require a substantial modification to the station maintenance and cleaning programs. [REDACTED]

Overall Financial Impact & Risk Assessment

Under 24-hour operation 7 days a week, the costs of failing to meet service delivery obligations, given the concerns outlined above, are estimated at [REDACTED] annually. [REDACTED]

11.1.3. Maintenance***Vehicle Maintenance***

Under 24-7 operations, vehicle movements will need to be carefully planned and considered to meet availability and quality requirements. This will reduce the flexibility with which maintenance activities will be performed, resulting in a reduction in the efficiency of vehicle maintenance activities overall.

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Guideway Maintenance

As stated above, all guideway maintenance activities performed under 24-7 train operations will require alternate service, and will likely result in service penalties. In order to reduce these penalties and, more importantly, the impact to riders, maintenance activities will be scheduled concurrently, resulting in risky, superposed works, and will be fast-tracked, whenever possible. Accelerating work in this way will result in an overall reduction in maintenance activity efficiency [REDACTED]

Facility Maintenance

Similar to guideway maintenance, station facility maintenance will need to be performed in service wherever possible. Maintenance activities will require a high degree of planning and will need to be executed quickly to minimize the impact to riders. [REDACTED]

Systems Maintenance

Maintenance on Canada Line systems, including ATC and communications systems is practically impossible to perform in service, and will require system wide shutdowns and alternate service arrangements. [REDACTED]

Overall Financial Impact & Risk Assessment

Under 24-7 operations, the costs of modified maintenance activities and maintenance inefficiencies, given the concerns outlined above, are estimated at [REDACTED] annually. [REDACTED]

11.1.4. Life Cycle Management

Vehicle Life Cycle

Under 24-7 operations, the vehicle kilometrage per year is expected to increase approximately 4%. This will result in an equivalent schedule compression on vehicle related capital replacement activities, [REDACTED]

Guideway Life Cycle

As above, the increase in train traffic will increase wear rates on trackwork and power rail components, [REDACTED]

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Facility Life Cycle

[REDACTED]

Systems Life Cycle

Canada Line systems are not expected to see a significant increase in wear as a result of this service modification. [REDACTED]

Overall Financial Impact & Risk Assessment

Under 24-7 operations, the annualized cost increase of system life cycle management, given the concerns outlined above, is estimated at [REDACTED] annually. [REDACTED]

11.1.5. Staffing and Labor

Operating Staffing

To support 24-7 operations, field ops staffing will need to increase to ensure coverage overnight. [REDACTED]

Maintenance Staffing

In order to make optimal use of the limited access to the guideway, maintenance staffing will have to be increased, and maintenance staff schedules will need to be made significantly more complex. [REDACTED]

[REDACTED] Again, the added shift complexity is expected to increase associated labour risks.

Admin Staffing

The added complexity of scheduling maintenance activities around 24-7 operation is expected to require the addition of [REDACTED] Full Time Equivalents to the maintenance planning team.

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Under 24-7 operations, the annualized cost increase to support the expected additional staffing requirements, given the concerns outlined above, is estimated at [REDACTED] annually. [REDACTED]

11.1.6. Health, Safety, Security and Environment***Employee Health & Safety***

[REDACTED]
[REDACTED] For field staff, increasing the evening hours will [REDACTED]
[REDACTED]
[REDACTED] particularly in
the case of superposed works. [REDACTED]
[REDACTED]

Policing on the Canada Line for 24-7 operations would be a key activity to ensuring that employees are and feel safe working during the extended service hours and requires further review.

Public Health & Safety

[REDACTED]

Policing on the Canada Line for 24-7 operations would be a key activity to ensuring that passengers feel safe using the Canada Line during extended service hours and requires further review.

Security

As outlined above, additional exposure to the general public system during late night hours is likely to import security risks, as is the increased frequency of maintenance activities scheduled during operational hours. [REDACTED]

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Policing of the system would therefore be a key element of successfully implementing any 24-hour service and requires further review.

Environment

The environmental impacts of 24-7 operations include an expected 4% increase in traction power usage and a commensurate increase in the usage of various consumable products, such as track grease, de-icing fluid, rail grinding dust, carbon shoe dust, etc.

Additionally, operational noise will continue throughout the night, including train movements and station announcements.



Overall Financial Impact & Risk Assessment

No attempt has been made to quantify the dollar value of the annualized cost of increased HSSE risk.



11.1.7. Business Considerations

Concessionaire Activities

Moving to 24-7 operations would limit some of the Concessionaire's revenue generating activities. In particular, Protrans may not be able to support, to the same extent, the updating of station platform advertisements.

Concession Agreement

Any change to operational hours would require a revisit of Concession Agreement Schedules 4 and 11. This includes the redefinition of service plans and associated performance measurements, special considerations for platooning trains, clarifications on

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station and vehicle quality expectations, staff response time expectations etc. [REDACTED]

[REDACTED] (estimated at around [REDACTED])

Key Sub-Supplier Relationships

Significant changes would be required to the contracts of some of Protrans's key sub-suppliers. In particular, the cleaning contract and the lifting device (elevator & escalator) service contract would need to be revisited. [REDACTED]

Alternate Service Relationships

As stated above, a number of required system maintenance activities will require complete system shutdowns, with alternate services (such as bus bridges) required to address passenger needs. [REDACTED]

Financial Estimates and Cost Certainty

Cost of Energy

The incremental cost of energy for 24-7 operations is low but not insignificant. [REDACTED]

Overall Financial Impact & Risk Assessment

Under 24-hour operation 7 days a week, the cost increase associated with business considerations, given the concerns outlined above, is estimated at [REDACTED] annually, with an additional [REDACTED] as a one-time contract renegotiation and PMS update cost. There is also a high level of risk associated with these considerations.

11.1.8. Scenario Summary

As calculated in the attached spreadsheet, the final estimated annual financial impact of implementing this scenario is estimated at [REDACTED] annually, with an additional [REDACTED]

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as a one-time contract renegotiation and PMS update cost. Furthermore the overall weighted risk level is [REDACTED] which represents [REDACTED] of the maximum possible risk for this methodology.

11.2. Twenty-four hour service on Friday and Saturday nights

11.2.1. Assumptions

- Service Plan will provide trains departures from terminals on a clock face basis at 15 or 30 minute intervals
- Transit Police are allocated to police the Canada Line during extended service hours (details subject to further review).
- No substantial changes are made to existing infrastructure.
- These estimates hold for projected 2020 fleet size and service level expectations.

11.2.2. Service Delivery

Vehicle Availability

As with 24-7 train operations, any maintenance activity in ATC territory performed on Friday and Saturday nights will require a modified service plan. The expected impact of this would be mitigated by adjusting the maintenance activity schedule to perform the majority of these activities on during Sunday to Thursday shutdowns. [REDACTED]

In the event of an extended suspension of services between stations due to a failure Protrans typically will use bus bridges. It is unlikely that this will be possible to organise during an all-night service at short notice.

Vehicle Quality

The overall impact to vehicle quality of this is expected to be small. However, there is an increased risk of vehicle quality deductions, particularly over the weekend, as there is a reduced availability of the trains for cleaning and vehicle quality maintenance purposes.

Station Availability

As above, non-revenue station maintenance requirements will need to be scheduled during non-service nights. This compresses the overall available window to perform this work and the inspection and maintenance activities will require some modification, [REDACTED]

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Station Quality



Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the costs of failing to meet service delivery obligations, given the concerns outlined above, are estimated at [REDACTED] annually, with a moderate risk of unplanned service delivery affecting issues and increased costs.

11.2.3. Maintenance

Vehicle Maintenance

Under this scenario, the impact to vehicle maintenance activities is expected to be small. Nevertheless, the reduction in activity scheduling flexibility will somewhat reduce overall maintenance activity efficiency.

Guideway Maintenance

Any guideway maintenance activities performed on Friday or Saturday night will require alternate service, and will likely result in service penalties. As such, most, if not all of these activities will be scheduled for the remaining nights, importing some risk and inefficiency due to scheduling complexity and concurrent or superposed works, [REDACTED]

Facility Maintenance

Similar to guideway maintenance, station facility maintenance will need to be performed in service or during remaining nightly shutdowns wherever possible, importing some risk and inefficiency due to scheduling complexity and concurrent or superposed works. [REDACTED]

Systems Maintenance

Maintenance on Canada Line systems, including ATC and communications systems is currently scheduled to avoid concurrent scheduling with heavy rail maintenance activities. Under this scenario, this will no longer be possible, [REDACTED]

Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the costs of modified maintenance activities and maintenance inefficiencies, given the concerns outlined above, are estimated at [REDACTED] annually, [REDACTED]

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11.2.4. Life Cycle Management

Vehicle Life Cycle

Under this scenario, the increase in vehicle kilometrage per year is expected to be minimal.

Guideway Life Cycle

As above, the increase in train traffic is expected to be minimal.

Facility Life Cycle

Similar to guideway life cycle management, an increase in station use will result in a slight increase annualized life cycle cost.

Systems Life Cycle

Canada Line systems are not expected to see a significant increase in wear as a result of this service modification.

Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the annualized cost increase of system life cycle management, given the concerns outlined above, is estimated at

11.2.5. Staffing and Labor

Operating Staffing

To support 24-hour operation on Friday and Saturday nights, field ops staffing will need to increase to ensure coverage overnight. The annual cost of this is estimated based on

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL***Maintenance Staffing***

In order to make optimal use of the limited access to the guideway, maintenance staffing will have to be increase, and maintenance staff schedules will need to be made somewhat more complex. The annual cost is estimated based on a headcount increase of [REDACTED]

Admin Staffing

The added complexity of scheduling maintenance activities for this scenario is expected to require the addition of [REDACTED] to the maintenance planning team.

Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the annualized cost increase to support the expected additional staffing requirements, given the concerns outlined above, is estimated at [REDACTED] annually. The potential cost of labour and staffing related risk is moderate.

11.2.6. Health, Safety, Security and Environment***Employee Health & Safety***

[REDACTED] In this scenario it is limited to just two nights of 24-hour operations, reducing so the overall risks in terms of the incremental hours of potential exposure. Typically, Friday and Saturday nights on the Canada line have the highest level of incidents [REDACTED] Policing on those nights would be a key activity to ensuring that employees are and feel safe working during the extended service hours and requires further review.

Public Health & Safety

Moving to 24-hour rail operations, imports a significant amount of health and safety risk to Canada Line employees as already stated in Section 10.1.6 for 24/7 operations but in this scenario, it is limited to just two nights of 24-hour operations.

As already stated, Friday and Saturday nights on the Canada line typically have the highest level of incidents [REDACTED] so Policing on those nights would be a key activity to ensuring that passengers feel safe when traveling during the extended service hours and requires further review.

**CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL**

Security

[REDACTED]

[REDACTED] Policing on those nights would be a key activity to ensuring that passengers feel safe when traveling during the extended service hours and requires further review.

Environment

The environmental impacts of 24-7 operations, includes an expected [REDACTED] increase in traction power usage and a commensurate increase in the usage of various consumable products, [REDACTED]

As stated in Section 10.16 for 24/7 operations, operational noise will continue throughout the night, including train movements and station announcements. [REDACTED]

[REDACTED]

Overall Financial Impact & Risk Assessment

No attempt has been made to quantify the dollar value of the annualized cost of increased HSSE risk. [REDACTED]

[REDACTED]

11.2.7. Business Considerations

Concessionaire Activities

This scenario would limit some of the Concessionaire's revenue generating activities. In particular, Protrans may not be able to support, to the same extent, the updating of station platform advertisements.

Concession Agreement

[REDACTED]

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL

Key Sub-Supplier Relationships

Under this scenario, changes would be required to the contracts of some of Protrans's key sub-suppliers. In particular, the cleaning contract and the lifting device (elevator & escalator) service contract would need to be revisited. [REDACTED]

Alternate Service Relationships

Without nightly shutdowns on Fridays and Saturdays, the requirement for alternate services to support unplanned and emergency incident is likely to increase. [REDACTED]

Financial Estimates and Cost Certainty

[REDACTED]

Cost of Energy

The incremental cost of energy for this scenario is minimal.

Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the cost increase associated with business considerations, given the concerns outlined above, is estimated at \$ [REDACTED] annually, with an additional [REDACTED]. There is also a high level of risk associated with these considerations.

11.2.8. Scenario Summary

As calculated in the attached spreadsheet, the final estimated annual financial impact of implementing this scenario is estimated at [REDACTED] annually, with an additional [REDACTED] as a one-time contract renegotiation and PMS update cost. Furthermore the overall weighted risk level is [REDACTED] which represents [REDACTED] of [REDACTED].

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL**11.3. Extended Service on Friday and Saturday Night (1-Hr)****11.3.1. Assumptions**

- Service Plan will extend the current late night service by exactly 60 minutes on Friday and Saturday night. Based on the present timetable the last train will depart Waterfront for Richmond-Brighouse at 02:15.
- Automatic trains are clear of the mainline track at 02:50 and launch begins at 04:15, leaving an 85-minute window for the performance of mainline track, guideway and system maintenance.
- Adequate policing is provided.
- No substantial changes are made to existing infrastructure.
- These estimates hold for projected 2020 fleet size and service level expectations.

NOTE: The 2-hour extended service scenario is not considered in this report. Analysis has shown the impact and risk to be identical to the 24-hour service scenario presented above. Automatic trains are clear of the mainline track at 03:50 and launch begins at 04:15, leaving a 25-minute window for the performance of mainline track, guideway and system maintenance.

11.3.2. Service Delivery***Vehicle Availability***

Under this scenario, the maintenance window for any activity in ATC territory performed on Friday and Saturday nights will be reduced by one hour. This will mean that only certain light duties will be able to be scheduled. The expected impact of this would be mitigated by adjusting the maintenance activity schedule to perform the majority of these activities on during Sunday to Thursday shutdowns. Nevertheless, some degree of special accommodation would be required, particularly for unplanned and emergency work.

Vehicle Quality

The overall impact to vehicle quality of this is expected to be minimal, with only a small increase in risk of vehicle quality deductions over the weekend.

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL

Station Availability

The expected impact of this scenario on station availability is expected to be negligible.

Station Quality

[REDACTED]

Overall Financial Impact & Risk Assessment

Under this scenario, the costs of failing to meet service delivery obligations, given the concerns outlined above, are estimated at \$ [REDACTED] annually, [REDACTED]

11.3.3. Maintenance

Vehicle Maintenance

Under this scenario, the impact to vehicle maintenance activities is expected to be small. Nevertheless, the reduction in activity scheduling flexibility will somewhat reduce overall maintenance activity efficiency.

Guideway Maintenance

As stated above, the available maintenance window on Friday and Saturday nights is such that the majority of guideway maintenance activities will be scheduled for the remaining nights, importing some risk and inefficiency due to scheduling complexity and concurrent or superposed works, [REDACTED]

Facility Maintenance

Similar to guideway maintenance, the majority of station facility maintenance will need to be performed in service or during remaining nightly shutdowns wherever possible, importing some risk and inefficiency due to scheduling complexity and concurrent or superposed works. [REDACTED]

Systems Maintenance

Maintenance on Canada Line systems, including Automated Train Control and communications systems is currently scheduled to avoid concurrent scheduling with heavy rail maintenance activities. Under this scenario, this will not be possible to the same extent, [REDACTED]

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL

Overall Financial Impact & Risk Assessment

Under this scenario, the costs of modified maintenance activities and maintenance inefficiencies, given the concerns outlined above, are estimated at [REDACTED] annually, with [REDACTED]

11.3.4. Life Cycle Management

Vehicle Life Cycle

[REDACTED]

Guideway Life Cycle

As above, the increase in train traffic is expected to be minimal. [REDACTED]

[REDACTED]

Facility Life Cycle

The incremental usage and wear of facility systems under this scenario are expected to be negligible. [REDACTED]

Systems Life Cycle

Canada Line systems are not expected to see a significant increase in wear as a result of this service modification. [REDACTED]

Overall Financial Impact & Risk Assessment

Under this scenario, the annualized cost increase of system life cycle management, given the concerns outlined above, is estimated at [REDACTED] annually, [REDACTED]

11.3.5. Staffing and Labor

Operating Staffing

To support scenario, field ops staffing and scheduling will need to be adjusted. The annual cost of this is estimated based on the equivalent of [REDACTED]

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL

[REDACTED]

Maintenance Staffing

No maintenance staffing increases are expected to be required to support this scenario.

Admin Staffing

The added complexity of scheduling maintenance activities for this scenario is expected to require the addition of [REDACTED] to the maintenance planning team.

Overall Financial Impact & Risk Assessment

Under this scenario, the annualized cost increase to support the expected additional staffing requirements, given the concerns outlined above, is estimated at [REDACTED] annually. [REDACTED]

11.3.6. Health, Safety, Security and Environment

Employee Health & Safety

Operating under the extended hours scenario presented here is not expected to significantly increase health and safety risk to Canada Line employees. [REDACTED]

[REDACTED]

Public Health & Safety

[REDACTED]

Security

As above, the additional exposure if the system during evening hours is likely to import security risks but these will be minimal.

Environment

The environmental impacts of this scenario include a minimal [REDACTED]

[REDACTED]

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL

Overall Financial Impact & Risk Assessment

No attempt has been made to quantify the dollar value of the annualized cost of increased HSSE risk. [REDACTED]

11.3.7. Business Considerations

Concessionaire Activities

This scenario is not expected to have a significant impact on the Concessionaire's [REDACTED]

Concession Agreement

Key Sub-Supplier Relationships

Under this scenario, minor changes would be required to the contracts of some of Protrans's key sub-suppliers. In particular, the cleaning contract and the lifting device (elevator & escalator) service contract would need to be revisited. [REDACTED]

Alternate Service Relationships

This scenario is not expected to have a significant impact on Protrans's alternate service requirements.

Financial Estimates and Cost Certainty

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL***Cost of Energy***

The incremental cost of energy for this scenario is minimal.

Overall Financial Impact & Risk Assessment

Under 24-hour operation Friday and Saturday, the cost increase associated with business considerations, given the concerns outlined above, is estimated at [REDACTED] annually, with an additional [REDACTED] as a one-time contract renegotiation and PMS update cost. [REDACTED]

11.3.8. Scenario Summary

As calculated in the attached spreadsheet, the final estimated annual financial impact of implementing this scenario is estimated at [REDACTED] annually, with an additional [REDACTED] as a one-time contract renegotiation and PMS update cost. Furthermore the overall weighted risk level is [REDACTED] which represents [REDACTED]

12. Potential Key Mitigation Strategies

The following mitigation strategies may be employed to reduce the overall financial impact or risk profile of the listed scenarios. These strategies either impact key assumptions, or address specific issues as outlined below.

Limited Stop Service

Implementation of limited stop service for overnight trains, for example stopping only at Waterfront, Vancouver City Centre, Broadway City Hall, Marine Drive, Bridgeport then YVR-Airport or Richmond-Brighouse, may result in the following benefits in terms of station and guideway maintenance:

- Allow for nightly station cleaning and equipment maintenance in station areas not immediately adjacent to the guideway.
- Allow revenue trains to pass through certain sections without stopping, decreasing travel time and possibly freeing up select areas for maintenance while trains utilize the opposite track for bidirectional travel.

Single-Tracking on Opposite Track

If the overnight train headway is kept to 30 minutes or longer, revenue trains can be diverted to utilize one track for bidirectional travel and free up the opposite track for regular maintenance. This strategy can also be combined with Limited Stop Service to minimize the risk of service delays. In order to minimize the number of staff members required over the long term, there is an initial one-time cost for ATC/Communications system updates.

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
PROPOSAL***Additional Crossovers***

The addition of crossovers along the main line, for example near Yaletown, King Edward or Aberdeen Centre, would enable revenue trains to single-track around the adjacent sections and facilitate guideway maintenance activities on the opposite track. It should be noted that the design and installation of new crossovers on an existing, heavily utilized track involves significant monetary cost and risk as well as potential disruptions to revenue service.

Scheduled System Shutdowns

Scheduled system shutdowns would facilitate recurrent large scale non-revenue maintenance of guideway infrastructure, electronic systems as well as station facilities. The importance of system shutdowns as a mitigation strategy would become increasingly crucial with higher risk scenarios such as 24-7 train operations.

13. References

Appendix A - Extended Service Hours Scenario Comparison Matrix





2019 Late Night Service Report

Appendix C

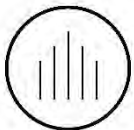
Expo & Millennium Line Phase 2



SkyTrain Extended Service Hours Feasibility Study

Stages 3 and 4

[TransLink](#)



Infrastructure

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Glossary/Abbreviation List

ATC	Automatic Train Control
BCRTC	British Columbia Rapid Transit Company Ltd. - maintains and operates the Expo and Millennium Lines in the lower mainland on behalf of TransLink
CLA	Collective Labour Agreement
Compass Card	A reloadable fare card used for public transit in Metro Vancouver
FoxPro	A database management software BCRTC uses for maintenance planning
LIM	Linear induction motor
LU	London Underground – a passenger railway system in London, England
Mark I/Mark II/Mark III	Types of passenger train currently serving the Expo and Millennium Lines
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OMC	Operations and Maintenance Centre
OP	Occupancy permit - a permit to access a section of guideway
OpenTrack	A rail simulation software
Prime Mover	The 2 nd most heavy-duty type of maintenance vehicle used on the SkyTrain guideway, it has a capacity of carrying 6 people
RAMS	Reliability Availability Maintainability and Safety
Run to fail	Assets are allowed to operate until they break down, this is an example of maintenance regime
SCADA	Supervisory Control and Data Acquisition
Speeder	The 3 rd most heavy-duty type of maintenance vehicle used on the SkyTrain guideway
TIDS	Track Intrusion Detection System - a system which detects passengers and objects who enter or fall onto the track
Unimog	The most heavy-duty type of maintenance vehicle used on the SkyTrain guideway, it has a capacity of carrying 4 people

1. Executive Summary

1.1. Remit

- 1.1.1 The SNC-Lavalin Steer partnership (the project team) was instructed by TransLink on 17 October 2018 to continue the study into the feasibility of operating the Vancouver SkyTrain (SkyTrain) to a 24/2 operating pattern.
- 1.1.2 This scope of work follows Stages 1 and 2, which were produced to determine the technical feasibility of operating SkyTrain beyond the existing revenue service. The focus of this study is to highlight, at a more detailed level, the constraints currently within the organization which would impact the successful implementation of 24/2 operating service in the medium and long terms.
- 1.1.3 This study reviews the ability of the SkyTrain system to operate a 24/2 service pattern, the implications on the operation and the maintenance (O&M) of the system, required mitigation measures or changes to operating or maintenance procedures, and consideration of the following areas for potential risk to the successful implementation of 24/2 in the medium term or long term (medium term and long term refer to the two time periods for TransLink to implement action items to facilitate 24/2 operation):
 - › Impact of reduced non-revenue hours to the maintenance of the SkyTrain
 - › Consideration of collective agreements in the context of resourcing for the extended operating hours
 - › Impact on a range of business goals such as capital projects

1.2. Approach

- 1.2.1 In order to cover the full breadth of this remit, the project team adopted a staged approach, to inform latter parts of the study with any of the key constraints that were discovered. The staging was agreed with TransLink in the form of a subtask schedule. The key methods adopted were as follows:
 - › Exploratory discussions with British Columbia Rapid Transit Company (BCRTC) teams and TransLink Project staff
 - › Identification of initiatives following the determination of key constraints, which, if adopted, would permit greater confidence in operating a 24/2 pattern
 - › Collation of these initiatives for review and response by stakeholders (in the form of presentations and report submittals)
 - › More detailed exploration of key issues with the BCRTC leadership

1.3. Findings

- 1.3.1 A maintenance simulation analysis was done to understand how 24/2 service on Friday and Saturday would affect the nightshift maintenance, upgrade and rehabilitation of the existing network. A two-month historical record provided by BCRTC was analyzed in the simulation. The simulation aimed to condense all the maintenance activities from seven nights per week (Sunday to Saturday) to five nights per week (Sunday to Thursday) in August and September 2018.
- 1.3.2 There are altogether 191 work orders on the eight Friday and Saturday nights in the simulation. The simulation determined that the activities undertaken could not be completed in the maintenance window presented in a 24/2 operating schedule, due to the lack of equipment and location conflicts.
- 1.3.3 The analysis has indicated the need for a reduction in revenue hours to support the capital and maintenance works in the medium to long terms.
- 1.3.4 Implementing 24/2 revenue service in the medium term will also impact a number of capital projects (such as station upgrades) and commissioning of new trains. Depending on the project scope and the guideway access requirements, the impact may vary.
- 1.3.5 Detailed planning and scheduling needs to be carefully considered as the longer weekend maintenance window would no longer be available. Alternatives (such as single tracking operations, temporary blockade of the system, and temporary suspension of the 24/2 operation) need to be considered if the work requires a longer guideway access time than what weekday maintenance windows can provide.
- 1.3.6 A similar situation also applies to running rail replacement projects, guideway intrusion equipment renewal, and other state of good repair projects that are planned in the medium term.
- 1.3.7 Extending the maintenance windows during weekdays is an option that can potentially resolve or reduce the impact on capital project works. This will increase flexibility for both the maintenance work and capital work to be planned and scheduled by improving utilization of engineering hours while maintaining the 24/2 service.

1.3.8 The following actions were identified as the next steps for TransLink and BCRTC to consider:

1.3.9 **Medium Term:**

- › Procure required additional maintenance equipment to support maintenance
- › Acquire sufficient equipment storage space
- › Create SkyTrain 24/2 operation timetable
- › Determine the justification of early and partial closures on statutory holidays
- › Identify all job assignments which will be affected by 24/2 operation, adjust job assignments and hire additional staff as necessary
- › Adjust resource management strategy to accommodate capital projects to the maintenance schedule (e.g. station upgrades and commissioning of new trains)

1.3.10 **Long Term:**

- › Conduct review to evaluate the situation and make adjustments as necessary
- › Retrofit selection of Mark I trains for use as engineering vehicles
- › Determine the requirements for successful introduction of the new MK III fleet to ensure the areas toward Lougheed are sufficient for stabling and testing
- › Implement an Asset Management System meeting BCRTC's needs (thereby offering opportunity to find maintenance efficiencies)
- › Implement a robust project governance strategy within TransLink to de-risk the implementation of capital projects on SkyTrain infrastructure

2. Introduction

- 2.0.1 This introductory section provides an overview of this feasibility study, including works that have been undertaken in previous Stages (1 and 2), together with the scope of work for Stages 3 and 4.

2.1. Study Objectives

- 2.1.1 TransLink engaged the SNC-Lavalin and Steer (the project team) to conduct a feasibility study on the extension of operating hours for the SkyTrain system.
- 2.1.2 The purpose of this feasibility study is to determine the potential impacts and required system changes if operating hours of Expo and Millennium Lines were to extend beyond the current schedule on Friday and Saturday nights. The possible extension to service hours on these lines seeks to meet growing demand for transit due to the events in the downtown areas, passengers to/from YVR Airport, early/late workers, and late night users across the SkyTrain system region.
- 2.1.3 SkyTrain currently operates beyond midnight. The term “*Friday nights*” where the extended service hours (also known as 24/2 operation or 24/2 service) are of concern in this study refers to the time period between late night on Fridays and early morning on Saturdays; and the term “*Saturday nights*” refers to the period between late night on Saturdays and early morning on Sundays.
- 2.1.4 The feasibility study was divided into four stages. In March 2018, the project team was instructed by TransLink to proceed Stages 1 and 2 of the feasibility study, with the findings presented to TransLink executives in June 2018.
- 2.1.5 Further to the presentation of the findings from Stages 1 and 2, the project team was further instructed by TransLink in mid-October 2018 to undertake Stages 3 and 4 of the study.
- 2.1.6 The remit requires that this study reviews the areas outlined in Section 1.1.3 of this report for any changes required to facilitate the 24/2 operation for the medium and long term timelines.

2.2. Study Stages

2.2.1 The key focus points for the four stages of this study are described as follows:

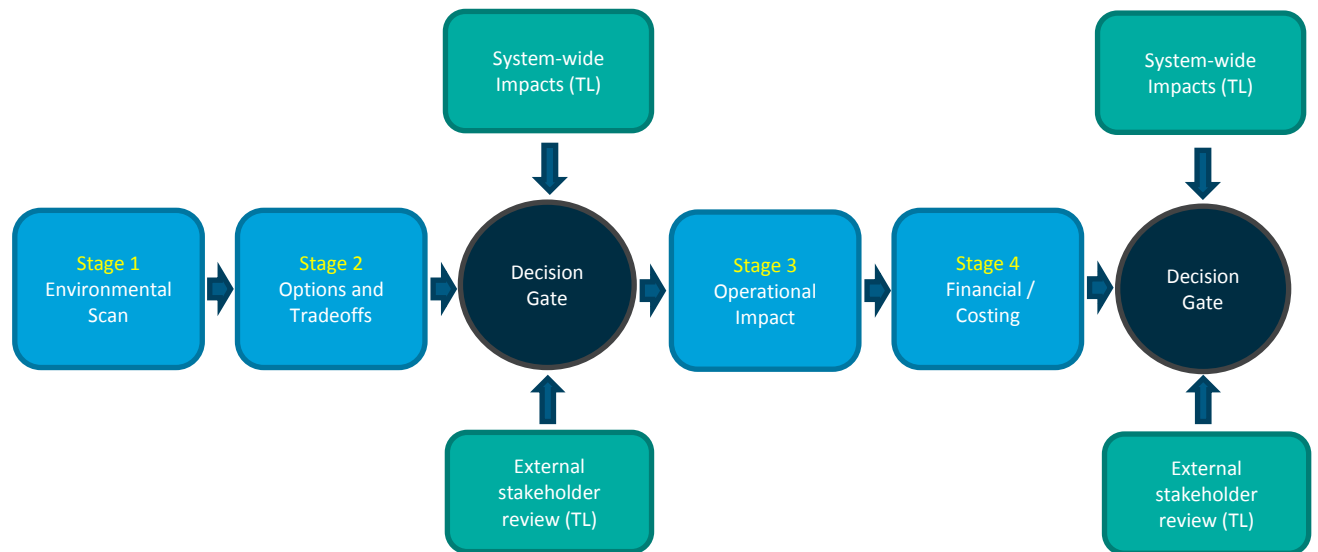


Figure 2.1 Overall Study Process

Stage 1 - Environmental Scan

2.2.2 Stage 1 reviewed the transit agencies that have implemented the service hour extensions. The reviews were compared and contrasted against BCRTC (operator of SkyTrain) to determine SkyTrain's feasibility to implement the service hour extension. To achieve this, a series of background reviews were undertaken, including:

- › The current service operations of SkyTrain
- › How other transit agencies have evolved into their current operational model
- › Industry best practices when extending service hours
- › Reliability Availability Maintainability and Safety (RAMS) including safety approval/certification implications
- › An evaluation framework for extending service hours

Stage 2 - Options and Trade-offs

2.2.3 Stage 2 required the review of any change to service hours needed, the implications (e.g. to Capital Projects), and the associated risks to the operation of SkyTrain. Stage 2 produced a series of options that best meet the functional requirements of TransLink and BCRTC.

- 2.2.4 The analysis considered the provision of overnight service to support early/late workers, late night users across the region, and passengers going to/from YVR Airport. It identified the potential passenger demand, service capacity and days of the week.

Stage 3 - Detailed Operational Impact Plan

- 2.2.5 Stage 3 builds upon Stage 1 and 2 by investigating “*how*” the 24/2 operation can be implemented in the medium and long terms.
- 2.2.6 A series of detailed analyses were undertaken to identify:
- › *how* the railway will be operated
 - › *how* the railway will be maintained
 - › *how* the personnel requirements will change
 - › *how* safety and security will be maintained and enhanced
 - › *how* the infrastructure and equipment requirements will change

Stage 4 - Financing/Costing

- 2.2.7 Stage 4 comprises a SkyTrain and NightBus ridership analysis, and a life cycle cost analysis of the 24/2 operation, including the benefit-cost ratio (BCR) and net present value.

2.3. Stages 1 and 2 Findings

- 2.3.1 Stage 1 of this study reviewed how transit agencies of other cities have introduced late-night service and their lessons learned, as well as how TransLink could make the change. The following transit agencies were reviewed:
- › Transport for London (London, UK)
 - › Massachusetts Bay Transportation Authority (Boston, USA)
 - › South Eastern Pennsylvania Transportation Authority (Philadelphia, USA)
- 2.3.2 A key lesson learned was that the 24/2 operation can be influenced by the level of passenger demand, political and social impacts. A robust business case helps transit agencies to implement the 24/2 operation.
- 2.3.3 A number of challenges and constraints have been identified in the SkyTrain system today that will need to be addressed in order to implement the 24/2 operation. The majority of these constraints and challenges are similar to those that other cities have addressed in order to implement extended hours. Some of these challenges could be overcome through changes in the approach to systems maintenance, maintenance procedures, track access procedures, and asset upgrades. A number of the above are already being considered.
- 2.3.4 An Asset Management System, that could further improve the efficiency and coordination of both maintenance and capital project works, is currently being developed.
- 2.3.5 Effective recruitment and staff training, as well as revising the renegotiation of the Collective Labor Agreement are key enablers that permit safe and reliable services during 24/2 operation.
- 2.3.6 Through the adaption and the development of revised maintenance processes, procedures and scheduling, and greater coordination with capital projects scheduling, SkyTrain could extend service hours.
- 2.3.7 In support of this initial high-level evaluation, four options were considered in Stage 2 of this study:
- › Option 1 - Extended Service Hours, Expo and Millennium Lines
 - › Option 2 - Extended Service Hours, Expo Line Only
 - › Option 3 - 24-Hour Service, Expo and Millennium Lines
 - › Option 4 - 24-Hour Service, Expo Line Only
- 2.3.8 After presenting these four options to TransLink executives, it was decided that Stages 3 and 4 should investigate, at a more detailed level, the impacts and

feasibility of Option 3 (i.e. a 24/2 service on both Expo and Millennium Lines) in the medium and long terms.

2.4. Lessons Learned from London Underground (LU)

2.4.1 LU's Night Tube frequency of six trains per hour is the highest globally. A number of constraints were identified prior to the implementation of 24-hour service by LU, these included:

- › maintenance window
- › noise and vibration
- › litter
- › potential need for increased policing
- › increased staffing
- › potential union resistance

2.4.2 The following constraints were determined to be high-risk, and warranted considerable study:

- › Maintenance - prior to Night Tube, engineers and operators had the mindset that night-time should be dedicated to maintenance. To overcome this mindset, the 'Access Transformation Program' was established, which aimed to reduce wasted maintenance time and resources, remove unnecessary controls, and facilitate quicker occupancy permits (OPs) for maintenance work.
- › Increased staffing and union negotiation - significant planning was required to streamline the hiring of additional operators, scheduling, and training prior to the implementation of 24-hour service by LU.

The key dilemma was for LU to decide on one of the two options:

Option 1: To incorporate the night-time hours into the existing staff rosters (initial plan)

Option 2: To create a dedicated pool of staff only operating the night-time hours (implemented plan)

2.4.3 After successful implementation, a lessons learned study (this study is not publicly available) was commissioned by LU to determine what improvement can be made in the event of implementing the Night Tube service on more LU lines.

2.4.4 The implementation of Night Tube was delayed by multiple union negotiations. A number of lessons learned were shared on those items that should be done earlier in the process:

- › Instigate early communication with trade unions

- › Consult with public and stakeholders
 - › Identify potential risks and budget contingency funding for corrective actions
- 2.4.5 LU's Director for Night Tube advised that the business case should justify sufficient benefits and passenger demand of 24/2 service before implementation. London's vibrant 'night time economy' has created a demand for the Night Tube service.
- 2.4.6 He also advised to take actions cautiously once 24/2 is implemented, because it is very difficult to reverse the process. LU noted this phenomenon through their Business Case Narrative (this document is not publicly available).

2.5. Purpose of this Report

- 2.5.1 The purpose of this report is to provide an overall road map for the implementation of 24/2 service, stating recommendations for implementation in the medium and long terms.
- 2.5.2 This report will identify potential issues by presenting the assumptions, methodology and results of the simulation, which reschedules all the maintenance activities from seven nights per week (Sunday to Saturday) to five nights per week (Sunday to Thursday) based on a two-month historical record provided by BCRTC.
- 2.5.3 Section 4 will provide detailed analyses of BCRTC's current maintenance practices and state of the assets, as well as the associated operational impacts. Detailed operational impact analyses have been conducted, and the findings are presented in various sub-sections under Section 4:
- › System maintenance
 - › Staffing/labor requirements
 - › Infrastructure/equipment requirements
 - › System requirements
 - › Capital project impacts
 - › Health and safety, security, and emergency impacts
- 2.5.4 Section 5 presents the recommended operations strategy including service level and fleet requirements as well as the expected changes in transit demand for 24/2 service.
- 2.5.5 The Business Case and financial model will also be presented in Section 6.
- 2.5.6 And finally, a list of recommendations for the next steps is stated in Section 7.

2.6. Exclusions

- 2.6.1 The term “SkyTrain” in this report refers to the current Expo and Millennium Lines including the recent Evergreen Extension. This study does not look into the implications of any potential extension to the existing SkyTrain network which is still under planning at the time of this study. This study also assumes the SeaBus, West Coast Express, and Night Bus service will operate as of today, i.e. no extended service hours, operations hours, nor cancellation of the SeaBus, West Coast Express, and Night Bus services, will be assumed in this study. Nevertheless, there are also other external factors, such as the operation of ride hailing and sharing or other alternatives which may affect the outcome of this study but are uncertain at the time when this study was conducted; these factors are not considered.
- 2.6.2 The scope of this report is limited to the SkyTrain; feasibility study of 24/2 operation on Canada Line falls within the scope of others.
- 2.6.3 During the execution phase of this project, TransLink issued an additional RFP to conduct a study that evaluates potential sites to accommodate expanded vehicle storage and maintenance facilities for the future fleet of the Expo and Millennium Lines in the medium and long term. The future availability and locations of these vehicle storage and maintenance facilities may also affect the outcome of this study. The analyses conducted in this report assumed the system will be running as is and have not taken into account the OMC 4 (Operations and Maintenance Centre 4) nor any other improvements from the Expo Millennium Upgrade Program (EMUP). This study, however, looks into how the 24/2 operation will impact the implementation of EMUP and other capital projects.
- 2.6.4 Note that the noise impacts of 24/2 were not considered in this study.

3. Maintenance Simulation Analysis

- 3.0.1 Stages 1 and 2 identified the risk to system maintenance by adopting extended operating hours. To determine the magnitude of the issue, a simulation was done to understand how 24/2 service on Friday and Saturday would affect the maintenance, upgrade and rehabilitation of the existing network.
- 3.0.2 A two-month historical record provided by BCRTC was analyzed in the simulation. The simulation condensed all the maintenance activities from seven nights per week (Sunday to Saturday) to five nights per week (Sunday to Thursday) in the months of August and September 2018.

3.1. Analysis of Historical Data

- 3.1.1 The primary discipline impacted by a reduction in non-revenue hours is guideway. The following documents from BCRTC and TransLink were reviewed for inclusion within the simulation report:
- › Spreadsheet
 - Annual Maintenance Plan
 - 2018 Planning Schedule Nightshift
 - GDWY Nightshift Daily Log 2018 AUG (GDWY stands for guideway)
 - GDWY Nightshift Daily Log 2018 SEP (GDWY stands for guideway)
 - Scheduled Maintenance WOs 2018 (WOs stands for work orders; export from FoxPro - a database management software BCRTC uses)
 - Work Order Labor Hours August 2018
 - Work Order Labor Hours September 2018
 - › Map/diagram
 - SkyTrain Expo Line Occupancy Permit (OP) Map
 - SkyTrain Millennium Line OP Map
 - Mainline Operations Map Expo Line
 - Mainline Operations Map Millennium Line
- 3.1.2 Data from the Annual Maintenance Plan (AMP) from January to September 2018 were reviewed. The August and September data was chosen for extended service simulation because they are the two consecutive months with the most shifts (one shift refers to one staff per night) completed by technicians, service personnel, and laborers, as shown in the figure below.

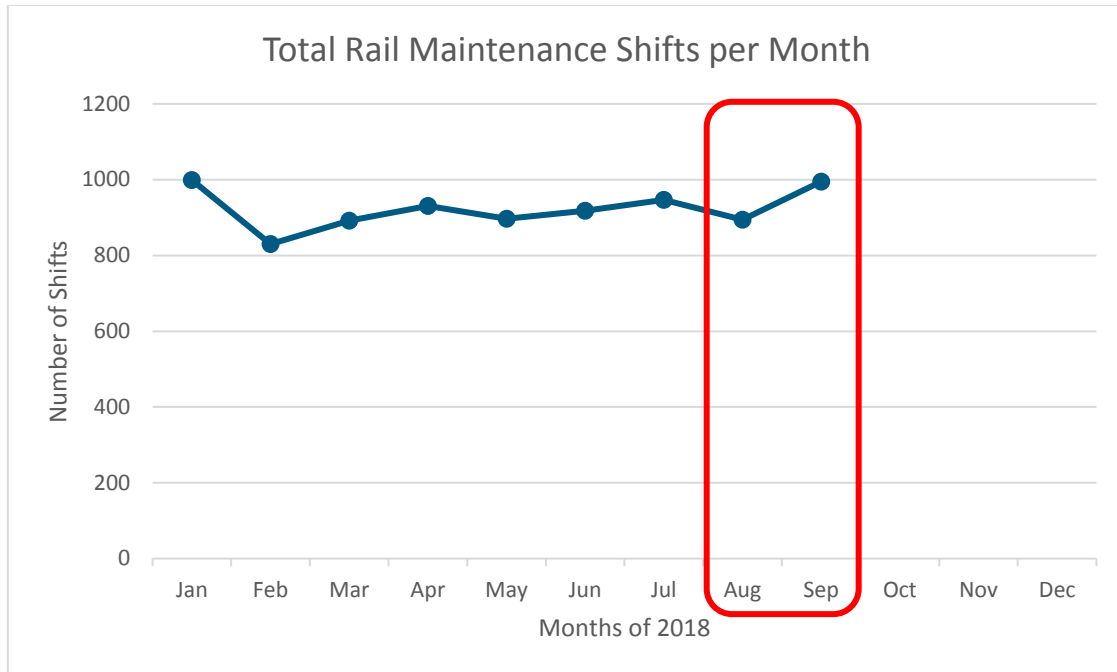


Figure 3.1 Total Rail Maintenance Shifts per Month

3.1.3 All maintenance activities from the 2018 Planning Schedule Nightshift spreadsheet between August 5 and September 29, 2018 (eight weeks in total) have been reviewed, which include:

- › Preventive Maintenance (e.g. walk/switch inspection and LIM reaction rail inspection)
- › Unscheduled Maintenance (e.g. welding, grinding, and repair after inspection)
- › Campaign (e.g. Trackwork C/O and LIM Lowering/Coring)
- › Projects & Support (e.g. LAMAR, PLANT Support/Activities, and projects).

3.1.4 Note that the above maintenance activity names are consistent with the 2018 Planning Schedule Nightshift.

3.1.5 Unexpected activities (distinct from unplanned maintenance), not included in the 2018 Planning Schedule Nightshift spreadsheet, were also reviewed. These added activities are not planned until the day of their occurrence. In other words, they do not appear in the 2018 Planning Schedule Nightshift (created three weeks prior to the workday). These unexpected activities were retrieved from the GDWY Nightshift Daily Log 2018 AUG and GDWY Nightshift Daily Log 2018 SEP spreadsheets. The simulation did not include these unexpected activities. However, after analyzing the unexpected activities (e.g. location of occurrence, frequency of occurrence, duration of each unexpected activity),

recommendations catering for the unexpected activities in the 24/2 operation are provided in Section 3.3.

3.2. Assumptions for Extended Service Simulation

3.2.1 The simulation aimed to condense all the maintenance activities, completed between August 5 and September 29, 2018, from seven nights per week (Sunday to Saturday) to five nights per week (Sunday to Thursday).

3.2.2 The following assumptions were made during the analysis of this information:

› **Work Order Location:**

- Due to safety concerns, the location envelope provided for maintenance activities is limited to one OP per work order per track direction as defined in the SkyTrain Expo Line OP Map and SkyTrain Millennium Line OP Map.
- If multiple work orders (e.g. similar inspections within the same area) were already grouped in the same location prior to rescheduling, it was allowed.
- “D-clean” is an annual switch cleaning activity which must be followed by “D repair” on the next available day as a follow-up. Since its work location is not specified in the 2018 Planning Schedule Nightshift, it is assumed that such activity will be performed wherever the work location is available.
- If a work order does not have its work location specified in any of the documents analyzed for this simulation (see the document list in Section 3.1), it is assumed that such work location is not a constraint in the 24/2 operation.
- Work orders without the direction specified (e.g. TSZ-NAZ from PLANT activity on September 20) are assumed to require OP on both track directions.
- The OP for Test Train (commissioning of new trains) requires one additional sub-station buffer distance before and after the actual test location for safety reasons.
- Inspection, in particular LIM reaction rail inspection, should be restricted if there are other work orders that require transport of heavy equipment along the same track (e.g. rail replacement) on the same night even though the inspection and the other work orders occur in two different OP zones.

› **Equipment Availability:**

- All existing equipment is in a state of good repair and remains functional at all time, i.e. no equipment failure is assumed. (Note that recommendations on additional equipment requirements, including spare equipment in case of failure, are provided at the end of Section 3.3).
- Equipment required for maintenance activities can be transported from yard to site in a timely manner, or there is enough track space outside of the yard for the staging of such equipment (e.g. VCC Clark tail track).
- It is assumed that equipment is required for the full non-revenue hours to complete the associated work order.
- The same equipment cannot be used at two different ends of the system in two consecutive nights due to insufficient window for transportation of the equipment from one end to the other.
- If the original equipment reserved was not available, alternative equipment with the same or higher functionality and capacity could replace it (e.g. Mog 1 could be replaced with Mog 2) if available.
- There are also some nights that equipment was reserved in the Planning Schedule Nightshift spreadsheet without any known activity specified. After validating with BCRTC, BCRTC suggests that it is fair to assume that such equipment is not available for use on that particular night due to unspecified work orders or staff training.

› **Duration of Work Orders:**

- Each work order (including the transport of equipment on site) requires the full non-revenue hours to complete for the following two reasons:
 - › The actual duration of each work order is not specified in any of the documents analyzed for this simulation; however, the maximum possible duration (the most conservative assumption) is the full non-revenue hours; and
 - › The transport of equipment on site may be time-consuming (depending on the distance between the equipment location and work order location).

› **Each OP section is limited to one work order per night:**

- A work order currently assigned to Friday nights can also be completed within the duration available in any other weekday nights. However, the work orders currently assigned to Saturday and Sunday nights, in general require a longer duration than the work orders currently assigned to weekday nights including Friday. A Saturday work order would therefore



need either 1) two consecutive weekday nights, or 2) one Sunday night to complete. These assumptions have been validated with BCRTC.

- Some work orders may also require single-tracking during revenue hours (e.g. rail grinding by LORAM and the Running Rail Replacement 2018).

› **Train Stabling on the Main Line:**

- Overnight train stabling on the Main Line will need to be coordinated with the maintenance activities.
- No train stabling on the tracks and track sidings where maintenance works or transport of equipment are required.

› **Resource/Staffing:**

- BCRTC can change their personnel scheduling structure or hire the required number of extra personnel to facilitate the 24/2 operation.

› **Rules for Rescheduling:**

- Preventive Maintenance activities from the Annual Maintenance Plan are typically inspections that occur at a certain frequency (e.g. weekly). Depending on the frequency of the activity, the work order could only be moved a certain amount in order to maintain that frequency. For example, a weekly switch inspection could only be moved 1 day before or after the original day, unless all subsequent weekly switch inspections were moved accordingly.
- Other maintenance activities that require multiple nights to complete were moved together. For example, if a work order needs to be done from Wednesday to Friday nights with different equipment and staff requirements per night, instead of just moving the Friday's requirement to Tuesday, the entire work order needs to be shifted and to be done from Tuesday to Thursday nights. This is to ensure that the correct equipment and staff requirements are assigned to each day of the week.

3.2.3 An initial review of the maintenance activities from BCRTC's records in 2018 revealed the challenge of compressing these activities from a seven nights per week (Sunday to Saturday) to five nights per week (Sunday to Thursday) schedule. In summary, there are limited ways to compensate for the lost maintenance hours on Friday and Saturday nights:

- › Reducing the current revenue hours on weekdays
- › Reducing the amount of maintenance works
- › Conducting staff training to increase maintenance efficiency
- › Integrating new technology to increase maintenance efficiency

- › Use of service suspensions in parts of the network (e.g. statutory holidays or periods of lower patronage) to undertake a vast array of maintenance and capital works
- › Maintaining maintenance equipment in a state of good repair

3.2.4 Since the intention of this simulation exercise is to identify the problems before identifying potential mitigations (which will be discussed in the subsequent Section 4), it is assumed that the same amount of maintenance works will be performed and the works cannot be done faster. The simulation was therefore held against the limitation of the existing equipment and maintaining the current revenue hours on weekdays.

3.3. Impact of Extended Service Hours on Work Activities

- 3.3.1 This section summarizes the results from the August and September simulations, taking into consideration location and equipment availability.
- 3.3.2 There are altogether 191 work orders on the eight Friday and Saturday nights in the simulation. The simulation has determined that the activities undertaken could not be completed in the maintenance window presented in a 24/2 operating schedule due to the lack of equipment and location conflicts.
- 3.3.3 The following characteristics of the current SkyTrain system prevent the successful re-profiling of maintenance works to Sunday-Thursday night shifts:
- › Lack of equipment to undertake scheduled work
 - › Insufficient storage and maintenance capacity for the maintenance vehicles
 - › BCRTC reliance upon a centralized location to maintain the growing SkyTrain network
 - › Lack of transportation options to distribute equipment and staff to site locations
- 3.3.4 The 17 outstanding work orders that could not be completed due to the lack of equipment as identified from the simulation (without the reduced revenue hours on weekdays) can be found in Appendix A. It should be noted that these outstanding work orders shown in Appendix A only include those that are not able to be performed due to the lack of equipment but do not include those with location conflicts (note: the outstanding work orders due to location conflicts are discussed later in this section).
- 3.3.5 Based on the simulation, the following additional equipment are required to facilitate 24/2 operation:



- › 1 additional prime mover with the same or better function as the existing Speeder 3 (Sp 3) and Speeder 4 (Sp 4)
- › 2 additional Unimogs with the same or better function as the existing Unimog 1 (Mog 1) and Unimog 2 (Mog 2)
- › 1 additional speeder with the same or better function as the existing Speeder 5 (Sp 5), Speeder 6 (Sp 6), Speeder 7 (Sp 7) and Speeder 8 (Sp 8)
- › 1 additional Crane Cart with the same or better function as the existing Crane Cart 1 (CC 1) and Crane Cart 2 (CC 2)
- › 1 Additional Flat Cart with the same or better function as the existing Flat Cart (FC)

- 3.3.6 Moreover, location conflicts have presented a number of constraints in the August and September simulation. These occur when a linear maintenance activity (e.g. LIM rail adjustment) interferes with a site based maintenance visit requirements (e.g. switch machine maintenance). Such conflicts require careful management due to worker safety risks – it is for this reason that hiring staff to meet the workload isn't an effective long-term strategy.
- 3.3.7 Despite the procurement of additional equipment, the simulation indicates that location conflicts remain an ongoing obstacle for maintenance and planning teams in 24/2 operation. These risks are carefully managed today by the maintenance and planning teams, who will be required to balance competing access needs.
- 3.3.8 These conflicts are likely to increase in frequency due to the reduced non-revenue hours. OP management and diversification of maintenance centers will reduce the effect this has on maintenance planning.
- 3.3.9 Out of the 191 work orders on the eight Friday and Saturday nights, there are 32 outstanding work orders (17%) that are unable to fit into any of the nights between Sunday and Thursday due to location conflicts even with the additional equipment provided. All the outstanding work orders due to location conflicts as identified from the simulation can be found in Appendix B.
- 3.3.10 The majority of the location conflicts is due to the station upgrade works which occurred almost every day, including Friday and Saturday nights. The remaining outstanding work orders are due to test train location conflicts. Refer to Section 3.4 for recommendations to resolve these location conflicts.

Recommendation to Cater for Unexpected Activity and Equipment Failure

- 3.3.11 The simulation exercise sought to identify trends in unexpected activities. One activity is found in August, whereas two are found in September. All three activities required one maintenance shift to resolve.
- 3.3.12 Each unexpected activity required two to four workers. However, the required type (technician and service personnel) and number of workers are activity-specific. The simulation activity determined that the required equipment was also activity-specific.
- 3.3.13 Repairing Track Intrusion Detection Systems (TIDS) mounting at Broadway inbound is an example of unexpected activity. Since it is not possible to predict the unexpected activities in advance, it is recommended that BCRTC evaluate the risk acceptance of encountering unexpected activities and equipment failure to determine the spare equipment needed.
- 3.3.14 Table 3.1 proposes a list of equipment (together with necessary storage, maintenance tooling and spares) to cover the unexpected activities as well as any equipment failure. Note that this is subject to BCRTC's confirmation.
- 3.3.15 Equipment staging locations for all new and existing equipment should be 1) provided at different locations across Expo and Millennium Lines and 2) planned ahead so that the travel time from the equipment location to the work location can be reduced.

3.4. Actions and Recommendations

Medium-Term Implementation

- 3.4.1 The current maintenance schedule will be impacted if 24/2 operation (maintaining the current revenue hours on the weekdays) is to be implemented in the medium term, without changes to current practices.
- 3.4.2 Nevertheless, lack of equipment and sidings to transport or pre-stage such equipment on site as well as location conflicts would not be easy to resolve in the medium term.
- 3.4.3 Reducing revenue hours and allowing shut-down services are two ways to address the outstanding work orders due to location conflicts.
- 3.4.4 In order to maintain state of good repair, the following issues or initiatives would need to be resolved or considered prior to implementation of 24/2 operation in the medium term:
 - › Purchase additional equipment and find additional storage space (e.g. within OMC 3) for such additional equipment as listed in Table 3.1
 - › Provide wayside maintenance equipment and storage needs around the system
 - › Reduce revenue hours on the weekdays
 - › Allow complete or partial shut-down of services on statutory holidays
 - › Improve coordination with capital projects (e.g. station upgrades and commissioning of new trains)
 - › Coordinate overnight train stabling on the main line with the maintenance activities
 - › Perform single track operation on Expo and Millennium Lines during weekday morning start-up period
 - › Distribute maintenance works more evenly throughout the entire year
 - › Improve coordination of the equipment (only use the equipment if it is necessarily required for the work order, see Section 4 for equipment usage observation)

Table 3.1 Equipment Requirements

Scenario	Prime Mover	Unimog	Speeder	Crane Cart	Flat Cart
Existing availability (and list of equipment)	2 -Speeder 3 -Speeder 4	2 -Mog 1 -Mog 2	4 -Speeder 5 -Speeder 6 -Speeder 7 -Speeder 8	2 -Crane Cart 1 -Crane Cart 2	1 -Flat Cart
Additional requirement to condense existing work orders from 7- night window to 5-night maintenance window	1	2	1	1	1
Proposed spare to cater for unexpected activity (subject to BCRTC's confirmation)	1	0*	1	1	0
Total requirement for 24/2 operation	4 (2 for Expo Line, 2 for Millennium Line)	4	6	4	2

* Extra prime movers are available to serve the same function in case of unexpected activities, at least 2 prime movers and 2 Unimogs should serve Expo and Millennium Lines individually.

Long-Term Implementation

- 3.4.5 While maintaining the medium-term implementation, new technology (refer to Sections 4.1.25 to 4.1.61) and a management tool (refer to Section 4.1.20) are envisioned to reduce the work order duration in the long-term.
- 3.4.6 It is therefore suggested that a review be undertaken three years after the execution of 24/2 in the medium term, to evaluate any operational or maintenance decisions undertaken in anticipation of 24/2 service.

In the long term, it is assumed that BCRTC would be able to implement a similar 'Access Transformation Program' as that implemented by London Underground, which aimed to maximize maintenance time and resources, minimize controls whilst maximizing safety, and enable quicker possessions to maximize the maintenance window and maintenance work. TransLink is suggested to contact London Underground directly to request information on 'Access Transformation Program'.

4. Detailed Operation and Maintenance Analysis

- 4.0.1 The SkyTrain system is currently undergoing a period of significant investment and change; the O&M teams at BCRTC demonstrate good practice in planning and executing maintenance and capital activities. The objective of this section is to determine how current O&M practice can be optimized to facilitate the migration to 24/2 operation.

4.1. Impact to System Maintenance

- 4.1.1 This study permitted detailed discussion with planners, managers and directors responsible for maintaining the state of good repair of the SkyTrain system. The methodology applied for this impact analysis was to undertake reviews of maintenance planning, resource allocation and other requested information to inform the project team.
- 4.1.2 Another key source of data for this review was the simulation activity detailed in Section 3 of this report. The simulation exercise allowed the team to review the requirements for maintenance tasks requiring direct access to the guideway, and determine how the system rehabilitation may be affected by the migration to 24/2.

Review of Current Maintenance Program

- 4.1.3 A key requirement for the 24/2 feasibility analysis is to maintain the asset condition despite the constraints and impacts 24/2 causes. Key aims for these discussions are to determine:
- What constraints exist in the existing practice? How do these affect the ability of the maintainer to undertake their works?
 - How is the asset base to be maintained in the 24/2 operating environment?
 - What is needed (equipment, recruitment, review of process) to facilitate the maintenance regime?
 - How should the organization migrate to this new maintenance regime?
- 4.1.4 In comparison with other industries, working on or alongside an operating rail network adds significant complexity, risk and safety concerns. Work may need to be carried out at certain restricted times, like evenings or weekends, which can mean that even minor interruptions or delays in the work program can have a significant impact on project duration and costs. BCRTC mitigations are in place to reduce the likelihood of any overrunning engineering works. These include:



- › Stabling trains on the mainline when planning teams are made aware of potential overrunning engineering works
- › Flexibility in use of sweep trains
- › Flexibility in use of single-tracking



Figure 4.1 Elevated Guideway Presenting Constraints to Undertaking Work in Non-revenue Hours

- 4.1.5 Figure 4.1 demonstrates the challenge of undertaking maintenance or capital enhancements due to the elevated sections presenting few opportunities to store materials or equipment. This constraint presents numerous challenges to the capital and maintenance teams, and results in the need to transport staff and equipment at the start and end of every work shift.
- 4.1.6 Conversely, Figure 4.2 presents a typical alignment for heavy-rail. This demonstrates the ample space made available to maintenance and capital teams, thereby facilitating the storage of equipment (and staff for passing trains) for works requiring successive nights.

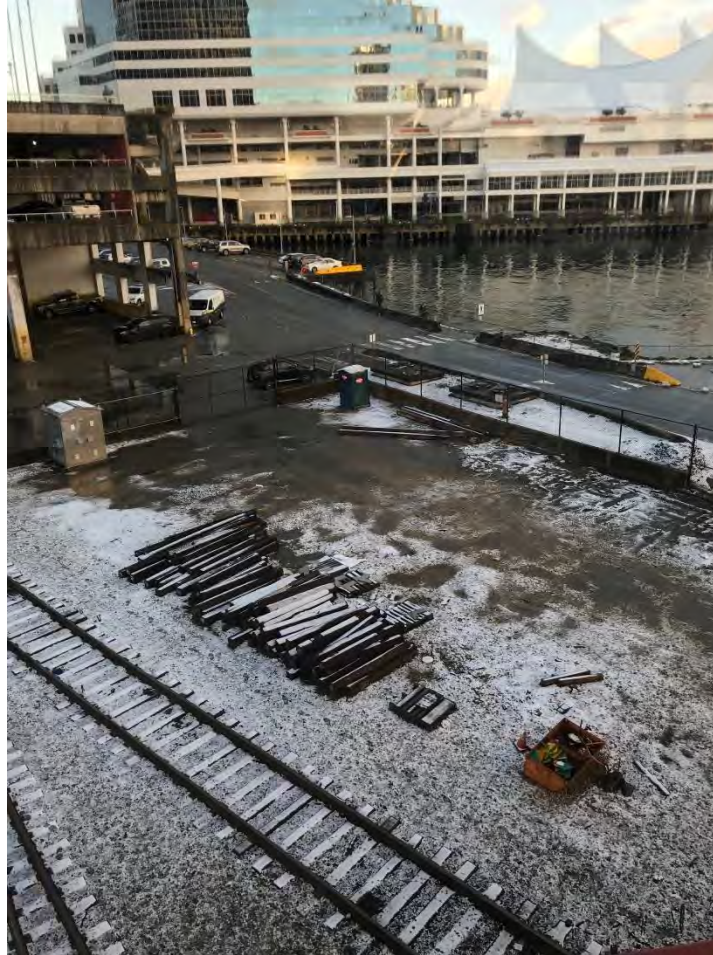


Figure 4.2 Typical At-grade Heavy Rail Alignment

- 4.1.7 The net result of the constraints mentioned in Section 4.1.5 above, is the need to intricately plan and forecast all guideway activities (such as asset monitoring, asset upgrades, asset renewals and capital enhancements) to ensure the risk of overrunning engineering works are mitigated.
- 4.1.8 There is also a much greater risk that capital projects will lead to operational disruption. As well as the standard construction risks that affect all sectors of the economy, rail industry enhancement projects are likely to face significant additional risks that can lead to cost overruns. This is of primary concern to the maintenance teams at BCRTC because these capital works are supported directly by the maintenance teams. The project team notes the continuing effort to rationalize the support for capital activities. The need to balance competing demands (i.e. undertaking maintenance and supporting capital projects, with limited hardware provision) highlights the layered complexity of delivering capital works within an operating railway – this applies to equipment, planning and staff.

- 4.1.9 One of the biggest concerns for those managing the maintenance of the SkyTrain is the overall reduction of non-revenue hours in the event of 24/2 operation. Discussions with BCRTC leadership were used to qualify a number of initiatives (discussed in Section 3.4) which include extending non-revenue hours outside of the weekend.
- 4.1.10 Stages 1 and 2 of this study identified the risks associated with extending operating hours without sufficient analysis and planning for the necessary maintenance activities. Examples of risks outlined in stages 1 and 2 are:
- › staffing (e.g. union resistance to the new Collective Labor Agreement)
 - › maintenance (e.g. insufficient time to complete guideway maintenance)
 - › operations (e.g. inadequacy of train stabling areas)
 - › cost (e.g. cost to operate extended service hours)
 - › Capital projects (e.g. cost increase in capital projects due to the operation hour extension)
- 4.1.11 Discussions with maintenance engineers have revealed a general philosophy of 'run to fail' (see section 4.1.36 to 4.1.38 for example). This conscious decision enables the railway to maximize asset value, acknowledging the potential to impact the operating service from service affecting failures.
- 4.1.12 One constraint identified in this study was the current scheduling of response technicians. Technicians respond to failures outside the core operating hours through an overtime arrangement – this is unlikely to satisfy the 24/2 operational requirements.
- 4.1.13 This study has identified a number of constraints which increase the time taken to undertake the activities needed to keep the railway in a state of good repair. There are a range of optimizations available which may be instigated within 'business as usual' rather than under the umbrella of 24/2 operation such as unreliability of tools (in our maintenance simulation, welding works were cancelled owing to equipment failure) and the lack of transportation for teams to travel to work sites.
- 4.1.14 The discussions undertaken confirmed that the existing team, equipment and processes meet the overall workload in the current operating regime.

Annual Maintenance Plan

- 4.1.15 The BCRTC annual maintenance plan (AMP) documents all the necessary maintenance activities on a 12-month schedule. These activities include:
- › Observation and inspection of wayside assets
 - › Light maintenance activities (e.g. measurement of rail wear)

- › Heavy maintenance (e.g. switch machine cleaning and internal maintenance)

4.1.16 Discussions with maintenance planners revealed that the summer months have more annual maintenance activities than the rest of the year, thereby benefiting from the improved weather. This planning regime has the consequence of concentrating maintenance activities in the summer months, thereby placing pressure on equipment and staff availability.



Figure 4.3 High-level maintenance plan

4.1.17 The AMP follows a traditional philosophy and captures the range of disciplines requiring attention (i.e. scope extends beyond guideway). The AMP also captures other periodic inspection or maintenance activities, with periodicities set by the Engineering department based on Maintenance Manuals and information from the Original Equipment Manufacturers (OEM).

4.1.18 Given the scale of works undertaken, the team demonstrates good practice in the planning, coordination and execution of maintenance activities. There are opportunities to optimize in the following areas:

- › Determination of true duration of work activities, to dovetail an increased number of work orders and drive efficiency
- › Better communication between maintenance planners and supervisors on the status of mission critical equipment – particularly where these assets are limited in supply (e.g. this has been shown as a constraint with welding equipment in August 2018)
- › BCRTC would benefit from minimizing the use of speeders to ensure activities that absolutely require that functionality have access. The use of

road vehicles to transport staff and equipment is recommended to free up these resources.

- › Instilling a culture of ‘every minute counts’. As an example, the delay by rail work contractor in transporting rail to the Waterfront siding presents opportunity for optimization. TransLink & BCRTC would benefit from undertaking a root and branch review of maintenance activities, together with their underlying requirements (e.g. tooling, transportation from the OMC, access to the guideway).
- › Publication of clear guidance to support the determination of priorities in assigning staff and equipment to capital vs. maintenance works.
- › Management of maintenance activities from one site (OMC 1) does not appear to have scaled well with a growing network. TransLink/BCRTC would benefit from a study to determine how best to manage activity in the context of future extensions to the SkyTrain network.

Execution of System Maintenance in 24/2 Operating Scenario

- 4.1.19 The analysis in Section 3 has highlighted the need for a reduction in revenue hours to support the capital and maintenance workload in the medium to long term.
- 4.1.20 In executing a 24/2 philosophy, the following processes will require detailed review for their suitability:
- › Asset Management Plan – BCRTC would benefit from rebalancing the annual activities to permit lower workload in the summer months
 - › Use of an Asset Management System (AMS) would facilitate a review of maintenance frequencies and durations, where data and evidence suggest assets are being over-maintained. A reduction in maintenance activities (where justified) was used at London Underground and can result in reduced work orders. With the maintenance frequency and duration data, AMS could also identify the design approaches which reduce the maintenance frequency and duration, yielding a rail system which meets functional requirements with reduced maintenance works. The case study below is an example of a new station design requiring high maintenance effort.
 - › Pooling of technical resources to facilitate capital projects in a timely manner
- 4.1.21 Once 24/2 operation is executed, the railway will operate continuously for three days. Serviceable failures (such as loss of switch machine detection or perceived ride quality) can be mitigated by locking (or clamping) switches or introducing temporary speed restrictions. Owing to the restricted access for maintainers, these failures will remain ‘open’ until the Sunday night – Monday non-revenue hours.

- 4.1.22 Maintenance planning will likely allocate the Sunday night – Monday morning shift to repair works rather than capital works, leaving the remaining nights available for maintenance and capital works.
- 4.1.23 The use of statutory holidays and planned suspensions in service will aid BCRTC in identifying suitable time for observations and repairs.
- 4.1.24 Currently, BCRTC limits the number of single-tracking sites to one (reasons appear to be related to impact to the passengers). BCRTC would benefit from determining whether this constraint can be relaxed to one single-tracking site for the Expo Line, and one single-tracking site for the Millennium Line.

CASE STUDY: STATION LIGHTING

Canada Line stations were installed in 2007, with Figure 4.4 presenting the typical arrangement. However, due to the tall vertical gap between the ground and the lighting fixtures, temporary scaffolding is needed for the simple task of repairing lightings. Instead, new temporary lightings were added while the old lightings remained unrepaired, as shown in the figure below.

During the station design phase, the Asset Management System would be able to raise the consideration that this station configuration could be improved to reduce the level of maintenance (frequency and/or duration) required.

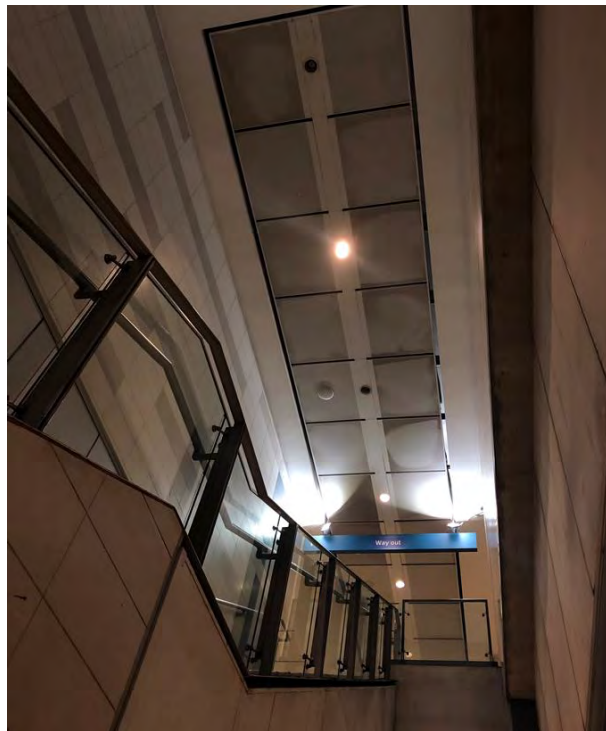


Figure 4.2 Station Upgrade Lighting

Equipment Constraints

- 4.1.25 The maintenance simulation report determined a shortage of maintenance vehicles formed a constraint to the adoption of 24/2 in the medium term.

Speeders

- 4.1.26 Where possible, maintenance technicians travel to work sites from OMC 1 in speeders. This cultural behavior stems from the need to carry heavy tools to sites for repair activities.
- 4.1.27 The transportation of equipment and tools to remote sites (at least 500m from the edge of station platforms) increases repair/maintenance time and introduces numerous inefficiencies and stresses to the work team. This experience is compounded when technicians are required to walk along the elevated guideway.



Figure 4.5 BCRTC Speeder

- 4.1.28 One option discussed with BCRTC Directors, was the use of decommissioned Mark I trains for transportation.

- 4.1.29 The Mark I trains are already equipped with ATC (Automatic Train Control) equipment and offer the benefit of being able to travel alongside passenger-carrying trains. Mark I trains are also able to traverse longer distances in the same travel time than speeders. While the use of Mark I trains introduces additional complexity (e.g. requiring traction power, or healthy batteries), BCRTC would benefit from studying this option further.



Figure 4.6 Network Rail's NMT

- 4.1.30 In the United Kingdom, Network Rail's New Measurement Train (NMT) is a converted passenger train equipped with track recording systems. The NMT is used to check the condition of most main lines on a 4-weekly cycle.
- 4.1.31 To distinguish the NMT from normal passenger trains, the NMT is painted yellow to minimize passenger efforts to board. BCRTC would benefit from a study outlining how and when to allocate Mark I trains for the use by maintainers.

Elevated Section – Safety Harness

- 4.1.32 One concern raised by technicians during interviews was the current provision of safety harnesses. These are required by Technical Safety BC to mitigate the issue of working at heights.
- 4.1.33 The harness system is heavy and introduces significant delay. This is a prime example of how the design of the rail system does not accommodate the needs

of the maintainers. As a result, the maintainers are forced to compromise, thereby removing flexibility and margin in their service offering. This results in inefficiencies and work orders requiring multiple nights to complete.

- 4.1.34 The project team is aware of reviews for alternative solutions (e.g. handrails on either side). This provision will bring efficiencies and increased safety to those working on the elevated guideway. It is hoped an innovative, cost effective solution can be introduced – at the very least on the Expo Line; where maintenance activities are likely to increase with the age of the asset.
- 4.1.35 As the system ages, this inefficiency/concern will extend to the Millennium Line and will likely impact long-term timescales for 24/2.

Equipment Reliability

- 4.1.36 Aborted engineering works (due to equipment unreliability, lack of staff or material shortages) have a tremendous impact on the constrained non-revenue hours. In the context of a 24/2 operation, having equipment and facilities tested prior to the commencement of these activities is vital to reduce the likelihood of cancellation.
- 4.1.37 The project team witnessed such an event during the simulation study; the welding equipment needed for guideway repairs was unserviceable, and all works in the months of August and September were cancelled. While staff were allocated to other work orders, the delay in completing this activity would have a significant impact in the context of 24/2 operation.
- 4.1.38 Contractor equipment reliability has also been determined as a concern; the project team identified derailment events during engineering hours which caused significant delays and safety risks. Determining the root cause of these events and minimizing such delays will contribute to the state of good repair in the 24/2 operation.

Maximizing Non-Revenue Hours

- 4.1.39 The following sections will provide recommendations on optimizing the usage of time provided for maintenance activities on the SkyTrain network with a realistic view in achieving 24/2 operation in short to medium terms. The topics are:
 - › Planning
 - › Single Tracking around Work Zones
 - › Track Time Usage
 - › Staging
 - › Transportation



- › Communication
- › Capital Planning & Engagement
- › Human Resourcing

Planning

- 4.1.40 The current level of planning for maintenance and capital works activities presents opportunities for further efficiency.
- 4.1.41 At present, maintenance planning commences three weeks prior to the planned shutdown and resources are secured at a much later date (i.e. Friday before the Monday work). BCRTC would benefit from an evaluation which extends this to 6-8 weeks look ahead and a more robust resource management scheme.
- 4.1.42 Better planning and coordination with third parties in advance of special events (e.g. downtown firework events) will enable a clearer level of forecasting and, therefore, allow BCRTC's maintenance activities to be better planned and coordinated. Through better planning and forecasting in anticipation of special events, track access can be optimally scheduled for both maintenance and capital works. This will support higher levels of efficiency throughout the entire organization.
- 4.1.43 Additionally, longer term planned shut downs potentially spanning the duration of long weekends or holiday seasons may be required to more effectively perform major maintenance works. This approach is not uncommon in other major transit systems around the world (e.g. London Underground shuts down entirely for Christmas day in order to allow a maintenance and capital upgrade 'blitz' of the entire network).
- 4.1.44 As the SkyTrain system continues to expand, and as major legacy assets continue to age to their end of life, it is recommended that TransLink consider the approach of extended shutdowns to facilitate the revitalization or heavy maintenance works required to keep the system in a good state of repair.

Single Tracking around Work Zones

- 4.1.45 Single tracking around work zones provide the ability to perform additional maintenance activities concurrently to revenue service.
- 4.1.46 A 24/2 operation does not preclude the use of single tracking during times of lower patronage; lower service frequencies (i.e. 15 minute headways) will facilitate their setup and use, thereby offering maintainers the opportunity to continue maintenance activities during the weekends.

- 4.1.47 However, single tracking will only benefit maintainers' access in certain areas where a single tracking headway of 15 minutes (or less) can be achieved.
- 4.1.48 There remain areas of the SkyTrain network where the location of switches form a constraint to the level of service provided by single-tracking. The Thales Desktop Simulator tool can be used to adequately ascertain the predicted frequency of services in these locations.

Staging

- 4.1.49 Identifying staging and lay-down areas in support of advanced planning of either maintenance or capital works and locating major equipment, material and tools in advance of work execution will help to support more efficient use of track time during the available maintenance windows.
- 4.1.50 Additional benefit can be realized by locating tools in lock boxes strategically positioned along the guideway or station areas. This will allow maintenance personnel to access tools closer to site locations as opposed to transporting back and forth from the OMC.
- 4.1.51 Another consideration that can be made is the better use of the existing pocket tracks (i.e. at Waterfront) for maintenance equipment. This will reduce travel time of maintenance equipment from the OMC and allow maintainers more time to focus on actual maintenance activities.
- 4.1.52 The transportation of equipment and tools may at times, be better undertaken by road or rail rather than SkyTrain. In the example of rail staging to Waterfront siding by rail contractor, BCRTC would benefit from a review to deliver these rail sections by Canadian National (i.e. Class 1 rail), and carried to the SkyTrain siding.
- 4.1.53 This staging approach will require further advanced planning efforts (i.e. weekly maintenance and capital works logistic plans) to ensure equipment, material and tools are prepared for scheduled works, but will result in a more effective use of track time during non-revenue hours.

Transportation

- 4.1.54 The use of the existing speeders draws risks to accessing site locations. One example of a risk may include the inability for a maintenance crew to access a particular site location due to rail-borne transportation equipment 'bottlenecks' ahead where advanced rail vehicles may hold up or prevent maintenance crews from accessing site in a timely manner.



- 4.1.55 The simple solution of rearranging the sequence of deploying transport vehicles to 'fastest' at the front and 'slowest' at the rear is not always achievable, as the sequencing of vehicles is linear nature and they must be arranged such that the first vehicles out is routed to the furthest site location, second vehicle out to the second furthest location, etc.
- 4.1.56 Another downside risk in the use of speeders is that they are prone to derailing. A suggested alternative to this existing method of travel to site is the use of road vehicles to transport personnel to site locations. The advantages in the use of road vehicles for transportation are as follow:
- › Arrival at the nearest (to the site) station platform in advance of revenue service draw-down or completion.
 - › Avoidance of waiting for 'advanced' rail vehicles to access site.
 - › Overall more flexibility in the movement between multiple site locations.
 - › Shorter journey time and response time.

Communication

- 4.1.57 The number of available radio channels have become a constraint in permitting additional radio traffic at times of high demand (during non-revenue hours).
- 4.1.58 Operators have limited 'windows' to communicate with field personnel due to busy radio traffic. This wastes valuable track time, especially when field personnel are waiting to be granted an occupancy permit to access a site or to setup a work zone.
- 4.1.59 Communication protocol training and refresher courses for operations and field staff can support a more efficient and effective communication environment. With increased efficiency of communication between the operators and field staff, non-revenue hours can be more effectively utilized for maintenance activities as opposed to standing-by while crews wait to access a work zone. Additionally, this will help to instill a stronger culture on the importance of efficiency in each task performed, and that every minute matters to the overall efficiency of the operation.
- 4.1.60 A further option to consider will be the use of cell phones for communication between field staff and the operators. A key consideration to note is that all conversations via the Operations Control Centre's landlines are recorded. With this proposed approach, all communication between operators and field staff is recorded and archived, just as all radio communication is recorded and archived. This ensures the ability to retrieve communications, if required.

- 4.1.61 It's noted that the current radio system is planned to be upgraded in the upcoming years. This upgrade, along with the Operations Control Centre, will provide more reliable and efficient communication, creating the necessary infrastructure that enables 24/2 operation.

Capital Planning and Engagement

- 4.1.62 The project team found opportunities for TransLink and BCRTC to optimize the scope-defying stages of capital projects. There appears to be some inconsistency between what BCRTC require to operate and maintain the railway asset, and what is delivered by TransLink. Robust project governance will offer tools and strategies to close the gap identified by the project team.
- 4.1.63 Opportunity exists for a more engaged level of communication, coordination and engagement between TransLink and BCRTC, specifically for future capital works. The planning efforts will allow BCRTC to voice any practical concerns and potential risks in proceeding down an early path of planning for capital spend.
- 4.1.64 As with any successful project, early stakeholder engagement with key parties is critical in ensuring a final product that offers value for money, meets functional and performance requirements, to all parties. In the situation of maintaining optimal service for SkyTrain, this early level of discussion is critical in ensuring an optimized service is continued to be delivered to the public.
- 4.1.65 In the prior section, there have been items identified which may overlap or could, at least, be a factor for consideration in future capital planning efforts. An example would be the planning for additional storage space (i.e. pocket or tail tracks) for maintenance equipment. The advantages of allowing a more 'distributed' approach in staging maintenance vehicles have been highlighted above, and a constructive dialogue outlining the positives and negatives of supporting additional mainline storage space for maintenance equipment has merit.
- 4.1.66 The distributed approach to maintenance management of the rail system is an example of adding inherent capacity for the maintainer. There is presently insufficient maintenance capacity for capital projects. One example is that lifting jacks for the Mark III vehicles were never procured. A shift in culture is needed in terms of engagement, maintenance consideration, etc. This change will play a key role in maintaining 'State of Good Repair' in the long term.
- 4.1.67 Based on experience of other metro operators, failure to adequately capture maintainer requirements in the scoping of capital projects will result in:

- › Extended durations for renewal projects such as track (e.g. insufficient storage capability alongside the network)
- › Increased resource hours to maintain equipment (e.g. continuing to use the safety harness for works at height will necessitate longer hours to undertake works – there will come a point whereby a handrail will become cost-effective)
- › Ineffective use of non-revenue hours while waiting for slow maintenance vehicles to travel the network; a growing issue noting the potential for extension to the network (this will in effect reduce usable engineering hours, delaying the completion of works – this is evident with the Evergreen Line)

Human Resourcing

4.1.68 In dialogue with BCRTC representatives, resourcing was raised as a potential area of concern given the current needs to maintain day-to-day operations and have an ability to manage major incidents or service affecting delays. A comprehensive review of the current level of resourcing from management to field support staff is required to ensure future sustainability and in retaining experienced and talented individuals. In an effort to help alleviate these potential issues, BCRTC can take the following steps:

- › Formalized succession planning should become a human resourcing priority in order to provide a long-term vision and a clearer path in career progression to staff. This will help provide a clear route to staff in achieving their career aspirations, as well as to external potential candidates in understanding what opportunities lay ahead. More specific to the scope of this report, this approach will help to retain and recruit the best talent to more effectively maintain the system. This will also help to provide clarity on projected levels of attrition, which in turn will provide the ability to leverage and 'download' the years of experience gained by dedicated staff that are approaching retirement age.
- › Regular training should be a top priority for all staff that play operation critical roles in ensuring the smooth daily operation of the system. With the correct training platforms and courses in place, staff can be both trained and/or refreshed on the latest processes, procedures, policies, etc. that are critical to the operation. This training should range across a wide spectrum of topics including but not limited to: equipment maintenance training, management and supervisor training, conflict resolution training, and project management training. Under a cohesive training regime, a common certification process will ensure all staff have received a pre-defined level of training and education and will be empowered to perform at their most optimal levels. This will, in turn, allow the most optimal maintenance and good state of

repair of the system's assets. People need to be trained and equipped with the right tools and knowledge in order to be set up for and achieve success.

- 4.1.69 TransLink project managers also play a critical role to ensure capital projects precisely capture the maintainer requirements. To achieve effective capital planning, project managers should engage in discussions with the BCRTC operations and maintenance teams (various levels of staff) to identify the needs and their priority of the rail system. This allows to understand the challenges from different staff perspectives at various stages of a project. In addition, maintenance observations (such as observing a rail replacement, daily operation in the OMC and ride along on a speeder) will further enable project managers to capture the challenges in delivering capital projects in more detail.



Medium-Term Implementation

- 4.1.70 The implementation of 24/2 service presents a number of issues or risks to the continued maintenance of the installed asset base. However, the execution of the following will help to de-risk this activity:
- › Loss of Maintenance hours on Friday and Saturday nights
 - › **Mitigation:**
 - Review opportunities for efficiencies in maintenance practices and tooling
 - Reduction of service hours in the evening by 60 minutes every weekday.
 - Use of statutory holidays to facilitate maintenance and capital project works
 - Additional service suspensions to offer maintenance teams capacity to undertake maintenance activities (e.g. no 24/2 service for some weekends on the Millennium Line)
 - › Increased maintenance shifts for Sunday – Thursday nights and need for additional maintenance equipment and maintenance access equipment
 - › **Mitigation:**
 - Procure additional guideway vehicles and associated maintenance equipment
 - Assign additional storage and maintenance tooling for these vehicles
 - Distribution of maintenance equipment (permanent way tooling) along the guideway. Use (where necessary, replenishment) of lockable storage along the guideway
 - Review opportunities for efficiencies in maintenance practices and tooling
 - › System expansion in medium-term will increase maintenance needs
 - › **Mitigation:**
 - Review maintenance capacity alongside forthcoming large capital extensions to the SkyTrain system
 - Embark on a recruitment and training program to ensure the needs of the railway are understood and met in anticipation of the growing railway network.

4.1.71



Long-Term Implementation

- 4.1.72 The key consideration for the long-term implementation of 24/2 is the provision of storage and maintenance facilities to complement the existing OMC site. These facilities will provide storage of maintenance vehicles and decentralize maintenance activities from the current single OMC location today. This decentralization will allow maintenance staff to start and end work at locations closer the maintenance need, increasing the maintenance hours around the system.
- 4.1.73 In addition to the provision of a decentralized maintenance approach as outlined above, the issues/risks and mitigations identified above for the medium-term implementation would also need to be considered. Additionally, the following mitigations should be considered:
- › Centralized maintenance limits maintenance hours
 - › **Mitigation:**
 - Procure land adjacent to the mainline for additional stabling/storage. E.g. TransLink to buy the land adjacent to the Waterfront turn back, to enable the storage of material (such as new rail).
 - › Loss of Maintenance hours on Friday and Saturday nights
 - › **Mitigation:**
 - Introduce design standards that include a focus on the maintainability of equipment, systems and assets.
 - Introduce an Asset Management System that permits discipline engineers to challenge maintenance periodicities time or complexity to undertake maintenance activities (e.g. lighting that needs scaffolding to access to replace lamps, see Figure 4.4 in case study)
 - Handrails for mature and/or complex areas of elevated guideway
 - Undertake a root and branch study of maintenance practices to determine how best to use non-revenue hours (to include renewals of equipment which require fewer maintenance visits or can be re-sited to allow maintenance during operating hours)



4.2. Staffing / Labor Requirements

- 4.2.1 Operational impact analysis for the proposed 24/2 operation scenario for the Expo and Millennium Lines considered implications to staffing and labor requirements and any constraints to achieving operational implementation from a labor management perspective.
- 4.2.2 Changes to service patterns considered in the 24/2 scenarios will have an impact on operational staffing for maintenance, operational support and front line employees, and will require realignment of shift coverage to support this initiative. Early identification of potential Collective Labor Agreement (CLA) or applicable Provincial Labor Standard issues is important for planning and risk mitigation processes.

Collective Agreements and Applicable Employment Standards

- 4.2.3 Two CLAs were examined as part of the Staffing/Labor Requirements analysis. Specifically:
 - › Agreement between SkyTrain British Columbia Rapid Transit Company Limited and Canadian Union of Public Employees (CUPE) Local 7000 – Effective September 1, 2016 – August 1, 2019
 - › South Coast British Columbia Transportation Authority (TransLink) and Canadian Office and Professional Employees (COPE) Union Local 378 – Effective April 1, 2016 – March 31, 2019
- 4.2.4 Additionally, the following British Columbia employment standards were examined to further understand if there are any applicable sections which need to be highlighted and mitigated in advance of a proposed change to unionized job assignments;
 - › Employment Standards Act of British Columbia [RSBC 1996] Chapter 113
 - › Section 4 - Hours of Work and Overtime
 - › Employment Standards Regulation of British Columbia Reg 396/95
 - › Part 5 – Hours of Work and Statutory Holiday Pay

Analysis Highlights Summary

- 4.2.5 The following is a summary of our analysis of the identified CLAs and Provincial employment standards, and a summary of highlighted applicable articles and sections which may affect changes to unionized employee job assignments.

4.2.6 CUPE Local 7000 Collective Labor Agreement (majority of affected employees)

- › Current contract expires on August 31, 2019 and it is our understanding that contract renewal negotiations will commence in March 2019.
- › Article 5.01 (e) and (f) – Job Descriptions: Current language in the CLA provides the employer a mechanism to change or revise existing job descriptions and create and post new job classifications.
- › Article 5.03 (a) – New Jobs: Current language in the CLA provides the employer a mechanism for creating and implementing new jobs classifications and descriptions.
- › Article 5.05 – Job Evaluation Appeal/Request Procedure: The current CLA provides a grievance process mechanism to resolve disputes regarding job descriptions and qualifications.
- › Article 9.00 – Technological and Procedural Change: Current CLA provides language to address technological and procedural changes. Based on the language provided in the CLA and typical industry practice, it is our opinion that any changes to job assignment shifts contemplated under a 24/2 operating scenario would not trigger a Technological and Procedural change.
- › Article 10.01 (c) Standards and Authorized Variations: Current CLA establishes the standard starting time as 08:00h with authorized variations of starting times between 06:30 and 09:30h.
- › Article 10.01 (d) Specific Positions Exceptions (LOU #38): Current CLA provides a mechanism for the employer to create exceptions to the standard and authorized variation times by Letter of Understanding (LOU).
- › Article 12.00 – Shift Work and Non-Standard Hours: Current CLA provides a listing of scheduled jobs on a shift basis due to the requirements of the Company. This establishes precedence for establishing job assignments which fall outside the standard definition of shifts based on Company operational requirements.
- › Articles 12.05 and 12.06 – Ten and Twelve Hours Shift Schedules: Current CLA establishes precedence for establishing ten and twelve hour shift assignments.
- › LOU #7 – Staffing Levels/Part Time Employees: CLA provides a process for ensuring adequate staffing levels and how the Company and Union achieve these requirements.
- › LOU #8 – Shift Development Procedure for Regular Employees: CLA provides a process for developing shift schedules for full-time and part-time regular employees. This LOU includes a mechanism for advising the Union and its membership of pending changes to job assignments and a process for soliciting employee feedback on schedules. There is also a provision for

implementing changes faster than defined in the notice period if the Company deems the change to be urgent.

4.2.7 COPE Local 378 Collective Labor Agreement (limited number of affected employees)

- › Current contract expires on March 31, 2019.
- › Article 5.01-5.07 – Job Descriptions and Evaluations: Current CLA provides a process for establishing jobs, creating job descriptions and an evaluation process. This clause of the CLA appears to be primarily focused on establishing job grades and relevant rates of pay and does not specifically address schedules and shifts.
- › Article 8.09 – Automation & New Procedure: Current CLA provides language to address automation, new equipment or new methods or procedures which might result in the displacement or down grouping of regular employees. Based on the language provided in the CLA and typical industry practice, it is our opinion that any changes to job assignment shifts contemplated under a 24/2 operating scenario would not trigger an Automation & New Procedure change.
- › Article 10.01 - Work Day and Week: Current CLA establishes the standard work week as Monday through Friday and the standard starting time as 08:00h with authorized variations of starting times between 06:00 and 12:00h.
- › Article 11.01 – Shift Work – Shift Job List: Current CLA provides a listing of exceptions to the standard and authorized variation times needed to meet the Employers operational requirements. This article states that the list is subject to change and establishes precedence to changes in assignments due to Employer operational requirements.

4.2.8 Employment Standards Act of British Columbia [RSBC 1996] Chapter 113

- › Section 4 - Hours of Work and Overtime: provides a general guide on establishing hours of work and overtime rules. The applicable CLAs are more restrictive that the minimum Provincial standard. No mitigation required.

4.2.9 Employment Standards Regulation of British Columbia Reg 396/95

- › Part 5 – Hours of Work and Statutory Holiday Pay: provides a general guide on establishing hours of work and Statutory Holiday pay rules. The applicable CLAs are more restrictive that the minimum Provincial standard. No mitigation required.

Potential Impact of Migration to 24/2 Operation

- 4.2.10 Based on the analysis of the Collective Labor Agreements, Employment Standards and Regulations reviewed, there were no concerns raised in any of the governing documents which would unnecessarily prohibit or prevent TransLink and BCRTC from establishing new, or revising existing job assignments under a 24/2 operating scenario.
- 4.2.11 As with all changes to employee work assignments that ultimately may affect quality of life, family responsibilities, personal routines, child or parental care responsibilities, the introduction of changes may not be viewed favorably by affected employees and may require extended discussion or negotiation.
- 4.2.12 The timing and method of introducing changes to job assignments to the Union and employees should be considered carefully and a strategy developed to achieve the most optimal outcome.
- 4.2.13 It should be noted, London Underground struggled to implement the necessary labor changes required for the Night Tube project. The overall project was delayed and strike action commenced, while negotiations proceeded.
- 4.2.14 TransLink will need to plan and communicate early on, any changes to the existing roster for operational and maintenance staff.

Consultative Process

- 4.2.15 The analysis of the applicable Collective Labor Agreements included an interview and discussion process with a Labor and Human Relations representative on January 11, 2019. This discussion included a brief overview of the 24/2 operating scenario followed by a review of questions provided in advance of the meeting pertaining to the applicable CLAs. The purpose of the questions and meeting was to gather information on the current status of CLAs, clarify the application and understanding of applicable CLA Articles and gauge the status of Labor/Management relations within TransLink and BCRTC.

- 4.2.16 













Medium-Term Implementation

- 4.2.17 Integral to a smooth transition from the current operating status to a 24/2 operating scenario is the development of a strategic labor relations approach to implementing assignment changes. This approach should consider at a minimum, the following actions and tasks:
- › Identification of all job assignments (by job classification) which will be affected by a 24/2 operating scenario. This includes considering which assignments currently cover part of the 24/2 scenario and which assignments will need to be created to provide partial and full coverage in the 24/2 scenario.
 - › Preparation of a current and proposed job assignment roster, by job classification, which clearly identifies:
 - Current job assignments affected (e.g. need to change)
 - New assignments that need to be created
 - Effective date
 - Estimated cost of the proposed changes (e.g. additional FTEs, recruitment, shift premiums, weekend premiums, training, tools and equipment, etc.).
 - › Development of a Labor Relations implementation strategy which addresses risks, employee morale/engagement, costs and any required mitigations. This should be presented to senior management and key stakeholders to ensure buy-in and consensus at all levels of the organization.
 - › Preparation of Union leadership communications.
 - › Identification of required and discretionary change advisories as defined by the applicable CLA and required date(s) of issue.
 - › In collaboration with the Union, prepare an internal employee communication memo to announce the 24/2 operation initiative and team meetings to summarize it.
 - › Schedule team meetings delivered by management, to provide a summary of the initiative, including timing, benefits to SkyTrain and any anticipated employee impacts.
 - › Include a Q&A session with the team meeting with responses based on the labor relations implementation strategy and company agreed mitigation responses.
 - › Capture employee feedback, confirm the labor relations implementation strategy is still appropriate and make any required changes and consequential corrective actions.

Long-Term Implementation

4.2.18 No supplemental long-term implementation actions are anticipated at this stage of the 24/2 operation initiative.

4.2.19 



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4.3. Analysis of Infrastructure / Equipment Requirements

Analysis of Systems Requirements

- 4.3.1 This section seeks to ascertain whether the existing infrastructure has the capability to support 24/2 operation. It should be noted that while the SkyTrain system was designed to operate with daily non-revenue/engineering hours, the operations team has operated beyond the traditional timetable without considerable effect for special events/occasions such as fireworks and New Year's Eve.

Systems Impacts

- 4.3.2 Analysis and understanding the impacts on the subsystems of SkyTrain is crucial for the success of the 24/2 operation.
- 4.3.3 The project team interviewed key staff members at both BCRTC and SNC-Lavalin with direct experience of the relevant systems.
- 4.3.4 While SkyTrain subsystems are designed to run continuously and are not impacted by 24/2 service, some system requirements and operational strategies may need to be reconsidered or updated for the safety and reliability of the SkyTrain system. This section discusses the key subsystems of the SkyTrain and the potential impacts from operating 24/2 service.

Automatic Train Control (ATC) System

- 4.3.5 The Automatic Train Control system is the most important sub-system that provides vital safety functionalities and enables automated train movements in the network. It is therefore crucial that the 24/2 operation does not pose any risk to the ATC system.
- 4.3.6 SkyTrain employs Thales SelTrac ATC system. After reviewing the system requirements document for the SelTrac system and interviewing staff members at BCRTC, it is deemed that the ATC system has the capability of operating 24/2 service with limited impact to the system.
- 4.3.7 In order to ensure the integrity of the Station Controller (STC), it performs a series of self-tests including life signal tests, relay tests, Vehicle Control Centre (VCC) channel switchover tests etc. These tests are programmed to occur once every 24 hours.

- 4.3.8 The self-tests on the various switch control systems start at 03:00 (non-revenue hour) every day with the exception of the storage yards, which start at 16:00. These self-tests generally last about 2 - 3 minutes and it is recommended to avoid issue commands to set/change the statuses of the wayside devices during tests. The test schedule works with the current timetable but may pose a potential risk when 24/2 operation is implemented.
- 4.3.9 In order to minimize the impact on operations, it's recommended that the current testing schedule is reviewed accounting for the 24/2 service.

Supervisory Control and Data Acquisition (SCADA) System

- 4.3.10 After interviewing the Principal Asset Discipline Engineer – Electrical from BCRTC, and the Systems Manager and Lead Designer of the SCADA system on Evergreen Line, it became clear that the current SCADA system was designed to operate 24 hours, and the 24/2 operation has minimal impact to the SCADA system.
- 4.3.11 There appears to be no need for SCADA system enhancements to support 24/2 operation. However, future upgrades to the SCADA system may require platform and guideway access that need to be considered and scheduled in regard to the newly extended timetable.

Track Intrusion Detection System (TIDS)

- 4.3.12 The TIDS employed on the SkyTrain undertakes a daily self-test to ensure network-wide functional adherence to the system design.
- 4.3.13 The TIDS is currently scheduled to start self-tests every 24 hours between 02:30 and 03:00. (The self-test duration can vary depending on location as these systems are not synchronized with the system time.)
- 4.3.14 In the event of failure detection, an alarm sounds in the control room and a technician is dispatched to resolve the issue.
- 4.3.15 As shown in the figure below, the self-test result in intrusion events being triggered at each station platform and causes CCTV images to present the relevant CCTV feed to the operator.

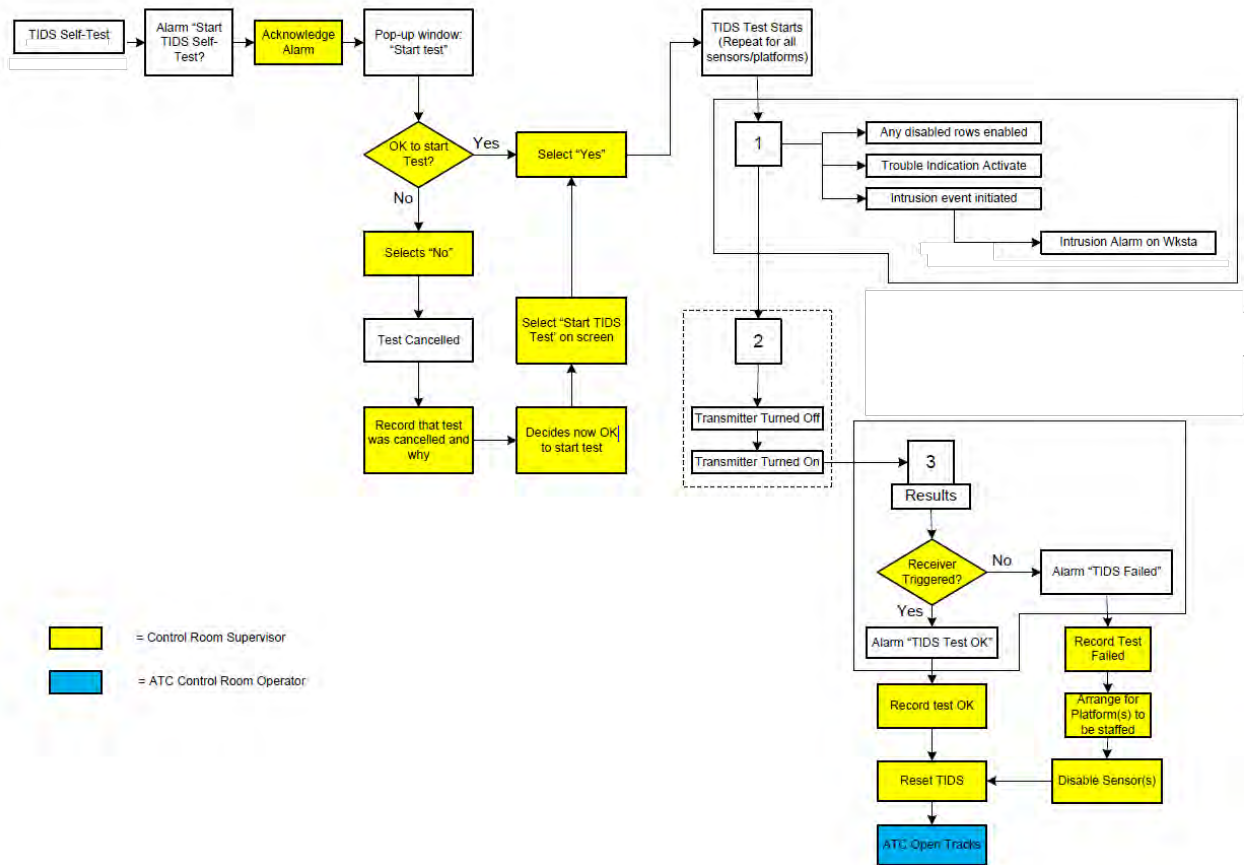


Figure 4.7 TIDS Operational Flowchart

- 4.3.16 The TIDS self-test function is designed to test component-level functionality every 24 hours. While tests are undertaken, real intrusion events are not reported to the ATC system nor the control room.
- 4.3.17 This behavior results in a loss of TIDS functionality while the self-test feature is undertaken. Furthermore, trains entering / servicing / leaving the station while the self-test occurs can cause TIDS self-test failure.
- 4.3.18 Two issues have been identified by the project team:
- › Should the TIDS be reprogrammed not to self-test during the operation of 24/2 service?
 - › Is there a corresponding impact to the safety argument for use of TIDS on the network?
- 4.3.19 BCRTC would benefit from analyzing the effect of 24/2 operation further on the TIDS system – in particular a safety analysis to determine what actions are acceptable from the perspective of residual risk to the passenger and maintainer.

Systems Requirements

- 4.3.20 This section discusses the different options and possible new system requirements to allow 24/2 operation implementation in the medium term and long term.

Medium-Term Implementation

- 4.3.21 In order to accommodate 24/2 operation in the medium term, a few recommendations can be considered to mitigate the potential risks introduced.
- › The Track Intrusion Detection System self-test shall be rescheduled to run within weekday non-revenue hours.
 - This change would require additional analysis of the safety case and Reliability, Availability, and Maintainability (RAM) for the Track Intrusion Detection System to understand the risk of delaying the self-test for two days.
 - › The Track Intrusion Detection System self-test may be manually initiated by platform staff and/or operators during the 24/2 operation. The staff member would coordinate system self-test at a suitable time window for each station and inform the passengers accordingly. This option may require further analysis and planning to implement this safely and efficiently.
 - › The ATC system self-tests, such as the Station Controller self-test, should be conducted at a pre-determined time window that doesn't interfere with any train movements. This can be achieved by staging the system self-tests in the entire network through coordinating with the timetable as the headway during Friday and Saturday nights is relatively long (15 - 20 minutes depending on the timetable strategy) compared with the time required to perform the self-tests.

Long-Term Implementation

- 4.3.22 In addition to the options outlined in the medium-term implementation section, an additional option is available that gives more flexibility while maintaining adequate safety and reliability of the system.
- › The ATC self-tests and Track Intrusion Detection System self-tests shall be staged at a pre-set time period for each area so the test will not impact 24/2 operation. The test shall be performed when no train is in the proximity of the tested area and CCTV cameras may be utilized by the operators to work together with the intrusion detection self-tests.
- 4.3.23 While this recommendation could be scheduled for the medium-term, the multi-disciplinary scope changes may introduce their own risks.
- 4.3.24 This option requires additional planning, updating and testing effort prior to enabling this strategy to operate in the long term, but this yields the least compromise to the system while enabling the system to operate 24/2 service.

4.4. Capital Project Impacts

- 4.4.1 With transportation forming one of the most pressing issues affecting quality of life and the economy in Metro Vancouver, TransLink regularly updates the long term regional transportation strategy, which informs the continued investment in transportation, results in the current 10-year investment plan.
- 4.4.2 The second phase of the current plan has unlocked significant funding for investment in the transit system. This funding seeks to:
 - › Offer convenient and sustainable transportation options
 - › Reduce network overcrowding
 - › Increase service quality
 - › Reduce journey times
- 4.4.3 From a rail perspective, the second phase of transportation improvements in the 10-Year investment plan include:
 - › Funding to plan the Surrey-Langley Line
 - › Construction and operation of the Millennium Line Broadway Extension
 - › Modernization of Expo-Millennium Line infrastructure, including upgrades to systems, stations and additional rolling stock
 - › Construction of a new operational and control center
 - › Construction of a new SkyTrain storage facility
- 4.4.4 Stages 1 and 2 of this report highlight the potential implications to capital projects from the reduction of non-revenue hours. In order to obtain a wide-view of BCRTC's approach to the management of these projects, the team conducted numerous interviews with BCRTC and TransLink staff to ascertain how these work packages were delivered.
- 4.4.5 The project team was provided with the TransLink Capital Projects (2018-2028) plan, which offered varying detail on what assets were to be upgraded and in which calendar year.
- 4.4.6 With parts of the rail system now reaching 30-35 years of age, it was noted that BCRTC were entering a steady-state of maintenance renewals for end-of-life infrastructure. This was particularly important for systems and guideway elements.
- 4.4.7 This study seeks to determine the impact to planned capital works; particularly noting sheer scale of works due to be undertaken in the forthcoming ten years.



Summary of Interview Findings

- 4.4.8 Interviews were conducted with Directors at BCRTC, in December 2018 to understand the plans and challenges for future capital projects in regards to 24/2 operation.
- 4.4.9 At present, all capital projects which enhance or renew the network are managed and coordinated by TransLink, within their project management framework. Organizational Governance and Management Control are key to the successful delivery of capital projects.
- 4.4.10 Management Control relates to the internal organization, governance, control and leadership implemented to achieve the strategy and obligations imposed.
- 4.4.11 Organizational Governance however, is concerned with how the delivery of obligations aligns to the strategy of the organization, which is in turn influenced by external factors. Managing external factors enables TransLink and BCRTC to deliver their obligations under the 10-Year vision.
- 4.4.12 Without effective governance and control, future projects present delivery risks, particularly in the context of the implementation of 24/2 service. These risks can present themselves in the following ways:
- › Omissions of scope
 - › Delay to the delivery of agreed scope
 - › Poor control of costs and Change Management
 - › Poor planning resulting in ineffective use of resources
 - › Non-compliance to standards/code
- 4.4.13 Discussions with members of the BCRTC and TransLink have identified a number of trends which present potential obstacles to the successful implementation of capital projects within the timeframe of 24/2 operation:
- › There is opportunity to develop further organizational governance within TransLink, to adequately take into account the requirements of the Operator and Maintainer (O&M) throughout the life cycle of projects.
 - › Systems and services delivered by TransLink offer limited operational flexibility, thereby introducing operational risk when the rail system is tasked with delivering a service outside of business norms.
 - › There are opportunities to further break down 'silos' through effective coordination and cooperation between TransLink and BCRTC.
 - › The delivery of Capital works (e.g. new Mark III trains) have in the recent past clashed with the delivery of maintenance works. Such events will

require careful consideration to reduce any significant impact in 24/2 operation.

- 4.4.14 To ensure shared goals are met, TransLink's Infrastructure Project Management Office (iPMO) would benefit from promoting their aims and processes among BCRTC staff for more cohesive and integrated Capital Project works.

Planning of Capital Works

- 4.4.15 The concept of ever-closer alignment between TransLink and BCRTC leadership and planners in particular, is promoted by this study to de-risk the effective delivery of capital projects.
- 4.4.16 It was found that many capital projects are forecast and planned one year ahead for BCRTC to implement (this typically occurs every April). The reduction in non-revenue hours will require re-planning to ensure resources and adequate non-revenue hours are available to project teams.
- 4.4.17 The project team notes that BCRTC has undertaken works to optimize human resources to support Capital Project works. As of January 2019, there are 14 spotters, 2 electrical technicians and 2 power technicians reporting to the BCRTC Director of Capital Projects. BCRTC is pushing ahead for pooled resources with other parties within the organization. This initiative aims to improve utilization of available resources and promote more efficient planning and resource management. These activities align to best practice undertaken by metros similar in size to SkyTrain.
- 4.4.18 The project team attended the daily planning meetings (8 am most weekdays) and has identified that the centralized and integrated planning is another key aspect that BCRTC needs to improve on.
- 4.4.19 Life-cycle planning is also required to form a well-rounded and effective strategy to improve and upgrade the SkyTrain system in future years. This is likely to form part of the forthcoming Asset Management System.



Quantum of Change (Infrastructure and Process)

- 4.4.20 Mature operating rail systems such as SkyTrain have a limit to the volume of changes incorporated into the system per year. Without effective Governance and Management Control, a number of symptoms surface in the event of unsustainable variation to the rail system.
- 4.4.21 The project team has identified opportunities to improve Change Management processes:
- › Strengthening the communication among project stakeholders allows clear and updated information (e.g. changes to project scope) to be delivered to all relevant stakeholders.
 - › TransLink would benefit from increased monitoring of third-party suppliers to ensure changes which affect the operational railway are captured in a timely manner and communicated effectively.
 - › Project deliverables have omitted functional requirements necessary for the optimal maintenance of engineering assets, thereby placing at risk State of Good Repair. In effect, this removes operational flexibility, to the detriment of all stakeholders. Examples include the lack of lifting jacks for Mark III trains and assurance documentation for new guideway maintenance plant.
 - › TransLink would benefit from monitoring and reporting not only the project expenditure and schedule, but also the actual progress in totality. Candidates for monitoring include:
 - Project safety incidents
 - Projected on-site work hours vs actual executed hours on site
 - Operational and Technical requirements satisfaction
 - Quantum of functional requirements omitted from original contract scope
 - › This enables TransLink to identify potential areas for improvements, as well as better allocate and coordinate resources in projects.
- 4.4.22 The successful delivery of TransLink's project obligations are not just related to time, cost and quality. Other fundamental factors such as safety – both workforce and customers – is an issue, as is the performance of the railway. In the context of reduced non-revenue hours, a cultural shift in the delivery of capital and maintenance works is necessary to de-risk an increase in the density of worksites during the non-revenue hours. This cultural shift would communicate:
- › The need to continue putting safety at the heart of every activity
 - › The need to make every minute of non-revenue hours count
 - › The need to optimize practices which are long established

Expo Millennium Upgrade Program 10-Year Plan

- 4.4.23 The Expo Millennium Upgrade Program (EMUP) 10-Year Plan has made significant capital available for system upgrades and extensions. The introduction of 24/2 service, while upgrades are being delivered, will present constraints which require detailed planning and mitigation to bring about successful integration.
- 4.4.24 EMUP consists of critical investments in fleet and infrastructure to address ridership demand on the SkyTrain network and enable the Mayor's Vision. The program is comprised of a number of projects under the six major program components, funded through Phases 1 and 2 of the 10-Year Investment Plan. Total budget of \$1.86 billion is supported by the provincial and federal governments.
- 4.4.25 As part of this study, the EMUP 10-Year Plan has been reviewed and analyzed to identify key projects that may be impacted or have an impact on the 24/2 operation. Out of the 184 capital projects, it's been identified that 49 projects may be affected or have an impact on the 24/2 operation as outlined in the table below:

Table 4.1 EMUP projects to be considered for 24/2 operation

Project Name	Anticipated Start
Expo Line Running Rail Replacement 2018	2017
Fibre Optic Cable System Upgrade	2015
Expo Line Traction Power Equipment Replacement	2018
Expo Line Tunnels Ventilation System (TVS) Rehab - Condition Assessment (Ph 1)	2017
Guideway Intrusion System Renewal	2018
Guideway CCTV Coverage (Expo & Mil lines)	2018
Edmonds OMC Capacity Upgrades (OMC 1+2)	2018
CCTV Camera System Upgrade on Expo and Millennium Lines - Implementation (Ph 2)	2018
ATC Existing Equipment Replacement - Phase 3	2017
2019 Expo Line Running Rail Replacement	2019
Expo Line Tunnels Ventilation System (TVS) Rehab - Implementation (Ph 2 & 3)	2019
Expo Line Traction Power Equipment Upgrade (EMUP)	2019
ATC Existing Equipment Replacement - Phase 4	2019
OMC1 Traction Power and Capacity Upgrade	2019
OMC 4	2020
Columbia/New West TVC (Tunnel Ventilation Control) - Phase 1	2020
Running Rail Replacement	2020
Guideway Geometry Asset Condition Monitoring Using an Outfitted MKII	2020
LIM Rail Retrofit	2020

Expo Line Tunnel Ventilation System - Phase 4	2020
Expo/ML Tunnel Intrusion System - Phase 1	2020
System-wide HVAC Replacement	2020
Guideway Drainage	2020
Guideway Intrusion System Renewal - Trial	2020
Expo Line Surrey Power Rail Replacement	2020
ATC Software Maintenance	2020
ATC Existing Equipment Replacement - Phase 5	2020
Running Rail Replacement	2021
SkyTrain Station Power Capacity Phase 2: Design & Implementation	2021
Seismic Upgrade of Expo Line Guideway - Implementation	2021
Columbia/New West TVC (Tunnel Ventilation Control) - Phase 2	2021
Expo/ML Tunnel Intrusion System - Phase 2	2021
ATC Existing Equipment Replacement - Phase 6	2021
Running Rail Replacement	2022
ATC Existing Equipment Replacement - Phase 7	2022
Guideway Intrusion System Renewal - Implementation	2022
State of Good Repair - 2022	2022
Running Rail Replacement	2023
State of Good Repair - 2023	2023
Running Rail Replacement	2024
DC Traction Power Breaker Replacement (11 Stations)	2024
State of Good Repair - 2024	2024
Running Rail Replacement	2025
ML Power Rail Replacement (20 kms of guideway)	2025
Guideway Structure Bearing Replacement	2025
State of Good Repair - 2025	2025
Running Rail Replacement	2026
State of Good Repair - 2026	2026
Running Rail Replacement	2027
State of Good Repair - 2027	2027
Running Rail Replacement	2028
State of Good Repair - 2028	2028

- 4.4.26 It is important to note that this list doesn't reflect all the capital projects planned for the next 10 years, and additional capital projects will be scheduled in the coming years.
- 4.4.27 The impacts of 24/2 operation must be planned and analyzed for projects implemented during 24/2 regime.
- 4.4.28 Once 24/2 operation starts, capital projects that require guideway access will need to primarily fit within the weekday maintenance windows. Capital projects

that require a long period of guideway access may need to consider single tracking operation, early finish during weekdays or partial closure of the system on certain days in order to grant enough guideway access to complete the work.

EMUP Impact analysis

- 4.4.29 The following section will present analysis of high-profile projects within the EMUP program for impact from reduced non-revenue hours.

Fleet Expansion

- 4.4.30 The primary concern for the expanding fleet is storage capacity. Without significant expansion of the vehicle storage provision, BCRTC will increasingly rely on stabling trains on the mainline.
- 4.4.31 The primary concern is the availability of track to stable trains when operating the 24/2 service. Other parts of this report have recommended stabling on the link between Lougheed and Braid – analysis undertaken as part of this project confirms that space and special conflict with other needs, rather than systems, present the biggest constraint. This may be overcome in the long term with the provision of OMC 4.
- 4.4.32 Train commissioning of the new fleet is also a significant concern since it requires guideway occupancy permit during the non-revenue hours. As indicated in Section 3.3.10 of the maintenance simulation analysis, train commissioning is one of the two major maintenance activities (station upgrade is the other major maintenance activity) that cause outstanding work orders. See Section 5.3.12 to 5.3.14 for recommendation on providing track availability for train commissioning during 24/2 operation.

Vehicle Storage (OMC 4)

- 4.4.33 This project currently falls within the timescales for 24/2 operation. However, noting this site is likely to be a new installation, the impact from a 24/2 operation is determined to be minimal until the testing and commissioning of the interface to the mainline(s).
- 4.4.34 Typically, 'over and back' activities (such as system testing at the interface to the mainline) would be undertaken over the weekend, offering increased non-revenue hours and lower the risk to the commencement of service the following day.
- 4.4.35 In the event of 24/2 operation, these works can either take place during a statutory holiday closure or a suspension of 24/2 in the affected area. Buses or other modes will be required.



- 4.4.36 Single-tracking may present a viable option, however without detailed analysis of the specifications, closures should be planned and communicated with stakeholders and the project inception phase.

OMC 1 and 2 Renovations

- 4.4.37 This body of work presents potential for considerable disruption to the network operator. With OMC 1 (and to a limited extent, OMC 2) forming the core for SkyTrain maintenance, upgrades have the potential to disrupt activities in the following way:
- Works that limit the ability for maintenance vehicles to depart OMC 1 will result in a greater number of nights for the same body of work
 - Any issue in the 'ramp down' of revenue service is likely to have a greater knock-on impact to the departure of the maintenance vehicles from OMC 1, resulting in delayed works
 - Activities to test and commission OMC 1 renovations will likely impact the ability of maintenance vehicles to depart OMC 1, resulting in delayed works
 - Without adequate planning, resource allocation to capital projects may impact the ability of BCRTC to schedule maintenance activities; particularly if projects overrun or technical complexity of the upgrades are underestimated
- 4.4.38 Mitigation candidates for the potential disruption are 1) clear governance and management controls, 2) clear scope demarcation, with extensive communication between the contractors, TransLink and BCRTC, and 3) integrated detailed planning.

Systems Upgrades

- 4.4.39 The upgrade of Expo and Millennium systems will be impacted by the reduction of non-revenue hours. These system upgrades are technically complex and are therefore typically undertaken during weekend non-revenue hours (e.g. Thales regression testing).
- 4.4.40 Owing to the loss of the favorable (longer) weekend non-revenue hours, activities such as ATC testing or Track Intrusion Detection System testing will likely require suspension of service (either 24/2 provision or statutory holiday) to enable these systems to be installed, configured and tested.
- 4.4.41 Project scope with the greatest coverage or technical complexity (where the package of work is new or novel to SkyTrain – e.g. Traction Power upgrades) may require greater geographic areas reserved for testing than systems such as Public Address or fire detection systems.

Running Rail Replacement

- 4.4.42 The reduction of non-revenue hours will not have a significant effect on the progress of running rail replacement works. These activities are typically undertaken together with single-tracking portions of the network. Most of these works are completed during the weekday currently while material transport is done over the weekend.
- 4.4.43 Complex areas (such as the crossover prior to reaching Waterfront) will likely require suspensions of service together with bus shuttles. These activities are typically undertaken by contractors – effective delivery of these projects require robust planning with all stakeholders (e.g. Coast Mountain Bus Company – CMBC), together with effective mitigation plans in the event of works overrun.

- 4.4.44 Below is a case study where the project team made observations on the running rail replacement performed by a rail contractor during non-revenue hours.

CASE STUDY: RUNNING RAIL REPLACEMENT OBSERVATIONS

Members from the project team attended the OMC during non-revenue hours to witness the ramp-down in service, the roll-out of maintenance vehicles and coordination of technical with the control room done by a rail subcontractor. The following observations were made:

Impacts	Observations
Delay in other work orders	A rail wagon was scheduled to leave OMC 1 and deliver new sections of rail at the Waterfront turn back. Due to the fact that it needed to traverse the entire line (behind the last Waterfront-bound train), Speeders were queued up behind the train.
Delay in the rail replacement works	The wagon required approximately an hour to traverse 'the chicane' (a series of tight turns in the track work between OMC 1 and OMC 2) and delayed the commencement of works by maintenance teams.
Potential Opportunities	Observations
OMC capacity	Noting the Waterfront siding lies adjacent to the Canadian Pacific yard, is there opportunity to deliver rail by Class 1 rail borne wagons? This would free up capacity at OMC 1 and de-risk the scheduled maintenance activities.
Storage for new rail	Noting the EMUP plan for track renewal, is there adequate storage capability around the SkyTrain network to efficiently store new rail without importing operational risk?

Station Upgrades

- 4.4.45 Noting the age of the network (particularly the Expo Line), TransLink has embarked upon a near-continuous program to upgrade stations and their facilities.

- 4.4.46 Station roofing has presented numerous safety and operational risks and as a result; any works by contractors on station canopies or roofs require a service suspension.
- 4.4.47 In the context of 24/2, TransLink and BCRTC are jointly required to work with contractors to determine a safe, yet effective means to protect workers (and trains). Innovative solutions to offer protection need to be promoted within industry owing to the pressure for 24/2 operation.
- 4.4.48 Figure 4.8 presents an image taken in January 2019 – such methods need to be reviewed and developed to allow as much station works to be undertaken during revenue hours. Transit operators in Europe and further afield have adopted these techniques to maintain a safe work site, while promoting efficient working during operating hours.



Figure 4.8 Station scaffolding

Impacts on Capital Projects

Medium-Term Implementation

- 4.4.48 Implementing 24/2 operation service in the medium term will impact a number of capital projects scheduled shown in Table 4.1. Depending on the scope of the project and the requirements for guideway accesses, the impact may vary.
- 4.4.49 Detailed planning and scheduling need to be carefully considered as the longer weekend maintenance window will no longer be available. Alternatives (such as single tracking operations, temporary blockade of the system, or temporary suspension of the 24/2 operation etc.) need to be considered if the replacement project requires longer guideway access time than what weekday maintenance windows can offer for installation, testing and commissioning.
- 4.4.50 Similar situation also applies to running rail replacement projects, guideway intrusion equipment renewal, and other state of good repair projects that are scheduled to take place in the medium term.
- 4.4.51 Extending the maintenance windows during weekdays can be a good option that can potentially resolve or reduce the impact on capital project works. This will allow higher flexibility for both the maintenance work and capital work to be planned and scheduled through providing more effective engineering hours utilization while maintaining 24/2 service over the weekend.
- 4.4.52 The use of OpenTrack (a railway simulation software) to better model the operating railway as the system grows, may offer opportunity to planners in the development of work orders for maintenance and capital works. The model will aid the decision-making for stabling trains in different configurations, and give confidence when seeking to ramp-up the service following non-revenue hour works.

Long-Term Implementation

- 4.4.53 The implementation of 24/2 operation in the long term will provide additional opportunity for the TransLink and BCRTC leadership to prepare for such a change. The study notes the volume of work to be undertaken prior to this date, however, the addition of vehicle storage (together with decentralizing the maintenance activities) will de-risk this considerable change.
- 4.4.54 As shown in Table 4.1, only state of good repair projects and running rail replacement projects are potentially impacted by the 24/2 operation. However, this doesn't represent the actual capital projects planned for year 2027 because capital project works are generally not planned ahead by this long.
- 4.4.55 Given this long time horizon, future capital projects shall treat the 24/2 operation as "Business as Usual" and plan their work and schedule accordingly. This will mitigate downstream impact to project work when the implementation of 24/2 operation as the planning of capital projects account for the constraints similar to any other service hours.

4.5. Health and Safety, Security, and Emergency Impacts

Introduction

- 4.5.1 Evaluation of the BCRTC systems and processes related to Health and Safety as it relates specifically to the 24/2 service of operation project is an important aspect of this review. A best practices approach has been taken for this review and the subsequent recommendations.
- 4.5.2 Industry best practice for the management of Health and Safety is based on the development and implementation of systems and processes. The Deming approach of the Plan, Do, Check, Act cycle as established in modern Safety Management systems (ISO 45001, OHSAS18001, CSA Z1000, ANSI Z10) serves as an excellent best practice approach. It is our understanding that BCRTC has plans to pursue certification to the ISO 45001 in the near future. There are several steps associated with ISO 45001 that should be applied to the planning, transition and ongoing 24-2 operations:
- › Review and understand your legal requirements – conduct a review of the legal requirements which may pertain to 24/2 service, occupational H&S regulations, industrial regulations, collective agreements etc.
 - › Review the scope and applicability of the current management system. Does the current system have sufficient scalability to meet the demands of the growing system?
 - › Review processes and procedures by assessing any potential changes to hazards or risk levels that 24/2 service may present. This should include input from stakeholders – especially BCRTC employees.
- 4.5.3 BCRTC should consider taking an open approach to any assessment, review or adaptation of their systems and processes. It is recommend that a fulsome review include processes for the consultation and meaningful participation of all affected stakeholders. The input of affected parties should be considered and addressed. Considerations to include input from the following groups should be made:
- › Employees
 - › Management
 - › Unions
 - › JOSH
 - › Operations
 - › Maintenance
 - › Public

- › Third-party service providers
- › Local Emergency Response Agencies

Priorities

- 4.5.4 As part of this process it will be necessary to prioritize action items. There is some natural prioritization which is inherent in the ISO 45001 Safety Management System. The Deming cycle of Plan, Do, Check, Act provides direction on a logical progression; Planning should naturally come before Doing.
- 4.5.5 At a more granular level, actions should be prioritized based on risk. As TransLink and BCRTC works through the planning process, actions that are deemed to be the highest risk should be prioritized. It may be a useful exercise to rank each action from highest risk level to lowest risk level. This will allow BCRTC to make logical, defensible decisions for their priorities.
- 4.5.6 Beyond this, TransLink and BCRTC should consider public risk separately from occupational risk. Risk to the public, due to the duty of care which is inherent to BCRTC's operations, may, under certain circumstances, take priority. These actions will need to be carefully considered and a clear rationale developed. The exercise of identifying and further quantifying risk to the public establishes clear consideration for one of BCRTC's main stakeholder groups.

Safety Management System

Planning and Objective Setting

- 4.5.7 Systems and processes for planning and objective setting should be developed and implemented. These processes should be led by management and include input from relevant stakeholders. At a minimum, planning and objective setting should be done once per year. The process should be documented. The 24/2 operation project should be included in the planning and objective setting process.

Management Commitment

- 4.5.8 As part of the Safety Management system, BCRTC should review their management commitment policy statement. As a best practice, this policy statement should be documented and freely available for review by interested parties. The policy statement should include commitment to the prevention of injury and ill health and establish a minimum standard of regulatory compliance.



Hazard and Risk Assessment Process

- 4.5.9 Hazard and Risk Assessment Process is a cornerstone to an effective program. The ability to effectively and consistently identify hazards, assess the level of risk and develop and implement effective controls suitable for 24/2 operation. A three-tiered approach to this process is recommended
- › Risk Registers
 - › Work Method/Job Instruction
 - › Field Level Risk Assessment
- 4.5.10 BCRTC should review their risk matrix and associated processes to ensure that they are able to address the complexities of 24/2 operation. Best practice would be to develop and implement a risk matrix that includes variables for consequence, probability and exposure. A systematic review of any current assessments to include changes to these variables as a result of implementing 24/2 operations should be considered.

Risk Register

- 4.5.11 A Risk Register is a tool to identify and quantify risks at the operational level. The BCRTC Risk Register provides the foundation for the development of environmental and health and safety actions and can further be used to document other project risks such as insurance, liability, operational and public issues.
- 4.5.12 Risk Registers are typically developed by project teams consisting of representatives from management, discipline section heads and safety and/or loss control personnel. In terms of SkyTrain, Risk Registers need to be looked at from both the operational side (BCRTC), and the capital side (TransLink).
- 4.5.13 With respect to the operational change of 24/2 operation, there are a number of potential hazards and safety requirements that should be reviewed and assessed. These hazards and safety requirements should be identified, evaluated and incorporated into the project Risk Register to ensure proper control measures are established which validate compliance with regulations and business requirements.

Work Methods/Job Instructions

- 4.5.14 Work Methods/Job Instructions are the detailed description of activities associated with the work and typically focus on ongoing or repeat tasks or high-risk operations. They typically include technical details and work methodologies; materials, equipment and manpower requirements; quality control and

assurance elements as well as environmental and health and safety requirements.

- 4.5.15 Hazards associated with the specific work activity as well as the general requirements of the area, conditions, personnel, and equipment are detailed into the Work Methods/Job Instructions for review and approval by the Management Team. Health and safety requirements are identified and detailed to the extent that field supervision will have an understanding of the health and safety needs and/or restrictions of the particular work, personnel or area. Safe work procedures, safety materials and equipment are incorporated and actioned by management and/or field supervision. These documents should be disseminated down to the field supervision level for review with the workforces.
- 4.5.16 As it relates to the change in operations to 24/2 operations, all work methods/job instructions should be reviewed to determine if there are any changes to risk levels. Changes in exposure levels should be carefully considered.

Field Level Risk Assessment

- 4.5.17 The Field Level Risk Assessments are used by front line workers and supervisors to identify the day of hazards and the appropriate controls needed to perform the work safely. It encourages all personnel to step back and take a minute at the commencement of a new day, new work assignment and/or when conditions have changed to think critically about their working environment.
- 4.5.18 Work teams or individuals are required to participate in the process. The Field Level Risk Assessment is a documented discussion of the HSE hazards, associated controls and subsequent risk levels associated with the planned work for that shift/day. The activities of every team member, as well as the activities of anyone else within the same area, are identified, documented and adequately controlled with a record retained.



Health and Safety Program

Roles and Responsibilities

- 4.5.19 As part of the 24/2 operation, BCRTC should review the current roles and responsibilities to ensure that they are applicable to any changes made. Management, Operations and Maintenance roles should be reviewed and assessed.

Fatigue Management Plan

- 4.5.20 The purpose of a Fatigue Management Plan is to provide guidance and assist in the assessment of the causes of fatigue so as to manage the risk factors and hazards as well as prevent related injury and illness. BCRTC should develop and implement a Fatigue Management Plan. In the event that this plan is already in place, it is recommend that a full review is conducted to assess operational changes and to develop strategies to manage any effects of those changes. Considerations should include both Operations and Maintenance staff.

Competency and Training

- 4.5.21 Establishing competency requirements and developing and implementing training requirements for BCRTC staff to reflect any changes to operational or maintenance procedures will be required. This should be considered during the review of the Work Method/Job Instruction review.

Documentation – Retention and Maintenance of Documents

- 4.5.22 In order to establish due diligence and to create an audit trail, BCRTC should ensure that all changes to documents and/or processes is tracked by their document control process. The process should identify documents that have been reviewed and track any changes made to those documents.

Monitoring/Auditing Program

Inspections

- 4.5.23 Inspections are a principal method for validating the effectiveness of the Health and Safety Management program and are undertaken both informally and formally. BCRTC should ensure that inspections include evidence from operations during 24/2 operation.

Internal Audits

- 4.5.24 Audits should be conducted on a regular basis to determine compliance with the health and safety systems and process as defined by BCRTC. Audits are a valuable tool in determining the effectiveness of the system and can contribute to continual improvement.
- 4.5.25 Any opportunities for improvement found during these audits should be addressed through a corrective action plan. As part of the recommendations, audits should include data from 24/2 operation to ensure a complete assessment.

Third-Party Audits

- 4.5.26 BCRTC may wish to engage in third-party verification of their safety management system. Several options are available including ISO/OHSAS and CoR. Third-party auditing of the system may assist with the continual improvement process.

Security Management Plan

- 4.5.27 As part of any move to 24/2 operation, it is recommend that BCRTC staff should undertake a Threat Assessment review. The review should include any potential additional risk attributable to 24/2 operation and be inclusive of BCRTC employees, contractors, the public and any other stakeholder groups likely to be affected by this potential change (i.e. local neighborhoods where SkyTrain operates).
- 4.5.28 Monitoring of incidents should continue. Trend analysis should specifically review 24/2 operations. This may require additional work regarding data collection and how incidents are codified/classified.

Emergency Response Plan

- 4.5.29 It is recommend that the Emergency Response Plan be reviewed by BCRTC to include 24/2 operations. Including stakeholders in this review, both internal and



external – including municipal fire services, police services, BC Ambulance, and E-Comm – could prove to be a useful exercise. These changes may have an impact on staffing and resources for these organizations.

Business Resilience and Resumption Plan

4.5.30 The Business Resilience and Recovery Plan should also be reviewed to include 24/2 operation. The review should include:

- › Does the Emergency Preparedness Team have coverage to include 24/2 operation?
- › Has BCRTC identified essential services/functions as they relate to 24/2 operation?
- › Has BCRTC identified the required skill sets and staff reallocation to support the project?
- › Has BCRTC Identified any potential issues the might stem from 24/2 operation?
- › BCRTC should prepare a plan for each essential service/function.
- › Has BCRTC effectively communicated the plan to all stakeholders?

5. Recommended Operations Strategy

- 5.0.1 Further to the detailed analyses of BCRTC's current maintenance practices and state of the assets as well as the associated operational impacts from the above, this section presents the recommended Operations strategy including service level and fleet requirements as well as the expected changes in transit demand for 24/2 service.

5.1. Recommendation from Stages 1 and 2

- 5.1.1 Stages 1 and 2 of the SkyTrain Extended Service Hours Feasibility Study identified a few key influences on the service strategy to provide extended service hours operation; these were:
- › The service would operate through the night into the next morning without a break in service.
 - › Late night Friday and Saturday ridership is similar; therefore, service is proposed on both days.
 - › The Expo Line would operate between Waterfront and Surrey Central (see Figure 5.1).
 - › King George, Braid and Sapperton stations on the Expo Line would not be served because these three stations have low alighting volumes. The purposes are to:
 - Simplify service
 - Provide location to store trains
 - › Millennium Line would operate between Commercial-Broadway to Lafarge Lake-Douglas (see Figure 5.1).
 - VCC-Clark station has low boarding and alighting volumes
 - › In line with other cities providing late-night rail service, it is proposed to run a "full" service serving all stations in between the above terminal stations of the Expo and Millennium Lines in both directions.
 - › A 15-minute headway (approximately) is assumed to be operated.
 - This was identified to provide a higher level of service than the night bus service and help limit wait times in consideration of the safety and security issues arising from crowding on platforms of late night passengers.
- 5.1.2 These influences have been used to develop a proposed service strategy which builds on the previous work to provide greater definition of the service frequency, train requirements, type of vehicle proposed, service transition and potential vehicle storage solutions. The service strategy also considers the following additional items that will need to be considered:



- Transition to full morning/daily service from overnight frequency
 - Removal of night trains for cleaning
 - Ramp up of service frequency
- Snow clearance operation on full system overnight during winter season
- Overnight train storage on the main line
- Commissioning of new trains

5.1.3 The following figure illustrates the proposed 24/2 SkyTrain service with the Expo Line highlighted in blue and the Millennium Line highlighted in yellow. The Night Bus Routes N9 and N19 which run in parallel to the SkyTrain alignment are also shown in the figure. The Night Bus Routes N9 and N19 are also shown because this study assumes that all the Night Bus services will operate as of today, i.e. no extended service hours, operations hours, nor cancellation of the services. The ridership forecast for the 24/2 SkyTrain service was conducted assuming the N9 and N19 Night Buses will continue running in parallel to the SkyTrain alignment. Note that these Night Bus Routes stop at every stop along the way (as opposed to only stopping at the SkyTrain stations), they are not a feasible substitute for the current SkyTrain service.

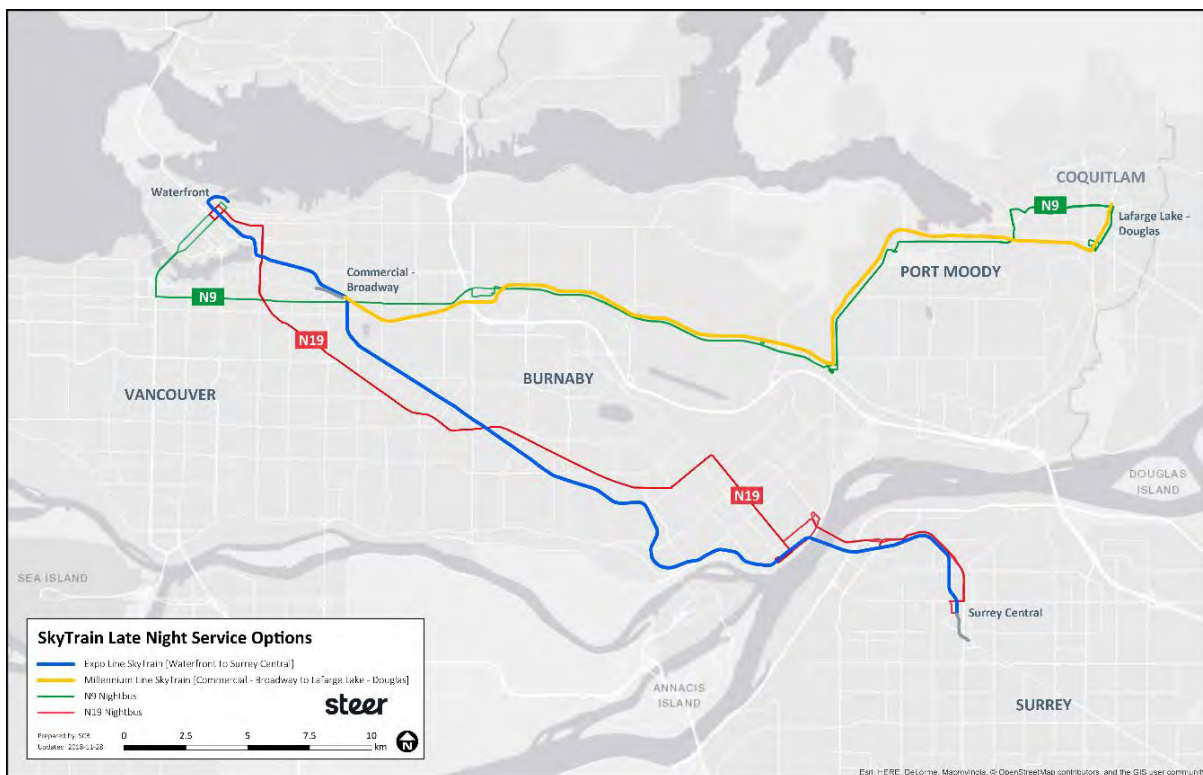


Figure 5.1 Proposed 24/2 Service on Expo and Millennium Lines

5.2. Service Frequency, Service Transition

5.2.1 Further changes are made to the proposed 24/2 service frequency upon Stages 1 and 2. It is proposed to run the 24/2 service with a 20-minute headway in the medium term and subject to subsequent review after implementation, increase the service to 15-minute headway in the long term. The following tables show the current operations service plan on Friday, Saturday and Sunday as compared with the proposed 24/2 operations service plan for the Expo and Millennium Lines.

Table 5.1 Proposed 24/2 Operations Service Plan for the Expo Line

Location	Day	Time of the Day	Current Headway (min)	Medium Term Proposed Headway (min)	Long Term Proposed Headway (min)
Waterfront to Columbia	Friday	Evening	3-5	3-5	3-5
		Late night	4-5	4-5	4-5
		Overnight	n/a	20	15
	Saturday	Early morning	4	4	4
		All day	3	3	3
		Overnight	n/a	20	15
Columbia to Surrey Central	Friday	Evening	6	6	6
		Late night	8-10	8-10	8-10
		Overnight	n/a	20	15
	Saturday	Early morning	8	8	8
		All day	6	6	6
		Overnight	n/a	20	15
Surrey Central to King George	Friday	Evening	6	6	6
		Late night	8-10	8-10	8-10
		Overnight	n/a	n/a	n/a
	Saturday	Early morning	8	8	8
		All day	6	6	6
		Overnight	n/a	n/a	n/a
Columbia to Production Way-University	Friday	Evening	6-8	6-8	6-8
		Late night	8-10	8-10	8-10
		Overnight	n/a	n/a	n/a
	Saturday	Early morning	8	8	8
		All day	6	6	6
		Overnight	n/a	n/a	n/a

Table 5.2 Proposed 24/2 Operations Service Plan for the Millennium Line

Location	Day	Time of the Day	Current Headway (min)	Medium Term Proposed Headway (min)	Long Term Proposed Headway (min)
VCC-Clark to Commercial-Broadway	Friday	Evening	6-8	6-8	6-8
		Late night	8-10	8-10	8-10
		Overnight	n/a	n/a	n/a
	Saturday	Early morning	8	8	8
		All day	6	6	6
		Overnight	n/a	n/a	n/a
Commercial-Broadway to Lafarge Lake-Douglas	Friday	Evening	6-8	6-8	6-8
		Late night	8-10	8-10	8-10
		Overnight	n/a	15	15
	Saturday	Early morning	8	8	8
		All day	6	6	6
		Overnight	n/a	20	15

5.2.2 The maintenance simulation analysis indicates that the current maintenance schedule will be affected if 24/2 operation is to be implemented in the medium term assuming there will be no change to the current practice while maintaining the current revenue hours on the weekdays. Even with the additional equipment available, the simulation still indicates that not all the maintenance activities completed in August and September of 2018 could fit into a 24/2 operation maintenance schedule due to many work location conflicts.

5.2.3 The analysis has indicated the need for a reduction in revenue hours to support the capital and maintenance workload in the medium and long term. Figure 5.2 below illustrates the total loss of 9 maintenance hours per week with the 24/2 operation as well as the two approaches in mitigating the loss. From the maintenance perspective, it is ideal to shorten the revenue hours on one of the weekday nights (Monday as currently proposed in the figure below) in order to provide the same duration of engineering hours as what a Saturday night is currently having. However, from the customer legibility and customer scheduling perspectives, it might be more practical to reduce the revenue hours on Sunday to Thursday consistently by one hour every day.

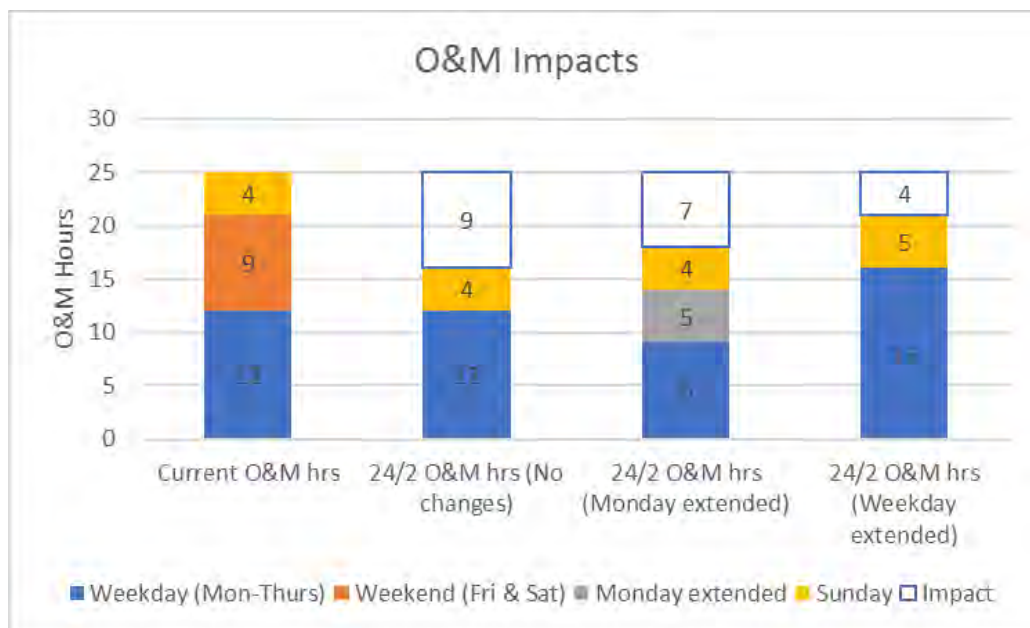


Figure 5.2 Proposed Mitigations to Compensate the Loss of Maintenance Hours due to 24/2 Operation

- 5.2.4 As can be seen from the above, the total loss of maintenance hours are indicated inside the white box under each scenario. The following section discusses the implications of reduced service hours on existing ridership.

Implications of Reduce Service Hours on Existing Ridership

- 5.2.5 In the medium term option, undertaking all the maintenance activities in a shorter maintenance period is unlikely to be achievable. To ensure the systems state of good repair and the completion of all the required maintenance activities, additional maintenance time would need to be achieved by reducing the service at other times of either morning or evening.
- 5.2.6 Prior to considering the reduction of current revenue hours on Sunday to Thursday to compensate for the maintenance hours lost on Friday and Saturday nights, the Sunday to Thursday evening and morning ridership data on the Expo and Millennium Lines are analyzed and shown in the figure below.

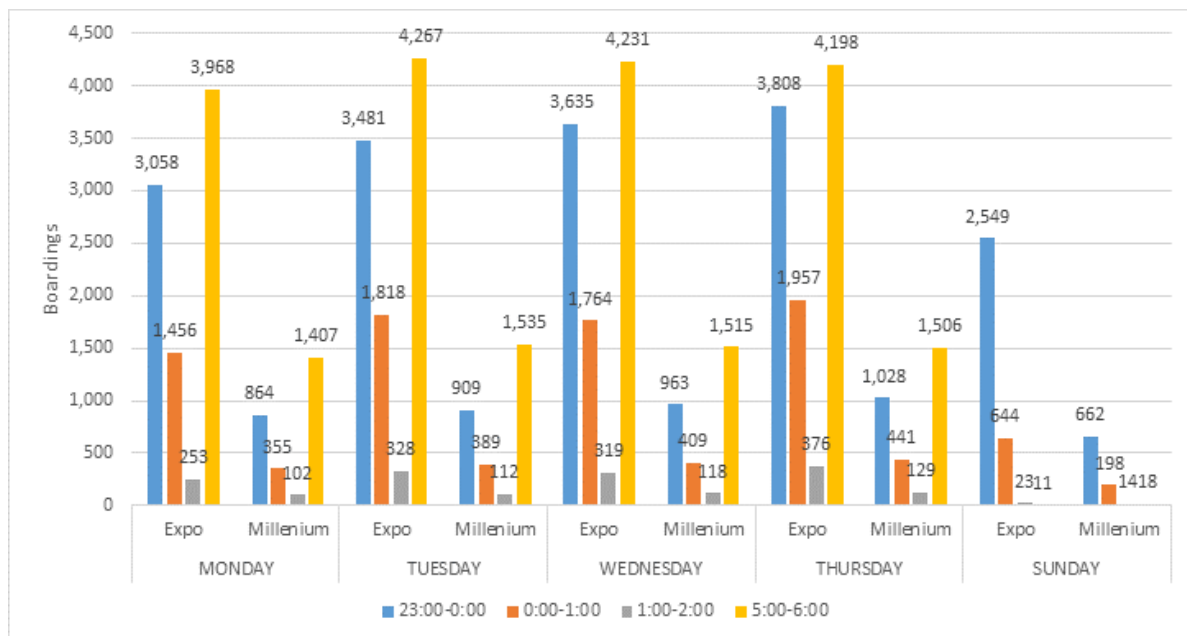


Figure 5.3 Sunday to Thursday Evening Ridership on Expo and Millennium Lines

- 5.2.7 As can be seen from the above figure, the early morning first hour of ridership is always higher than the late evening ridership. The Sunday morning ridership is not shown as the service starts later on this day. This higher morning ridership suggests that any adjustment in the operating hours to compensate for lost maintenance hours due to 24/2 operation would be least impactful to ridership on midweek nights.
- 5.2.8 With 24/2 operation, the current end times of the last Sunday trains on the Expo and Millennium Lines may also warrant adjustment as the system will have operated continuously for 67 hours from Friday morning to Sunday midnight.
- 5.2.9 From the customer legibility and customer scheduling perspectives, it might be more practical to reduce the revenue hours on Sunday to Thursday nights consistently by one hour every night. However, the required number of engineering hours could potentially be reduced through the medium-term maintenance recommendations outlined earlier in the report. Recommendations include the availability of more rail maintenance equipment, the distribution of equipment around the system to minimize the time taken to travel to a maintenance site, and the use of road vehicles to access locations in proximity to stations or other access points for some activities.
- 5.2.10 The current service plans and train storage at the end of service from Sunday to Thursday may need to be further considered. This allows to better optimize the termination of service and help maximize the non-revenue hours. This could

include stabling last trains at termini to alleviate the need and time to return trains to the OMCs; and the short running of some services rather than full end-to-end services again allows trains and the overall service movements to be curtailed earlier. Coordination of these terminating services with the start of the night bus service could help mitigate impacts to passengers using these services.

5.3. Vehicle Type and Number Required

- 5.3.1 To aid on train passenger security, it is proposed that walk through trains are used on each of the overnight services; as of January 2019, the appropriate fleet includes 54 2-car Mark II trains and 21 4-car Mark III trains.
- 5.3.2 With a focus being travel from downtown Vancouver outbound on the Expo Line, to further aid on train security, using a larger walk through train would allow passengers to spread within the train and help alleviate interactions, the opportunities for conflict and move away from any issues if they occur.

Travel Times

- 5.3.3 The travel times for each of the services and the train requirements are shown in Table 5.3 and Table 5.4.

Table 5.3 Service Travel Times 20 Minute Headway

Service	End to end Journey time	Round trip	Timetabled time based on repeating 20 min Headway	Trains Required	Cars in Service
Waterfront to Surrey Central	39 min	80 min	80 min	4	16
Commercial-Broadway to Lafarge Lake-Douglas	35 min	72 min	80 min	4	8



Table 5.4 Service Travel Times 15 Minute Headway

Service	End to end Journey time	Round trip	Timetabled time based on repeating 15 min Headway	Trains Required	Cars in Service
Waterfront to Surrey Central	39 min	80 min	90 min	6	24
Commercial-Broadway to Lafarge Lake-Douglas	35 min	72 min	75 min	5	10

- 5.3.4 The suggested strategy is to use up to 6 4-car Mark III trains to operate the service on the Expo Line and 5 2-car Mark II trains on the Millennium Line to achieve the outlined approach.

Vehicle Storage

- 5.3.5 The ongoing development of SkyTrain through the Expo Millennium Upgrade Program will see the fleet of trains increase to meet the increasing passenger demand on the system. By the end of 2020, the fleet will be 342 cars made up of 172 Mark I cars, 108 Mark II cars, and 84 Mark III cars. This results in an increasing need to store vehicles on the running lines.
- 5.3.6 The current and future proposed storage of vehicles at termini locations is good for system operation as trains are located close to their service start location. The arrangement may need to be considered further as these are also the location of switches and associated equipment, which are an element of the track system that needs regular inspections and maintenance. The storage of vehicles at termini will impede these activities.
- 5.3.7 The train length and length of storage required based on a 10-metre (m) gap between trains is shown in Table 5.5.

Table 5.5 Train Lengths

Type	Number of Cars	Length (m)	Storage Length (m)
Mark I	2 Car	26.0m	36.0m
Mark I	4 Car	52.0m	62.0m
Mark I	6 Car	78.0m	88.0m
Mark II	2 Car	34.7m	44.7m
Mark II	4 Car	69.4m	79.4m
Mark III	4 Car	67.4m	77.4m
New	5 Car Equivalent	85.2m	95.2m

5.3.8 The 24/2 service will use up to 5 Mark II cars, operating as 2-car trains on the Millennium Line and 6 Mark III 4-car trains on the Expo Line. This leaves a need to store 2 short trains at VCC-Clark, 5 long trains between Columbia and Braid on a single line and 7 long trains at King George. The potential storage arrangement of trains is shown in Figure 5.4. Additional trains will be procured to increase passenger capacity and to support the replacement of the Mark I cars starting around 2023/24 after which additional trains will need to be stored on the running lines. With extended hours these could potentially be stored between Columbia and Braid, still on a single line.

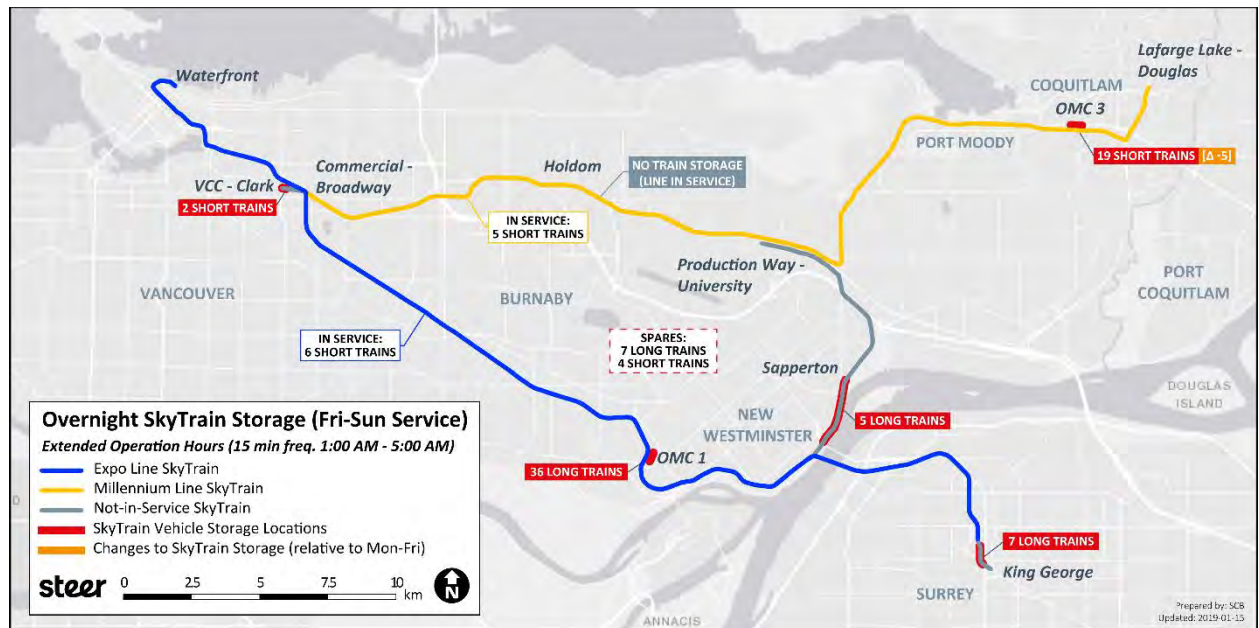


Figure 5.4 Trains Storage with 24/2 Service

- 5.3.9 The length of available online storage in the Sapperton area is approximately 700m north of the station and 1,200m south of the station assuming no trains would be stored in the station itself to limit access and the potential for vandalism/graffiti.
- 5.3.10 The length of track required is approximately 765m for the 17 2-car Mark II trains and 968m for the equivalent of 11 6-car Mark I trains. The trains may need to be spaced to ensure only eight trains are within each ATC loop, although a review of the current ATC arrangement suggests that this will not be an issue.
- 5.3.11 To aid security, cameras could be located at each end of the Sapperton Station platform canopies, down each side of the guideway and the central walkway. These could be further equipped with person detection to present alarms in the control room if persons are detected on the system.

Train Commissioning

- 5.3.12 To help mitigate the loss of overnight track access for train commissioning and burn in kilometers (km), train stabling between Columbia and Loughheed would use one of the two running lines, preferably the inbound to Waterfront track.
- 5.3.13 The remaining line which provides just over 5km of track length could be used to undertake train commissioning tests. The storing trains as suggested could also help limit the propagation of noise from the testing to the adjacent residential areas between Columbia and Braid; from Braid to Loughheed the area is more commercial in nature. The whole corridor is also adjacent to the existing freight lines and yard that generate noise overnight.
- 5.3.14 This would allow commissioning tests to be undertaken when 24-hour operation was happening and limit the impact of these tests on the remaining 5 maintenance windows on the remainder of the network.

Snow Clearance

- 5.3.15 During snow events, to ensure the SkyTrain remains operational and to ensure any snow is cleared from the system. Trains are operated overnight as required. With the current storage of vehicles on the running lines today, the majority of this storage would not be possible as sections of the system could see a buildup of snow in adjacent areas. To alleviate this the stored trains today would need to be moved around the system to ensure snow is cleared. Currently the snow trains are operated with a member of staff on board each vehicle overnight to ensure the tracks, reactor plates and platform fall protection are kept clear of snow.
- 5.3.16 This requires station staff to be deployed during overnight snow events to attend and if appropriate drive trains.
- 5.3.17 During the medium-term 24/2 operation scenario, vehicles are proposed to be stored on the system between Columbia and Loughheed presenting an issue as this area of guideway would also need to be kept clear of snow. In this scenario, the same principles as today would need to be used if there is a snow event during the 24/2 operation with any stabled vehicles moved regularly or the service frequency increased to use the stored vehicles for snow clearance, removing these stationary vehicles from the running lines.
- 5.3.18 In the longer-term scenario no vehicles are proposed to be stored on the running lines.

5.4. Operational Staffing and Safety

Staff

- 5.4.1 In support of the service strategy outlines above both for the medium-term and longer-term scenarios, it is proposed that station attendants are provided at all underground and major ridership stations. In addition, roving station attendants would be provided to allow staff to react to any events on the system particularly for un-attended stations. Supervisor staff would also be provided to manage attendants and provide additional system presence overnight.
- 5.4.2 To help eliminate the need to return trains to OMC1 for cleaning, cleaning staff are proposed to be provided at each terminus to clean trains prior to each return service.

Transit Police

- 5.4.3 An additional establishment of Transit police are proposed to be provided, providing four additional 10 hours shifts to the existing roster, these shifts would be used to police Expo, Millennium and Canada lines. Each Shift is formed of 1 Sergeant and 16 Offices with additional support staff.
- 5.4.4 Below is a case study comparing the New Year's Eve operation and the 24/2 operation to show their similarities and differences.

CASE STUDY: NEW YEAR'S EVE BCRTC SERVICE PROVISION

The project team benefitted from over 120 minutes of face-to-face discussion with VP Operations, BCRTC. It was noted that BCRTC operated an extended service during periods of higher-than-usual patronage. Typical events include Vancouver Fireworks, sport events and New Year's Eve (NYE).

This brief case study seeks to highlight the similarities and differences between a 24/2 service and the provision for NYE:

Key Aspects	New Year's Eve (NYE) Operation	24/2 Operation
Service Headway	3 minutes	15-20 minutes
Number of Trains on the system	50 trains	7 trains
Maintenance Activities	No maintenance conducted through NYE	Potential single tracking allowing some maintenance work to be carried out
STA's	Approximately 70 STAs were used (Roughly 2 per station)	Similar to STA
Train Cleaning	Trains with cleanliness issues would be pulled.	Trains with cleanliness issues would be pulled.
Policing	The frontline staff (police, STA's, etc.) have learned how to manage the late night crowd through numerous years of operating this late night service. The operation and security teams have shown maturity in dealing with such events. The interview presented an engaging record for the commencement of NYE services.	Policing effort would be very similar to NYE operation. Even though it may seem counterintuitive, lessons learned from both London Underground's late night implementation and SkyTrain's NYE suggest that the requirement of additional policing above and beyond its standard would not be required. However, the 24/2 service recommendation would be for additional policing to start, then slowly dial back if it is not required – in a similar fashion to London's experience.
Ridership Demand	Demand for NYE services slumped rapidly after midnight.	During a late night service, there is likely to be a similar result to start. Ridership is expected to increase as people learned about the offering and potential economies to be developed to take advantage of the service.

6. Business Case

6.1. Ridership

- 6.1.1 An overview of the existing SkyTrain ridership is detailed below as this provides a context against which to understand the potential overnight ridership using a 24/2 service and the potential trade-off against existing system ridership if the current service hours are reduced to provide additional time to undertake maintenance activities.

Expo and Millennium Lines

- 6.1.2 Figure 6.1 shows the Expo and Millennium Lines daily profile of boardings by day of the week. Some key observations are listed below:
- › Low demand in some periods as limited or no services is operating. Below are two example periods:
 - between 1:00 a.m. and 2:00 a.m. on Monday to Thursday
 - between 5:00 a.m. and 6:00 a.m. on Saturday and Sunday
 - › Evident AM and PM peaks for Monday – Thursday and Friday
 - › The Friday evening ridership (after 10 p.m.) is higher than Monday to Thursday, and the early Saturday morning ridership is significantly reduced
 - › The Saturday evening ridership (after 10 p.m.) is higher than Monday to Thursday, and the early Sunday morning ridership is significantly reduced
 - › Sunday has the lowest ridership
 - › The morning ridership on Monday to Friday is higher than Saturday and Sunday



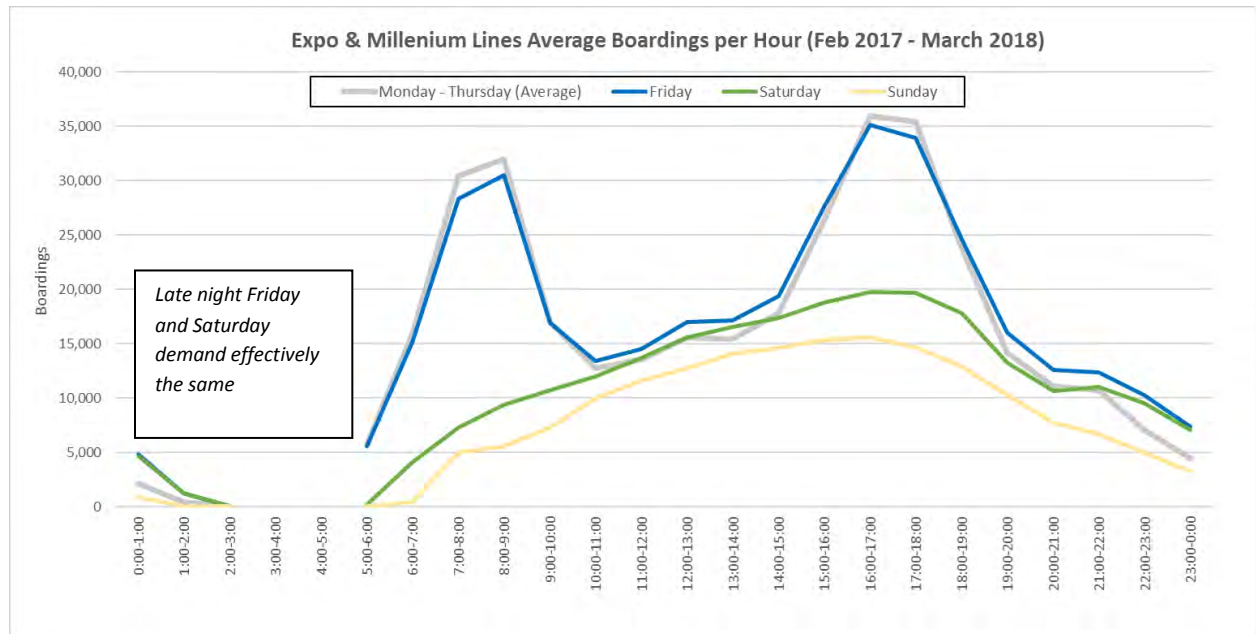


Figure 6.1 Average SkyTrain Boardings by Day of the Week

- 6.1.3 The overview of the SkyTrain ridership correlates against the demand on all transit modes which is also low late at night (defined as passenger taps between midnight and 4 a.m.). The late-night demand across all modes represents 0.7% of daily ridership Sunday to Thursdays. The demand is more significant on Friday and Saturday nights representing 1.4% of daily ridership.

NightBus

6.1.4 Figure 6.2 below presents the NightBus network.

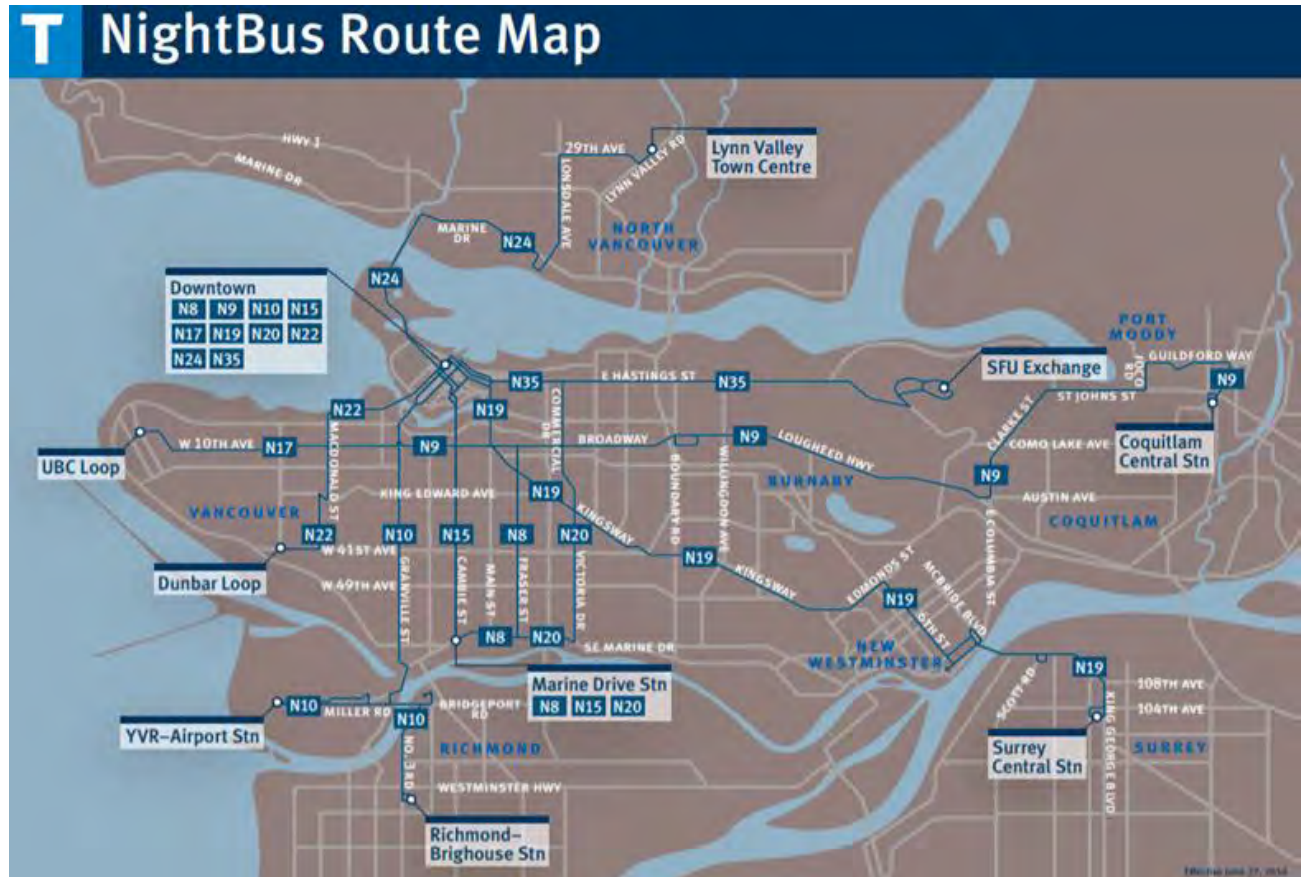


Figure 6.2 NightBus Route Network

6.1.5 The ridership was reviewed for routes N9 (Vancouver to Coquitlam) and N19 (Vancouver to Surrey) as they 'mirror' the Millennium and Expo lines respectively. The average boardings per hour are shown in Figure 6.3.

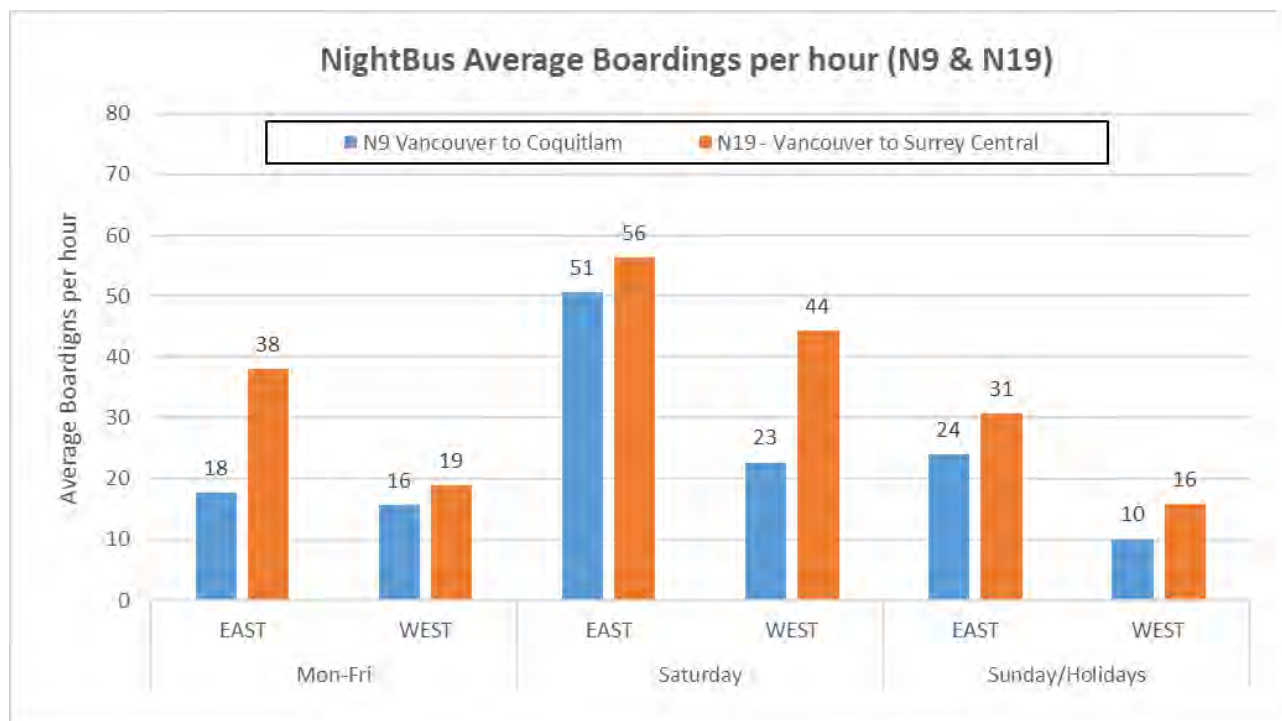


Figure 6.3 Average Hourly Boardings by Day of the Week for Routes N9 and N19

- 6.1.6 The highest demand is on route N19 leaving Downtown on Saturday and data showing high peak load factors (up to 95%) on the 2:00 a.m. – 3:00 a.m. time period. However, in absolute values, the Night Bus demand levels are low, as the highest average boarding is 56 passengers per hour.
- 6.1.7 The above analysis has a number of limitations, since Friday's data was merged with the rest of the week. However, in comparison with the SkyTrain, the data suggests comparable demand levels on Friday and Saturday. Note that NightBus service is significantly less frequent and slower than SkyTrain.
- 6.1.8 TransLink is currently reviewing NightBus service alternatives including frequency increases, express services and route realignments among other options. In the summer of 2018, TransLink ran the 'NightBus District'. This was a pilot program where all 10 NightBus routes from the downtown core were grouped at a new well-lit hub at Granville and West Georgia.

Seasonal Variations

- 6.1.9 A seasonal service increase could be considered to improve late night services. In reviewing this, TransLink analyzed monthly Compass taps between 12 a.m. (midnight) and 4 a.m. across the SkyTrain network and this is shown in the figure below:

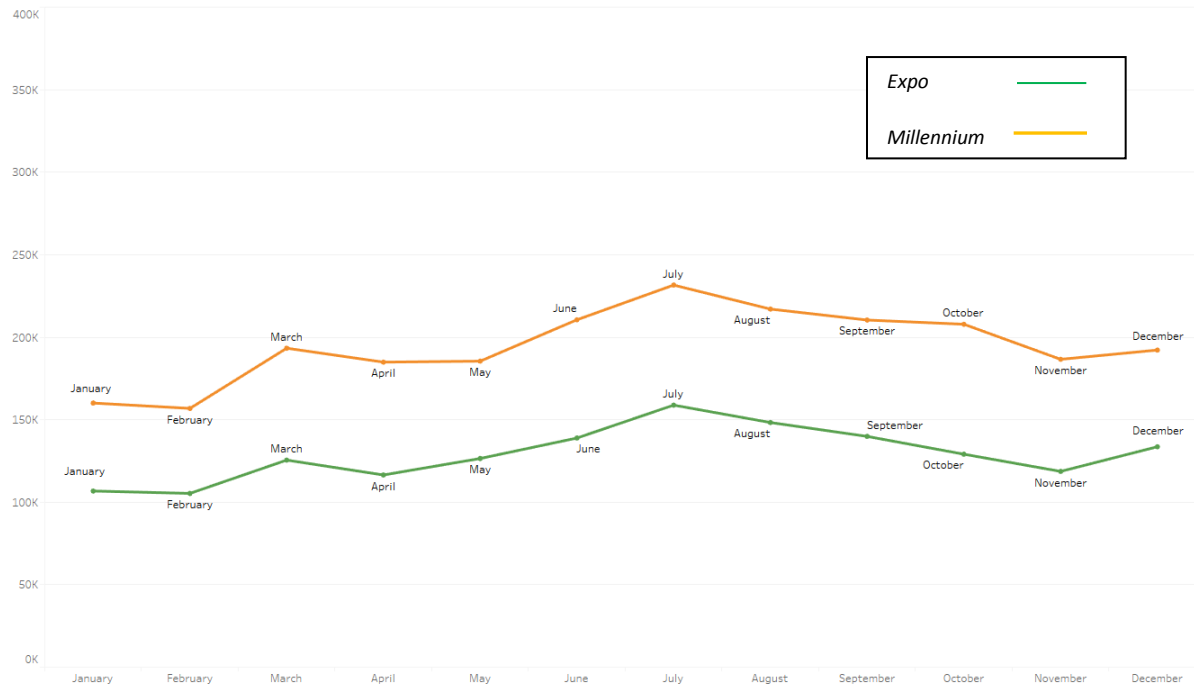


Figure 6.4 Seasonal Variation of Ridership (Source: TransLink)

- 6.1.10 The figure above confirms there are a few months with increased demand. However, there is at least one “busy month” in each of the seasons (spring, summer, fall and winter).
- 6.1.11 The above finding suggests seasonal service changes would not be attractive for the customer, since late night demand is distributed throughout the year.

SkyTrain 24/2 Operation Demand

- 6.1.12 Running a 24-hour service on Fridays and Saturdays means the earliest train would need to start launching to the main line at around 04:30 Friday morning and the last train would continue running until 00:30 Monday morning.

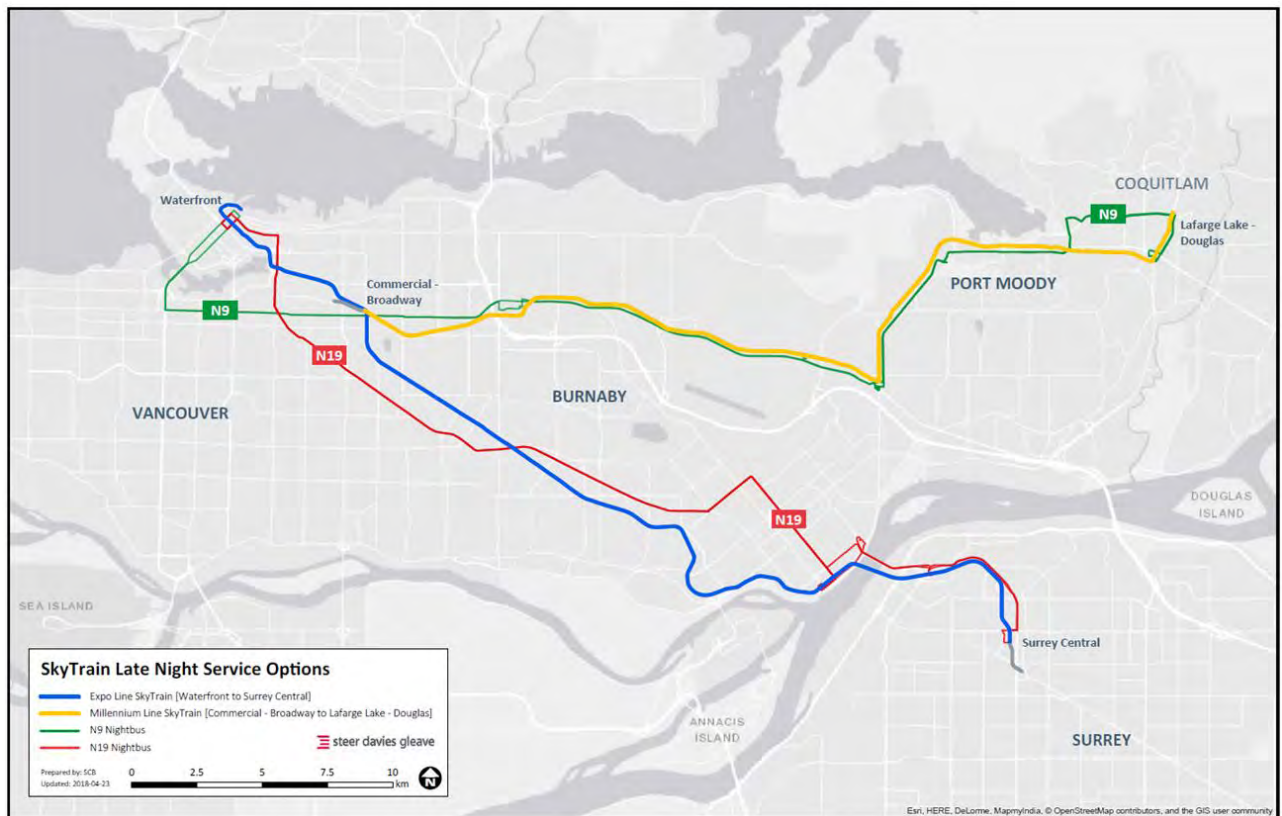


Figure 6.5 SkyTrain Late Night Service Option

- 6.1.13 With SkyTrain in operation during all weekend hours, additional maintenance time may need to be accommodated during weekdays to offset maintenance time missed during the weekend. Figure 6.6 shows the existing ridership for the last hour of service for all weekdays which would be potentially affected (Sunday to Thursday nights) and compares it to the total estimated extended hours ridership generated over the weekend period. The extended hours ridership has been estimated based on NightBus demand hourly profile applied to late night SkyTrain demand and accounting for frequency improvements.
- 6.1.14 The figure shows the existing ridership in potential weekday maintenance times is considerably higher than the demand generated from extended weekend SkyTrain services in the medium and long term scenarios.

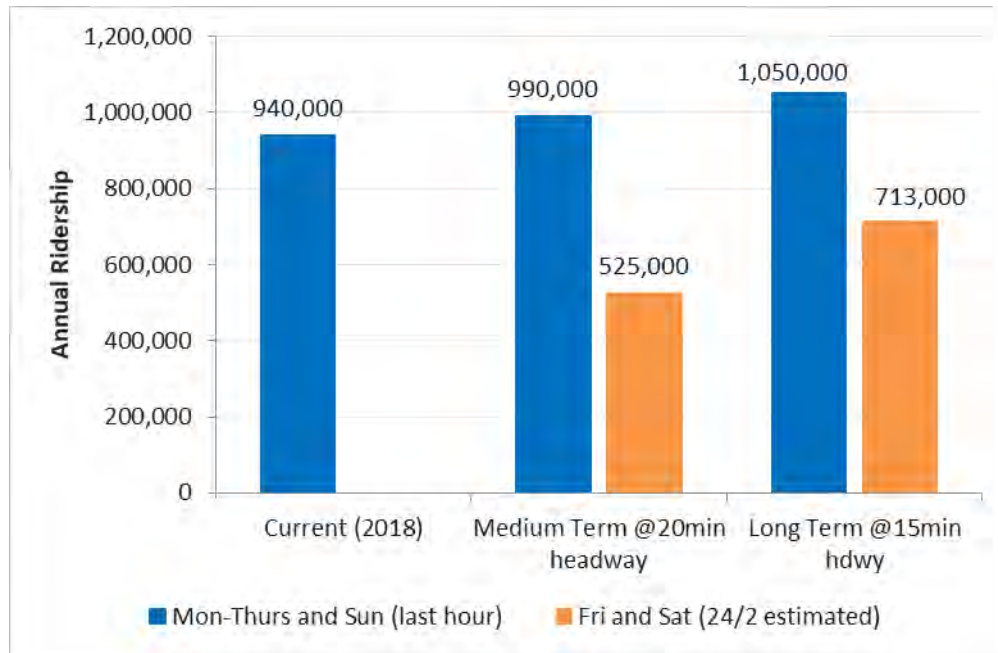


Figure 6.6 Expo and Millennium Line Boardings Comparison
(Note: these estimates are based on October 2017 data)

6.2. Costs

Operation and Maintenance Costs

- 6.2.1 Operation and maintenance estimated based on a medium term option and long term option are described below.
- 6.2.2 The operating costs reflect the additional services operated on the Saturday and Sunday early morning services at 20 minutes (medium term) and 15 minutes (long term) headways. This includes the additional station staff and the costs associated with increased train kilometers operated and the associated power used. Station operating costs include ticketing, lighting, escalators, elevators, and station attendants complete with appropriate supervision is included.
- 6.2.3 The maintenance costs for the system consider the train kilometers operated. The increase in trains kilometers operated on the infrastructure and any increase in maintenance needs is not considered. The staff hours currently allocated to weekend nights are assumed to be allocated to weekday nights, and in combination with improved maintenance practices are assumed to meet the maintenance needs of the system without the need for additional staff.

6.2.4 Order of magnitude operating and maintenance costs based on the factors above have been developed based on 2015 SkyTrain costs and the budgeted costs for 2019. These costs are split into:

- › Operations
- › Wayside
- › Vehicles
- › Engineering
- › Propulsion power
- › Administration

6.2.5 The estimated operating and maintenance cost is \$6.1 million per year in the medium term (20-minute headways) and \$7.9 million per year in the long term (15-minute headways).

Policing Costs

6.2.6 Transit Police do not currently provide overnight coverage of the system. To support the delivery of 24/2 operation, additional police shift would be required. An additional complement of police officers would be required, which would provide a team of officers for, four additional 10 hour shifts at a cost of \$3.4 million including supervision, support and vehicles. Only two of these additional shifts would be required, one for the Friday night to Saturday morning and one for the Saturday night to Sunday morning. A cost of \$1.7 million has been included for these additional police coverage, with the remainder of the costs allocated to providing enhance policing at other times.

Capital Costs

6.2.7 Capital costs reflect costs related to work or equipment required due to the extension of service hours. The following have been included:

- › Reprogramming of Compass fare system (\$1.0 million)
- › ATC upgrades (\$1.5 million)
- › The costs of additional guideway maintenance equipment to improve maintenance of the system maintenance equipment (\$5.6 million) are detailed in Table 6.1.
- › Project delivery costs of (\$1.0 million) to project manage and facilitate the organizational change prior to 24/2 operation
- › 2 X 100m storage lane for maintenance equipment (\$3 million)
- › Contingency of 25% for a total capital cost of \$15.1 million

Table 6.1 Additional Guideway Maintenance Equipment Costs

Budget Categories	Capital Budgets	Accuracy Level (+/- %)
Prime mover #1	\$930,000	Class D 20-30%
Prime mover #2	\$930,000	Class D 20-30%
Unimog #1	\$780,000	Class D 20-30%
Unimog #2	\$780,000	Class D 20-30%
Speeder #1	\$700,000	Class D 20-30%
Speeder #2	\$700,000	Class D 20-30%
Crane Cart #1	\$300,000	Class D 20-30%
Crane Cart #2	\$300,000	Class D 20-30%
Flat Cart #1	\$150,000	Class D 20-30%
Total Cost	\$5,570,000	Class D 20-30%

Source: BCRTC



6.3. Benefits

- 6.3.1 Project benefits are quantified in terms of travel cost estimated from the travel time difference between the SkyTrain and NightBus for existing transit users on Friday and Saturday nights.
- 6.3.2 Between 525,000 and 713,000 additional annual weekend transit users on SkyTrain's 24/2 services have been estimated (see Figure 6.6). Travel time benefits or dis-benefits are estimated assuming these users would travel by car/taxi if there were no SkyTrain's 24/2 services.
- 6.3.3 Other benefits such as impacts on night time economy are also considered and discussed in this chapter but not included at this stage due to limited data to support estimates.

Current User Benefits

- 6.3.4 Extending SkyTrain services would have direct impacts to the existing ridership on two NightBus routes:
 - › N19: Downtown Vancouver to Coquitlam Centre
 - › N9: Downtown Vancouver to Surrey Central
- 6.3.5 There is an average of approximately 420 NightBus riders on those two lines between 1 a.m. to 5 a.m. Saturday and Sunday morning based on 2016 September counts.
- 6.3.6 SkyTrain travel time is considerably faster than NightBus travel time which will generate shorter travel time and lower travel cost as shown in figure below:

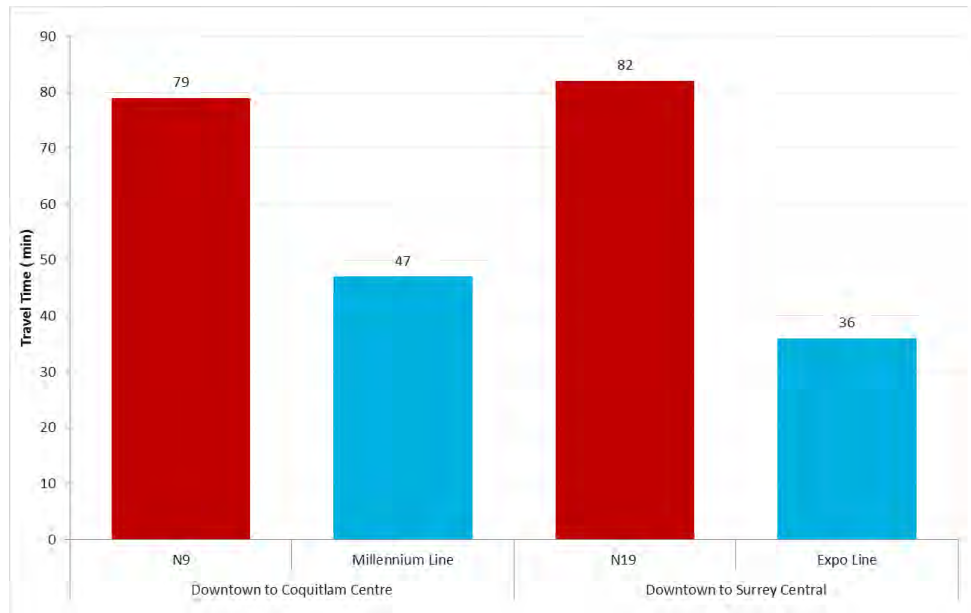


Figure 6.7 SkyTrain and NightBus Travel Time Differential

- 6.3.7 The long-term plans assume the frequency of 24/2 service will improve from 20 minutes to 15 minutes adding an extra service every hour. This would mean shorter wait time for passengers on SkyTrain compared to the current N19 and N9 services each running at 20 minutes frequencies during their peaks (frequency increase to 30 minutes to 45 minutes after 3 a.m.).
- 6.3.8 The total travel time savings which would benefit existing NightBus riders have been estimated as 36,000 passenger hours in the medium term and 53,000 passenger hours in the long term. Estimates are based on comparing travel times from a range of stop locations and existing SkyTrain demand distribution profile.

New User Benefits

- 6.3.9 The 24/2 SkyTrain service is estimated to generate approximately 525,000 new SkyTrain users in medium term and 713,000 users in the long term on the Expo and Millennium Lines between 1 a.m. to 5 a.m. on Saturday and Sunday/Holiday mornings.
- 6.3.10 These new trips would have otherwise travelled by car (e.g. driving, carpool or taxi), and it is not guaranteed that travel time savings would occur. Based on Google, when travelling at 1 a.m. during the weekend, there are a few locations where vehicle is faster than SkyTrain in which there will be a dis-benefit in terms of travel time savings.

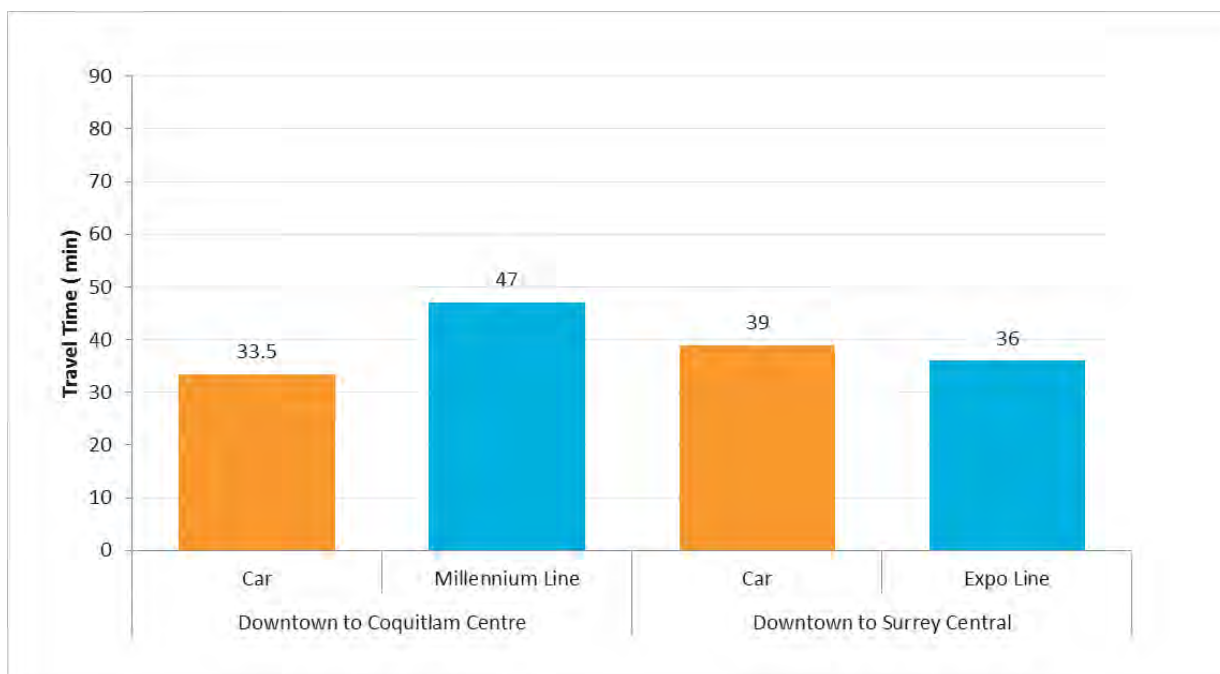


Figure 6.8 SkyTrain and Car Travel Time Differential

- 6.3.11 The total travel time savings which would benefit new SkyTrain riders is equivalent to 690,000 passenger minutes in the medium term and 936,000 passenger minutes in the long term. Note that this is an overestimate of benefits as driving, carpool and taxi would be door-to-door trips; whereas SkyTrain is station-to-station, and additional transfers are required to reach the users' final destinations.
- 6.3.12 In addition, new riders will generate additional revenue from transit fares. It is estimated that \$0.4 million and \$0.5 million is generated from new SkyTrain riders in medium and long term respectively based on additional fare revenue per passenger of \$0.75 provided by TransLink. This is based on 69% of passengers using a monthly pass therefore not contributing additional revenue, 5% paying a full fare of \$2.95 and 26% paying the Compass fare of \$2.30.
- 6.3.13 Note that the auto operating cost and taxi travel cost savings have not been considered at this stage. The more substantial passenger saving (no taxi fare) is not a 'true' economic saving as the taxi driver would incur a loss of the corresponding revenue.

Other Benefits

- 6.3.14 A number of studies (cma.org/articles/article/nighttime-economy) document the value and growth potential of the night time economy. These include:
- › San Francisco CA where a 2016 study found growth of 12,000 jobs in nightlife businesses between 2010 and 2015 (25% increase to more than 60,000) slightly outpacing overall employment growth, while sales increased 43% to \$6 billion.
 - › Edmonton AB where the city conducted a comparison study between 2010 and 2014 with estimate by 2014 of \$1.33 billion in combined economic output, doubling the \$687 million generated in 2010. There was also a comparable doubling of full-time jobs to almost 12,000.
- 6.3.15 In Vancouver, the Hospitality Vancouver Association (HVA) estimates that the 14 liquor-primary businesses in the Granville Entertainment District are responsible for more than 900 jobs and \$43.5 million in annual revenue. In addition, the Vancouver Music Ecosystem study released in 2018 found the sector represents \$690 million for the city “including employment and additional revenue” and a considerable proportion is likely focused in the downtown area and during the night time.
- 6.3.16 24/2 service would support Vancouver’s late night economy especially in the downtown core. This would translate to increases in drink-led activities (bars, pubs, and clubs), food-led activities (seat-in and take out) and entertainment (theatres, music venues) which would trigger a range of economic benefits.
- 6.3.17 In addition, the provision of additional transport options may assist people in leaving downtown more effectively and reduce incidents between individuals waiting for transport, improving public safety.
- 6.3.18 The provision of additional transportation would be supportive of people’s ability to work around the region, benefitting the region’s economy.
- 6.3.19 Finally, the provision of 24/2 service could potentially reduce road accidents as people transfer to SkyTrain and avoid driving, particularly if under the influence of alcohol and drugs.



6.4. Economic & Financial Performance

- 6.4.1 This section addresses and summaries the economic and financial benefits of the project.

Assumptions

- 6.4.2 The table below summarizes the assumptions used to evaluate the 24/2 operation.

Table 6.2 Benefit-Cost Analysis Assumptions

Factor	Description	Value
Opening Years	Year of project opening (short term/ long term)	varies for the medium and long term options
Evaluation Period	Period for which costs and benefits are accounted for	Through to 2051
Value of Time (VoT)	Value applied to convert time into monetary units based on RTM social/recreational trip-based estimates	\$17.60 (2016) \$18.29 (2018) 2018 value uplifted based on CPI
Discount Rate	Rate applied to discount all future costs and benefits consistent with MOTI business cases	6%
Consumer Price Index (CPI) – Historical	Inflation	2016: 128.4 2018: 133.4 (+3.9%)

Economic Analysis

- 6.4.3 Based on the assumption above, the summary of the project's economical and financial performance summarized in Table 6.3 below. Total costs and benefits are calculated and compared as net present value (discounted to 2018\$). Note that revenue is categorized as a cost and therefore it is a negative value.

Table 6.3: Benefit-Cost Analysis Summary

Categories	NPV (2018 M\$)
Existing Users Travel Time	\$10.4M
New Users Travel Time	\$3.4M
Total Benefits	\$13.8M
Revenue	(\$8.1M)
Operations & Maintenance	\$99.1
Capital	\$12.9
Total Costs	\$103.9M
Benefit-Cost-Ratio (BCR)	0.13

- 6.4.4 A ratio of 0.13 indicates for each dollar spent on capital, operation, and maintenance for the project, a monetary value of 13 cents of travel time cost savings and transit revenue from fares collected is returned, a loss of 87 cents.
- 6.4.5 As mentioned previously, the benefits in this analysis exclude late night economic benefits and accident savings.



6.5. Related Projects Impact

Impacts on Future System Expansion Plans

Station Upgrades

- 6.5.1 The provision of overnight service on a Friday and Saturday nights with either the medium or long term scenarios will either limit or reduce the efficiency of upgrade work being undertaken on stations overnight on these days. Currently the Saturday night provides a longer window for platform or station works in and around the guideway. The loss of this opportunity on the Saturday night may result in a need to undertake these activities on an alternate night.
- 6.5.2 To help mitigate this, the long term planning of system upgrade works should be coordinated with the maintenance planning to coordinate longer overnight upgrade activities with times when regular maintenance activities are not planned in the area to make best use of the available longer maintenance windows.
- 6.5.3 In the short-term strategy, single track operation through one platform face may be possible allowing works to be undertaken on the alternate platform or wayside areas.
- 6.5.4 Due to the limited non-revenue hours, it may result in works needing to be undertaken over additional nights increasing the cost and potential complexity.

Station Upgrade Design

- 6.5.5 Emphasis should be given to reducing the need for maintenance in the development of all future system upgrades or expansions. Where maintenance activities continue to be undertaken these should also be considered to maximize the intervals and to ensure activities can be undertaken as effectively and efficiently as possible.
- 6.5.6 A simple example is the use of LED light fittings and locating these in a way in which they can be easily replaced, i.e. using a ladder rather than the need for temporary scaffolding which would significantly increase the time and complexity of this simple task. See Figure 4.4 in case study.

System Expansion

- 6.5.7 Any expansion of the SkyTrain system should start to consider the need for greater provision for wayside maintenance equipment and storage needs around the system. The current focus of storing maintenance equipment at OMC 1 results in extended time to get to the extremities of the system to

undertake work. In expanding the system, consideration should be given to providing additional facilities on each extension to provide for storage of rail-based maintenance equipment, laydown areas and reporting and accommodation of maintenance personnel. This approach is common practice around the world, enabling maintenance staff to access areas of the system more quickly increasing the time available for works to be undertaken.



7. Next Step

To support medium-term implementation, the following steps could be taken:

- › Procure required additional maintenance equipment to support maintenance
- › Acquire sufficient equipment storage space
- › Create SkyTrain 24/2 operation timetable
- › Determine how to justify early and partial closures on statutory holidays
- › Identify all job assignments which will be affected by a 24/2 operation scenario, adjust job assignments and hire additional staff as necessary
- › Adjust resource management strategy to accommodate capital projects to the maintenance schedule (e.g. station upgrades and delivery of new trains)

To support long-term implementation, the following steps could be taken:

- › Conduct review to evaluate the situation and make adjustments as necessary
- › Retrofit selection of Mark I trains for use as engineering vehicles
- › Review the need to diversify the provision of maintenance activities for the growing SkyTrain network.
- › Determine the requirements for successful introduction of the new MK III and new 5-car Equivalent fleet to ensure the areas toward Lougheed are sufficient for stabling and testing
- › Implement an Asset Management System meeting BCRTC's needs (thereby offering opportunity to find maintenance efficiencies)
- › Implement a robust project governance strategy within TransLink to de-risk the implementation of capital projects on SkyTrain infrastructure

Appendix A Outstanding Work Orders due to the Lack of Equipment as identified from Simulation

Work Order	Date	Reason
Trackwork C/O DC62 Rail C/O Point & Stock	August 10 (Friday)	Equipment – required Speeder 3 (or Speeder 4), Mog 2 (or Mog 1), Crane Cart 1 and Crane Cart 2. Neither Mog 1 nor Mog 2 was not available on August 7 for rescheduling.
Trackwork C/O DC62 Rail C/O Point & Stock	August 11 (Saturday)	Equipment – required Speeder 3 (or Speeder 4), Mog 2 (or Mog 1) Crane Cart 1 and Crane Cart 2. None of Speeder 3, Speeder 4, Mog 1 and Mog 2 was not available on August 8 for rescheduling.
Expo Escalator GWY support (GPA0280)	August 17 (Friday)	Equipment – required Mog 1 (or Mog 2) and Flat Cart. Neither Mog 1 nor Mog 2 was available on August 19 for rescheduling.
Expo Escalator GWY support (GPA0280)	August 18 (Saturday)	Equipment – required Mog 1 (or Mog 2) and Flat Cart. None of Mog 1, Mog 2 and Flat Cart was available on August 20 for rescheduling.
Expo Escalator GWY support (GPA0280)	August 25 (Saturday)	Equipment – required Mog 1 (or Mog 2) and Flat Cart. Neither Mog 1, Mog 2 was available on August 26 for rescheduling.
Unscheduled Maintenance M-Line EVGL	August 25 (Saturday)	Equipment – required Mog 1 (or Mog 2). Neither of them was available on August 26 for rescheduling.
GSPPTIC PR Insp	August 25 (Saturday)	Equipment – required Speeder 7 (or Speeder 8). Neither of them was available on September 9 for rescheduling.
Trackwork C/O	August 31 (Friday)	Equipment – required Mog 1, Mog 2, Crane Cart 1, and Crane Cart 2. Mog 2 was not available on August 30 for rescheduling.
Unscheduled Maintenance EXPO WEST	September 1 (Saturday)	Equipment – required Speeder 7 (or Speeder 8). Neither of them was available on August 29 for rescheduling.
Unscheduled Maintenance EXPO WEST	September 1 (Saturday)	Equipment – required Speeder 7 (or Speeder 8).

Work Order	Date	Reason
		Neither of them was available on August 30 for rescheduling.
Trackwork C/O GUD7989	September 1 (Saturday)	Equipment – required Mog 1, Mog 2, Crane Cart 1 and Crane Cart 2. Neither Mog 1 nor Mog 2 was available on August 29 for rescheduling.
LORAM GPA0289	September 7 (Friday)	Equipment – required Speeder 7 (or Speeder 8). Neither of them was available on September 6 for rescheduling.
Trackwork C/O GUD 0649, 8981, 8984	September 7 (Friday)	Equipment – required Mog 1, Mog 2, Crane Cart 1, and Crane Cart 2. None of Mog 1, Mog 2, and Crane Cart 2 was available on September 3 for rescheduling.
Trackwork C/O GUD 0649, 8981, 8984	September 8 (Saturday)	Equipment – required Mog 1, Mog 2, Crane Cart 1, and Crane Cart 2. None of Mog 1, Mog 2, and Crane Cart 2 was available on September 4 for rescheduling.
Trackwork C/O GUD 0649, 8981, 8984	September 8 (Saturday)	Equipment – required Mog 1, Mog 2, Crane Cart 1, and Crane Cart 2. None of Mog 1, Mog 2, and Crane Cart 2 was available on September 5 for rescheduling.
D repair	September 15 (Saturday)	Equipment – required Speeder 7 (or Speeder 8). Neither of them was available on September 16 for rescheduling.
Trackwork C/O	September 22 (Saturday)	Equipment – required Speeder 3 (or Speeder 4), Mog 1 (or Mog 2), Crane Cart 1 (or Crane Cart 2), and Flat Cart. None of Mog 1, Mog 2, Crane Cart 1 and Crane Cart 2 was available on September 24 for rescheduling.

Appendix B Outstanding Work Orders due to Location Conflicts as identified from Simulation

Work Order	Date	Reason
Test Train (Aug 17: BW I/B, BWZ-NAZ I/B; Aug 18: MN-BW-NA, STZ-JYZ B/B)	August 17 -18 (Friday- Saturday)	Location – required 3 consecutive weekday nights (or Sunday and Monday), which were not available.
Joyce Station Upgrade (GPA0282)	August 24 (Friday)	Location – required 1 weekday/Sunday night, which was not available because the same work order had already occupied the other nights.
Joyce Station Upgrade (GPA0282)	August 25 (Saturday)	Location – required 2 consecutive weekday nights (or 1 weekend night), which was not available because the same work order had already occupied the other nights.
M-Line Classic: Pull Apart	August 25-26 (Saturday-Sunday)	Location – required 4 consecutive weekday nights (or Sunday, Monday, Tuesday), which were not available.
Joyce Station Upgrade (GPA0282)	August 31 (Friday)	Location – required 1 weekday/Sunday night, which was not available because the same work order had already occupied the other nights.
GSSWFOL/ GSSFW/ GSSWFOL	August 31 (Friday)	Location – required 1 weekday/weekend night, which was not available. Adjacent dates had rail replacement “22:00 WFT-ESSTO TS1086-1065” at the same location.
Test Train (ESST-JYZ both sides)	September 1 (Saturday)	Location – required 2 weekday nights (or Sunday), which was not available. Broadway Station Upgrade (GPA0206) happened nearly daily, and it had location conflict with Test Train.
Joyce Station Upgrade (GPA0282)	September 7 (Friday)	Location – required 1 weekday/weekend night, which was not available because the same work order had already occupied the other nights.
Joyce Station Upgrade (GPA0282)	September 8 (Saturday)	Location – required 2 consecutive weekday nights (or Sunday), which were not available because the same work order had already occupied the other nights.
Power Collector Camera, WFT-WFT I/B Test Train	September 14 (Friday)	Location – required 1 weekday/weekend night, which was not available. Adjacent dates had rail replacement “22:00 WFT-ESSTO TS1086-1065” at the same location.

Work Order	Date	Reason
Joyce Station Upgrade (GPA0282)	September 15 (Saturday)	Location – required 1 weekday/weekend night, which was not available because the same work order had already occupied the other nights.
KG O/B Switch	September 21-22 (Friday-Saturday)	Location – required 3 consecutive weekday nights (or Sunday and Monday), which were not available on adjacent dates.
Tunnel flushing	September 21-22 (Friday-Saturday)	Location – required 3 consecutive weekday nights (or Sunday and Monday), which were not available on adjacent dates.
Running Rail Replacement 2018 (GPA0286) RBE - WFT	September 21 (Friday)	Location – required 1 weekday/weekend night, which was not available because this work order had already been assigned to adjacent dates.
GSSLHW	September 22 (Saturday)	Location – required 2 consecutive weekday nights (or Sunday), which were not available. Also, required frequency (weekly) for this work order restricted rescheduling to an earlier night in the month.
LORAM Grinding GPA0298	September 22 (Saturday)	Location – required 2 consecutive weekday nights (or Sunday), which were not available.
Joyce Station Upgrade (GPA0206)	September 22 (Saturday)	Location – required 1 weekday/weekend night, which was not available because this work order had already been assigned to adjacent dates.
GSSWFOL/ GSSFWF/ GSSWFOL	September 28 (Friday)	Location – required 1 weekday/weekend night, which was not available. Adjacent dates had rail replacement “22:00 WFT-ESSTO TS1086-1065” at the same location.
GSSLHW repair	September 28-29 (Friday-Saturday)	Location – required 3 consecutive weekday nights (or Sunday and Monday), which were not available. Also, required frequency (weekly) for this work order restricted rescheduling to an earlier night in the month.
Joyce Station Upgrade (GPA0282)	September 28 (Friday)	Location – required 1 weekday/weekend night, which was not available because the same work order had already occupied the other nights.
Joyce Station Upgrade (GPA0282)	September 29 (Saturday)	Location – required 2 consecutive weekend nights (or Sunday), which were not available because the same work order had already occupied the other nights.
Testing Train (ESBQ-FCZ)	September 29 (Saturday)	Location – required 2 consecutive weekend nights (or Sunday), which were not available.
Trackwork C/O (DC13)	September 29 (Saturday)	Location – required 2 consecutive weekday nights (or Sunday), which were not available
LORAM Grinding GPA0289	September 29 (Saturday)	Location – required 2 consecutive weekday nights (or Sunday), which were not available.

Appendix C ISO 45001 Action Plan

The following are some ISO 45001 specific clauses and their potential implications for BCRTC and the Extended Hours Project

#	Title	Context	Implication for Extended Hours
4.1	Understanding of the organization and its context	BCRTC will need to be able to demonstrate that they have determined external and internal issues that are relevant to their operations and that affect its ability to achieve successful outcome(s) of their OHSMS.	Ensure that the internal and external issues arising out of the extended hours faced by BCRTC and their stakeholders are identified and considered. Document the process.
4.2	Understanding the needs and expectations of workers and other interested parties.	You will need to be able to demonstrate that you have identified all interested parties and their needs and expectations that are relevant to the OH&S management system.	Interested Parties (including workers/employees) should have input into the process. Identify third-party stakeholders as they relate to Extended Hours of Operation and determine their needs and expectations. Consider if any of these might become legal requirements.
4.3	Determining the scope of the OH&S management system	<p>Evidence of the taking into account and/or consideration of:</p> <ul style="list-style-type: none"> • How the boundaries of the OH&S management system's scope have been determined - what has been considered? • The activities, products and services included within the scope of your OH&S management system. • Why and how the scope of your OH&S management system has changed. 	<p>BCRTC should consider the implications of extended hours of operations on the following:</p> <ul style="list-style-type: none"> • The boundary and applicability of their OH&S scope • Will the changes to the services affect the scope of the OH&S system • Changes should be documented



#	Title	Context	Implication for Extended Hours
4.4	OH&S management system	Establish, implement, maintain and continually improve your OH&S management system, through the adoption of the necessary processes in accordance with the requirements of the standard. Provide information on your OH&S processes and how these interact.	As the Extended Hours Project represents both a change to services and operations, it should be considered within the contexts of this clause. Are changes to the OH&S management system or process necessitated by this change?
5.1	Leadership and commitment	Evidence that Top Management is engaged with and demonstrate leadership and commitment to the OH&S management system including developing, leading and promoting a positive OH&S culture, the provision of a safe and healthy workplace, the prevention of work-related injury and ill-health.	<p>Ensure that the OH&S policy and related objectives align with the business's strategic direction.</p> <p>Ensure that the OH&S management system processes are integrated into other business processes.</p> <p>Ensures active worker participation, the implementation of processes for consultation and participation in the OH&S management system, and supporting the establishment and functioning of health and safety committees.</p> <p>Ensure that the resources needed are available.</p> <p>Communicate the importance of effective OH&S management.</p> <p>Protection of workers from reprisals when reporting incidents, hazards, risks and opportunities.</p>

#	Title	Context	Implication for Extended Hours
5.3	Organisational roles, responsibilities and authorities	Consideration should be given to how top management have established and communicated responsibilities and authorities for the effective operation of the OHSMS and how reporting on the performance of the management system is communicated to top management.	Top management need to ensure that the responsibilities and authorities for relevant roles are assigned, communicated and understood throughout the organisation. This must be maintained as documented evidence. Roles, responsibilities and authorities should be reviewed as they relate to the Extended Hours Project; and, where appropriate, amended as necessary.
5.4	Consultation and participation of workers	The organisation must establish, implement and maintain a process(es) for consultation and participation of workers at all applicable levels and functions, and, where they exist, workers' representatives, to continually improve the OHSMS	As the Extended Hours Project represents a significant operational change, BCRTC should include it in their processes to OHSMS
6.1	Actions to address risks and opportunities	Consideration should be given to how the organisation determines and assesses the risks that can affect occupational health and safety performance and how it manages these risks, including hazard identification, legal requirements and performance assessment.	BCRTC should include a complete review of the 24/2 project to ensure that both the hazards and the level of risk for the change are known, understood and effective controls are implemented.
6.2	Occupational health and safety objectives and planning to achieve them	Consideration should be given to how the organisation ensures occupational health and safety objectives are relevant to the organisation's policy, how they are communicated and how the results are to be evaluated.	BCRTC should establish occupational health and safety objectives that are linked to the occupational health and safety risks, opportunities and performance criteria which the organisation has identified as having the highest priority. The operational changes should be considered and included in this process.



#	Title	Context	Implication for Extended Hours
7.1	Resources	Consideration should be given to how internal and external resource requirements are considered for the establishment, implementation and improvement of the OHSMS.	BCRTC should have an understanding of the resources required to achieve occupational health and safety objectives, e.g. money, people, equipment, organisational knowledge and any constraints, such as budget and schedule, that need to be considered.
7.2	Competence	Consideration should be given to how the organisation ensures that competence requirements are established, and that workers have the relevant competence to carry out their activities in a safe and healthy way.	BCRTC will need to determine the competencies required of their employees and ensure that these are met and maintained.
7.3	Awareness	Consideration should be given to how workers are made aware of the OHSMS management system objectives, policy and occupational health and safety performance and how it affects them and how their own actions can affect it.	This clause covers occupational health and safety awareness, and workers should also be made aware of relevant hazards and related occupational health and safety risks that can impact them, including those that might not be related to their individual activities.
7.4	Communication	Includes both internal and external communications relevant to the OHSMS.	BCRTC will need to think about what they need to communicate, when, to whom and how with regards to this project.
7.5	Documentation	Consideration should be given to how the organisation will create, update, control and retain documented information relating to the occupational health and safety management system.	The Extended Hours Project should create, maintain and retain documents in accordance with BCRTC policies and procedures.
8.1	Operational planning and control	Requirements relate to the management of change, elimination of hazards and reduction of occupational health and safety risks (hierarchy of control) and the control of procurement.	BCRTC should consider including the Project in their process for Change Management.

#	Title	Context	Implication for Extended Hours
8.2	Emergency preparedness and response	This clause requires the organisation to establish, implement and maintain the processes required to prepare for and respond to potential emergency situations.	BCRTC should consider the implications related to emergency preparedness and response in relation to the Extended Hours Project.
9.1	Monitoring, measurement, analysis and evaluation	The organisation should consider how and when they will monitor and evaluate their occupational health and safety performance.	BCRTC will need to determine when monitoring and measurement will be performed and when the results will be analysed and evaluated, but the operations associated with the extended hour project should be considered.
9.2	Internal Audit	The organisation needs a process to address internal audit requirements	The operations associated with the Extended Hours Project should be specifically included in internal audits.
9.3	Management Review	Top Management shall conduct reviews of both internal and external factors.	BCRTC should include the Extended Hours Project as part of their management review process.
10.1	General Improvement	This clause covers the general need for improvement and the need to actively look for opportunities for improvement and implement the necessary actions to achieve the intended outcomes of the OHSMS.	There should be no additional work from a system perspective as a consequence of the Extended Hours Project. BCRTC should continue to apply the principles of continual improvement.
10.2	Incident, nonconformity and corrective action	This clause covers the requirement for establishing processes to investigate incidents, near misses and other non-conformities and provide a corrective action plan.	There should be no additional work from a system perspective as consequence of the Extended Hours Project. BCRTC should continue to identify, track, mitigate, assess and document.



The background is a light blue gradient. It features numerous small, white, five-pointed stars of varying sizes scattered across the page. On the right side, there is a large, stylized crescent moon in a light blue color. Inside the curve of the moon, there are three overlapping circles of different shades of blue, creating a layered effect.

2019 Late Night Service Report

Appendix D

Canada Line Phase 2



CANADA LINE EXTENDED SERVICE HOURS FEASIBILITY STUDY

Scope of Services: Stage 3 - Detailed Operational Impact Plan

May 31 2019

Prepared by:	<div></div>	<div></div>	
Reviewed by:	<div></div>		
Approved by:	<div></div>	<div></div>	
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Document No.		Rev.	B
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CANADA LINE EXTENDED
SERVICE HOURS FEASIBILITY
STUDY STAGE 3

REVISION LOG

Revision No.	Revision Date	Revision			Description of Revision
		Prepared	Reviewed	Approved	
0	25/01/2019				Draft – Open comments on AWA
A	19/02/2019				Update – TransLink Comments
B	31/05/2019				Added Appendix B

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1. Introduction

InTransit BC, (The Concessionaire) has been requested by TransLink to contract the Operator of the Canada Line (Protrans Operations BC Ltd.) for providing an estimate on performing an Extended Hours Feasibility Study. The intention is for the proposed extended hours of service, including all obligations will flow down from the Concessionaire to the Operator as defined under an Ancillary Works Agreement Request (AWA) including any other incremental mutually agreed commercial requirements.

Protrans was provided with the full scope of work from TransLink. Protrans understands that the full scope of work for the feasibility study, as communicated and provided by TransLink has been delineated into four phases/packages of work.

The scope of work for the feasibility study Stage 3 is as follows:

- *Based from the results of Stage 2, a detailed operational impact analysis shall be completed for a 24/2 extended service scenario for Canada Line.*
- *Provision of an overall road map, including timeline for extended service hours implementation.*
- *The road map shall consider the current maintenance and operations practices, while taking into consideration the expected service expansion and other planned changes with focusing on the Extended Service Implementation Cost Impact.*

2. Executive Summary

A key assumption incorporated within this study is the evident need of Transit Police attendance sustainability on the Canada Line during the proposed extended service hours. This is for the safety and security of both our employees and passengers, as well as protection of the assets under ProTrans custodianship.

[REDACTED] To encourage passenger's use of the Canada Line during these late hours, it will be important to ensure that the Customer Experience being delivered is perceived to be safe, secure and reliable.

Our proposed solution to ensure the delivery of safe, secure and reliable passenger experience is to come to the following agreement for the policing of the Canada Line during the extended service hours:

- [REDACTED]
- This level of policing will be fully reviewed by TransLink with the Transit Police before extended service hours commence.

CANADA LINE EXTENDED SERVICE
HOURS FEASIBILITY STUDY
STAGE 3

- TransLink will review the level of policing on the Canada Line in extended service hours with Protrans and the Transit Police based on [REDACTED]

Within this study, Protrans has proposed two options for Service Plans during the extended service hours for TransLink's consideration:

Option A – This Service Plan serves all stations (30 minute headways) with two trains operating between Waterfront and Richmond Brighthouse and one train operating between YVR-Airport and Bridgeport station which would be the point of interchange.

Option B – This Service Plan serves all stations with alternate services from Waterfront to Bridgeport Station (15 minute headways) to YVR-Airport (30 minute headways) and Richmond (30 minute headways) with four trains and no passenger physical interchanges at Bridgeport.

When we completed the financial review in Stage 4, we anticipate that Option B will conclude with higher costs. However, resulting in a more balanced Customer Experience (one seat ride and higher frequency). Additional costs entails the use of more trains (kilometers) and resource planning to accommodate the risk and further restricted access for maintenance activities. Due to a 15-minute headway, there would be inability to access some areas of the track using single tracking where as it is possible with the 30-minute services. As we suspect that the eventual ridership utilizing extended service on the Canada Line could be somewhat seasonal and Special Event(s) driven, TransLink may want to consider a hybrid of the two options and operate as per Option A providing a better access for maintenance at a lower cost weighed against customer acceptance and other tradeoffs. Option B then can be exercised as warranted by Special Event ridership events dates (Canada Day, New Years Eve etc).

Overall, the Detailed Operational Impact Plan concludes with the earlier Stage 2 Study that extended service hours could be implemented on the Canada Line but changes would need to be made to the way that Protrans currently maintains the system to ensure that the assets remain in a good state of repair. These changes and other changes such as an increase in staffing levels would incur incremental costs. [REDACTED]

[REDACTED] Key to ensuring safe, secure and reliable extended hours services ultimately ensuring that this change is a success will be the policing strategy during these hours.

2.1. Disclaimer/Non Disclosure





3. Extended Hours Scenario

The conclusion from the Phase 2 study was as follows:

“Protrans conclusion from this feasibility study is that if TransLink intends to continue with considering the extended service hours on the Canada Line, then additional service hours on Friday and Saturday nights would be the best and most achievable option. Furthermore, Protrans preference is sustaining its operations seamlessly through the whole night on Friday and Saturday for the reasons that have been described with this feasibility study (Phase 2). Protrans also considers that this option will gain the best value in promoting of the usage of the extended services giving access to a regular and reliable service throughout the night”.

This Phase 3 study will therefore focus on the delivery of extending services through Friday and Saturday nights (Saturday and Sunday mornings 02:00-04:00).

Note that in the Phase 2 Study, Protrans also recommends for TransLink to consider a 15-minute Service Plan for the extended service hours as this would promote higher ridership and move passengers quickly through the system. Within this study for Phase 3, we have reviewed some alternative options for Service Plans for TransLink’s consideration which would allow better access for maintenance and anticipated lower operating and maintenance costs as compared to the 15-minute service.

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4. Canada Line Existing Service Hours (Copy from last study)

The current revenue service of the Canada Line is defined by the Concession Agreement as follows (Note this is expected to Change in 2020 in association with the new Canada Line trains that TransLink have procured):

Weekdays	Saturdays	Sundays / Stat. Holidays
04:48 – 06:30 6:00 minute headway	04:48 – 09:00 6:00 minute headway	04:48 – 10:00 6:00 minute headway
06:30 – 09:30 3:08 minute headway	09:00 – 19:00 3:20 minute headway	10:00 – 19:00 3:20 minute headway
09:30 – 15:00 3:20 minute headway	19:00 – 23:00 6:00 minute headway	19:00 – 23:00 6:00 minute headway
15:00 – 19:00 3:08 minute headway	23:00– 01:41 10:00 minute headway	23:00– 01:41 10:00 minute headway
19:00 – 23:00 6:00 minute headway		
23:00– 01:41 10:00 minute headway		

Note this is expected to Change in 2020 in association with the new Canada Line trains that TransLink have procured. In terms of the effects of this change on an extended hours of operation on Saturdays through to Thursdays the 06:00 minute headway will be extended to 24:00 and on Fridays it will be a 4 minute headway between 23:00 – 24:00.

5. Current Engineering Hours

The current available engineering window for the performance of track and system maintenance is dependent on the asset being worked on, type support to be delivered and area needed to conduct the technical work, including the speed and efficiency at which the system can be shut down and trains be routed to the yard. As implied above, the window between the last and first revenue service trains is from 01:41 to 04:48. In general, automatic trains are cleared from of the mainline track at 01:50 and re-launch begins at 04:15, leaving a 145-minute window for the performance of mainline track, guideway and system maintenance. It is important to note that the resource deployment travel time must also be included in this maintenance window, although it is occasionally possible to stage equipment or crews, or even scheduling certain maintenance equipment movements in concurrence with the system shutdown protocols.

For the large scale maintenance tasks conducted in appropriate areas, single tracking is

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employed, in which a section of the mainline is closed early and trains are routed bi-directionally along the remaining open track. This imposes certain restrictions, the most notable of which being the minimum time between trains, which is constrained by the location of the specific crossover track switches which must be used to re-route the trains around the chosen maintenance area.

During the current Engineering Hours there are several tests/maintenance activities that would impact the service that would present a major challenge to be performed at any other time. These include:

- Nightly automatic self-tests of the entire Guideway Intrusion Detection System which temporarily disables automatic train operation at platforms during the test
- Preventative Maintenance to the ATC central system which suspends all train movement during this maintenance
- Use of the tunnel ventilation for testing and support of other maintenance which could create a problem for passengers on platforms with high noise, wind and dust

Other maintenance currently performed in engineering hours which is likely to be invasive to passengers at stations includes:

- Nightly routine cleaning and deep cleaning
- Re-lamping which can involve scaffolds
- Painting
- Advertising
- Other 3rd party requests (TransLink contractors)

6. Operational Requirements

6.1. Suggested implementation Timeline

There are 3 significant capital projects that Protrans is aware of which should be considered in regards to the implementation Timeline for extended service hours on the Canada Line. A suggested timeline is included in Appendix B.

6.1.1. Canada Line Capacity Expansion Project

This project currently involves the procurement of 12 new Canada Line trains and updates the OMC, Systems and Stations to accommodate the new trains. The current forecast timescale for the 12 new Canada Line trains is that they will be delivered from July 2019 through to June 2020 with the first new train being fully commissioned and approved for service in October 2019. Although the exact date is still to be confirmed, TransLink intends to implement a change to the current Canada Line Service Plan early in 2020. This will generally increase the capacity in the peak hours and between 23:00 and 24:00 resulting to reduced capacity during weekend day time. The full scope of this project is envisioned to be completed by July 2020 and will not be practical to attempt implementing any extended hours during the life of this project.

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[REDACTED] Protrans had to assume that the baseline for this study is the current Service Plan. Protrans recommends that a review of this study is performed once the Change Instruction for PCI70 Phase 3 is executed and any adjustments made in a revised version which will include completion of Stage 4 (the detailed financial review).

6.1.2. Capstan Station

[REDACTED]

6.1.3. Broadway Subway project

[REDACTED]

6.1.4. Timeline

Protrans conclusion regarding the timeline to be considered for any implementation of extended hours of service on the Canada Line; the initial launch should be scheduled at a period after the Service Plan change for PCI70 has been implemented and has been allowed to “bed in and mature”.

This Service Plan change will require an estimate of eight (8) additional trains to be operated in the peak passenger hours and there may be a period where initially, the Operator’s personnel and TransLink passengers adapt to a higher frequency service level. With Capstan Station possibly also being in construction within 2020 and then opening in 2021, this may be disruptive to any extended hours services due to the requirements on performing some construction activities, testing and commissioning during scheduled Engineering maintenance.

This will also be the first new additional station that is constructed on the Canada Line while the system is operational. Again, the opening of the new station will require a revised Service Plan and they may be a period where new service needs to “mature”. For this reason, Protrans recommends that consideration is made to target any extended hours on the Canada Line, at least 6 months after Capstan Station is opened.

Protrans also suggests that there would be some trials of the extended service hours in advance of implementation. These will allow Protrans employees to experience operations in these hours and fine tune plans including response to incidents and emergencies in conjunction with the ERAs and Transit Police. These could be targeted on nights when there are special events, Canada Day, for example; can be a media event promotion, encouraging usage of the extended hours of service. [REDACTED]



6.2. Service Plan

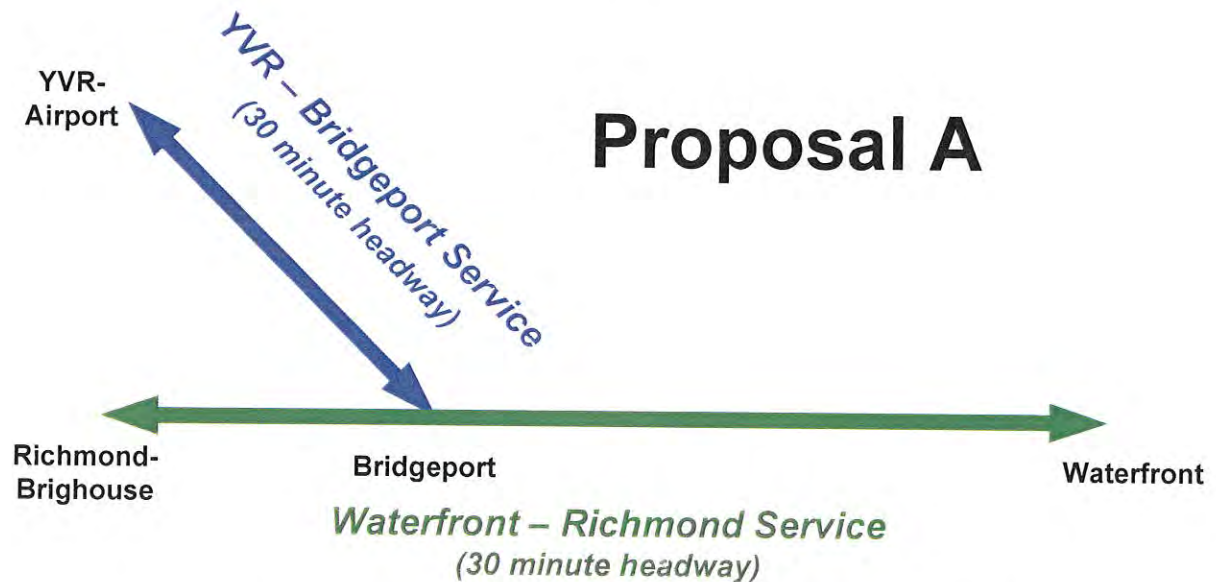
This feasibility study proposes two potential service plans for revenue service extension on Friday and Saturday nights. Proposal A involves the utilization of 3 revenue trains providing 30 minute headways throughout the system whereas Proposal B involves 4 revenue trains with 15 minute headways between Waterfront and Bridgeport stations; 30 minutes on the branches from Bridgeport station to the YVR airport and Richmond terminus respectively. An overview of the two options is summarized in the following table.

Table 1: Overview of Service Plan Proposals

	Terminus Headway			Trains	Annual Revenue km
	Waterfront	Richmond	YVR-Airport		
Proposal A	30	30	30	3	28,080
Proposal B	15	30	30	4	46,280

6.2.1. Proposal A – 30 Minute Headway to Richmond with Branch Line to YVR

This proposed Late-Night Train Service provides train departures at 30 minute intervals between Waterfront and Richmond Brighthouse, with a branch line service (shuttle) connecting passengers between Bridgeport and YVR-Airport at the same frequency.



In terms of train kilometrage, the Late Night Trains Service involves 7.5 round-trips between Waterfront and Richmond-Brighouse performed by the two mainline trains and 8 round-trips between Bridgeport and YVR-Airport/Richmond-Brighouse performed by the shuttle train per night.

The proposed train service schedule is presented in the table below:

Table 2: Proposal A – 30 minute headway to Richmond with Branch Line to YVR

Outbound Train Service

Train Service*	Depart WFS	Depart BPS	Arrive RBS
Regular Service	1:15	1:35	1:43
Late Night Service	1:30	1:50	1:58
Late Night Service	2:00	2:20	2:28
Late Night Service	2:30	2:50	2:58
Late Night Service	3:00	3:20	3:28
Late Night Service	3:30	3:50	3:58
Late Night Service	4:00	4:20	4:28
Late Night Service	4:30	4:50	4:58
Regular Service	4:48	5:08	-

*Assumes Capstan Station in Service

Inbound Train Service

Train Service*	Depart RBS	Depart BPS	Arrive WFS
Regular Service	0:45	0:53	1:13

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Late Night Service	1:00	1:08	1:28
Late Night Service	1:30	1:38	1:58
Late Night Service	2:00	2:08	2:28
Late Night Service	2:30	2:38	2:58
Late Night Service	3:00	3:08	3:28
Late Night Service	3:30	3:38	3:58
Late Night Service	4:00	4:08	4:28
Late Night Service	4:30	4:38	4:58
Regular Service	5:02	5:10	5:30

*Assumes Capstan Station in Service

YVR Train Service

Train Service	Depart YVR	Arrive BPS	Depart BPS	Arrive YVR
Regular Service	0:57	1:04		
Regular Service			1:25	1:32
Late Night Service	1:23	1:30	1:53	2:00
Late Night Service	2:13	2:20	2:23	2:30
Late Night Service	2:43	2:50	2:53	3:00
Late Night Service	3:13	3:20	3:23	3:30
Late Night Service	3:43	3:50	3:53	4:00
Late Night Service	4:13	4:20	4:23	4:30
Late Night Service	4:43	4:50	4:53	5:00
Regular Service			5:08	5:15

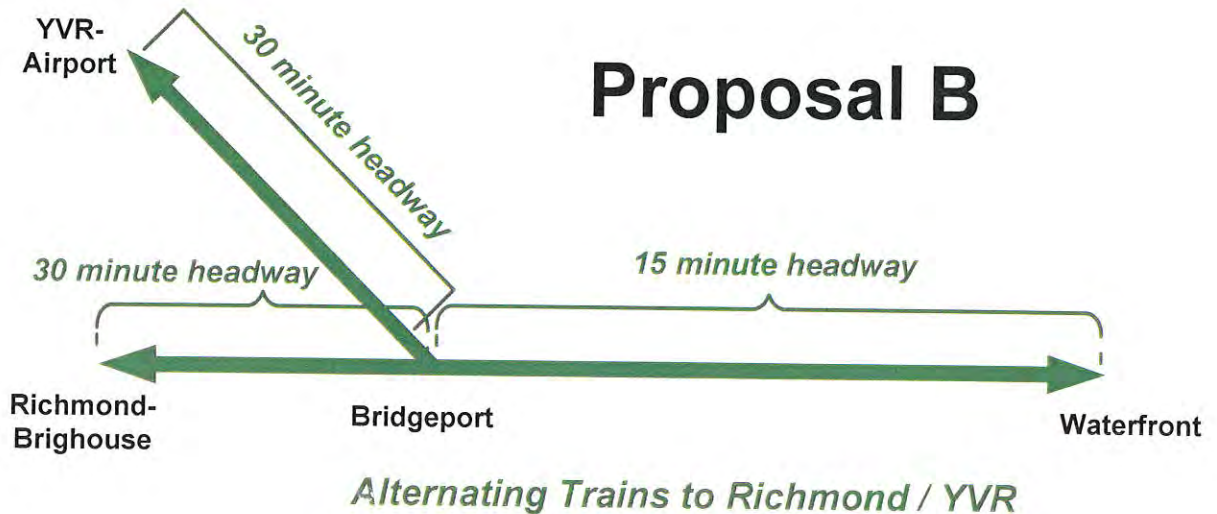
Morning Connection to Richmond-Brighouse

Train Service	Depart BPS	Arrive RBS
Late Night Service*	4:50	4:58
Late Night Service	5:22	5:30
Regular Service	5:50	5:58

* Trip listed above in Outbound Train Service

6.2.2. Proposal B – 15 Minute Headway

This proposed Late Night Train Service provides departures at 15 minute intervals from Waterfront with trains departing for Richmond Brighouse and YVR-Airport in alternation, employing the same service pattern as regular daytime service.



In terms of train kilometrage, the Late Night Trains Service involves 15 round-trips between Waterfront and Richmond-Brighouse performed by the four mainline trains per night.

The proposed train service schedule is presented in the table below:

Table 3: Proposal B – 15 minute headway

Outbound Train Service				
Train Service*	Depart WFS	Depart BPS	Arrive RBS	Arrive YAS
Regular Service	1:05	1:25	-	1:33
Regular Service	1:15	1:35	1:43	-
Late Night Service	1:30	1:50	-	1:58
Late Night Service	1:45	2:05	2:13	-
Late Night Service	2:00	2:20	-	2:28
Late Night Service	2:15	2:35	2:43	-
Late Night Service	2:30	2:50	-	2:58
Late Night Service	2:45	3:05	3:13	-
Late Night Service	3:00	3:20	-	3:28
Late Night Service	3:15	3:35	3:43	-
Late Night Service	3:30	3:50	-	3:58
Late Night Service	3:45	4:05	4:13	-
Late Night Service	4:00	4:20	-	4:28
Late Night Service	4:15	4:35	4:43	-
Late Night Service	4:30	4:50	-	4:58

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Late Night Service	4:45	5:05	5:13	-
Regular Service	4:48	5:08	-	5:16

*Assumes Capstan Station
in Service

Inbound Train Service

Train Service*	Depart RBS	Depart YAS	Depart BPS	Arrive WFS
Regular Service	0:45	-	0:53	1:13
Regular Service	-	0:56	1:03	1:23
Late Night Service	1:15	-	1:23	1:43
Late Night Service	-	1:30	1:38	1:58
Late Night Service	1:45	-	1:53	2:13
Late Night Service	-	2:00	2:08	2:28
Late Night Service	2:15	-	2:23	2:43
Late Night Service	-	2:30	2:38	2:58
Late Night Service	2:45	-	2:53	3:13
Late Night Service	-	3:00	3:08	3:28
Late Night Service	3:15	-	3:23	3:43
Late Night Service	-	3:30	3:38	3:58
Late Night Service	3:45	-	3:53	4:13
Late Night Service	-	4:00	4:08	4:28
Late Night Service	4:15	-	4:23	4:43
Late Night Service	-	4:30	4:38	4:58
Late Night Service	4:45	-	4:53	5:13
Regular Service	5:02	-	5:10	5:30
Regular Service		5:08	5:16	5:36

6.3. Impact on Existing Canada Line systems

6.3.1. Performance Monitoring System



6.3.2. Automatic Train Control System (ATC)

The Guideway Intrusion System (Section 6.3.7) self test will have an effect on the ATC system during extended service hours.

We also perform some required tests and inspections on mission critical ATC equipment when the system is closed

6.3.3. SCADA System

Extending service hours on the Canada Line is not expected to affect the SCADA System.

6.3.4. Communications Systems

Extending service hours on the Canada Line is not expected to affect the communications systems including PA, Platform Information Displays, and voice and data radios.

6.3.5. Tunnel Ventilation System

Extending service hours on the Canada Line is not expected to directly affect the tunnel ventilation systems.

6.3.6. Power Supply System

Extending service hours on the Canada Line is not expected to affect the power supply system.

6.3.7. Guideway Intrusion System (GIDS)



6.4. Maintenance and Repair Requirements

Implementing 24-7 operations is expected to have a significant impact on the maintainability of the system, particularly with respect to the performance of non-revenue system wide communication and train control systems, guideway and track maintenance in mainline ATC territory. Maintenance on Canada Line systems, including Automated Train Control, SCADA and communications systems is currently scheduled to avoid concurrent scheduling with heavy rail service activities. Under this scenario, it will no longer be possible, [REDACTED]

[REDACTED] station facility maintenance will need to be performed in service or during remaining nightly shutdowns whenever possible resulting to an increase of work force requirements [REDACTED]. In both cases, management of the work will require additional resources on the remaining nights.

Any mainline Guideway, track and systems maintenance activities performed on Friday or Saturday night will require alternate service, which will likely result in a disruption to passenger service and the Customer Experience. As such, most, if not all of these activities will be scheduled for the remaining 5 week nights. Currently, these nights are used primarily for system wide Guideway inspections, as well as for larger scale activities that are emergent in nature, or were overrun from, or not able to be scheduled during heavy

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Guideway work nights [REDACTED] Interposing these inspections with heavier activities will require modification to the inspection process in order to avoid scheduled activities and will require an increase in work force on the remaining nights. Safety critical maintenance activities will require alternate service (with associated disruption), and overrun work will no longer be possible.

If the 30 minute headway option is implemented, it is possible to accommodate several different single-tracking service modes without negatively impacting the proposed extended service hours schedule. This will allow some degree of track maintenance activities to be performed, although there will be added complexity in staging and transporting equipment and crews to the worksite, [REDACTED] As such, work performed on these nights is expected to be significantly less efficient.

Under either scenarios, the impact to vehicle maintenance activities is expected to be minimal. Nevertheless, the reduction in activity scheduling flexibility will moderately reduce the efficiency for overall maintenance activity.

6.5. Rolling Stock [REDACTED] cleaning

[REDACTED]

Cleaning and other routine maintenance on trains that were used for night service will require these trains to be cycled out of service during morning launch. This will add complexity [REDACTED]

6.6. Maintenance practices and asset management

In general, the asset management methodology currently in use on the Canada Line will not require modification. However, as outlined in section 7.5, significant changes will be required to the maintenance practises supporting the additional scheduling complexity, and allowing the superposed works requirements.

Currently, maintenance activities are classified as revenue and non-revenue. With the 30% reduction in non-revenue hours, a review will be required of all non-revenue activities in an effort to identify activities that could potentially be performed during light service periods, or in the case of the 30 minute service option, during partial system shutdowns.

6.7. Work that may require scheduled shutdowns

As outlined in section 7.5, all effort will be made to schedule large scale maintenance activities during the 5 remaining weekly system shutdowns. However, conditions observed during the day or the previous night may indicate the need for critical maintenance. Typical activities that may require shutdowns are as follows:

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- Trackwork repairs required to correct a condition that would result in a significant operational impact (ie: rail flaw requiring a slow speed for safe operation).
- Replacement of a guideway component that, based on condition monitoring, presents a significant risk to operation (switch machine, ATC loop splice, etc).
- Performance of safety critical guideway inspections that cannot be otherwise accommodated.

6.8. Work that may be impacted by scheduled shutdowns

Note: TransLink to clarify difference between 6.7 and 6.8.

6.9. Capacity and limitations of infrastructure and maintenance equipment

All proposed modifications to maintenance practices herein are based on the current systems and infrastructure limitations. These include the mainline trackwork layout (which limits alternate service possibilities), as well as systems that require offline maintenance.



6.10. Staffing and Costs



6.11. Maintenance key performance indicators such as mean distance between failures



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6.12. Identify possible opportunities for improvements via automation or capital expenditures

There are many possible modifications to systems and infrastructure which would improve maintainability, reduce risks and cost to maintain. Modifications to the mainline track that would improve the ability to run adequate alternate services concurrently with nightly maintenance are possible, similar with modifications to communications and control systems, which would allow in-service testing and troubleshooting.

7. Staffing Labor Assumptions

7.1. Changes to staffing/shift arrangements

[REDACTED]

[REDACTED] On more detailed review for this within this Stage 3 study we have considered our staffing levels in relation to responding to requests for customer service/assistance and responding to disruption/incidents when operating a 15/30 minute service for the extended service hours on a Saturday and Sunday morning. [REDACTED]

[REDACTED]

[REDACTED]

The above levels of staffing will form part of the stage 4 financial review. [REDACTED]

[REDACTED]

7.2. Collective Agreement Considerations

[REDACTED]



8. Infrastructure/Lifecycle Requirements

8.1. Capital Assets Life Cycle impact analysis

Under the proposed service plans, the increase in vehicle kilometrage per year is expected to be minimal [REDACTED]. In either case, this will result in a similar increase in wear for vehicle, trackwork, and PS&D components, resulting in equivalent schedule compressions for capital asset replacement and refurbishment activities. Similarly, an increase in station use will result in a slight increase annualized life cycle cost. This would result in an estimated [REDACTED] schedule compression to lighting, lifting devices, and station fixtures. Canada Line communications, and train control systems are not expected to see a significant increase in wear, resulting in no expected increase in cost or introduced risks.

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Additionally, required modifications to the inspection and maintenance programs will increase the planning and scheduling complexity capital asset replacement activities, [REDACTED] As such, the anticipated per activity cost of impacted activities is expected to increase.

8.2. Additional Capital Equipment

8.2.1. On train CCTV



8.3. Rolling Stock Life Cycle impact analysis

As outlined in section 11.1, Vehicle lifecycle capital maintenance places are expected to see an activity schedule compression commensurate with the increase in kilometrage.

8.4. RAMS impact analysis



8.5. Supply chain and spare parts impact analysis

The proposed service plan is not expected to have any impact on inventory supply chain or spare parts availability.

8.6. Electrical Load analysis

The proposed Service Plans is not expected to have any impact on Electrical Load as they operate with fewer trains than are operated today.

8.7. Incremental power consumption and cost

The two service plan proposals outlined above results in different power consumption numbers:

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For Proposal A based on a 30 minute headway between Waterfront and Richmond-Brighouse and one shuttle train operating between Bridgeport and YVR-Airport, the incremental revenue kilometrage is estimated at approximately 270 km per night of extended service, or 28,080 km per annum.

For Proposal B based on a 15 minute headway from Waterfront, the incremental revenue kilometrage is estimated at approximately 445 km per night of extended service, or 46,280 km per annum.

The incremental power consumption for stations is assumed to be negligible.

8.8. Asset Handback considerations

[REDACTED]

9. Capital and Related Project Impacts

9.1. Impact of/on upcoming Capital Projects

As described already in Section 6.0, the Canada Line Capacity Enhancement Project will include a change to the current Service Plan which will provide more capacity through a reduced headway between 23:00 to 24:00. Protrans has recommended that extended services should be considered after this change is completed which is envisaged to be end of July 2020.

[REDACTED]

10. Emergency and Incident Response Impacts

10.1. Impact on SMS and emergency response procedures

As part of mobilisation for extended hours, PROTRANS expects to fully review our SMS including how we will maintain high levels of employee and passenger safety and security during extended hours. [REDACTED]

[REDACTED]



Protrans will also need to review and update Operations and maintenance procedures where necessary due to this change.

10.2. Emergency incident management



10.3. Replacement Bus Services

Protrans currently has an Agreement with CMBC for provision for both preplanned and unplanned bus services



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Protrans currently has not entered into any discussions on replacement bus services with CMBC and as these services will involve financial discussion this dialogue can be started with CMBC for the completion of the Stage 4 study.

10.4. Risk Analysis

Protrans has performed the following risk analysis. Note this focused on indentifying the top 20 risks. It is not ranked in order of severity. TransLink is currently allocated as the owner of all the risks as this is a TransLink initiative.



Appendix A – Schedule of Implementation



Appendix B – Option Comparison Matrix





2019 Late Night Service Report

Appendix E

Transit Accessibility Isochrones

SkyTrain Service Typically Ends at 1AM

3 min service during peak hours along peak segments

Expo and Millennium span of service:

5AM - 1AM on Weekdays

6AM - 1AM on Saturdays

7AM - 12AM on Sundays

Canada Line span of service:

5AM - 1AM all week

A map of the Greater Vancouver area showing the three SkyTrain lines: Expo Line (blue), Millennium Line (yellow), and Canada Line (light blue). The map highlights late night service frequencies (indicated by double hash marks ##) for each line. The Expo Line has 10 min service between Vancouver and Burnaby, 5 min service between Burnaby and New Westminster, and 10 min service between New Westminster and Surrey. The Millennium Line has 10 min service between Vancouver and Burnaby, and 10 min service between Burnaby and Port Moody/Coquitlam. The Canada Line has 20 min service between Vancouver and Richmond, and 20 min service between Richmond and YVR. A legend in the top right corner defines the line colors and the late night frequency symbol.

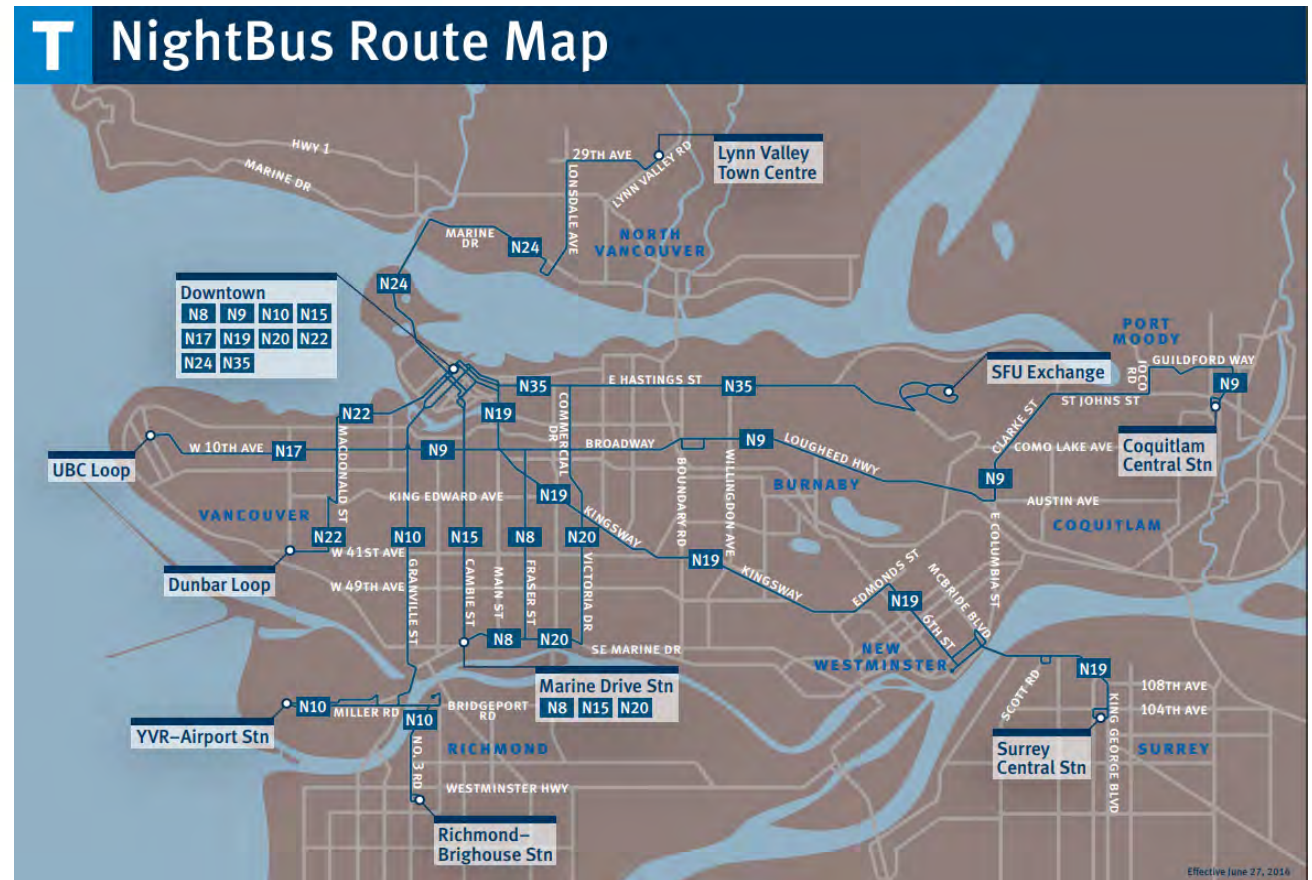
Line	Segment	Late Night Frequency
Expo Line	Vancouver to Burnaby	10 min
Expo Line	Burnaby to New Westminster	5 min
Expo Line	New Westminster to Surrey	10 min
Millennium Line	Vancouver to Burnaby	10 min
Millennium Line	Burnaby to Port Moody/Coquitlam	10 min
Canada Line	Vancouver to Richmond	20 min
Canada Line	Richmond to YVR	20 min

TRANS LINK

2

NightBus Network Provides Overnight Service along Key Corridors

- Service runs every 30 minutes on most lines
- Trips start at 1:30 a.m.
- Last trip on most routes departs Downtown Vancouver at 3:30 AM
- Some services resemble day time routings some others have alignments that are only operated at night
- Entertainment district is a focal point

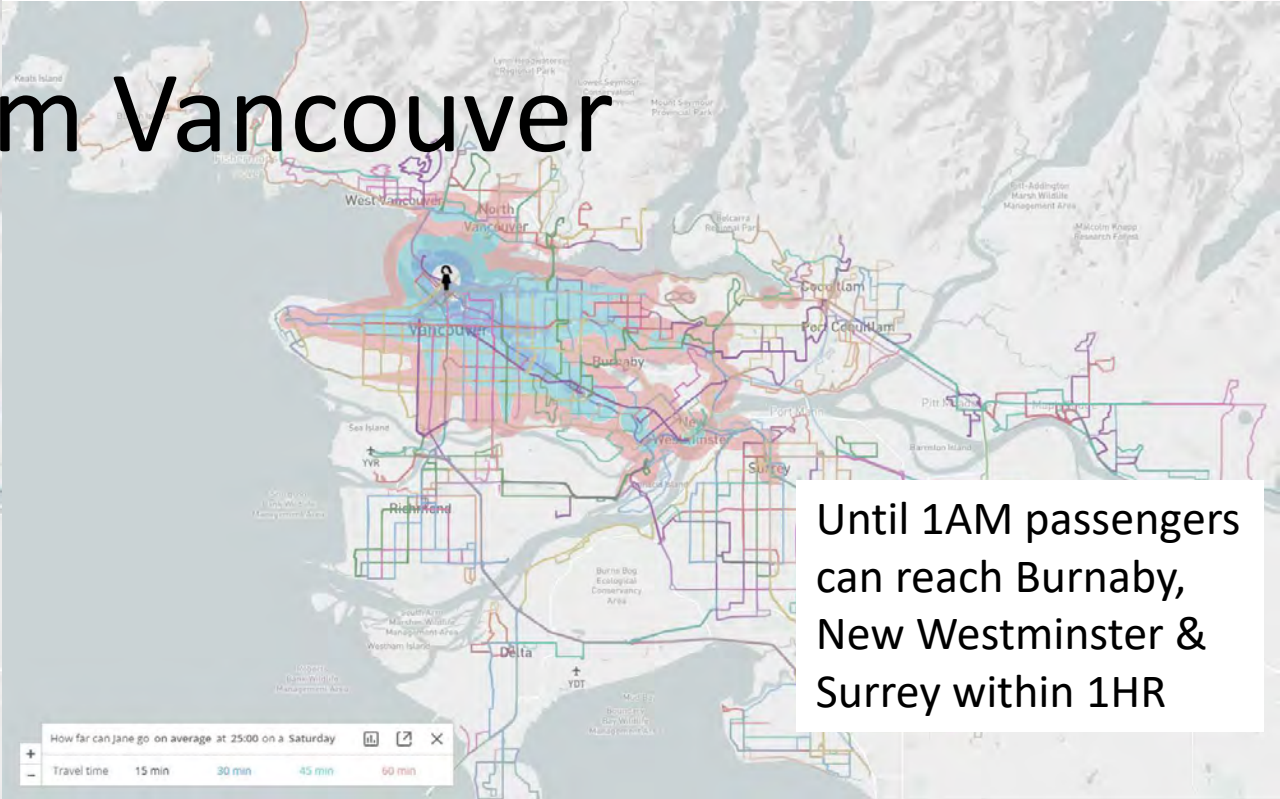
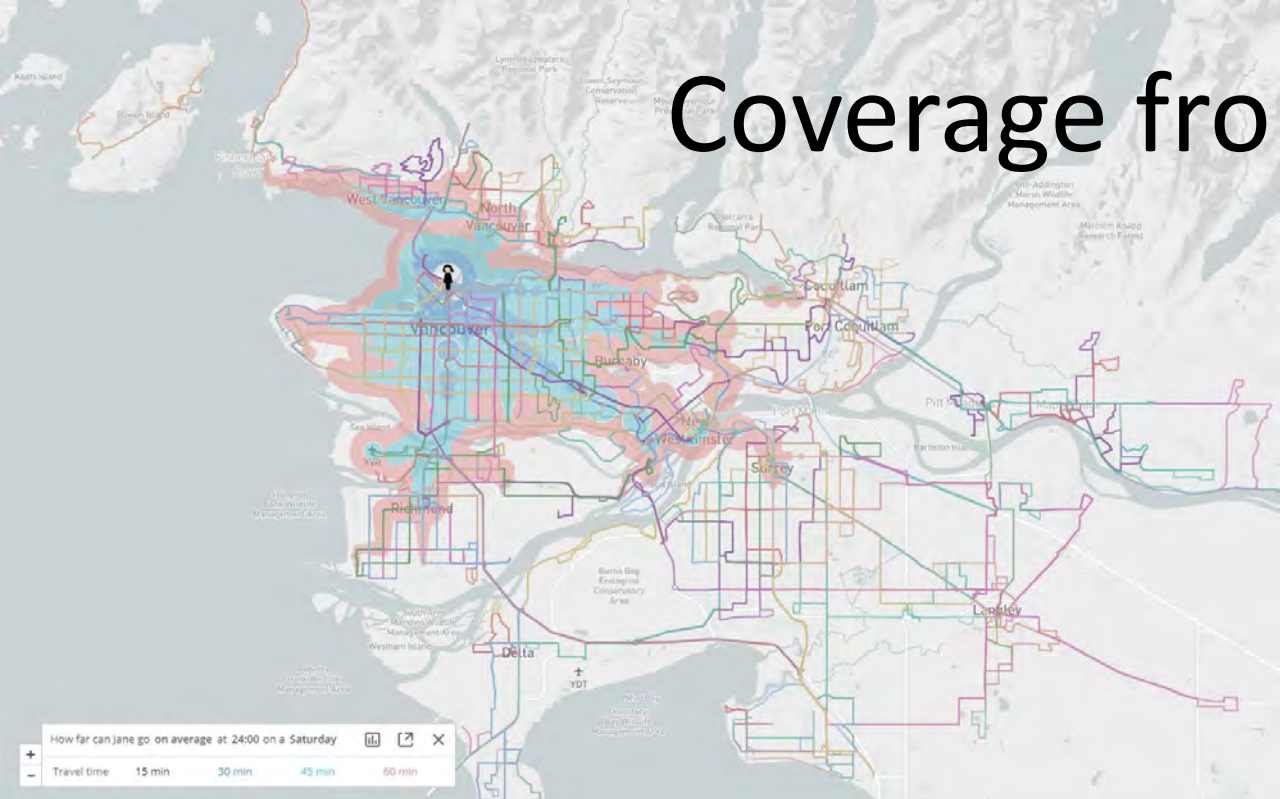




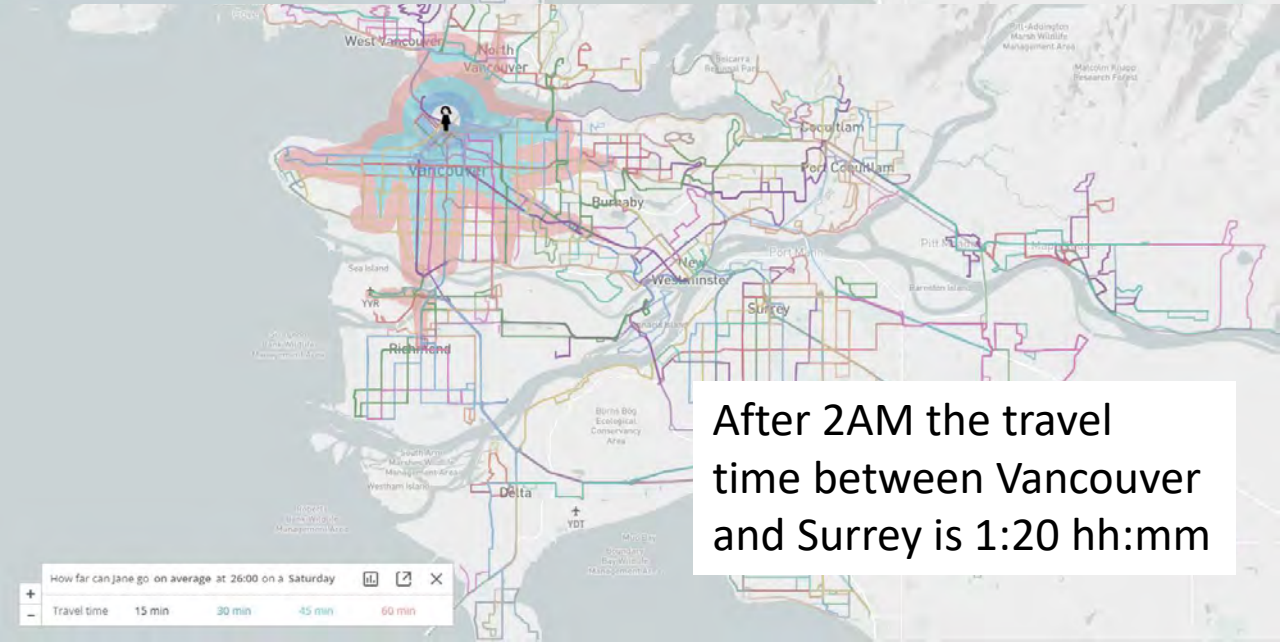
How Far Can I go....

Defining Coverage Using Isochrones

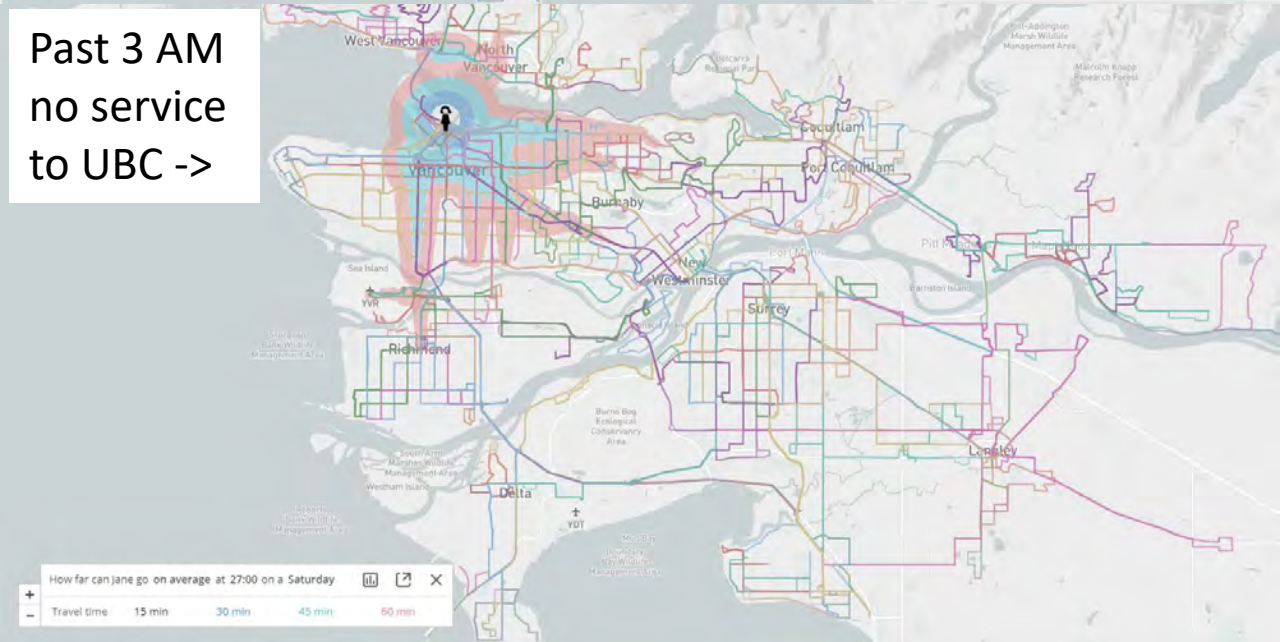
Coverage from Vancouver



Until 1AM passengers can reach Burnaby, New Westminister & Surrey within 1HR

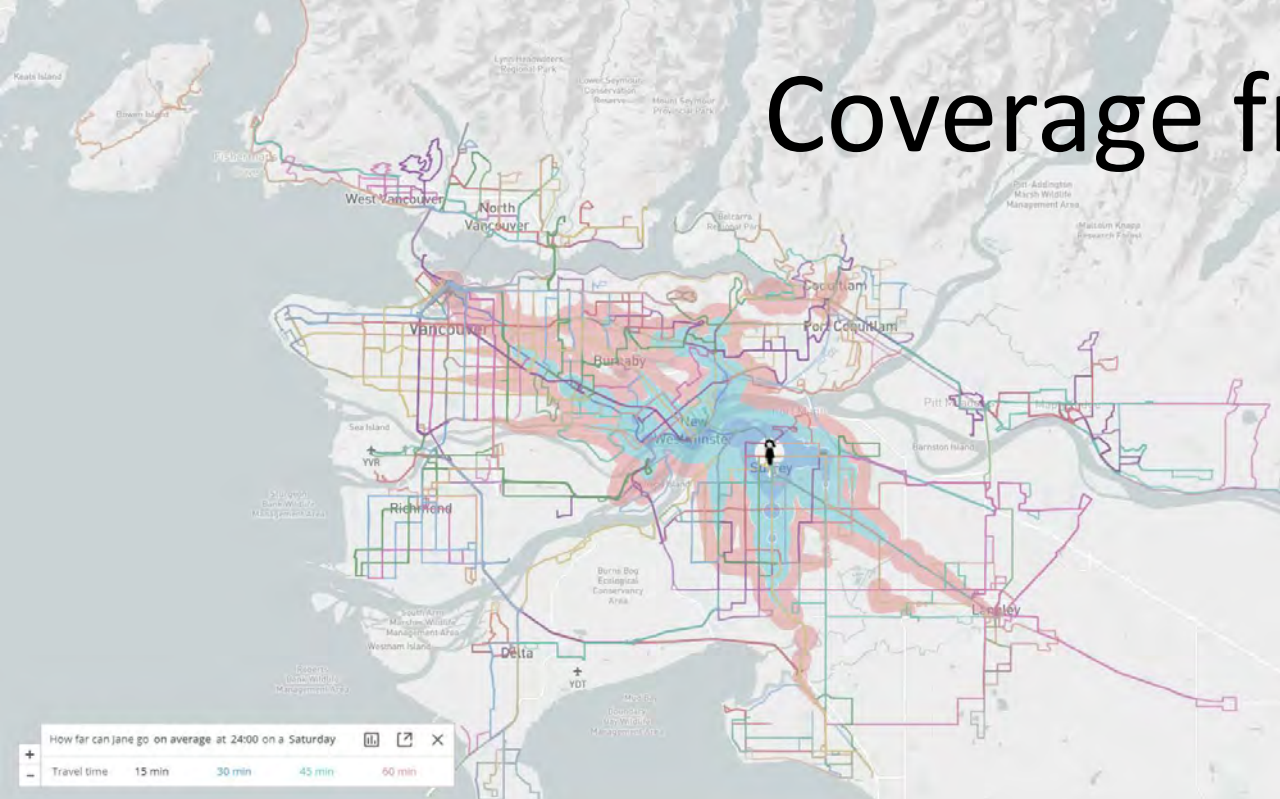


After 2AM the travel time between Vancouver and Surrey is 1:20 hh:mm

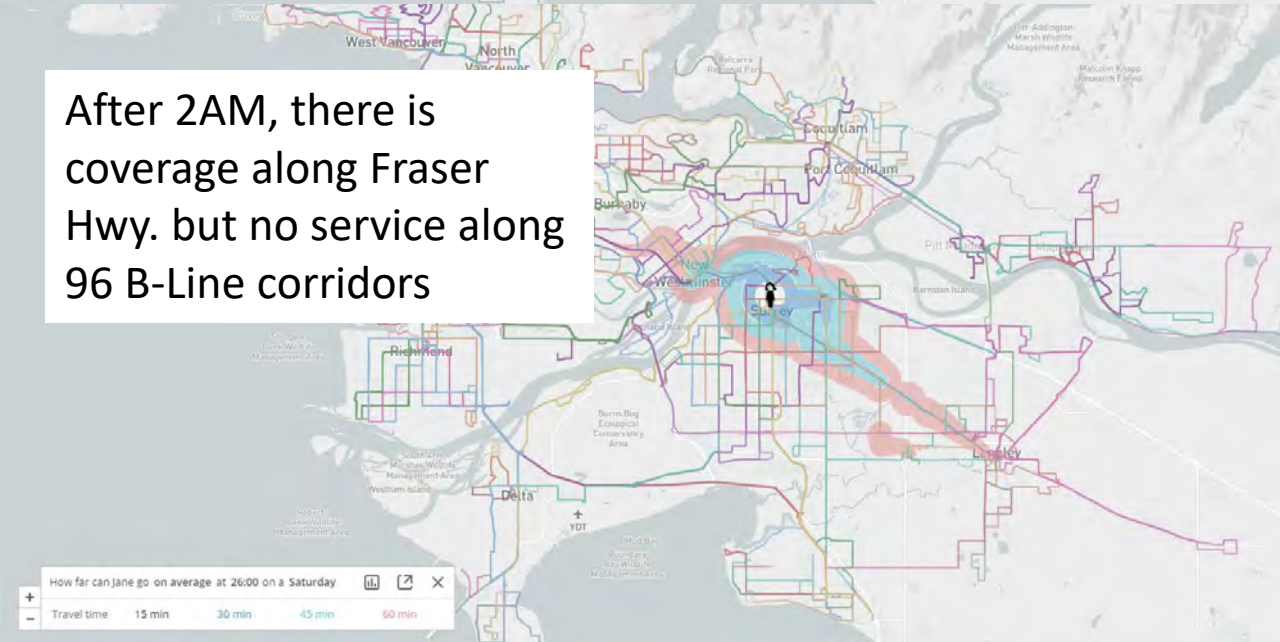


Past 3 AM no service to UBC ->

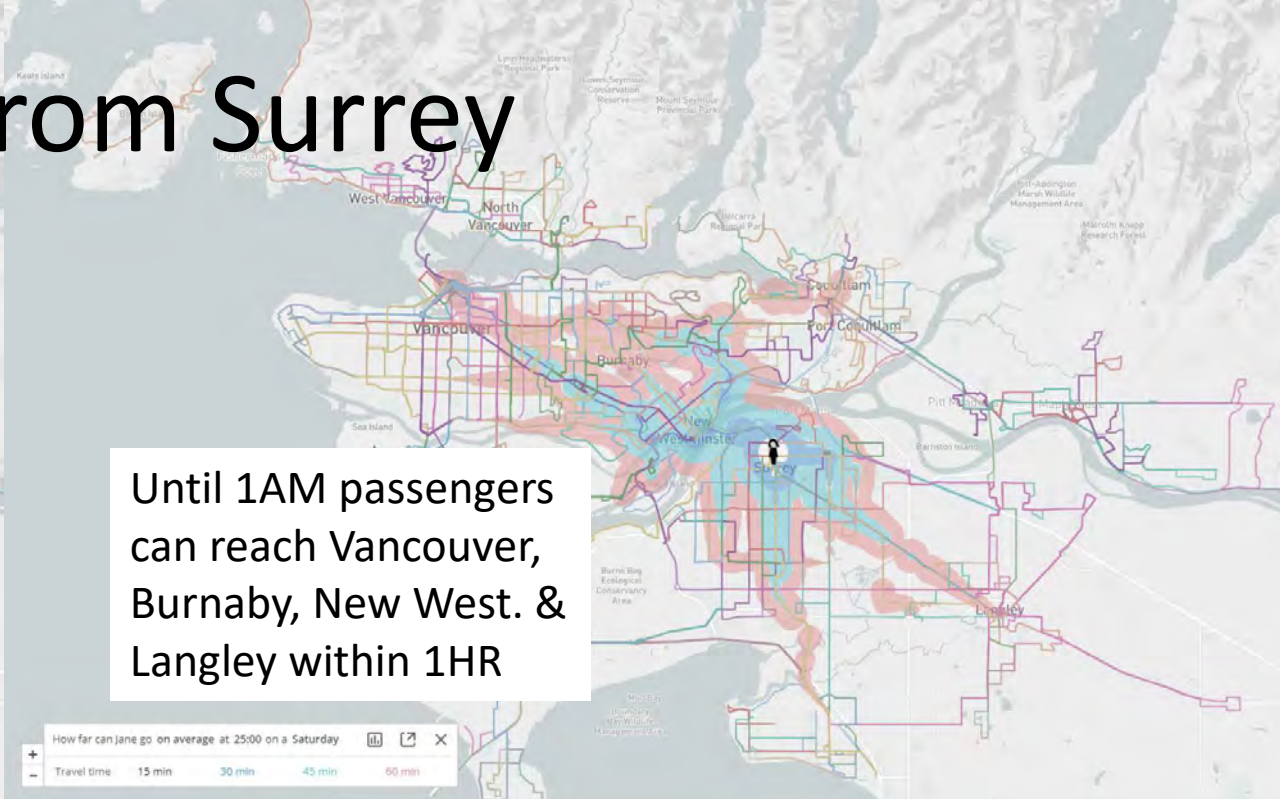
Coverage from Surrey



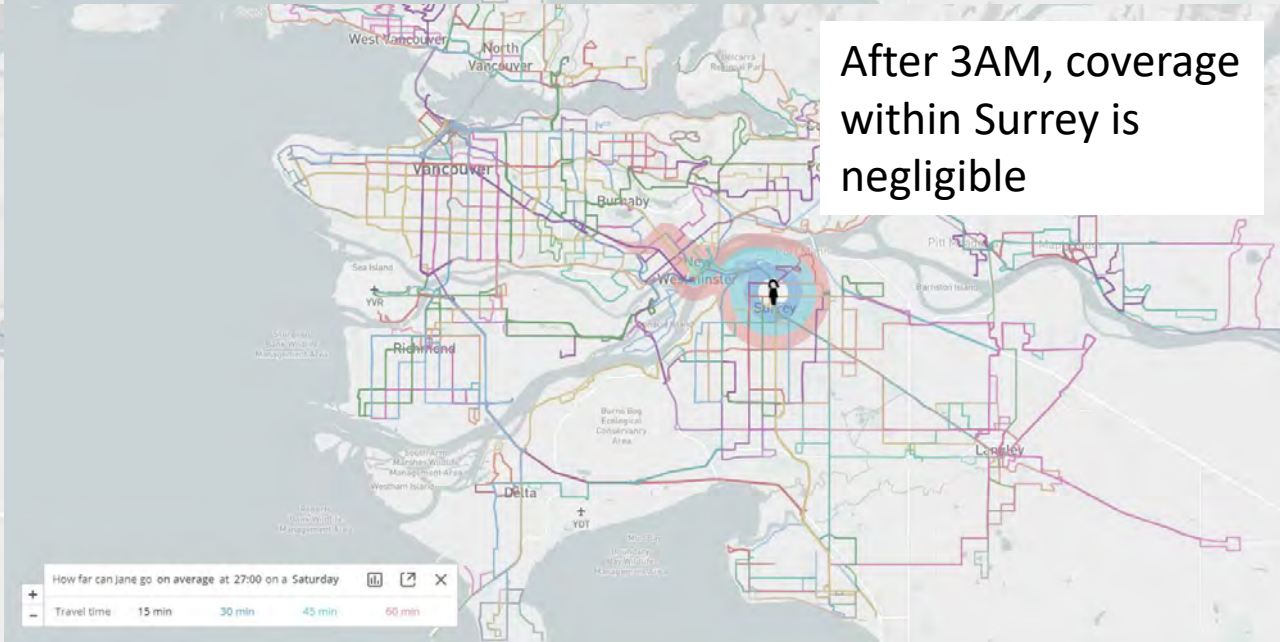
After 2AM, there is coverage along Fraser Hwy. but no service along 96 B-Line corridors



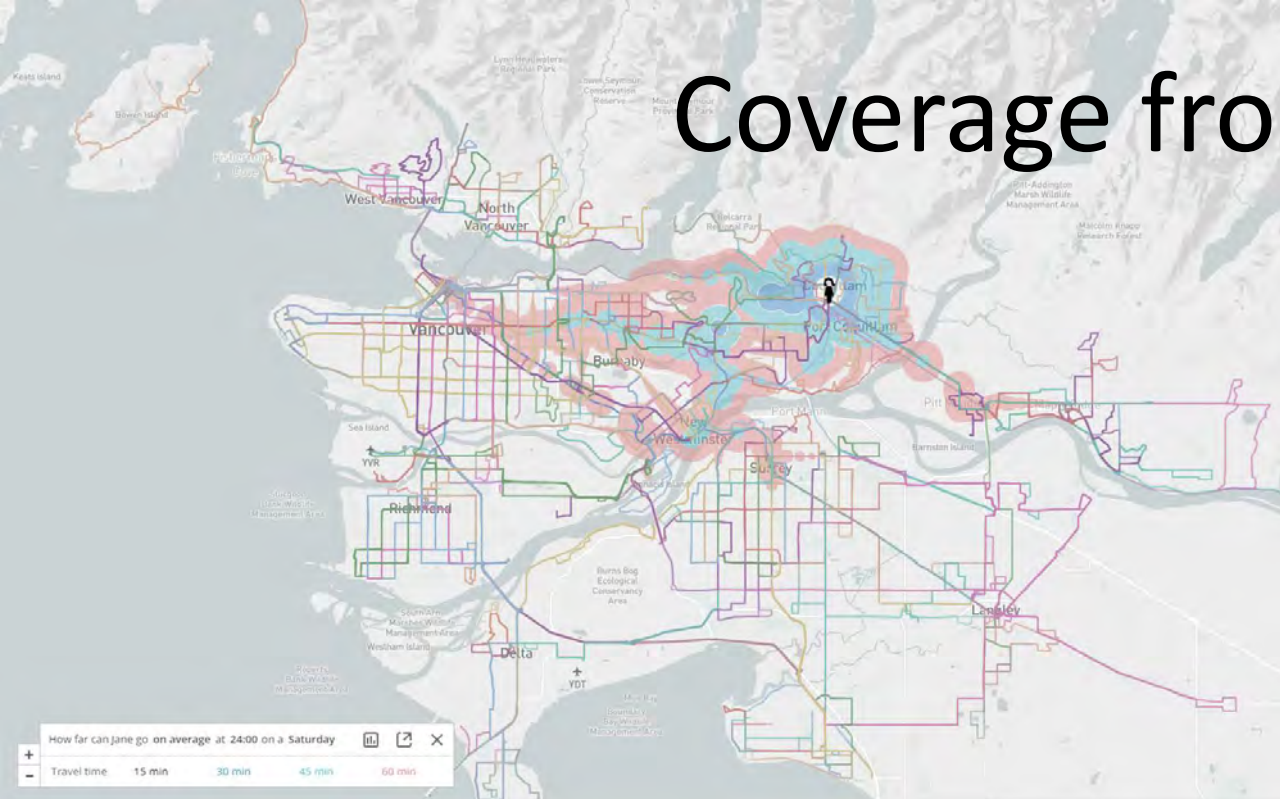
Until 1AM passengers can reach Vancouver, Burnaby, New West. & Langley within 1HR



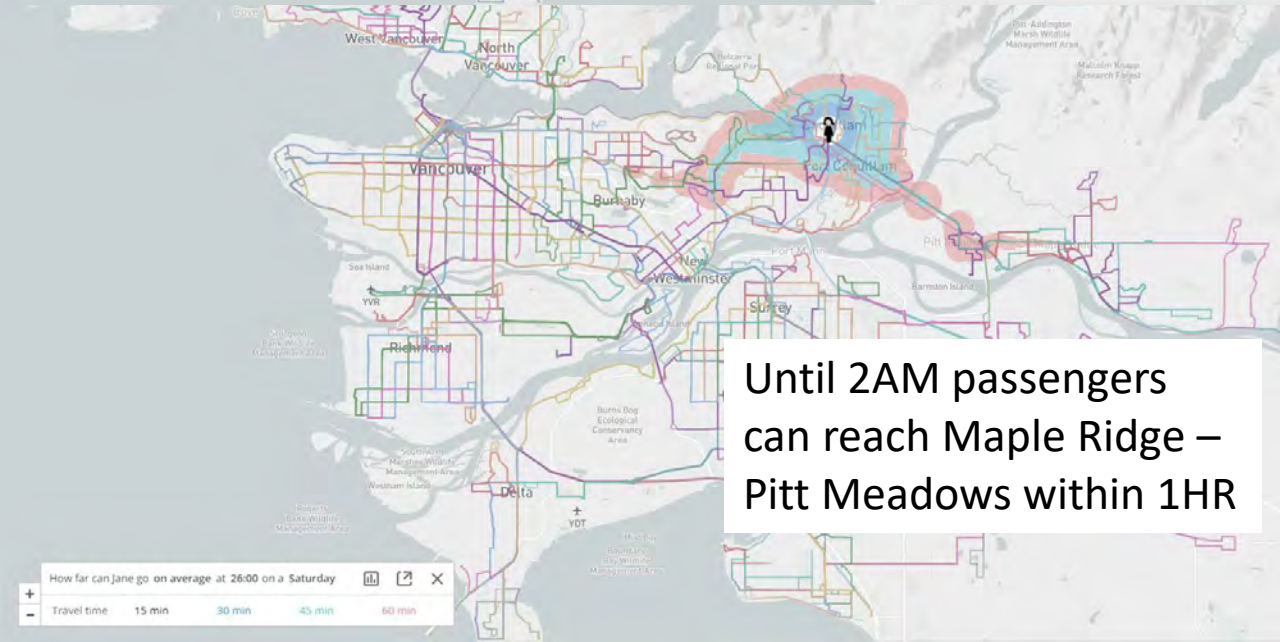
After 3AM, coverage within Surrey is negligible



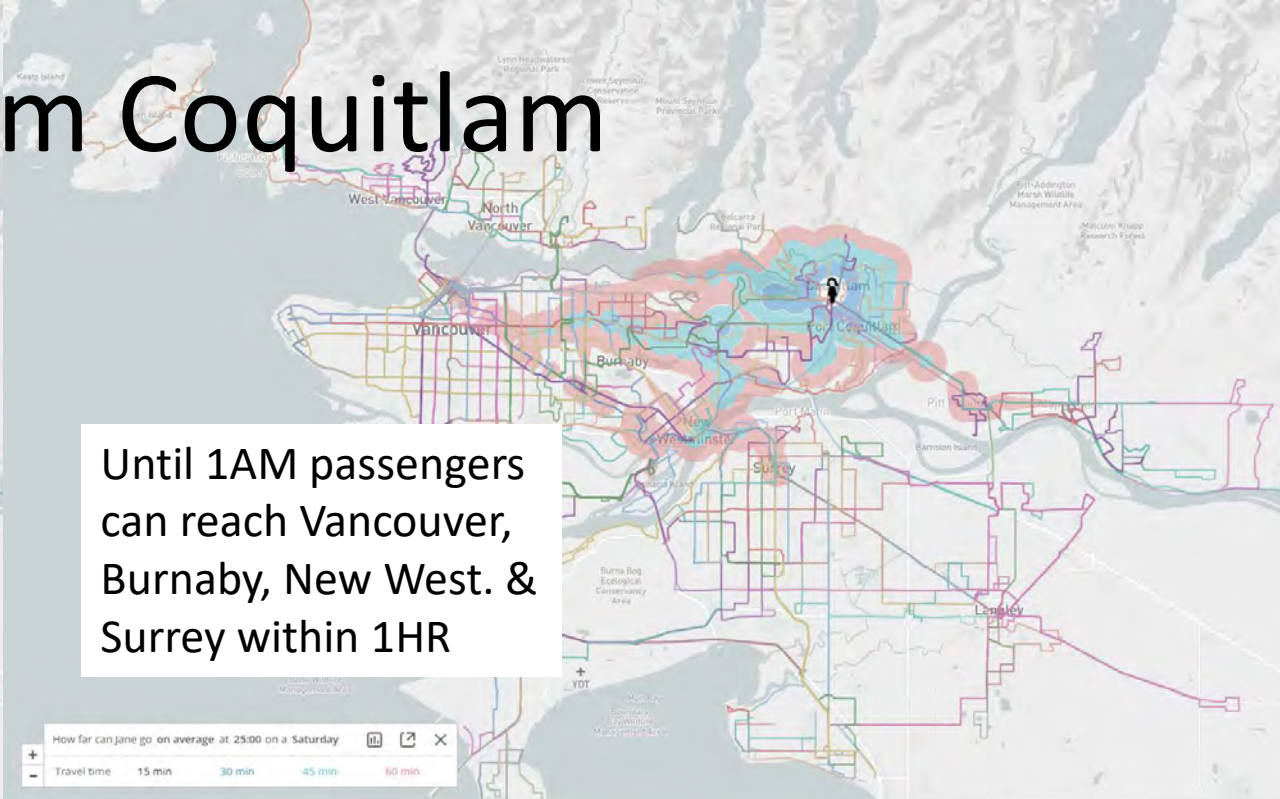
Coverage from Coquitlam



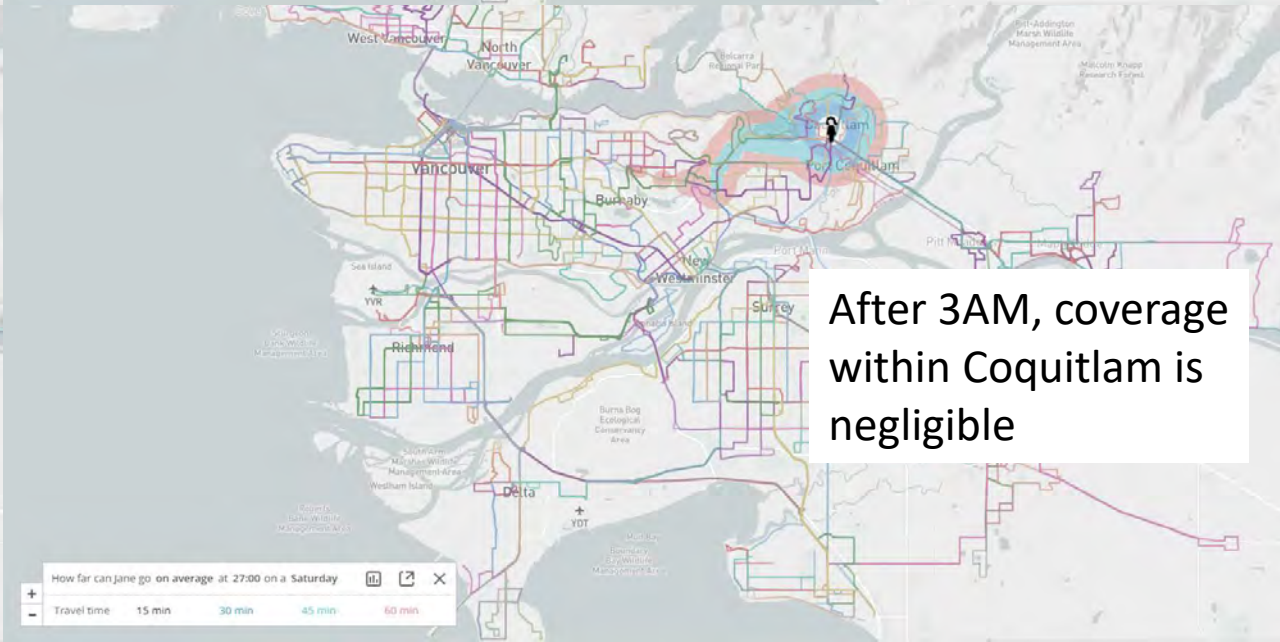
Until 1AM passengers can reach Vancouver, Burnaby, New West. & Surrey within 1HR



Until 2AM passengers can reach Maple Ridge – Pitt Meadows within 1HR



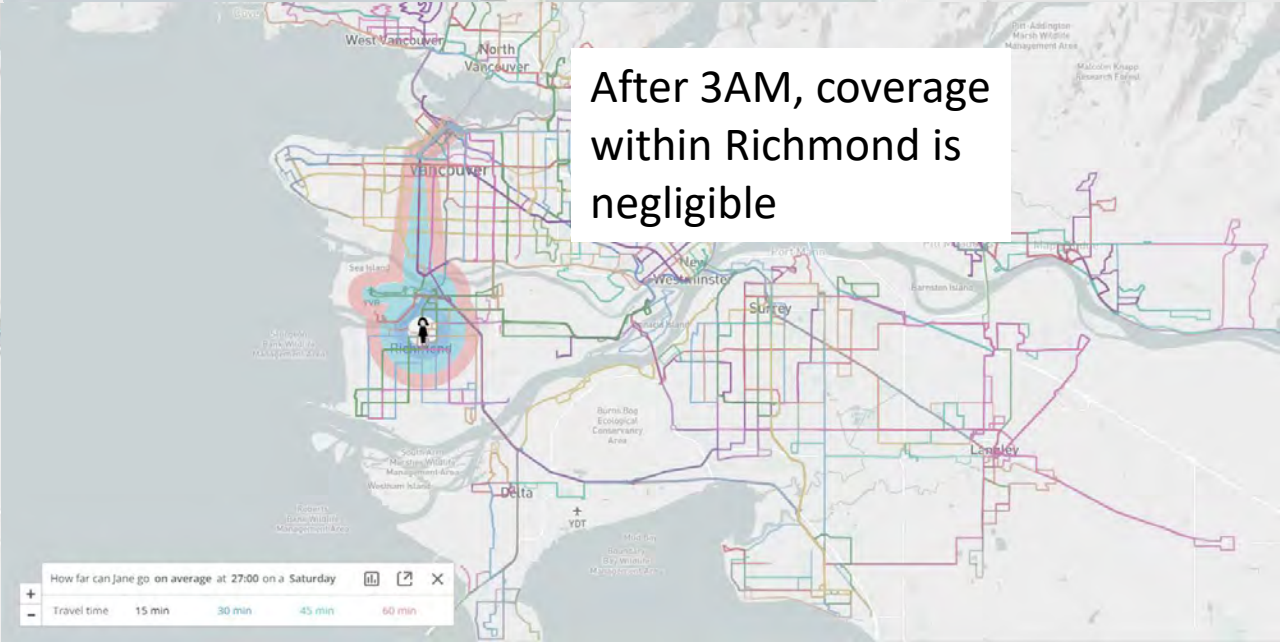
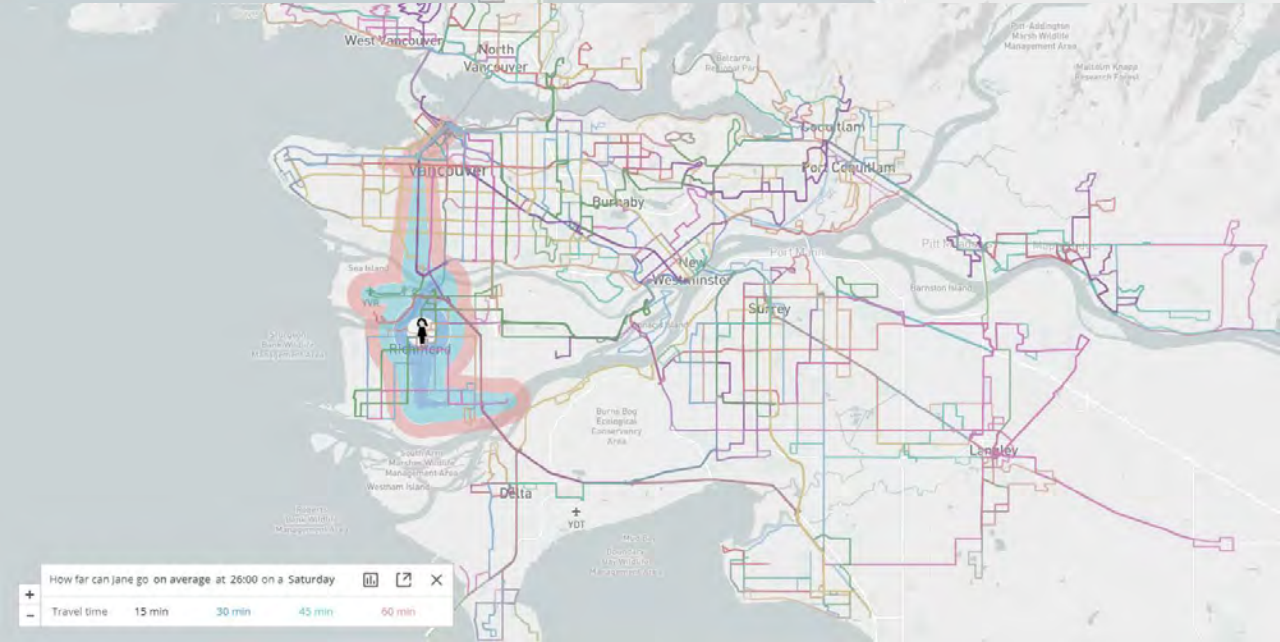
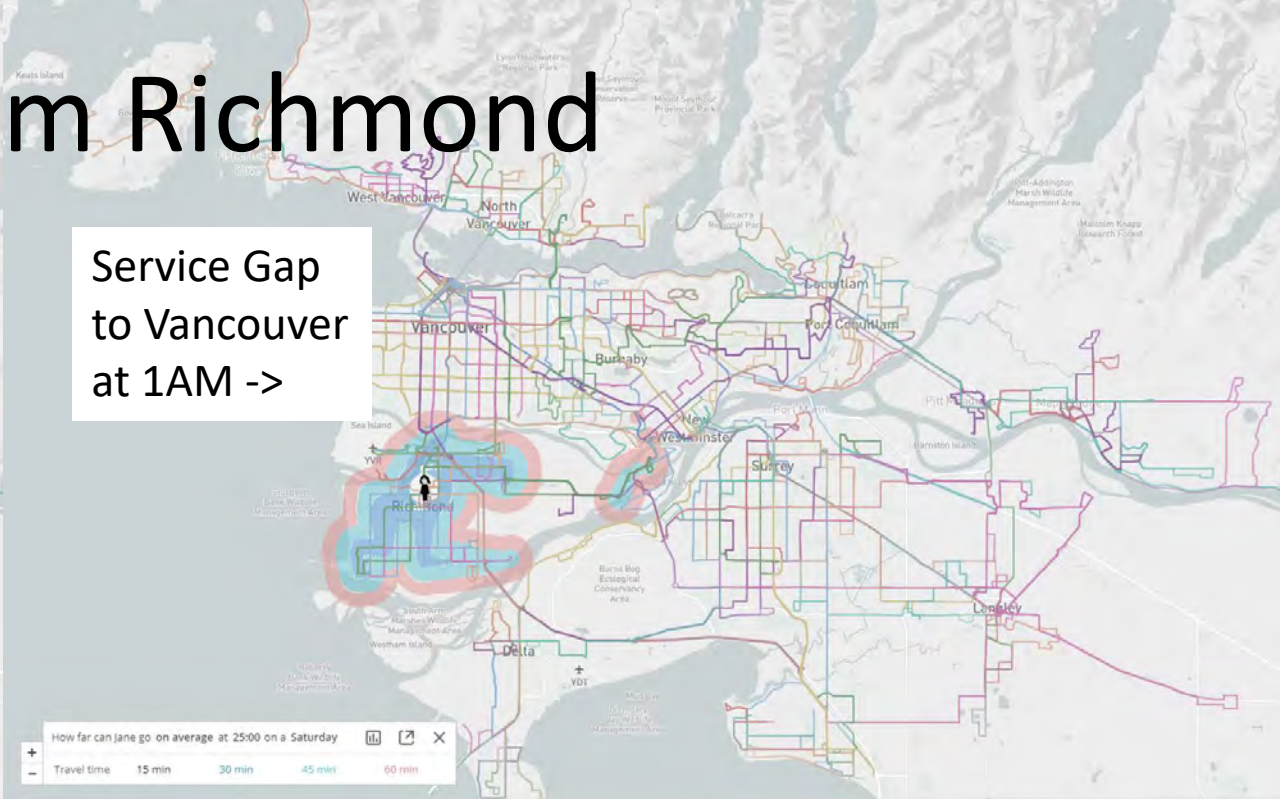
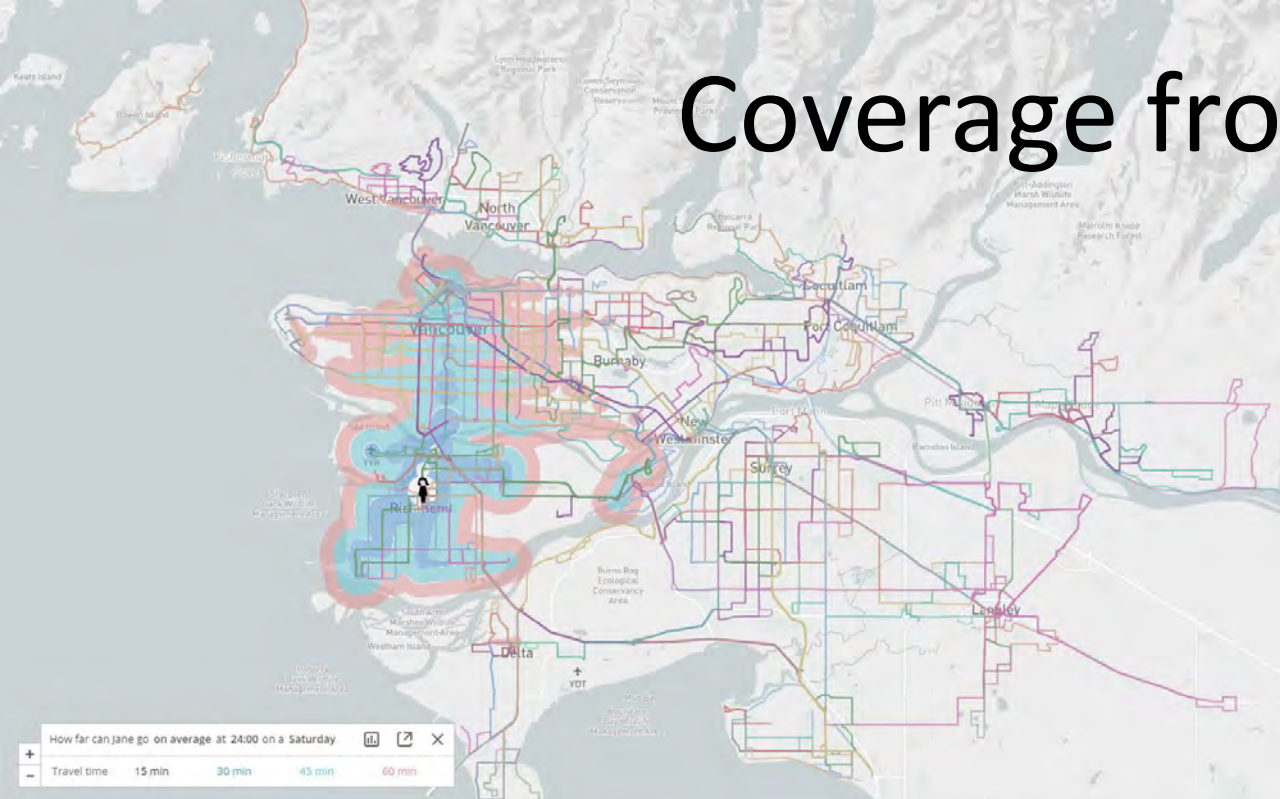
After 3AM, coverage within Coquitlam is negligible



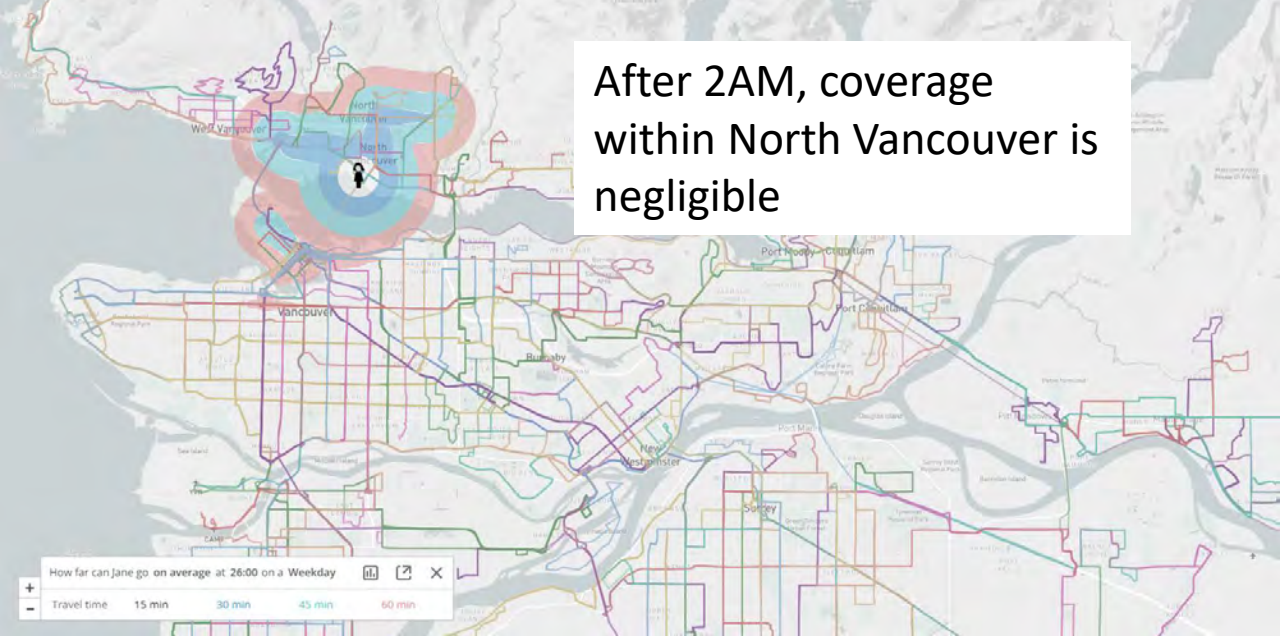
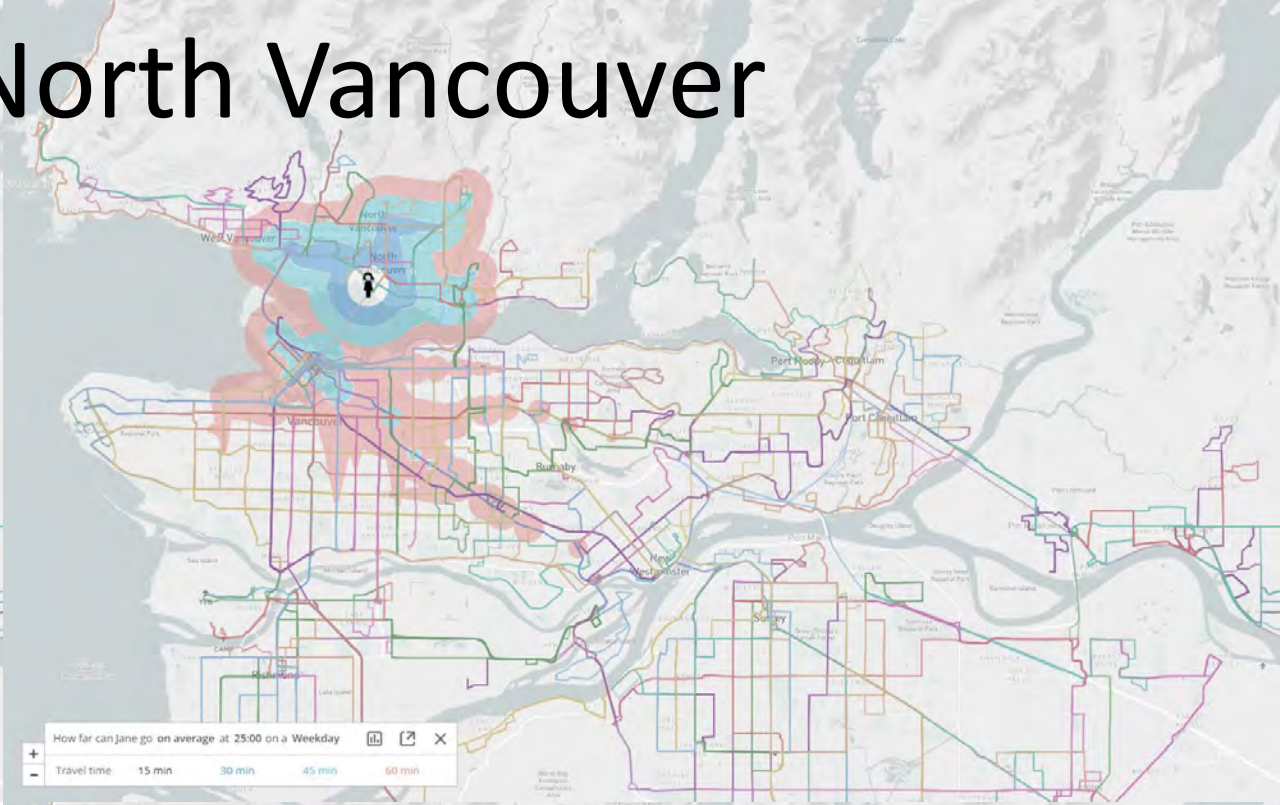
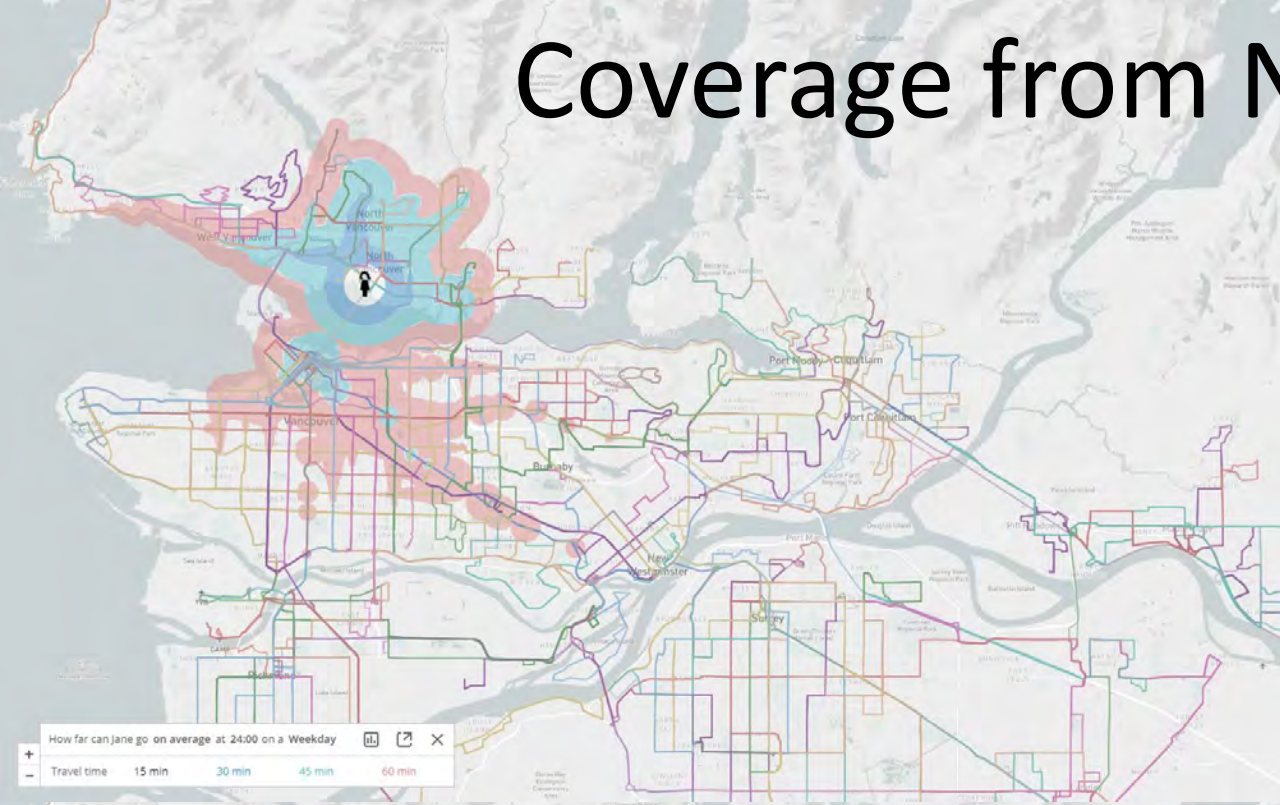
Coverage from Richmond

Service Gap
to Vancouver
at 1AM ->

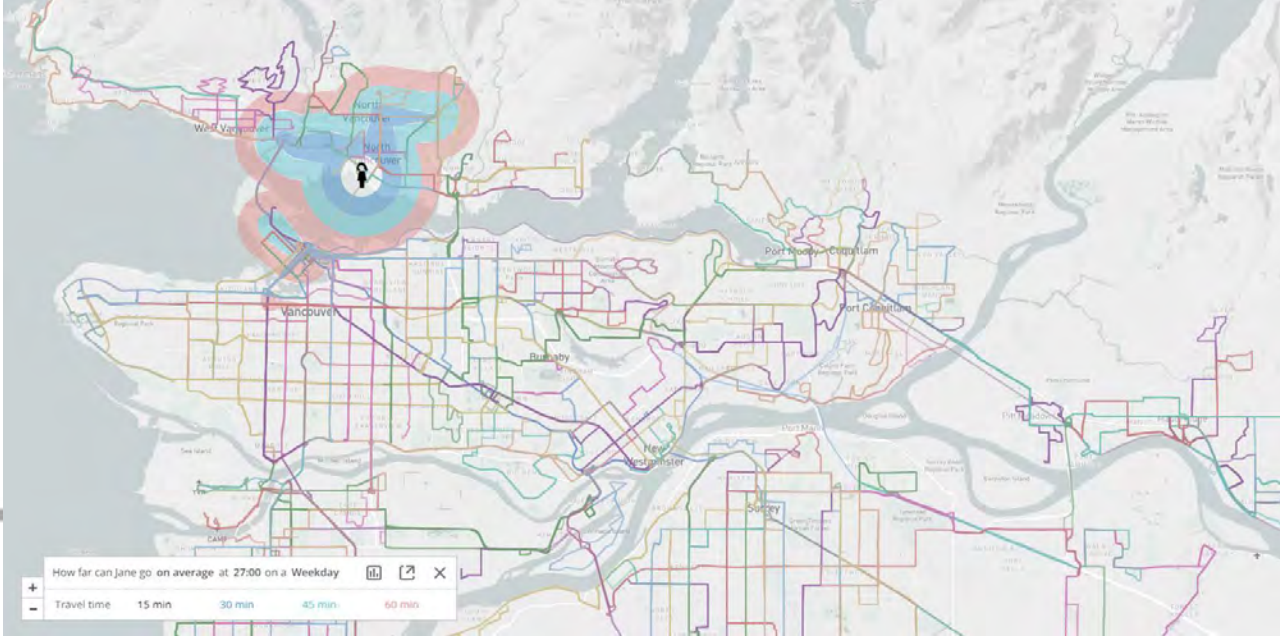
After 3AM, coverage
within Richmond is
negligible



Coverage from North Vancouver



After 2AM, coverage within North Vancouver is negligible



Key Takeaways

- Most areas of the region have **attractive coverage until 1AM** (passengers can reach several neighboring municipalities within 1HR)
- Entertainment district and Vancouver have the highest level of service
- Some markets experience service gaps between last SkyTrain and first NightBus including **YVR** and **UBC**. NightBus investments have been secured to address this issue.
- Most SkyTrain and B-Line corridors have overnight services with the exception of the **96 B-Line**. NightBus investments have been secured to address this issue.



Alignment, Stopping Patterns and Travel Times

Contrasting regular lines with NightBus









2019 Late Night Service Report




Appendix F

Evaluation of Bus Alternatives

Objective 1 - Maximize Usefulness to Customer

	Five Hwy Express Lines	Six Stn to Stn Lines	24hr B-Line Service plus Six Stn to Stn
			
Customer Benefits	Can be implemented all week Attractive for entertainment and other markets		
	 Does not expand coverage	 Does not expand coverage	 Expands coverage

Objective 2 – Maximize Attractive Features like Speed and Legibility




	Five Hwy Express Lines	Six Stn to Stn Lines	24hr B-Line Service plus Six Stn to Stn
			
Attractive Service Design	<p>Not legible</p> <p>✓</p> <p>Faster than Stn-to Stn Bus</p>	<p>More legible than Hwy-Express but not as legible as SkyTrain</p> <p>✓</p> <p>Slower than Hwy Express. B-Lines reduce transfer times.</p>	<p>More legible than Hwy-Express but not as legible as SkyTrain</p> <p>✓✓</p> <p>Slower than Hwy Express. B-Lines reduce transfer times.</p>

Objective 3 – Minimize Financial Impacts

	Five Hwy Express Lines	Six Stn to Stn Lines	24hr B-Line Service plus Six Stn to Stn
			
Financial Impact (Operating Costs)	<p>\$</p> <p>\$2.7M/year</p>	<p>\$\$</p> <p>\$4.4M/year</p>	<p>\$\$\$</p> <p>\$11.1M/year</p>

*Assumes service is operated seven nights per week, 30 min frequency
Current (2018) NightBus operating cost is approx. \$3.6M/year*

Objective 4 – Minimize community impacts and increase perceived security

Five Hwy Express Lines	Six Stn to Stn Lines	24hr B-Line Service plus Six Stn to Stn	
			
Social and Security	Reduced likelihood of noise complaints since Bus Services would operate along 24hr truck-routes		
	<div>✓</div> <div>✓</div> <div>✓</div> Reduced perception of security, primarily due to absence of CPTED features at bus stops		

CPTED = Crime Prevention Through Environmental Design

Objective 5 – Implement in a Reasonable Timeframe

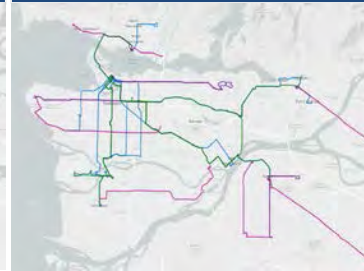
Five Hwy
Express Lines



Six Stn to Stn
Lines



24hr B-Line
Service plus
Six Stn to Stn



Delivera-
bility

These options do not require negotiation of collective agreements

Does not require new infrastructure or new equipment



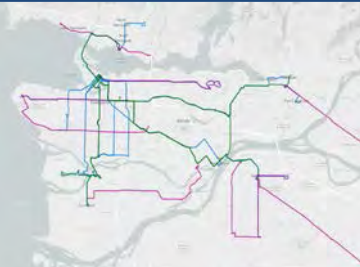





Some bus depots are already open 24 hours, no need for special vehicles



B-Lines require branded buses

Objective 6 - Maximize Ridership

	Five Hwy Express Lines	Six Stn to Stn Lines	24hr B-Line Service plus Six Stn to Stn
			
Estimated Additional Annual Ridership	 0.6M/year	 1.0M/year	 2.4M/year

*Assumes service is operated seven nights per week
2018 Systemwide Annual Boardings were 407 Million*



2019 Late Night Service Report

Appendix G

NightBus Hub

TRANSLINK AFTER DARK

NightBus District

- Thanks to a successful pilot project throughout the Summer of 2018 – the NightBus District is now part of regular service
- All 10 NightBus routes now start their routes at our well-lit NightBus District in the heart of downtown, at the corner of West Georgia at Granville Street
- Makes it easier for customers to find a reliable, after-hours ride home from Downtown Vancouver





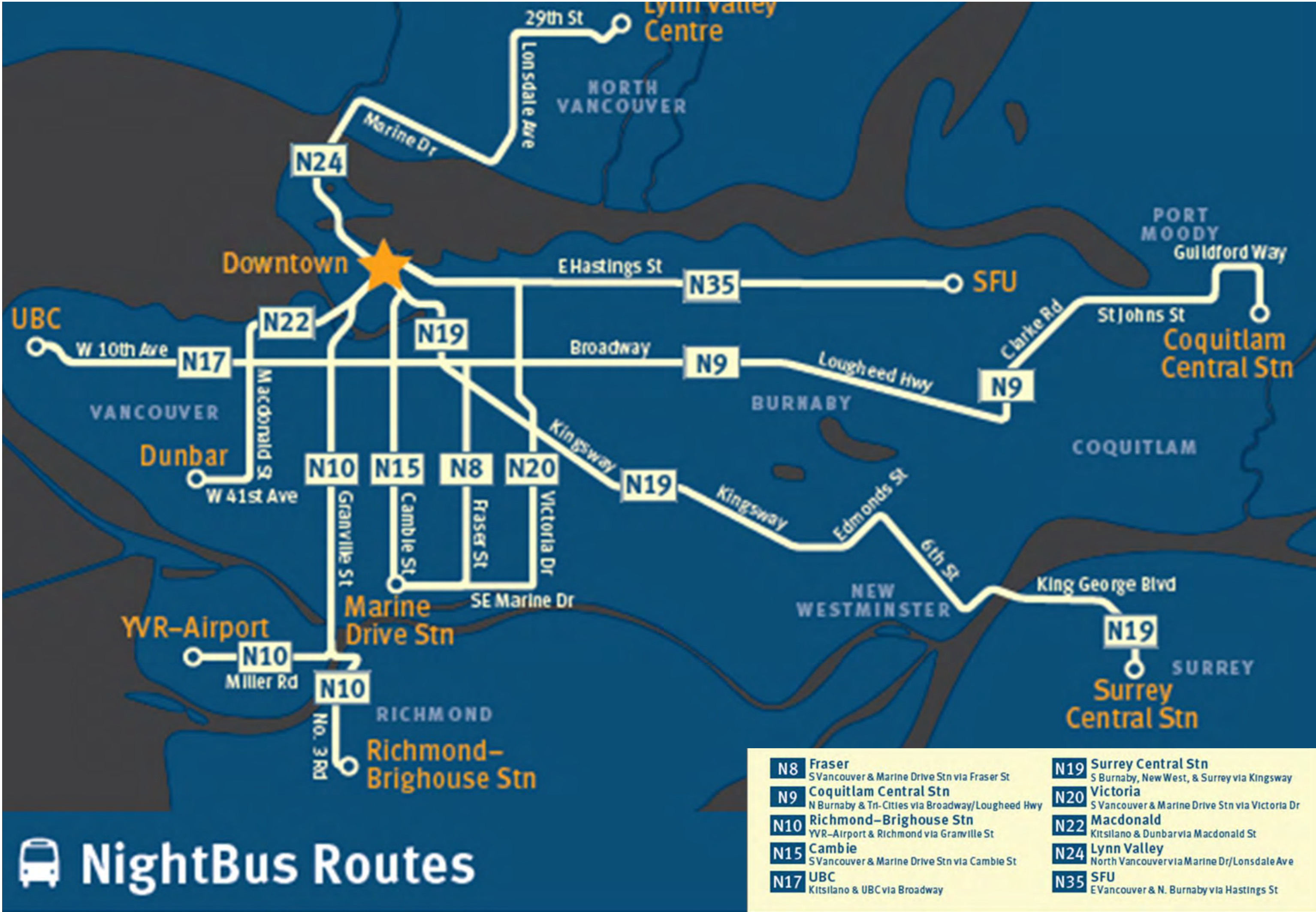
Our Partnership delivered:

- Extensive marketing campaign
- Earned media attention
- Positive social media feedback



Together all the way





20%



**Increase in NightBus ridership from summer 2017-2018*



Together all the way

