Brightstar Canada

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Nova Scotia Department of Business
Last Mile Strategy

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Disclaimer:

The material contained in this Report is current and accurate as of the date of submission. Business analysis is ongoing with private sector service providers, and this analysis may lead to new and/or updated information. The work reported in this document is based on independent analysis conducted by Brightstar and its consultants. Any public reference to specific providers or carriers must be limited to generic descriptions such as Service Provider A or Service Provider B.

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Executive Summary

Significant parts of rural Nova Scotia are either unserved or under-served with respect to high-speed Internet services. This means businesses, citizens, health workers, and education providers lack access to the benefits of utilizing the Internet for work or pleasure. The Province of Nova Scotia recognizes access to the Internet is essential to the province's economic and social well-being. Enhancing a connected Nova Scotia, especially in the unserved and under-served communities, will help bring sustainable services to all parts of the Province and help grow the local and provincial economies.

Part of the vision for a connected Nova Scotia includes the expansion and upgrade of the networks needed to deliver broadband Internet services. This includes the middle mile and last mile networking equipment. *Last mile* is the final leg of a telecommunications network that delivers Internet services to end-users. It connects the *middle mile*—normally from a Point of Presence (POP) location—to the users in that geographic area. The last mile technology can be delivered by a wired, wireless, or satellite solution, and the actual distance covered may be anything from a few metres to many miles, depending on the proximity of the end user to the middle mile POP, as well as on the technology being used.

A middle mile strategy, which includes infrastructure performance goals, a reference design, and financial analysis, was released in March, 2018. One of the key findings of the middle mile strategy was that a last mile strategy was required, since the business case for the expanded middle mile infrastructure required last mile revenue in order to be financially viable. The current document, *Nova Scotia Department of Business Last Mile Strategy*, is complementary to that of the middle mile strategy.

Brightstar's development process for the last mile strategy included consulting with Internet Service Providers (ISP), mapping existing ISP last mile infrastructure, creating reference designs for wireless and wireline last mile networks to address service gaps, conducting the business case analysis, and creating a satellite strategy to ensure an option exists for customers who may not have access to the expanded last mile infrastructure.

The last mile infrastructure that is developed should support **Internet service speeds of at least up to 50 Mbps download and 10 Mbps upload for wireline last mile services; and at least up to 25 Mbps download for wireless last mile and satellite services**. The 50 Mbps target is consistent with recent CRTC goals for connectivity in Canada.[1] A 25 Mbps download service is appropriate for Internet browsing, and video streaming purposes for a small household. The 50 Mbps target is appropriate for heavier use and can support multiple connected devices simultaneously within a household or business. These last mile speed targets are tabulated below.

[1] Telecom Regulatory Policy CRTC 2016-496

Service Type	Minimum Speed (Mbps)
Wireline (e.g., Fibre and Hybrid Fibre-Coax)	Up to 50 Mbps down/10 Mbps up
Fixed Wireless Service	Up to 25 Mbps down/5 Mbps up
Satellite Service	Up to 25 Mbps down/1 Mbps up

In terms of coverage, the **last mile infrastructure should cover at least 95 per cent of populated property locations outside of urban Sydney and urban Halifax with a wireline or wireless service**. The majority of the balance of populated rural property locations could then be serviced through satellite technologies. Due to the expense of the last mile infrastructure, the timeline for its usefulness must extend out several years. For the last mile infrastructure, the team is recommending that the **infrastructure electronics selected for design should be suitable to meet 5-year demand projections**. Proponents should, however, be asked to indicate how they will address scalability to help ensure continued growth in the quality of the service.

The Brightstar team has developed a reference wireless and wireline design for the expanded last mile infrastructure that can meet the infrastructure performance goals. The reference design was developed so as to estimate the costs of the expanded infrastructure and to serve as a reference for evaluation of potential applications for funding from the service providers. The reference design for the last mile infrastructure will very likely not be the actual design to be implemented by the service provider(s), since there are many possible design solutions. For example, the technologies proposed for implementation by the service providers are not likely to align perfectly with those projected by the team to be built out in all areas where there are service gaps. The reference design is based on Internet demand maps generated from Property Valuation Services Corporation (PVSC) data and consider existing last mile infrastructure supply, using confidential service provider input.

Using 5-year demand projections derived from the PVSC property locations and published Internet usage forecasts, the wireless reference design shows a need for approximately 55 site locations. Similarly, the wireline reference design shows a need for approximately 8,900 km of last-mile fibre. The variation in infrastructure requirements for tower sites and last mile fibre exists because a trade-off exists between cost and wireless and wireline coverage.

If all partners contribute, the expected benefit is that approximately 72,000 under-served households will have access to broadband speeds consistent with the infrastructure performance goals.

Even with this expanded infrastructure, there will remain some remote areas of the province that may still not have access to high-speed Internet services. To enable service for a majority of these users, Brightstar is recommending that Nova Scotia issue an RFP (Request for Proposal) for satellite services that are capable of achieving the satellite broadband speed targets of at least 25 Mbps download and 1 Mbps upload.

It is projected that between roughly 15,000 and 24,000 households could benefit from a satellite service in areas where suitable wireline or wireless services will be unavailable from the expanded broadband infrastructure.

The estimated total last mile infrastructure cost to implement the 5-year reference design is about $250–300 million. The annual last mile operating costs are estimated to be about $8–10 million.

When combined with the middle mile business case for the 5-year design, the total infrastructure cost is estimated to be about $300–500 million, while annual operating expenses are estimated to be about $10–15 million.

Recommendations:

- Coverage:
  - At least 95 per cent of populated property locations outside of urban Sydney and urban Halifax
- Speed targets:
  - Wired: 50 Mbps download/10bps upload
  - Wireless: 25 Mbps download/5 Mbps upload
- Timeline:
  - Build: 2–5 years to complete the build
  - Infrastructure: electronics built to meet 5-year network demand projections, with requirement that they can evolve to continue to meet future demands
- Finances:
  - Government and its partners provide investment as required to alleviate market failure and create the business case for private sector to proceed
  - Subsidies provided should support capital costs and not be provided for ongoing operating expenses
- Process:
  - Recommend competitive process for all services, inclusive of those that may have limited providers, such as satellite

1 Introduction and Background

1.1 Background and Motivation

Statement of the Problem

Significant parts of rural Nova Scotia are either unserved or under-served with respect to high-speed Internet services. This means businesses, citizens, health workers, and education providers lack access to the benefits of utilizing the Internet for work or pleasure. Access to the Internet is essential to the province's economic and social well-being. Enhancing a connected Nova Scotia, especially in the unserved and under-served communities, will help bring sustainable services to all parts of the province and help grow the local and provincial economies.

Part of the vision for a connected Nova Scotia included the development of a *middle mile strategy* that will support current and future high-speed Internet infrastructure across the province. In addition to, and in conjunction with, the *middle mile strategy*, the Province of Nova Scotia requested the development of a *last mile strategy* to more fully support this vision.

What is Last Mile and its Relationship to Middle Mile?

Last mile is that final leg of a telecommunications network that delivers telecommunication services (in this case Internet access) to retail end-users (or customers). It connects the *middle mile* (normally from a POP location) to the users or customers in that geographic area. It can be wired or wireless, and the actual distance covered may be anything from a few metres to many miles, depending on the proximity of the end user to the middle mile POP, as well as on the technology being used.

A *middle mile* strategy will ensure that there is a network with sufficient supply of Internet bandwidth to meet the needs of the province, whereas the *last mile* strategy will provide a blueprint for connecting residents and businesses to that network.

Goal and Objective of the Last Mile Project

Background

The province recognizes the importance of dependable, affordable high-speed Internet services to the prosperity of Nova Scotia's residents, businesses, education, and health sectors. A key focus for the Department of Business is to develop a program and process to ensure sufficient bandwidth is available to meet current and future demand. Government understands that enabling consumers from all sectors to get connected requires effective networks that

- they can reach at work, at home, and in schools, colleges, universities, and health facilities
- provide enough capacity to carry the Internet traffic today and into the future

What Has Already Been Done?

In 2007, the ambitious Broadband for Rural Nova Scotia (BRNS) project was launched to improve Internet access for thousands of Nova Scotians. BRNS connected 99 per cent of 93,500 residents that were unable to access high-speed Internet services in the province with a targeted bandwidth of 1.5 Mbps. The 1.5 Mbps service BRNS delivered was considered a high-speed service level, given the number of computers and types of Internet services that households used at that time.

Demand for Internet services has continued to grow over the past ten years. Today, the average Canadian household has seven devices connected to the Internet using bandwidth-intensive service such as streamed audio and video[2]. To ensure that Nova Scotians are able to connect and access the ever-increasing services that are offered online, it is time once again to expand and enhance access to Internet services across the province. A solution that can accommodate the growth in demand for Internet services over the next number of years is required.

In 2016 the Nova Scotia Department of Business commissioned the report, "Review of Alternatives for Rural High Speed Internet." The report outlined the state of Internet technologies in Nova Scotia at that time and found that

> the reliability and speed of broadband solutions could be negatively affecting social and economic opportunities for residents in rural communities. In areas that lack reliable broadband service access, possible impacts may include decreased home values, limited opportunity to access online educational resources, challenges in recruiting and retaining employees within rural areas and challenges accessing government services via electronic channels.[3]

The report concluded that market forces alone would not drive the necessary investments in Internet infrastructure in Nova Scotia and that the province will need to play an active role in its development and deployment.

For this reason, the province committed funding in 2016 to improve Internet service levels across Nova Scotia. These funds supported 22 municipal and community-led projects, part of the Municipal and Community Group Rural High-Speed Internet Funding program that was launched in November of 2016.

In addition, an RFP was also released in 2016 to create a long-term middle mile strategy for Nova Scotia. Upon implementation, this strategy would ensure the necessary infrastructure is built so that both current and future Internet service-level demands can be met.

In March of 2018, the province announced it was investing about $120 million in the Nova Scotia Internet Funding Trust to connect more communities, homes, and businesses to high-speed

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[2] http://www.cantechletter.com/2016/08/households-now-use-average-seven-connected-devices-every-day-report/

[3] Review of Alternatives for Rural High Speed Internet

Internet. These funds are expected to be used to leverage other private and public commitments to improve Internet service.

As the province was addressing its middle mile strategy, the CRTC announced that Canadians should have access to Internet speeds of up to 50 Mbps download and up to 10 Mbps upload, which vastly exceed the speeds many rural residents presently have. This federal announcement supports the work the province has started, and ongoing discussions are under way between the two levels of government to develop and implement a coordinated strategy to improve Internet service.

As work progressed on the middle mile strategy, it was apparent that a corresponding last mile strategy was also needed. This last mile strategy document will provide an overview of the infrastructure and costs required to reach the unserved and under-served areas of the province.

Developing the Last Mile Strategy

Developing an actionable last mile strategy on a provincial scale is a significant challenge that requires stakeholder agreement, a deep technical understanding of Internet technology, market trends, and financial analysis expertise. In developing this strategy, the Brightstar team met with seven service providers within the province. We also met with representatives from 50 municipalities as part of middle mile strategy consultations, which included discussions around last mile strategy performance goals. These consultations helped shape the goals for the strategy, which in turn formed the basis for the last mile infrastructure requirements. Based on these requirements, and in conjunction with Brightstar's middle mile strategy, Brightstar engineered an expanded last mile infrastructure that was priced and tested for market viability without government support.

1.2 Document Overview

This document consists of seven main sections: Introduction and Background, Approach and Methodology, Stakeholder Engagement Process and Feedback, Engineering Process and Results, Financial Analysis Process and Results, Satellite Service Strategy, and Recommendations.

In the introduction, the current problem is defined and some historical context is provided. A summary of past work that has been done in the province with respect to rural high-speed Internet, including the work on the middle mile strategy, is also presented, along with the province's vision, goals, and objective for high-speed rural Internet. A List of Acronyms, Terms, Definitions is included to assist with the technical terminology used.

The Approach and Methodology section describes the approach taken to develop the last mile strategy. This section includes a description of the stakeholder engagement activities, the engineering process, and the financial analysis process.

The Stakeholder Engagement Process and Feedback section identifies those we consulted, the goals of stakeholder engagement, and what was discussed during the stakeholder engagement sessions. This section also summarizes the key stakeholder engagement findings that helped inform the last mile strategy.

In the Financial Analysis Process and Results section, the financial analyses for implementing the middle mile and last mile strategies are presented based on the costs and revenues associated with the budgetary last mile infrastructure design.

The Satellite Service Strategy section provides an approach for utilizing satellite technology for some of the remote and difficult-to-service properties in the province. In addition, it details a recommended procurement approach for satellite usage.

The last section of the report provides the recommendations from the project team regarding the last mile strategy.

1.3 List of Acronyms, Terms, Definitions

Acronym or Term	Term or Definition
ABC	Activity Based Cost
AMP	Amplifier. A device used to boost signal strength, typically used between optical nodes and customers.
ARPU	Average Revenue per User
Backhaul	See "Middle Mile"
Biz	Business
Broadband	A high-capacity transmission technique using a wide range of frequencies, which enables many messages to be communicated simultaneously.
BTS	Base Transceiver Station. A piece of equipment that facilitates wireless communication between user equipment and a network. User equipment are devices like mobile phones and computers with wireless Internet connectivity.
Cable	In terms of this report, Internet access provided via a cable television provider
Cable Company	Traditionally a company that offered cable television services, but may also offer telecommunications and Internet services as well
CAGR	Compound annual growth rate
CapEx	Capital Expenditures. Funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. It is often used to undertake new projects or investments by the firm.
Cisco VNI (Visual Networking Index)	Report from a leading Information Technology company, Cisco, on Internet usage.
Coax	Coaxial cable, a type of insulated cable.
CPE	Customer Premises Equipment. Any terminal and associated equipment located at a customer's premises and connected with a carrier's network.
CRTC	Canadian Radio-television and Telecommunications Commission
CTI	Connect to Innovate
Dark Fibre	Refers to unused fibre-optic cable. Often companies install more cable than necessary to allow for growth.
Demand	In terms of this report, the calculated volume of Internet traffic required to support an average household, business or other site.
DL	Downlink, refers to transmissions in the direction toward the end user
Download	Data that is received by a computer or network (see DL)
DSL/ADSL	Digital subscriber line or asymmetric digital subscriber line which is defined as the way a computer connects to the Internet at high-speeds using telephone lines
EORN	Eastern Ontario Regional Network
Eq	Equivalent
FAA	Financial Administration Act
FDH	Fibre Distribution Hub is where the fibre from the POP is distributed to the homes.

Acronym or Term	Term or Definition
Fibre	Fibre optic (or "optical fibre") refers to the medium and the technology associated with the transmission of information as light impulses along a glass or plastic wire or fibre
Fixed Wireless	The operation of wireless devices or systems used to connect two fixed locations (e.g., building to building or tower to building) with a radio or other wireless link
FTTH	Fibre to the home
FTTN	Fibre to the node
Gap	In terms of this report, the difference between the demand for Internet bandwidth and the potential supply of bandwidth.
GB	Gigabyte
Gbps	Gbps stands for billions of bits per second and is a measure of bandwidth on a digital data transmission medium such as optical fibre.
GIS	A system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.
GPON	Gigabit Passive Optical Network
HFC	Hybrid fibre coaxial. A broadband network that combines optical fibre and coaxial cable. It has been commonly employed globally by cable television operators to deliver Internet connectivity.
HH	Household
HH-equiv	See HH-equivalent
HH-equivalent	Household-equivalent. This represents the expected Internet demand of an “equivalent” household. Based on 5-year demand projections, this equals 2.74 Mbps. The term HH-equivalent is used as a metric for measuring the coverage and unit cost of middle mile infrastructure with consideration to all Internet demand sources. This term is not the same as actual households because Internet is used not only by households, but by other property types as well including businesses, hotels, health care, etc.
IFL	Intermediate Frequency Link
IoT	Internet of Things refers to the increasing list of dedicated devices that now connect to the Internet such as household thermostats, security systems, lighting controls etc.
IRR	Internal Rate of Return
ISED	Federal Government Department of Innovation, Science, Economic Development Canada
ISP	Internet Service Provider
IU	Indoor Unit
Last Mile	Final leg of a telecommunications network that delivers telecommunication services to retail end-users (customers).
Lit Fibre	Fibre-optic cable (used for carrying data between two designated points) that has been installed and activated by carriers (service providers)
LTE	Long-Term Evolution (LTE) is a standard for high-speed wireless communication for mobile phones and data terminals
MB	Megabyte

Acronym or Term	Term or Definition
Mbps	Short for megabits per second, a measure of data transfer speed (a megabit is equal to one million bits)
Middle Mile	The segment of a telecommunications network that links a network's core to last mile local facilities. It is commonly called the "backhaul" network
Mobile	May refer to portable Internet-capable devices or also the access to the Internet via smartphones or other portable devices.
MW POP	A POP, Point of Presence, which uses a microwave radio usually on a tower to connect remote locations that are not accessible by a wired connection. Microwave POPs are often used to provide bandwidth to locations such as an island or mountainous location.
NOC	Network Operations Centre
NPV	Net Present Value
OLT	Optical Line Terminal. The endpoint hardware device in a passive optical network.
ONT	Optical Network Terminal. This is customer premise equipment (CPE) that can be used to deliver Internet, telephone and television services.
OpEx	An operating expense, operating expenditure, operational expense, operational expenditure or OpEx is an ongoing cost for running a product, business, or system.
Optical Node	Electronic equipment that translates a digital signal from a light beam to electrical signal. This is equipment is found in a Hybrid fibre-coaxial (HFC) network.
OU	Outdoor Unit
Pole Costs	Cost of connecting cable, fibre or other equipment to power distribution poles.
POP	Point of Presence. The local access point for Internet Service Providers. Facility contains telecommunications equipment that allows ISPs to connect to their customers to the Internet. Often located in a central office but can also be a field cabinet.
PVSC	Property Valuation Services Corporation
RENS	Regional Enterprise Networks are groupings of municipalities in Nova Scotia that provide regional economic leadership and help develop regional economic strategies, while supporting small, local businesses.
RF	Radio frequency
RFI	Request for information
RFP	Request for proposal
Satellite	Refers to Internet access provided via satellites.
SLA	Service Level Agreement
SOC	Satellite Operation Centre
Supply	In terms of this report, the potential bandwidth available at an Internet connection point of presence (POP)
Service Provider	Shortened form of Internet Service Provider or ISP.
Spare Fibre	Refers to unused fibre optic cable. Often companies install more cable than necessary to allow for growth.

Acronym or Term	Term or Definition
SW	Switch. A piece of electronic networking equipment that routes an input signal to an output line.
Tap	Tap is a passive component consisting of a coupler and a splitter which splits the RF signals for servicing several homes.
Telco	Company that provides telecommunications services such as telephony and data communications
TT&C	Tracking, Telemetry and Command
TPS	Triple-Play Services: Internet, television and telephone services delivered from a single provider's connection.
UL	Uplink, refers to transmissions in the direction toward the Internet
UT	User Terminal
Upload	Data that is sent from a computer or network toward the Internet. (See UL)
VPN	Virtual Private Networks
WACC	Weighted Average Cost of Capital
Wi-Fi	Technology for wireless local area networking
Wireless	The transfer of information or power between two or more points using radio technology rather than wire

2 Approach and Methodology

This section describes the methodology followed for arriving at the last mile strategy.

2.1 Process Overview

The essential elements of the last mile strategy include:

1. Project Goals (Infrastructure Performance Goals)—the goals that the last mile is expected to meet. This includes speed of service, availability or coverage of high-speed Internet service within the province, and timeline for the solution.
2. Budget—How much it will cost to implement the strategy; how much of the cost can be covered by the private sector; and how much government investment would be required.

The process for arriving at a last mile strategy typically begins with consultations with several key stakeholder groups: municipalities and allied agencies, municipal associations, and Internet Service Providers, all of whom have a strong interest in a provincewide last mile strategy. The objective of these consultations is to inform, educate, and obtain input into the development of the last mile strategy, including its goals.

Internet Service Providers (ISPs) are private sector companies that connect their customers to the Internet. It is important to gather information directly from them, particularly concerning key issues of understanding their last mile infrastructure, revenue, and costing data, as well as their views on project goals. With such input, combined with Brightstar's expert knowledge regarding industry trends and engineering design methodologies, infrastructure performance goals can be defined and used to develop a budgetary design for the last mile to address infrastructure gaps. The costs required to operate the additional infrastructure is then estimated, along with revenue that can be expected from its use, to arrive at a project budget and business case.

3 Stakeholder Engagement Process and Feedback

3.1 Municipality Consultations

The team consulted representatives from 50 municipalities during the middle mile strategy process. These consultations included soliciting feedback concerning the infrastructure performance goals for the project, including speed and coverage targets. Details of these public consultations are described in detail in Brightstar's *Nova Scotia Department of Business Middle Mile Strategy*, dated March 2018.

3.2 Service Provider Consultations

The team contacted several last mile service providers in Nova Scotia with the goal of getting feedback on the proposed engineering design methodology and to gather information needed for conducting the last mile engineering design and financial analysis. Buy-in and support from the private sector was seen as critical to ensure accuracy in the engineering and the financial analyses, as well as to ensure involvement of the private sector in the implementation phase of the project.

3.2.1 Service Providers Consulted

The Brightstar team met with the following last mile ISPs

- Eastlink
- Bell Aliant
- Mainland Telecom
- High Tech Communications
- Xplornet Communications
- Seaside Communications

3.2.2 Stakeholder Engagement Requested

Requests made of the service providers included their tower and last mile footprint information, which was needed for last mile supply mapping. Financial inputs were also requested, including last mile capital expenditure (CapEx) and operating expenditure (OpEx) information for support in building the financial models. Requests made of the service providers are detailed in Appendix A – Stakeholder Engagement Consultations.

3.2.3 Service Provider Feedback

General observations on the feedback are summarized below.

<u>Last Mile Targets</u>
Brightstar presented the project goals relating to coverage, speeds, and timeline. There was general agreement that the targets selected were appropriate. Brightstar was interested to get input from the ISPs about increasing the fixed wireless speed targets from 10 Mbps download/2 Mbps upload to

25 Mbps download/5 Mbps uplink, in order to align more closely with CRTC goals. There was general agreement that increasing download speeds was appropriate given the time horizon for the project. However, a number of ISPs expressed concern about the 5 Mbps upload target as being too aggressive, especially in that many ISPs do not have access to licensed spectrum, which has advantages of range and protection from interference when compared with unlicensed bands. However, these targets are achievable in areas closer to the tower sites and by adjusting the download/upload ratios for TDD technologies.

Engineering Input

There was general agreement that the engineering approach proposed for the last mile design was valid. The approach involved estimating the demand using last mile sources of Internet derived from PVSC data and Cisco VNI reports, estimating supply based on a fixed last mile service radius around POP locations and RF coverage predictions around towers, and then calculating the supply shortfall. Some ISPs expressed concern about inaccuracies in making assumptions on a fixed last mile service radius around the POP locations. To help reduce this inaccuracy, many of the ISPs shared their actual last mile service area footprints.

Financial Input

Information about capital expenses (CapEx) and operating expenses (OpEx) were important to establish the last mile infrastructure costs. Some ISPs provided or validated detailed financial inputs, including tower costs, radio and antenna costs, last mile fibre and cable costs, and costs for the last mile electronics. Financial inputs relating to OpEx, including rent, warranty, license fees, billing, customer support, and maintenance, were also provided or validated by some ISPs. Some ISPs also shared expected revenue and household penetration rates. The information gathered was combined with Brightstar's knowledge of broadband infrastructure capital and operating expense information.

4 Engineering Process and Results

4.1 Infrastructure Performance Goals Driving the Engineering Analysis

The infrastructure performance goals driving the engineering analysis are in alignment with the middle mile strategy and described below.

4.1.1 Data Rates

The data-rate goal for the middle mile strategy was established based on the stakeholder feedback, and on the recent CRTC Internet speed targets to all Canadians. Therefore, for the last mile strategy, Brightstar is recommending a speed goal for last mile Internet of 50 Mbps in the download direction and 10 Mbps in the upload direction. The 50 Mbps download/10 Mbps upload target is appropriate for heavy Internet use and can support multiple connected devices simultaneously within a household or business. In areas where a wired solution is not practical, a speed goal for wireless last mile Internet of 25 Mbps download/5 Mbps upload is recommended.

This represents an increase from an earlier 10 Mbps download/2 Mbps upload target for fixed wireless services. The new rate is more closely aligned with CRTC targets, and is more appropriate for a household in which there may be more than one connected device or user. Fixed wireless technology continues to advance, making 25 Mbps download/5 Mbps upload targets now attainable. In cases where a wireless solution is impractical, a satellite solution may be more appropriate. Satellite-based services can support speeds of 25 Mbps download/1 Mbps upload.

4.1.2 Project Time Horizon

The project time horizon for the middle mile strategy was set at 10 years for middle mile electronics, with the initial electronics deployment sufficient to meet 5-year demand projections. The lifespan of last mile technologies, particularly wireless solutions, is not as long as 10 years, owing to technology obsolescence. A 5-year lifespan for last mile wireless electronics is more appropriate. Technology refreshing would likely be required beyond five years as demand continues to grow.

4.1.3 Coverage Target

Brightstar recommends that last mile coverage targets should be at least 95 per cent of all properties in populated areas, outside of urban Halifax and Sydney. The majority of the balance of populated rural property locations could be serviced through satellite technologies that do not rely on middle mile infrastructure. Satellite speeds of up to 25 Mbps download will be available later in 2018 with the launch of new satellites.

These coverage targets are consistent with those defined as part of the middle mile strategy.

4.2 Last Mile Technology Options for Addressing Infrastructure Performance Goals

Cable and FTTH last mile technologies are capable of delivering speeds in excess of 50 Mbps download. Fixed wireless services, through use of wider licensed channels, may be capable of delivering 50 Mbps download speeds, but this target will be difficult to achieve in the near term using unlicensed spectrum. However, a 25 Mbps download service would be achievable, and would represent the lower end of the project speed target. DSL services in Nova Scotia top out at 7 Mbps download, making the existing DSL infrastructure incapable of supporting the project goals.

The last mile technologies capable of achieving the infrastructure performance goals are described briefly in the section below.

4.2.1 FTTH Technology

Fibre technology provides a variety of options to the service providers for last mile service. FTTn or FTTb provides a fibre connection from a POP to the neighborhood or the building. Existing copper lines can then be used to connect the customer to node or building. In a new build, fibre is deployed from the POP to the customer location. This last mile technology scenario is called FTTH.

A popular FTTH architecture is GPON, due to its simplicity and price. Below is a schematic of a FTTH GPON network with its components.

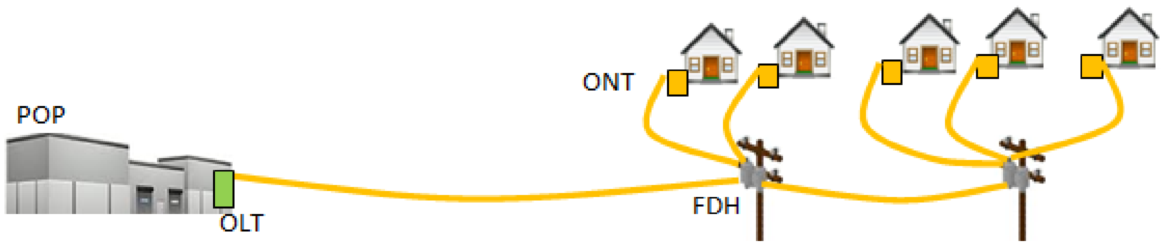

Figure 4-1 FTTH Schematic Diagram

In the above figure, the OLT is located in the POP and connected to the core network through switches and routers.

The FDH is where the fibre from the POP is distributed to the homes. It contains several passive optical splitters, usually in a combination of 1x4, 1x8, or 1x32 splitters. FDH comes in various configurations, including FDH-144, FDH-216, and FDH-288.

The ONT is the CPE endpoint of the FTTH network. The ONT is an optical-to-electrical device which can deliver triple-play services. GPON is completely passive, and therefore at this endpoint there must be a power connection to perform the optical-to-electrical conversions for the services.

In rural areas where household density is low, the splitting is done in several steps. For example, instead of using a 1x32 splitter, 1x4 and 1x8 splitters can be used along the fibre path to minimize total fibre length. The total length of fibre from the POP to the ONT should be less than 20 km.

4.2.2 HFC Technology

There are several different architectures for HFC systems, such as Tree and Branch, Star, Ring, and Cascading Hubs. A simple HFC structure is shown below to highlight the main elements of the HFC system.

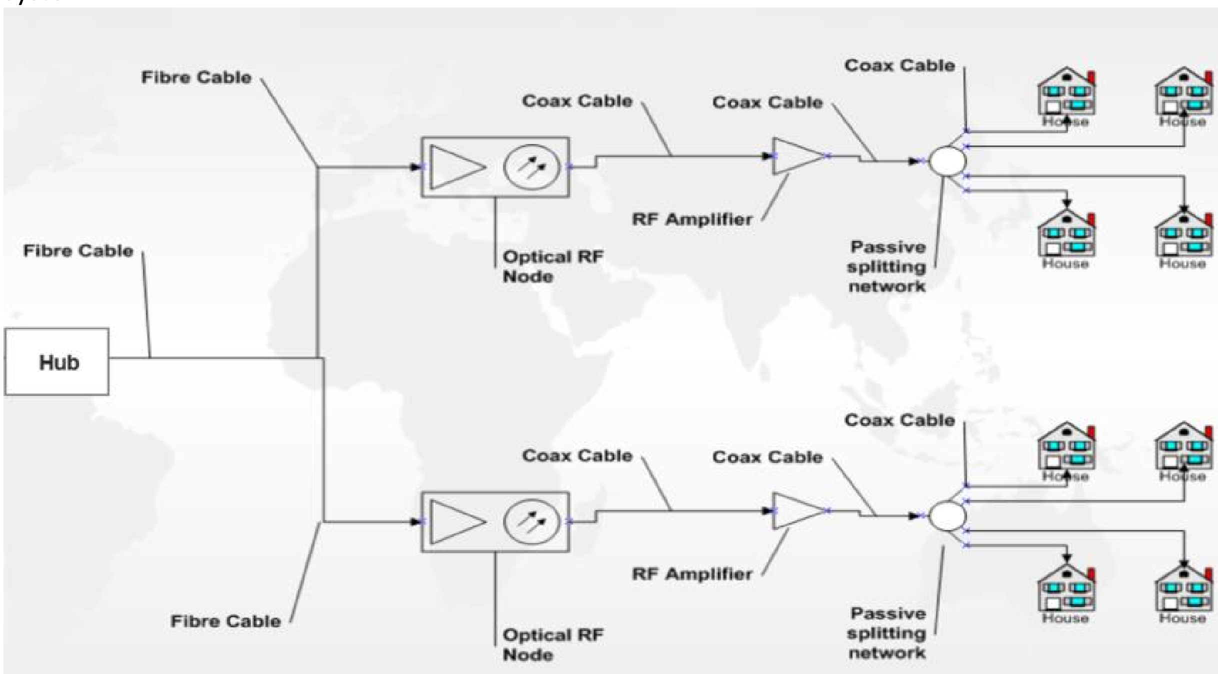

Figure 4-2 HFC Schematic Diagram

The node, or Optical Fibre Node, is a broadband optical receiver that converts the download optical signals coming from the Hub to RF signals going to homes through coaxial cables. A node can typically serve about 250 houses, and in special cases it can serve up to 2,000 homes, although doing so is not recommended. Nodes can be connected to one another by fibre. The typical distance between the nodes is 5 to 40 km. For long distances, an amplifier can be used between nodes to maintain adequate signal strength.

Optical fibre nodes fed using home run fibre from a master headend are used to convert the optical signals to electrical in the download and, conversely, to convert electrical to optical signals in the upload. A cable modem device using DOCIS 3.0 is used in the customer's premises to convert the RF (electrical) based signals to Ethernet, which then can be processed by the customer's computer or home network.

4.2.3 Fixed Wireless Technology

In Fixed Wireless systems, Internet service is delivered wirelessly from a tower site to a transceiver at the customer location. The tower site can be connected by fibre or by wireless microwave link to the POP. Towers can be interconnected using a variety of topologies including Branch and Tree, Ring, or

Star. The figure below shows a Branch and Tree topology, where three wireless towers are connected to one another via microwave links.

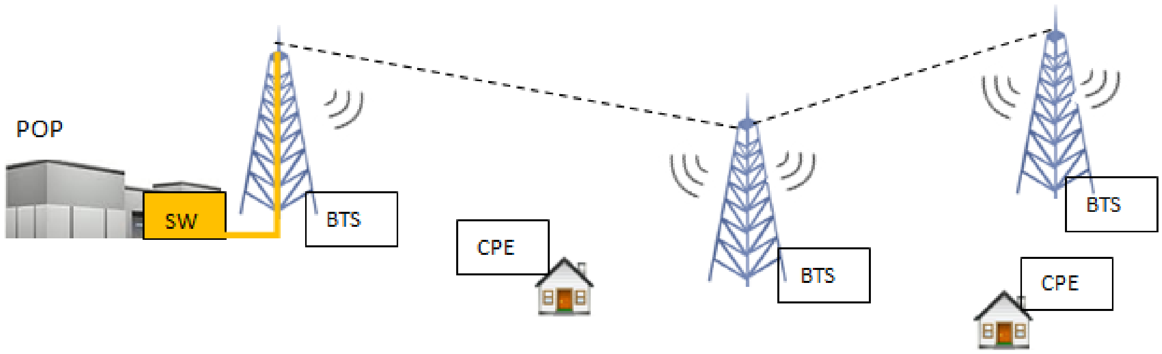

Figure 4-3 Fixed Wireless Schematic Diagram

In the above diagram, the CPE is the equipment located at the customer's location. It typically consists of an outdoor antenna and transceiver equipment and can deliver triple-play services to the customer.

The BTS is the equipment located at the tower site. Together with tower-mounted antenna equipment, the BTS provides wireless communications between the CPE and the network.

At the POP, switching equipment aggregates the traffic from many customers serviced by the tower sites and sends the traffic to the core of the network through the middle mile fibre network.

4.3 Engineering Process Overview

At a high level, the process for scoping the enhancement of the last mile network in Nova Scotia involves mapping the demand for Internet, mapping the existing last mile infrastructure in the province, and then determining the areas where the Internet demand exceeds the capacity of the existing infrastructure to deliver the required service. A budgetary design can then be conducted to address the service gaps—for example, by adding new or expanded infrastructure to service unserved or under-served areas. This process is shown graphically below.

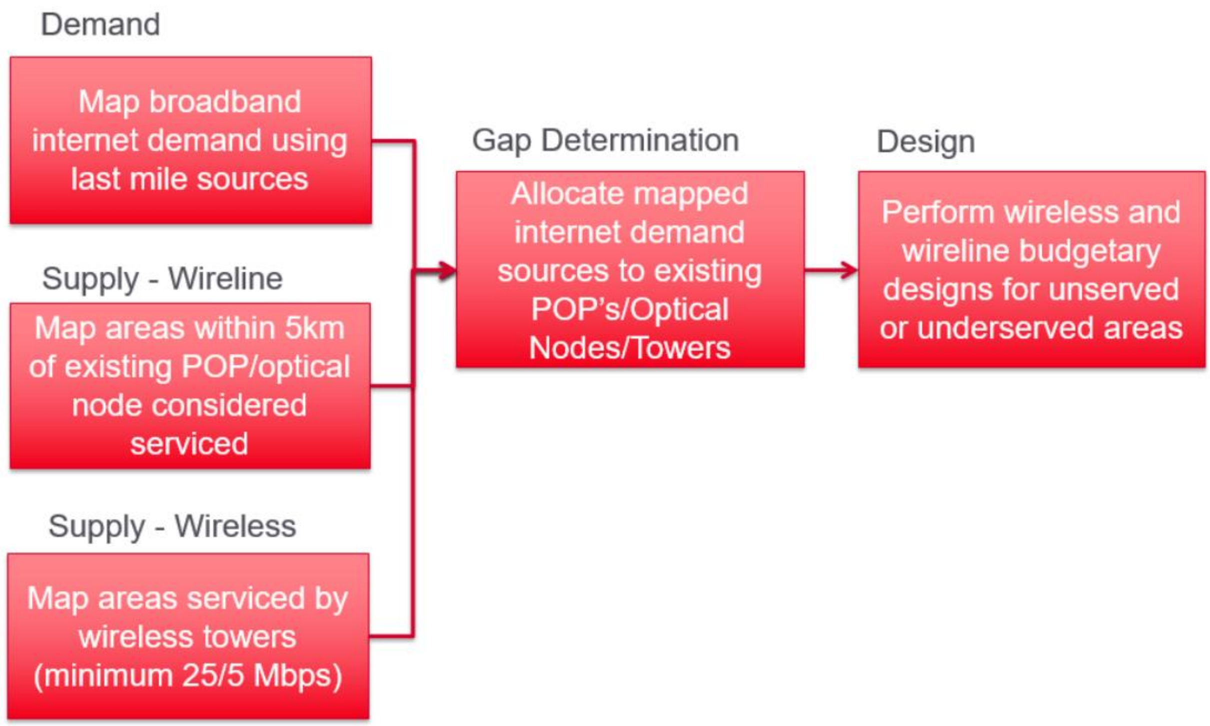

Figure 4-4 Engineering Process Flow Diagram

4.4 Demand Mapping Process and Results

4.4.1 Demand Mapping Process

It is critical that the last mile network is able to meet the peak network demand requirements throughout the province. To determine the peak Internet demand, it was necessary to map the Internet demand sources and calculate the peak demand from these demand sources.

The process for mapping the demand for Internet in the province is the same for last mile as it is for middle mile services, with one notable exception: mobile Internet traffic demand sources do not apply for fixed Internet demand mapping. The steps detailed below for demand mapping have been reused from the *Middle Mile Strategy* document.[4]

The approach followed in order to map the peak demand:

Step 1. Identify the potential sources of fixed Internet demand
Step 2. Model the traffic from each source of fixed Internet demand
Step 3. Calculate the demand from each fixed Internet source by time of day
Step 4. Adjust the peak demand to account for Internet traffic growth
Step 5. Aggregate the peak demand into 1 km^2 grids for presentation and analysis purposes

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[4] NS DoB – Middle Mile Strategy, March 31, 2017

Step 1. Identify the potential sources of fixed Internet demand

To support mapping of the last mile traffic in the province, the Brightstar team used property data received from Property Valuation Services Corporation (PVSC). The data set used was current as of November 2016 and included planned property listing changes for 2017.

The PVSC data resolution was to the lot level, and each property was categorized by type and included building size and location information. The Brightstar team met with the PVSC team to ensure the data could be filtered to exclude any properties that should not be treated as a potential source for Internet demand. The selection rules applied are captured in Appendix B – Property Selection Rules and Demand Data. Of the 637,651 properties in the original database, 370,771 were identified as demand sources for mapping purposes.

It was learned that the PVSC did not include residences within military bases and in First Nations territories. Brightstar leveraged publicly accessible data from Statistics Canada[5] and from the First Nations Profiles Interactive Map[6] to locate the First Nations households on our demand map. The Canadian Forces were contacted directly and provided relevant household information.

Step 2. Model the traffic from each source of Internet demand

Of the properties identified as demand sources, the Brightstar team assigned usage profiles and usage quantities based on the property category. Usage profiles fell into one of four categories, as listed below.

- HH (residential): this traffic profile is typical of a household, characterized by high traffic in the evenings when people are home from work and lower traffic levels in the day.
- Biz (business): this traffic profile is typical of a business, characterized by higher daytime traffic and lower levels in the night time and early morning.
- HH-flat: this traffic profile has usage volumes similar to a household, but traffic is spread relatively consistently across daytime and evening periods.
- Biz-flat: this traffic profile has usage volumes similar to a business, but traffic is spread relatively consistently across daytime and evening periods.

These profiles were derived in part using feedback received during the service provider consultation sessions.

Usage volumes were applied to each property based primarily on the property category (e.g., apartment unit, residential, school) and in some cases also based on the building size.

[5] http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/search-recherche/lst/results-resultats.cfm?Lang=E&TABID=1&G=1&Geo1=&Code1=&Geo2=&Code2=&GEOCODE=12#

[6] http://cippn-fnpim.aadnc-aandc.gc.ca/index-eng.html

Step 3. Calculate the demand from each fixed Internet source by time of day

The peak demand may occur for different times of day, depending on the relative density of the Internet demand sources. For example, areas with a high residential concentration will tend to have peak demands in the night time, whereas commercial and business regions will have peak demands during the day.

To calculate the peak demand for each demand source, the team made use of average monthly data usage information from the Cisco VNI Report, 2015–2020, in combination with the usage profile and quantity information as described in Step 2.

Monthly usage data was available in the Cisco VNI Report for Canada for both residences and businesses. The average monthly residential usage in Canada is 120 GB, compared with 325 GB for businesses.[7] Feedback on the accuracy of these metrics as part of middle mile stakeholder engagement consultations with the service providers was varied (too low, too high, and about right). The Cisco data is seen as extremely useful for this study, because it reflects actual usage whose average is weighted toward a larger proportion of urban users who are likely to have the option of purchasing Internet speeds of 50 Mbps and higher (last mile target speeds for this project). The last mile network that is being proposed should be capable of supporting the expected peak traffic once high quality last mile Internet service options are available. Usage when lower quality last mile options are available will naturally tend to be lower, thereby reducing the demand as experienced by the network. The Cisco numbers also intrinsically factor in the uptake rate of a wide range of plans (some lower, some higher than 50 Mbps), considering a range of variables such as economics and need. This is important, for just because a 50 Mbps service plan is available does not mean that everyone will subscribe to it. In some cases, the customer may not see a need for higher service plans or is not willing or able to pay more for one.

Step 4. Adjust the peak demand to account for Internet traffic growth

The Cisco VNI Report has projected a compound annual growth rate in Internet usage of 18 per cent per residence and 17 per cent per business.[8] Penetration of broadband Internet in Canada is flattening out, with a compound annual growth rate of 1.3 per cent over the last 5 years.[9]

Using these metrics, 5- and 10-year demand projections per residence and business were calculated.

Based on 5-year demand projections, the data shows that for residential properties, a peak download data rate of 2.52 Mbps per residence occurs in the night time, whereas for business properties, a peak download data rate of 7.90 Mbps occurs in the daytime. Residences and businesses with flat usage profiles will have sustained download data rates of 1.17 Mbps and 4.14 Mbps, respectively.

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[7] Cisco VNI Report, 2015–2020

[8] Cisco VNI Report, 2015–2020

[9] http://www.internetlivestats.com/internet-users/canada/

Step 5. Aggregate the peak demand into 1 km^2 grids for presentation and analysis purpose
In the last step of demand mapping, the download peak demand rates for day and night scenarios were applied to each property in accordance with the usage volume and profile as classified in Step 2 for present-day, 5-year, and 10-year time frames.

Property demands were allocated within 1 km x 1 km square grids, based on lot location, to facilitate analysis. Because residential areas have a higher night peak usage and business areas have higher peak usage in the daytime, the demand map used for the study considered the maximum peak demand (day versus night) within each 1 km x 1 km grid. This “worst case” demand map was then derived and compared with the last mile supply maps to arrive at areas that would benefit from expanded last mile infrastructure.

4.4.2 Demand Mapping Results

A demand map showing the distribution of demand data throughout the province is shown below. Grids shown in pink have a density of more than 20 household equivalents; grids shown in green have between 2 and 20 household equivalents; grids shown in blue have two or fewer household equivalents. Areas without grids contained no properties identified as sources of Internet demand, based on the PVSC, First Nations, and military-base information used for the study.

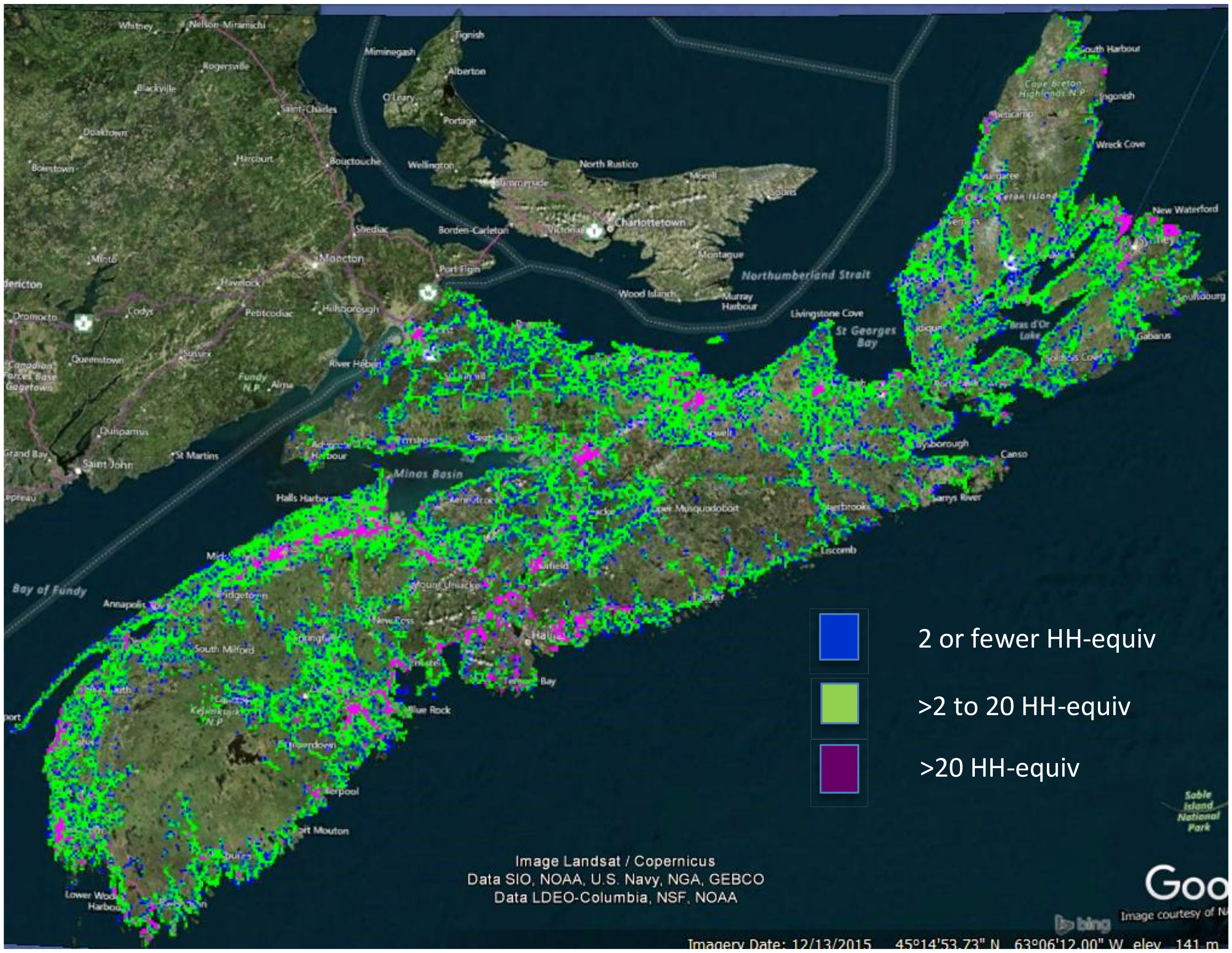

Figure 4-5 Demand Map in Units of HH-equiv

In the above map, a household equivalent (HH-equiv) equals 1.03 Mbps today, 2.52 Mbps in 5 years, and 6.14 Mbps in 10 years. For conducting the last mile budgetary design, 5-year demand maps were used. The total aggregate demand for the province is 325,832 HH-equiv. This excludes the demand outside of urban Halifax and urban Sydney.

4.5 Supply Mapping Process and Results

4.5.1 Supply Mapping Process

4.5.1.1 Supply Mapping – Wireless Last Mile Infrastructure

Last mile infrastructure includes tower sites and radio equipment for wireless services, as well as last mile fibre and electronics download of the POP/hub for wireline services. The mapping of the last mile infrastructure required input from the last mile service providers, because the locations of the infrastructure is proprietary information. It also includes updates to the middle mile reference design based on further service provider information gathered.

Wireless last mile services are typically delivered through radio and antenna equipment mounted on tower or rooftop sites within a service area. Rooftop-mounted antennas connected to a modem are often present at the customer location for communicating with the tower or rooftop sites so that the Internet service can be delivered to customer premises.

The steps to determine the coverage areas within the province for last mile wireless services were as follows:

Step 1. Conduct a link budget analysis for the radio equipment to determine the maximum allowable path loss between the tower site and the customer location in order for a minimum 25 Mbps download/10 Mbps upload service level to be achieved.

Step 2. Map the tower sites and radio equipment locations using EDX SignalPro, an industry standard RF network engineering tool used by many service providers for fixed wireless network designs.

Step 3. Import terrain and land cover (clutter) information into the tool for the province. RF signal propagation is greatly affected by forests, buildings, hills, valleys, landforms, and other obstacles and types of land cover. Brightstar used terrain and clutter data with a resolution of 50 m for the coverage predictions. The data was rendered from 2016 satellite data.

Step 4. Using EDX SignalPro, run the RF coverage predictions. Coverage maps will be generated to show where 25 Mbps download/5 Mbps upload service levels can be achieved.

It is notable that most, but not all, ISPs provided tower and radio information to Brightstar as part of the stakeholder engagement process. It is understood that sites which were not shared were built and loaded to meet speeds of up to only 5 Mbps, which means they are unlikely to be capable of achieving the strategy's higher speed targets. Only sites capable of meeting the 25 Mbps download/10 Mbps upload service-level targets should be included in the wireless supply maps.

4.5.1.2 Supply Mapping – Wireline Last Mile Infrastructure

Through the stakeholder engagement process, Brightstar received detailed footprint information from the wireline ISPs, showing the locations where wireline services of at least 50 Mbps download/10 Mbps upload can be obtained. These footprints were overlaid on the demand map so that wireline last mile service areas could be determined.

4.6 Gap Analysis Process for Last Mile Services

By overlaying the last mile supply maps (as described in Section 4.5) on top of the demand maps (as described in Section 4.4), coverage gaps in last mile services can be shown to exist wherever a demand grid is outside the coverage area of the supply map.

Determining service gaps due to inadequate capacity is slightly more complicated, because areas shown as covered may in fact lack the capacity to provide sufficient services to everyone. For wireline last mile services, adding capacity can be achieved by expanding the last mile infrastructure electronics at the POP. ISPs did not share detailed information about capacity at existing POP locations during stakeholder engagement. As a result, Brightstar made some design assumptions for capacity of the network. The ISPs did, however, provide some guidance on the cost to upgrade the middle mile infrastructure to accommodate the impact of expanding services. This has been factored in to the financial analysis for the strategy.

Determining the gaps in service due to insufficient capacity for fixed wireless last mile services involves the following process:

- Allocate each unit of HH-equiv demand to the wireless sector within which it resides
- Calculate the total demand of HH-equiv within each sector
- If the total demand in each sector exceeds its capacity, then a capacity gap exists for the sector, meaning that the sector must be upgraded or additional sectors added.

4.7 Budgetary Design Process and Results for Last Mile Services

A budgetary design to address the last mile coverage and capacity gaps is needed to estimate the required infrastructure for the last mile strategy.

4.7.1 Wireline Last Mile Budgetary Design Process

Wireline services are typically delivered through fibre connections from a POP site to Optical Network Terminals (ONTs) at the customer location. The fibre is distributed at the POP through an Optical Line Terminal (OLT) via several Fibre Distribution Hubs (FDHs) that are strategically located to service multiple customer locations. In Nova Scotia, the fibre is not buried, but rather is carried on utility poles managed by Nova Scotia Power. The amount of fibre and the number of FDHs, as well as the OLT size for each POP site, depends primarily on the density of customer locations and the road density around the POP.

As part of the middle mile strategy, new POP sites were identified for enabling wireline last mile services. Time does not permit a detailed wireline design to be conducted for all of the new POP sites identified for this report. Rather, detailed designs were conducted for about 5 per cent of the POP sites. The process involved identifying the fibre routes along roadways from the POP site to each serviceable property within the POP serving area. In conducting the design, mathematical relationships between the length of roadway and property counts with respect to the infrastructure equipment requirements can be established. These relationships can then be used to estimate the last mile infrastructure requirement for the remaining 95 per cent of the POP sites.

4.7.2 Wireless Last Mile Budgetary Design Process

Wireless last mile services are typically delivered through radio and antenna equipment mounted on tower or rooftop sites within a service area. Rooftop-mounted antennas connected to a modem are often present at the customer location for communicating with the tower or rooftop sites so that the Internet service can be delivered to customer premises.

The wireless budgetary design process described below was applied for areas shown to be highly uneconomical using a wireline service option. This tends to occur in areas where customer density is low enough that the wireline service revenue is insufficient to offset the costs to operate the service.

For planning purposes, it is assumed that the radio equipment to be used for the design is a mix of newer LTE-based fixed wireless equipment operating in a shared-licensed band, such as 3.65GHz, as well as 3.5GHz licensed equipment. This combination of equipment reflects a mix of fixed wireless technologies by spectrum license holders and non-license holders alike within the province.

The steps to conduct the budgetary design within the wireless service areas were as follows:

> Step 1. Research nearby towers using the ISED frequency search database[10] as potential co-location sites. The ISED database includes all towers and site locations that involve transmitters operating with licensed spectrum. Towers that include any unlicensed frequency bands are not included. Brightstar also considered towers provided by ISPs as part of stakeholder engagement as potential co-location sites. However, not all ISPs shared their site information. In cases where these towers have only equipment operating in unlicensed bands, Brightstar would not have knowledge to include them as potential co-location site candidates.
>
> Step 2. Map the tower sites and radio equipment locations in EDX SignalPro, an industry standard RF network engineering tool used by many service providers for fixed wireless network designs.
>
> Step 3. Import terrain and land cover (clutter) information into the tool for the province. RF signal propagation is greatly affected by forests, buildings, hills, valleys, landforms, and other obstacles and types of land cover. The team has used terrain and clutter data with a resolution of 50 m for the coverage predictions. The data has been rendered from 2016 satellite data.
>
> Step 4. Using EDX SignalPro, run the RF coverage predictions. Coverage maps will be generated to show where 25 Mbps download/5 Mbps upload service levels can be achieved from the co-location towers.

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[10] https://sms-sgs.ic.gc.ca/frequencySearch/searchByGeographicArea?execution=e1s1

Step 5. Identify candidate new tower build locations to address the remaining coverage gaps. The attachment heights of the radio equipment on the new towers are assumed to be at 45 m.

Step 6. Repeat steps 4 and 5 until the coverage gaps are sufficiently closed to meet the project coverage targets.

Step 7. Once the coverage maps are completed, allocate each HH-equiv to the sector within which it resides and calculate the total demand for each sector.

Step 8. If the sector demand exceeds its capacity, a capacity gap exists. Additional sectors need to be added until the capacity gap is eliminated within the sector's coverage area. Note that this step also applies for capacity gaps that exist within the province's existing wireless coverage footprint.

4.7.3 Reference Engineering Design

For wireless services, the design includes 51 new tower sites and 2 co-location tower sites to address service gaps due to insufficient coverage and capacity

For wireline services, 95 OLTs, 1,074 FDHs, as well as 8,913 km of last mile fibre are included in the reference design. The table below summarizes the infrastructure requirements for the reference design.

Table 4-1 Infrastructure for Reference Design

Design 1 Infrastructure	Total
Last Mile Fibre (*)	8,913 km
New wireless towers	51
Co-location towers	2
Total Towers	53

(*) includes feeder and drop fibre

4.7.4 Unserved Property Identification

Following the budgetary design, some HH-equiv will remain unserved by the existing or by new wireless or wireline last mile designs. Properties affected are most likely to be served through a satellite Internet service. Satellite speeds of up to 25 Mbps download will be possible later in 2018 with the launch of new satellites. These coverage targets are consistent with those defined as part of the last mile strategy.

5 Financial Analysis Process and Results

5.1 Financial Analysis Process

The financial analysis for the middle mile strategy determined that the projected middle mile revenue would not be sufficient to offset the operating expenses. This indicates that it is not viable to implement the expanded middle mile unless last mile revenue sources are also considered. The financial analysis process to be conducted as part of the last mile strategy would therefore consider revenue opportunities and costs for both last mile and middle mile infrastructure.

The objective of the financial analysis was to estimate the cost to build and operate the additional network infrastructure and to determine the public investment that would be needed to ensure it remains viable and sustainable. The process followed was to estimate the capital (CapEx) and operating (OpEx) expenses and revenues that would result from building and operating the network infrastructure based on the reference engineering design. The financial analysis of the CapEx and resulting net operating return or loss was then used to determine if a market failure condition exists.

The CapEx and OpEx used for the budgetary engineering design were determined largely from ISP feedback. Middle mile infrastructure CapEx that was considered included the costs for POP and fibre equipment and their installation. OpEx that was considered included the ongoing costs to operate and maintain the middle mile infrastructure equipment, including rent, pole access costs for fibre, cost of power, maintenance, and warranty. Last mile CapEx that was considered included the costs for the tower, base station, and antenna equipment, as well as the last mile cabling and electronics. Last mile OpEx that was considered included spectrum license costs, pole access costs for fibre, rent, power, customer care, maintenance, and warranty expenses.

The infrastructure revenue, CapEx, and OpEx, together with third-party sourced rates of return for the industry, were used to conduct a net present cash flow analysis to determine if the private sector would be likely to proceed with the build on its own, or if a government investment would be required.

5.2 Financial Analysis Results

The financial analysis for the middle mile strategy determined that the projected middle mile revenue would not be sufficient to offset the operating expenses. This indicated that it was not viable to implement the expanded middle mile infrastructure unless last mile revenue sources were also considered. The financial analysis process conducted as part of the last mile strategy therefore considered revenue opportunities and costs for both last mile and middle mile infrastructure.

For reference purposes, the five-year design used as the basis for the financial analysis is described in Section 4.7.3 and tabulated below.

Table 5-1 Infrastructure for Reference Design

Infrastructure Element	Design
Microwave POPs	3
New Fibre POPs	58
DSL POP Upgrades	34
TOTAL POPs	95
Middle Mile Fibre (km)	1,044
New tower builds	51
Co-location tower builds	2
Last Mile Fibre (km)	8,913

The financial analysis concludes that a market failure does exist and that subsidy for capital expenses is required.

5.3 Funding Last Mile Infrastructure – Market Failure

Notwithstanding all of the evidence and analysis that has been summarized to support the adoption of universal service objectives for the Province of Nova Scotia, a wide range of opinion about who should fund the expansion of broadband infrastructure to meet these objectives still exists. If the funding comes from both private and public sectors, how much should each contribute? Many people observe that private sector telecom companies make substantial profits and wonder why governments would provide any funding to companies that are already profitable. In areas where the population density is lower, the business case for the private sector does not warrant proceeding. Government support for capital costs allows for the revenue generation to ease the market failure and proceed with providing service. For this reason, Brightstar has concluded that

> **the government of Nova Scotia should provide funding and organizational support for the deployment of broadband infrastructure only in cases of clearly identified market failure or a compelling public policy imperative.**

The rapid evolution of the Internet and the resulting growth of a digital economy are creating a shift in the perception of public versus private goods. Historically, broadband services have evolved out of private sector innovation and investment, but now all citizens require access to the Internet if they wish to participate in the digital economy. Under a purely market-driven model, rural citizens would either get no or insufficient access to broadband, or they would have to pay exorbitant fees. In this case, broadband has become an essential public good like street lighting or police services.

The following process was used to identify whether or not there is indeed market failure in the supply of broadband infrastructure in Nova Scotia:

- Analyze the current and future supply of broadband infrastructure in Nova Scotia.
- Map existing known broadband infrastructure assets.
- Consult with ISPs on future development plans.
- Identify the current and future demand for broadband in Nova Scotia, using industry analyst projections and modeling.
- Determine if there is a gap between supply and demand.
- Analyze what it would cost to close the gap between supply and demand, using industry average infrastructure costs.
- Would using industry average economic analysis of internal rates of return (IRR) determine whether the private sector would likely invest enough money to close the gap?
    - If yes, on what timeline would they close the gap? If the private sector is likely to close the gap with its own investment on a reasonable timeline, then there is no need for government investment.
    - If no, then there is a situation of market failure and the government should intervene.

If there is a market failure condition, the following process should be considered:

- Use a competitive procurement process to identify the most cost-effective way (least amount of government investment to achieve universal service objectives) to close the gaps between supply and demand.
- Negotiate service-level agreements that require private sector broadband providers to continue ongoing infrastructure investments in the future.

6 Satellite Service Strategy

The primary focus of the last mile strategy for the Nova Scotia Department of Business is on the assessment of terrestrial broadband gaps (which might be closed with a mix of technologies such as DSL, fixed wireless, cable, fibre, etc.) and on analysis of possible market failure conditions that would indicate a need for government investment. Regardless of how detailed the last mile mapping and analysis is, there will always be rural and remote residents who are unlikely to get terrestrial broadband services due to factors such as uneven terrain, low household density, and obstruction by trees, water, etc. For this reason,

> **Brightstar recommends that Nova Scotia undertake a competitive process for satellite services that would provide the more rural and remote areas of the province with high-speed satellite broadband services.**

6.1 Satellite Network Components

Satellite networks consist of three main components:

1. the satellite in the sky
2. a Network Operations Centre (NOC) or gateway on the ground connected to the Internet
3. individual units at the customer's location (a dish or CPE)

Satellite technology is ideally suited to serving very large geographic areas, particularly those with low population densities. A simple network configuration is illustrated below. Each customer obtains access to the Internet by having a small dish and modem installed at their premises. This device communicates with the satellite, which in turn connects the customer to the Internet via the earth station or NOC. The following diagram shows a typical satellite configuration.

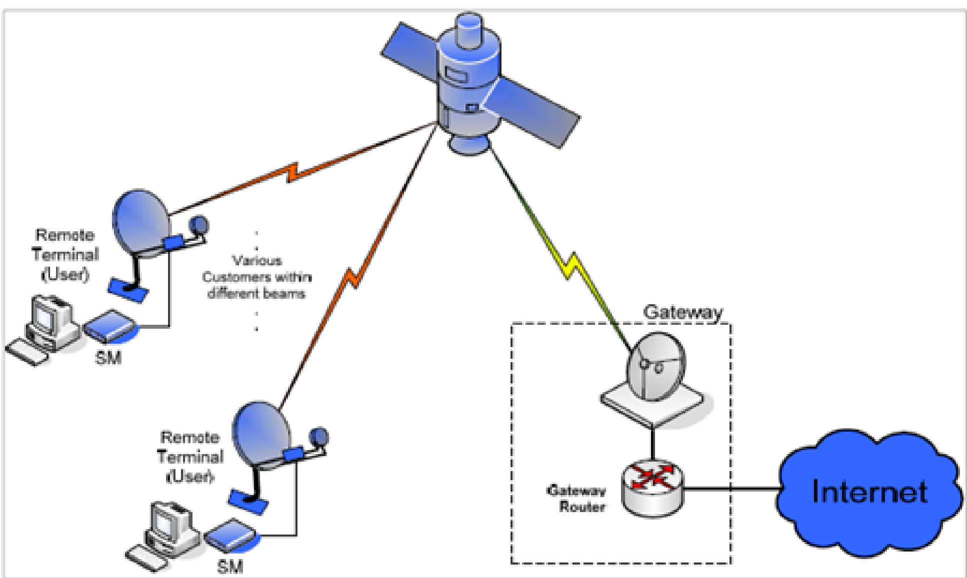

Figure 6-1 Satellite Network Components

In the most hard-to-reach and sparsely populated areas there is often no business case for ISPs to deploy land-based broadband, because the capital and ongoing operating costs would be much higher than projected revenues.

6.1.1 Space Segment

The Space segment is comprised of the satellite spacecraft and ancillary support functions, the Satellite Operations Centre (SOC), as well as Tracking, Telemetry and Command (TT&C) functions. The SOC is managed by third-party companies who specialize in managing and controlling satellites used for DTV, digital radio, digital mapping, and other government purposes, in addition to broadband.

6.1.2 Ground Segment

The ground segment contains all the technical equipment and management systems that are required to provide broadband services to customers. It consists of multiple gateways and an NOC. The purpose of each gateway is to provide connectivity between the satellite and the Internet. The purpose of the NOC is to provide management of the gateway, as well as the operational support tasks associated with the day-to-day operation of the network.

6.1.3 User Segment

The user segment is comprised of the User Terminal (UT) and the CPE.
The CPE can be one PC or several Internet-enabled devices within a local area network. Although the user terminal appearance may vary between platforms, they all operate in a similar manner. The UT is comprised of the Outdoor Unit (ODU) and the Indoor Unit (IDU). The ODU is the antenna and associated electronics (radio transceiver) that interface with the IDU through an Intermediate Frequency Link (IFL). The antenna portion of the ODU is typically 75 cm or less and is installed on the building exterior (wall- or roof-mounted). The IFL cable is typically a coaxial cable that is installed to connect the electronics on the ODU with the IDU. The IDU is essentially a modem that converts RF signals to IP and interfaces with the CPE via a standard 10/100 baseT Ethernet cable. The size of the IDU is similar to current-day DSL or cable modems. The following picture shows example of both the IDU and ODU.

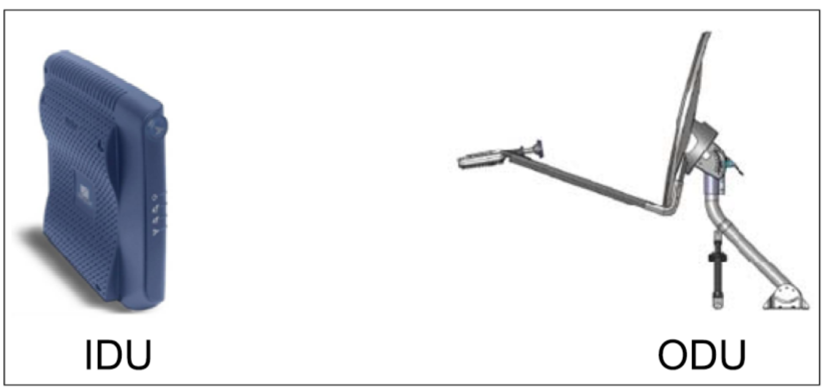

Figure 6-2 Satellite User Segment Components

6.2 Satellite Market Forecast

Currently there are a limited number of satellite service providers in Canada and coverage is limited over some parts of Nova Scotia. A new satellite (with capacity contracted by Xplornet) called Viasat 2 was launched at the end of April 2017, and it has full coverage over all of Nova Scotia. The aim of this new satellite is not only to deliver a more focused beam of coverage, enabling generally higher capacity, but also to support new Internet applications that require greater speed and capacity. For many years, satellite services have been slower and less reliable than terrestrial services, but the newest generation of satellites, called 4G, have been able to offer higher speeds (it is anticipated that 25/1Mb services will be available) and better reliability. All satellite services have inherent latency issues with the requirement for data to travel up through the satellite to the ground station and back to the dish at end-user locations.

Based on gap analysis data and input from terrestrial network providers during the consultation stage, Brightstar estimated that 16,345 (approximately 5 per cent) of households outside of urban Halifax and Sydney might need access to satellite services. This analysis is based on a calculation of household equivalents outside of wireline and fixed wireless coverage areas for the reference design conducted (see Section 4.7.3 for details). The ISPs in the satellite industry typically expect to see a market penetration of 40 per cent to 60 per cent over a three- to five-year period from customers in areas with less than 3 HH per km^2. Many ISPs use a benchmark of four to six homes per square kilometre for determining areas that are generally uneconomical for terrestrial services such as DSL or wireless. In Nova Scotia this would translate into 15,269 potential satellite customers in the 3HH per km^2 calculation, with a range up to 23,980 potential satellite customers in a 5HH per km^2 calculation.

The figure below graphically explains the cost performance of three last mile technologies as broadband is deployed from Canada's most densely to least densely populated regions:

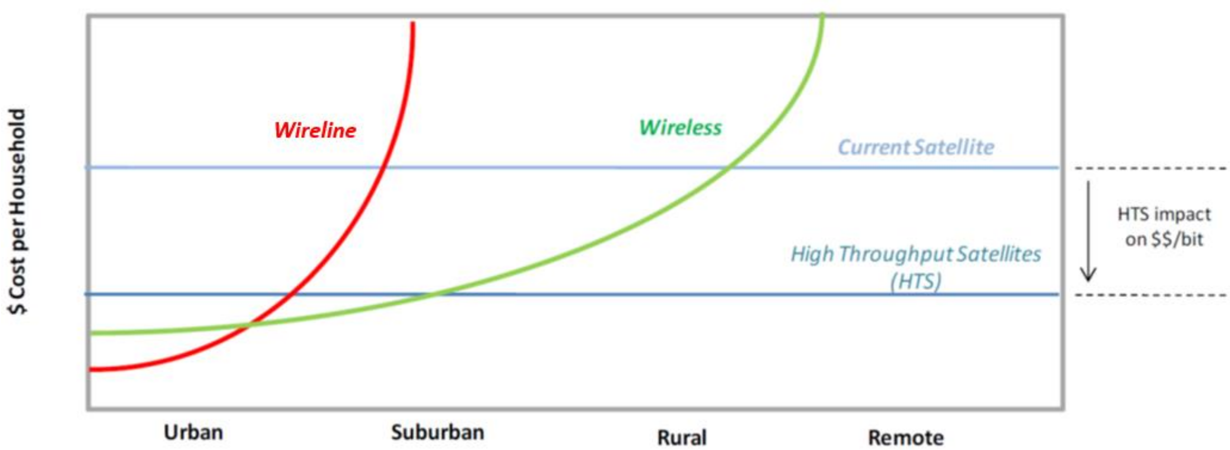

Figure 6-3 Coverage Economics

As indicated above, the cost per household increases dramatically for wireline (cable or fibre) and for fixed wireless systems as the household density decreases. Satellite is most economical for rural or remote densities and has the unique characteristic of a uniform cost structure, regardless of household density.

6.3 Technology Considerations

6.3.1 Latency

Latency is defined as the amount of time it takes from the request of a packet of data until it is received. In general, latency is expressed in terms of milliseconds (ms), or thousandths of a second. Latency has long been a criticism of satellite Internet technology, but such criticism is a bit overblown for the common Internet user. It is true that satellite Internet latency is much greater than terrestrial Internet latency (fibre cable). Terrestrial latency ranges in the 20–50 ms range, whereas satellite Internet latency can be 500 ms or more. The main reason for the difference is the greater distance that the data for satellite Internet communications must travel.

The geosynchronous satellites employed for satellite Internet are positioned approximately 35,000 km above the earth. That is a long way for the data to travel, and yet it is accomplished in milliseconds. The most obvious effect of latency is on gaming, when ultra-quick responses are necessary. Satellite Internet is not suitable for heavy gaming applications, multi-party voice or video communications, or Virtual Private Networks (VPNs); however, normal email, browsing, photo sharing, etc., are not significantly affected by latency.

6.3.2 Weather and Look Angle

Severe thunderstorms, heavy snow, and blizzards can temporarily interrupt satellite transmissions; however, the problem isn’t as significant with the newest generation of satellites. This condition is commonly called “rain or snow fade.” The signal is restored as soon as the storm passes. Heavy accumulations of snow can be removed from around the satellite dish to restore communications. In contrast, a heavy thunderstorm with fallen trees, etc. could disable cable or DSL for days. Again, most satellite Internet customers are in rural areas that do not have access to DSL or cable, and so the problems associated with rain fade are minimal when compared to alternative, slower means of Internet service.

Since satellite Internet utilizes a beam of spectrum that is projected from the satellite down to the ground and to the CPE at the end-user’s location, there is a requirement for the CPE to be positioned within the look angle of the satellite beam. If the end user’s location is below the look angle (behind a hill or densely treed area), then it is possible that an aerial would be needed to position the CPE within the look angle of the satellite beam.

7 Recommendations

Part of the vision for a connected Nova Scotia includes the expansion and upgrade of the networks needed to deliver broadband Internet services. This includes the middle mile and last mile networking equipment. *Last mile* is the final leg of a telecommunications network that delivers Internet services to end-users. It connects the *middle mile* (normally from a POP location) to the users in that geographic area. The last mile can be wired or wireless, and the actual distance covered may be anything from a few metres to many miles, depending on the proximity of the end user to the middle mile POP, as well as the technology being used.

Brightstar has arrived at the following goals for the last mile infrastructure, which is in alignment with the middle mile strategy infrastructure goals and recent CRTC service targets.

1. Speed: The last mile infrastructure that is developed should support **Internet service speeds of at least up to 50 Mbps download and 10 Mbps upload for wireline last mile services; and of at least up to 25 Mbps download for wireless last mile and satellite services**. The 50 Mbps target is consistent with recent CRTC goals for connectivity in Canada.[11] A 25 Mbps download service is appropriate for Internet browsing and video streaming purposes for a small household. The 50 Mbps target is appropriate for heavier use and can support multiple connected devices simultaneously within a household or business. These last mile speed targets are tabulated below.

Service Type	Minimum Speed (Mbps)
Wireline (e.g., Fibre and Hybrid Fibre-Coax)	Up to 50 Mbps down/10 Mbps up
Fixed Wireless Service	Up to 25 Mbps down/5 Mbps up
Satellite Service	Up to 25 Mbps down/1 Mbps up

2. Coverage: The **last mile infrastructure should cover at least 95 per cent of populated rural property locations with a wireline or wireless broadband service**. The majority of the balance of populated rural property locations could then be serviced through satellite technologies. Satellite speeds of up to 25 Mbps download will be possible with the launch of the new satellite service.
3. Timeline: Due to the expense of the last mile infrastructure, the timeline for its usefulness must extend out several years. The team is recommending a time horizon of **5 years for infrastructure electronics**.

After developing the reference design for the expanded last mile wireless and wireline infrastructure that can meet the infrastructure performance goals, Brightstar performed a financial analysis of the expanded middle mile and last mile infrastructure and confirmed that a condition of market failure

[11] Telecom Regulatory Policy CRTC 2016-496

exists. This demonstrates a need for public investment in order for the expanded middle mile and last mile to be built; conditions are not sufficient for the infrastructure to be built by the private sector alone. Even with this expanded infrastructure, some rural and remote areas of the province still may not have access to high-speed Internet services. To enable service for these users, Brightstar recommends that Nova Scotia goes through a competitive process to secure satellite capacity for the province, which could be used to offer services to residents living in remote areas. The Brightstar team has determined that the capital costs requirement may be about $300–$500 million of public and private investment for both middle mile and last mile.

Appendix A – Stakeholder Engagement Consultations

As part of the development of a last mile strategy for the Province of Nova Scotia, the engagement of a variety of key stakeholders was deemed as essential. This section provides the questions and input requested of the stakeholders as part of these consultations.

1.1 Service Provider Stakeholder Engagement

Service providers were consulted so as to gather feedback concerning Brightstar's proposed last mile design methodology, as well as to gather technical and financial inputs needed for creating a budgetary last mile design. The technical and financial input requested is outlined in the subsections below.

1.1.1 Engineering and Financial Inputs and Questions – Fibre Last Mile Services

The following engineering and financial inputs and questions were posed to service providers that offer fibre-based last mile services such as Fibre-to-the-Home (FTTH).

- Has there been any middle mile or last mile infrastructure development since our last consultation?
  - New POP sites?
    - Lat/Long/capacity information
    - POP conversions/upgrades to support 50/10 services?
  - CTI Project Awards
    - New POP locations – lat/long/capacity
    - Service map showing planned households served
    - Service levels offered
- Please provide guidance on the number of households passed per km of road where you would proceed with a fibre design under the following scenarios:
  - No government subsidy
  - 50% government subsidy
  - 75% government subsidy
  - 90% government subsidy
- CapEx costing inputs for fibre last mile services:
  - Cabling (cost of last mile fibre per metre)?
  - FDH (cost of FDH for passive fibre distribution)?
  - OLT (cost of Optical Line Transmitter)?
  - Any other CapEx elements and their pricing?
- OpEx costing inputs for fibre last mile services:
  - OpEx costs to service the household (e.g., modem fees, support, or billing costs?)
  - Pole access fees?
  - Customer support and billing costs?
  - One-time customer activation costs net of revenue?
  - Other OpEx elements?
  - Fibre maintenance costs?

- Revenue inputs for fibre last mile services:
  - Average revenue per household?
  - Percentage of households that will purchase the service?

1.1.2 Engineering and Financial Inputs and Questions – Cable Last Mile Services

The following engineering and financial inputs and questions were posed to service providers that offer cable-based last mile services such as HFC (Hybrid Fibre Coax).

- Has there been any middle mile or last mile infrastructure development in 2017, since our last consultation?
  - New POP/hub sites?
    - Lat/Long/capacity information
  - CTI Project Awards
    - New POP/hub locations – lat/long/capacity
    - Service map showing planned households served
    - Service levels offered
- Please provide guidance on the number of households passed per km of road where you would proceed with a wireline (cable) design under the following scenarios:
  - No government subsidy
  - 50% government subsidy
  - 75% government subsidy
  - 90% government subsidy
- CapEx costing inputs for cable last mile services:
  - Cabling (cost of last mile coax per metre)?
  - Cabling (cost of last mile fibre from hub to node)?
  - Hub (cost per hub)?
  - Node (cost per node)?
  - Any other CapEx elements and their pricing?
- OpEx costing inputs for cable last mile services:
  - OpEx costs to service the household (e.g., modem fees, support, or billing costs?)
  - Pole access fees?
  - Last mile equipment warranty and maintenance costs?
  - One-time customer activation costs net of revenue?
  - Other OpEx elements?
- Revenue inputs for cable last mile services:
  - Average revenue per household?
  - Percentage of households that will purchase the service?

1.1.3 Engineering Inputs and Questions – Fixed Wireless Last Mile Services

The following engineering inputs and questions were posed to service providers that offer fixed wireless-based last mile services.

- Could you provide us with your list of tower sites with last mile equipment (existing or recently constructed/awarded through CTI or other program)?

- For each tower site, please provide, if available: RF equipment, RF equipment technology, Operating Frequency (MHz), Channel Size (MHz), number of sectors, antenna azimuths, antenna model, antenna mounting heights
- For each tower site, please provide if the tower has last mile equipment capable of delivering an up to 25/5 service.
- For each tower site, please provide if the tower is fibre fed or if backhaul is sufficient to offer 25/5 service.
- Please provide us the following information about your CPE equipment (i.e., customer premises or modem equipment)
  - Type – indoor or outdoor
  - If outdoor, typical mounting height (e.g., rooftop at 6 m)
  - CPE make/model
  - CPE antenna model
  - CPE antenna gain
  - CPE transmit power (in Watts)
  - CPE receiver sensitivity (in dB, if available)
  - Typical measured noise floor (specify range if available)
- Please provide feedback on our design assumptions, tabulated below:

Parameter	Value	ISP Feedback on Value
Technology	TDD-LTE	
Frequency	3.65GHz	
Channel Size	20MHz TDD	
Speed Target	25Mbps/5Mbps	
Transmit Power (BTS)	28dBm / 20 dBm	
Tx Power (CPE)	23 dBm	

Parameter	Value	ISP Feedback on Value
MIMO (BTS)	4 antennas	
MIMO (CPE)	2 antennas	
Antenna Gain (BTS)	18 dBi	
Antenna Gain (CPE)	16 dBi	
MAPL	140/132 dB	
CPE Height	6m	
Tower Height	45m	

- CapEx costing inputs for wireless last mile services:
  - Cost of a 45 m tower site complete with equipment (switching, power, and radio equipment)?
  - Co-location tower site costs?
  - Any other CapEx elements and their pricing?
- OpEx costing inputs for wireless last mile services:
  - Power and rent costs for a typical tower site?
  - Equipment maintenance and warranty costs per tower?
  - OpEx costs to service the household (e.g., modem fees, support, or billing costs?)
  - Microwave license fees?
  - Monthly bandwidth costs?
  - Other OpEx elements?
- Revenue inputs for wireless last mile services:
  - Average revenue per household?
  - Percentage of households that will purchase the service?

- Could the investment in expanded last mile infrastructure result in other benefits (e.g., potential rental income for co-locators; cost sharing with mobile services) and any suggestions on how this benefit could be quantified?

Appendix B – Property Selection Rules and Demand Data

1.1 Property Selection Rules

The property data provided by PVSC included over 600,000 listings, not all of which could be considered potential sources of Internet demand. After discussions with PVSC, Properties with Property Codes (LUC Codes) as follows were excluded from our study as sources of Internet demand:

- 0408 – Sports field/parks
- 0504 – conservation properties
- 0507 – blank – for future use
- 0805 – incubator malls
- 1003 – highway commercial
- 1004 – waterfront development land
- 2001 – natural gas processing facility
- 2002 to 2005 – pipelines
- 2006 – related natural gas sites
- 2007 – distribution lines
- 3002 – fibre optics
- 3100 to 3150 – power generation
- 3210 to 3211 – substations
- 3250 – towers lines poles
- 5555 – condo parking spaces
- 6666 - $0 value land
- 7777 - $0 value condo parking space
- 8888 – possible commercial sale
- 9999 – income valued in another account

Additional rules are listed below.

- Apartments – INCLUDE this group.
- Commercial Sale – EXCLUDE this group.
- Commercial Vacant Land – INCLUDE this group if Building Size >1000.
- Condominiums – INCLUDE this group.
- Default LUC – INCLUDE this group if Building Size >1000.
- Industrial – INCLUDE this group if Building Size >1000.
- Lodgings – INCLUDE this group if Building Size >1000.
- Mobiles – INCLUDE this group.
- Office – INCLUDE this group.
- Pipeline – EXCLUDE this group.
- Professional Services – INCLUDE this group if Building Size >0.
- Public Buildings – INCLUDE this group if Building Size >1000, regardless of VACANT/IMPROVED.
- Restaurants/Recreational – INCLUDE this group if Building Size >1000.
- Retail – INCLUDE this group if Building Size >1000.
- Services – INCLUDE this group if Building Size >1000.

- Special Purpose/Heavy Industrial – INCLUDE this group if Building Size >1000.

1.2 Property Demand Data

After the property data was filtered to include only potential Internet demand sources, each property was assigned a usage quantity and profile, in accordance with the property category, as tabulated below. For some categories, more than one usage profile was applied.

Category	Description	Usage	Profile	Usage	Profile
Apartment Units	each apartment in building	1	HH		
Commercial	general commercial	1	Biz		
Condo Units	each apartment in building	1	HH		
Res Units	house	1	HH		
Industrial Units	warehouse, distribution facility, light manufacturing	0.4	Biz		
Hotels	Hotels - hotel with multiple rooms	10	HH	1	Biz
Motels	Motels - motel with multiple rooms	3	HH		
Campgrounds	Campground	2	HH		
Country Inn	Country Inn - inn with multiple rooms	2	HH		
Residential	house	1	HH		
Daycare	Daycare	0.5	Biz		
Senior Home	Senior Home	1	HH-Flat	1	Biz-Flat
Retirement Home	Retirement Home	1	HH-Flat	1	Biz-Flat
Resorts	Resorts	5	HH		
Cottage	Cottage	1	HH-Flat		
Nursing Home	Nursing Home	1	HH-Flat	1	Biz-Flat
B&B	B&B	1	HH		
Mobiles	Trailers in a trailer park - one per trailer	1	HH		
Office < 3000	Office < 3000 sq-ft	1	Biz		
Office < 30000	Office < 30000 sq-ft	5	Biz		
Office > 30000	Office > 30000 sq-ft	10	Biz		
Professional Services Units	Includes banks and medical buildings	1	Biz		
Church	Church	0.1	Biz		
Education	Schools - this data has already been provided by Gvt	10	Biz		
Courts	Courts	2	Biz		
Fire Stn	Fire Stn	1	Biz-Flat		
Police Stn	Police Stn	2	Biz-Flat		
Post Office	Post Office	0.2	Biz		
Museum	Museum	0.5	Biz		
Halls	Assembly halls	1	Biz-Flat		
Fast Foods	Fast Foods	1	Biz-Flat		
Dining	Restaurant	0.5	Biz-Flat		
Bar	Bar	1	Biz		
Sports Facility	Sports Facility	2	HH		
Racetrack	Racetrack	1	Biz-Flat		
Bowling	Bowling	1	HH		
Arena	Arena	2	HH		
Theatre	Theatre	1	HH		
Marina	Marina	1	Biz		
Retail	Malls, plazas, grocery stores, dept stores, shops, big box stores	1	Biz-Flat		
Services	Car dealerships, garages, gas stations, transport companies	1	Biz		
Special Purpose	Refineries, gypsum plants, ship building, pulp mills	1	Biz		