Satellite Inquiry Report

October 2014

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Note on the Public Report

Commissioner Candice Molnar was appointed by the Commission as an Inquiry Officer in Telecom Notice of Consultation 2014-44, and pursuant to section 70 of the *Telecommunications Act*, to conduct an inquiry with respect to the Canadian marketplace for satellite services that are used by telecommunications service providers (TSPs) to provide telecommunications services to Canadians. Commissioner Molnar completed her review and reported her findings to the Commission in October 2014.

Some information submitted by parties to the Inquiry Officer included confidential information. In order to ensure the public report is as meaningful as possible, the Inquiry Officer sought disclosure of certain confidential information on the public record from various parties. Where the Inquiry Officer decided not to require disclosure of the information designated as confidential, that information has been removed for the publication of the report. This includes specific information such as detailed breakdowns of providers' costs, and future plans of satellite operators. Where information has been removed due to reasons of confidentiality, this is referenced in the report, including through the use of footnotes and/or with the use of the '#' sign.

Information in this report is current as of October 2014.

Acknowledgments

While this report is the work of the Inquiry Officer, it also reflects the work of a large number of people and organizations who participated throughout the inquiry process. As such, it represents the efforts of a team of Commission staff, as well as the invaluable knowledge, expertise and information provided by satellite operators, providers of telecommunications services, government officials, and community representatives.

The Inquiry Officer sincerely thanks all parties for their contributions to this report.

Commissioner Candice Molnar

Inquiry Officer

Foreword

Canadians who depend on satellite services for some or all of their telecommunications needs are located in some of the nation's most remote areas, where access infrastructure, whether it is roads or terrestrial telecommunications transmission facilities, is often non-existent. These communities are typically small and geographically dispersed. They are located in Nunavut, the Northwest Territories, and Yukon, as well as in certain remote areas of British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec. During this inquiry, 83 communities were identified that rely on an aggregated satellite transport model for the delivery of voice services, and 89 communities were identified that rely on this model for Internet services.

In these remote communities, incumbent telephone companies remain the dominant service providers for wireline voice services. These services are regulated by the Commission and are, for the most part, provided in satellite-dependent communities at comparable price and quality to terrestrially served communities. For broadband Internet and mobile wireless services, there has been market entry by alternative providers of telecommunications services. However, Internet speeds in satellite-dependent communities are well below those available in communities served by terrestrial facilities, and are, in most cases, below the Commission's target speeds of 5 megabits per second (Mbps) download and 1 Mbps upload. Mobile wireless services offered in satellite-dependent communities, if available, typically use older, less advanced technology with low data speeds compared to what is available elsewhere in Canada. There have been many studies done to identify the unmet demand for better Internet and other telecommunications services in remote communities, especially in the North. Addressing this unmet demand and the service disparities raises issues regarding capacity, quality, cost, and affordability.

The inquiry was intended to provide the Commission with a better understanding of the key factors influencing the current and future cost and availability of satellite-based transport services, refresh the Commission's knowledge of the satellite industry, and examine whether the Commission's current regulatory framework for satellite services remains appropriate. The inquiry was not intended to look at the affordability of services delivered to end-users or potential Commission-initiated subsidy mechanism(s).

Over the course of the inquiry, information was obtained through a number of methods and from different sources. There were one-on-one meetings with a number of stakeholders, and a review of the relevant industry literature, studies, reports, and service contracts and agreements between satellite operators and users. Various requests for information were sent to parties and other stakeholders, and comments were invited from all interested persons on the issues within the scope of the inquiry. All of the information received was reviewed and synthesized, and is summarized in this report.

The inquiry report presents information, observations, and conclusions of particular note. For instance, 9 satellite operators are authorized to provide satellite services in Canada. However, presently, only 3 satellite operators provide services to telecommunications services providers and other service providers (e.g. Internet service providers) in Canada. One such satellite operator is Telesat, which has a dominant market position, in terms of market share, in each of the 3 satellite spectrum bands (C-band, Ka-band, and Ku-band) for fixed satellite services (FSS) that are used by providers of telecommunications services to offer end-users voice, mobile, and broadband Internet services. The other satellite operators that provide these services in Canada are SES, which provides C-band and Ku-band capacity via its affiliate New Skies Satellites, and Hughes, a wholly owned subsidiary of EchoStar Corporation, which provides Ka-band capacity.

FSS are used in 2 different ways to provide telecommunications services to households in remote areas, including in the North. One way is a community aggregator model, through which C-band capacity is transported via satellite to a community earth station, which is connected to a local access distribution network, which then connects to individual households, businesses, and government buildings. During this inquiry, 96 communities in Canada were identified as receiving access to fixed voice and/or Internet services through this model. Bell Aliant, Ice Wireless, the Kativik Regional Government, K-Net, MTS Allstream, Northwestel, SSi, and other providers use this model to deliver their telecommunications services to end-users. The other approach is a direct-to-home model, through which service is delivered directly to households. Xplornet uses the direct-to-home model, using Ka-band capacity, to provide Internet services to all regions of Canada.

There is some disagreement in the industry as to which approach is best, both for now and into the future. C-band has the benefits of being the most resilient against weather and has less pronounced latency effects. Ka-band, on the other hand, can deliver higher broadband Internet speeds more efficiently, and new technologies are being used (such as spot beams) and developed (such as high-throughput satellites [HTS]) to increase capacities and speeds even further. Through this inquiry, it was concluded that both models have a role, and will continue to have a role in the future, in meeting the telecommunications needs of households and communities in remote areas of Canada, including the North.

HTS technology has considerable promise in changing the cost structure of satellite services used for telecommunications purposes, as current high-throughput services cost 1/10 of C-band services costs on a per-Mbps basis. This differential is expected to increase into the future as prices for bands with HTS capabilities are expected to decrease, while C-band prices are expected to increase. At present, there are 7 satellite-dependent communities using the community aggregator model that are within the footprint of HTS. Additional high-throughput capacity is expected to be in service by 2016; however, it does not appear that this capacity will be sufficient to meet the demands of all satellite-dependent communities and rural/remote households across Canada. It is noteworthy that approximately 1.2 million Canadian households do not have access to broadband Internet service at the Commission's target speeds (5 Mbps download and 1 Mbps upload). Roughly 18,000 of those households are located in satellite-dependent communities.

Thus, while HTS offers significant promise, there will be continued reliance on the more costly C-band services over the foreseeable future.

Over the years, the high cost of provisioning and maintaining telecommunications services to remote households and communities has been subsidized through a number of funding programs. Local voice service is subsidized through the Commission's National Contribution Fund. Internet services are subsidized through numerous federal, provincial, territorial, and municipal programs. Unfortunately, a large number of these programs are time limited, while the cost of satellite transport continues on as a recurring monthly expense.

Through the inquiry, the full satellite transport costs incurred by providers of telecommunications services that use the community aggregator model were examined. These costs include not only the space segment (satellite link) costs, but also the costs to build and maintain earth stations and electronic equipment, to supply power, etc. The cost estimates, provided by providers of telecommunications services, are varied due to a number of factors, such as the quantity or capacity purchased and the contract length, among others. Nevertheless, these estimates indicate that space segment costs are the largest costs incurred by the service provider. These estimates also show the huge difference between satellite transport costs compared to costs of terrestrial transport systems, with satellite transport being hundreds of times more costly than fibre-optic-based transport when compared on a per-Mbps basis.

Since satellite transport costs represent a large portion of the cost of delivering telecommunications services to satellite-dependent households and communities, it was an important part of this inquiry to consider the appropriateness of pricing levels of satellite transport now and into the future. Another consideration is that it is the responsibility of the Commission to ensure that the prices for satellite services are, and remain, just and reasonable and that they do not inappropriately inflate the amount of money (i.e. subsidies) required to fund these services. Therefore, during the inquiry, the regulatory framework that is currently in place for FSS was examined, as well as what the framework should be going forward.

The Commission has maintained minimal regulatory oversight of the satellite industry since the industry was opened to competition in 2000. Telesat is the only Canadian satellite operator, and it is subject to a price ceiling that was established approximately 15 years ago for certain C-band and Ku-band services.

Telesat's current position in the C-band market is, in part, a consequence of (i) its history as the initial, monopoly provider of satellite services in Canada, and (ii) a result of obligations placed on Telesat by Industry Canada's satellite regulatory framework. Telesat is required to provide ubiquitous C-band coverage of all of Canada, including the North. Also, Telesat is the only satellite operator that has been required to provide free transponder space to select providers of telecommunications services in the North. Further, the Ka-band spot beams from Telesat's Anik F2 satellite are the only Ka-band spot beams that cover the North. For these reasons, among others, Telesat is the dominant provider of FSS in the C- and Ka- spectrum bands in Canada.

Current market prices are significantly lower than the Commission's price ceiling for Telesat's C-band FSS. In assessing whether this regulatory framework remains appropriate, it was examined whether there is sufficient competition to protect the interests of providers of telecommunications services that rely on FSS for transport purposes. In performing this examination of the degree of competiveness in the Canadian satellite market, the methodology and criteria set out in Telecom Decision 94-19 were used.

This examination was limited to those geographic markets where (i) there are no terrestrial facilities, and (ii) communities are dependent on satellite transport services. Within these geographic areas, the Inquiry Officer considers that the different spectrum bands represent separate product markets, and that Telesat has market power within the C-band and Ka-band product markets. The analysis also shows that the future outlook for these 2 product markets, in terms of competition, is different. It is anticipated that Telesat will remain the dominant player in the C-band product market, and that there is not anticipated to be much new competitive entry to meet the needs of providers of telecommunications services, including the need for complete coverage of Canada to deliver real-time services, such as voice communications. The analysis did not result in the same conclusion for the Ka-band market, as there is evidence that new technologies and anticipated new entrants will sufficiently increase the level of competition within this product market such that regulatory oversight may not be required.

While no evidence was provided that Telesat has abused its market power, given its market power and the anticipated trends in the C-band market, the Inquiry Officer considers that Commission regulatory oversight is still required. Therefore, the Inquiry Officer recommends that the Commission initiate a proceeding to review the price ceiling for Telesat's C-band FSS, including a review of the types of C-band services to which the price ceiling should apply, and to adjust the price ceiling as appropriate.

1) Introduction

1. In rural and remote communities where the deployment of terrestrially based communications networks is challenging, many communities access some or all of their telecommunications services (e.g. voice, wireless, and broadband Internet) through fixed satellite services (FSS). One type of FSS is satellite transport, which is used by providers of telecommunications services in the long-haul section of their networks. This technology enables the provision of telecommunications services so that end-users in satellite-dependent communities can connect to the rest of Canada and to the world.

2. Governments and non-government institutions are providing an increasing number of services to citizens via the Internet. Access to telecommunications services in satellite-dependent communities is therefore important so that Canadians can access fundamental services such as health care, education, government programs, and banking.[i] Research on Northern communities also highlights the potential socio-economic benefits of increased connectivity.[1] Improved connectivity would increase the attractiveness of doing business in remote areas as well as improve the competitiveness of small and medium-sized businesses in these communities. Conversely, infrastructure deficits, including deficits in connectivity, have been found to be serious impediments to economic activity, adding to the costs of doing business and increases the logistical challenges involved in development in the North.[ii]

3. In Telecom Regulatory Policy 2013-711, the Commission stated that modern telecommunications services are necessary for economic development in the North.[iii] While many Northerners are adopting new communications technologies, they are restrained from using them effectively due to connectivity constraints.[iv,2]

4. During the Commission's public proceeding to review issues associated with Northwestel's regulatory framework (the Northwestel proceeding, initiated by Telecom Notice of Consultation 2012-669), interveners acknowledged that transport infrastructure, and in particular satellite transport and the associated costs of provisioning services over satellite, is a concern in the North.[v] Northern telecommunications service providers (TSPs) stated that it is technically feasible for them to offer broadband Internet service at the Commission's target download speed of 5 megabits per second (Mbps) and target upload speed of 1 Mbps (the 5/1 Mbps target speeds) in satellite-served communities, but that the cost of satellite transport is the biggest impediment to affordable broadband Internet services.

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[1] See, for example, Nordicity's *Northern Connectivity: Ensuring Quality Communications* report, January 2014; and the Strategic Networks Group's *An Assessment of the Socioeconomic Impact of Internet Connectivity in Nunavut* report (prepared for the Nunavut Broadband Development Corporation), 12 March 2012.

[2] For example, the Strategic Networks Group's *An Assessment of the Socioeconomic Impact of Internet Connectivity in Nunavut* report indicated that organizations and individuals in Nunavut are waiting for higher-capacity service to be able to effectively implement and use the appropriate electronic solutions that will support and accelerate local socio-economic development.

5. The Commission indicated in the resulting decision (Telecom Regulatory Policy 2013-711) that there was insufficient information on the record of the proceeding to make an informed decision on issues related to satellite transport services provided in Canada. Therefore, the Commission indicated that it would launch an inquiry in 2014 to gain a better understanding of the satellite transport services that are or can be used to provide telecommunications services in Canada.[vi]

Consultation process

6. The Commission issued Telecom Notice of Consultation 2014-44 on 6 February 2014, in which it appointed Commissioner Candice Molnar as an Inquiry Officer pursuant to section 70 of the *Telecommunications Act* to conduct an inquiry with respect to the Canadian marketplace for satellite services that TSPs[3] use to provide telecommunications services to Canadians.[vii] As part of the notice, interested persons were invited to identify themselves and file submissions with the Inquiry Officer. The Inquiry Officer issued a letter, dated 22 April 2014, to satellite operators and interested persons, and subsequently issued various requests for information to stakeholders. Parties were given an opportunity to reply.

7. The Inquiry Officer met with a number of stakeholders who identified themselves pursuant to the Notice of Consultation as having an interest in the inquiry. Background research was also conducted, and a list of relevant literature is included in Appendix G of this report. In addition, Northern Sky Research's[4] 2014 report entitled *Global Satellite Capacity Supply & Demand* was purchased and information from the report was used as the basis for some of the findings in this report. All information relied on by the Inquiry Officer in analysis and determinations is included in this public report (as included in tables, graphs, and statements).

8. Electronic versions of the submissions and related documents are available on the Commission's website at www.crtc.gc.ca by using file number 8663-C12-201401041.

Scope of the inquiry

9. As outlined in Telecom Notice of Consultation 2014-44, the inquiry focused on the following areas:
    i. satellite services provided by satellite operators to TSPs, including
        a) which satellite operators are providing services to Canadian TSPs
        b) the rates TSPs pay for satellite services and how these rates are established
        c) technical limitations on satellite services that affect the quality of services that TSPs can provide

[3] Although the Notice of Consultation referenced in this section uses the term "telecommunications service providers (TSPs)," the full scope of providers considered in this inquiry includes a broader category of entities that are referred to in this report as "providers of telecommunications services" as they can include entities that provide telecommunications services other than basic telecommunications services.

[4] Northern Sky Research is a market research and consulting firm that provides service to the global satellite industry.

d) current and future satellite capacity that is available to TSPs to provide telecommunications services to Canadians

e) potential changes to technology, the competitive environment, sources of funding, or the regulatory environment that may affect the rates, quality, and/or capacity of satellite services in the future

f) whether the Commission's existing regulatory framework for satellite services remains appropriate, and, if not, what changes are required

ii. the use of satellite services by TSPs to provide telecommunications services, including

a) which TSPs use satellite services, where these TSPs operate, the numbers of customers who have access to their services and the numbers of customers they serve, what services they deliver to end-users, and what, if any, limitations apply to these services

b) the costs to a TSP of providing telecommunications services by way of satellite technology, both in terms of the rates charged by satellite operators and the costs that TSPs bear for ancillary infrastructure, such as ground stations, and sources of funding that impact the overall costs to TSPs

c) potential changes to the TSPs' costs arising from technological or other changes

10. While there are alternatives to satellite transport (i.e. fibre and microwave) these were not evaluated as part of the inquiry. The purpose of this inquiry is to inform the Commission on the satellite transport services in Canada and their role in meeting the needs of Canadians' telecommunications services requirements. The inquiry will also inform the Commission's future proceeding in which it intends to establish a mechanism to fund infrastructure investment in transport facilities in Northwestel's operating territory, as outlined in Telecom Regulatory Policy 2013-711. Since the inquiry is focused on satellite transport, last-mile network subsidies were not considered. The Commission has previously announced that it will undertake a comprehensive review of basic telecommunications services to determine what services (e.g. voice and broadband Internet) are required by all Canadians to fully participate in the digital economy and whether there should be changes to the subsidy regime and the national contribution mechanism.[5] As such, these issues were not considered as part of this inquiry.

Areas of consideration and layout of the report

11. Consistent with the scope of the inquiry, this report identifies the stakeholders, namely satellite operators, providers of telecommunications services, communities, and governments, and describes the current state of telecommunications services in satellite-dependent communities. The report then considers FSS pricing, costs to providers of telecommunications services (including space segment costs and costs on the ground), and the costs of offering Internet services in satellite-dependent communities that meet the Commission's 5/1 Mbps target speeds.

[5] Further information on the Commission's review of basic telecommunications services can be found in the CRTC Three-Year Plan 2014-2017

12. Looking forward, the report then examines future FSS prices and efficiencies, particularly the potential of high-throughput satellites (HTS), and notes some considerations brought forward by parties relating to subsidizing satellite transport. Finally, the report examines the regulatory environment, including whether the Commission's existing regulatory framework for FSS remains appropriate.

13. Appendix A consists of a glossary of complex terms used in the report. Appendix B provides background information on satellite technology. Appendix C provides a list of communities that obtain telecommunications services through satellite transport using the community aggregator model. Appendix D describes government programs and subsidies for satellite services. Appendix E elaborates on cost and technology efficiencies. Appendix F contains a list of parties that participated in the inquiry, including the full names and short forms of certain organizations mentioned in the report. Finally, Appendix G provides a list of relevant literature.

2) Background

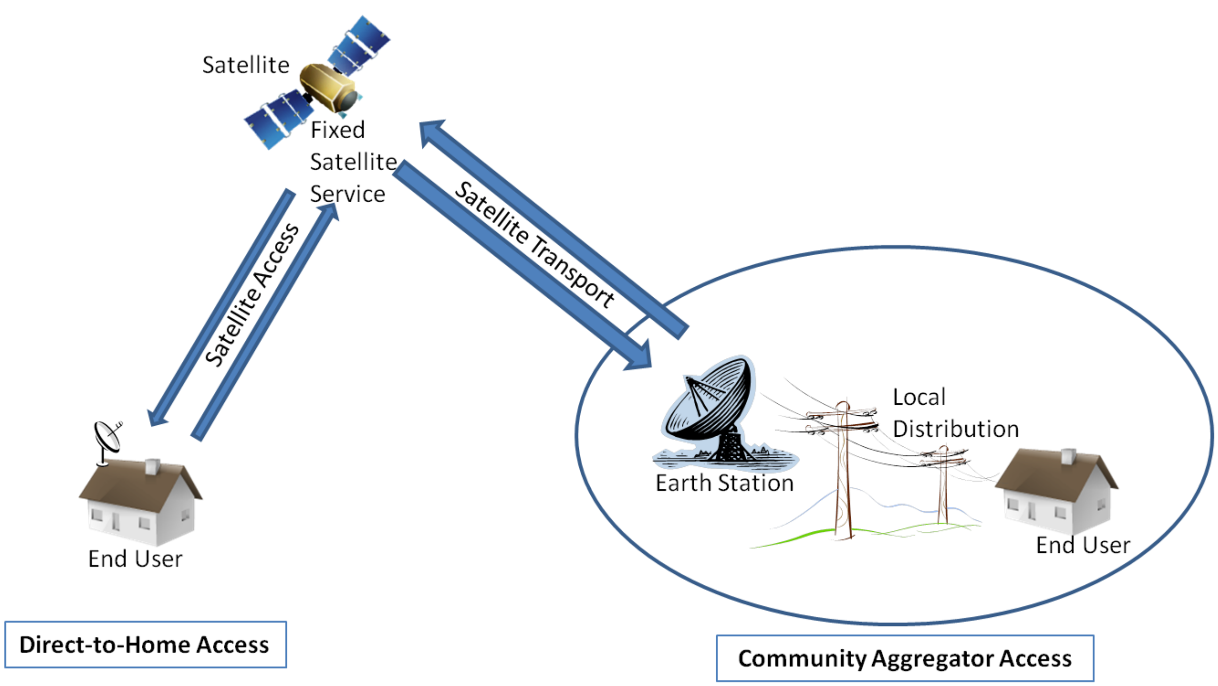
Key points

- *In communities that depend on satellite for telecommunications services, these services are provided in one of two ways:*
  - *through a community aggregator model: this uses a local access distribution network that connects end users to an earth station using satellite transport, which can support both voice and data services. This model is suitable for voice, data and broadband services due to low latency effects; or*
  - *through a direct-to-home model, through which satellite access connects end-users directly to a satellite. This model is primarily used for data and broadband services due to more pronounced latency effects.*

Satellite network overview

14. The figure below shows the two ways in which fixed satellite service is used to provide telecommunications services to end-users: 1) through a direct-to-home model, through which satellite access is provided directly to end-users, and 2) through a community aggregator model, through which satellite transport provides a link between a satellite and an earth station, and local access is subsequently provided to end-users. This figure is followed by key terms and definitions that are used in the report. Additional terms and definitions can be found in the Glossary in Appendix A.

Figure 2.1: Direct-to-home and community aggregator models



Definitions

Community: In this report, a community is where there is a group of households, businesses, and/or government buildings. Also see definitions of **satellite-dependent community** and **partially dependent community** for communities considered in this report.

Earth station: a terrestrial installation, consisting of an antenna (also known as a dish), electronics, and electrical systems, that communicate with a satellite to enable communications services, provided that the earth station is located within the satellite footprint (the area that the satellite covers). The earth station is often recognized by the antenna, which can be small (less than a metre in diameter) or very large (greater than 10 metres in diameter). The choice of antenna depends on the frequency band to be used. Also included in the earth station is the modem, which sends and receives signals to and from the satellite and, in the case of traditional fixed satellite service systems, converts the satellite capacity into a usable format (mostly megabits per second).

Earth station operator: an entity that owns and/or operates one or more terrestrial transmitting/receiving stations that communicate with a satellite(s) to provide communications services.

End-users: retail customers who purchase communications services (including Internet access) at retail rates and who do not, in turn, sell these services to other customers.

Fixed satellite service (FSS): a radio-communications (either one-way or two-way) link, transport or backhaul service between earth stations or other types of terrestrial antenna, such as those used for direct-to-home services, and a satellite, where the satellite stays in the same position relative to the earth station(s)/antenna(s) that are linked to that satellite.

Partially satellite-dependent community: a community that may have some form of terrestrially based telecommunications facilities (e.g. micro-wave) for some telecommunications services (e.g. voice services) but no suitable terrestrial facilities for other telecommunications services (e.g. broadband Internet service), which must be provided via satellite.

Provider of telecommunications services: In the context of this report, an entity that provides telecommunications services, such as voice, wireless (both fixed and mobile), or Internet services to end-users in Canada. These entities typically provide their telecommunications services over either owned or leased in-community wired or wireless distribution networks. In satellite-dependent communities, these distribution networks are typically connected to an earth station for carriage of voice and data traffic to the public switched telephone network and/or the Internet.

These entities may also provide **direct-to-home** satellite-based communications services, without the need for a terrestrially-based network to deliver services to their end-users.

Satellite access: the one-way or two-way wireless path between an antenna at an end-user's location and a satellite over which communications is passed for the provision of direct-to-home satellite service.

Satellite-dependent community: a community that has no connection to terrestrially based telecommunications facilities for connection to the public switched telephone network (PSTN) and/or the Internet, and that relies on satellite transport to receive one or more telecommunications services (such as voice, wireless [both fixed and mobile], and Internet services).

Satellite link: wireless path between an earth station (known as the ground segment) and a satellite (known as the space segment) using spectrum allocated to fixed satellite services, which is used for the delivery of commercial telecommunications services.

Satellite operator: a licensed entity that is authorized to own or operate satellites and provides commercial satellite services to customers.

Satellite transport: the one-way or two-way communications link between an earth station and a satellite over which communications is passed for the provision of communications services.

3) Stakeholders

Key findings

- *Communities that rely on the community aggregator model for their telecommunications services are located outside densely-populated areas of Canada, and in all provinces and territories except for Atlantic Canada and Alberta.*
- *83 communities rely on the community aggregator model for fixed voice services, and 89 communities rely on it for Internet access. Of these, 76 communities rely on the community aggregator model for both fixed voice services and Internet access.*
- *Placement of satellites into space is a licensed process that is administered on a global and national level, and there is a finite number of orbital positions.*
- *9 satellite operators have fixed satellite service (FSS) satellites that are approved for use in Canada. During this inquiry, 3 satellite operators identified that they provide FSS to providers of telecommunications services in Canada.*
- *Telesat is the only Canadian satellite services provider operating in Canada. It is the 4th largest satellite operator in the world.*
- *Providers of telecommunications services that use satellite transport services consist of incumbent local exchange carriers (ILECs), mobile service providers, competitors, First Nations groups, and governments.*
- *Governments have been an important source of funding for telecommunications services in satellite-dependent communities. Multiple initiatives have been undertaken by governments at all levels to expand access and improve services in these communities.*
    - *Regarding voice services, the Commission's National Contribution Fund subsidizes local residential telephone services in high-cost serving areas, including in satellite-dependent communities.*
    - *Regarding Internet access, federal, provincial/territorial, and municipal governments have undertaken a wide range of programs and subsidies. These have included the provision of satellite capacity and funding for the construction of ground infrastructure for the community aggregator model, as well as a reduction in the cost of direct-to-home broadband service.*

Communities

15. The Inquiry Officer issued a letter to stakeholders, dated 2 June 2014, that contained a list of over 200 communities that were believed to receive telecommunications services by way of satellite transport. Parties that provided comments on the list included providers of telecommunications services (i.e. Bell Aliant, Bell Mobility, Ice Wireless, MTS Allstream, the Northern Indigenous Community Satellite Network [NICSN], Northwestel, SaskTel, SSi, and TCC), and satellite operators (i.e. Hughes and Telesat).

16. Based on the input received from these parties, the community list in the 2 June 2014 letter was updated. 96 communities were identified that receive fixed voice services and/or Internet access through the community aggregator model. Specifically,

    - 83 communities receive fixed voice services through the community aggregator model.

- 7 of these communities have access to fixed voice services using the community aggregator model, but rely on the direct-to-home model for Internet services.

- 89 communities receive Internet access through the community aggregator model.[6]
  - 13 of these communities receive Internet access through the community aggregator model, and receive fixed voice services via terrestrial backhaul.
- Overall, 76 communities receive *both* fixed voice services and Internet access through the community aggregator model.

17. As identified in the table below, the communities that receive fixed voice services and/or Internet access through the community aggregator model are located in all three territories, as well as in British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec. None of these communities are located in Alberta or in Atlantic Canada. Detailed lists of these communities are included in Appendix C, and further information on the telecommunications services that these communities receive, including the limitations of these services, is included in section 4 of this report.

Table 3.1: Communities that receive telecommunications services through the community aggregator model (by province and territory)

Province/ territory	Voice and Internet	Only voice	Only Internet	Total
BC	0	3	0	3
AB	0	0	0	0
SK	0	2	0	2
MB	9	1	11	21
ON	10	0	0	10
QC	17	1	2	20
NB	0	0	0	0
NS	0	0	0	0
PE	0	0	0	0
NL	0	0	0	0
YK	2	0	0	2
NT	13	0	0	13
NU	25	0	0	25
Total	76	7	13	96

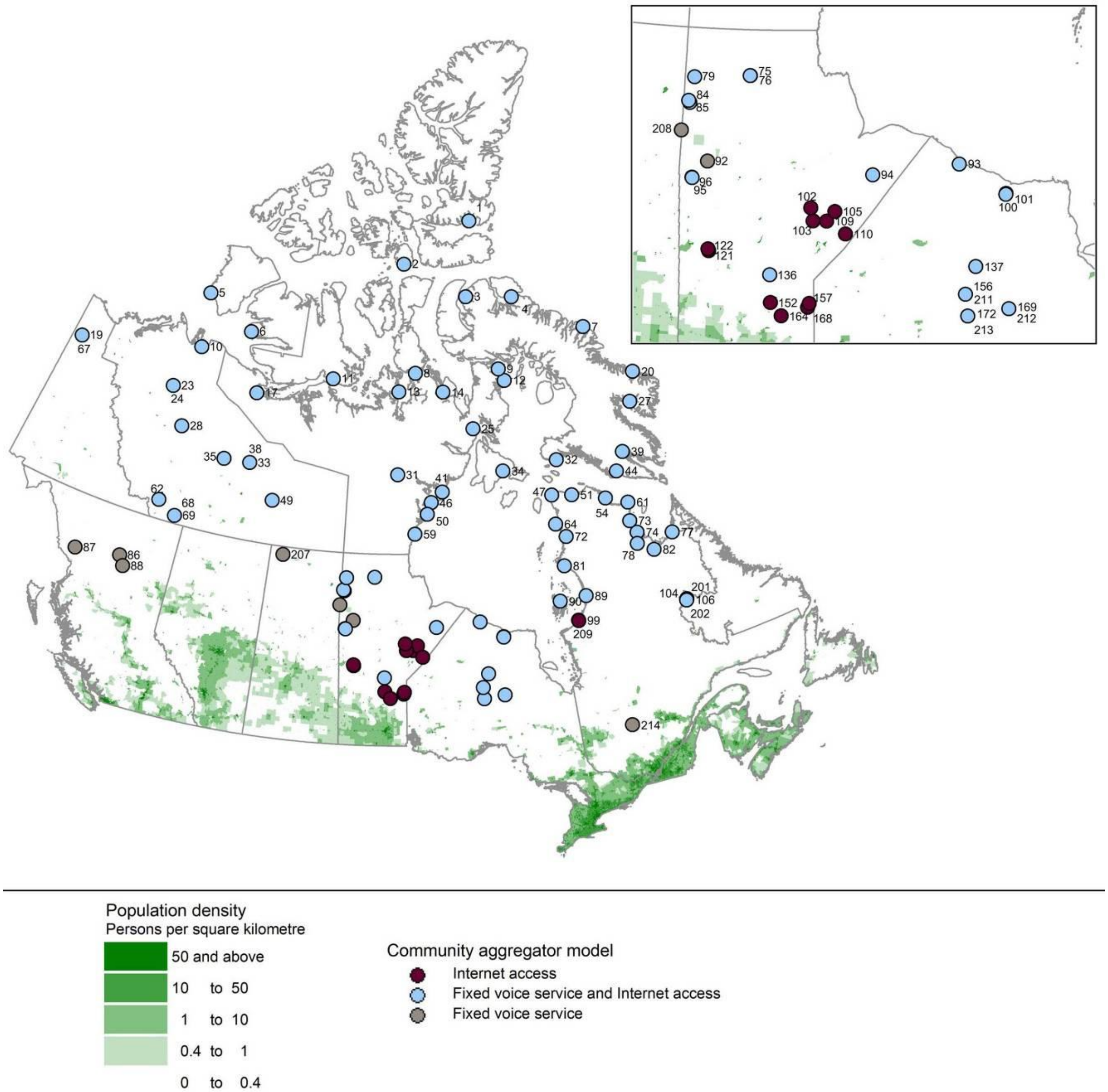
83 communities that receive fixed voice services

89 communities that receive Internet access

[6] These communities also have access to Xplornet's direct-to-home Internet service. Further details are included in section 4 of the report.

18. The following map shows that these communities are located in remote areas outside any densely populated areas.

Figure 3.1 Communities that receive fixed voice services and/or Internet access through the community aggregator model



Satellite operators

19. Both domestic and foreign satellite operators provided submissions during the inquiry. In 2000, the Canadian market was opened to competition, which permitted foreign satellite operators to offer

service in Canada. Telesat submitted that 87 foreign satellites[7] have been authorized to provide FSS in Canada and could offer satellite transport service in satellite-served communities.[8] Based on Industry Canada information, and including domestic satellite operators, the following 9 satellite operators operate FSS satellites that are approved for use in Canada:

- Ciel Satellite Group: www.cielsatellite.ca
- Echostar Corporation: www.echostars.com
  - Echostar also includes Hughes, a wholly owned subsidiary of Echostar – www.hughesnet.com
- Eutelsat: www.eutelsat.com
  - Satmex was acquired by Eutelsat in 2014.
- Hispasat: www.hispasat.com
- Horizons Satellite LLC (a joint venture between JSAT and Intelsat): www.horizonsat.com
- Intelsat: www.intelsat.com
- SES: www.ses.com
- Telesat: www.telesat.com
- ViaSat: www.viasat.com

20. Telesat is the main satellite operator that provides FSS in Canada. Telesat provides satellite services using the Anik series of satellites (Anik F1R, Anik F2, and Anik F3), and owns the Canadian payload on ViaSat's ViaSat 1 satellite. Of the 9 satellite operators mentioned above, only the following 3 identified themselves during the inquiry as providing FSS to providers of telecommunications services in Canada: Hughes (a wholly owned subsidiary of EchoStar Corporation), SES (through its affiliate New Skies Satellites), and Telesat. Hunter anticipated offering FSS on the Ku-band starting in June 2014 using satellite capacity from Eutelsat America's Satmex 5 satellite, but Hunter does not currently have any executed agreements. While Intelsat, Eutelsat America Corp., and Ciel Satellite Group indicated that they do not offer satellite service in Canada to providers of telecommunications services at this time, some of their satellites do have coverage of Canada. Each company's satellite coverage can be found on their respective websites.

Providers of telecommunication services that use satellite services

21. Providers of telecommunications services that use satellite transport to deliver services (e.g. voice and broadband Internet services) to the satellite-dependent communities were identified in the inquiry. The following is a list of the providers of telecommunications services that provided information during the inquiry, and the satellite-dependent (or partially satellite-dependent) communities in which they operate.

- Bell Aliant: offers fixed voice services and business data services in certain remote areas of northern Ontario and northern Quebec.

[7] Of note, some satellite operators own multiple satellites that are authorized to provide FSS in Canada.

[8] Industry Canada provides a List of Satellites Approved to Provide Fixed-satellite Services (FSS) in Canada, including foreign satellites.

- Bell Mobility: offers mobile phone and data services to Old Crow, Yukon, and to several communities in Nunavut. The company also provides 2-way radio service to support certain emergency dispatching services in a number of remote communities in Northern Ontario.
- Broadband Communications North (BCN): offers fixed wireless Internet services to certain communities in Manitoba.
- Ice Wireless: offers fixed voice, mobile voice, and mobile broadband Internet services to Iqaluit.
- the Kativik Regional Government (KRG): offers broadband Internet, Internet Protocol (IP)-based videoconference, and private broadband IP services to certain communities in northern Quebec.
- K-Net: offers mobile phone and broadband connectivity services to certain communities in northern Ontario and northern Quebec.
- Lynx Mobility: offers mobile phone services to certain communities in Nunavut and in northern Quebec.
- MTS Inc.: offers local fixed voice services to certain communities in Manitoba using satellite transport.
- Northwestel: offers retail and business fixed voice services to certain communities in the Northwest Territories and Nunavut, in parts of northern British Columbia, and in Old Crow, Yukon. In addition, Northwestel provides many of these communities with broadband Internet and mobile phone services, including 4G services to some communities.
- SaskTel: offers residential fixed voice services to two communities in northern Saskatchewan (Kinoosao and Uranium City). The company also offers those two communities Internet access via satellite, in partnership with Xplornet. In addition, the company offers broadband wide area network (WAN) service using FSS to several schools, libraries, highway transport offices and police stations located throughout the province.
- SSi: offers Internet access to communities in Nunavut and certain communities in the Northwest Territories.
- TCC: offers residential fixed voice services to one community (Tsay Keh Dene) in northern British Columbia.

22. The Inquiry Officer notes that Xplornet offers Internet access through the direct-to-home model everywhere in Canada, including to all communities that also use the community aggregator model.[9]

23. Additionally, Juch-Tech operates a carrier-neutral teleport providing a variety of satellite services, including services to northern Canada.

[9] Galaxy Broadband Communications Inc. also provides similar direct-to-home service; however, it did not participate in this inquiry.

Governments' roles and responsibilities

24. Satellites are regulated on a global and a national level. The International Telecommunication Union (ITU) administers orbital positions and frequency use. Nationally, Industry Canada administers the orbital positions and spectrum that have been assigned to Canada, as well as the earth stations that operate within Canada.

ITU

25. The ITU and national spectrum regulators have adopted rules to authorize and coordinate satellite deployments across the globe. In doing so, they have defined different satellite services, consisting of FSS, mobile satellite service, and broadcasting satellite service to ensure that there is sufficient spectrum for different purposes.

26. Canada is a state party to the Constitution and Convention of the ITU and its complementary Administrative Regulations. Consequently, Canada follows the ITU's coordination process for licensing satellites. Canada has negotiated agreements with other countries and has successfully obtained orbital positions and spectrum for Canadian administration and licensing by Industry Canada.

Government of Canada (Industry Canada)

27. Industry Canada is the department responsible for the technical aspects of satellite use in Canada as well as policies on the use of satellites in Canada. The department licenses satellites for Canadian orbital positions, obtains spectrum, and approves the earth stations that are used to communicate with satellites. It also develops and publishes policies and regulations concerning satellite use in Canada. To obtain a licence to provide satellite services to Canadians, a satellite operator must meet Industry Canada's requirement that the footprint of any FSS satellite used to provide services in Canada must cover all of Canada,[10] including communities in the North.[11] This requirement does not apply to the use of foreign FSS satellites that provide service to the Canadian market.

Satellite coordination and licensing process

28. Presently, under the coordination process that the ITU administers, a satellite operator must coordinate its satellite(s) to avoid creating interference with other operating satellites. The ITU uses a first-come, first-served process in which a country sends it an application/coordination package (e.g. Industry Canada would send the package on behalf of Canada). This package contains information regarding the satellite network, and is usually submitted in conjunction with the satellite operator.

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[10] Based on Industry Canada's *Policy Framework for Fixed-Satellite Service (FSS) and Broadcasting-Satellite Service (BSS)*, published in November 2013, a geostationary satellite positioned in the Canadian arc is required to cover the entire Canadian territory visible from the satellite.

[11] Presently, Telesat is the only satellite operator that consistently covers all of Canada, including remote areas in the North.

29. This process for licensing a satellite can last up to 7 years. Given this time commitment and the significant capital investments associated with satellites and their supporting networks, satellite operators tend to keep their orbital positions. Therefore, as part of the coordination and licensing process, applications are also submitted (by Industry Canada on behalf of Canada) to the ITU in order to retain both spectrum and orbital positions, and to add services when new frequency bands are opened for licensing.

30. A number of orbital positions secured by Canada are considered ideal to serve all of Canada, including the northernmost communities. While Canada has secured orbital positions and spectrum, Canada can license them to non-Canadian satellite operators. Even though Canada has secured access to certain orbital positions and FSS spectrum, and even with a first-come, first-served process, other countries are not prevented from submitting applications for the same orbital positions and spectrum.

Canadian Radio-television and Telecommunications Commission

31. The Commission is responsible for regulating the rates, terms, and conditions of the satellite services provided to Canadians. The Commission has maintained minimal regulatory oversight of the satellite industry since the year 2000, when the Commission partially forbore, under the *Telecommunications Act*, from regulating Telesat, and established a price ceiling for some of Telesat's FSS. The Commission's current regulatory requirements for other satellite operators that provide service in Canada are very minimal, consisting of registration with the Commission in the "Other Carriers" category, completion of associated forms, annual information filing, and demonstration that the satellite operators own transmission facilities that are exempt from Canadian ownership and control requirements.

Governments as a source of funding

32. In rural and remote areas of Canada, where the economic incentives are low for private sector deployment of telecommunications services, government intervention has expanded access to these services. Multiple initiatives have been undertaken by governments at all levels across Canada to improve telecommunications services, many of which include satellite services as a component. Government initiatives and subsidies have enabled the construction of ground infrastructure and the acquisition of satellite capacity for broadband access to be offered in rural and remote areas through the community aggregator model, and funded direct-to-home service to expand access in unserved areas. For voice services, the National Contribution Fund continues to provide a sustained industry-based revenue mechanism that subsidizes residential telephone services in high-cost serving areas, including in satellite-dependent communities. A non-exhaustive list of sources of satellite funding (including initiatives and funding that apply to satellite services) is provided in Appendix D.

4) State of telecommunications services in communities that use satellite services

Key findings

- *There are 83 communities with a total of 16,553 households that have access to fixed voice services through the community aggregator model.*
- *There are at least 20 communities that have access to 4th generation (4G) mobile services (voice and Internet). However, some satellite-dependent communities do not have access to any mobile wireless services, while others only have access to wireless networks using older technologies with low data speeds.*
- *There are 89 communities that have access to the Internet through the community aggregator model; however, none of these communities meet the Commission's broadband Internet service target speeds of 5 Mbps (download speed) and 1 Mbps (upload speed) [the 5/1 Mbps target speeds] using this model.*
    - *These communities are also covered by Xplornet for direct-to-home satellite Internet service; however, only 7 of these communities have access to broadband Internet service at speeds that meet the 5/1 Mbps target speeds.*

Introduction

33. To gather information on the current state of telecommunications services in satellite-dependent communities, the Inquiry Officer requested information from providers of telecommunications services regarding the services they offer (e.g. voice, wireless, and Internet) in these communities via satellite transport, and any limitations to these services. This section discusses the state of telecommunications services in communities that obtain them using satellite services.

Wireline voice retail market sector

34. In 2013, over 100 providers of local telephone services were operating throughout Canada.[viii] On average, there were between 3 and 9 local service providers in major urban centres,[ix] and typically one local service provider (typically the incumbent local exchange carrier [ILEC]) in communities that rely on fixed satellite services (FSS).

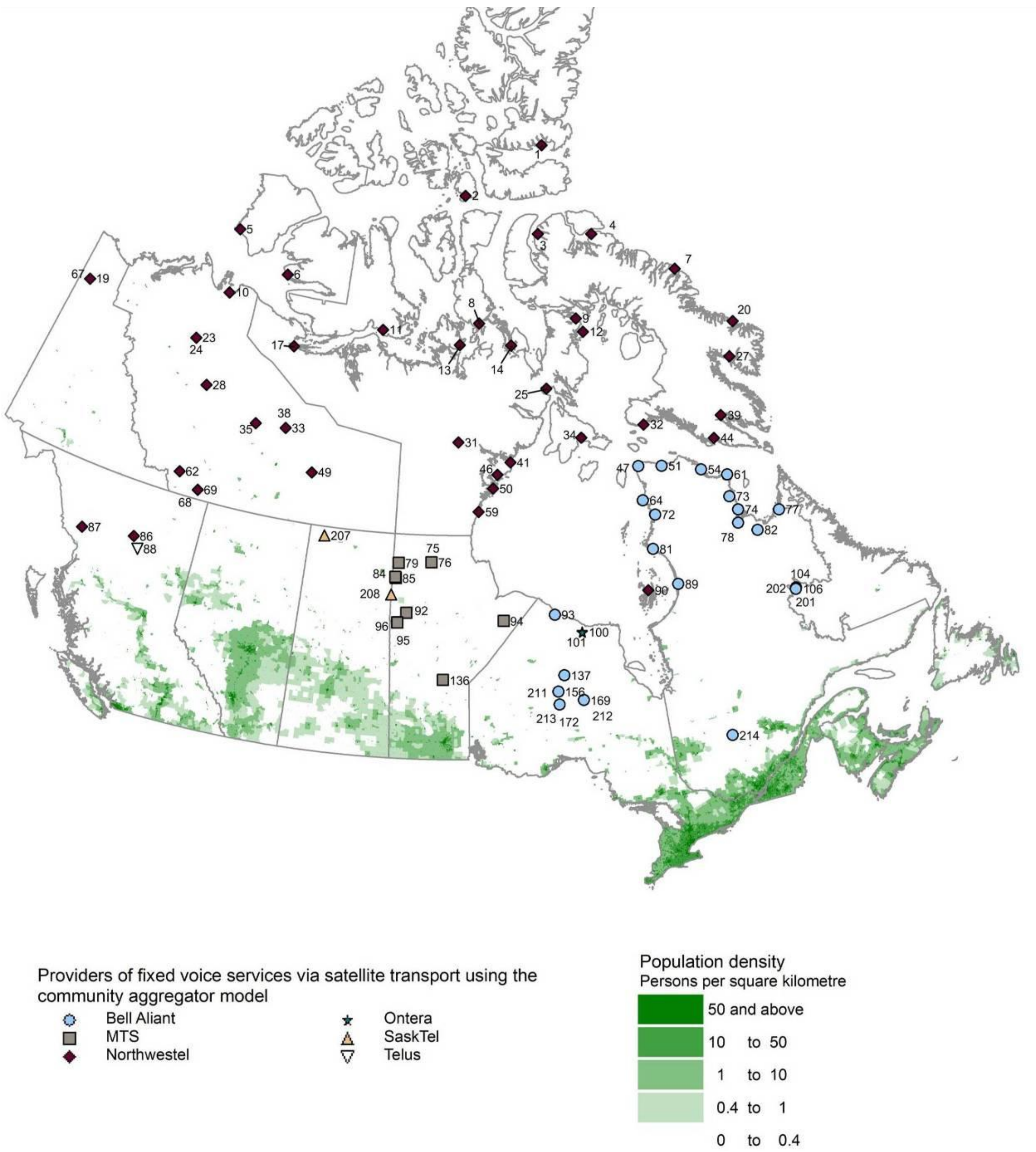
35. As indicated in the following table, 83 communities rely on FSS via community aggregator earth stations to receive fixed voice services. These communities are located in all three territories, as well as in remote areas of British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec. In total, over 16,000 households have access to fixed voice services using the community aggregator model.

Table 4.1: Numbers of communities and households that rely on satellite transport using the community aggregator model to offer end-users fixed voice services

Province/territory	# of communities	# of households
BC	3	132
SK	2	46
MB	10	1,261
ON	10	1,219
QC	18	3,898
YK	2	110
NT	13	788
NU	25	9,099
Total	**83**	**16,553**

36. The following map indicates that those communities are located outside any densely-populated areas. The providers of telecommunications services serving those communities are Bell Aliant, MTS Allstream, Northwestel, Ontera, SaskTel, and TCC.

Figure 4.1: Communities that rely on satellite transport using the community aggregator model to offer end-users fixed voice services



Mobile wireless retail market sector

37. Mobile wireless networks cover approximately 20% of Canada's geographic land mass and reach 99% of Canadians. In contrast, wireless coverage is available to 84% of the population in Canada's North (Yukon, Northwest Territories, and Nunavut).[x] In 2013, advanced wireless services (e.g. Evolved High-Speed Packet Access (HSPA+) were available to 99% of Canadians across the country, compared to 58% of Canadians in the North. The long-term evolution (LTE) network, which delivers even higher speeds than previous generation networks, was available to approximately 81% of Canadians across the country, compared to 42% of Canadians the North.[xi]

38. While the majority of Canadians have access to LTE technology, there are communities with satellite ground infrastructure that do not receive any mobile services (e.g. 12 communities in Nunavut). Other communities are accessing older technologies with lower data speeds while others are accessing newer, but not current, technologies such as Global System for Mobile Communications (GSM) technology (for instance HSPA and HSPA+). Some providers offer more advanced wireless services in satellite-dependent communities through FSS. For example, Northwestel offers 4G mobile service to 12 communities in the Northwest Territories and 8 communities in Nunavut, and Ice Wireless offers 3G mobile service in Iqaluit.

Internet market sector and broadband availability

39. In Telecom Regulatory Policy 2011-291 (the Obligation to serve decision), the Commission recognized that Internet service is becoming an increasingly important means of communication. The Commission established the national 5/1 Mbps target speeds for broadband Internet access mentioned above. The Commission expects all Canadians to have access to the 5/1 Mbps target speeds by the end of 2015.

40. According to the 2014 CRTC Communications Monitoring Report, 95% of Canadian households have access to a 5 Mbps download speed. Of these, as of December 2013, 91%[xii] also had access to a 1 Mbps upload speed.

41. As indicated in the following table, 89 communities rely on the community aggregator model to access high-speed Internet. Notably, none of these communities meet the Commission's 5/1 Mbps target speeds. Of these communities,

    - 15 receive high-speed Internet access below 1.5 Mbps download, and
    - 74 receive broadband Internet at or above 1.5 Mbps download.

42. Iqaluit is the only community that receives broadband Internet at a 5 Mbps download speed through the community aggregator model. Northwestel provides broadband service with a 5 Mbps download speed; however, this service does not meet the 5/1 Mbps target speeds since it includes an upload speed of only 512 kilobits per second (kbps).

Table 4.2: Communities that have Internet access through the community aggregator model

Province/ territory	No. of communities (comm)	No. of households (HHs)	Less than 1.5 Mbps		Between 1.5 Mbps and 4.99 Mbps		At or above 5 Mbps down *and* 1 Mbps up	
			No. of comm	No. of HHs	No. of comm	No. of HHs	No. of comm	No. of HHs
MB	20	3,177	--	--	20	3,177	0	0
ON	10	1,219	10	1,219	0	0	0	0
QC	19	3,860	4	169	15	3,691	0	0
YK	2	110	--	--	2	110	0	0
NT	13	788	1	36	12	752	0	0
NU	25	9,099	--	--	25	9,099	0	0
Total	**89**	**18,253**	**15**	**1,424**	**74**	**16,829**	**0**	**0**

Note: This table assigns households to the highest broadband speeds available in the community. It does not indicate whether the community also has access to lower Internet speeds.

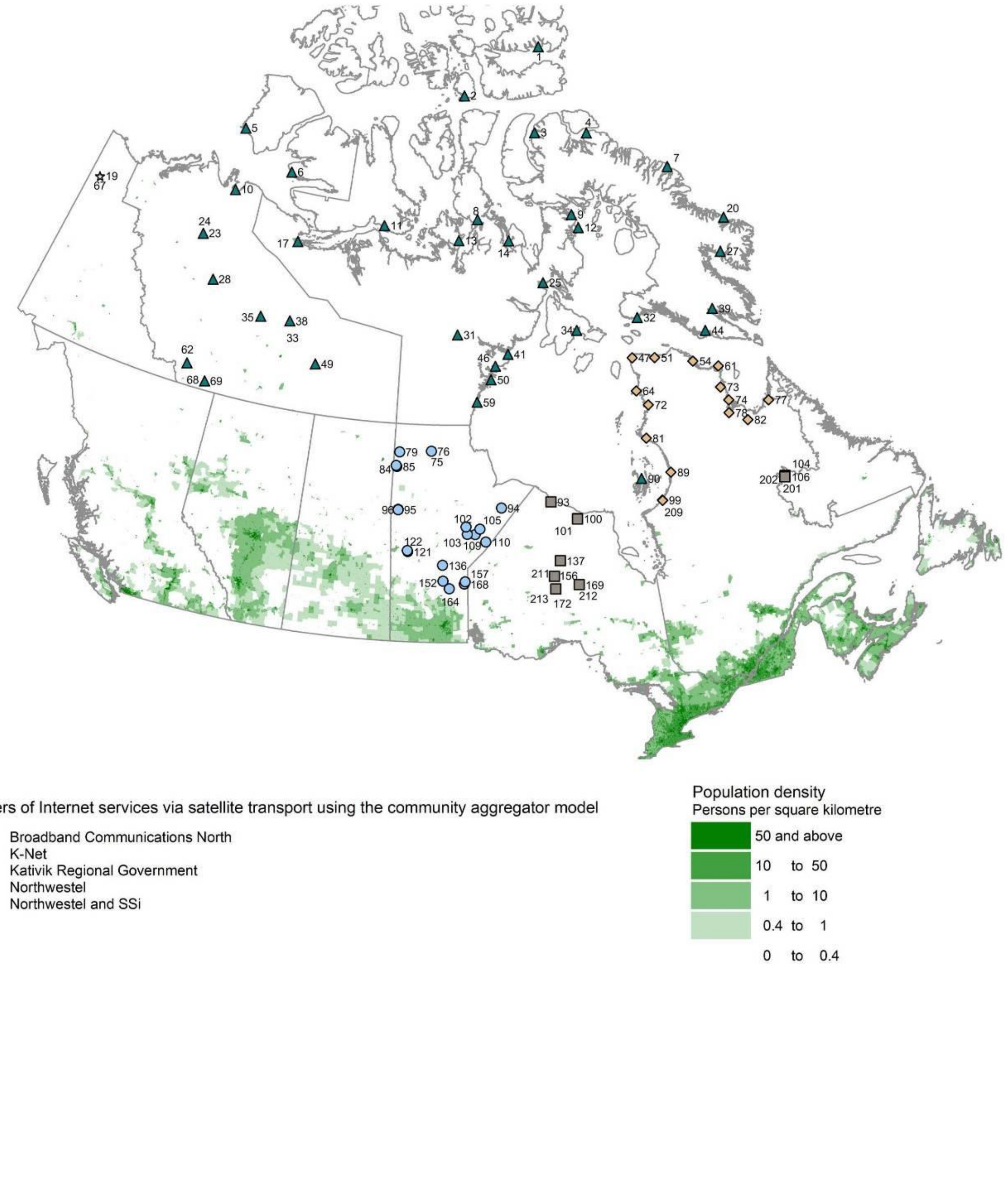
43. These 89 communities also have access to Xplornet's direct-to-home satellite Internet service. Seven of these communities[12] are located in Manitoba, where Xplornet[13] offers a 10 Mbps direct-to-home broadband Internet service. At the time of writing this report, the remaining communities generally had access to Xplornet's 3 Mbps download direct-to-home broadband Internet service.

[12] These seven communities are Berens River, Bloodvein, Little Grand Rapids, Moose Lake, Mosakahiken Cree Nation, Pauingassi First Nation, and Poplar River First Nation.

[13] Details of Xplornet's service can be found on its website.

44. The following map indicates that the 89 communities are located outside of any densely populated areas in all three territories, as well as in remote areas of Manitoba, Ontario, and Quebec. The communities are served by Broadband Communications North (BCN), K-Net, Tamaani Internet (the Kativik Regional Government [KRG]), Northwestel, and SSi.

Figure 4.2: Communities that have Internet access through the community aggregator model



5) Satellite coverage and capacity

Key findings

- *Three frequency bands are used in Canada for commercial fixed satellite service (FSS): C-band, Ku-band, and Ka-band. These bands have different characteristics that result in differing uses of these bands for specific applications, including telecommunications services.*
  - *C-band is commonly used to provide transport service to deliver voice, mobile, and high-speed Internet access services, through a community aggregator model.*
  - *Ku-band is mostly used for broadcasting and broadcasting distribution services.*
  - *Ka-band is mostly used to deliver Internet access services directly to end-users.*
- *New Ka-band high-throughput satellite (HTS) technology has been introduced in the market, including in Canada, and it is used to dramatically increase the amount of satellite capacity.*
- *C-band and non-HTS Ka-band cover all of the 89 communities that rely on the community aggregator model, while the new HTS Ka-band covers only 7 of these communities.*
- *A significant portion of C-band capacity on Telesat's satellites remains available (unused), which could be used by providers of telecommunications services to improve telecommunications services to Canadians. Other satellite frequency bands (Ku- and Ka-band) on Telesat's satellites have little to no spare capacity.*
- *Xplornet has acquired most of the Canadian Ka-band capacity on both HTS and non-HTS satellites.*

Satellite coverage

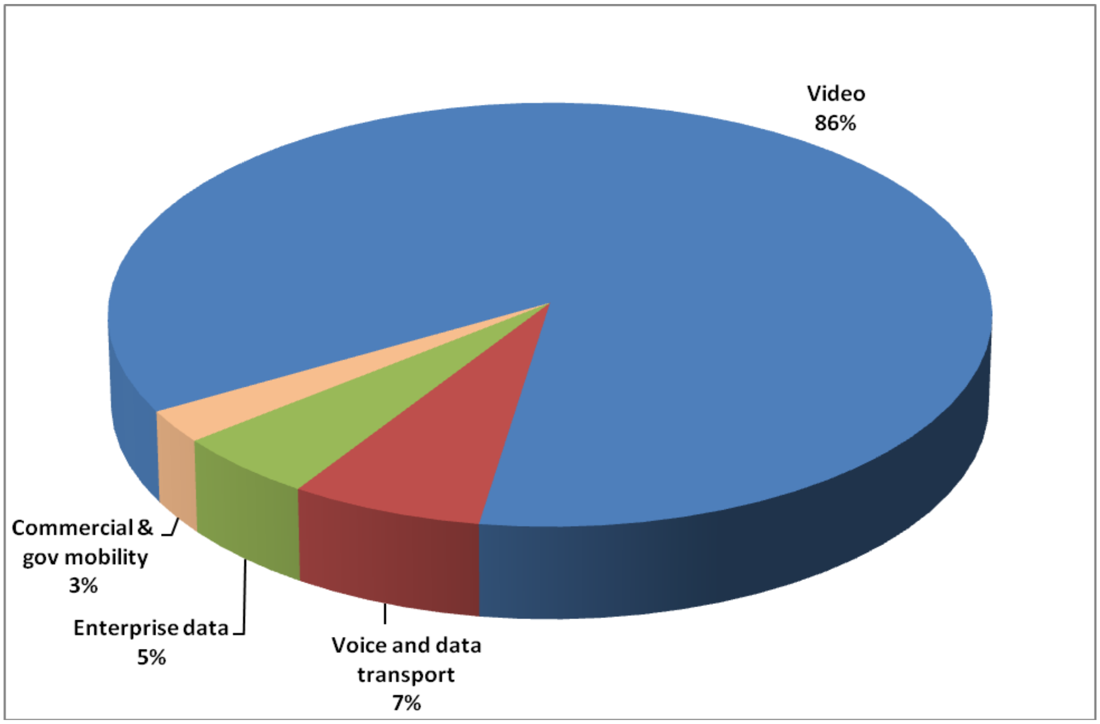
Frequency bands

45. Three different frequency bands are used for commercial FSS. Each frequency band is divided in two: one portion is reserved for communications from the antenna to the satellite (uplink), and the other is reserved for the reverse direction (downlink). The characteristics of these bands are summarized below. For details on the technical aspects of satellite and frequency bands, refer to Appendix B.

46. The **C-band** was historically the first frequency band allocated to satellite service. The services provided using this band generally require high availability and reliability. The signals transmitted on this frequency band are less susceptible to attenuation due to rain (also called rain fade) than on other frequency bands. This means that there is a consistent signal at all times. The drawbacks of using the C-band include the use of larger (more costly) antennas and less ability to provide bandwidth-intensive services, such as broadband Internet access. The figure below shows that C-band capacity is primarily used in video-related applications, such as the transport of television channels for distribution through television broadcast, cable, and Internet Protocol television (IPTV)

networks.[14] In terms of telecommunications services, C-band is used to transport voice and data, which enables the delivery of telecommunications services such as voice, high-speed Internet access, and wireless services using a community aggregator model.

Figure 5.1: North American C-band usage by application, 2014

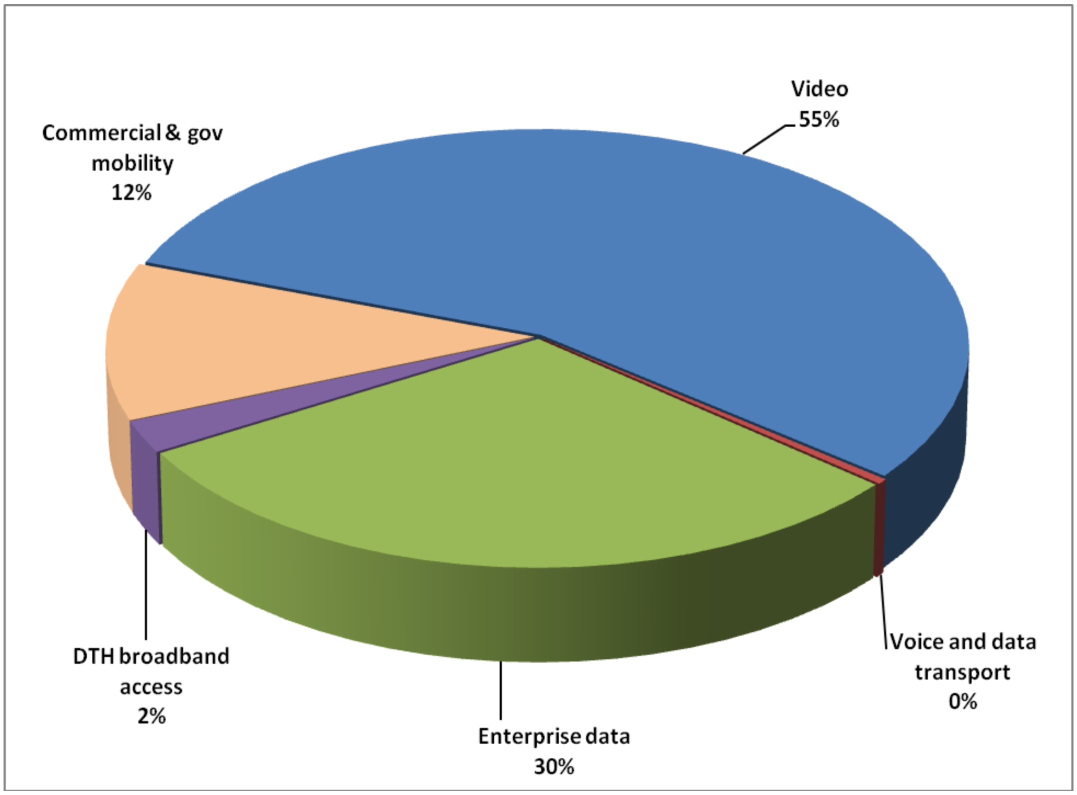


Source: Northern Sky Research, *Global Satellite Capacity Supply & Demand 2014*

[14] See Appendix A for definitions of the various applications.

47. The **Ku-band** is in high demand for video service. Signals carried over this band can suffer from some rain fade. Links are maintained in most cases, but short interruptions can be noticed during heavy downpours. However, smaller antennas can be used. The figure below shows that Ku-band is mostly used in video-related applications, such as direct-to-home (DTH) satellite television services; enterprise data services, such as network connectivity for oil and mining companies; and point-of-sale terminals for gas stations and post offices. Ku-band is rarely used for voice and data transport or DTH broadband Internet access.

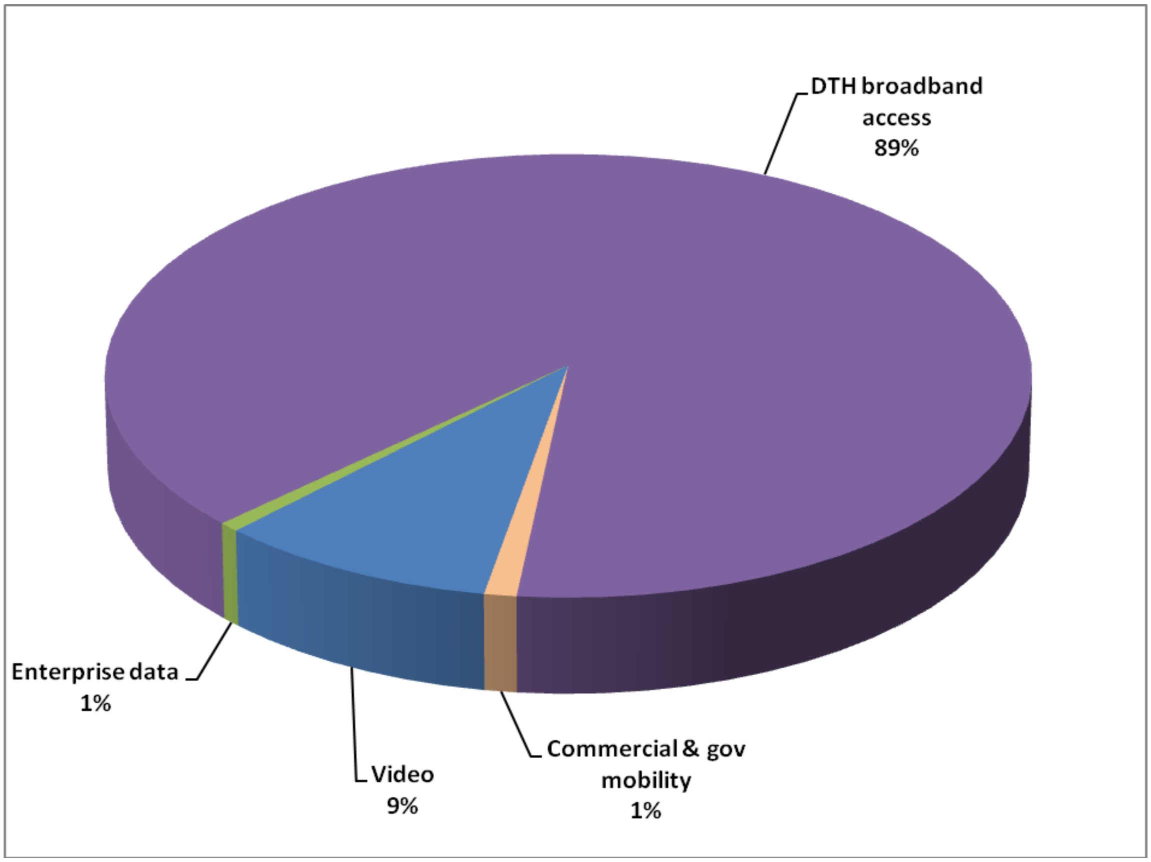
Figure 5.2: North American Ku-band usage by application, 2014



Source: Northern Sky Research, *Global Satellite Capacity Supply & Demand 2014*

48. The **Ka-band** is the newest frequency band allocated to satellite services. The figure below shows that this band is mainly used to deliver broadband Internet access, directly to the home or business. It features the smallest antennas – users are required to install an antenna on (or near) their residential or business dwellings. This band also suffers more than C- and Ku-bands from weather-related impairments.

Figure 5.3: North American Ka-band HTS usage by application, 2014



Source: Northern Sky Research, *Global Satellite Capacity Supply & Demand 2014*

49. As noted above, new HTS technology has been introduced in the market. HTS can be deployed using Ka-band, Ku-band, or C-band satellite spectrum. Ka-band has been the most popular HTS band to date given the greater availability of spectrum that can be used in new satellite deployments. One of the innovations is the use of spot beam technology which has been used to dramatically increase satellite capacity. This technology enables HTS capacity in excess of 100 gigabits per second (Gbps), compared to approximately 1.7 Gbps on C-band.[15]

[15] The capacity figure of 1.7 Gbps comes from the use of Quaternary Phase Shift Keying (QPSK), a modulation technique used in satellite communications that has a spectral efficiency of 2.0 bps/Hz, on all C-band transponders onboard a satellite.

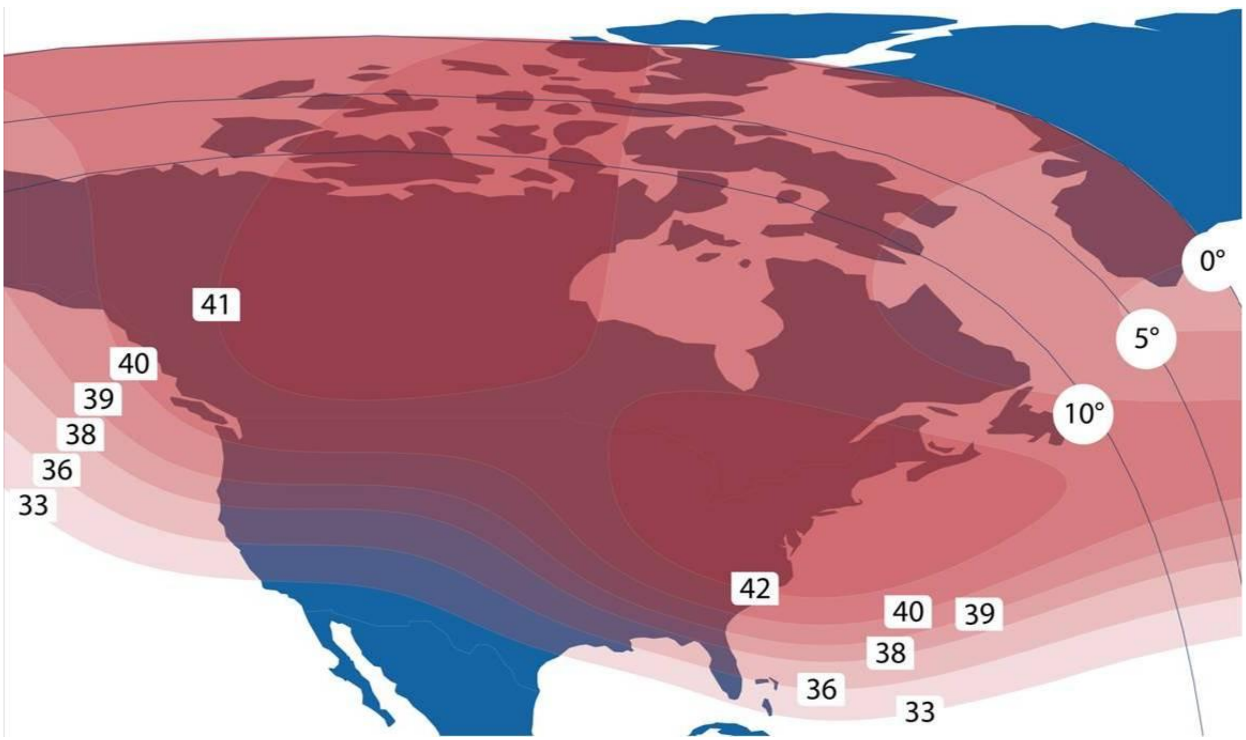
Coverage by band

50. As outlined below, the different frequency bands have very different coverage in Canada. Telesat's Anik F2 and Anik F3 are two of the most-used satellites for FSS transport services, and they include both C-band and non-HTS Ka-band satellite capacity.

C-band

51. Telesat's Anik F2 and Anik F3 have similar C-band coverage. The figure below presents the coverage of Anik F2 C-band. As this figure illustrates, Anik F2 provides broad C-band coverage of Canada (and beyond).

Figure 5.4: Telesat's Anik F2 C-band coverage

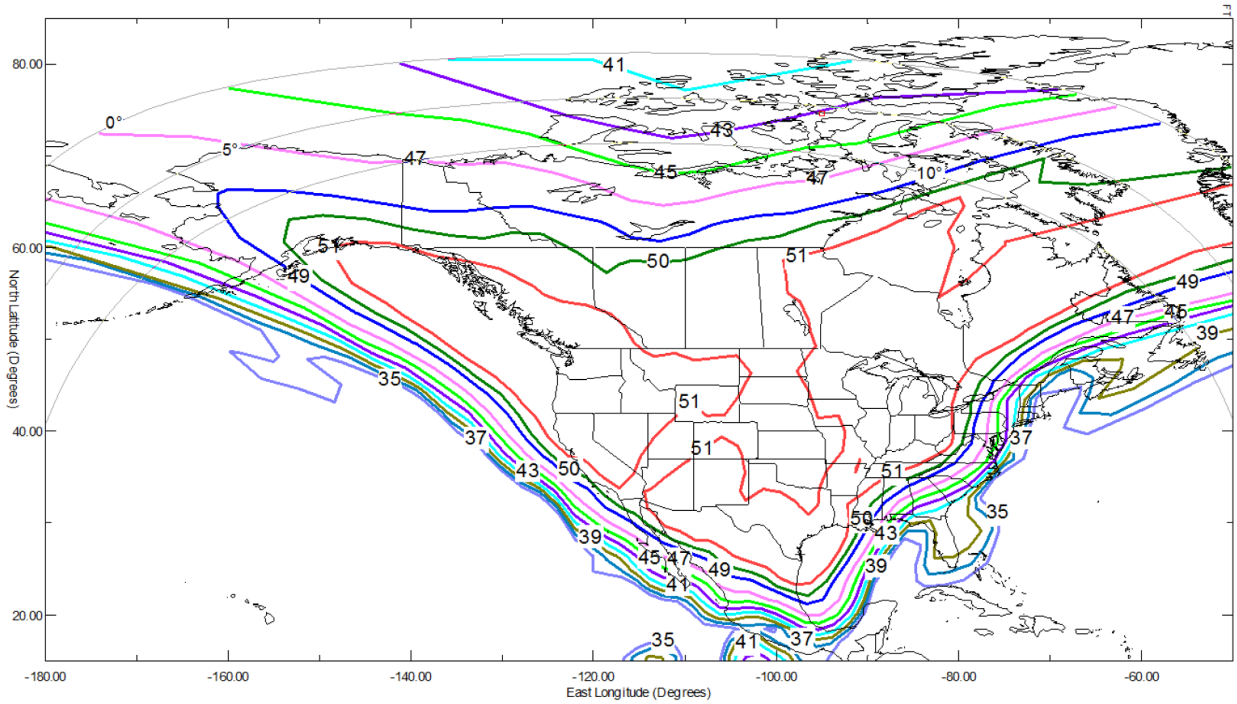


Source: Telesat

Ku-band

52. The figure below illustrates where Hunter intends to offer Ku-band service through Eutelsat America's Satmex 5 satellite.

Figure 5.5: Hunter's Ku-band coverage through Eutelsat America's Satmex 5 - Canada/US Ku-band EIRP (Inclined Orbit)



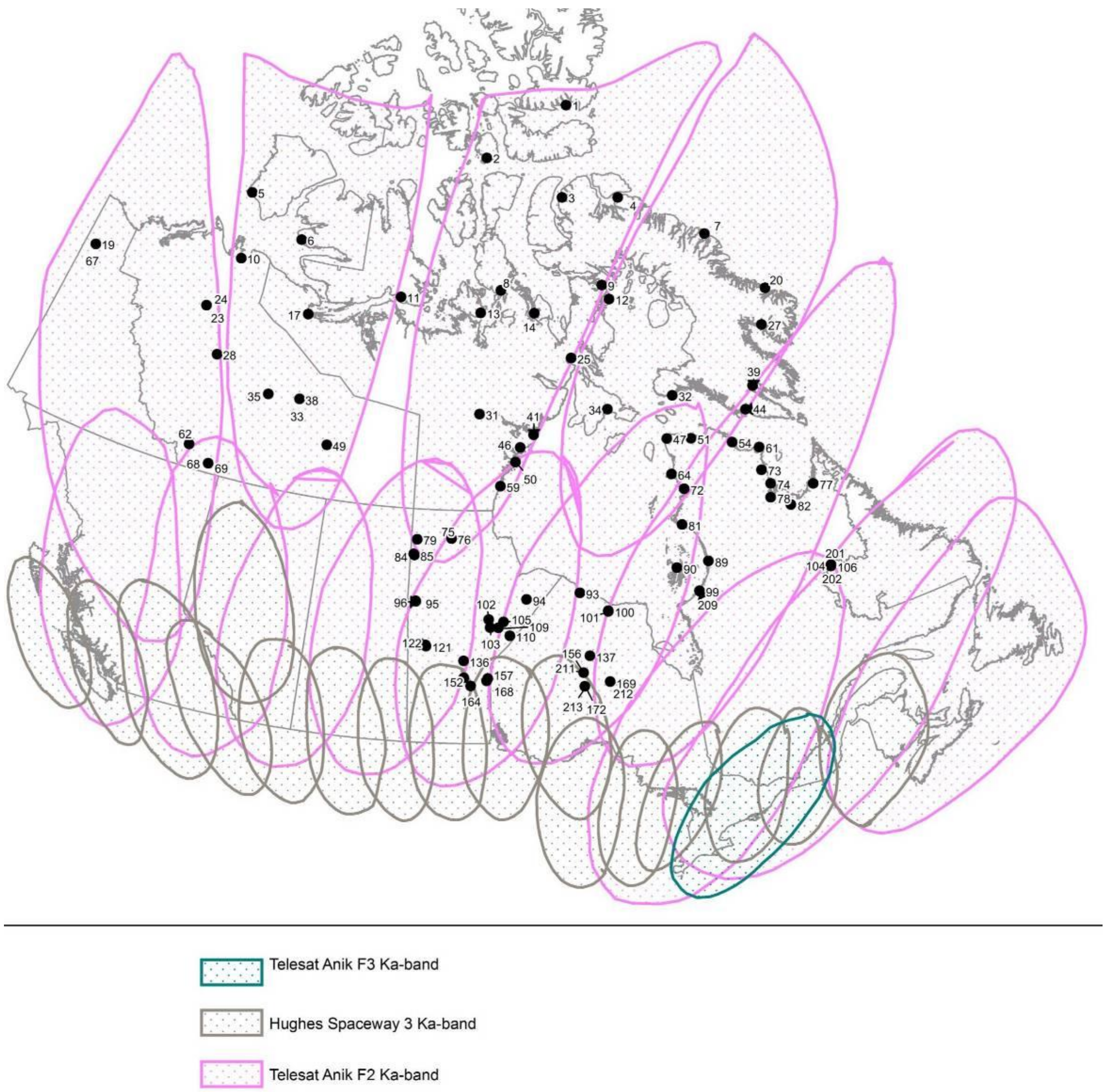
Source: Hunter Communciations

Ka-band

53. The following map illustrates Ka-band service over non-HTS satellites. Telesat's Anik F2 satellite has 45 Ka-band spot beams that cover Canada and the United States, while its Anik F3 satellite has one Ka-band spot beam that covers a large portion of Ontario and Quebec (including a portion of northern Ontario and northern Quebec). A third satellite, Hughes' Spaceway 3, also covers southern Canada.

54. Combined, Telesat's Anik F2 and Anik F3, and Hughes' Spaceway 3 satellites cover close to all communities that are presently served with C-band; however, this does not necessarily mean that there is enough capacity to serve all household, business, and government needs in these communities. Further information on the satellite capacity needs of communities and households in Canada that are presently served through satellite can be found in Appendix B.

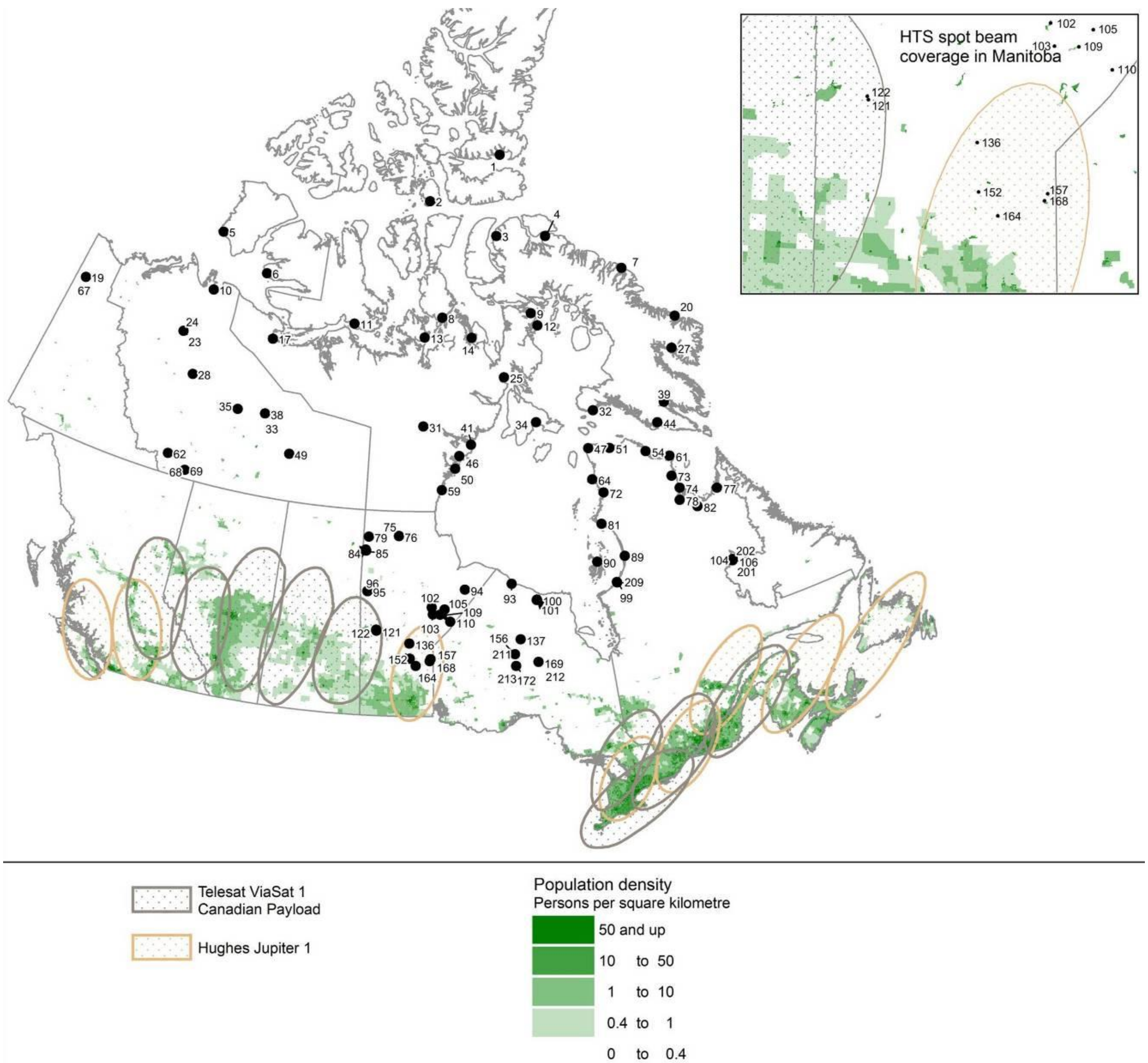
Figure 5.6: Non-HTS Ka-band satellite coverage and satellite-dependent communities



Ka-band HTS

55. As mentioned, new HTS technology has been introduced in the market and can be deployed using any of the 3 frequency bands. Ka-band has been the most popular HTS band to date, given the greater availability of spectrum that can be used in new satellites. HTS on Ka-band is already being used in Canada with Telesat's Canadian payload on ViaSat 1, and with Hughes' Jupiter 1 satellite, delivering Internet speeds in excess of the Commission's target download speed of 5 megabits per second (Mbps). The following figure provides ViaSat 1 and Jupiter 1 HTS Ka-band coverage in Canada.

Figure 5.7: HTS Ka-band coverage and satellite-dependent communities



56. As indicated in the above map, while Telesat's ViaSat 1 Canadian payload and Hughes' Jupiter 1 satellite both provide HTS coverage in Canada, the majority of satellite-dependent communities fall

outside the coverage areas of these satellites. Combined, these HTS satellites cover only 7 of the 89 satellite-dependent communities that rely on the community aggregator model. All 7 communities covered by HTS satellites are located in Manitoba.

Satellite capacity

57. Given the reliance of satellite-dependent communities on FSS for their telecommunications services, satellite capacity significantly affects the types and quality of services available to these communities.

58. During this inquiry, satellite operators reported that generally, satellites can provide many of the same services that are provided over terrestrial networks. However, there are a few differences in these services. First, the large distance between the earth station and the satellite introduces a significant delay of 240 milliseconds in the signal (round trip), which is also known as latency, for example a delay can be heard in the conversation for voice and videoconferencing. Some applications delivered over the Internet can be difficult (if not impracticable), such as virtual private networks, online word processing tools (e.g. Google Docs or Office 365), or gaming sessions requiring quick responses. A second issue with services provided over satellite is related to the capacity available to providers of telecommunications services. Since satellite capacity is often shared among multiple earth stations, the overall capacity to any one community is reduced.

59. The following is an overview of current satellite capacity used and available (unused) for the provision of telecommunications services in Canada, presented by frequency band due to the differing use of each band for specific telecommunications services.

C-band capacity

60. Telesat's satellites that are used to provide telecommunications services using designated Canadian orbital positions and spectrum are designed, by licence conditions, to serve all of Canada, including Northern communities. Foreign satellites that are authorized to provide services in Canada can offer significant coverage of Canada, but in most cases, these satellites provide lower effective isotropic radiated power (EIRP) values in the most remote corners of the country. Thus, providers of telecommunications services in remote communities would have to compensate for the lower EIRP by building larger antennas.

61. To take advantage of the satellite capacity offered by an authorized foreign satellite operator, an antenna would need to be repointed to the alternative satellite or a new antenna would need to be installed. Service interruptions can occur if no backup antennas are available. The Northern Indigenous Community Satellite Network noted that small communities have experienced 5 days of downtime when it repointed antennas from Telesat's Anik F2 to Anik F3.

62. Most telecommunications services in Canada are provided over Telesat's Anik F2 and Anik F3 satellites. Each Anik satellite has 24 C-band transponders[16] that receive and retransmit signals to

[16] See Appendix B for more information on transponders.

satellite antennas on the ground. Customers can lease full or partial transponder(s) from a satellite operator, depending how much satellite capacity they need and how much capacity is available.

63. The figure below displays the purchased and available (unused) C-band capacity[17] on Telesat's Anik F1R,[18] Anik F2, and Anik F3 satellites that have coverage in Canada. A significant amount of this C-band capacity remains available (unused). However, a significant amount of this unused C-band capacity requires additional hardware at the earth station to support unused polarization. In fact, most earth stations used by providers of telecommunications services only support one of the polarizations offered on Telesat's Anik satellites. This means that there remains unused C-band capacity and that earth station modifications are required to take advantage of this unused capacity.

Figure 5.8: Telesat's C-band capacity in MHz by provider of telecommunication services, April 2014

This Figure was removed due to reasons of confidentiality.

Source: Confidential contracts submitted by Telesat.

64. SES (through New Skies Satellites B.V.) also offers service to Ice Wireless, on the AMC-9 satellite.[19]

Non-HTS Ka-band

65. The figure below displays the purchased and available (unused) non-HTS Ka-band capacity on Telesat's satellites that have coverage in Canada. Telesat has a small amount (relative to total) of Non-HTS Ka-band capacity available. Only two providers of telecommunications services were identified as using non-HTS Ka-band capacity: Galaxy Broadband Communications Inc.[20] and Xplornet, which both offer direct-to-home Internet access for residential customers and small and medium-sized enterprises. Over #[21] of the Canadian Ka-band capacity has been purchased by Xplornet. Xplornet also has access to Canadian Ka-band capacity on Hughes' Spaceway 3 satellite.[22]

Figure 5.9: Telesat's non-HTS Ka-band capacity in MHz by provider of telecommunications services, April 2014

This Figure was removed due to reasons of confidentiality.

Source: Confidential contracts submitted by Telesat.

[17] "Unused capacity" refers to the additional capacity available to Canadian providers of telecommunications services. "Purchased (or used) capacity" refers to the capacity that providers of telecommunications services use to deliver telecommunications services; it does not include capacity used for video or any other service that falls outside the scope of the inquiry.

[18] Anik F1R is mostly used for video distribution services.

[19] Additional contractual details have been removed due to reasons of confidentiality.

[20] As noted in footnote 9, Galaxy Broadband Communications Inc. did not participate in this inquiry.

[21] Specific information on capacity was removed due to reasons of confidentiality.

[22] Specific details and technical information on capacity was removed due to reasons of confidentiality.

Ka-band HTS capacity

66. Xplornet has access to 100% of the Canadian Ka-band HTS capacity on the ViaSat 1 satellite.[23] It also has 100% of the Canadian capacity on Hughes' Jupiter 1.[24] This HTS Ka-band provides over 10 times the capacity of non-HTS Ka-band; however, coverage is limited to only 7 of the satellite-dependent communities that rely on the community aggregator model in Canada.

Ku-band capacity

67. Telesat noted that little Ku-band capacity is used by providers of telecommunications services, since most capacity is used to provide direct-to-home television, and to distribute television signals to cable and IPTV headends.[25] Infosat Communications, SaskTel, and TCC are the known users of Ku-band capacity to provide telecommunications services, but these services are private network type services or, in the case of TCC, seasonal telecommunications services. The Arctic Communications Infrastructure Assessment (ACIA) report indicates that there is no Ku-band capacity available across Telesat's Anik F1R, F2 and F3.

68. Hunter stated that it will bring new Ku-band capacity to the Canadian marketplace.[26] In its plans, Hunter proposes to use Ku-band capacity onboard Eutelsat America's Satmex 5 satellite to provide telecommunications services in northern Canada.[27]

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[23] Specific technical information regarding capacity was removed due to reasons of confidentiality.

[24] Specific technical information regarding capacity was removed due to reasons of confidentiality.

[25] A headend is a facility used to receive television signals from over-the-air transmitters, satellite and/or cable technology (optical fibre/copper), which are then transmitted to consumers over a local distribution/access network (i.e. the telephone copper network, coaxial cable, fibre-to-the-premise).

[26] Hunter will introduce 8 Ku-band transponders, each with a bandwidth of 36 MHz.

[27] Satmex 5 operates in an inclined orbit, which means that earth stations must be equipped with motors to track the satellite. The use of such capacity is better suited for larger antennas or antennas on mobile platforms (e.g. on ships and aircraft).

6) Fixed satellite service pricing

Key findings

- *Fixed satellite service (FSS) prices are negotiated between sophisticated parties, and vary based on a wide range of technical and commercial considerations.*
- *The quantity of capacity purchased, and the duration and timing of FSS contracts appear to have the strongest impact on prices in these contracts.*
- *Telesat's C-band prices decreased significantly between 2005 and 2014. The average price for C-Band in Canada is in-line with prices in other regions. However, a significant amount of C-band capacity on Telesat's satellites remains available (unused).*
- *The average prices for high-throughput satellite (HTS) in North America are 1/10 of C-band prices when compared on a per-Mbps basis.*

How FSS prices are established

69. The Inquiry Officer requested information on how satellite operators establish FSS prices. FSS providers submitted their contracts to supply FSS to Canadian providers of telecommunications services, and these were analyzed to provide the information in this section.

70. Satellite operators can use a number of different methods to establish prices. FSS prices are negotiated between sophisticated parties and vary based on a wide range of technical and commercial considerations. Satellite operators providing services in a competitive market will consider how, and at what level, competitors are setting their prices when deciding how to price their own services. Most satellite operators indicated that pricing decisions are based on supply and demand conditions within a given market.

71. Satellite operators consider the costs of satellite design, construction, launch, and operation when negotiating prices for their FSS. The overall design, construction, and launch of a satellite is a capital-intensive endeavor, which contributes to significant FSS prices. For example, National Broadband Network (NBN) Co Limited in Australia plans to launch two next generation Ka-band satellites in 2015, which will require an investment of approximately $2 billion.[xiii][28] The satellites themselves will cost approximately $620 million, and are designed to provide service for 15 years or more.[xiv] The launch of the satellites will cost up to $300 million, and the ground systems will cost up to $280 million.[xv]

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[28] Commercial satellite operators generally regard satellite costs as commercially sensitive information; therefore, there is little publicly available information on costs for Canadian satellite design, construction, launch, and operation. However, NBN Co Limited is owned by the Australian government, and has made its satellite cost information publicly available.

***Contract Terms*[29]**

72. Contract terms can have a significant impact on the price per megahertz (MHz) of FSS capacity. In general, contracts signed in more recent years for larger amounts of FSS capacity tend to have the lowest cost per unit of capacity. The table below outlines how the amount of capacity purchased affect the average price per MHz of C-band capacity.[30]

Table 6.1: Canadian C-band prices by capacity purchased

Quantity purchased	Average price per MHz	Highest price per MHz	Lowest price per MHz
0-10 MHz	#$ #	#$ #	#$ #
11-36 MHz	#$ #	#$ #	#$ #
37+ MHz	#$ #	#$ #	#$ #

Source: Confidential contracts

73. Satellites are a depreciable asset and typically have an expected life of approximately 15 years.[xvi] Sometimes, customers with sizeable capacity requirements are able to purchase some or all of the capacity on a satellite for its entire useful life. In this case, the financial risk shifts from the satellite operator to the customer, and the customer may receive a comparatively lower FSS price. If a satellite is launched with unsold capacity, as is often the case, satellite operators will later sell some or all of the remaining capacity to earn a return on their investment.

74. A review of existing FSS contracts provided by parties during the inquiry found that the duration of a contract affects the price per MHz of C-band capacity. The table below outlines the average, highest, and lowest prices per MHz for different contract lengths.

Table 6.2: Canadian C-band prices by contract duration

Contract duration	Average price per MHz	Highest price per MHz	Lowest price per MHz
0-36 months	#$ #	#$ #	#$ #
37-65 months	#$ #	#$ #	#$ #
66+ months	#$ #	#$ #	#$ #

Source: Confidential contracts

75. In general, contracts with lengthier durations tend to have the lowest cost per unit of capacity.[31]

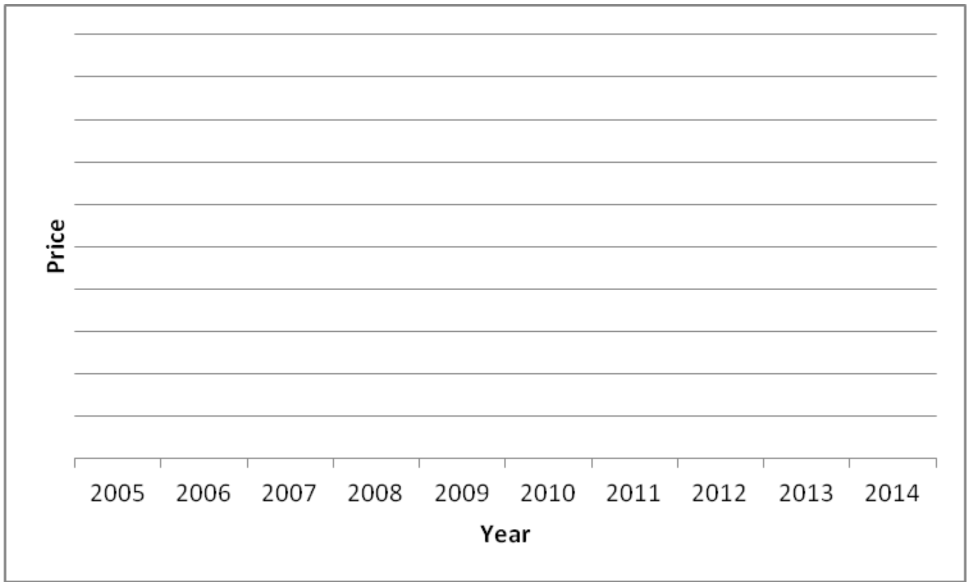
[29] There is an insufficient number of data points to complete a similar analysis for HTS Ka-band.

[30] Specific information on contract prices was removed due to reasons of confidentiality.

[31] Specific information on contract prices was removed due to reasons of confidentiality.

76. Telesat submitted that, in general terms, prices for C-band capacity decreased significantly between 2005 and 2014. Contracts signed in the mid-2000's will generally have higher C-band prices per MHz than contracts signed in more recent years.

Figure 6.1: Telesat's average C-band price per MHz per month



Source: Telesat. Information has been removed from the graph due to reasons of confidentiality.

Supply and demand of C-band in North America

77. As depicted in the figure below, Northern Sky Research's (NSR) *Global Satellite Capacity Supply and Demand* report found that there is presently a significant amount of unused C-band satellite capacity available in North America.[32] Although satellite operators do not earn revenue from unsold capacity, they submitted that such unused capacity exists for the following reasons:

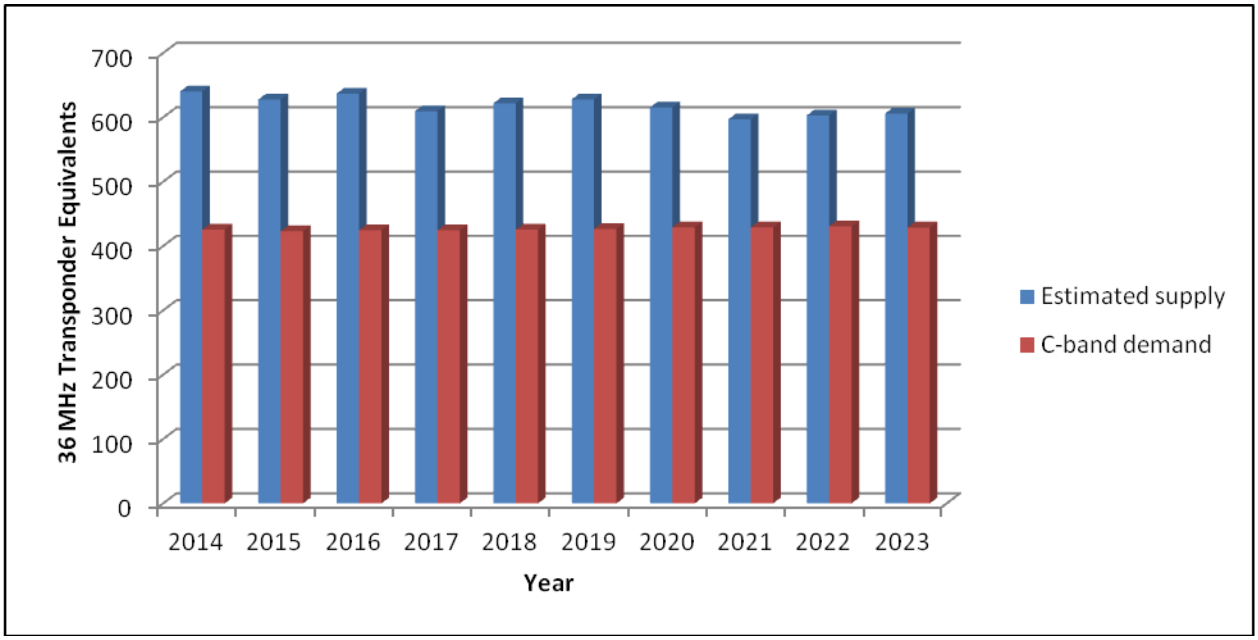
- investment in the satellite industry is inherently "lumpy," since the basic unit of capacity that can be added is an entire satellite;
- there is a need for redundancy and backup in the case of transponder failure on the spacecraft; and
- satellite operators have yet to find a customer that will buy unused satellite capacity at a price point that recovers operating costs and provides an appropriate return on risk and investment.

78. Given the versatility of satellite technology, unused satellite C-band capacity is not limited to telecommunications services. NSR forecasts that between 2013 and 2023, there will be little change in overall C-band demand in North America. Growing video demand, caused by market developments in high-definition (HD) and ultra-HD television distribution services, will be mostly

[32] Information on projected C-band supply and demand in the Canadian market is not available.

mitigated by contracting demand for all other services, such as telecommunications services provided through C-band FSS. Overall, it is expected that C-band supply will continue to be greater than demand, and that the fill price for C-band in North America is expected to remain in the high 60% and low 70% range.

Figure 6.2: North American C-band supply and demand



Source: Northern Sky Research's *Global Satellite Capacity Supply and Demand* report, 11th Edition, July 2014

Note: Estimated supply is the commercialized supply that does not include backup capacity or satellites in inclined orbit.

Canadian and international FSS prices

79. In evaluating Canadian C-band and HTS Ka-band prices, the Inquiry Officer has compared Canadian prices to global prices using the above-mentioned NSR report. In general, satellite operators set prices based on the supply and demand conditions present in the country or region being served, as described above.

C-band

80. The annual NSR report compares characteristics of the global satellite market. Canadian C-Band FSS prices are slightly higher than average North American telephony and carrier C-band FSS prices.[33]

[33] Canadian prices were computed based on the confidential contracts provided by satellite operators; other prices are from the NSR report. Specific information on Canadian prices was removed due to reasons of confidentiality.

Canadian prices are also higher than South America, Western Europe, East Asia, and Middle East and Africa.[34] See the table below.

Table 6.3: Comparison of international voice and data transport C-band prices in 2014[35]

Region	Average monthly C-band price per MHz ($CAD)	Estimated average monthly C-band price per Mbps ($CAD)[36]
Canada	#$ #	#$ #
North America	$2,551	$1,276
South America	$2,776	$1,388
Western Europe	$2,651	$1,326
East Asia	$2,426	$1,213
Middle East and North Africa	$2,526	$1,263

Source: Northern Sky Research's *Global Satellite Capacity Supply and Demand* report, 11th Edition, July 2014, and FSS contracts (confidential).

[34] Canadian prices were computed based on the confidential contracts provided by satellite operators; other prices are from the NSR report. Specific information on Canadian prices was removed due to reasons of confidentiality.

[35] C-band prices vary according to how the capacity will be used (i.e. its application). The voice and data transport application includes FSS purchased by providers of telecommunications services for the transport of voice and data.

[36] The average monthly C-band prices per MHz were converted into Mbps so that they could be compared to the average monthly Ka-band HTS prices, which are also expressed in Mbps. The estimated prices assume that 2 Mbps of capacity can be delivered for each MHz of C-band capacity purchased, which is referred to as spectral efficiency. Note that most providers of telecommunications services that provide Internet service by way of satellite get approximately 1-2.5 Mbps of transport bandwidth for each MHz of C-band satellite capacity purchased, depending on equipment and network provisioning practices.

HTS[37]

81. HTS broadband access prices are generally 1/10th of C-band prices on a per-Mbps basis across the world. Canadian HTS broadband access prices are lower than the North American average, as well as those in South America, Western Europe, East Asia, and the Middle East and North Africa, as outlined in the table below.

Table 6.4: Comparison of international HTS prices used for direct-to-home broadband access

Region	Average monthly Ka-band HTS price per Mbps in 2014 ($CAD)[38]
Canada	#$ #
North America	$98
Western Europe	$125
South America	$167
Middle East and North Africa	$199
East Asia*	$333

Source: Northern Sky Research's *Global Satellite Capacity Supply and Demand* report, 11th Edition, July 2014 and FSS contracts (confidential). *For 2017

[37] The NSR report defines an HTS as any satellite that has at least twice the throughput of a traditional FSS satellite for the same amount of allocated C-band, Ku-band, or Ka-band frequency.

[38] Canadian prices were computed based on the confidential contracts provided by satellite operators; other prices are from the NSR report. Specific information on Canadian prices was removed due to reasons of confidentiality.

7) Costs and funding to providers of telecommunications services

Key findings

- *Delivery of telecommunications services to Northern and remote satellite-dependent communities is an inherently costly endeavour.* [39] *On average, providers of telecommunications services have estimated that it costs between #$ to #$ per month to deliver 1 megabit per second (Mbps) of capacity to a community by way of C-band fixed satellite services (FSS).*
- *Delivery of capacity to a community by way of FSS is significantly more expensive than by way of terrestrial transport.*[40] *For example, Northwestel's average cost of delivering 1 Mbps of capacity to a community by way of C-band FSS is #$ per month while Northwestel's cost of delivering 1Mbps of capacity to a community by fibre and/or microwave transport ranges from $42 to $564 per month.*
- *Providers of telecommunications services have identified C-band prices as a barrier to providing telecommunications services in satellite-dependent communities that are comparable to services found in terrestrially served communities. Payments to satellite operators for C-band capacity ranged from 37% to 65% of providers' costs.*
- *A substantial amount of public funding has been allocated over the years to support the development and deployment of telecommunications services in rural and remote communities. Multiple programs and subsidies at all levels of government have significantly funded telecommunications services in satellite-dependent communities.*
- *Identified government programs and subsidies are diverse; they have been structured in different ways, and they fund different costs and components of service. For example, certain programs and subsidies are specific to voice or broadband Internet services, some are geared towards community aggregator models, others are geared towards direct-to-home models, and some programs, such as Industry Canada's Broadband Canada: Connecting Rural Canadians program, have funded both models.*
- *While concerns have been raised regarding the expiration of current funding, the Government of Canada has announced additional funding, which includes a dedicated Northern component, as part of the Broadband Canada: Connecting Rural Canadians program, which was launched in 2014.*
- *Broadband service in particular has been funded on an incremental basis, which has raised concerns regarding short-term funding and the challenges of investing and planning for the long term by providers of telecommunications services.*

Costs to providers of telecommunications services

82. In the proceeding that led to Telecom Regulatory Policy 2013-711 (Northwestel Inc. – Regulatory Framework, Modernization Plan, and related matters), several providers of telecommunications

[39] Specific information on costs was removed due to reasons of confidentiality.

[40] Specific information on costs was removed due to reasons of confidentiality.

services submitted that the high price of FSS is a barrier to providing service in satellite-dependent communities. In order to evaluate the validity of these submissions, the Inquiry Officer has collected information on the costs to deliver capacity to a satellite-dependent community, including FSS and other costs.

83. Providers that deliver telecommunications services by way of FSS were asked to explain their costs to deliver 1 Mbps of capacity to a community. This section focuses on the costs to providers of telecommunications services that use FSS to provide retail broadband Internet service, namely SSi, Northwestel, and the Kativik Regional Government (KRG).

84. Internet services are particularly affected by the cost of FSS capacity, given the growing use of broadband, including data-intensive applications, and therefore the ever-increasing need for more FSS capacity. Other telecommunications services, such as voice services, are not likely to experience increased capacity demand without a corresponding increase in subscribers or use. Consequently, this section does not relate to the costs to providers of telecommunications services that use FSS to provide telecommunications services other than retail broadband Internet.

85. The figure below shows the average monthly cost of delivering 1 Mbps of capacity to a community for Northwestel, SSi, and the KRG using the community aggregator model.

Table 7.1: Average monthly cost of delivering 1 Mbps of capacity to a community by way of FSS

	Northwestel	SSi	KRG
FSS payments[41]	#$ #	#$ #	#$ #
Other	#$ #	#$ #	#$ #
Total expenses related to payments to third parties	#$ #	#$ #	#$ #
Earth station expenses	#$ #	#$ #	#$ #
Maintenance	#$ #	#$ #	#$ #
Power	#$ #	#$ #	#$ #
Service provisioning	#$ #	#$ #	#$ #
Total other expenses	#$ #	#$ #	#$ #
Total average cost	#$ #	#$ #	#$ #

Source: Confidential responses to requests for information

[41] The average monthly cost of FSS is different from the estimated average monthly C-band price per Mbps because (i) spectral efficiency differs between providers of telecommunications services, and (ii) actual C-band prices are different from estimated average C-band prices due to, for instance, timing, quantity of capacity purchased, and contract duration.

86. The cost to deliver capacity to a community by way of FSS is significantly higher than by way of terrestrial transport. To illustrate the significant difference in costs, the Inquiry Officer has compared Northwestel's monthly cost to deliver 1 Mbps of capacity to a community by way of FSS to its monthly cost to deliver 1 Mbps of capacity by way of its Wholesale Connect service.[42] Northwestel's costs to deliver terrestrial transport capacity on a per-Mbps basis range from a low of $42 in core communities served by fibre transport links (e.g. Whitehorse, Yukon and Yellowknife, Northwest Territories) to a high of $564 in communities that connect to core communities through a combination of high-capacity microwave radio and fibre transport links (e.g. Dawson City, Yukon). Northwestel's average cost of delivering 1 Mbps of capacity by way of C-band FSS is exponentially higher[43] than its cost of delivering 1 Mbps of capacity by way of terrestrial transport.

FSS capacity costs

87. The largest single cost item for providers of telecommunications services that serve satellite communities are payments to satellite operators for FSS capacity, which range from 37% to 65% of a provider's costs of delivery of satellite capacity to a community. Given that satellite transport is significantly more expensive than terrestrial transport and that it makes up a large portion of the overall costs of delivery of capacity to a community, FSS capacity expenses play a major role in the difficulty for providers to offer telecommunications services, especially broadband Internet services, that are comparable to those in terrestrially served communities.

Ground equipment costs

88. The second-largest cost item for providers of telecommunications services tends to be the earth station equipment.[44] Earth station equipment costs generally relate to the cost of the satellite antenna itself, as well as electronic equipment, civil engineering, freight, and installation costs. Earth station equipment is large, with some antennas measuring upwards of 20 metres in diameter. Larger antennas are generally more expensive, and have higher freight, installation, and civil engineering costs than smaller antennas. The type of power amplifier required can also cause earth station costs to vary significantly. Many of the communities that depend on satellite transport are inaccessible by road, so equipment arrives at its destination by air or sea (with limited shipping windows) at a higher cost compared to transportation by land. Given the number of variables, the overall cost of installation of a new earth station can vary considerably, ranging from $100 thousand to $1 million. The figure below shows a breakdown of the average installed first costs[45] of an earth station with a small antenna (approximately 4 metres in diameter).

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[42] Northwestel's Wholesale Connect service allows competitors to transport telecommunications traffic across the portion of Northwestel's network served by fibre or high-capacity microwave radio transport links.

[43] Specific information on costs was removed due to reasons of confidentiality.

[44] Specific information on costs was removed due to reasons of confidentiality.

[45] An installed first cost is made up of the equipment price, the company's engineering and installation labour, non-company labour, and warehouse and distribution costs.

Table7.2: Breakdown of an average earth station's installed first costs

Cost	Percentage of total
Antenna installation/civil engineering	#% #
Electronics (modems, routers, etc.)	#% #
Power amplifier/generator	#% #
Satellite dish	#% #
Shipping	#% #
Telecommunications equipment shelter	#% #
Other	#% #

Source: Confidential responses to requests for information

Operational costs

89. Maintenance expenses generally make up the third largest expense related to the delivery of satellite capacity to a community.[46] Maintenance personnel often need to be flown in to communities to service or install equipment, and may receive higher compensation than their southern counterparts due to the higher cost of living in satellite-dependent communities, both of which contribute to higher maintenance expenses compared to terrestrially served communities.

90. Power costs are a relatively minor expense for providers of telecommunications services that serve satellite-dependent communities.[47] However, electrical power is often produced by diesel generators in Northern and remote communities, and has a much higher cost per kilowatt-hour (kWh) than in southern and urban communities. For example, power in Whale Cove, Nunavut costs 111.2 cents/kWh, whereas power in Ottawa, Ontario costs 7.5-13.5 cents/kWh.

[46] Specific information on costs was removed due to reasons of confidentiality.

[47] Specific information on costs was removed due to reasons of confidentiality.

Costs to serve a Northern community

91. To provide a sense of the scale of the costs involved in the delivery of satellite capacity to a Northern community, SSi's upfront (one-time) earth station and ongoing (monthly) average costs are presented in the table below. Note that SSi has, on average, # subscribers per community.

Table 7.3: SSi's costs to deliver satellite capacity to a community

Upfront (one time)		**Ongoing (monthly)**	
Expense	**Cost**	**Expense**	**Cost**
Land preparation and fencing	#$ #	Payment for FSS	#$ #
Foundation	#$ #	Lease costs and taxes	#$ #
Tower	#$ #	Earth station	#$ #
Satellite dish	#$ #	Maintenance	#$ #
Communications shelter	#$ #	Power	#$ #
Back-up power generator	#$ #	Service provisioning	#$ #
Electronics	#$ #	**Total**	**#$ #**
Shipping	#$ #		
Total	**#$ #**		
Per subscriber	**#$ #**	**Per subscriber**	**#$ #**

Source: Confidential responses to requests for information

Observations

92. The economics of providing telecommunications services in satellite-dependent communities can be vastly different from those in terrestrially served communities. Generally, terrestrially served communities benefit from relatively inexpensive ground transportation, readily available labour, and electrical power generated by efficient power stations. While FSS capacity does represent a significant portion of a provider of telecommunications services' costs to deliver capacity to a community by way of FSS, several other factors are at play, such as the costs of shipping, labour, and power for remote communities. These factors contribute to making the costs of the provision of telecommunications services in satellite-dependent communities inherently higher than in terrestrially served communities.

Government programs and subsidies

93. As outlined in the Telecom Notice of Consultation 2014-44, the scope of this inquiry includes consideration of the costs to providers of telecommunications services of providing telecommunications services by way of satellite technology, including the sources of funding that impact the providers' overall costs. This section outlines major government programs and subsidies for the provision of telecommunications services via satellite.

94. Given the high costs associated with the provision of telecommunications services via satellite, government intervention and funding has been, and continues to be, critical in the expansion of access to such services in communities that are reliant on FSS. Between 2002 and the present, over $200 million in federal funding was identified for programs and initiatives geared towards the provision of telecommunications services via satellite, including the estimated value of public benefit capacity.[48] This does not include the announced Digital Canada 150 funding for the North, the Commission's National Contribution Fund (which is an industry-contributed subsidy), nor provincial, territorial, or municipal funding. Overall, the identified sources of funding are not exhaustive; however, they are intended to give a sense of the high level of funding that has been committed to the provision of telecommunications services via satellite. Major programs and subsidies are summarized below, with additional information provided in Appendix D. Figures specific to funding for telecommunications services provided via satellite are included in the Appendix where available; however, many subsidies include satellite as one component among others and a breakdown of satellite-specific funding may not be available.

95. For voice services, the Commission's National Contribution Fund (NCF) subsidizes residential telephone local access service in high-cost serving areas. The NCF is a revenue-based collection mechanism whereby contributions are paid by telecommunications service providers (TSPs), or groups of related TSPs, that have $10 million or more in eligible Canadian telecommunications service revenue. Monies from the NCF are then paid out to the incumbent local exchange carriers (ILECs) that provide residential telephone service in high-cost serving areas. These high-cost serving areas include communities that rely on the community aggregator model for fixed voice services.

96. Of note, Northwestel has previously requested subsidy funding for satellite transport, arguing that the company's satellite toll-connect link costs should be recovered from the NCF; however, this request was denied by the Commission.[49]

97. Programs and subsidies at all levels of government have expanded and improved telecommunications services in satellite-dependent communities. These programs include the provision of public benefit satellite capacity through Industry Canada for use by public institutions (e.g. education and health care), and multiple programs for broadband Internet service in rural and remote areas, including the satellite-dependent communities identified in this inquiry. As part of

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[48] In 2000, Industry Canada introduced a new condition of licence for some satellite licences in response to the growing requirements of public (e.g. educational and health care) institutions for telecommunications capacity in remote areas. This "public benefit" obligation was to direct a small percentage of revenues (2%), or an equivalent amount in satellite capacity, towards special initiatives to improve connectivity in underserved areas of Canada. The benefits were to be available for the operational lifetime of a satellite, typically 15 years.

[49] Northwestel's proposal and the Commission's decision are outlined in Telecom Regulatory Policy 2011-771. Northwestel submitted that, since satellite technology is used to serve over 40% of its communities, the long distance network is essentially an extension of the local network. Northwestel further submitted that its carrier access tariff rate (CAT rate) is based on the average cost to provide all consumers across the North with comparable rates for long distance services, and that this led to a degree of cross-subsidy since its two centres in Whitehorse, Yukon, and Yellowknife, Northwest Territories do not incur toll-connect costs but are charged the same CAT rate.

the National Satellite Initiative, $85 million was allocated from the Government of Canada's Canada Strategic Infrastructure Fund to fund the acquisition of satellite capacity and ground infrastructure for satellite-based broadband projects in isolated and remote communities across Canada,[xvii] including the purchase by the Northern Indigenous Community Satellite Network of two C-band satellite transponders for 43 communities in the northern regions of Quebec, Manitoba, and Ontario. Other Industry Canada programs, such as Broadband for Rural and Northern Development (BRAND) and Broadband Canada: Connecting Rural Canadians, have also extended broadband coverage, including funding for satellite. As part of the Broadband Canada: Connecting Rural Canadians program, SSi in Nunavut has received funding to assist in defraying the cost of FSS to all 25 communities, the KRG has added two C-band transponders for exclusive use in Nunavik, and Xplornet has received approximately $33.6[50] million to provide direct-to-home Ka-band satellite capacity to unserved households in multiple geographic areas.

98. Provincial and municipal-led programs have also provided subsidies to expand broadband service to households in rural and remote communities. As part of this inquiry, Xplornet identified multiple provincial programs through which it has received subsidies to reduce the cost of Internet packages available to its customers. Additionally, the provinces of British Columbia and Alberta introduced the BC Broadband Satellite Initiative and the Central Alberta Rural Connectivity Initiative, respectively, in 2013. These initiatives both focus on direct-to-home broadband Internet and make funding available to contribute to the one-time satellite installation fee with Xplornet.[xviii,xix]

99. As outlined above and in Appendix D, there is a diversity of government programs that include funding for telecommunications services delivered by satellite. These programs have been structured in different ways, and fund different percentages of costs and different components of service provision. For example, under Broadband Canada: Connecting Rural Canadians, up to 50% of the eligible costs of providers of telecommunications services were funded. Under Infrastructure Canada's New Building Canada Fund, one-third of project costs are federally funded, with the exception of projects in the territories, which are eligible for federal funding of up to 75% of the project cost. Infrastructure Canada's Canada Strategic Infrastructure Fund also provided funding of up to 75% of project costs and funded both satellite capacity and ground infrastructure. Under the public benefit condition of licence, satellite capacity is provided to public institutions free of charge, with a small amount of the costs paid by governments to initially implement the program, and with service providers managing the free bandwidth at a cost that was passed on to governments.[xx] Furthermore, both service providers that use the community aggregator model and those that use the direct-to-home model have received government funding to serve households in rural and remote areas, with ongoing provincial funding in Alberta and British Columbia to reduce the installation costs of direct-to-home broadband service.

[50] See Appendix D - Table 11.7 for further information on Broadband Canada Program funding

Specific examples of subsidies and costs to providers of telecommunications services

100. In response to requests for information from the Inquiry Officer, providers of telecommunications services submitted further information on the subsidies they receive and on how these subsidies offset their costs. The responses are summarized below and are expanded upon in Appendix D.

101. The only subsidy identified by providers of telecommunications services for voice service was the NCF, which subsidizes the provision of residential telephone service in high-cost serving areas (which includes communities served using the community aggregator model).

102. Under the subsidies identified and broken down by parties, satellite capacity costs were by far the most significant subsidized costs.[51] The Northern Indigenous Community Satellite Network noted that no subsidies cover its operating costs.

103. As an example of the extent of broadband funding, the KRG submitted that the total average subsidy per community per year for Nunavik communities is $241,329,[52] and that it estimated that the current annual value of subsidies was over $3.2 million for its communities. The KRG further estimated that the current annual value of subsidies represented 37% of the total costs it incurred for the 2013-2014 fiscal year.[53] The KRG serves 14 satellite-dependent communities in total, comprising 3,543 households. Therefore, the total amount of subsidy represents over $900 per household per year.

Ongoing and future funding

104. Concerns have been raised regarding the expiration of current subsidy programs.[54] Namely, funding under the Broadband Canada: Connecting Rural Canadians program for Nunavut and Nunavik expires in 2016; however, as noted above, Infrastructure Canada's New Building Canada Fund (2014-2024) includes satellite capacity as an eligible component for funding under its "connectivity and broadband" subcategory.[xxi]

105. Furthermore, with the launch of Industry Canada's Connecting Canadians program in July 2014, the Government of Canada announced that it will invest up to $305 million over 5 years to extend high-speed Internet service to 280,000 households in rural and remote regions of the country that currently have slow or no Internet access.[xxii] Connecting Canadians includes a $50-million[xxiii] dedicated Northern component for the satellite-dependent communities in Nunavut and Nunavik to ensure that 12,000 households[xxiv] in these communities continue to have access to broadband services. [xxv] This new funding will also require that projects under the Northern component deliver

[51] Specific breakdowns of subsidized costs were provided to the Inquiry Officer in confidence.

[52] This average is for 13 of the 14 communities served by the KRG that received funding through Broadband Canada: Connecting Rural Canadians (an average of $160,024/community per year). As submitted by the KRG, one of the communities it serves (Kuujjuarapik/Whapmagoostui) was not funded under this program. Therefore, this community has an average subsidy of $81,305 per year.

[53] The KRG noted that the operating costs for the years 2014 to 2019 remain unknown, so this is not an exact percentage.

[54] See, for example, Nordicity's *Northern Connectivity – Ensuring Quality Communications* report, January 2014.

higher Internet speeds of a targeted 3 to 5 Mbps. The call for applications to serve Nunavut and Nunavik was launched on 15 October 2014. Applications to serve the North will be evaluated separately, and the successful projects must be completed by March 2016.[xxvi]

106. In the near future, the Commission will review which services (e.g. voice and broadband) are required by all Canadians to fully participate in the digital economy, and whether there should be changes to the current subsidy regime and the national contribution mechanism.[xxvii] Furthermore, the Commission has announced that it intends to establish a mechanism, as required, to support the provision of modern telecommunications services in Northwestel's operating territory. This mechanism may fund capital infrastructure investment in transport facilities, such as satellite transport, as well as the cost of maintaining and enhancing these facilities.[55]

Observations

107. The satellite business in Canada is a costly and challenging endeavour. As a result, a substantial amount of public funding has been allocated over the years to support its continued development and deployment. Based on the information gathered throughout this inquiry, it seems clear that there will be continued reliance on public monies to deploy satellite transport services in rural and remote regions in Canada. The key – and this report is not the first to make such observations or recommendations – will be to have a smart, coordinated, and cost-effective approach to funding.

108. As the overview above shows, there is a variety of programs with funding for telecommunications services provided by way of FSS. This has led to the development of overlapping, subsidized networks in communities. For example, in Iqaluit, Northwestel receives an NCF subsidy for the provision of residential telephone service in high-cost serving areas, while SSi receives a federal subsidy for the provision of broadband Internet service under the Broadband Canada: Connecting Rural Canadians program. In Manitoba, satellite-dependent communities receive wired voice service through MTS Allstream, which receives funding from the NCF, while broadband Internet service is provided by BCN over a shared satellite-based network as part of the Northern Indigenous Community Satellite Network, which has a public benefit transponder and received funding from the National Satellite Initiative.

109. Funding for broadband services has been provided on an incremental basis, and concerns have been raised regarding whether this has prevented companies from making large, long-term commitments for satellite capacity at better prices. The Arctic Communications Infrastructure Assessment Report previously identified a number of issues resulting from this incremental funding, including the lack of sustained funding to help pay for required earth station upgrades in remote communities. Specifically, this report noted that "service providers operate in an extremely uncertain environment, with both technological change and funding changes that are unpredictable, making it difficult to invest and plan for the future."[xxviii] The recommendations outlined in the report include sustained, multi-year funding commitment for communications network development.

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[55] As set out in Telecom Regulatory Policy 2013-711, this mechanism will be considered during the Commission's review of basic telecommunications services, which has been announced in the CRTC Three-Year Plan 2014-17.

110. It should be noted that the programs and subsidies identified above do not include funding for businesses. Furthermore, aside from the Commission's NCF, government funding for voice service, and particularly for satellite transport for voice service, was not identified in background research for this inquiry.

111. During this inquiry, the Nunavut Broadband Development Corporation (NBDC) submitted that the major cause of the lack of competitive satellite offerings in the North is the short-term nature (generally under 5 years) of government funding. In the NBDC's view, this does not incent providers of telecommunications services to purchase satellite capacity for periods longer than the government funding timelines. The NBDC further submitted that a mechanism to provide long-term, stable, and scalable funding to support the delivery of telecommunications services in the North would be the most effective measure to encourage competitive entry. For its part, Telesat submitted that the biggest remaining challenge to bringing high-speed broadband connectivity to residents of Northern Canada is to find a way to amortize the costs of satellite and related terrestrial communications network facilities across a very small and thinly dispersed population, one which may be best met through government and/or regulatory subsidies.

8) Future outlook

Key findings

- *High-throughput satellites (HTS) are expected to help improve the delivery of telecommunications services and narrow the service capability gap between communities that are dependent on satellite transport, and those that are served by terrestrial transport networks.*
- *HTS have lower per-megabit-per-second (Mbps) prices and higher capacity than traditional C-band fixed satellite services (FSS).*
  - *Due to almost no expectation of new entrants and a steady, albeit declining, stream of replacement capacity coming online, North American C-band prices are forecasted to increase by 31% over the next 9 years, to over $3300 per MHz in 2023.*
  - *North American HTS prices are forecasted to decline by 55% over the same period, to under $50 per Mbps in 2023.*
- *Xplornet is currently using two Ka-band HTS satellites to deliver direct-to-home (DTH) broadband Internet access to Canadian consumers, and has purchased all of the Canadian capacity on two more Ka-band HTS satellites that are expected to launch in the near future.*
- *Other providers of telecommunications services will require significant and expensive changes to their telecommunications networks to benefit from HTS.*
- *There are some drawbacks associated with Ka-band HTS, especially for latency-sensitive applications, such as voice. The delivery of at least some telecommunications services by way of C-band is likely to continue into the foreseeable future.*
- *Total unused C-band capacity is greater than the capacity required to meet the Commission's target speeds of 5 Mbps download and 1 Mbps upload for all residential households in the satellite-dependent communities; however, it appears neither practical nor affordable to expect all of this capacity to be deployed for residential broadband Internet service.*

Introduction

112. The scope of this inquiry included an examination of future satellite capacity, as well as changes in technology, the competitive environment, sources of funding, and the regulatory environment that may affect the rates, quality and/or capacity of satellite services in the future.

113. During this inquiry, no significant changes in the regulatory or competitive environment, and no additional sources of funding (beyond the recently announced Connecting Canadians program) were identified.

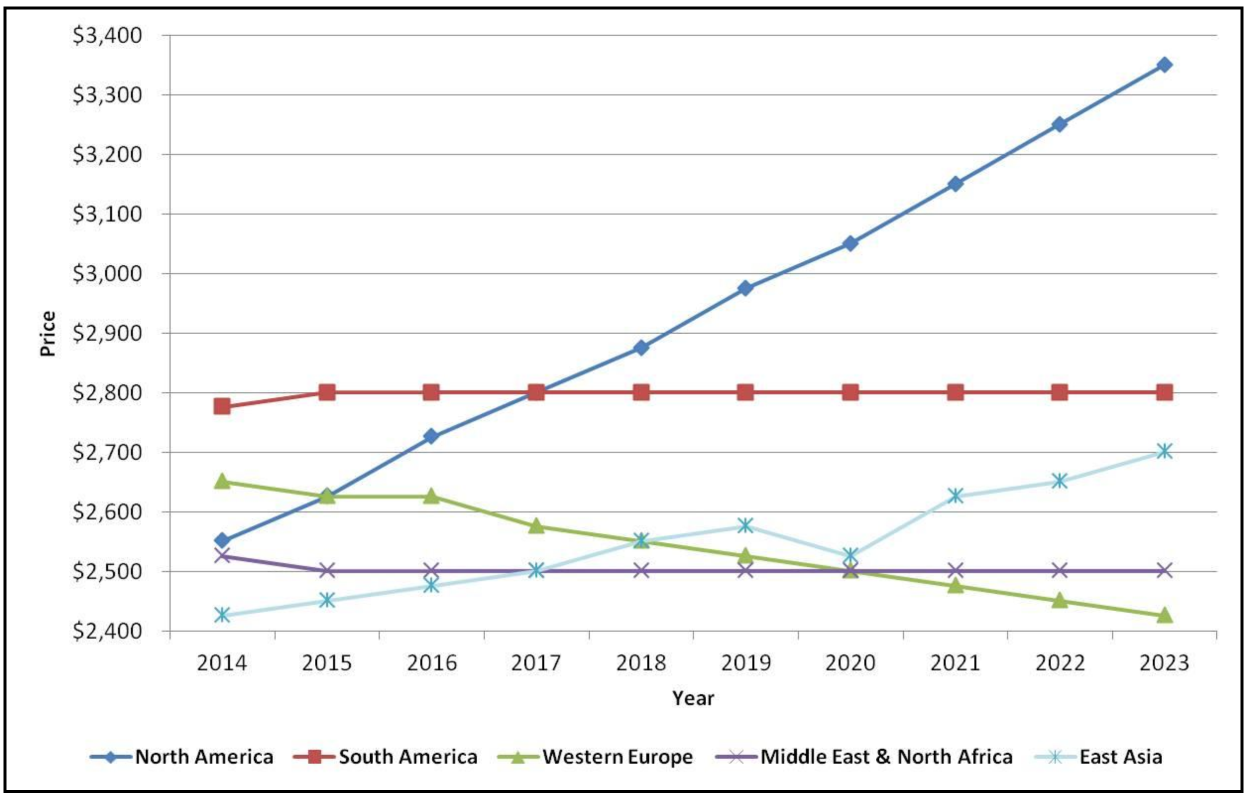
114. By far, the most significant change affecting the satellite industry is the availability and adoption of HTS, which are expected to improve Internet service speeds, capacity, and costs. HTS presently use Ka-band spectrum, which allows for narrow (spot) beams and frequency re-use, resulting in high-capacity satellites and ultimately much lower costs per Mbps in the delivery of high-speed internet. HTS can deliver more data than legacy satellites, at comparable build and launch costs, resulting in a lower cost per bit of data delivered to the customer.

C-band prices

115. As noted previously, North American HTS prices are a fraction of C-band prices when compared on a per-Mbps basis. Furthermore, North American C-band prices are expected to increase in the future, while HTS prices are expected to decline, thereby increasing the price difference between C-band prices and HTS prices.

116. Northern Sky Research predicts that average C-band prices for voice and data transport services in North America[56] will increase by approximately 31% over the next 9 years, while C-band prices in Western Europe will decrease by 8% over the same period. Northern Sky Research reports that with almost no scope for new entrants and a steady, albeit declining, stream of replacement capacity, there is no reason for operators to drop C-band prices for any services in North America. The figure below shows how C-band prices for voice and data transport services are forecasted to change between 2014 and 2023.

Figure 8.1: Forecasted C-band prices for voice and data transport



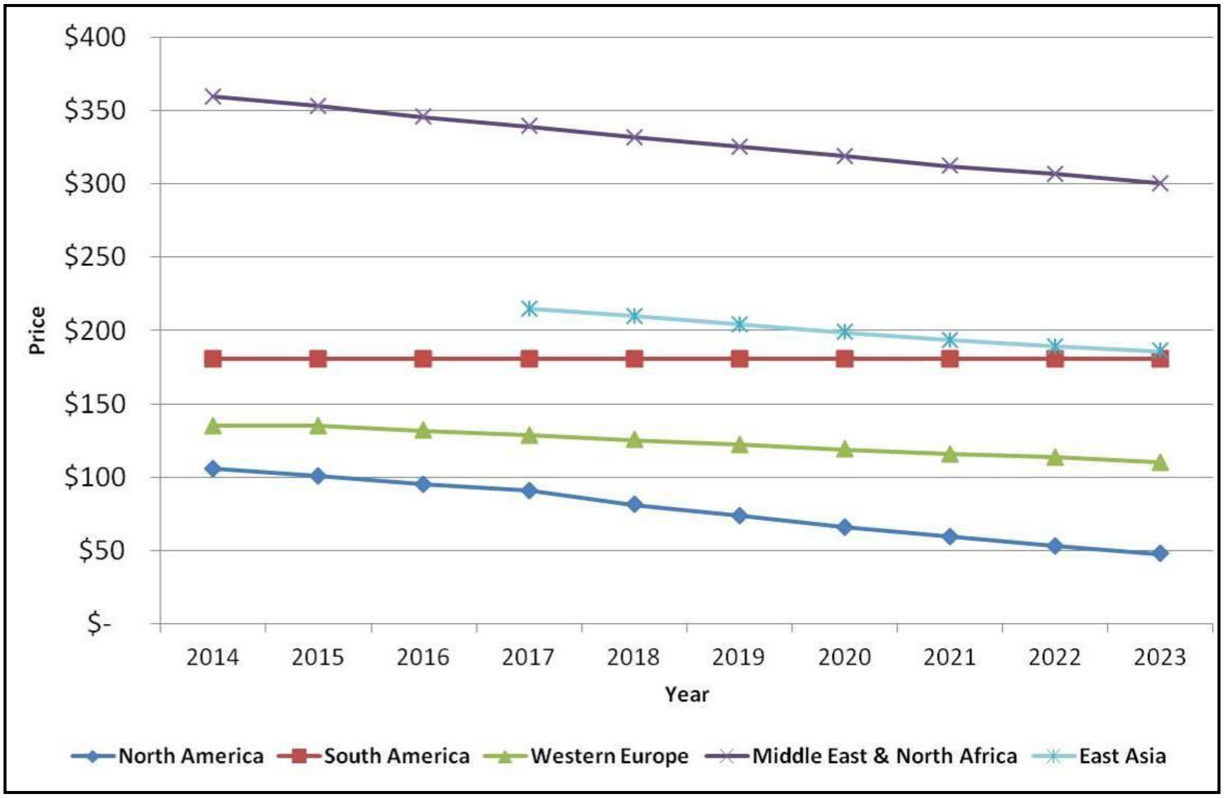
Source: Northern Sky Research, *Global Satellite Capacity Supply & Demand 2014*

117. In contrast to increasing C-band prices, Northern Sky Research predicts that average HTS prices for DTH broadband access will fall significantly. North America will see the largest reduction in HTS prices compared to other regions, with a decline of 55% between 2014 and 2023. Northern Sky

[56] Information on future C-band rates in the Canadian market only is not available.

Research reports that further pressure from increased supply will reduce per-megabit pricing for DTH broadband access in North America – pricing that is already at an all-time low for the industry. The figure below shows how HTS DTH broadband access prices are expected to change between 2014 and 2023.

Figure 8.2: Forecasted HTS DTH broadband access prices



Source: Northern Sky Research, *Global Satellite Capacity Supply & Demand 2014*

Future HTS capacity

118. NSR forecasts that the North American supply of HTS capacity will triple from 300 gigabits per second (Gbps) in 2013 to 900 Gbps in 2023, and DTH broadband access will be the primary use of this HTS capacity.

119. Where and in what timeframes additional HTS capacity will become available to the Canadian market, and particularly to satellite-dependent communities, is less certain. During the inquiry, most parties were hesitant to provide any information on their future business plans.

120. During the inquiry, Telesat provided information, in confidence, regarding future business plans.[57]

[57] Information on the future plans was removed due to reasons of confidentiality.

Figure 8.3: Telesat's proposed HTS plans

This Figure was removed due to reasons of confidentiality.

Source: Telesat

121. Xplornet submitted that it has already begun incorporating HTS into its network, and that it offers 5-Mbps and 10-Mbps broadband Internet service over HTS satellites – albeit not in all satellite-dependent communities at this time. Some information was provided by Xplornet that provides an indication of its plans to increase broadband speeds across its fixed wireless and satellite broadband Internet coverage footprints.

122. Xplornet submitted that, in general terms, its network capacity plans are designed to service at least # Canadian households by 2016 and at least # Canadian households by 2018, using a combination of terrestrial and satellite technologies. Xplornet's collective satellite capacity north of the 60th parallel will be able to provide service to an estimated # households by 2017. Xplornet submitted that it has designed its network capacity to provide service to its anticipated share of the competitive marketplace which is typically between #% and %# of potential customers in the relevant area.[58]

123. Xplornet has purchased all of the Canadian Ka-band capacity on the following high-throughput satellites:[59]

- ViaSat 1, with a proven capacity of 134 Gbps[60];
- EchoStar XVII (also known as Jupiter 1);
- ViaSat 2, which is scheduled to launch in 2016. ViaSat 2 is expected to approximately double the bandwidth economics of ViaSat 1 and have Canadian coverage from coast to coast to coast, including in the North;[61] and
- EchoStar XIX (also known as Jupiter 2), which is planned to launch in mid-2016 with over 150 Gbps[62] of throughput capacity.

124. Using the two HTS already in orbit, Xplornet is able to provide improved DTH broadband access to Canadians, and the two planned HTS[63] are expected to further improve Xplornet's ability to deliver

[58] Details regarding the number of households to be served and anticipated market share were removed due to reasons of confidentiality.

[59] Specific information on Xplornet's future plans was removed due to reasons of confidentiality.

[60] Viasat 1 capacity found on the Guinness World Records website

[61] Xplornet refused to provide the contracts, and capacity and beam information for new HTS satellites, which include ViaSat 2 and Jupiter 2 (also known as Echostar XIX**)**. The Inquiry Officer chose not to pursue further.

[62] See Hughes' press release for capacity information.

[63] See Xplornet's press release regarding the company's acquisition of all the Canadian satellite broadband capacity on Hughes' EchoStar XIX Satellite (Jupiter 2), and its press release regarding the company's contract with ViaSat to acquire all the residential capacity covering Canada on the upcoming ViaSat 2 satellite.

telecommunications services. Xplornet has stated that it will be able to deliver 25-Mbps Internet service plans to all Canadians by 2016 by way of HTS.

125. Xplornet stated that it has undertaken to upgrade the Anik F2 satellite to 4G technology and will replace equipment at the three gateways for that satellite. The transition is anticipated to take six months in total and to be complete before the end of 2014.

126. The figure below provides details regarding Xplornet's plans to offer 25 Mbps broadband Internet service using a combination of satellite and terrestrial wireless technologies.

Figure 8.4: Map of Xplornet's planned 25 Mbps service

This Figure, and associated information regarding Xplornet's future plans, was removed due to reasons of confidentiality.

Source: Xplornet

Costs to providers of telecommunications service to bring HTS capacity to their networks

127. At this time, all identified HTS capacity in Canada has been contracted by Xplornet. Other providers of telecommunications services, which serve satellite-dependent communities via the community aggregator model, have identified that HTS could be (i) adopted in a DTH capacity, or (ii) incorporated into their aggregated satellite transport network – should capacity become available and the network change be supported by a positive business case.

128. These providers of telecommunications services would need to make significant changes to their telecommunications networks to benefit from HTS. Northwestel submitted that it would need to make investments in new antennas, switching equipment, and civil infrastructure, which would amount to an average cost of #$ to $# per site, while KRG estimated that it would cost them #$# per site to upgrade to HTS.

129. In addition, providers of telecommunications services may need to continue operating their existing C-band networks to provide fixed voice services, to supply redundancy in the event of an HTS failure, and to cover any communities outside the serving area of an HTS spot beam, which could result in additional costs.

130. HTS spot beams are presently designed primarily to provide links between users in remote locations and content available on servers located far from the user, usually in southern Canada or in the United States. However, the architecture of HTS does not lend itself well to communications *between* remote users, especially if the users are located in different spot beams. For these types of communications, real-time services, such as voice or videoconferencing, are subject to twice the latency, since the signal goes up and down the satellite twice.[64] Additionally, services delivered using HTS are subject to varying quality of service since these satellites presently operate in Ka-band and are subjected to increased propagation impairments with precipitation.

[64] This situation is also known as "double hops."

131. As part of the inquiry, no stakeholder identified a solution for the foreseeable future for real-time services (e.g. voice) over HTS Ka-band. Therefore, for real-time and critical services, there will likely be a continued need for C-band satellite services.

Achieving the Commission's 5-Mbps download and 1-Mbps upload target speeds

132. During this inquiry, questions were asked as to (i) what role satellite services would play in meeting the Commission's existing broadband Internet target speeds of 5 Mbps download and 1 Mbps upload (referred to as the 5/1 target), (ii) how much capacity would be required to reach the 5/1 target, and (iii) whether the 5/1 target could be reached at all.[65]

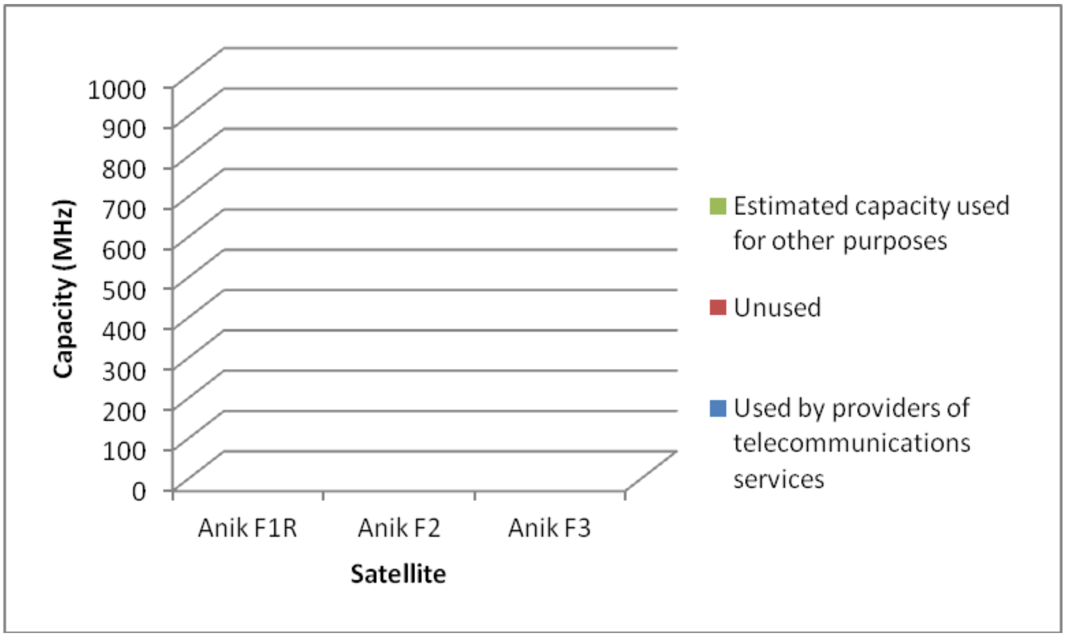
133. While HTS offers the promise of higher speeds and lower cost, current HTS coverage includes only 7 communities that receive Internet service through the community aggregator model. Although additional satellite capacity is planned to be made available by 2016, it does not appear that this additional capacity will be sufficient to serve all Canadians outside the terrestrial broadband footprint – including households in rural and remote areas, and communities that rely on the community aggregator model.

134. As of December 2013, 91% of Canadian households have access to terrestrial broadband connections that can provide speeds of at least 5 Mbps download and 1 Mbps upload. Therefore, it is estimated that approximately 1.2 million households do not have access to broadband Internet access at the Commission's 5/1 target. Roughly 18,000 of those households are located in communities where C-band community aggregator model infrastructure is in place.

[65] The affordability of telecommunications services delivered through FSS was not within the scope of this inquiry.

135. Information was gathered through this inquiry to determine if spare C-band capacity is sufficient to meet the Commission's 5/1 target in communities that rely on the community aggregator model. Analysis of this information is detailed in Appendix B. Of note, and as shown in the figure below, Telesat has a significant amount of unused C-band capacity.

Figure 8.5: Telesat's C-band capacity by satellite



Source: Capacity by satellite was removed due to reasons of confidentiality.

136. While this analysis indicates that total unused C-band capacity is greater than the capacity required to meet the 5/1 target for all residential households in these communities, it appears neither practical nor affordable to expect all of this capacity to be deployed for residential broadband.

137. The needs of businesses and governments must also be accommodated. One recent study[66] has indicated that Internet service plans with minimum speeds of 9 Mbps download and 1.5 Mbps upload would need to be delivered to Northern communities by 2019 to meet projected consumer, business, and government needs. However, only 29%, 87%, and 90% of households in Nunavut, the Northwest Territories, and the Yukon, respectively, have access to broadband at speeds of 5 Mbps to 9.9 Mbps.

138. Northwestel estimates that the satellite capacity cost of offering a 5/1-Mbps Internet service plan is roughly #$# per subscriber per month. Although there is sufficient aggregate FSS capacity available to deliver Internet service plans at such speeds, the price of C-band capacity translates into costs for such plans that would likely far exceed customers' ability to pay for them.

139. Moreover, some providers of telecommunications services submitted that a significant portion of earth station and distribution network infrastructure would not be able to support 5/1-Mbps

[66] See Nordicity's *Northern Connectivity – Ensuring Quality Communications* report, January 2014

Internet service plans. For example, satellite antennas, solid state power amplifiers, modems, routers, traffic shapers, wireless distribution infrastructure, customer premises equipment, and other electronics may need to be upgraded. As discussed in section 7, the total cost of installing a new earth station can range from approximately $100 thousand to $1 million. Providers of telecommunications services are not investing in new C-band equipment because of the significant capital required to do so, and because they do not believe that they can earn an appropriate return on their investment.

140. Telesat's Anik F2 and Anik F3 satellites, which currently supply most of the C-band capacity used to provide telecommunications services in Canada, were launched between 2005 and 2007, meaning that they could reach the end of their useful lives between 2019 and 2022. Upgrades to equipment to handle faster speeds could entail the replacement of satellite antennas, end-user modems, and everything in between. Providers of telecommunications services are reluctant to upgrade earth station infrastructure that is tied to existing satellites that have a limited remaining useful life since it is difficult to justify the additional investment in this equipment.

141. Finally, based on findings in the ACIA report, some C-band satellite capacity on Telesat's Anik F1R satellite is available, however most providers of telecommunications services do not have satellite antennas pointed at this satellite. Therefore, these providers would need to modify or install new earth stations to access the available C-band capacity on Anik F1R. Furthermore, a portion of this capacity is on polarizations that are not supported by the earth stations used by certain providers of telecommunications services.

9) Technological Improvements and Efficiencies

Key findings

- *Although technological advancements can improve the delivery of telecommunications services by way of fixed satellite services (FSS) to a degree, major changes are required to narrow the gap between telecommunications services provided in satellite-dependent and terrestrially-served communities.*
- *Both the community aggregator model (which uses C-band FSS) and the direct-to-home (DTH) model (which uses non-high-throughput satellite (HTS) Ka-band and HTS Ka-band) have their respective strengths and weaknesses, and will likely be used for the delivery of telecommunications services for the foreseeable future.*
- *SSi proposed that the Commission implement a single transport model, which in SSi's view, can help enable more efficient delivery of telecommunications services to satellite-dependent communities.*

Technological and other improvements

142. Technological and operational improvements related to the provision of telecommunications services by way of FSS often lead to cost savings for providers. These cost savings may be passed along to end-users in the form of price reductions or improved services. Alternatively, such savings may reduce the amount of subsidy required to meet basic service requirements.

143. During this inquiry, a number of technological and other improvements that may lead to cost savings and enhanced capacity for providers of telecommunications services in the future were examined, including the following:

   - the pooling of satellite capacity;
   - combining voice, Internet, and wireless networks;
   - upgrades to earth stations so that they are compatible with both polarizations, thereby increasing the amount of FSS capacity available to a provider of satellite services; and
   - earth station co-location and sharing of personnel, land, power, and logistics.

144. Details regarding these opportunities can be found in Appendix E. These and other efficiencies implemented by providers of telecommunications services will play a role in enabling the delivery of better and more cost-effective telecommunications services in the future. However, providers of telecommunications services have also cautioned that such efficiencies will probably not make telecommunications services significantly more affordable in satellite-dependent communities. Many providers have submitted that an entirely new model is needed to serve Northern and remote communities, with either high-throughput Ka-band satellites or terrestrial transport being more effective than satellite C-band.

145. In light of the information gathered during the inquiry, the Inquiry Officer agrees that major changes, which go far beyond improvements to existing network infrastructure, are required to narrow the gap between telecommunications services provided in satellite-dependent and

terrestrially served communities. Notably, and as discussed in section 8, the Inquiry Officer considers that HTS have the greatest potential to reduce cost and/or improve service.

146. Parties to this inquiry debated two other efficiency-related opportunities: the use of the community aggregator versus DTH model, and the potential use of a single transport model. These opportunities are explored further below.

Community aggregator model and DTH model

147. Telecommunications services provided by way of satellite are generally provided using either the community aggregator model or the DTH model. In the community aggregator model, all traffic originating from and destined for a particular community is uplinked and downlinked at a single location called an aggregation point. Traffic is then distributed to and from the aggregation point via an access network within the community. For example, Northwestel, SSi, and the KRG use the community aggregator model. In the DTH model, each customer premise has an antenna installed, and traffic is uplinked and downlinked directly to the satellite. Xplornet uses the DTH model.

148. During the inquiry, providers of telecommunications services expressed conflicting opinions on whether the community aggregator model or the DTH model was the best way of delivering telecommunications services by way of satellite.

Community aggregator model

149. Northwestel stated that the community aggregator model is more efficient than the DTH model in isolated communities that are sufficiently compact to allow for a terrestrial access network. Through the community aggregator model, consumers are not required to purchase a DTH antenna, which makes service installations and repairs more affordable. Skilled install-and-repair technicians are frequently not available in isolated communities, thus any installation and repair work would require that a technician fly to the community, which is expensive.

DTH model

150. Northwestel submitted that the DTH model is very attractive to operators serving rural residents who may be accessed by road, but where terrestrial transport is not feasible because the residents are spread out across a sparsely populated area. Northwestel submitted that the DTH model has some disadvantages in terms of voice services, since calls require a double satellite hop to be performed, which significantly compromises service quality and doubles the amount of space segment required to support a given call volume.

151. Xplornet submitted that the DTH model is a more efficient, cost effective, and reliable way to deliver telecommunications services to remote communities than the community aggregator model. Through the DTH model, Xplornet currently offers Internet packages with speeds that meet the Commission’s 5-Mbps download and 1-Mbps upload target in some communities, and the company plans to deliver Internet service plans with speeds of 25 Mbps in the future. Xplornet’s purchased satellite capacity covers all inhabited parts of Canada, including north of the 60^{th} parallel. Xplornet submitted that the DTH model is more efficient than the community aggregator model given that the DTH model involves less equipment on the ground (i.e. the DTH model does not

require an earth station or distribution infrastructure), and therefore has lower hardware, operating, and maintenance costs. In some remote communities, such as those accessible only by plane, Xplornet has arranged to install hardware for multiple customers to keep costs at a reasonable level. Furthermore, Xplornet trains local community champions on basic service and maintenance needs in such remote communities. The Inquiry Officer notes that the DTH model does still require a small antenna, and associated electronics.

152. As in the discussion above, each model has advantages and challenges. As a result, it is likely that both models will be used for the delivery of telecommunications services for the foreseeable future.

A single transport model

153. During this inquiry, SSi proposed that the Commission implement a utility backbone[67] model, which would offer wholesale customers in the North open access to backbone connectivity services at regulated, cost-based rates. SSi submitted that, at this point in time, the utility backbone model is the best opportunity to enable more efficient delivery of telecommunications services to satellite-dependent communities. SSi proposed the implementation of an "open access" wholesale backbone provider that

- "acquires satellite (or other) backbone transport from network operators;
- "lights" this capacity through the use of ground infrastructure, earth stations, and other needed equipment and electronics;
- brings this capacity into a point of presence in each community; and
- makes backbone connectivity services and co-location facilities available in an open and non-discriminatory basis to each local provider wishing to purchase such services in a given community."

154. Providers of telecommunications services were requested to comment on SSi's utility backbone model, and on whether it would (i) improve the delivery of transport capacity to satellite-dependent communities, (ii) affect the efficient use of FSS capacity and ground station infrastructure, and (iii) facilitate a least-cost satellite transport network. In their responses, parties identified points in favour of and against this model, and additional considerations, which are summarized below.

- MTS Allstream submitted that if price regulation is required, a utility backbone model may be a reasonable approach.
- Ice Wireless submitted that mandated wholesale access at regulated rates is required for FSS, and that SSi's utility backbone model is consistent with Ice Wireless's proposed approach.

[67] The backbone is the major or large capacity routes that carry aggregated traffic and connect different parts or different networks together.

- SaskTel submitted that the utility backbone model has the potential to reduce the cost per megabit in larger isolated communities where FSS is the only choice for backbone connectivity, since this model would increase economies of scale and reduce the operation and maintenance costs associated with a large earth station with high capacity. However, SaskTel expressed concern regarding the capital costs (and lack of recovery of these costs) associated with upgrading earth stations to implement a utility backbone model in locations with very low populations. SaskTel therefore suggested that such a model only be used in communities with a sufficient population base to ensure that the associated capital costs can be sufficiently recovered.

- Keewaytinook Okimakanak submitted that there needs to be some mechanism whereby more than one vendor can purchase transport at equivalent prices; however, Keewaytinook Okimakanak expressed uncertainty over whether a utility backbone model facilitates a least-cost satellite transport network, and whether a least-cost network would be appropriate, since efficiencies for businesses and governments could result in the associated costs being absorbed by residential customers at a lower rate of quality.

155. Multiple parties responded favourably to a utility backbone model that would offer wholesale customers open access to backbone connectivity services at regulated, cost-based rates. However, these parties also raised additional considerations regarding the characteristics of the model.

- The First Mile Connectivity Consortium (FMCC) submitted that a utility backbone model was a potentially useful solution; however, the FMCC emphasized the need for the system to be owned and managed by a non-profit entity responsible to the communities it serves. The FMCC also identified other key principles that should be considered: open access, tariffed rates, and funding opportunities that enable local organizations to build infrastructure and provide services. The FMCC also submitted that the Commission should consider the alternative utility backbone model supplied by the non-profit cooperative, the Northern Indigenous Community Satellite Network.
- The Nunavut Broadband Development Corporation also noted that an open-access network that is largely reliant on and that benefits from public funding should be non-profit and locally controlled. The Nunavut Broadband Development Corporation supported an open-access model with the following characteristics: transparent and non-discriminatory terms, wholesale-only, structurally separate from any telecommunications service provider offering services to the end-user, and technology-neutral for backhaul/backbone.
- The Kativik Regional Government (KRG) favoured an open-access model for transport, and submitted that the aggregation of traffic allows for greater efficiencies and bandwidth sharing. The KRG also noted the importance of accountability to communities, and aboriginal ownership and control. The KRG submitted that given the very small markets and the need for government subsidies, it favours a non-profit model.

156. In contrast, several parties submitted that the SSi's utility backbone model should not be pursued by the Commission.

- Bell Aliant, Bell Mobility, Northwestel, and Télébec submitted that wholesale FSS transport service may assist FSS purchasers in providing richer offerings to their customers. Northwestel[68] submitted that if the Commission were to consider increasing its oversight over FSS rates, it should broadly consider the regulatory options available and not pursue a utility backbone model as proposed by SSi. Northwestel submitted that there is no evidence that the regulatory burden associated with the implementation of rate-of-return regulation with respect to FSS is needed, nor would this be a proportional response to address potential pricing concerns.
- TCC submitted that the transport market is not monopoly supplied, and that therefore, the utility backbone model should not be applied. TCC also submitted that this model would discourage competitive supply and the lower costs that competition brings, create a disincentive to invest in transport capacity, and discourage the efficient use of competitive FSS suppliers, to the extent that the model encourages consolidation to a single ground station.
- Xplornet submitted that the Commission should encourage investment in new technologies that are more cost efficient and provide higher-quality telecommunications services rather than a utility backbone model that applies to older and more expensive technology. Xplornet submitted that although its business model is not dependent on subsidies, it is able to offer very competitively priced packages that compete with services offered by providers that receive subsidies for their FSS. Xplornet submitted that subsidies and other cost allocations mask true expenses, and create impediments to the entry and adoption of more efficient technologies. Xplornet stated that it believes that private capital is available to invest in the infrastructure for the provision of broadband in Canada, including in the far North.

157. In contrast to SSi's model, Northwestel submitted that the Commission should consider implementing a wholesale transport service for Telesat's FSS. Northwestel noted that while such a service may assist FSS purchasers, a subsidy may be needed to meet the Commission's broadband Internet 5-Mbps download and 1-Mbps upload speed targets. Northwestel suggested that the Commission should take steps to ensure that any subsidy regime is based on just and reasonable inputs.

158. In Telecom Regulatory Policy 2013-711, the Commission outlined its plan to launch a proceeding in which, among other things, it intends to establish a mechanism to fund infrastructure investment in transport facilities in Northwestel's operating territory. Based on the points raised by the parties during this inquiry, both the single transport model and the wholesale satellite service may be options that would merit consideration by the Commission when this proceeding is initiated. Reliance on new technologies and private capital may also deserve consideration.

[68] Bell Aliant, Bell Mobility, and Télébec referred to Northwestel's submission.

10) Competition and Regulation

Key findings

- *Fixed satellite services (FSS) for satellite transport can be divided into three relevant product markets based on the type of spectrum used: Ku- band, Ka-band, and C-band.*
- *The relevant geographic market for FSS for satellite transport is communities that are wholly or partially dependent on satellite transport, with no presence of, or inadequate, terrestrial transport facilities.*
- *Market differentiation is based on a number of factors, namely (i) the different characteristics of the spectrum (e.g. susceptibility to weather conditions and coverage), which make each band suited to delivering different types of services, and (ii) the high cost of switching between bands (e.g. the duplication or re-pointing of earth stations, the replacement of electronics and antennas, and service interruptions).*
- *There are significant barriers to changing FSS providers, given the costs, complexity, and contracts involved.*
- *The C-band market in Canada consists of a dominant operator (Telesat), with a very high[69] market share of the C-band capacity used by providers of telecommunications services.*
    - *Telesat has complete C-band coverage of Canada, including all remote communities. For a number of real-time applications, this band is the only one that can be used.*
    - *There are significant costs to switching FSS providers.*
- *C-band service is becoming a legacy service due to the emergence of high-throughput satellites (HTS) in the Ka-band, so there is little incentive for other satellite operators to enter the C-band market.*
- *Consequently, since Telesat is the dominant provider in the C-band market, some form of regulatory oversight remains appropriate. While Telesat's price ceiling appears to have functioned as intended, it has not been reviewed in over 15 years.*
- *In light of market changes and projected trends in the C-band market, the Inquiry Officer considers that it would be appropriate for the Commission to conduct a review of Telesat's price ceiling on C-band FSS to confirm (i) the level of the price ceiling, and (ii) which of Telesat's C-band satellite services should be subject to price ceilings.*
- *While Ka-band market analysis indicates that this market is not presently very competitive, there are indications of evolution: the introduction of spot beam technology and HTS services, recent announcements of new satellite operator entrants in the near future, and an expectation that Ka-band prices will decrease over the next decade due to increasing supply. On a prospective basis, it is*

[69] Market share was calculated based on confidential information provided by parties. Specific market share information has been removed due to reasons of confidentiality.

anticipated that the Ka-band market will be sufficiently competitive, such that no regulatory intervention is required.

Commission regulation of FSS

159. The Commission has adopted a light regulatory approach to satellite services. Prior to 2000, Telesat was the monopoly provider of satellite services in Canada. In Telecom Decision 99-6, the Commission partially forbore from regulating Telesat's FSS,[70] and established a price ceiling for all FSS on Anik E and Anik F1, consisting of $170,000 per month for unprotected, pre-emptible, full-period channels[71] for minimum 5-year leases for both C-band and Ku-band channels. The Commission noted that the substantial forbearance granted in that Decision would also apply to all FSS services provided by Telesat including those to be provided on Anik F2 when it was launched. This framework remains in place today. In March 2000, the Canadian satellite market was opened, and foreign satellite operators were permitted to provide satellite services in Canada.

International regulatory landscape

160. There is also evidence abroad of the light regulatory touch applied to satellite services. The satellite operators that participated in this inquiry indicated that other jurisdictions in which they operate do not regulate the price of satellite capacity. For example, Telesat submitted that it has landing rights in more than 130 countries and that it is not rate-regulated in any of these countries, including in those where it has FSS operations. Telesat added that it is not aware of any country where the rates of FSS satellite operators are regulated. Similarly, Hughes, Hunter, and Intelsat submitted that their FSS rates are not regulated in any countries where they provide service.

161. In a review of licensing practices in 8 jurisdictions[72] for Industry Canada in 2010, Nordicity found that only Mexico requires satellite operators to reserve a portion of their satellite capacity for use by the state without charge (e.g. for national security and services of a social character).[xxix] SSi submitted that in Mexico, "concessionaires" (which include any satellite operator with landing rights) must register their tariffs with the Public Registry of Concessions, which is managed by the country's national regulatory authority. The tariffs that are registered are the maximum tariffs applicable; however, operators may freely determine discounts as well as other rates, terms, and conditions of service. SSi submitted that the main purpose of the registry is to enable Mexico's national regulatory authority to monitor anti-competitive conduct.

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[70] The Commission forbore from the application of sections 25, 29, and 31, and subsections 27(3) and 27(6) of the *Telecommunications Act*.

[71] At the time of Telecom Decision 99-6, channels were referred to as "transponders." Full-period refers to the use of one full transponder, as opposed to the use of a partial transponder. Pre-emptible means that a service can be bumped from operation. For example, if a transponder being used by a priority service fails, that priority service can bump the pre-emptible service off of its transponder and take its place.

[72] Australia, Brazil, France, Luxembourg, Mexico, New Zealand, the United States, and the United Kingdom.

Satellite operators

162. Telesat and other parties have noted that since 2000, there have been 87[73] foreign satellites authorized by Industry Canada to provide FSS in Canada and that could offer satellite transport service in satellite-served communities.[74] Of these, 54 have C-band capacity. Based on information from Industry Canada, there are 9 satellite operators, including both domestic and foreign, that operate FSS satellites that are approved for use in Canada.

163. The evidence obtained through the inquiry has indicated that, while a large number of satellite operators could provide satellite services in Canada, only a small number of satellite operators actually presently provide satellite services to providers of telecommunications services and end-users in Canada. During the inquiry, three satellite operators identified that they provide FSS to providers of telecommunications services in Canada.

- Telesat: provides FSS on C-band, with a footprint that covers all of Canada, including the North. Telesat also provides Ku-band services, mainly for broadcasting distribution, and Ka-band services that are used to provide Internet services directly to consumers.
- SES: provides FSS on C-band[75] through its affiliate, New Skies Satellites. SES does not provide services directly in Canada and has no earth station operations in Canada.
- Hughes: a wholly owned subsidiary of EchoStar Corporation,[76] provides all of its Canadian Ka-band FSS to Xplornet for DTH Internet broadband service.
- Hunter: was expected to offer FSS on Ku-band starting in June 2014, but does not currently have any executed agreements.[77]

Satellite coverage

164. Telesat appears to provide optimal service in terms of coverage as well as quality/strength of the signal. Among the satellite operators offering C-band capacity in Canada, only Telesat's C-band footprint covers the far reaches of Canada's North. The C-band footprints of most other satellite operators in Canada cover the central areas of the North (from a geographic perspective), and do not necessarily cover the far eastern, northern, and western portions. Therefore, while there is a partial overlap of footprints from other satellite operators with Telesat's footprint, and service is possible through alternative satellites, other satellite operators' services are offered under less-

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[73] Of note, satellite operators own multiple satellites that are authorized to provide FSS in Canada.

[74] Industry Canada provides a List of Satellites Approved to Provide Fixed-satellite Services (FSS) in Canada, including foreign satellites.

[75] SES is a satellite operator based in Luxembourg that offers service in Canada through its affiliate, New Skies Satellites.

[76] EchoStar Corporation does not directly provide satellite services in Canada.

[77] Hunter is a satellite space segment provider based in New York and Alberta, which has partnered with Satmex to deliver coverage of Canada, with a focus on providing capacity for non-DTH purposes. Its satellite is operating in inclined orbit.

than-optimal conditions (e.g. with a higher cost, less-than-universal coverage, and weaker signal strength) compared to those that Telesat can offer. This has implications for the services that can be provided to end users in satellite-dependent communities.

165. The situation is similar for non-HTS Ka-band coverage, since only Telesat's Anik F2's Ka-band beams reach the North.

166. These factors identified above may be why Telesat is the predominant FSS provider in satellite-dependent communities. In this regard, a number of companies, such as Northwestel, Bell Mobility, Bell Aliant, MTS Allstream, TCC, and SSi, indicated that they purchase FSS only from Telesat.

Current supply of FSS in Canada

167. The record of this inquiry shows that the market for FSS that are used to provide telecommunications services in Canada is highly concentrated. Three satellite operators presently provide FSS in the three spectrum bands to providers of telecommunications services, as shown in the following table.

Table 10.1: Market share of satellite operators by satellite band

Operator	**Market share by revenue**			**Overall**
	C-band	**Ku-band**	**Ka-band**	
Telesat	Highly dominant	Highly dominant	Dominant	Very dominant
Hughes	Minimal	Minimal	low	Minimal
SES	Very low	Very low	Minimal	Very low

Source: Confidential information. Market share information was calculated based on confidential information provided by parties. Specific market shares have been removed for the public version of the report due to reasons of confidentiality.

168. Telesat indicated in its submissions that it is acutely aware of the role that satellite transport services play in the North and the increasing demand for high-speed transport. Telesat noted that it has consistently provided high-quality services with an overall C-band reliability of 99.9858% of in-service time. Telesat also noted that it continues to be a challenge to make a business case to significantly expand transport services in high-cost/low population areas. Telesat noted that, due to the cost of satellite transport, it is almost impossible to make a viable business case to implement retail Internet or wireless services in the North that are comparable to equivalent services in the South.

169. Telesat further noted that the Canadian satellite transport market is competitive, given the number of other satellite operators authorized to provide satellite services in Canada. Telesat added that one of the reasons it has had such success in the Canadian market is due to the level of customer

service it provides. Telesat noted that it has invested in facilities that are optimized to provide high-quality services to Northern Canada at a low overall cost to providers of telecommunications services in the North.

Re-examination of the regulatory framework for satellite services

170. As part of this inquiry, the Commission's existing regulatory framework for satellite services was examined as to whether it remains appropriate. As noted earlier, the Commission last examined Telesat's regulatory framework in 1999. In Telecom Decision 99-6, the Commission (i) forbore from regulating, among other things, Telesat's rates for radio frequency channel services provided over FSS facilities, and (ii) established a price ceiling for these rates that Telesat could charge in certain circumstances. The Commission also retained some of its powers under section 24 but forbore from the regulation of FSS under subsections 27(1), (2), (3), (4), and (5) of the *Telecommunications Act* in that decision.

171. In Telecom Decision 94-19, the Commission established a framework, based on principles from economics and competition policy, for determining whether or not to refrain from the regulation of telecommunications services. This framework uses the concept of market power as the standard by which to determine whether a market is, or is likely to become, competitive.

Relevant geographic market

172. The first step in the Decision 94-19 analysis is to determine the geographic area and the smallest group of products in which a firm with market power can profitably impose a sustainable price increase in the relevant market.

173. During this inquiry, a number of parties were of the view that the relevant market should include all types of transport facilities, since telecommunications companies are relatively indifferent to the type of technology used to provide transport services. However, it was further noted that when terrestrial facilities are present, they will always be used over satellite transport due to the advantages that services provided through terrestrial facilities have over satellite services in terms of the cost and the quality of service (including speed) for an equivalent level of service. The one exception is where a terrestrial facility cannot support the provision of telecommunications services. For example, some microwave facilities can support voice traffic, but do not have sufficient capacity to support the delivery of data or broadband Internet services. In these instances, a remote community will be partially dependent on satellite services for those services that cannot be supported by the existing terrestrial facilities.

174. Therefore, there are essentially two types of satellite-dependent communities in the North and other remote areas: (i) those that have some form of terrestrial facilities that can support some telecommunications services (i.e. voice) but are insufficient to support other telecommunications services (i.e. broadband Internet), which must be provided via satellite facilities, and (ii) those that lack any form of terrestrial facilities and are solely dependent on satellite transport services in order to receive any and all types of telecommunications services. Thus, the geographic area for satellite

services should be considered as those communities that are either wholly or partially dependent on satellite transport services for telecommunications service backhaul.

Relevant product market

175. Parties expressed differing views on whether different frequency bands make up one, two, or three separate product markets. The satellite operators were generally of the view that there is one product market, stating that the three bands are strong substitutes for each other. The providers of telecommunications services that use satellite services were generally of the view that each band is a separate product market with limited substitutability.

176. The general characteristics of and services that use each band are as follows:

a) C-band

177. FSS provided over C-band is used to provide a number of services, such as broadcasting distribution, occasional-use television, and telecommunications voice and data services. Of these three service categories, telecommunications services represent the smallest category. Compared to the other bands, C-band operates at a lower frequency, which allows for more robust transmission that is not as easily impacted by adverse conditions, such as weather. Another advantage of C-band is its national footprint, which minimizes latency effects between any calls made in Canada and interconnection points to Canadian terrestrial distribution networks.

b) Ku-band

178. Ku-band is currently used for enterprise data services, broadcasting services (including DTH satellite television, occasional-use television) and several other services. Ku-band operates at a higher frequency than C-band and is thus more easily impacted by weather conditions, making it a less desirable band to use as the backbone for the delivery of voice telephony services. Ku-band has a smaller footprint than C-band, such that national coverage of Canada is not possible using Ku-band.

c) Ka-band

179. Ka-band is currently being used to provide DTH broadband/data services. It can also be used to some extent for voice services through over-the-top Internet techniques [i.e. voice over Internet Protocol (VoIP)], but there are significant time delays (latency), which significantly reduce the quality of the services provided using this band, especially for calls made between satellite-dependent communities. The antenna size is small enough that it can be used for DTH services, which eliminates the need for a satellite transport service to a terrestrially based distribution network(s) within a community. Like Ku-band, Ka-band can be susceptible to adverse weather conditions, but the effects can be somewhat mitigated with higher power levels and newer encoding techniques.

Band differentiation

180. While it may be possible to technically substitute different bands for different services, it may not be practical or desirable to do so due to the trade-offs that would have to be made (i.e. in terms of the robustness and reliability of service), and the necessary equipment changes (each band requires

different equipment to enable the transmission of signals) which increase the costs of using other spectrum bands. It is therefore unlikely that a customer would substitute different bands in response to a sustainable price increase imposed by a satellite operator with market power.

181. The above suggests that there are three distinct product markets for FSS in Canada: C-band, Ku-band, and Ka-band.

182. During this inquiry, many submissions were made regarding the advent of new satellite technologies, such as HTS in the Ku- and Ka-bands. It is anticipated that future satellite services will increasingly use Ku-band and Ka-band, since these bands can accommodate much higher data bandwidth and DTH services at lower costs. The differentiation of the three frequency bands into different product markets is therefore likely to continue into the future.

Switching to an alternative FSS provider

183. For a market to be efficient and competitive, not only do alternative FSS providers need to be present, but FSS customers also need to be able to take advantage of competitive offers or otherwise respond to price changes in the marketplace by switching suppliers. If the barriers to switching FSS providers are too significant, very few FSS customers will be able to reap the benefits of competition.

184. At present, three satellite operators provide FSS to providers of telecommunications services in Canada and, according to Industry Canada, there are over 100 Canadian and foreign satellites approved to provide FSS in Canada. It is therefore apparent that providers of telecommunications services have a degree of choice in their FSS provider, but the question remains of how easy (or difficult) it is for a provider to exercise that choice if a new FSS provider is desired. In assessing the competitiveness of the satellite industry, information was collected during the course of the inquiry on how feasible it is for a provider of telecommunications services to switch from one FSS provider to another.

185. FSS customers generally have the greatest flexibility in choosing an FSS provider when first purchasing FSS services. Once an FSS provider has been selected and satellite ground infrastructure is in place, there are several barriers to switching to a different provider. Assuming that a customer can find a new FSS provider that provides adequate coverage, capacity, service quality, and continuity, a number of expenses will be incurred when switching providers, some of which can be substantial. In the best-case scenario, the satellite antenna would be re-pointed at the new satellite and the electronic equipment would be re-used. However, as parties have noted, it is likely that a new antenna and electronic equipment would be required to be compatible with the new FSS provider. Also, if service interruptions associated with the switch are to be avoided, then a gradual transition would be needed, meaning that it would be necessary to duplicate earth station(s). The costs to build a new station can vary quite significantly. As previously noted, the total cost of installing a new earth station can range from approximately $100 thousand to $1 million. In addition to these costs, if a switch in FSS provider is made before the end of a contract term, contract termination costs incurred would also be a barrier to switching providers.

186. Some providers of telecommunications services operate in more than one community using FSS capacity purchased off a single satellite. If this is the case, the above-noted costs must be incurred for each community, making the switch that much more expensive and the business case for switching that much more difficult. Also, for voice services that use C-band transport, all of the communities served by a provider of telecommunications services using the same satellite would have to be switched at the same time to maintain the mesh networking functionality[78], which keeps latency levels at a minimum.

187. There are also issues in switching FSS providers for providers of telecommunications services that use Ka-band to provide DTH broadband service, since the terminal equipment at each customer's premises may require changes. These changes may consist of simply re-pointing the satellite dish, or may require a complete change of the equipment, all of which would most likely be at the expense of the providers of telecommunications services.

188. Given the costs, complexity, and contractual issues involved, the Inquiry Officer considers that the barriers to switching FSS providers are significant and challenging.

Market competitiveness

189. In the Commission's forbearance framework, articulated in Telecom Decision 94-19, the Commission set out a number of criteria to be examined when determining whether a market is competitive. These criteria include the following:

- the market shares of the dominant and competing companies;
- the demand conditions, in terms of the availability of substitutes or the ability to reduce consumption, switching costs, and the essentiality of the product as an input;
- the supply conditions, in terms of the capacity available, the likelihood of additional entry, and the barriers to entry; and
- evidence of rivalrous behaviour, for example, in terms of falling prices, vigorous marketing activities, or an expanding scope of activities; and
- other factors, such as the nature of innovation and technological change.

190. Given that Ku-band is used predominantly to deliver broadcasting services, and given the scope of this inquiry, the market analysis that follows will focus primarily on the C-band and Ka-band capacity that is used by providers of telecommunications services for the delivery of telecommunications services in Canada. There are a number of similarities between the C-band and Ka-band product markets; however, there are differences − in particular, based on the technologies used, competitive responses, and customer demand − as evidenced in the following table.

[78] This provides for some call switching on the satellite platform, which permits direct routing from one earth station to another earth station as long as both earth stations are aimed at the same satellite.

Table 10.2: Market analysis according to the Decision 94-19 framework

Criterion	Band	
	C-band	Ka-band
Market share	There are two operators in Canada, with Telesat as the dominant provider based on information submitted in confidence on the record of this inquiry.	
	It is unlikely there will be any new satellite operators providing C-band services in Canada.	**Within the next few years, additional satellite operators will be adding coverage and capacity for use in Canada.**
Demand conditions		
Availability of economically feasible and practical substitutes	Only Telesat has a national footprint.	
	Telesat uses mesh networking, which is critical for voice services. Also, other bands may not be as reliable or robust as C-band against service interruptions.	**Hughes' footprint does not cover most portions of the North. Additional coverage will be added in the next few years by other satellite operators.**
Customer costs to switch suppliers	Costs are very high since customers may have to replace or duplicate earth station infrastructure and electronics, with reduced time to recoup these investments due to the age and limited remaining lifespan of some satellites	
Whether the product is an essential input	Yes. Each band provides connectivity to the public switched telephone network/Internet for providers of telecommunications services.	
Supply conditions		
Availability of additional capacity by satellite operators to accommodate a large switch of customers	A major portion of satellite capacity is typically spoken for before a satellite is launched. The only way to add capacity is to launch a new satellite, which is very expensive and dependent on the availability of orbital parking spots. **At present, there is unused C-band capacity, but it is somewhat fragmented, and earth station enhancements (which can be costly) would be required to access it.**	Capacity is typically spoken for before a satellite is launched. The only way to add capacity is to launch a new satellite, which is very expensive and dependent on the availability of orbital parking spots. **New capacity for Canada has been announced by foreign satellite operators.**

Criterion	Band	
	C-band	**Ka-band**
Likelihood of entry	Satellites are very expensive to build and launch (in the order of $500 million), and the ability to put a new satellite into orbit is dependent on the availability of orbital parking spots. It can take up to 7 years to get such a spot for a Canadian footprint. It is possible to enter the market using non-Canadian orbital parking spots, but coverage by satellites in these orbital positions of some parts of Canada may be sub-optimal.	
Nature of entry barriers	Very high, given the high cost of a satellite, the lengthy approval process to obtain an orbital spot (up to 7 years), and a scarcity of vacant orbital parking spots (one left for Canada).	
Evidence of rivalrous behaviour	Little evidence of rivalrous behaviour between the two current satellite operators.	
	Future satellites will focus on the provision of Ku-band and Ka-band services, resulting in less supply of C-band capacity in the future.	**Some recent announcements (by Xplornet) suggest that there will be additional competitive supply within the next 3-4 years.**
Nature of innovation and technological change	Satellite innovation can only occur whenever a new satellite is launched.	
	There is little evidence that new technologies are on the way for C-band services.	**Spot beam technology is being increasingly used to provide capacity where needed.** **HTS are expected to be launched within the next several years. These satellites will provide for Internet speeds that are comparable to the speeds of terrestrially based networks.**

C-band competition

191. As shown in the above analysis, Telesat has market power in the C-band product market. This can be attributed, at least in part, to Telesat's position as the incumbent satellite operator in Canada and to the company's ability to provide customers with a national footprint.

192. This situation is not expected to change in the future, since based on the evidence collected during this inquiry, C-band is becoming more of a legacy service. Because demand for telecommunications services is shifting more towards data services, voice services have become a mature market with

flat-to-decreasing demand, resulting in very little incentive for new satellite operators (either existing operators or new entrants) to build C-band capacity or to bring additional C-band capacity to the market, especially for areas in the North or other remote areas with very low population densities and low revenue opportunities. It is expected that C-band will in many instances be increasingly overtaken by HTS services that use Ka-band frequency. It is therefore unlikely that the C-band market will become any more competitive than it is at present, and Telesat will likely remain the dominant supplier of C-band FSS. However, there will be a continued need for C-band for services that depend on real-time communications with minimal latency effects, such as voice services.

Ka-band competition

193. While the Ka-band market analysis above indicates that the Ka-band market is not presently very competitive, the future outlook is quite different for Ka-band than for C-band. There are indications of evolution of technology, with the introduction of spot beam technology and HTS services, as well as recent announcements[79] of new satellite operator entrants in the near future. The newer satellite/transponder technologies provide for a more dynamic Ka-band capacity supply since spot beams can be re-aimed to where additional capacity can be used. Also, Northern Sky Research's report indicated that Ka-band prices in North America are expected to decrease over the next 9 years due to increasing supply. On a prospective basis, it could therefore be concluded that the Ka-band market will become sufficiently competitive, such that no regulatory intervention is needed.

Regulatory framework

194. The Commission's only regulatory measure that is currently in place is a price ceiling on C-band and Ku-band for full-period, unprotected, pre-emptible radiofrequency channel service[80] over FSS for lease terms of at least 5 years.

195. Despite the claim made by Telesat that the Canadian satellite service market is competitive, the above analysis raises some concerns regarding the actual state of competition in the Canadian satellite market for telecommunications services, especially in remote areas.

196. Such concern was expressed by MTS Allstream, which tested Telesat's claim by sending out requests for satellite services in Manitoba. MTS Allstream noted that it sent out 13 requests and received just 3 responses representing 4 companies. MTS Allstream noted that some of the responses indicated that there was no satellite service coverage in Manitoba, and other responses indicated that satellite operators were only interested in selling the entire capacity of a satellite to a single customer. Some responses suggested that MTS Allstream should consider sub-leasing capacity from a company that had made bulk purchases. MTS Allstream concluded that its

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[79] Specific details on announcements by satellite operators were provided to the Inquiry Officer in confidence. Given their competitively sensitive nature, these details are not being publicly released and have been removed.

[80] This service is for a transponder that is used full time, not occasionally or part time. Also, this service can be bumped off of a transponder by a protected, un-pre-emptible service in the event of a protected transponder failure.

investigation showed that it does not have competitive choice in satellite operators. It therefore suggested to the Inquiry Officer that some form of regulation may be required.

197. Similarly, other parties such as Bell Aliant, Bell Mobility, Ice Wireless, SSi, Télébec, and the Northern Indigenous Community Satellite Network, were of the view that some form of regulatory oversight may be required in the Canadian satellite service market given (i) that Telesat, in many remote areas including in the North, is the sole provider of FSS, and (ii) the impact that FSS have on the nature of the telecommunications services ultimately provided to end-users. However, a number of parties, such as Hunter, Juch-Tech, SES, TCC, ViaSat, and Xplornet, expressed the view that no further regulatory oversight or measures are required for any satellite services in Canada. Some of these parties also indicated that the current price ceiling on C-band services should be removed, since it is no longer relevant because the current prices are well below the price ceiling. Despite some calls for greater regulatory oversight, no participants in the inquiry specifically argued that Telesat had or has been abusing its dominance or power in the marketplace. Moreover, a number of Telesat's customers stated that they are satisfied with Telesat's quality of service and level of customer service.

198. The regulatory measures called for by the parties that submitted that regulatory oversight is required ranged from the Commission updating the current price ceiling, establishing a utility backbone service, setting transport prices based on Phase II costs plus a markup, to setting wholesale transport rates.

199. The Commission could take a number of approaches regarding the current C-band product market, that range from:

- maintaining the status quo, including substantial forbearance granted in 1999 and a price ceiling on Telesat's FSS rates, pursuant to Telecom Decision 99-6;
- maintaining the status quo, with the addition of an annual reporting requirement as a means of monitoring changes in/evolution of the market;
- maintaining the substantial forbearance granted, while reviewing and adjusting (if necessary) the price ceiling applicable to full transponders on long-term leases;
- reversing forbearance for Telesat's FSS provided over C-band, and requiring Telesat to file tariffs for Commission approval.

200. When the price ceiling was established for Telesat's full-period FSS in Telecom Decision 99-6, the Commission noted that this price ceiling would provide Telesat with the flexibility to compete in the market (which had just been opened to competition), while making available a basic underlying component of satellite service and affording a degree of continuing regulatory protection for users who may not have access to competitive alternatives.[81] The price ceiling was set at the approved rates that existed at the time. Evidence provided during this inquiry indicates that prices for C-band

[81] See Telecom Decision 98-24, Telecom Public Notice 98-40, and Telecom Decision 99-6.

capacity used for voice and data transport in Canada has decreased significantly[82] since 2005, and that these prices are well below the price ceiling established in Telecom Decision 99-6. This seems to indicate that the price ceiling approach has served both Telesat and its customers well, and that the current rates are reasonable and reflective of the nature of the satellite market.

201. Based on submissions made during this inquiry, Telesat will likely remain the dominant provider of C-band FSS in wholly and partially satellite-dependent areas for the foreseeable future, especially considering that Telesat has the most extensive C-band coverage in Canada and that there is unlikely to be any strong competitive entry in the Canadian C-band market in the future. In fact, projections indicate that C-band supply is likely to slightly decrease in the coming years. Also the current price ceiling rates have not been reviewed since 1999, and while prices have fallen significantly since then, some forecasts have indicated that C-band prices in North America could increase by over 30 percent from 2013 price levels by the year 2023. Further, much has changed since the price ceiling rates were established, including the introduction of new satellites serving Canada, new technologies (i.e. spot beams and HTS), and the changing demand for services (i.e. high-speed broadband).

202. Therefore, it would seem that some form of regulatory oversight continues to be required. With few prospects of competitive entry into the C-band market expected, it is suggested that the Commission should continue its regulatory oversight at this time. This oversight would provide a continued safeguard for providers of telecommunications services against unreasonable price increases in a market dominated by a single provider. However, this oversight should continue to allow for competition in the C-band product market, while providing Telesat with the flexibility to respond to any competitive pressures. In the Inquiry Officer’s view, continuing the price ceiling approach, with a review of the level of the price ceiling, would reflect the above-noted considerations.

203. Therefore, the Inquiry Officer considers that it would be appropriate for the Commission to conduct a review of Telesat’s price ceiling for C-Band FSS, regarding both the level of the price ceiling and to confirm which C-band satellite services should be subject to the price ceiling, and under what conditions (e.g. length of contracts, partial use of transponders, conditions of use, etc).

204. While the Ku-band was not examined in any detail during this inquiry, since the majority of services provided using this band are broadcasting services, the Inquiry Officer is of the view that there will be additional competitive entry into the Ku-band market, as noted by Xplornet, Hughes, and Hunter. Since the price ceiling on Ku-band satellite services also dates from 1999, the Commission may want to consider a re-examination of that price ceiling and consider whether there is a continued need for it.

205. The Inquiry Officer considers that both private-sector investments and government funding have a role in the issues involving satellite transport and bridging the digital divide between satellite-dependent and terrestrially-served communities, particularly as satellite-dependent communities

[82] Specific information on prices – in this case, the percentage decrease in prices – has been removed due to reasons of confidentiality.

are likely to remain reliant on FSS for the foreseeable future. Telesat noted that the key challenge is to find a way to amortize the costs of satellites and related terrestrial telecommunications network facilities across a very small and thinly dispersed population, and that this challenge may be met by providing some level of government and/or regulatory funding.

206. That said, the level of any funding should be assessed and set in relation to rates that are reasonable. Furthermore, it is the role of the Commission to ensure that FSS rates are fair and reasonable, while ensuring the continued implementation of Canada’s telecommunications policy objectives. Given Telesat’s dominant position in the marketplace, a review of the price ceiling for Telesat’s C-Band FSS, which is now over a decade old, would help to ensure that the rates charged by Telesat for these services in Canada are reasonable into the future.

11) Appendices

Appendix A: Glossary of terms

207. This appendix contains definitions of commonly used and technical terms used throughout this report, as well as terms used by Northern Sky Research in its *Global Satellite Capacity Supply and Demand* report which have been referenced in this report.

Broadcasting satellite service: a radiocommunication service whereby signals, intended for direct reception by the general public, are transmitted by space stations.

Communications payload: the equipment, on board a satellite, required for the provision of communications services.

Community: In the context of this report, a community is a group of households, businesses, and/or government buildings. Also see definitions of **satellite-dependent community** and **partially satellite-dependent community**.

Direct-to-home service: telecommunications and/ or broadcasting distribution services that are delivered directly to the home without going through a telecommunications or broadcasting distribution network. Typically, a direct-to-home service is provided using a small antenna that can be installed on residential buildings.

Earth station: a terrestrial installation, consisting of an antenna (also known as a dish), electronics, and electrical systems, that communicate with a satellite to enable communications services, provided that the earth station is located within the satellite footprint (the area that the satellite covers). The earth station is often recognized by the antenna, which can be small (less than a metre in diameter) or very large (greater than 10 metres in diameter). The choice of antenna depends on the frequency band to be used. Also included in the earth station is the modem, which sends and receives signals to and from the satellite and, in the case of traditional fixed satellite service systems, converts the satellite capacity into a usable format (mostly megabits per second).

Earth station operator: an entity that owns and/or operates one or more terrestrial transmitting/receiving stations that communicate with a satellite(s) to provide communications services.

Effective isotropic radiated power (EIRP): the power transmitted at the output of an antenna usually expressed in watts.

End-users: retail customers who purchase communications services (including Internet access) at retail rates and who do not, in turn, sell these services to other customers.

Fixed satellite service (FSS): a radio-communications (either one-way or two-way) link, transport or backhaul service between earth stations or other types of terrestrial antenna, such as those used for direct-to-home services, and a satellite, where the satellite stays in the same position relative to the earth station(s)/antenna(s) that are linked to that satellite.

Frequency bands: subdivisions of the frequencies that make up the electromagnetic radiation spectrum. These subdivisions are allocated for specific radiocommunication services, which include fixed satellite service.

Gateways: High capacity earth stations that link a satellite network to the public switched telephone network (PSTN) or the Internet.

Geostationary orbit: a satellite orbit 35,786 kilometres from sea level above the Earth's equator where satellites orbit in the same direction of the Earth's rotation and thus appear stationary to a user on the ground.

Latency: the time delay between the transmission and reception of a signal.

Mobile satellite service: a radiocommunication service between mobile earth stations and one or more satellites.

Orbital positions: specific positions along the geostationary orbit at which geostationary satellites are placed, expressed in degrees of longitude.

Oversubscription ratio: the number of subscribers that share a common path or link between a satellite and an earth station.

Partially satellite-dependent community: a community that may have some form of terrestrially based telecommunications facilities (e.g. micro-wave) for some telecommunications services (e.g. voice services) but no suitable terrestrial facilities for other telecommunications services (e.g. broadband Internet service), which is provided via satellite.

Polarization: the orientation of the transmission plane of a signal relative to an antenna.

Provider of telecommunications services: In the context of this report, an entity that provides telecommunications services, such as voice, wireless (both fixed and mobile), or Internet services to end-users in Canada. These entities typically provide their telecommunications services over either owned or leased in-community wired or wireless distribution networks. In satellite-dependent communities, these distribution networks are typically connected to an earth station for carriage of voice and data traffic to the public switched telephone network and/or the Internet.

These entities may also provide direct-to-home satellite-based communications services, without the need for a terrestrially-based network to deliver services to their end-users.

Public switched telephone network (PSTN): The worldwide set of interconnected switched voice telephone networks that deliver telephone services to the general public and that are usually accessed by customer premise equipment, such as telephones, key telephone systems, private branch exchange trunks, and certain data arrangements. Voice and other audio, video, and data signals are transmitted through these networks by completion of a circuit between the points of call originator and the call receiver. The PSTN includes a number of different network elements, such as local loops; short-haul trunks; long-haul trunks, including international links; exchanges; and switching technology.

Satellite: a platform that is placed in orbit above the Earth and is used as a relay station to provide communications services.

Satellite access: the one-way or two-way wireless path between an antenna at an end-user's location and a satellite over which communications is passed for the provision of direct-to-home satellite service.

Satellite-dependent community: a community that has no connection to terrestrially based telecommunications facilities for connection to the public switched telephone network (PSTN) and/or the Internet, and that relies on satellite transport to receive one or more telecommunications services (such as voice, wireless [both fixed and mobile], and Internet services).

Satellite link: wireless path between an earth station (known as the ground segment) and a satellite (known as the space segment) using spectrum allocated to fixed satellite services, which is used for the delivery of commercial telecommunications services.

Satellite operator: a licensed entity that is authorized to own or operate satellites and provides commercial satellite services to customers.

Satellite transport: the one-way or two-way communications link between an earth station and a satellite over which communications is passed for the provision of communications services.

In communities that receive telecommunications services through satellite transport, a large satellite antenna (or dish) is installed in the community and provides the link between the satellite and the local distribution network. The local distribution network can be built using copper cables, fibre optics, or antennas and towers in the case of a wireless distribution network. The use of these networks for the provision of telecommunications services is known as the community aggregator model because all traffic is aggregated at a central point in the community (contrary to the direct-to-home model, through which service is provided directly to the end-user without going through a local distribution network).

Spectrum: the range of all possible frequencies used for electromagnetic radiation.

Spot beam: a satellite beam that is specially concentrated to cover a limited large area. Together a group of these beams typically covers a large area such as a country or a continent (as compared to the **wide beam**).

Teleport: a large earth station, usually containing many antennas, that provides a link between a satellite and the public switched telephone network or the Internet for the delivery of telecommunications services.

Terrestrial backhaul facilities: ground-based transmission facilities that consist of any wire, cable, radio, optical or other electromagnetic system, or any similar technical system used for the transmission of communications between network termination points.

Transponders: equipment onboard a satellite that creates communications channels that take an uplinked signal, at the uplink frequency from an earth station, amplify it, and change the signal to the downlink frequency for retransmission to another earth station.

Transport or backhaul service: high-capacity telecommunications links that provide various telecommunications services to a community network and its subscribers. Transport services are used in the delivery of fixed and mobile voice services, and Internet services to communities.

Virtual private network (VPN): a private network that extends across a public network, such as the Internet, and provides secure private access between end-users.

Wide beam: a single satellite beam that typically covers a country or a continent.

The following terms are used in Northern Sky Research's *Global Satellite Capacity Supply and Demand* report[83]

Commercial and government/military mobility: services for maritime, aeronautical, and land mobile applications for commercial and government customers.

Direct-to-Home Broadband Access: is an Internet access service that makes use of satellite space capacity for residential, small and medium-sized enterprises and corporate end users. Broadband access services are provided on a "best effort" basis without any special provisions for "networking" individual sites/subscribers together as is the case for a VSAT network.

Enterprise data: includes very-small-aperture terminal (VSAT) networking services, IP trunking services, and backhaul services for business customers.

Video: Includes video distribution, Direct to Home satellite television, Contribution, and Occasional Use Television Services. Video distribution is the transport of television channels for distribution through television broadcast, cable and Internet Protocol television (IPTV) networks. Direct to Home satellite TV delivers television programming through a satellite dish located at the customer's residence. Video contribution is the transport of unedited video and other content from one location to another prior to distribution to the television viewer. Occasional Use Television is the purchase of capacity under short-term contracts.

Voice and data transport: FSS purchased by providers of telecommunications services for the transport of voice and data for the provision of various telecommunications services. This also includes capacity that is used as backup in the event of terrestrial network outages or to accommodate short periods of very high demand.

[83] The definitions included here have been adapted from Northern Sky Research's *Global Satellite Capacity Supply and Demand* report

Appendix B: Satellite technology and capacity

208. This appendix provides additional detail on satellite technology and capacity. It includes an overview of satellite technology, including satellites and earth stations, satellite orbits, spectrum, and networks, as well as how satellites operate in general terms.

Satellite network overview

209. Satellites are used to provide a variety of services, including both broadcasting and telecommunications services, across large areas. However, this inquiry focuses on telecommunications services delivered via satellite, which is reflected in the following overview.

Satellite

210. A satellite is a platform that is launched into space contains various subsystems. Propulsion, power, thermal and telemetry, and tracking and telecommand (TT&C) subsystems form the base of the satellite and are known as the bus. The communications subsystem includes the antenna and transponders, and is key to enabling space-based communications. This equipment required for communications is also known as the communications payload.

211. Transponders are channels that are defined by separate pieces of equipment on the satellite and allow it to take the uplinked[84] signal at the uplink frequency and change it to the downlink frequency for re-transmission to an earth station. In most cases, satellites are simple relays in space, redirecting signals without processing them. This particular case is often referred to as "the bent-pipe configuration."

212. In a conventional fixed satellite service (FSS) satellite network, transponders play an important part in defining satellite capacity. Providers of telecommunications services purchase access to one or more transponders[85] (depending on the services they provide), with capacity measured in megahertz (MHz), and use this satellite capacity to provide a service, often expressed in megabits per second (Mbps) or kilobits per second (kbps). These providers of telecommunications services are responsible for designing the terrestrial network, which includes the selection and design of the earth station that will use the transponders.

213. The measure of satellite capacity is a factor of transponders (or bandwidth), power and polarization,[86] and antennas, both in space and on the ground. Satellites that offer dual polarization effectively double the capacity of traditional FSS satellites. However, to take advantage of this

[84] Uplinked in this case is reserved for communications from the earth station to the satellite. Downlink refers to the transmission from the satellite to the earth station.

[85] Access to a transponder (for a fee) is also referred to as "RF [radio frequency] channel services."

[86] Each signal is composed of an electric and a magnetic field, which are at 90 degrees from one another. Dual polarization means that two non-overlapping signals are sent in opposite polarizations, i.e. one signal is sent with the electrical field in one position and the other signal is rotated 90 degrees prior to being sent. This arrangement, combined with frequency interleaving, minimizes interference between the signals and effectively doubles satellite capacity.

additional capacity, the earth stations must be designed and built to support one or both polarizations.

214. The capacity of FSS networks that use spot beams is often measured in Mbps per beam, instead of MHz. In satellite systems that offer spot beam coverage, frequencies are reused multiple times, effectively increasing the overall bandwidth available to providers of telecommunications services and, therefore, to end-users.

Earth station

215. Earth stations are platforms on the ground which act as the interface to the satellite. Earth stations, operated by providers of telecommunications services include power systems, cooling equipment, antenna(s), and electronics required to establish a link with a satellite. At least 2 earth stations are needed to establish a satellite link. In practice, satellites are often used with multiple earth stations.

216. The antennas used in the earth station play an important role in defining what telecommunications services can be delivered. Larger antennas can improve a service, but also cost more to install and maintain. Care must be taken to select the appropriate antenna for a given service.

217. Among the electronic equipment in an earth station is the modem (short for modulator-demodulator). The modem plays an important role in converting the bandwidth available on a satellite: essentially, it converts the MHz available to a provider of telecommunications services to Mbps. New modems incorporate new technologies and standards to improve service delivery.

218. Earth stations may incorporate sophisticated technology to optimize the link between the satellite and the earth station. Some antennas may use tracking equipment to follow the movement of a satellite in inclined orbit. In cases where the earth station itself is likely to move, such as in maritime applications, special stabilization equipment is used to compensate for this movement.

Satellite link

219. A satellite link is a wireless link established between the 2 major elements of a satellite network: the satellite itself, also known as the space segment, and the earth station, which is also known as the ground segment. The link is established using spectrum allocated to satellite services.

220. Satellite link performance and availability is determined based on satellite bandwidth, the amount of power reaching the antenna(s), the size of the antenna(s), the frequency, and other telecommunications service requirements. Fluctuations in signal quality are possible due to inclement weather, sun activity, interference, and other natural and man-made phenomena, and these fluctuations will affect service quality. The impact of these fluctuations differs between frequency bands (explained in more detail below, under “Satellite spectrum”).

221. When a satellite is within an earth station’s line of sight, the earth station is said to have a view of the satellite. It is possible, even desirable, for a satellite to communicate with more than one earth station at a time.

Satellite orbits

222. Communications satellites operate in different orbits depending on their application. Some satellites orbit close to the Earth (known as low-Earth orbit or LEO), while others operate much further away.

223. The most popular orbit for communications satellites is the geostationary orbit, where satellites orbit at a distance of 35,786 kilometres (km) from sea level at the equator.

224. The benefit of the geostationary orbit is that most antennas[87] do not need motors to track satellites in this orbit and, once installed, the antennas remain pointed at the same position. Geostationary satellites are licensed based on orbital positions that are expressed in degrees of longitude and frequency spectrum.

225. Geostationary satellites are typically spaced 2 degrees apart (approximately 1,466 km). This separation, combined with the use of parabolic dishes, enables multiple satellites to operate while minimizing interference between satellite networks, but also limits the number of satellites that can operate in the geostationary orbit.

226. Another advantage of using geostationary satellites (and satellites in general) is that they are able to connect communities at a fixed cost, regardless of the distance between communities, provided that the communities are located in the satellite's coverage area.

227. A drawback of using geostationary satellites to deliver telecommunications services is that services that involve the use of sizeable bandwidth (C-band satellite transport service for example) require the use of parabolic dishes, which can be large and costly. Another drawback is that latency tends to be high[88] for real-time services, such as voice services, videoconferencing, online auctions, and gaming, and other real-time applications. For instance, for voice communications services offered via satellite, delays can be noticed in the conversation due to the time it takes for a signal to reach the satellite and come back down.

228. Other satellite orbits are also used to provide satellite service. The LEO (800 to 1,200 km above sea level) is presently used to provide low-bit-rate services, such as voice services, directly to handsets. Satellites deployed in LEO tend to be smaller and cover a much smaller area than geostationary satellites. Multiple LEO satellites may be required to offer global services,[89] making the deployment of such networks very expensive.

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[87] The one exception is very large antennas, which need motors to track the satellite as it drifts from its nominal orbital position and from satellites that operate in inclined orbit.

[88] It takes approximately 240 milliseconds for a signal to go from the earth station to the satellite and back down again.

[89] Iridium Communications Inc. operates a LEO satellite constellation consisting of 66 satellites to offer low-bit-rate communications services.

229. Another orbit that is used to provide satellite service is medium-Earth orbit (MEO) [8,000 km above sea level]. A satellite constellation[90] operating at this orbit requires fewer satellites than one operating in LEO.

230. A disadvantage of using both LEO and MEO is that antennas have to track the satellites as they move in orbit, resulting in the use of more expensive earth stations.

Satellite spectrum

231. Different frequency bands are used for commercial FSS. Each frequency band is divided in two: one portion is reserved for communications from the earth station to the satellite (uplink), and the other for the reverse direction (downlink).

232. The **C-band**, also referred to as the 4/6 gigahertz (GHz) band, was historically the first frequency band allocated to satellite service. Services provided using this band generally require high availability and reliability, meaning that there is a consistent service at all times. Signals transmitted on this frequency band are less susceptible to attenuation due to rain (also called rain fade). Drawbacks of using the C-band include the use of larger (and more costly) antennas and less power available to provide bandwidth-intensive services, such as broadband Internet access.

233. The **Ku-band**, also referred to as the 12/14 GHz band, is in high demand for satellite services. Signals offered over this band suffer slightly more from rain fade (i.e. links are maintained in most cases, but short interruptions can be noticed during heavy downpours). However, smaller antennas can be used. While the Ku-band can be used for the delivery of telecommunications services, this band is often used for broadcasting television content directly to the end-user, especially in Canada.

234. The **Ka-band**, also referred to as the 20/30 GHz band, is seeing increasing interest from satellite operators and service providers. This band is used in new satellite systems to deliver bandwidth-intensive telecommunications services, such as broadband Internet access, directly to the home. While the Ka-band is even more susceptible to rain fade than the Ku-band, recent technological developments have enabled satellite operators to address this issue. Links are maintained in most cases with the use of adaptive coding and modulation and uplink power control, which adapt the service to the environmental conditions. Using this technology, link throughput can be reduced during the rain fade event and then recover to the initial throughput after the event.

FSS

235. FSS is a category of telecommunications services delivered via satellite that reflects notions found in the field of spectrum management. They are defined as services delivered over satellite to earth stations at given positions. Services delivered via FSS include video services delivered to cable headends[91] and telecommunications services delivered to remote communities and households.

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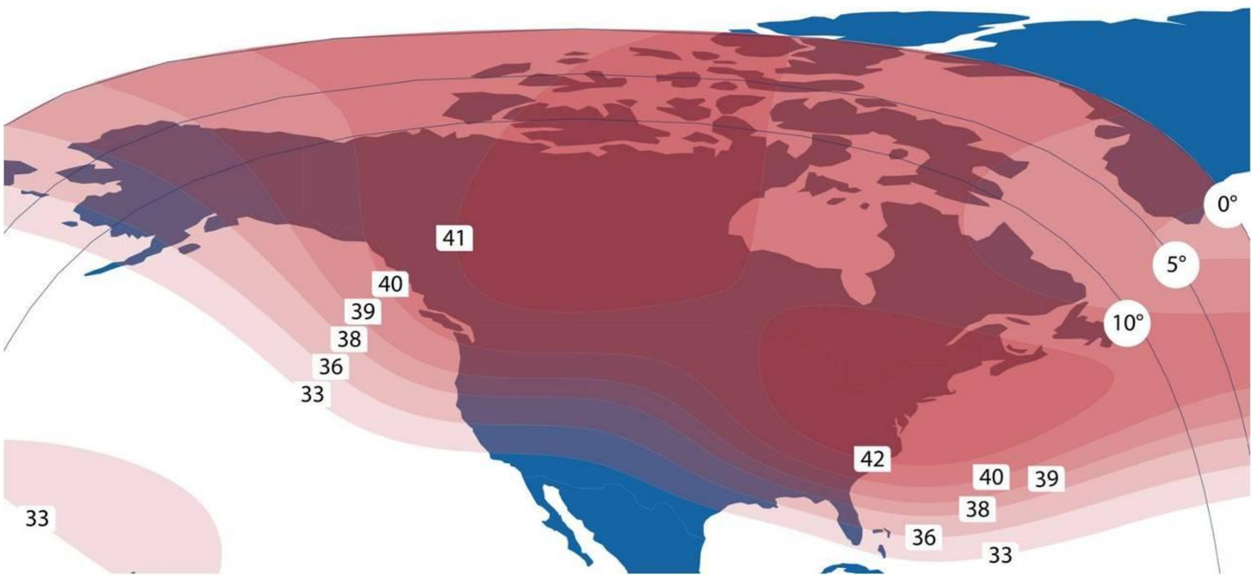
[90] A satellite constellation is a group of satellites that is coordinated to operate as a one network to offer service. O3b operates a constellation of 8 satellites, which can be expanded to meet increasing demand.

[91] A headend is a facility used to receive television signals from over-the-air transmitters, satellite and/or cable technology (optical fibre/copper), which are then transmitted to consumers over a local distribution/access network (i.e. the telephone copper network, coaxial cable, fibre-to-the-premise).

236. A geostationary satellite can cover a large portion of the Earth. However, to effectively serve an area, coverage is focused in specific areas. As a general rule, the coverage area of a satellite is defined by the frequency band used, the power coming out of the antenna, and the antenna beam design and architecture (spot beam versus traditional wide beam coverage), which are defined in themselves by business or market requirements. FSS requirements depend on the satellite link, including not only satellite coverage, but also satellite capacity, the sharing of capacity, and earth station requirements (dish size, location, etc.).

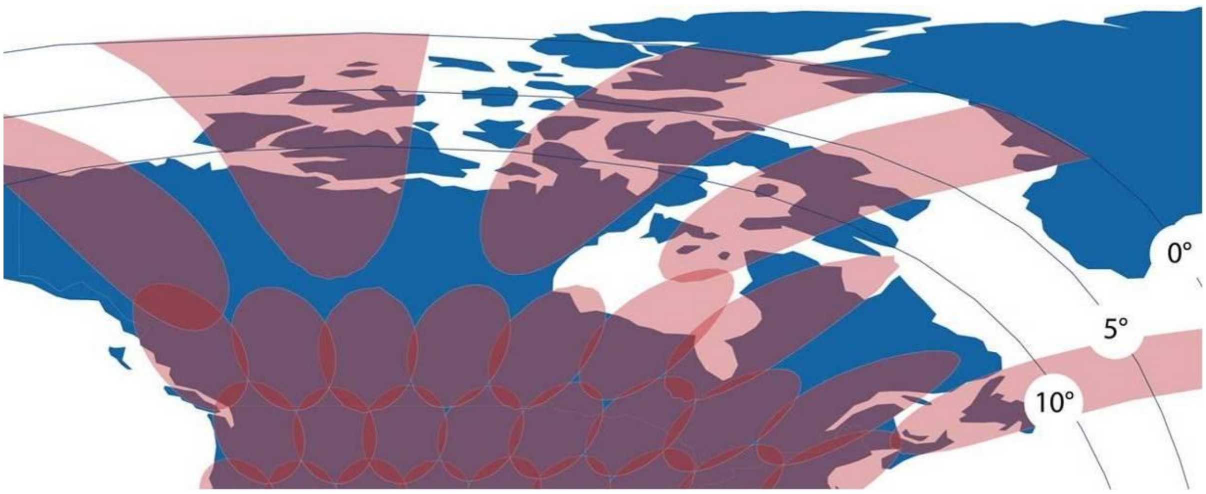
237. The following figures highlight the differences between wide beam coverage and spot beam coverage for Telesat's Anik F2 satellite.

Figure 11.1: Telesat's Anik F2 wide beam C-band coverage



Source: Telesat

Figure 11.2: Telesat's Anik F2 spot beam Ka-band coverage



Source: Telesat

Satellite service delivery models

238. Satellite services are delivered in Canada using two models: the community aggregator model and the direct-to-home model. In the community aggregator model, an earth station with a large satellite antenna (dish) is installed in a community, and communications services are often provided using the C-band satellite spectrum. The earth station is then connected to the local distribution network, and telecommunications services are provided over this local network. The local distribution network can be built using copper cables, fibre optics, or towers and antennas, and is used to provide homes and businesses with Internet access or access to the public switched telephone network (PSTN). Any services that require a connection outside the satellite network need to pass through a gateway, which is a large earth station that provides a link to the Internet or the PSTN.

Figure 11.3: Community C-band antenna in Gjoa Haven

Source: SSi Micro

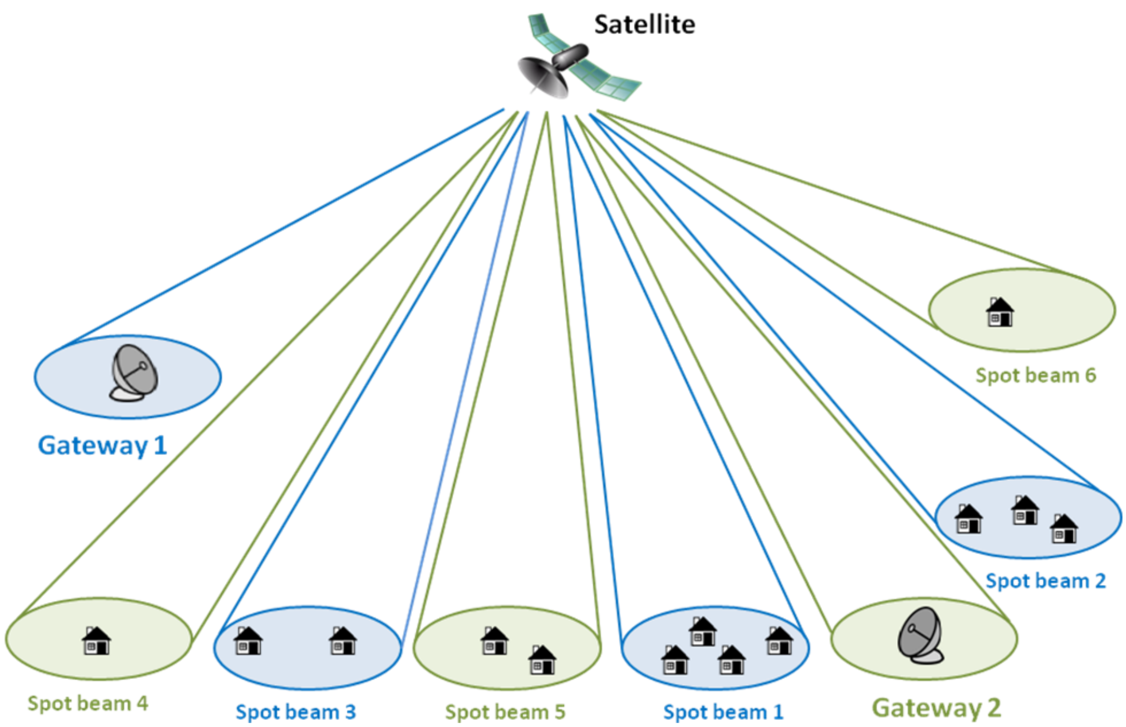
239. In the direct-to-home model, which evolved following the adoption of the Ku- and Ka-band as satellite frequency bands, small antennas that are attached to the side of a house or building communicate directly with a satellite to provide telecommunications services. For example, modern broadband Internet access services delivered directly to the home by satellite use the Ka-band with spot beam coverage.

Figure 11.4: Direct-to-home Ka-band satellite dish

Source: Xplornet Communciations Inc.

240. In the direct-to-home satellite network, a few gateways connect thousands of customers who access telecommunications services through their own small dish. The gateways are located in satellite beams that are different from those that serve the end-user. This is done to increase overall network capacity. The conceptual diagram below shows the principles behind direct-to-home satellite Internet service delivered using spot beam technology and the concept of frequency reuse.

Figure 11.5: Direct-to-home satellite network



241. High-throughput satellites (HTS) have combined Ka-band spot beam technology with the concept of frequency reuse, and enable even more total throughput to be delivered than conventional FSS satellites (which cover their markets using one large beam). Current HTS satellites offer 100+ gigabits per second (Gbps) of total throughput, close to 100 times what is possible with a conventional FSS satellite. While HTS is presently deployed in the Ka-band, plans are underway to deploy HTS that support the Ku-band.

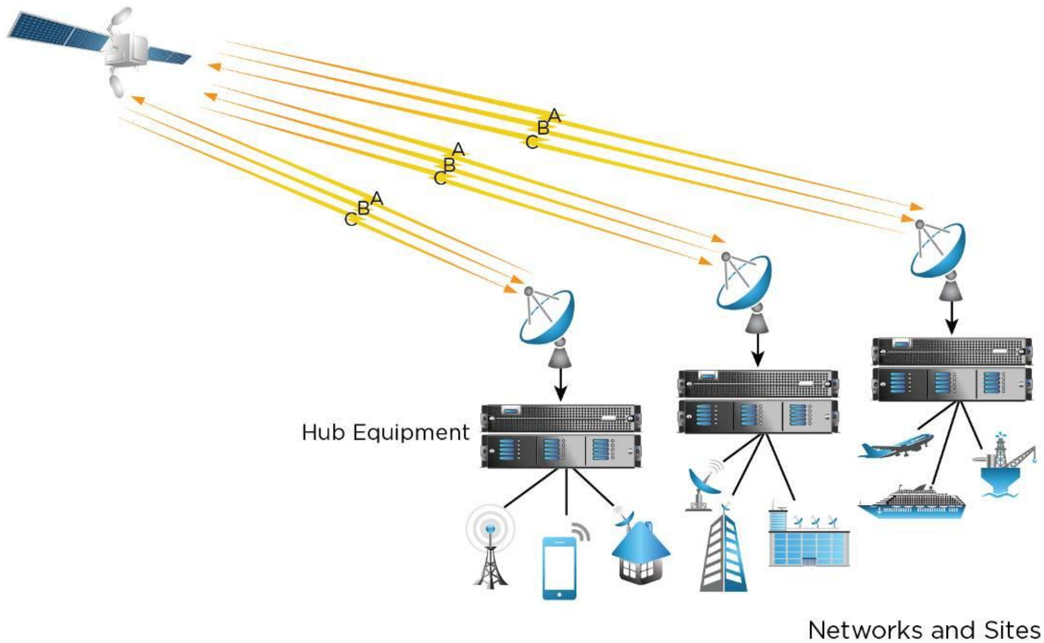
Satellite networks

242. Unlike fibre optic and microwave networks, which provide point-to-point connectivity, satellite technology is versatile. Satellites can be used to provide service to multiple sites over wide areas or to provide services between 2 sites in a point-to-point fashion, even with the use of wide coverage beams.

243. However, to serve multiple communities, satellite capacity has to be shared between the communities. A network configuration called mesh networking enables multiple satellite-served

communities to be connected to a satellite. Through this configuration, both downlink and uplink satellite bandwidth can be shared between all communities.

Figure 11.6: Mesh networking diagram (hub equipment is installed in each community served by the satellite)



Source: Intelsat

244. Point-to-point satellite links use the same antenna beam that is used to serve many communities, but reserves satellite capacity so that all of it is dedicated between 2 sites. However, satellite technology provides sufficient flexibility so that providers of telecommunications services can configure their networks to mix dedicated and shared bandwidth in the same network to meet the demands of the different communities they serve.

Satellite capacity required to meet the Commission's Internet service target speeds

245. As discussed in section 4, it was found through the inquiry that there is a gap between the telecommunications services delivered to communities that rely on the community aggregator model, and terrestrially served communities. During the inquiry, providers of telecommunications services were asked (i) what role satellite services would play in achieving the Commission's broadband Internet target speeds of 5 Mbps (download speed) and 1 Mbps (upload speed) [the 5/1 Mbps target speeds], and (ii) whether this target could be reached in communities that rely on the community aggregator model. The responses varied based on underlying assumptions used in the providers' calculations of the estimates of the satellite capacity required to reach this target.

246. As of December 2013, 91% of households in Canada had access to terrestrial broadband Internet connections which could provide at least the 5/1 Mbps target speeds.[xxx] It is estimated that

approximately 1.2 million households in Canada do not have broadband Internet available at these speeds using a terrestrial network.

Table 11.1: Estimated number of households without access to the 5/1 Mbps target speeds when considering existing satellite capacity

Number of households in Canada without access to 5/1 Mbps (terrestrially):	1,199,000
Less: number of households that could subscribe to 5/1 Mbps by way of C-band[92]	19,000
Less: number of households that could subscribe to 5/1 Mbps by way of HTS Ka-band	166,000
Less: number of households that could subscribe to 5/1 Mbps by way of non-HTS Ka-band[93]	9,000
Number of households for which there is not enough satellite capacity to deliver the 5/1 Mbps target speeds:	**1,005,000**

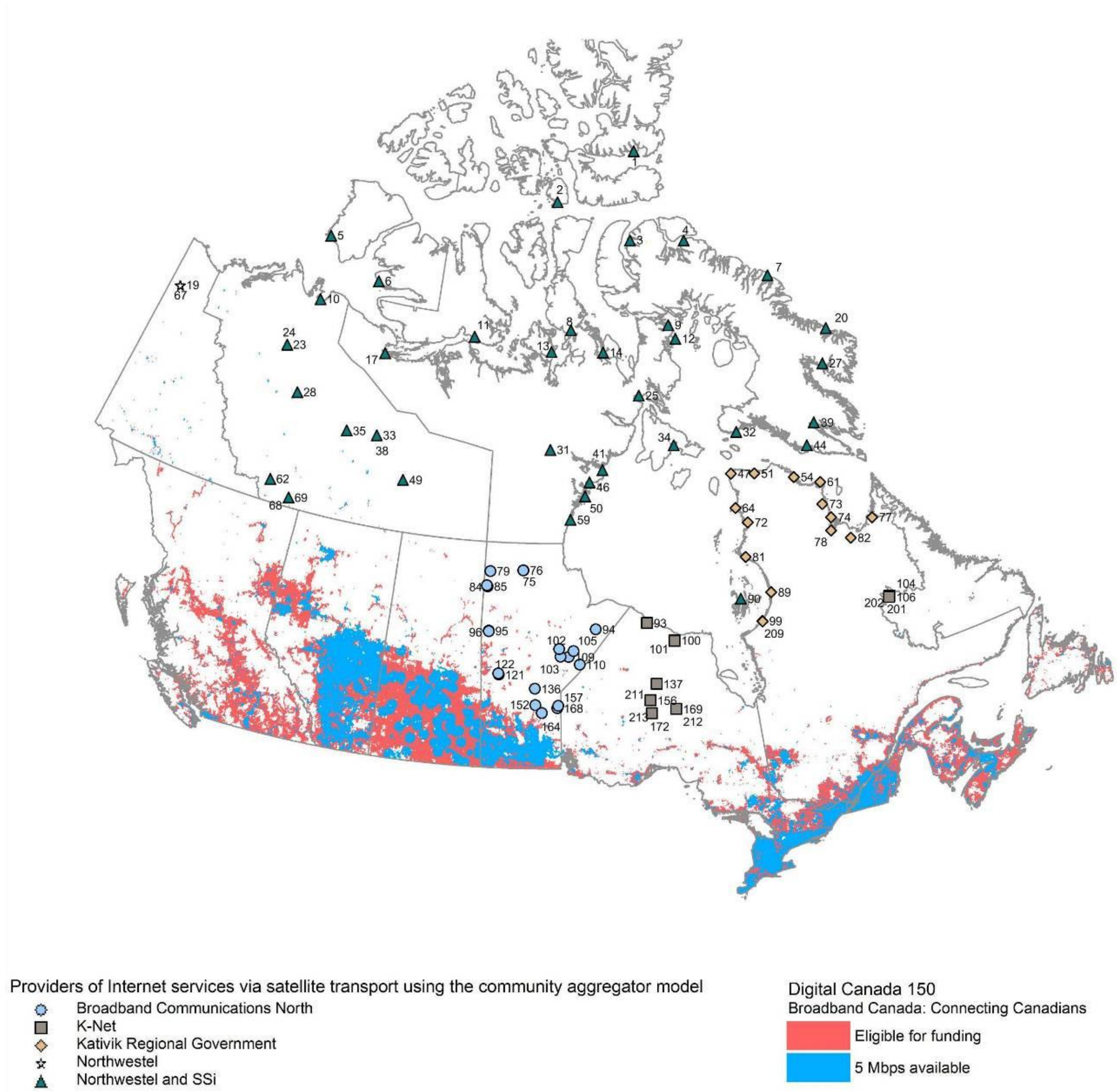
247. According to the Industry Canada Digital Canada 150 website, over the next five years, the Government of Canada will work with Internet service providers (ISPs) and other stakeholders across Canada to make broadband Internet (at a 5-Mbps download speed) available to hundreds of thousands of households. The Government has stated that it is targeting to expand access to this speed to up to 280,000 households over the next few years.[xxxi]

248. The figure below shows the 89 communities that rely on the community aggregator model and which of those communities have access to a 5-Mbps Internet download speed. ISPs may apply for funding from the *Connecting Canadians* program to make 5-Mbps Internet available in the areas highlighted in red below, including the 89 communities that rely on the community aggregator model for Internet access. The analysis that follows uses this map and its underlying information to discuss the availability of broadband Internet access in communities that rely on the community aggregator model, and the general availability of broadband Internet access at 5 Mbps.

[92] Details on the C-band capacity calculation are provided later in this Appendix.

[93] The upload speed of 1 Mbps is not a certainty.

Figure 11.7: Communities that rely on the community aggregator model and 5-Mbps service availability



C-band capacity

249. Given that the purchased and available C-band satellite capacity is known and that C-band covers all of Canada, it can be determined how much C-band capacity is required to provide broadband Internet access service at the 5/1 Mbps target speeds.

250. Prior to determining this capacity, some assumptions have to be made. In the case of communities reliant on C-band satellite transport, it is assumed that[94]

- the 5/1 Mbps target speeds are offered in all communities where Internet access is provided through the community aggregator model. The subscription rate has been set at 77%, which corresponds to the present subscription rate for a 1.5 Mbps service.
- A downstream oversubscription ratio (OSR) of 30:1 and an upstream oversubscription ratio of 40:1 are used. The lower downstream OSR accommodates streaming video.
- Spectral efficiency varies according to the provider of telecommunications services to account for the different terrestrial networks. A higher spectral efficiency is used in the forward direction to account for more efficient modems and larger antennas used in hubs compared to remote sites. The spectral efficiencies used in these calculations reflect the values provided in the submissions received during the inquiry, which account for ground infrastructure. In cases where 2 values were provided, an average was used.

251. Using the above assumptions, it is estimated that 37 C-band transponders would be required to provide Internet service at the Commission's 5/1 Mbps target speeds for 77% of households in communities served by C-band through the community aggregator model. In total, #[95] C-band transponders would be required to provide voice and fixed broadband Internet services in these communities.

252. Combined, Telesat's Anik F2 and Anik F3 satellites, which are predominantly used by providers of telecommunications services, have a total of 48 C-band transponders. However, given that some transponders are used for purposes other than the provision of broadband Internet services, the total required capacity would exceed the total capacity on both the Anik F2 and Anik F3 satellites.[96] This means that if providers of telecommunications services were to rely only on the Anik F2 and Anik F3 satellites, there would not be enough capacity to meet the demands of communities that obtain telecommunications services through the community aggregator model. Therefore, to offer Internet service at the 5/1 Mbps target speeds, another satellite with C-band, such as Telesat's Anik F1R,[97] would have to be used, and new antennas and ground infrastructure would also be required to point at this satellite. Of note, the estimated capacity requirement mentioned above does not include the telecommunications service needs (such as broadband Internet services) of businesses and government offices in these communities, or the demand for wireless data services.

253. The following table provides an estimate of the amount of capacity each provider of telecommunications services would require to offer a 5/1 Mbps broadband Internet service.

[94] Specific assumptions used in some parties' calculations were removed due to reasons of confidentiality.

[95] Specific information on currently used capacity was removed due to reasons of confidentiality.

[96] Information on the number of transponders used to provide other services, and the number which would be required to deliver voice and fixed broadband Internet service, have been removed due to reasons of confidentiality.

[97] Anik F1R is predominantly used for broadcasting services.

Table 11.2: Estimated total C-band capacity required to meet the 5/1 target speeds in communities that rely on the community aggregator model

Provider	Estimated capacity required (MHz)
Northwestel	#
SSi	#
Kativik Regional Government	#
K-Net	#
Broadband Communications North Inc.	#
Total	**1321 (36.7 transponders)**

Source: Confidential information submitted by parties. Specific information on estimated capacity required, per provider of telecommunications services, was removed due to reasons of confidentiality.

254. Based on the evidence filed on the record of this inquiry, it is estimated that providers of telecommunications services would need to purchase #[98] MHz of additional C-band capacity to meet the Commission's 5/1 Mbps target speeds in communities that rely on the community aggregator model.[99] The additional capacity required to deliver 5/1 Mbps Internet service plans is broken down by provider of telecommunications services in the figure below.

Figure 11.8: Estimated total C-band capacity required by provider of telecommunications services to deliver 5/1 Mbps Internet service

[*This figure was removed due to reasons of confidentiality*]

Source: Confidential information submitted by parties

Estimates from providers of telecommunications services of the C-band capacity required to meet the 5/1 Mbps target speeds in communities that the rely on the community aggregator model

255. No common methodology was used among the providers of telecommunications services to obtain their estimates of the C-band capacity required to meet the 5/1 Mbps target speeds in communities that rely on the community aggregator model. Some providers used assumptions that broadband

[98] Specific information on capacity was removed due to reasons of confidentiality.

[99] These figures are estimates only; a more detailed study would be required to account for variances between the networks and infrastructure of providers of telecommunications services. Additional satellite capacity would also be required for the delivery of mobile wireless Internet access and to accommodate growth for business and government customers.

Internet service was close to a dedicated 5/1 speed to the end-user, while others used different criteria.[100]

- K-Net stated that to meet the 5/1 Mbps target speeds and to serve 850 households, it would need 51 C-band transponders.
- The Kativik Regional Government submitted that 13 C-band transponders would be required to provide broadband Internet access at the 5/1 Mbps target speeds to the communities it serves, which have a total of 3,543 households.
- SSi stated that it would need #[101] to meet demand for services in its serving territory for the next # years. However, the Inquiry Officer notes that # is # the C-band capacity on all #. SSi did not specifically provide C-band capacity requirements for the 5/1 Mbps target speeds to be met.
- Northwestel stated that there would not be enough C-band capacity to offer the 5/1 speed to every household in every satellite dependent community. It estimated that #[102] C-band transponders would be required to offer this service to all households in all of the satellite-dependent communities it serves, under the assumption that #.[103]

[100] Certain estimates of capacity required to meet the 5/1 Mbps target were removed due to reasons of confidentiality.

[101] Specific information on capacity was removed due to reasons of confidentiality

[102] Specific information on capacity was removed due to reasons of confidentiality

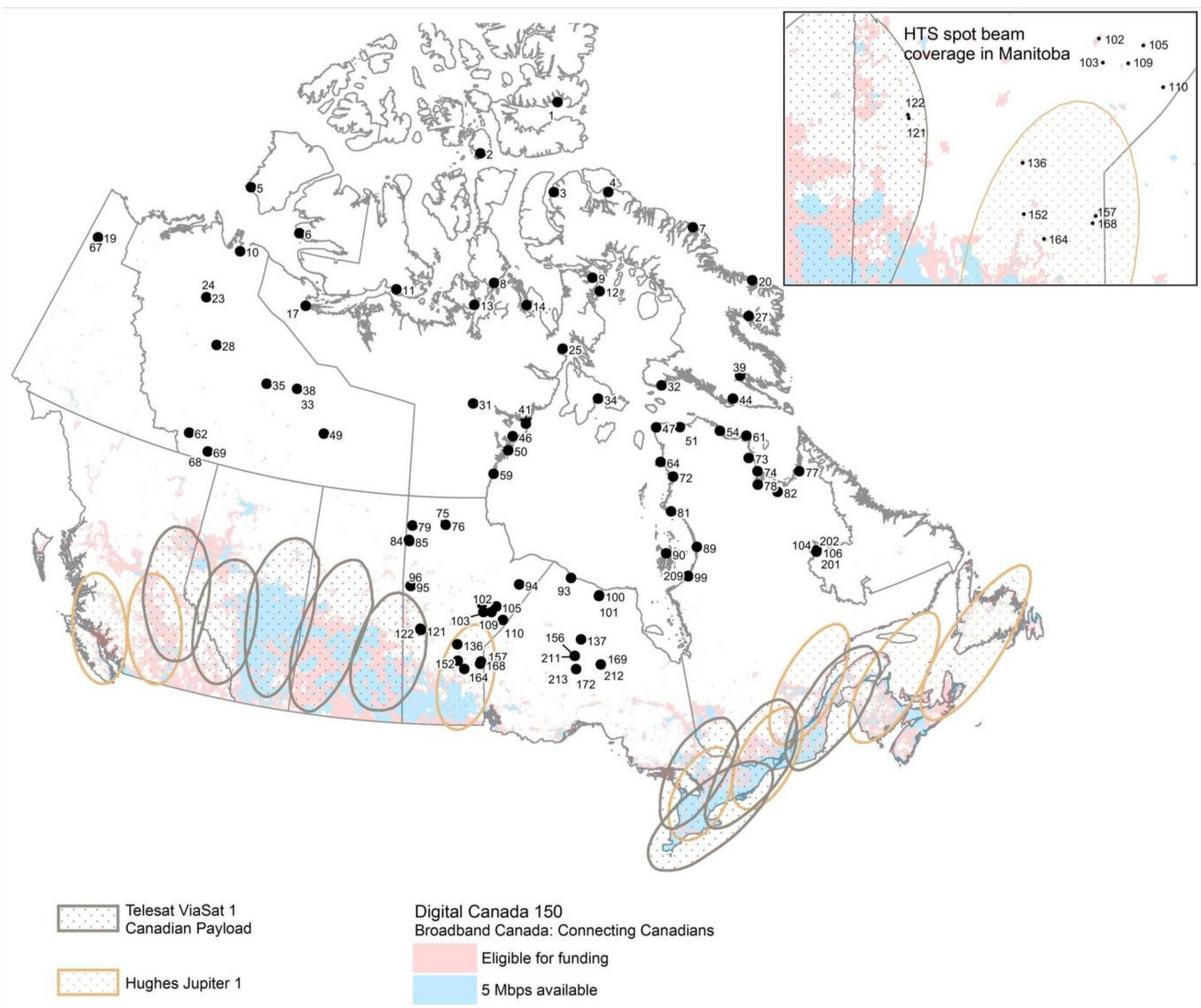
[103] Specific assumptions were removed due to reasons of confidentiality

Ka-band capacity

HTS Ka-band

256. As indicated in the figure below, while Telesat's Canadian payload on the ViaSat 1 satellite and Hughes' Jupiter 1 satellite both provide HTS coverage in Canada, the majority of communities that rely on the community aggregator model fall outside the coverage area of these satellites. Combined, these satellites cover only 7 communities that rely on the community aggregator model (all located in Manitoba), while the remaining 82 communities fall outside the satellites' coverage area. Using these satellites, Xplornet offers each of the 7 communities Internet service with download speeds of up to 10 Mbps.

Figure 11.9: HTS Ka-band coverage, communities that rely on the community aggregator model, and 5-Mbps service availability



257. Assumptions are also required to proceed with a capacity analysis for HTS Ka-band, which are as follows:

- A 5 Mbps download speed is offered to all households with HTS coverage. The subscription rate has been set at 77%, which corresponds to the present subscription rate for a 1.5-Mbps service.
- A downstream OSR of 90:1 is used. This ratio was suggested by Vantage Point Solutions in a presentation to the U.S. Federal Communications Commission.

258. Based on the above-noted assumptions, 166,000 households in Canada could subscribe to direct-to-home satellite broadband Internet service with a 5-Mbps download speed.[104]

259. As noted above, coverage of HTS satellites is located in southern Canada and, for the most part, cannot presently address the needs of most communities that rely on the community aggregator model with satellite transport delivered via C-band.

Non-HTS Ka-band

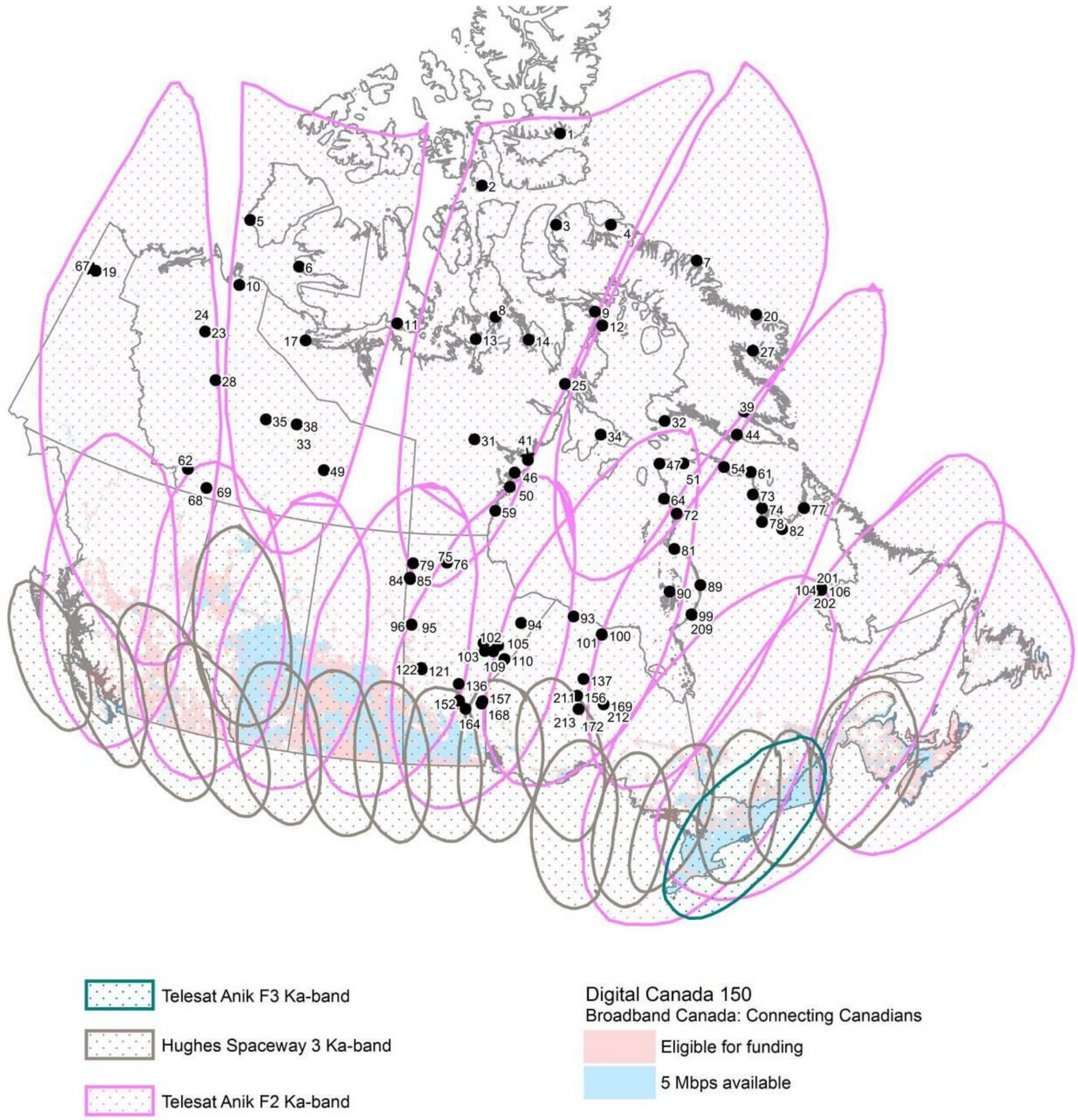
260. Ka-band services are offered across Canada. However, the Internet service offerings in most satellite-dependent communities are provided via first generation (legacy) Ka-band spot beam satellites, which means that they have download speeds of up to only 3 Mbps. Of Telesat's non-HTS Ka-band capacity[105], # is used, while # remains available for Canadian providers of telecommunications services to serve some communities. However, this limited amount of legacy Ka-band capacity is unlikely to materially increase the number of communities in which Internet service plans that meet the 5/1 Mbps target speeds can be offered.

261. As mentioned earlier in this report, Telesat's Anik F2 and Anik F3 are two of the most used satellites by providers of telecommunications services for FSS transport service, and they also include non-HTS Ka-band capacity. Through Hughes' Spaceway 3 satellite, Internet service at the 5/1 Mbps target speeds is offered. The following map illustrates Ka-band service coverage over the following non-HTS satellites: Telesat's Anik F2 and Anik F3 satellites, and Hughes' Spaceway 3 satellite.

[104] It is likely that the satellite could serve a larger number of subscribers if other plans, such as 1.5-Mbps plans, are still offered to subscribers.

[105] Specific information on used and available capacity was removed due to reasons of confidentiality.

Figure 11.10: Non-HTS Ka-band satellite coverage, communities that rely on the community aggregator model, and 5-Mbps service availability



262. As depicted in the above figure, Hughes' Spaceway 3 coverage brings Ka-band capacity near the Canada-U.S. border, away from the communities in which satellite transport is delivered via the community aggregator model. Telesat's Anik F3 provides additional coverage in Eastern Canada, but little capacity. However, Telesat's Anik F2 provides service across Canada and therefore offers the potential to serve these communities. The number of households that could subscribe, by way

of non-HTS Ka-band, to Internet with a speed of 5 Mbps downstream is estimated to be 9,000.[106] This assumes that the capacity that is presently used to provide broadband Internet service at 3 Mbps is used to provide a speed of 5 Mbps to all households, and that an upstream/downstream OSR of 90:1 is used.

263. The addition of new HTS satellite capacity could cover a significant number of the households that currently do not have access to broadband Internet service at the 5/1 Mbps target speeds.

[106] Hughes' Spaceway 3 and Telesat's Anik F3 were not considered in this analysis because their coverage overlaps with HTS satellite coverage. Therefore, it is assumed that, given the choice of satellite, subscribers would be served by either Telesat's Canadian payload on ViaSat 1 or Hughes' Jupiter 1 (using HTS Ka-band).

Appendix C: Communities

264. This appendix contains additional information about the communities identified in this inquiry that receive telecommunications services through satellite transport via the community aggregator model (e.g. regarding their locations, number of households, and providers). It includes a list of the 83 communities that rely on this model to receive fixed voice services, and the 89 communities that receive Internet access through this model.

265. Finally, it includes a list of the communities that were included in the Inquiry Officer's 2 June 2014 letter but for which no submissions identified as either having an earth station or being reliant on satellite transport through the community aggregator model.

266. The community ID numbers are those originally listed on the 2 June 2014 letter. New communities that were added are listed from ID number 207 and up.

Table 11.3: Communities in which end-users receive fixed voice services through satellite transport via the community aggregator model

ID	Community	Province/ territory	Number of households	Latitude	Longitude	Provider
87	Bob Quinn Lake	BC	25	56.98	-130.25	Northwestel
86	Kwadacha	BC	77	57.42	-125.63	Northwestel
88	Tsay Keh Dene	BC	30	56.90	-124.96	TCC
208	Kinoosao	SK	14	57.08	-102.02	SaskTel
207	Uranium City	SK	32	59.57	-108.61	SaskTel
85	Brochet	MB	156	57.88	-101.67	MTS Allstream
84	Barren Lands	MB		57.94	-101.73	
92	Granville Lake	MB	5	56.23	-100.57	MTS Allstream
79	Lac Brochet	MB	145	58.62	-101.50	MTS Allstream
136	Poplar River First Nation	MB	260	52.99	-97.28	MTS Allstream
95	Pukatawagan	MB	415	55.75	-101.33	MTS Allstream
96	Mathias Colomb	MB		55.73	-101.32	
94	Shamattawa First Nation	MB	165	55.85	-92.09	MTS Allstream
76	Tadoule Lake	MB	115	58.72	-98.48	MTS Allstream
75	Sayisi Dene First Nation	MB		58.72	-98.49	
172	Eabametoong First Nation	ON	286	51.56	-87.89	Bell Aliant
213	Fort Hope	ON		51.56	-87.90	
93	Fort Severn	ON	148	55.99	-87.62	Bell Aliant
169	Marten Falls	ON	191	51.66	-85.92	Bell Aliant
212	Ogoki	ON		51.63	-85.95	
156	Neskantaga First Nation	ON	91	52.21	-87.90	Bell Aliant
211	Lansdowne House	ON		52.21	-88.02	

ID	Community	Province/ territory	Number of households	Latitude	Longitude	Provider
100	Peawanuck	ON	59	55.02	-85.42	Ontera
101	Weenusk	ON		54.99	-85.43	
137	Webequie	ON	444	52.99	-87.28	Bell Aliant
64	Akulivik	QC	148	60.82	-78.14	Bell Aliant
74	Aupaluk	QC	59	59.31	-69.60	Bell Aliant
81	Inukjuak	QC	444	58.46	-78.11	Bell Aliant
47	Ivujivik	QC	91	62.42	-77.92	Bell Aliant
77	Kangiqsualujjuaq	QC	191	58.71	-65.99	Bell Aliant
54	Kangiqsujuaq	QC	174	61.60	-71.95	Bell Aliant
73	Kangirsuk	QC	163	60.02	-70.03	Bell Aliant
82	Kuujjuaq	QC	925	58.10	-68.42	Bell Aliant
214	Obedjiwan	QC	463	48.65	-74.92	Bell Aliant
72	Puvirnituq/Povungnituk	QC	489	60.04	-77.27	Bell Aliant
61	Quaqtaq	QC	91	61.04	-69.64	Bell Aliant
51	Salluit	QC	315	62.20	-75.65	Bell Aliant
106	Schefferville	QC	169	54.81	-66.81	Bell Aliant
104	Kawawachikamach	QC		54.86	-66.76	
201	Lac-John	QC		54.81	-66.81	
202	Matimekush	QC		54.80	-66.82	
78	Tasiujaq	QC	72	58.70	-69.94	Bell Aliant
89	Umiujaq	QC	104	56.55	-76.52	Bell Aliant
19	Old Crow	YT	110	67.57	-139.83	Northwestel
67	Vuntut Gwitchin First Nation	YT		67.58	-139.82	
23	Colville Lake	NT	36	67.04	-126.09	Northwestel
24	Behdzi Ahda" First Nation	NT		67.02	-126.07	
28	Deline	NT	177	65.19	-123.42	Northwestel
35	Gamèti	NT	95	64.11	-117.35	Northwestel
49	Lutselk'e	NT	113	62.41	-110.74	Northwestel
62	Nahanni Butte	NT	36	61.03	-123.43	Northwestel
10	Paulatuk	NT	76	69.35	-124.07	Northwestel
5	Sachs Harbour	NT	48	71.99	-125.25	Northwestel
69	Trout Lake	NT	34	60.44	-121.24	Northwestel
68	Sambaa K'e Dene	NT		60.46	-121.20	
6	Ulukhaktok	NT	128	70.73	-117.76	Northwestel
33	Wekweèti	NT	45	64.19	-114.19	Northwestel
38	Dechi Laot'i First Nations	NT		64.09	-114.20	
3	Arctic Bay	NU	182	73.04	-85.14	Northwestel

ID	Community	Province/ territory	Number of households	Latitude	Longitude	Provider
59	Arviat	NU	534	61.11	-94.06	Northwestel
31	Baker Lake	NU	525	64.32	-96.02	Northwestel
11	Cambridge Bay	NU	517	69.12	-105.06	Northwestel
32	Cape Dorset	NU	378	64.23	-76.53	Northwestel
41	Chesterfield Inlet	NU	120	63.34	-90.71	Northwestel
7	Clyde River	NU	198	70.47	-68.60	Northwestel
34	Coral Harbour	NU	227	64.14	-83.17	Northwestel
13	Gjoa Haven	NU	267	68.62	-95.87	Northwestel
1	Grise Fiord	NU	55	76.40	-82.89	Northwestel
12	Hall Beach	NU	166	68.76	-81.22	Northwestel
9	Igloolik	NU	375	69.38	-81.81	Northwestel
39	Iqaluit	NU	2,420	63.75	-68.51	Northwestel
44	Kimmirut	NU	129	62.84	-69.87	Northwestel
14	Kugaaruk	NU	145	68.53	-89.82	Northwestel
17	Kugluktuk	NU	411	67.82	-115.10	Northwestel
27	Pangnirtung	NU	421	66.15	-65.71	Northwestel
4	Pond Inlet	NU	361	72.70	-77.97	Northwestel
20	Qikiqtarjuaq	NU	162	67.56	-64.03	Northwestel
46	Rankin Inlet	NU	775	62.81	-92.08	Northwestel
25	Repulse Bay	NU	161	66.52	-86.23	Northwestel
2	Resolute Bay	NU	77	74.71	-94.98	Northwestel
90	Sanikiluaq	NU	180	56.54	-79.23	Northwestel
8	Taloyoak	NU	209	69.54	-93.53	Northwestel
50	Whale Cove	NU	104	62.17	-92.58	Northwestel
Total	**83 communities**		**16,553**			

Note: Several communities listed above are located next to each other and access the same earth station (e.g. Brochet, MB; and Barren Lands, MB).

Table 11.4: Communities that have Internet access through the community aggregator model

ID	Community	Province/ territory	Number of house-holds	Lati-tude	Longi-tude	Earth station operator	Maximum speed bucket range
152	Berens River	MB	301	52.18	-97.23	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
164	Bloodvein	MB	168	51.79	-96.71	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
85	Brochet	MB	156	57.88	-101.67	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
84	Barren Lands	MB		57.94	-101.73		
109	God's Narrows	MB	266	54.56	-94.48	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
79	Lac Brochet	MB	145	58.62	-101.50	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
168	Little Grand Rapids	MB	185	52.04	-95.46	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
105	Manto Sipi Cree Nation	MB	101	54.83	-94.06	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
121	Moose Lake	MB	204	53.64	-100.30	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
122	Mosakahiken Cree Nation	MB		53.69	-100.33		
103	Oxford House	MB	441	54.57	-95.16	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
102	Bunibonibee Cree Nation	MB		54.95	-95.26		
157	Pauingassi First Nation	MB	95	52.15	-95.38	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
136	Poplar River First Nation	MB	260	52.99	-97.28	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
95	Pukatawagan	MB	415	55.75	-101.33	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
96	Mathias Colomb	MB		55.73	-101.32		

ID	Community	Province/ territory	Number of house-holds	Lati-tude	Longi-tude	Earth station operator	Maximum speed bucket range
110	Red Sucker Lake	MB	160	54.17	-93.56	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
94	Shamattawa First Nation	MB	165	55.85	-92.09	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
76	Tadoule Lake	MB	115	58.72	-98.48	Broadband Communications North Inc.	between 1.5 and 4.99 Mbps
75	Sayisi Dene First Nation	MB		58.72	-98.49		
172	Eabametoong First Nation	ON	286	51.56	-87.89	K-Net	less than 5 Mbps
213	Fort Hope	ON		51.56	-87.90		
93	Fort Severn	ON	148	55.99	-87.62	K-Net	less than 5 Mbps
169	Marten Falls	ON	191	51.66	-85.92	K-Net	less than 1.5 Mbps
212	Ogoki	ON		51.63	-85.95		
156	Neskantaga First Nation	ON	91	52.21	-87.90	K-Net	less than 5 Mbps
211	Lansdowne House	ON		52.21	-88.02		
100	Peawanuck	ON	59	55.02	-85.42	K-Net	less than 5 Mbps
101	Weenusk	ON		54.99	-85.43		
137	Webequie	ON	444	52.99	-87.28	K-Net	less than 5 Mbps
64	Akulivik	QC	148	60.82	-78.14	Kativik Regional Government	between 1.5 and 4.99 Mbps
74	Aupaluk	QC	59	59.31	-69.60	Kativik Regional Government	between 1.5 and 4.99 Mbps
81	Inukjuak	QC	444	58.46	-78.11	Kativik Regional Government	between 1.5 and 4.99 Mbps
47	Ivujivik	QC	91	62.42	-77.92	Kativik Regional Government	between 1.5 and 4.99 Mbps
77	Kangiqsualujjuaq	QC	191	58.71	-65.99	Kativik Regional Government	between 1.5 and 4.99 Mbps
54	Kangiqsujuaq	QC	174	61.60	-71.95	Kativik Regional Government	between 1.5 and 4.99 Mbps
73	Kangirsuk	QC	163	60.02	-70.03	Kativik Regional Government	between 1.5 and 4.99 Mbps

ID	Community	Province/ territory	Number of house-holds	Lati-tude	Longi-tude	Earth station operator	Maximum speed bucket range
82	Kuujjuaq	QC	925	58.10	-68.42	Kativik Regional Government	between 1.5 and 4.99 Mbps
99	Kuujuarapik	QC	425	55.27	-77.76	Kativik Regional Government	between 1.5 and 4.99 Mbps
209	Whapmagoostui	QC		55.25	-77.75		
72	Puvirnituq / Povungnituk	QC	489	60.04	-77.27	Kativik Regional Government	between 1.5 and 4.99 Mbps
61	Quaqtaq	QC	91	61.04	-69.64	Kativik Regional Government	between 1.5 and 4.99 Mbps
51	Salluit	QC	315	62.20	-75.65	Kativik Regional Government	between 1.5 and 4.99 Mbps
106	Schefferville	QC	169	54.81	-66.81	K-Net	less than 1.5 Mbps
104	Kawawachikamach	QC		54.86	-66.76		
201	Lac-John	QC		54.81	-66.81		
202	Matimekush	QC		54.80	-66.82		
78	Tasiujaq	QC	72	58.70	-69.94	Kativik Regional Government	between 1.5 and 4.99 Mbps
89	Umiujaq	QC	104	56.55	-76.52	Kativik Regional Government	between 1.5 and 4.99 Mbps
19	Old Crow	YT	110	67.57	-139.83	Northwestel	between 1.5 and 4.99 Mbps
67	Vuntut Gwitchin First Nation	YT		67.58	-139.82		
23	Colville Lake	NT	36	67.04	-126.09	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
24	Behdzi Ahda First Nation	NT		67.02	-126.07		
28	Deline	NT	177	65.19	-123.42	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
35	Gamèti	NT	95	64.11	-117.35	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
49	Lutselk'e	NT	113	62.41	-110.74	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
62	Nahanni Butte	NT	36	61.03	-123.43	Northwestel (1) SSi (1)	less than 1.5 Mbps
10	Paulatuk	NT	76	69.35	-124.07	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps

ID	Community	Province/ territory	Number of house-holds	Lati-tude	Longi-tude	Earth station operator	Maximum speed bucket range
5	Sachs Harbour	NT	48	71.99	-125.25	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
69	Trout Lake	NT	34	60.44	-121.24	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
68	Sambaa K'e Dene	NT		60.46	-121.20		
6	Ulukhaktok	NT	128	70.73	-117.76	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
33	Wekweèti	NT	45	64.19	-114.19	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
38	Dechi Laot'I First Nations	NT		64.09	-114.20		
3	Arctic Bay	NU	182	73.04	-85.14	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
59	Arviat	NU	534	61.11	-94.06	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
31	Baker Lake	NU	525	64.32	-96.02	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
11	Cambridge Bay	NU	517	69.12	-105.06	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
32	Cape Dorset	NU	378	64.23	-76.53	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
41	Chesterfield Inlet	NU	120	63.34	-90.71	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
7	Clyde River	NU	198	70.47	-68.60	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
34	Coral Harbour	NU	227	64.14	-83.17	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
13	Gjoa Haven	NU	267	68.62	-95.87	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
1	Grise Fiord	NU	55	76.40	-82.89	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
12	Hall Beach	NU	166	68.76	-81.22	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
9	Igloolik	NU	375	69.38	-81.81	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
39	Iqaluit	NU	2,420	63.75	-68.51	Ice Wireless Inc. (1), Northwestel (1), SSi (2), Telesat (3)	between 1.5 and 4.99 Mbps

ID	Community	Province/ territory	Number of house-holds	Lati-tude	Longi-tude	Earth station operator	Maximum speed bucket range
44	Kimmirut	NU	129	62.84	-69.87	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
14	Kugaaruk	NU	145	68.53	-89.82	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
17	Kugluktuk	NU	411	67.82	-115.10	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
27	Pangnirtung	NU	421	66.15	-65.71	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
4	Pond Inlet	NU	361	72.70	-77.97	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
20	Qikiqtarjuaq	NU	162	67.56	-64.03	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
46	Rankin Inlet	NU	775	62.81	-92.08	Northwestel (1) SSi (2)	between 1.5 and 4.99 Mbps
25	Repulse Bay	NU	161	66.52	-86.23	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
2	Resolute Bay	NU	77	74.71	-94.98	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
90	Sanikiluaq	NU	180	56.54	-79.23	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
8	Taloyoak	NU	209	69.54	-93.53	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
50	Whale Cove	NU	104	62.17	-92.58	Northwestel (1) SSi (1)	between 1.5 and 4.99 Mbps
Total	**89 communities**		**18,253**	**Internet households**			

Notes: The 89 communities listed above that rely on satellite transport for Internet access are also covered by Xplornet’s direct-to-home Internet service. Several communities listed above are located next to each other and access the same earth station (e.g. Brochet, MB; and Barren Lands, MB).

Table 11.5: Communities that were listed on the Inquiry Officer's 2 June 2014 letter but for which no submissions identified as having an earth station or as being reliant on satellite transport through the community aggregator model

ID	Community	Province/ territory	Latitude	Longitude
80	Beaver First Nation	AB	58.468	-116.571
108	Beaver Lake Cree Nation	AB	54.669	-111.871
98	Babine - Fort Babine	BC	55.318	-126.625
198	Babine - Tachet	BC	54.817	-126.148
181	Da'naxda'wx	BC	50.570	-126.612
194	Ditidaht	BC	48.810	-124.671
199	Gwawaenuk Tribe	BC	50.723	-127.496
200	Halfway River First Nation	BC	57.504	-121.992
191	Hesquiaht	BC	49.397	-126.469
132	Kluskus	BC	53.047	-124.704
186	Nuchatlaht	BC	49.868	-126.802
83	Prophet River	BC	58.097	-122.713
184	Samahquam	BC	50.098	-122.536
185	Skatin	BC	50.098	-122.410
97	Takla Lake First Nation	BC	55.483	-125.966
178	Tlatlasikwala	BC	50.917	-127.933
193	Uchucklesaht	BC	48.899	-125.275
183	Birdtail Sioux	MB	50.265	-101.163
180	Fisher River	MB	50.603	-96.336
118	Gambler	MB	53.857	-94.659
117	Garden Hill	MB	53.874	-94.649
107	God's Lake	MB	54.670	-94.155
161	Hollow Water	MB	51.903	-97.308
161	Kinonjeoshtegon First Nation	MB	51.903	-97.308
91	Marcel Colomb First Nation	MB	56.495	-100.342
111	Northlands	MB	53.984	-97.809
111	Norway House Cree Nation	MB	53.984	-97.809
173	O-Chi-Chak-Ko-Sipi First Nation	MB	51.509	-99.229
142	Sapotaweyak Cree Nation	MB	52.738	-100.699
187	Sioux Valley Dakota Nation	MB	49.853	-100.497
160	Skownan First Nation	MB	51.958	-99.604
113	St. Theresa Point	MB	53.938	-94.834
175	Tootinaowaziibeeng Treaty Reserve	MB	51.223	-100.958
116	Wasagamack First Nation	MB	53.889	-94.947
179	Waywayseecappo First Nation Treaty Four - 1874	MB	50.675	-100.927
150	Wuskwi Sipihk First Nation	MB	52.511	-100.862
153	Battle Harbour	NL	52.272	-55.584
124	Black Tickle	NL	53.468	-55.777
146	Burke Island	NL	52.577	-55.730
155	Cape Charles	NL	52.219	-55.641

ID	Community	Province/ territory	Latitude	Longitude
171	Capstan Island	NL	51.570	-56.733
126	Domino	NL	53.460	-55.766
123	Eagle River	NL	53.617	-57.418
148	Francis Harbour	NL	52.563	-55.722
145	Georges Cove	NL	52.581	-55.754
133	Hawke Harbour	NL	53.042	-55.811
147	Kings Cove, Labrador	NL	52.575	-55.743
174	L'Anse Amour	NL	51.468	-56.872
154	Lodge Bay, Labrador	NL	52.232	-55.850
129	Mud Lake	NL	53.309	-60.168
139	Norman's Bay	NL	52.937	-55.907
127	Paradise River	NL	53.425	-57.234
143	Pincent’s Arm	NL	52.689	-55.890
170	Pinware	NL	51.624	-56.708
165	Pinware River	NL	51.747	-56.630
159	Pitts Harbour	NL	52.017	-55.890
166	Red Bay	NL	51.745	-56.426
125	Salmon Bight	NL	53.462	-55.786
149	William’s Harbour	NL	52.560	-55.774
16	Aklavik	NT	68.227	-135.017
56	Deh Gah Gotie Dene Council (Fort Providence)	NT	61.358	-117.660
45	Dog Rib Rae (Behchoko)	NT	62.830	-116.050
26	Fort Good Hope	NT	66.257	-128.628
21	Gwichya Gwich'in	NT	67.445	-133.737
15	Inuvik Native	NT	68.410	-133.815
55	Jean Marie River First Nation	NT	61.491	-120.649
63	Ka'a'gee Tu First Nation	NT	60.940	-117.417
53	Liidlii Kue First Nation (Fort Simpson)	NT	61.845	-121.350
42	Pehdzeh Ki First Nation	NT	63.213	-123.430
22	Tetlit Gwich'in	NT	67.431	-134.875
30	Tulita Dene	NT	64.900	-125.570
43	Wha Ti First Nation	NT	63.160	-117.254
196	Algonquins of Pikwàkanagàn	ON	45.551	-77.222
114	Bearskin Lake	ON	53.916	-90.972
192	Big Grassy	ON	49.054	-94.307
190	Biinjitiwaabik Zaaging Anishinaabek	ON	49.444	-88.131
167	Cat Lake	ON	51.725	-91.813
197	Chippewas of Georgina Island	ON	44.375	-79.294
144	Deer Lake	ON	52.617	-94.059
188	Ginoogaming First Nation	ON	49.729	-86.512
135	Kee-Way-Win	ON	52.999	-92.801
134	Kingfisher	ON	53.027	-89.841
119	Kitchenuhmaykoosib Inninuwug	ON	53.817	-89.875

ID	Community	Province/ territory	Latitude	Longitude
195	Michipicoten	ON	47.991	-84.901
177	Mishkeegogamang	ON	51.065	-90.273
128	Muskrat Dam Lake	ON	53.362	-91.847
141	Nibinamik First Nation	ON	52.797	-88.461
138	North Caribou Lake	ON	52.957	-91.272
151	North Spirit Lake	ON	52.505	-93.019
182	Ojibway Nation of Saugeen	ON	50.500	-90.760
163	Pikangikum	ON	51.809	-93.984
158	Poplar Hill	ON	52.082	-94.309
115	Sachigo Lake	ON	53.894	-92.162
131	Sandy Lake	ON	53.074	-93.327
176	Slate Falls Nation	ON	51.169	-91.591
189	Wabigoon Lake Ojibway Nation	ON	49.605	-92.523
120	Wapekeka	ON	53.721	-89.539
130	Wawakapewin	ON	53.242	-89.142
140	Wunnumin	ON	52.852	-89.286
65	Champagne	YT	60.755	-136.478
37	Dease River	YT	64.097	-129.295
57	First Nation of Nacho Nyak Dun	YT	61.356	-135.881
70	Kluane First Nation	YT	60.171	-138.990
71	Ross River	YT	60.068	-132.449
52	Selkirk First Nation	YT	62.089	-136.565
58	Ta'an Kwach'an	YT	61.257	-134.600
66	Taku River Tlingit	YT	60.736	-133.644
40	Tr'ondëk Hwëch'in	YT	63.595	-139.418
18	White River First Nation	YT	67.576	-140.875
Total	**109 communities**			

Appendix D: Examples of Government programs and subsidies for telecommunications services provided via satellite

267. This appendix contains information on government programs and subsidies for telecommunications services provided by satellite. Part A of this Appendix identifies broad examples of major programs and subsidies at the federal, provincial/territorial, and municipal levels for telecommunications services provided via the community aggregator model and/or the direct-to-home model. Part B contains information and analysis based on parties' specific submissions identifying the subsidies received by providers of telecommunications services, and the costs incurred by those providers.

Part A: Examples of major government programs and subsidies for telecommunications services provided via satellite

268. The following is a non-exhaustive list of major government programs and subsidies for telecommunication services provided via satellite, and those that include satellite as a component. Figures specific to funding for satellite are included where available; however, many subsidies include satellite as one component among others and satellite-specific funding may not be available. These are intended to give an indication of the scale of government programs and funding for telecommunication services provided via satellite.

Major Government-of-Canada-led programs and subsidies

269. **National Contribution Fund (CRTC):** The National Contribution Fund (NCF) is the Commission's national revenue-based contribution collection mechanism through which residential telephone service is subsidized in high-cost serving areas. These areas include satellite-dependent communities (where voice services are provided via C-band) on the basis of the high cost incurred to provide service to these communities. Contributions are paid into the NCF by telecommunications service providers (TSPs), or groups of related TSPs, that have $10 million or more in eligible Canadian telecommunications service revenues annually. Funds are then paid out to the incumbent local exchange carriers (ILECs) that provide residential telephone service in high-cost serving areas. These areas include communities served by Bell Aliant, MTS Allstream, Northwestel, SaskTel, and TCC, which use the community aggregator model to provide fixed voice services.

270. **Public Benefit (Industry Canada) 2000:** In 2000, Industry Canada introduced a public benefit obligation as a condition of licence for some satellite licences in response to the growing requirements of public institutions for telecommunications capacity in remote areas.[xxxii] Through Industry Canada's authorization of the Anik F3 satellite, Telesat committed to providing public benefit satellite capacity to serve public institutions in unserved areas.[xxxiii] As a result, the equivalent of two C-band transponders was made available free of charge for use by public institutions.[xxxiv] Governments paid an amount to initially implement the program (e.g. $400,000 in the Northwest Territories), and service providers supplied the necessary earth station equipment and management of the free bandwidth at a cost that was passed on to governments.[xxxv] This public benefit capacity was assigned in 2 rounds. In the first round, capacity was provided to the public

institutions discussed below. In the second round, capacity was assigned through the Government of Canada's National Satellite Initiative.

- Nunavut: 12.5 megahertz (MHz) of C-band satellite capacity from 2003 to 2022, with an estimated value of $15.675 million. This funding provides satellite capacity for schools and health-care centres.[xxxvi]
- Northwest Territories: 6 MHz of C-band satellite capacity from 2003 to 2022, with an estimated value of $7.52 million. This funding provides satellite capacity for schools and health-care centres.[xxxvii]
- Northern Ontario (K-Net): 12.5 MHz of C-band capacity[xxxviii] from 2002 for 23 communities, including for education and telehealth.[xxxix]

One additional transponder became available in 2003, valued at approximately $20 million.[xl] In 2004, as part of the National Satellite Initiative described below, 28 MHz of this satellite capacity was allocated to 4 successful candidates, representing approximately 52 communities in British Columbia, Manitoba (Broadband Communications North Inc.), Ontario (the Grassy Narrows First Nation), and Quebec (the Kativik Regional Government).[xli]

271. **National Satellite Initiative (NSI) [Industry Canada, Infrastructure Canada] 2003-2007:** The NSI was launched in 2003 by Industry Canada in partnership with Infrastructure Canada to make available affordable satellite capacity for the deployment of broadband services to communities in the mid-to-far North, and to isolated and remote areas of Canada.[xlii] The program extended broadband access to an additional 180 un-served communities.[xliii]

- The NSI was assigned in 2 rounds. Round 1 consisted of the acquisition of satellite capacity (28 MHz) from Telesat's public benefit transponder, valued at $20 million, for use by public institutions (included above under Industry Canada's Public Benefit).
- In Round 2, $85 million was allocated to the NSI from the Government of Canada's Canada Strategic Infrastructure Fund for the acquisition of satellite capacity and ground infrastructure for satellite-based broadband projects in isolated and remote communities across Canada.[xliv] Among other benefits, this funding enabled the Northern Indigenous Community Satellite Network to purchase two C-band satellite transponders for 43 communities in the northern regions of Manitoba, Ontario, and Quebec. These are set to expire in 2019. $20.6 million of the funding from the NSI accounted for approximately 75% of the project cost, with the remaining cost covered by the Northern Ontario Heritage Fund Corporation ($1.3 million), the Government of Quebec's Villages branchés program ($2.2 million), and Telesat ($2.9 million) A summary of the NSI's Round 2 funding from the Canada Strategic Infrastructure Fund is below: [xlv]

Table 11.6: Canada Strategic Infrastructure Funding for the National Satellite Initiative – Round 2

Region	Project/Beneficiary	Funding (in millions)
Manitoba, Ontario, and Quebec	the Northern Indigenous Community Satellite Network	$20.6
Northwest Territories	Broadband Phase 1	$7.0
Northwest Territories	Broadband Phase 2	$14.8
Nunavut	Nunavut Broadband Phase 1	$7.8
Nunavut	Nunavut Broadband Phase 2	$21.6
Quebec	Naskapi Imuun Inc. Broadband	$4.7
First Nations	First Nations' Emergency Services Society	$7.9

Source: Infrastructure Canada

272. **Broadband for Rural and Northern Development (BRAND) [Industry Canada] 2002-2007:** This program provided a one-time capital-cost-sharing fund to support community deployment of broadband infrastructure. As a result of this program, the non-profit Nunavut Broadband Development Corporation was created. With SSI and other organizations, this led to the creation of the QINIC network to serve communities in Nunavut with wireless broadband Internet, delivered via satellite.[xlvi]

- **Nunavut:** $3,885,000 in 2004-2005 to fund public high-speed Internet access to homes and offices; not for government use.[xlvii]
- **Northwest Territories:** $5,368,318[xlviii] in 2004 for capital build for public high-speed Internet access to homes and offices; however, no specific information on funding for satellite service is currently available publicly.

273. **Broadband Canada: Connecting Rural Canadians (Industry Canada) 2009-2012:** This program provided funding to extend broadband Internet service coverage to unserved households, including approximately $60 million in funding for satellite.

- **Nunavut:** SSi submitted that it receives funding from this program for network upgrades and to assist in defraying the cost of satellite connectivity for fixed satellite service (FSS) to deliver more affordable broadband Internet service to consumers in 25 Nunavut communities at a set rate per month. SSi receives approximately $10.7 million,[xlix] which it must match. SSi is also required to comply with pre-established oversubscription ratios to deliver a certain quality of service. The funding expires in 2016.

- **Nunavik:** The Kativik Regional Government added two C-band transponders for use exclusively in Nunavik communities until 2016 through this program. The federal government provided $7.4

million in funding for the project, along with $3 million from the Quebec provincial government, and $2.5 million from the Kativik Regional Government.[107]

- **Direct-to-home satellite Internet:** Approximately $33.6 million in funding was provided over a 5-year period (ending in 2016) for Xplornet to provide Ka-band satellite capacity sufficient for the company to offer broadband services to up to 32,729 subscribers in multiple geographic areas. The subsidies were used to lower the cost of packages available to end-users.
- Below is a list of the satellite initiatives in British Columbia, Nunavut, Ontario, and Quebec that were supported under the Broadband Canada: Connecting Rural Canadians program, with funding provided until 2016:

Table 11.7: Broadband Canada: Connecting Rural Canadians program funding for satellite[108]

Company/Recipient	Province/Territory	Total
Galaxy Broadband Communications[109] Inc.	British Columbia	$7,440,359
Galaxy Broadband Communications	Ontario	$944,587
Barrett Xplore Inc.[110]	Ontario	$2,538,035
Barrett Xplore Inc.	Quebec	$31,033,709
Kativik Regional Government broadband project	Quebec	$7,401,557
Ssi Micro & Northern Broadband	Nunavut	$10,681,375
Total		**$60,032,622**

Source: Industry Canada

274. **Knowledge Infrastructure Program (Industry Canada) 2009-2011:** This program provided funding for universities and colleges to construct new buildings and upgrade existing ones. Under this program, Nunavut Arctic College provided cyber infrastructure, including Internet connectivity, for its 5 campuses and 25 community learning centres. The Nunavut territorial government contributed $2.7 million of the $5 million project cost.[l]

[107] Telesat contributed an additional $2 million. The federal portion of the project cost was approximately 50%.

[108] Information obtained from Industry Canada. Further information on Industry Canada's grants and contributions, including the amounts to specific recipients, can be found on their website.

[109] Galaxy Broadband received a total of $8,384,946 under this program for satellite in British Columbia and Ontario.

[110] Xplornet received a total of $33,571,744 under this program for satellite in Ontario and Quebec.

275. **Building Canada Fund (Infrastructure Canada) 2007-2014:** This program provided funding for projects through investments in public infrastructure. All projects were cost-shared, with the maximum federal contribution to any single project at 50%. The Communities Component included connectivity and broadband as an eligible program category.[li]

- The Building Canada Fund supported the Eastern Ontario Regional Broadband Network project, which included a satellite component. The total project cost was $221 million, with project costs eligible for funding estimated to be $170 million. Of this, $55 million was federally-funded, of which a portion was dedicated to a satellite component.[111]

276. **New Building Canada Plan (Infrastructure Canada) 2014-2024:** This $14-billion fund supports projects of national, regional, and local significance that promote economic growth, job creation, and productivity. Satellite capacity is included in the program under the connectivity and broadband subcategory of the Provincial-Territorial Infrastructure Component: Small Communities Fund.[lii] No funding agreements have yet been concluded relating to satellite under this program.

277. **The Federal Gas Tax Fund (GTF) [Infrastructure Canada]:** As part of the New Building Canada Plan, the renewed federal GTF provides predictable, long-term, stable funding for Canadian municipalities for local infrastructure projects. Broadband and connectivity is now an eligible subcategory of the GTF.[liii] No funding agreements have yet been concluded relating to satellite under this program.

278. **First Nation Infrastructure Fund (FNIF) [Aboriginal Affairs and Northern Development Canada]:** This fund provided $234 million to improve the environment and quality of life in certain First Nations communities between 2007 and 2013. In November 2012, the Government of Canada announced that it would renew the FNIF with a permanent contribution from the GTF to begin in 2014-2015, at $139 million for the first five years.

- The connectivity component of the FNIF includes satellite capacity as an eligible subcomponent. For example,
    - $320,500 was provided in 2010-2011 and $320,500 in 2011-2012 to support the purchase of satellite equipment in Kawawachikamach, Quebec; and
    - $427,722 was provided in 2010-2011 to support satellite connectivity in Mushuau, Newfoundland and Labrador.

Provincial- and municipal-led programs and subsidies

279. Provincial and territorial governments have also provided subsidies to expand broadband Internet service, including funding programs that include satellite service as a component to serve households in rural and remote areas. Examples of additional provincial- and municipal-led initiatives for telecommunications services provided via satellite are included below.

280. During the inquiry, Xplornet identified multiple provincial programs through which it has received subsidies, which have reduced the cost of packages available to end-users:

[111] Funding for the satellite component was removed due to reasons of confidentiality.

- The Ministry of Municipal and Regional Affairs, Province of Quebec – Communautés rurales branchées (MAMROT): funding of $1 million over 5 years (ended in 2014) for projects to expand broadband Internet services to unserved and underserved households in rural communities in Quebec.
- Broadband Program, Province of New Brunswick: $6 million to provide broadband Internet services at below $50 per month and an installation fee of $99 (ended in 2014)
- Rural Broadband Initiative – Zone 5, Province of Newfoundland and Labrador: $1.67 million to offer broadband Internet services to up to 7,500 subscribers in central Newfoundland.

281. Additionally, the Provinces of British Columbia and Alberta introduced the B.C. Broadband Satellite Initiative and the Central Alberta Satellite Solution, respectively, in 2013. These initiatives both focus on direct-to-home broadband Internet and make funding available to contribute to offsetting the one-time satellite installation fee with Xplornet. The B.C. Broadband Satellite Initiative will provide $2 million in funding to assist over 40,000 people in remote areas, while the Central Alberta Satellite Solution is available to 4,300 households. [liv][lv]

282. The Government of Nunavut's Department of Economic Development and Transportation committed $375,000 in matching funds for project management and communications over three years (starting in 2012), as part of Round 2 of the National Satellite Initiative outlined above. As well, the Government of Nunavut has committed $1.8 million to support the Nunavut Broadband Development Corporation's core operations since its inception in 2003.[lvi]

Part B: Subsidies and costs to providers of telecommunications services

283. The following information was derived from parties' responses to the Inquiry Officer's requests for information, and represents a subset of the subsidies provided for telecommunications services via provided satellite identified above. Parties were requested to provide more detailed information on their costs and the subsidies they receive, which is summarized below.

National Contribution Fund for basic fixed voice service

284. MTS Allstream and TCC provided specific information on their costs and the funding they receive to provide basic voice service in communities that rely on the community aggregator model. MTS Allstream uses FSS transport to provide telecommunications services to seven communities. As these are High Cost Serving Areas, MTS Allstream receives a subsidy from the National Contribution Fund each month for each residential line in these communities to deliver basic residential voice service. MTS Allstream's price was capped at $30 from June 2013 to May 2014; the National Contribution Fund subsidy offsets the difference between the monthly equivalent cost of providing service and a deemed monthly revenue of $35 - $30 from the monthly rate for basic residential services, plus a $5 contribution from optional services.

    - MTS Allstream received a total subsidy of $599,068 in 2013 to deliver service through a total of 829 local residential lines in these seven communities. This represents $723 per residential line in 2013, or $60 per line per month.

285. TCC provided information for Tsay-Keh-Dene in British Columbia, which is the only community TCC serves using FSS.

- TCC received $10,460 for 47 residential lines in 2013, or $18.55 per line per month.

286. TCC and MTS Allstream provided their average monthly costs for rate band G exchanges in which they provide fixed voice service. The companies noted that these costs (of which the subsidies represent from 35% to 63%) do not necessarily reflect those for specific satellite-dependent communities.

Overall subsidies for providers of telecommunications services

287. Satellite capacity was by far the most significant subsidized cost identified by providers of telecommunications services for communities that rely on the community aggregator model, compared to other costs such as earth station construction and equipment and local distribution networks.[112,113]The Northern Indigenous Community Satellite Network noted that no subsidies cover operating costs.

288. The Kativik Regional Government submitted that the total average subsidy per community per year for Nunavik communities is $241,329[114] and estimated that the current annual value of subsidies was $3.2 million. The Kativik Regional Government further estimated that the current annual value of subsidies represented 37% of the total costs incurred for fiscal year 2013.[115] The Kativik Regional Government serves 14 satellite-dependent communities in total, with 3,543 households. Therefore, the total subsidy amount represents over $900 per household per year.

[112] Providers of telecommunications services submitted information on funding from programs including Public Benefit (the Northern Indigenous Community Satellite Network), Broadband Canada: Connecting Rural Canadians (SSi and the Kativik Regional Government), and the Canada Strategic Infrastructure Fund (the Northern Indigenous Community Satellite Network and Northwestel).

[113] Specific breakdowns of subsidized costs were provided to the Inquiry Officer in confidence.

[114] This average is for 13 of the 14 communities served by the Kativik Regional Government that received funding through Broadband Canada: Connecting Rural Canadians (an average of $160,024/community per year). Since Kuujjuarapik/Whapmagoostui was not funded under this program, this community has an average subsidy of $81,305 per year.

[115] The Kativik Regional Government noted that the operating costs for 2014 to 2019 remain unknown, so this is not an exact percentage.

Appendix E: Cost and technology efficiencies

Current State of Efficiencies

289. In general, providers of telecommunications services have obtained cost efficiencies to date by

- migrating to more efficient equipment and technology
- investing in technology that produces a better bit/megahertz (MHz) ratio, which results in a lower cost per megabit per second (Mbps) delivered. For example, Bell Aliant's earth stations are in the process of migrating to IP technology, which is expected to provide a meaningful improvement in bandwidth efficiency.[116]
- using power more efficiently, which is significantly more expensive in northern Canada than in southern Canada
- negotiating longer contracts to get favourable monthly fixed satellite service (FSS) prices
- investing in local technicians, which could cost less than flying in technicians from other parts of the country for installation and repair work
- pooling capacity. For example, the Kativik Regional Government merged the government private network with public Internet, which allows each network to access unused capacity from the other network. The Nunavut Broadband Development Corporation suggested that the Government of Nunavut follow a similar approach to allow consumer broadband networks to access the territorial government's idle capacity after business hours. However, such pooling of capacity has not been implemented in Nunavut.
- sharing a hub and having a common technology platform (specific to the Northern Indigenous Community Satellite Network partners).

Further opportunities for cost efficiencies

290. The inquiry examined the following opportunities for greater cost efficiency. These efficiencies and others will play a role in enabling the delivery of better and more cost-effective telecommunications services. However, it is acknowledged that these opportunities will not significantly impact the overall cost of satellite service delivery.

Pooling satellite capacity

291. Business and residential Internet service end-users consume capacity at different times of the day. In general, most business Internet traffic is generated on weekdays during the daytime, while most residential Internet traffic is generated in the evenings and on weekends. The pooling of FSS capacity between separate networks gives one network access to the unused capacity of the other network. Effective sharing/pooling of capacity would reduce the overall cost of FSS capacity for customers. The Kativik Regional Government has merged the government and public Internet networks in Nunavik, although the Government of Nunavut's wide area network does not pool its capacity with the Qiniq and Airware consumer broadband networks due to contractual reasons.

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[116] Specific information on efficiencies was provided to the Inquiry Officer in confidence.

Combined voice, Internet, and wireless networks

292. Some entities that use FSS to provide telecommunications services offer more than one type of telecommunications service to their customers, such as home telephone (voice), Internet, and wireless services. When more than one type of service is offered to customers, providers of telecommunications services have generally agreed that it is theoretically more efficient to deliver these services using combined networks that pool satellite capacity.

293. In general, more capacity is available to end-users when capacity is pooled than when it is segregated. The pooling of capacity also helps to avoid situations in which the quality of one service is degraded because all of the capacity allocated to it is used, while spare capacity available for other services remains idle.

294. However, the delivery of reliable and efficient telecommunications services over combined voice and data networks can be complex and onerous to operate and manage. For example, voice traffic transferred over a network must be prioritized over Internet traffic to maintain acceptable call quality. In practice. a number of factors prevent some providers of telecommunications services from pooling space segment capacity:

- limitations to technology and network design;
- some customers require that their traffic be segregated from other shared resources;
- traffic segregation allows platforms to be optimized for their respective applications;
- C-band transponders provide 36 MHz of spectrum at most, and once that capacity limit is reached, the network must be segmented.

Single- versus multiple-antenna earth stations

295. Currently, most earth stations in Canada have a single antenna that transmits data to and from the satellite. Some parties submitted that operating earth stations with multiple antennas would improve network reliability through greater redundancy and diversity, and would make it easier to migrate to a competing satellite operator. Other parties submitted that earth stations with a single antenna are sufficiently reliable and more cost effective, and that they provide an acceptable level of service; therefore, multiple antennas are not necessary.

Earth station co-location

296. Co-location has been used to a certain extent in the provision of telecommunications services as a way to reduce costs by sharing resources. Through the inquiry, multiple earth stations were identified in certain communities, and information was collected on whether co-location could help reduce costs for providers of telecommunications services.

297. Providers of telecommunications services submitted that there is limited co-location of earth station infrastructure for the following reasons:

- There is no incentive for incumbent providers to share their facilities with competing service providers, irrespective of any potential cost savings.
- Different network architectures make it difficult to share infrastructure.
- Co-location requires additional investment.
- One provider of telecommunications services submitted that co-location facilities were only available if purchased in conjunction with satellite capacity from a specific satellite operator.
- Adequate co-location facilities are not available in all communities, and where such facilities do exist, providers of telecommunications services often determined that it was more cost effective to deploy their own facilities.
- Northwestel stated that it does not see any opportunity to share earth station antennas and earth station radio frequency infrastructure, given that the infrastructure that is currently in place is required to meet the company’s own capacity requirements. However, Northwestel enables sharing of earth station buildings and power-generation facilities through its site space co-location and power tariffs.

Appendix F: List of parties who participated in the inquiry

Satellite operators

Ciel Satellite Group
Hughes Network Systems LLC (Hughes)
Hunter Communications Canada
Intelsat
Omnispace LLC
SES S.A. (SES)
Telesat
ViaSat, Inc. (ViaSat)

Providers of telecommunications services and earth station operators

Bell Aliant Regional Communications, Limited Partnership (Bell Aliant)
Bell Mobility Inc. (Bell Mobility)
Broadband Communications North
Coman Arctic Ltd.
Eeyou Communications Network
Iristel Inc. / Ice Wireless Inc. (Ice Wireless)
Juch-Tech Inc. (Juch-Tech)
K-Net
Lynx Mobility
MTS Inc. and Allstream Inc.
(collectively, MTS Allstream)
The Northern Indigenous Community Satellite Network
Northwestel Inc. (Northwestel)
Saskatchewan Telecommunications (SaskTel)
SSi Micro Ltd. (SSi)
Télébec, Limited Partnership (Télébec)
TELUS Communications Company (TCC)
Total North Communications
Xplornet Communications Inc. (Xplornet)

Governments/Government organizations

Aboriginal Affairs and Northern Development Canada
The Kativik Regional Government
The Government of Nunavut
The Government of the Northwest Territories
The Government of Yukon
Industry Canada
Infrastructure Canada
Network BC
The Nunatsiavut Government
The Province of British Columbia

Organizations/Interested persons

Canada's Public Policy Forum
First Mile Connectivity Consortium (FMCC)
Isuma Distribution International Inc.
The Public Interest Advocacy Centre
The Nunavut Broadband Development Corporation (NBDC)
Individuals who submitted comments

Appendix G: Relevant literature

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