Remote Rural Broadband Systems in Canada

Gregory Taylor

Department of Communication, Media and Film, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada

1. Introduction

Wireless broadband in many remote areas of northern Canada in 2017 can trace its inception to a late addition to a footnote in a report issued in Istanbul, Turkey in 2000. It was there at the World Radiocommunication Conference (WRC) that Canada joined other countries in what was institutionally labelled MOD S5.293; a change in allotment of frequencies to mobile services.

> *Different category of service:* in Canada, Chile, Colombia, Cuba, the United States, Guyana, Honduras, Jamaica, Mexico and Panama and Peru, the allocation of the bands 470–512 MHz and 614–806 MHz to the fixed and mobile services is on a primary basis…. The international in-country footnote S5.293 has allocated the bands 470–512 MHz and 614–746 MHz for fixed and mobile services on a co-primary basis with the broadcasting service. (Industry Canada, June, 2001)

With this change in the spectrum allotment structure for members of region two of the International Telecommunications Union (ITU), Canada began to reconfigure its national frequency allocations to allow for fixed broadband in these bands that had traditionally been reserved for television broadcasting. In the years to follow, Canada embarked upon a unique policy experiment involving the opening of television white spaces for fixed wireless broadband service in the country's vast rural hinterland. Canada has limited over-the-air (OTA) television broadcasting and after the digital television transition of 2011, many broadcasters, including the national public broadcaster, ceased OTA transmissions in all but the major urban centers of the country (Taylor, 2013). "Remote Rural Broadband Systems" (RRBS) is a Canadian wireless policy initiative that holds great promise: it encourages and supports new entrants into the wireless broadband sector; it makes use of spectrum that is by and large idle; it explicitly seeks to expand service into underserved areas; and the signal provided by these frequencies offers strong propagation qualities, with the ability to penetrate a common obstacle in rural Canada: trees.

The stated goal of equality of access to communications services in all regions is a regular refrain in Canadian communications policy. The discrepancies between Canada's metropolitan centres and rural hinterland has been a central feature of the history of Canadian communications, as outlined in the 1950s by Canadian scholar Harold Innis (Innis & Drache, 1995). Broadband is the latest in a line of communications cleavages between urban and rural Canada, from the telephone to broadcasting, which have posed a challenge for national connectivity. Market failure is a consistent feature of communications in rural Canada, prompting government to play an active role to entice development. The Telecommunications Policy Review Panel Final Report 2006 outlined recent efforts by the Canadian government to promote wired broadband access in underserved areas, including the *Broadband for Rural and Northern Development* (BRAND) program which ran from 2002 to 2007 (Canada, 2006, pp. 8–3); this program was in turn superseded by the 2009 announcement of the *Broadband Canada: Connecting Rural Canadians* program, which ran until 2012 (Industry Canada, 2010).

Rural broadband policy announcements have proven a popular pastime for Canadian politicians; however broadband in rural areas remains stubbornly mired in lower speeds and higher prices. Recent data from the national media regulator the Canadian Radio-Television and Telecommunications Commission (CRTC) demonstrates that basic broadband coverage (under 5 megabits per second

[Mbps]) in Canada is fairly uniform, however rural areas quickly drop in comparison to their urban compatriots when higher broadband speeds are factored in. The following table includes various broadband services: DSL/fibre, cable modem, fixed wireless, and mobile (HSPA+ and LTE bars show the additional effect that inclusion of these technologies would have on the respective categories) (see Fig. 1).

Likewise, low-level wireless packages are similarly priced in urban and rural Canada; however, advanced packages see a strong price differential. A one GB data plan starts at $38 in urban Alberta and Ontario, but the same plan costs $50 in rural Alberta and Ontario. A two GB data plan that sells for $35 in urban Alberta and Ontario is priced at $60 in rural Alberta and Ontario (Canadian Radio-Television and Telecommunications Commission, 2016).

More detailed data on rural Canadian connectivity is frustratingly sparse. A 2014 Nordicity study commissioned by the Federation of Canadian Municipalities, notes

> Impeding an assessment of the state of broadband in Canada is the lack of complete data. Anecdotally, we often hear messages regarding the poor state of Internet access in Canada, particularly in rural and remote areas, while simultaneously being told that network operators are pouring billions of dollars into network improvements. Detailed information is a closely guarded secret and, the information that is publicly available is often not completely representative of the situation (Federation of Canadian Municipalities, 2014, p. 8)

The demand for connectivity in rural Canada is clearly there, which is why politicians have spent a great deal of political and financial capital trying to bridge this element of the digital divide (Federation of Canadian Municipalities, 2014). Politicians are aware that the advantage of broadband access in remote Canada is strongly felt by residents. A 2010 study of the northern town of Chapleau, Ontario found that with the arrival of broadband "Instead of being an isolated island unto itself, Chapleau (became) more like a well-attached island with many Internet bridges to the outside" (Collins & Wellman, 2010, p. 21; see also; Industry Canada, 2004). The RRBS policy was another effort on the part of the government to ease the isolation felt by remote sections of the country using the abundant local resource of vacant 600 MHz television spectrum. This was a plan to further the national goal of rural digital development via new spectrum allocation and licensing procedures. As a case study, RRBS in Canada provides a useful template for countries struggling with their own digital divides.

Despite early signs of promise, in 2017 RRBS is struggling in Canada and may soon find itself jettisoned to the dustbin of ambitious but under-realized communications policy. After an encouraging start, the overwhelming majority of Canadian RRBS providers have either folded their businesses or moved on to other, more established methods of delivering service, such as wired access or utilizing less desirable 3500 MHz spectrum that has lower propagation and penetration properties. The problems encountered with RRBS were not due to a spectrum shortage. Television white space is abundant. This made-in-Canada approach to the problem of broadband access has largely been constrained by regulatory indecisiveness. It has never received the institutional support required to turn a bold initiative into lasting policy. RRBS is a policy approach with potential to reshape the market, albeit a limited section of the market where large providers lack incentive to expand. It offers a case study of how regulatory uncertainty can prove an impediment to digital development. If it officially comes to an end, RRBS will be a victim of Canada's subordinate telecommunications policy structure vis-à-vis its American neighbour, as well as a lack of commitment on behalf of Canada's regulators to offer support for small market entrepreneurs in the
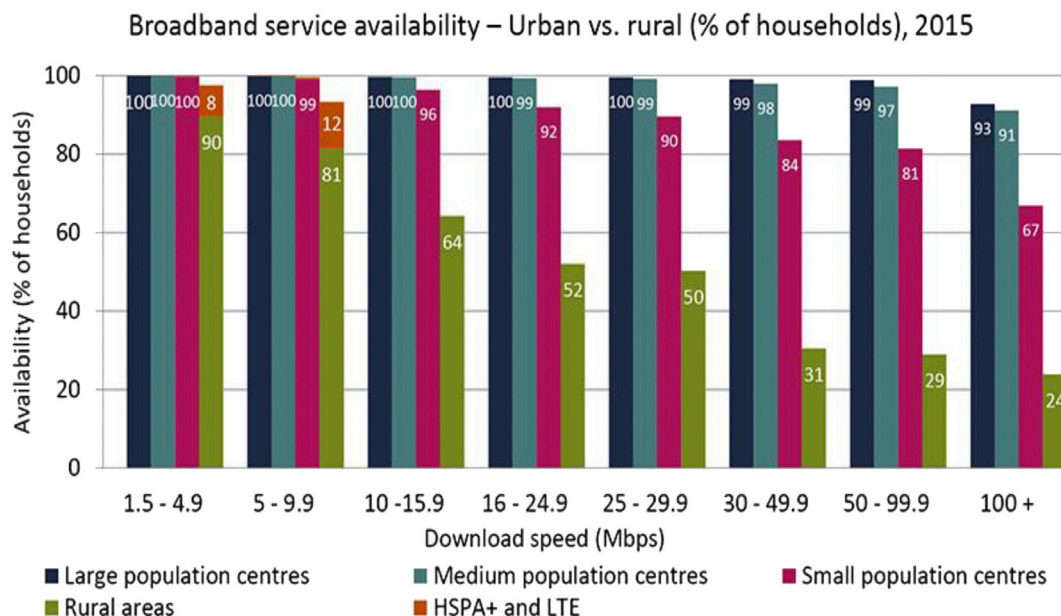

Fig. 1. Canadian Radio-Television and Telecommunications Commission, 2016 5.3.13.

wireless sector.

This paper explores the history and development of the Remote Rural Broadband Systems policy in Canada as it moved from secondary concept on a 2004 Industry Canada call for comments, to a bold communications policy initiative to use Canada's vast space to its advantage. It chronicles the gold rush-like scene shortly after the policy launch, followed by a precipitous drop in licensed RRBS providers within two short years. This study of RRBS has a specific Canadian focus but is of relevance to all countries exploring policy options for potential uses of idle television white space (TVWS), ways to bring new players into the wireless market, as well as policy strategies for providing affordable digital access to underserved regions.

This work is based upon primary sources from Industry Canada (renamed Innovation, Science and Economic Development, or ISED, in 2015). It also offers first hand accounts from small wireless service providers who saw such promise in this new approach that they maintained RRBS services after most other licensed providers in the market had ceased operations. The views of these providers illuminate the impact of this policy on the ground, where entrepreneurs are trying to gain a foothold in the oligopolistic and capital-intensive wireless industry. RRBS service providers are usually small businesses offering fixed wireless in areas where major providers see little economic incentive. This qualitative approach to data collection yielded some unexpected twists. The remaining RRBS operators often survive via cooperative efforts that harken to an earlier western Canadian economic experience of assisting fellow small business people for mutual benefit. These interviews offer insight into the potentials and shortcomings of RRBS and why this policy was, and in the view of many service providers, remains, particularly suitable for the Canadian wireless market.

2. RRBS: what is it?

"These systems, called RRBS, are unique to Canada and are established on a no-protection, no-interference basis with respect to all TV broadcast stations, including low-power and very low-power TV" (Industry Canada, 2011).

RRBS systems provide fixed wireless broadband access to rural and remote areas via unutilized analog television waves in the 512–608 MHz and 614–698 MHz frequency bands (or channels 21 to 51, except channel 37 which is allocated for radio astronomy service). Thus far, Canada has only authorized 614–698 MHz for RRBS. At 6 MHz per licence, this should mean potentially up to 14 licences in areas that meet RRBS criteria, though this number rarely, if ever, materialized. Distinct from unlicensed, such as Wi-Fi, or shared infrastructure or wholesale access (Sims, Youell, & Womersley, 2015), RRBS providers are largely independent operators licensed under strict conditions.[1] RRBS service is offered on a subscriber basis.

Under the RRBS policy, the broadcasting licensee has priority; however, the fixed wireless provider is licensed and allowed access on a non-interference basis. RRBS service providers use base stations and fixed customer premises equipment. Base stations operate at up to 500 W and can provide service to a radius of 2–20 km, depending on the equipment used and physical encumbrances (Industry Canada, 2011). As a secondary service, RRBS operators are not entitled to claim protection from broadcasting services and cannot cause interference to them. Frequencies for RRBS are assigned on a 6 MHz block basis with upper and lower boundary frequencies identical to the 6 MHz broadcast channel plan. A maximum of 2 channels (12 MHz) can be assigned in the same market to the same licensee (Industry Canada, March 2007).

In 2001, the U.S. and Canada codified spectrum use along the border (including the Alaskan border) to ensure there would be no interference to broadcasters in either country (Industry Canada, January, 2001). This was updated in 2008 to formalize allotments and assignments within 360 km of the borders (including Alaska) upon completion of the digital television transition, which in turn impacted RRBS regulations (Canada Gazette, Dec 20 2008).

There are strict geographic parameters for this service. RRBS licence holders can only operate:

1) in rural remote communities where applied-for spectrum is not being used for broadcasting service, and
2) in locations that are more than 121 km from the Canada-US border, and
3) at a sufficient distance away from major urban areas and broadcasting facilities (see map Figs. 2–6)
4) any RRBS service within 400 km of the US border subject to non-interference with US signals – a major headache for RRBS providers, which is one reason many providers are much further north than the required 121 km (Industry Canada, August 2011).

RRBS may have a "made in Canada" stamp on the policy; however, it bears a strong resemblance to spectrum assignment methods outlined in other jurisdictions. RRBS utilizes what UK spectrum scholars Martin Cave and William Webb call "vertical sharing"; under this approach to spectrum allocation, "a licensee is identified which typically has a prior right of access, but others obeying certain rules requiring them not to interfere with that licensee or with one another can also be accommodated" (Cave & Webb, 2015, p. 47). In the Canadian RRBS example, a television broadcaster still has right of access, and the RRBS provider has no protection and must not interfere with any nearby broadcasting signal. Many RRBS providers complain of having to change their transmission range if a television broadcaster decides to increase power from their transmitter. Under the policy, the RRBS provider has no recourse in this situation and must make adjustments.

RRBS also largely echoes Licensed Shared Access (LSA), defined by Radio Spectrum Policy Group in Europe as

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[1] A notable exception to the independent RRBS operators is Bell Aliant, a division of Canada's largest communications company, Bell Canada. Bell Aliant is listed in Industry Canada's 2015 list of RRBS licensees (Industry Canada, August 14, 2015 Annex B). Bell Aliant did not respond to requests to participate in this study.

"A regulatory approach aiming to facilitate the introduction of radiocommunication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under the licensed shared access (LSA) approach, the additional users are authorized to use the spectrum (or part of the spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorized users, including incumbents, to provide a certain quality of service" (Mazar, 2016, p. 308).

Unlike RRBS, LSA is not restricted to use by fixed wireless providers. It is open to a broader range of deployment.

In the United States, the FCC has made efforts to encourage new wireless internet service providers (WISPs) in the 3650–3700 MHz band with the explicit goal of expanding service in rural America (Federal Communications Commission, March 16, 2005). The program began in 2007 with licences granted on 10-year term, subject to renewal. The program proved short lived. Starting in April 2015, the FCC ceased to issue new licenses for 3650–3700 MHz band for WISPs. The 3650 MHz band would be incorporated as a part of the 3550–3700 MHz band in the *Citizens Broadband Radio Service* program, a spectrum sharing program adopted by the FCC (Federal Communications Commission, April 21, 2015). Regulatory uncertainty regarding the future of rural programs in the United States including White Space (largely in the 600 MHz band and, like Canadian RRBS, impacted by the incentive auction) and Educational Broadband Spectrum (2.5 GHz, allotted to educational institutions) was noted in a recent American study (Yankelevich, Shapiro, & Dutton, 2017).

Other countries may have similar approaches but none completely mirror the Canadian policy. RRBS had higher transmission power than TVWS devices and there is no central database as is the case in the United States and the UK (Industry Canada, October 2012). The 600 MHz frequencies offer better propagation characteristics than fixed wireless on the 3500 MHz band. Spectrum of this quality is often out of range for the budgets of small broadband providers. The important 700 MHz auction of 2014 and the AWS-3 auction of 2015 offered tier 2 service areas, which meant participants would have to bid on the entire province of Alberta – out of the question for smaller service ISPs. Smaller tier four licences are rarely on offer at spectrum auctions – in recent years only in the Northwest Territories, Yukon and Nunavut (Industry Canada, Jan 2014). The government did not offer direct funding to potential RRBS providers, only affordable spectrum access. The RRBS policy drew few objections during consultations largely because the quality of service of incumbent broadcasters on this spectrum was never compromised. Broadcasters maintained priority. Smaller fixed broadband providers make use of spectrum that would otherwise sit idle. Given the wide swaths of lightly populated areas of Canada with little broadcasting service, the RRBS geographical restrictions still leave much of the country viable for those who wish to offer wireless service on the sought-after television frequencies. RRBS is particularly well-designed for the rural Canadian context.

In an interview, Robert Wu of the Ottawa-based communications hardware manufacturer 6 Harmonics described RRBS as "… something that's really economic and well fit to our environment.… This (RRBS) standard has a really Canadian flavour. So no other country has this similar standard" (Robert Wu, July 20, 2016). Wu had reason to support the initiative. The unique Canadian standard also allowed for companies like 6 Harmonics and Vecima Networks of Saskatchewan to gain a foothold in the wireless hardware market, an industry that has often proven difficult for Canadian companies. Vested interest aside, Wu's observation is correct that in the beginning RRBS seemed to find the sweet spot for wireless policy suitable for Canada's vast hinterland.

Descriptors like "remote" and "rural" can prove tricky in a country with the second largest national landmass in the world but only the 39th largest population (Central Intelligence Agency, 2017). For this reason the RRBS regulations are precise:

"these communities are defined as areas that have fewer than 100,000 people living within a 50 km radius, and are located at a sufficient distance from major population centres to avoid causing interference to local broadcasting facilities and their service contour" (Industry Canada, August 2011)

The regulations are clear that any RRBS service within 400 km of the border had to ensure their transmissions did not interfere with U.S. signals. Since negotiating U.S. interference was a problem few small RRBS providers wanted to take on, the new policy was particularly suitable for Canada's north. RRBS offered a rare case in Canadian communications of the north being advantaged. This also eliminated a large portion of the marketplace, since nearly two thirds of Canadians live less than 100 km from the U.S. border, a land mass that only accounts for approximately 4% of the total area of Canada (Statistics Canada, 2006). The requirements of distance from the U.S. border, coupled with strict non-interference regulations with urban broadcasters means that RRBS is not an option in the most populous regions; however large swaths of the country stand to benefit.

The following five maps, moving from east to west across Canada along the U.S. border, offer a clear glimpse of the geographic potentials of RRBS Figs. 2–6. The pink shaded areas (lighter shade in black and white) are too populous or too close to urban centres to qualify for RRBS service, while the (darker) purple regions are too close to the U.S. border and therefore ineligible (Industry Canada, August 2011 Appendix A).

The vast white areas indicate large regions of the Canadian territory are open to RRBS service, even if the majority of the population is excluded. Under RRBS, government policy intervenes where the market has repeatedly failed to deliver.

3. Development: the road to RRBS

RRBS began inauspiciously enough: in 2004, it was the last item on a topic list for *SP-746 MHz Issue 1 — Mobile Service Allocation Decision and Designation of Spectrum for Public Safety in the Frequency Band 746–806 MHz*. The change in allotment at WRC in 2000 had freed up the potentials for this band and Industry Canada opened the door to suggestions for potential uses, including "advanced communication services" and licensing options. While spectrum for public safety in Canada was the key focus of this announcement, under a section called *Further Consideration: Facilitating Advanced Communications in Remote Rural and Northern Communities*, Industry
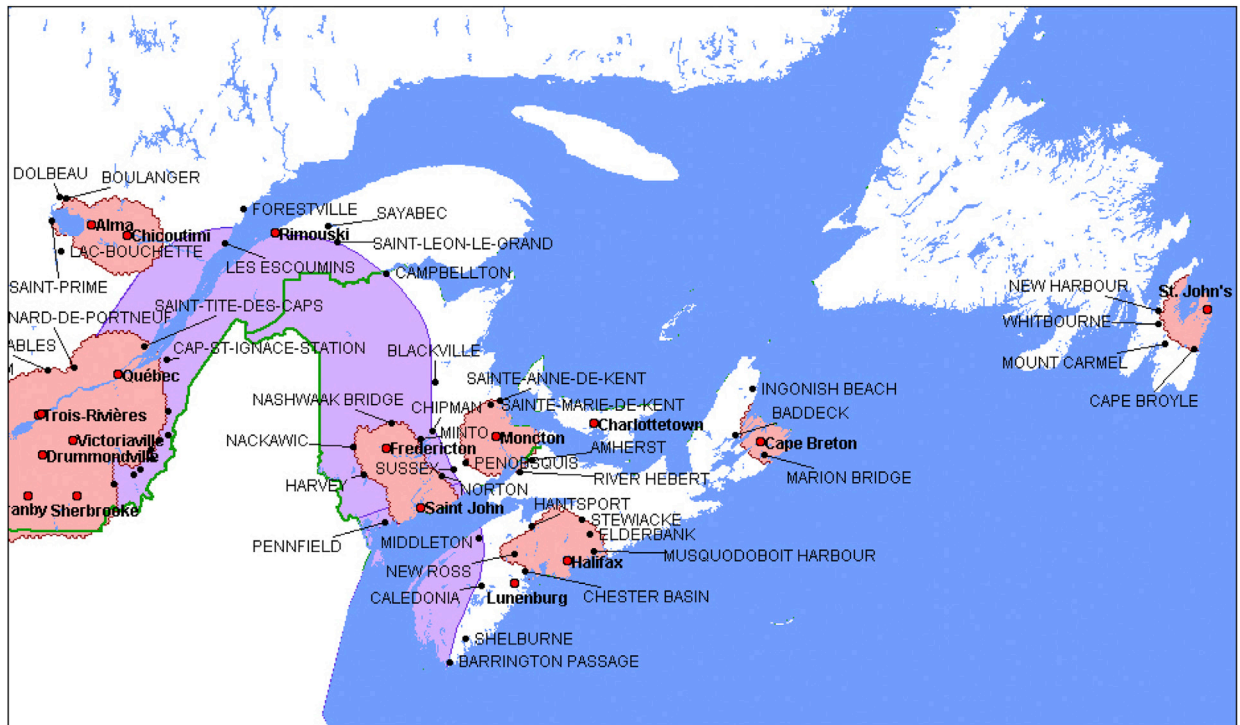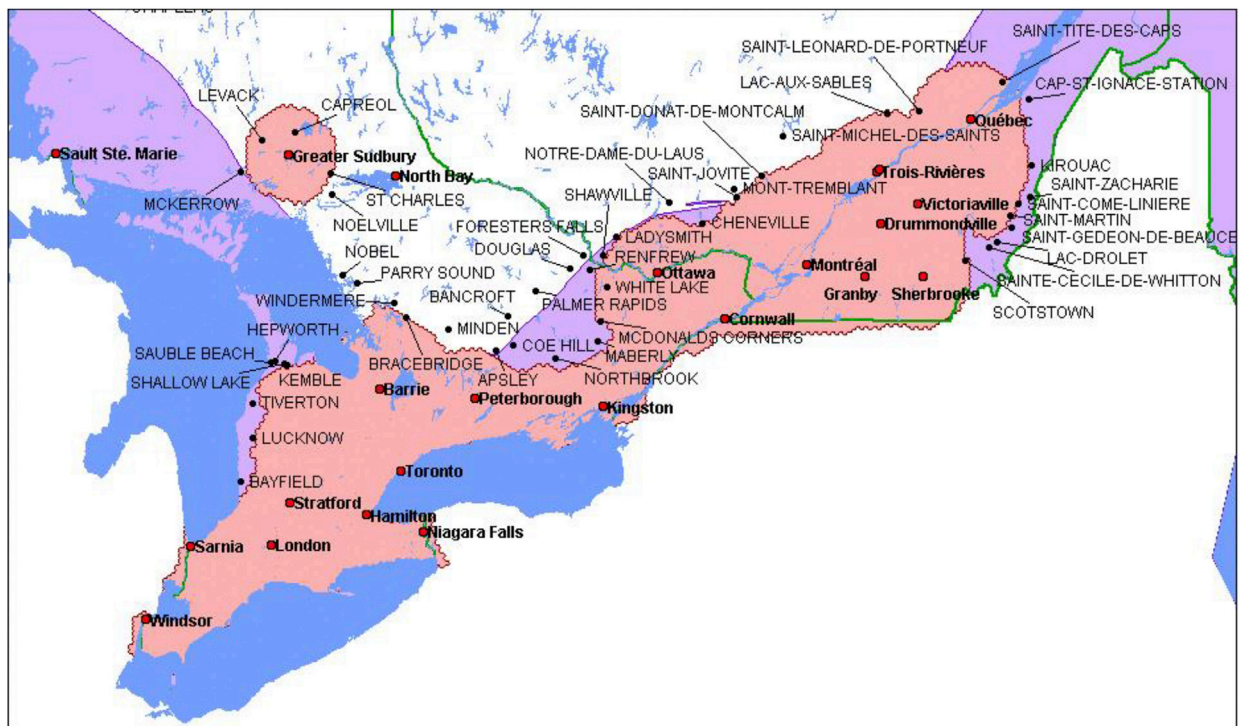
Fig. 2. East Coast.

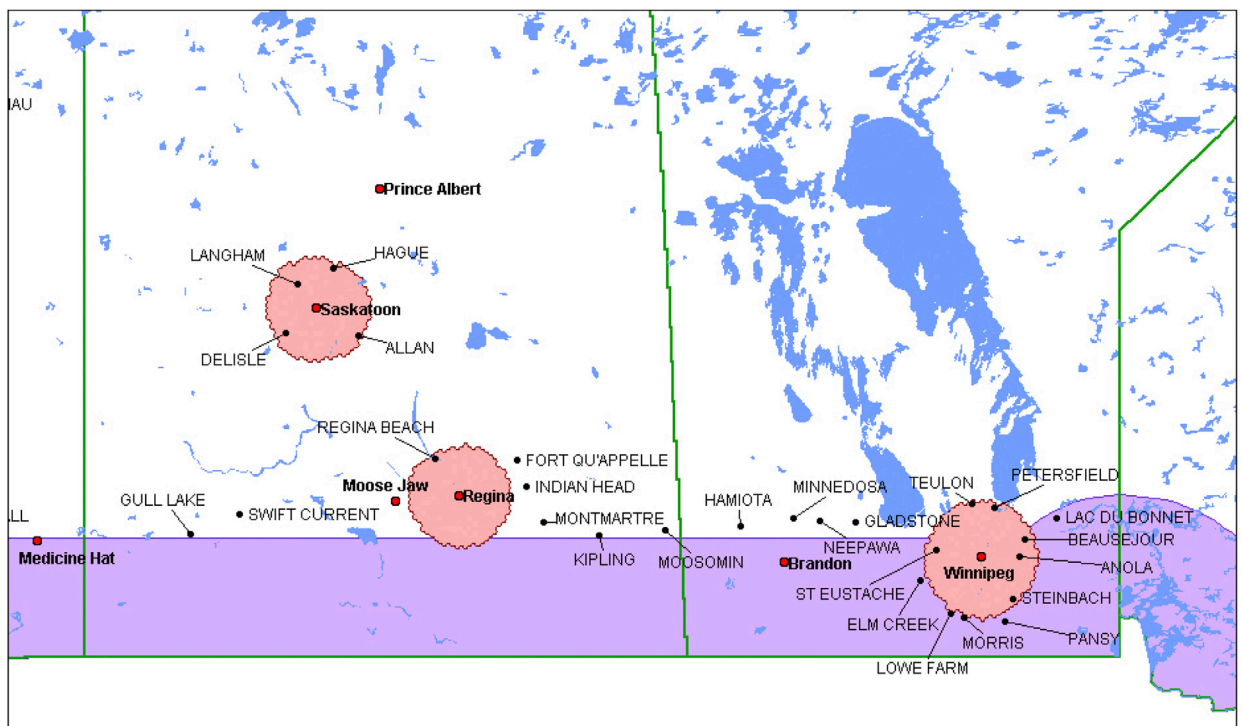**Fig. 3.** Ontario and Quebec.

Fig. 4. Northern Ontario.
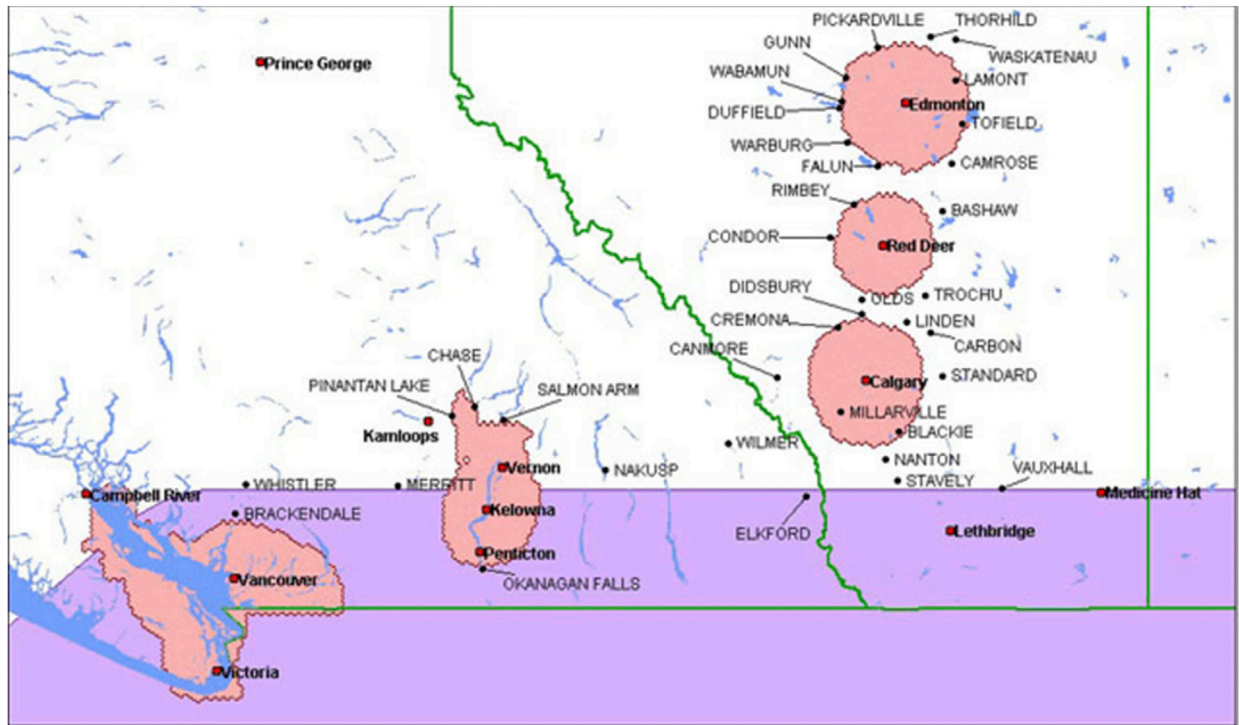
Fig. 5. Manitoba/Saskatchewan.

Fig. 6. Alberta and British Columbia.

Canada was clear that connecting the hinterland was a central priority for the government and expressed particular concern with communication access in Canada's expansive northern regions.

> "It has been the long standing approach of the Department to facilitate advanced communications services in high cost serving areas such as remote rural and northern communities" (Industry Canada, October 2004).

Industry Canada sought comments on its idea for the significant amount of television broadcasting spectrum (channels 2 to 59) neither used, nor allotted, in rural and remote communities to extend access to advanced broadcasting and telecommunications services, including broadband Internet access and wireless broadcast distribution.

The initial call for comments in 2004 was decidedly wide-ranging. The regulator asked for reactions to the following:

i. the potential uses of this spectrum to provide advanced communications including broadband Internet access and wireless broadcast distribution; and
ii. whether temporary or permanent authorization should be granted and if so, in either case under what conditions (Industry Canada, October 2004).

Early reaction to this initiative was not overwhelming: only three groups responded to this particular call from the regulator.

The Canadian Association of Broadcasters did not oppose the idea but requested that any future proposals regarding authorizing non-broadcasting services in TV bands be limited to "individually-licensed services", rather than "license-exempt facilities" because the latter approach could not be policed as effectively for issues of interference with broadcasters (Canadian Association of Broadcasters, Jan 14, 2005). The Canadian Cable Telecommunications Association (CCTA) supported the idea of bringing advanced communications to the north but also advocated that coaxial cable operators be allowed to access spectrum to compliment their television distribution networks. The CCTA also called for permanent authorization for their members to access this spectrum (Hennessy, Jan 14, 2015). A third voice was provided by a small Manitoba Internet service provider, Rainy Day Software Corporation/Rainy Day Internet Service (now Voyageur Internet). Rainy Day was concerned with rampant unlicensed use causing interference in these limited frequencies and recommended that spectrum within the 700 MHz band be allocated for "professional wireless operators seeking to provide public or private broadband services" (Rainy Day Software Corp, Jan 14 2005). Rainy Day also suggested granting licenses for pilot wireless projects in rural and remote areas.

However limited, there was positive response and little opposition to the idea of using this high quality spectrum for advanced communications in rural and northern communities. In 2006, Industry Canada issued the following statement concerning their call for

comment on Facilitating Advanced Communications in Remote Rural and Northern Communities:

> "Respondents generally supported the use of this spectrum to promote advanced radio services in remote and rural communities. Comments from the broadcasting community sought further definition of the term "rural". In addition, it was felt that as long as the allocation remains exclusive to the broadcasting service, any licensing should be on a non-standard basis" (Industry Canada, June 2006).

In short, broadcasters would not oppose provided they still had priority to the spectrum should they choose to deploy on those frequencies.

In this case, policy took the lead: the impetus to make use of underused spectrum was coming from Ottawa, where Industry Canada demonstrated a disposition toward flexible regulation. The term "northern" was removed from future descriptions as the department recognized that there were certain unserved and underserved regions that would benefit from this new policy that were rural and remote, however, *northern* is a relative concept in a country with as much arctic geography as Canada. Still, later qualifications of distance from the U.S. border ensured the north of Canada was a key beneficiary of the policy.

In March 2007, Industry Canada released the licensing procedure for this new initiative (Industry Canada, March 2007). It was the first time Industry Canada began using the term "Remote Rural Broadband Systems" to refer to this effort to extend broadband access to sparsely populated areas of Canada. This document formalized the rules to obtain a license and technical requirements to operate a fixed wireless system in this band. This licensing procedure was replaced in 2011 and the updated version offers the following concise definition of RRBS:

> "*Remote Rural Broadband System* means a fixed station that offers a fixed service and operates in the 512–608 MHz and 614–698 MHz frequency bands" (Industry Canada, August 2011)

Industry Canada also threw cold water at cable television companies who looked to expand their footprint: "…only subscriber-based broadband Internet applications will be allowed for licensing at this time" (Industry Canada, March 2007).

Certainly the price was right for upstart service operators. Until 2011, licenses were awarded by a flat fee of $242 per 6 MHz channel. That changed with Industry Canada's 2011 update of the Licensing Procedure for Remote Rural Broadband Systems in 2011. After that, the cost to the licensed provider was based upon a sliding scale to determine telephone channels where the cost was reflective of the size and speed of the operation.

According to the Industry Canada guidelines:

$$\text{Number of equivalent telephone channels} = \frac{\text{modulation bit rate of the system}}{64 \text{ Kbps}}$$

The modulation bit rate is the total number of bits carried from the transmitter to the receiver including, but not limited to, traffic carried for supervisory, error coding, internal communication, etc.

For example, for a network operating at an average speed of 3.0 Mbps, the number of equivalent telephone channels would be 3.0 Mbps divide by 64 kbps = 50 channels.

Therefore, the radio licence fee would be $42 (i.e. renewal fee) per radio frequency for each transmitter or receiver (assuming one transmit frequency (TX) and one receive frequency (RX) using the whole bandwidth)

(Industry Canada, August 2011).

Shortly after the initial 2007 licensing procedure was released, wireless broadband providers across the country began organizing to access these available and affordable frequencies. In an era of over-valued spectrum auctions, access to high quality spectrum licenses at a low price, even in remote areas of the country, seemed like too good a deal to pass up.

Industry Canada announced that licences would be reviewed on a first come first serve basis and that "the Department will permit as many applicants as the spectrum availability permits within a particular geographical area" (Industry Canada, March 2007). A wireless gold rush was on.

4. Results: new market players (primarily in one province)

Initial interest in offering RRBS services was strong. By the spring of 2011, Industry Canada had issued 555 licences for RRBS operations in Canada to a total of 14 licensees (Industry Canada, 2011). The vast majority of the licencees were new players in the wireless market. This was welcome news in a sector that had struggled to find alternatives to the concentration of power of the big three wireless providers: Rogers, Telus and Bell. In 2011, the big three accounted for 91% of wireless subscriber market share and 93% of the revenue market share in Canada (Canadian Radio-Television and Telecommunications Commission, 2012). This growth of new players in the sector was most pronounced in one province.

The overwhelming majority of the licenses issued were for the province of Alberta. In 2011, Industry Canada announced that geographic distribution of RRBS licences was:

- 7 in British Columbia;
- 450 in Alberta;

- 56 in Saskatchewan;
- 36 in Ontario;
- 5 in Quebec; and
- 1 in Nunavut. (Industry Canada, August 2011)

Over 80% of RRBS licenses were found in only one of the ten Canadian provinces.

What about Alberta made it the overwhelming leader in RRBS adoption in Canada? The province does have a culture of entrepreneurship that has been noted as the strongest in the country (Toneguzzi, May 29, 2015). But this overwhelming dominance in this new area of Canadian wireless was not all attributable to individual drive —some of the RRBS providers also received government funding from various federal broadband initiatives. Government submissions and interviews with RRBS providers pointed to a few different reasons for the strong RRBS-Alberta connection.

Geography and population densities certainly played a factor. The Canadian prairie, where flat geography is dotted with large farm properties, forms much of Alberta and is ideally suited to RRBS. As described by Brenda Bouchette of ABC Communications, "You put up a decent tower in Alberta or Saskatchewan...and you can cover a huge range. And the population patterns in Alberta and Saskatchewan are …sparsely distributed to evenly distributed. So there's the large farms and …a pretty even, yet low, distribution of households that you could sell to. (Bouchette, Feb 3, 2016). The strong propagation qualities of 600 MHz signals mean that fewer towers are required to reach a widely dispersed audience. The low spectrum was not a panacea for all problems. Physical barriers such as trees and, beyond the prairies, hills remained problematic even with this prime spectrum and continued to pose a challenge to providers.

Despite the obstacles, small RRBS providers found they could provide a product to compete or better the speeds offered by major providers. Interviews with providers offered a range of performance evaluations, from a lower end download speed of 10 Mbps; to higher end reports of 27–30 Mbps download speeds. These offerings more than met the CRTC's aspirational goal of 5 Mbps for all Canadians established in 2011 (Canadian Radio-Television and Telecommunications Commission, May 2011). All providers claimed even higher speeds were possible but only if they were able to acquire contiguous 6 MHz blocks, something that often proved elusive.

A key infrastructure element in the growth of RRBS in Alberta is access to the government-built Alberta Supernet, a last mile fibre network started in 2001, extending across much of the province. The province owns this backbone and Axia NetMedia operates and provides access to the Supernet. In a 2011 submission to the Industry Canada on the future of unlicensed services below 698 MHz, Axia notes the substantial RRBS deployments in Alberta reflect the competitive backhaul facilities available in the province, linking the wireless system to the core network: "This is strong evidence that where there is affordable and accessible access to competitive broadband backhaul services, such as that available in rural Alberta through the Alberta SuperNet, RRBS provides a valuable resource in delivering high-quality Internet services to rural Canadians" (Hoffman, Nov 10, 2011).

Many of the providers agreed. A small RRBS provider who wished to remain anonymous noted that Supernet was "…getting an awful lot of Internet access to a lot of small hamlets throughout the province". Not all RRBS providers used the Supernet for backhaul; some had agreements to access fibre lines from major broadband companies. Still, there is little doubt that the accessibility of Supernet as a wireless backhaul was a factor in the initial proliferation of RRBS in Alberta (see Fig. 7).

In a province known for a culture of conservative politics and individualism, interviews with RRBS providers in Alberta revealed an unexpected element to the early years of this new policy: small businesses were assisting each other. This was most clearly articulated by Andrew van Dirstein of Harewaves Wireless in Eckville, Alberta (population 1125):

> "…around Alberta, you know, if somebody needs something we try to work together. And it works in our favour if we get enough people using RRBS so that there's more equipment out there and easier sourcing. We try to work together to buy …in bulk or whatever so that we can meet the quotas of the manufacturing facility's need".

There are clear economic advantages in working together, and there is certainly historic precedent in the province. The history of cooperative movements in Alberta is deep and well-documented (Rennie, 2000). The Canadian west is the home of the United Farmers of Alberta (once a provincial political party now an agricultural supply store), wheat pools, and, more recently, collectively run train lines (Barney, 2011) that challenge the dominant market-based political culture of the last decades.

The significance of supporting fellow RRBS providers was emphasized by Guerrilla Wireless of Lacombe Alberta (population 13,057), who spoke with great praise for fellow RRBS provider, Harewaves, 60 km away: "…we help each other …if it wasn't for their help, I could have never survived really …I always call them the gurus". VM Systems of Vegreville, Alberta (population 5500) noted that Harewaves had helped them with their application process for RRBS. [2] A spirit of cooperation was clearly a factor in the growth of this policy in Alberta.

The Canadian government took notice. RRBS providers received a sign of encouragement from the federal regulator in 2013 in a decision on the development of television white space devices. Industry Canada had considered phasing out RRBS but noted, "Many respondents to the consultation do not agree with this conclusion and argue persuasively regarding the continued importance of RRBS". In a rare demonstration of recognition and support by the federal regulator, it was determined that "Incumbent licensees of RRBS will be protected from harmful interference caused by TVWS devices" (Industry Canada, 2013).

In short, in the formative early years the RRBS system worked. For smaller companies unable to afford to enter the capital-intensive world of wired service, nor could reasonably expect to gain spectrum via auction, using RRBS for fixed wireless offered a viable alternative. The RRBS policy offered access to quality spectrum for smaller players that market mechanisms simply could not offer. In the

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[2] If Harewaves are the "gurus" of new wireless services in rural Alberta, their "ashram" is in the back of a toy store on the main street of Eckville, Alberta.

RRBS case study, policy gave shape to small market actors that benefited the underserved regions of Canada.

The small providers interviewed were overwhelmingly positive in their belief in the potentials of this approach. "RRBS will give a lot more rural people up here especially, Internet capability than fibre will… if I could, I would expand the (RRBS) system… Way, way, way cheaper than running fibre." (Byron Garnish, Crossover Communications, July 26, 2016). Another Alberta-based provider who chose to remain anonymous noted the policy's specific applicability to the sparsely populated and heavily forested regions of Canada: "in the rural areas it is difficult to find spectrum that propagates as well as the RRBS frequencies. It gives us the range and tree penetration to make it a viable service."

Through a combination of geography, demographics, an accessible public/private backbone, and cooperative business practices, this creative policy brought some new players into the wireless market and introduced greater competition into a traditionally closed sector. With RRBS, many small entrepreneurs found they could offer robust service at a reasonable price. Or, as one RRBS provider put it: "giving us a chance to use licensed spectrum like the big boys" (Anonymous, 2016).

4.1. Results: a rapid decline

It wasn't long until the bloom started to fade on this new policy. The seemingly explosive growth of licences in the early years of RRBS was misleading—the vast majority of these licences were never deployed. The RRBS Licence Conditions included only a vaguely worded statement that required licence holders "to demonstrate that their spectrum is being put to use at a level acceptable to the Department. Failure to do so may result in cancellation of associated RRBS licences" (Industry Canada, August 2011 Annex B). Many wireless companies hedged their bets that they would be able to generate the capital to launch on these frequencies or else tried to acquire as many licences as possible to keep them away from competitors.

Arthur Beaudette of VM Systems reflected on the initial RRBS roll-out: "in the beginning there was a land grab. … (Businesses) were going to sit on it and see what happens…We saw a lot of (companies) buying up spectrum" (Beaudette, March 30, 2016).

Another key barrier to growth was the expense of the hardware required. Canada has always suffered from poor economies of scale in electronics. Robert Pennington of Guerrilla Networks in Lacombe Alberta noted the difficulties of finding equipment. "RRBS equipment is very, very expensive… You're talking $600, $700 per customer, per household. It's pricey." The same point was shared by Brenda Bouchette of ABC Communications who noted an inescapable problem of made-in-Canada initiatives: "Because this is a band that is only available in Canada, … there's no economies of scale in producing equipment" (Bouchette. March 16, 2016).

The greatest hindrance to the continued development of RRBS services came from the government. The boost from the regulator in the 2013 TVWS announcement proved to be short lived. The 600 MHz band faced an uncertain future as the United States planned to embark upon an unprecedented incentive auction. Coordination with American spectrum plans put unique policies such as RRBS in jeopardy. In 2014, Industry Canada announced a review of 600 MHz frequencies which included the following:

Effective immediately, the Department will no longer accept the following types of applications:

- new applications for licensing of RRBS stations;
- applications for modification of an existing RRBS station which would increase the coverage in any direction or change operating frequencies
(Industry Canada, Dec. 18, 2014)

This announcement did not explicitly end RRBS in Canada, but it certainly slowed any momentum that had been building to a crawl. RRBS providers found themselves stuck, unable to expand service in an era of exponentially increasing data demands. One of the largest RRBS providers argued against the moratorium. "When the moratorium was put on, (our company) said, well, let's make sure the moratorium is not on beyond the 250 miles or 400 km (of the U.S. border). But that didn't fly" (Anonymous August 2, 2016). As this provider argued, if the 600 MHz was about coordinating with U.S. signals, why couldn't RRBS remain since they were a sufficient distance from the U.S. border that there would be no interference? This appeal was unsuccessful and the moratorium remained.

After this announcement, small RRBS entrepreneurs found themselves facing an uncertain future. As Glen Moore of I Want Wireless in Debolt, Alberta (population 121) lamented, "the biggest problem with RRBS is they keep screwing around with trying to figure out what they're doing and then they cancel it and change it and move things around. And nobody builds equipment for something that has no stability" (Moore, August 10, 2016). The same providers who had entered this market with enthusiasm now found themselves economically restricted.

This was followed by a decision on the future of the 600 MHz band the following year. It told of a murky future for RRBS:

For RRBS operating in the repurposed 600 MHz spectrum, a displacement notification period of two years will apply. Following the incentive auction in the United States and the development of the joint implementation plan for broadcast transmitters in both Canada and the United States, Industry Canada will work with RRBS operators to clarify their options for continued operation. Additional frequencies in the range 470–512 MHz may be made available if required to accommodate existing RRBS operations following the finalization of the new DTV allotment plan.

(Industry Canada, August 14, 2015)

As of 2017, the options are still unclear for the future of RRBS. While operators are allowed to continue service, they realize they will face relocation when the band is auctioned for mobile service. That auction date is not yet determined. Beaudette of VM Systems knows he is facing an uncertain future: "we're limited — we're stuck now. We can't add customers … right now we're kind of in this purgatory.

Fig. 7. Alberta supernet map (Axia, 2017).

We don't know what's happening" (March 30, 2016). Harewaves "guru" Andrew Van Dirstein agreed: "it's pretty hard to make a forward plan" (March 16, 2016).

Speculative licence holders, poor economies of scale and, most importantly, faint government support have severely weakened this burgeoning new area of Canadian wireless. The result was a dramatic decline. In 2011, there were 450 RRBS licenses in the province of Alberta alone; in 2014, there were 83 remaining RRBS stations operating in British Columbia, Alberta, Saskatchewan, Ontario and Quebec. By 2015, there were 52 RRBS stations operating in Canada. A national policy that began with such optimism now faces an abrupt descent and uncertain future.

5. Discussion

The RRBS example offers a clear case study of a bold policy initiative to bring service to difficult regions and introduce new smaller players into concentrated wireless markets. It is largely the product of forward-thinking policy makers—the initial call for comments generated very limited response from the public or industry, yet regulators at Industry Canada recognized its early potential. What is not so apparent is whether or not the current problems faced by RRBS are due to inherent limitations of the policy itself or if the Canadian government chose to allow RRBS providers to whither on the vine while plans are made for yet another spectrum auction. The solution by the Canadian government seems to have reverted to the same path most governments have taken since the 1990s: sell spectrum licences to major providers and reap the financial rewards. Modern, forward thinking spectrum policy has to think beyond such short term economic models and consider wider social benefits including accessibility and market competition.

Contemporary governments are enamored with talk about the importance of entrepreneurialism. In Canada, money is being poured into universities in the hopes of fostering an entrepreneurial culture among young people (Cukier, Fox, & Rahnama, 2012; Ontario Centres of Excellence, 2017). RRBS offers a clear case study of real-world start-ups looking to crack into the difficult sector of wireless broadband service. The stories of RRBS providers were replete with tales of being "self-taught", "hard work", "sheer necessity", and "Mom and Pop operations". These entrepreneurs asked for access to spectrum few companies want, and some certainty from the regulator that they will be able to offer service on a long-term basis. The limited success they briefly enjoyed was often the product of individual ambition and mutual assistance. RRBS providers are a unique entrepreneurial mix of capitalist drive coupled with a decidedly cooperative sensibility.

6. Conclusion

"…(the Canadian government) had something going which was quite unique worldwide. And for a while they were quite enlightened and then, you know, you get a change of a minister or a deputy minister and a couple of others and frankly, you get a change in attitude and all of a sudden there's not the same interest."

(Anonymous RRBS provider. August 2, 2016)

In their 2016 study, "Exploring the Predictors of the International Digital Divide", Skaletsky et al. conclude that among lesser and more highly developed nations, "the quality of regulation is most important for highly digitalized countries (Skaletsky, Galliers, Haughton, & Soremekun, 2016, p. 47). Regulation and national institutions are essential elements in fostering the trust necessary to expand and develop new initiatives such as RRBS. After a strong start, the prospect of an uncertain future, clearly manifested in the Industry Canada decision to place a moratorium on new licenses in 2014, precipitated the prompt decline in a budding new element of Canada's digital infrastructure.

There is no panacea for digital connectivity. Bridging the broadband divide of access will require a range of initiatives. The Canadian RRBS policy offers a unique take on the licensed/unlicensed debate that has been going on for some time (Benkler & Lessig, 1998; Calabrese, 2008; Noam, 1997). RRBS service is licensed but utilizes advantages inherent in empty spaces and a disperse population. It recognizes the continued place of broadcasting while noting that place is not nearly as prevalent as it once was.

If major companies truly wanted to deploy broadband in rural Canada, the government would have had no need to unveil a series of federal programs over the past decades. The small wireless providers interviewed for this study did not speak of dreams of great wealth; their primary concern was economic survival. If successful, they could fill in the patches in Canada where major Internet providers often are reluctant to deliver services, and provide a significant service alternative in an industry that struggles to offer competition.

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