Phase 5:

Technologies and their Forecasts

VRS Feasibility Study

Mission Consulting

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RESEARCH SUMMARY

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Technologies and Their Forecasts

Executive Summary

1. Overview

This research summary represents the findings of the fifth of twelve phases of a study commissioned by Bell Canada (Bell). The feasibility study was commissioned by Bell as part of a deferral account proposal. The objective of the feasibility study is to provide information to facilitate informed decisions regarding potential regulations and implementation of Canadian video relay service (VRS). Bell engaged Mission Consulting to conduct an independent and comprehensive study of the feasibility of VRS for Canada. The final feasibility report will draw, in part, on information contained in this research summary.

This Phase 5 research summary, *Technologies and Their Forecasts*, reviews the technologies currently or projected to be available to deliver VRS to the consumer. This research includes:

- ☑ Historical background of VRS technologies
- ☑ Transmission speeds necessary for VRS
- ☑ Broadband availability to Canadian consumers
- ☑ Plans or initiatives to expand the reach of broadband
- ☑ Average costs of broadband, by type, to the consumer
- ☑ Terminal devices that support VRS
- ☑ Terminal equipment costs and complexity
- ☑ Other technical considerations
- ☑ Future technology trends

2. Summary Findings

Salient points of this analysis of current and future technologies for VRS include the following:

- □ Communications access technologies for Deaf and hard of hearing individuals have progressed along with general communications technology advancements.
- □ While a variety of factors affect the functionality of VRS, one of the most significant factors is the two-way transmission speeds between the end-user and the VRS provider.
- □ Canada has a very high level of available access to the Internet at speeds sufficient to support VRS, (i.e., broadband access).

- Although Canada has significant broadband *availability*, it is unclear what percentage of the Deaf and disabled population are currently *subscribers* of high-speed broadband.
- Actual versus advertised broadband speeds will need to be understood by VRS end-users when they select Internet connectivity packages.
- Internet Service Provider and Wireless Service Provider contracts, data capacities, and overage charges may present financial and service satisfaction challenges for VRS users.
- As technology devices and service costs have become more affordable, many potential VRS users are able to afford a variety of computers, laptops, tablets, and smartphones. Therefore, VRS end-users will expect VRS services that can be accessed from many different devices and network connections.
- Consumer technical assistance in the installation and operation of VRS will most likely be required.
- The explosive growth of 3G and 4G wireless networks and devices will likely increase expectations for VRS services over wireless networks and mobile devices.
- Other potential technical considerations include interoperability, fraud prevention or mitigation, quality of service, and call distribution options. These types of considerations will need to be balanced against non-technical considerations.
- Advancements in automated technologies, such as computer generated interpreting of sign language may hold the promise to provide additional video and sign language interpreting options in the future, but it is uncertain that these technologies will be robust or accurate enough to satisfy the personal interaction generally required in relay services.

3. Conclusion

Developments in technologies directly pertinent to VRS have in recent years have progressed in many areas. New highly capable technical products such as computers, mobile devices and videophones offer consumers unprecedented communication capabilities. These together with the very high availability of wired and wireless broadband to almost all Canadians, and advances in VRS provider services, all indicate that there are no technical barriers to implementing VRS in Canada.

The primary challenges to selecting and implementing the technical VRS solutions will be non-technical, such as consumer education and training, cost considerations, and other policy and program issues, which will be explored in other phases of this VRS Feasibility Study.

Technologies and Their Forecasts

Research Summary

1. The VRS Feasibility Study

This research summary represents the findings of the fifth of twelve phases of a study commissioned by Bell Canada (Bell). The feasibility study was commissioned by Bell as part of a deferral account proposal. The objective of the feasibility study is to provide information to facilitate informed decisions regarding potential regulations and implementation of Canadian video relay service (VRS). Bell engaged Mission Consulting to conduct an independent and comprehensive study of the feasibility of VRS for Canada. The final feasibility report will draw, in part, on information contained in this research summary.

The twelve phases of the study are as follows:

Phase 1	Project Confirmation
Phase 2	Legal Background for Canadian VRS
Phase 3	Consumer Interests and Perspectives
Phase 4	VRS Models in Other Countries
Phase 5	Technologies and their Forecasts
Phase 6	Interpreter Considerations
Phase 7	Quality of Service
Phase 8	Potential Related Services
Phase 9	Forecasts of VRS User Demand
Phase 10	VRS Cost Variables and Forecasts
Phase 11	Potential Canadian VRS Models
Phase 12	VRS Feasibility Study Report

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- ☑ Other technical considerations
- ☑ Future technology trends

2. Historical Background

The Deaf and hard of hearing communities have used technology to communicate over telephone networks for almost 50 years. The technology that first enabled this was the development of the TTY (teletypewriter) in 1964.[1] The TTY was invented in the United States and became a de facto standard there. Later developments evolved as it was adopted in Canada and around the world. The TTY is a typewriter-like device with a keyboard, a small electronic screen to display text, and optionally a small tape printer to print the text. TTYs plug into a standard phone line jack or they use of an acoustic coupler to connect to a standard telephone handset. The text is transmitted live over the telephone network via the distinct tones generated by the different keys to another device (e.g., a TTY) that uses a similar communication protocol. There are many different TTY communication protocols. The original TTY standard was the Baudot code. [2] Other TTY protocols include DTMF, EDT, V.21, V.18, V.23 and TurboCode.[3] These protocols have been adopted by different countries and are not always compatible. For example, V.21 is more common in the UK and some EU countries, while Baudot and TurboCode is more widely used in Canada and the U.S. In 1994, V.18 was announced as the standard TTY protocol by the ITU (the International Telecommunications Union).

As TTYs were adopted by consumers in the United States, small community-based or private relay services were developed to relay conversations between the TTY user and a hearing telephone user. Eventually these relay services were replaced by relay centers operated or contracted by the regional telephone companies. These relay centers provide message relay services (MRS) to all telephone company customers, so that the consumers with a TTY can communicate to anyone served by a telephone line and telephone. With the advent of advances in TTY technology, these larger relay centers also offered additional communication modalities such as Hearing Carry Over (HCO) and Voice Carry Over (VCO), which enable the relay operator to only relay specific portions of the call according to the desire of the consumer.[4]

The advent of text paging, cell phone texting, mobile smartphones, computers and the Internet have revolutionized the accessibility options available to the Deaf and hard of hearing all around the world.

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[1] The TTY is also known as a TDD (telecommunications device for the Deaf). In Europe it is commonly referred to as a textphone, and in the United Kingdom it is called a minicom.

[2] The Baudot protocol runs asynchronously at 45.5 or 50 baud, 1 start bit, 5 data bits, and 1.5 stop bits.

[3] TurboCode is a proprietary but popular code of Ultratech TTYs. See www.ultratec.com/support/turbocode.php.

[4] HCO allows the TTY user to hear the voice of the distant party. VCO allows the TTY user to speak for his or her self.

In 2002 MCI[5] started offering Internet-based access to its relay call centers. This service, which became known as IP Relay, used a text chat feature similar to instant messaging between the consumer and the relay operator. This freed the consumer from the need to have a TTY to make a relay call, and also allowed for additional features and faster transmission times. IP Relay is a "major technological advance for the Deaf community," said Steve Johnson, MCI's Vice President of Information Services and Solutions.[6]

IP Relay was authorized in the United States by the FCC in 2002.[7] IP Relay services were mandated in Canada in 2009 when the CRTC directed all Canadian LECs to provide IP Relay services by July 21, 2010[8]. Significant growth of IP Relay has been documented in the United States, with a corresponding decline in TTY use. However, due to implementation delays, at the time of this writing[9] many Deaf and hard of hearing Canadians still rely upon traditional TTY relay to communicate with voice telephone users.

Compared to signed or spoken conversation, text relay is slow and cumbersome. In a regular conversation people are able to interrupt each other as the flow of the communication goes back and forth. With most text relay, it is impossible to interrupt the other caller or at best interruptions involve delays in the communication.[10] In addition, when using TTY relay or IP relay the operator usually has to ask the hearing person to "slow down" or "repeat" something they said because the relay operator cannot type as fast as the hearing person is speaking.[11] This creates unnatural breaks in the communication and causes a stunted and slowed dialogue. Finally, most Deaf people use sign language as their primary language and may be more limited with their writing and/or typing abilities (e.g., written French or English). Because they are depending on typed text relay to communicate with others, this slows the communication process and creates additional challenges for people with disabilities, especially in a business environment.

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[5] Known as WorldCom, later purchased by Verizon.

[6] WorldCom News; History, Questions, Answers and Updates, 2002

[7] "The Commission authorizes Internet Protocol relay service as a recognizable TRS service. The Commission finds that IP Relay falls within the statutory definition of TRS and those IP Relay providers are eligible to recover their costs in accordance with Section 225 of the Communications Act of 1934." (www.fcc.gov,TRS history docket) "MRS" is referred to as "TRS" in the United States.

[8] CRTC Broadcasting and Telecom Regulatory Policy 2009-430, at http://www.crtc.gc.ca/eng/archive/2009/2009-430.htm. Also note that implementation is delayed in some telephone territories.

[9] May 15, 2011.

[10] Conversations between two devices that use TurboCode can interrupt each other.

[11] Spoken conversation averages 200 words a minute, while TTYs transmit at 60 words a minute and IP relay is limited to typing speed which usually falls between 60 and 100 words per minute. (CRTC report shows 40 – 50 wpm: Bell Canada(CRTC) 10 June 2008-100c) PN 2008-8_Attachment 2 Abridged Page 14 of 24; The Future of Bell Relay Services; The Pelorus Group; Prepared for Bell Canada; October, 2004.

Video Relay Service (VRS) is similar to text relay in that it uses a relay operator to communicate with the hearing population.[12] VRS is dissimilar to text relay in that the consumer communicates via sign language to the relay operator, at a conversational pace limited by the sign language abilities of the user. It is easy for all parties to interrupt each other as the speed of sign-to-sign communication is similar to that of an oral conversation. The relay operator is able to use sign language to interpret what the hearing person is saying at the same speed and flow, so the need to "slow down" is removed. Ultimately, the Deaf community is able to use their native language, e.g., LSQ, ASL, to communicate effectively and efficiently with others. Therefore, VRS offers a solution to many of the challenges of text-based relay communications. The technology to enable VRS has matured to a point that the available network and systems potentially make this service widely accessible.

Video relay works by connecting a Deaf consumer with the relay center operator in a two-way visual method to enable the use of sign language, a visual language.[13] The Deaf person uses a camera capable of video transmission to capture their image so it can be seen by the video relay operator (Video Interpreter or VI). In turn, the VI has a camera to enable real-time signed communications back to the user. To generate a call to the third party, the VI uses the equivalent of a standard telephone line to communicate via speech to a hearing telephone user.

The VRS user can connect to the relay center operator through any of several devices:

- a videophone;
- a computer with a web camera running video chat or a proprietary video relay software program (also called a client) which is downloaded and installed on the end user's computer;
- a computer with web camera running a browser-based chat or video relay software program (i.e., no software installation required on the end-user's computer); or
- a mobile or tablet device with wireless or cellular Internet connectivity.

Each of these devices and software components has its own minimum hardware and software requirements. However, regardless of what type of device or software is used, the user must have a sufficiently fast network connection, to successfully transmit the video images between the Deaf user and the relay center operator. See section 3 for information about network types and speeds, and section 6 for information about the various types of video hardware and software presently in use with VRS.

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[12] Video relay operators are often referred to as "video interpreters" or VI".

[13] This is different from point-to-point video calls that are made between two users who use sign language to communicate with each other and do not need the assistance of a video relay operator (VI). Similarly, VRI (video remote interpreting) is different in that the Deaf user is in the same room as the hearing person. Traditionally interpreting between parties in the same location is accomplished through an on-site interpreter (also referred to as "community interpreting"). VRI is not usually considered Message Relay Service (MRS) and is discussed in this VRS Feasibility Study's Phase 8 deliverable, Ancillary Services.

3. Minimal two-way transmission speeds necessary for functional VRS

The factors that affect the function and quality of VRS include the following:

- Transmission speed
- Network factors, such as latency
- Transport Protocols
- Compression/Codec
- Device Frames Per Second (FPS)
- Device video resolution
- Functional screen size (especially for mobile devices), functional camera angle

Of all these factors, a most basic consideration for the use of VRS in a home or consumer environment is sufficient two-way transmission speed, i.e. a "broadband" Internet connection.

3.1. Definition of Broadband

"Broadband" is a relative term, technically referring to a telecommunication methodology, but generally used to mean higher speed than dial-up or ISDN technologies. For home Internet connectivity, broadband usually refers to DSL or Cable connections.

"Broadband" in Canada is specified by the CRTC as connectivity with a minimum download speed of 1.5 Mbps and a target speed of 5 Mbps (as opposed to "Basic services" below or equal to 1.5 Mbps)[14].

While the International Telecommunications Union Standardization Sector (ITU-T) defines broadband as 1.5 to 2 Mbps, other nations and agencies define broadband at different speeds. For example, in the United States the FCC has defined broadband as Internet connectivity with download speeds as low as 200 Kbps[15]. The Organisation for Economic Co-operation and Development (OECD) defines broadband as connections "providing Internet access at speeds higher than 256 Kbps[16]", however they note that some European Union member States gather data based on a broadband definition of 144 Kbps. Other countries, such as Norway, have defined both wireless and fixed broadband as "access to data transmission services with a perceived bit-rate of at least 640 Kbps downstream and 128 Kbps upstream"[17], and Italian coverage rates reported to the OECD were based on a broadband definition of connections enabling at least 640 Kbps download. Other nations use rates similar to or higher than

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[14] CRTC Communications Monitoring Report 2011, Appendix 4, Page 4, http://www.crtc.gc.ca/eng/publications/reports/PolicyMonitoring/2011/cmr.htm.

[15] FCC "Getting Broadband", http://www.fcc.gov/guides/getting-broadband. The FCC defined speed is generally too slow to effectively support VRS. See section 3.2.1 of this paper.

[16] 2009 OECD Report: Indicators of Broadband Coverage, http://www.oecd.org/dataoecd/41/39/44381795.pdf, Page 38.

[17] Ibid, Page 39.

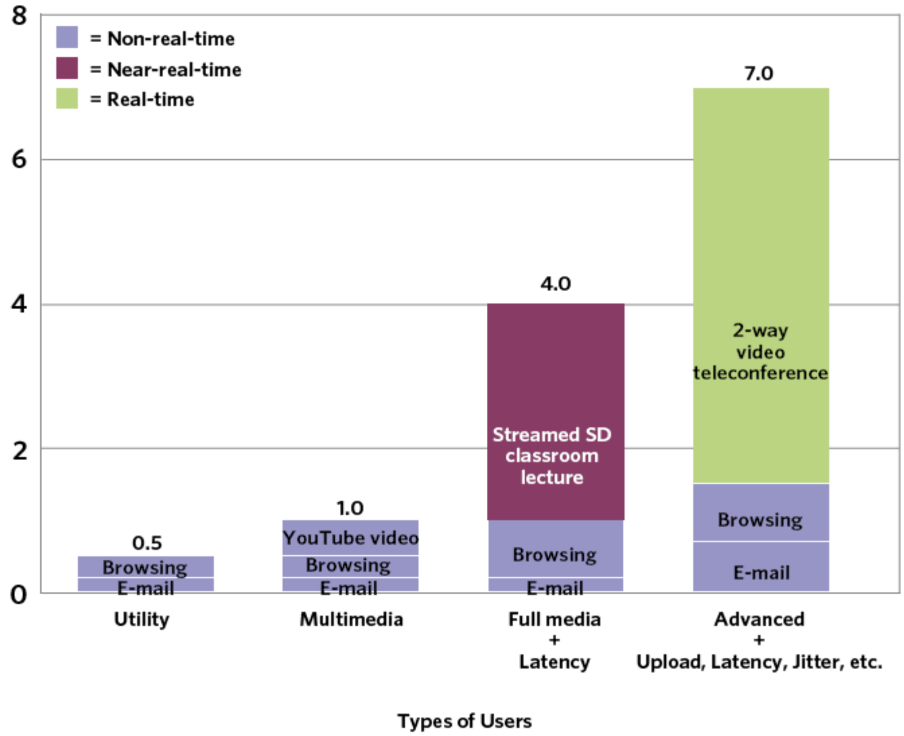
Canada's definition. Sweden for example defines broadband rates as being above 2 Mbps (download) and Turkey uses 1 Mbps[18].

It bears noting that while many cable service Internet connections are faster than DSL, a cable broadband connection is a shared connection, or node. Therefore a cable consumer's Internet speed is subject to network congestion. When a node is congested, both available upstream and downstream transmission are slower than the published maximum rates.

While network speed is a primary factor affecting VRS functionality, the end-users' individual computers or local connections also are a significant factor. For example, a five-year-old PC with an inexpensive video card and web camera may not have the memory, processing power, graphics memory and speed to successfully enable VRS or run a VRS provider's software. Another example could be a scenario in which a user is connecting to VRS with a sufficiently fast and powerful computer, or a stand-alone videophone device, and a fast Internet connection -- but the fast Internet connection is shared with multiple other users in the household, all of whom are accessing the Internet at the same time. The end result may be slow or jittery video, and may even create timeouts in the connection to the video relay service. As web-accessible and Wi-Fi-ready devices become increasingly prevalent in the home, it is not uncommon for an individual who lives alone to have multiple devices accessing the home Internet connection at the same time. *Figure 1: Actual Download Speeds Necessary to Run Concurrent Applications (Mbps)* shows an example of the increased demand on a users' Internet connection with concurrent applications running.

[18] Ibid, Page 39.

Figure 1: Actual Download Speeds Necessary to Run Concurrent Applications (Mbps)[19]



3.1.1. Reliability of Broadband Services

Another factor of consumer or home-based broadband services is that most Internet Service Providers do not guarantee minimum speeds or throughput, nor do they guarantee 24/7 functionality. However, since the Internet has become such an integral component of people's lives most ISPs have matured home Internet service technologies sufficiently as to minimize Internet connectivity disruptions.[20]

In conjunction with broadband network service reliability is the consideration that the device connected to the Internet is also dependent upon reliable local electrical power. These factors represent risks to all users who rely on the Internet as their only form of communication for emergency purposes.

[19] United States FCC National Broadband Report, Exhibit 3-C, http://www.broadband.gov/plan/3-current-state-of-the-ecosystem/

[20] Unlike the public switched telephone network (PSTN) with a P.01 grade of service and an engineered reliability of 99.999%, there are no downtime regulations on Broadband availability to write into a service contract guaranteeing connectivity and stability.

3.2. Individual VRS Vendor Requirements

3.2.1. Vendor Platforms

Historically, most initial VRS providers used proprietary platforms to support their VRS services. Each of these platforms had different connectivity requirements, and often they would not support interoperability between end-users' different hardware/software or between different VRS providers. For early adopters of VRS in the U.S. and elsewhere this interoperability was complicated by non-compatible communication technologies, such as ISDN versus ADSL.

However with the increase of Internet VoIP and video services, as well as the advances in wireless cellular communication through 3G and 4G technologies, came a natural progression toward a more open, cross-compatible approach to VRS. VRS services are now widely available via traditional videophone hardware, computer videophone software applications (called 'clients'), web browser-based clients, and 3G/4G and Wi-Fi connected mobile devices such as cellular phones and tablet computers. Although many VRS providers still use proprietary internal system platforms, providers are moving toward an environment where users can connect to them from almost any broadband or 3G/4G connected device.

Users in Sweden, for example, can call VRS using just about any device –any IP connected video telephones, web clients, or 3G telephones. Additionally, approved videophones in Sweden follow a European "Total Conversation" standard[21] in which users can choose to use video, speech, and/or text at the same time.[22] The Total Conversation methodology is at the heart of one of the leading VRS platform developers, nWise and its nWise MMX platform. The nWise MMX platform is currently being used in EU countries such as Sweden, Finland, Norway, Denmark and Germany to provide video relay services, and meets ETSI (European Telecom Standards Institute) requirements for open platforms and universal services. It supports connectivity to and from video relay users via a variety of Gateways including: textphones (Baudot, V.21, EDT, the ITU standard of V.18), Skype video and voice, H.323, H.264 M (3G video), standard API for SIP-enabled equipment such as media gateways, as well as the PSTN.

Another commercially available VRS call center platform is the AuPix APS-50 which is deployed in a variety of video applications including Lifelinks, a VRS provider in the U.S. It also has a high level of compatibility with a variety of Gateway protocols and follows the European "Total Conversation" standard. These include most video and audio protocols such as Video ITU-T H.323, Video H.264 and H.263, Audio G.711 and optionally G.729. The AuPix APS-50 conforms to the industry standard SIP protocol to support a wide range of videophones, set-top boxes, soft phones and SIP handsets. In addition, the company says the system is capable of transcoding between incompatible standards.

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[21] Total Conversation is "An audiovisual conversation service providing bidirectional symmetric real-time transfer of motion video, text and voice between users in two or more location." ITU F.703 Recommendation, http://www.itu.int/rec/T-REC-F.703-200011-I/en.

[22] See the Sweden section of this VRS Feasibility Study's phase 4, *VRS Models in Other Countries*.

Therefore while a majority of public and private Video Relay service providers around the globe have developed or re-engineered their own proprietary call center platforms, nWise MMX and AuPix APS-50 are two commercially available VRS platform solutions that have been successfully deployed in multiple countries.

An example of a country that has evolved to more open/compatible systems is Australia. Australia began video relay services on a closed, proprietary platform. Eventually Australia moved to a system which utilizes the Skype standard, since Skype is a functioning platform with a significant installation base. Furthermore, Skype is a technology familiar to most of their Deaf Internet users.

There are many other VRS vendor requirements that are determined by the technical platform of the selected VRS provider. These requirements can be divided into two categories, those that benefit the consumer (Deaf user) and those that benefit the administrative control or regulatory agency of a country. For example:

1. Consumer Requirements
    a. Call distribution to services and queues (provides equal access to next available video interpreter (VI) or to a VI with an appropriate skill set)
    b. Queue messages in video, text and voice
    c. Voice carry over
    d. Hearing carry over
    e. Accessibility and ease of use
    f. Active directory
    g. Video and voice conferencing
    h. Text function for clarifying names, places, etc.
    i. Audio and video prompts assuring user of place in queue
    j. Video mail
    k. Interoperability with other videophone or device hardware/software
    l. Quality of Service (QOS)

2. Administrative Requirements
    a. Call distribution to services and queues (provides efficiency within VI resource pool)
    b. Interoperability with database systems, invoicing systems, etc.
    c. Call Detail Record (CDR) records and reports
        1) Call duration
        2) Set-up time
        3) Billing info. (Long Distance vs. local or regional)
        4) Staffing levels, affecting average speed of answer (ASA)
        5) Abandoned calls
        6) Skill sets reports (different languages, conference calls, modalities, etc.)
        7) Many other reports
    d. Transfer of video call to other VI's (skill set, teaming, staffing)
    e. Measurement of users connection speeds or software compatibility
    f. Ability of VI to log into multiple queues (bilingual, etc.)

The itemization above is not a complete or exhaustive list and developers are continuing to offer enhancements. The applicable features would be determined by each country's regulatory body as it defines requirements in formal requests for proposals and in the vendor selection process, and as legislation or regulations are passed to require certain minimum services and standards. The above are examples of what individual VRS vendor requirements may contain, some of which may be optional, to illustrate how much the functionality of VRS is affected by the technical requirements that are specified.

For example, a significant consumer complaint about some early VRS providers in the U.S. was that users of one provider's VRS services were dependent upon a videophone supplied by the vendor that could not access other VRS providers or communicate point-to-point with Deaf users who did not have that vendor's hardware.[23] This lack of interoperability is declining as technology trends towards allowing open, standard IP access.

3.2.2. Vendor Connectivity Requirements

While many VRS providers or Videophone vendors specify only "high-speed Internet" or "broadband" as a speed or connectivity requirement, several specify 256 kbps upstream and down as a minimum, with 512kbps as a recommended minimum in both directions. The following table summarizes some VRS providers' specific Internet speed recommendations or requirements. Note that the minimum speeds may not produce the quality of service desired by most VRS consumers, and many consumers may elect to have significantly higher speeds.

[23] In the U.S. the lack of device interoperability by the dominant VRS provider (Sorenson) was finally resolved by an FCC order in response to consumer complaints and advocacy group pressure. FCC regulations now require that VRS hardware distributed by a certified VRS provider must be interoperable, that is, compatible with VRS services and equipment available from other certified VRS providers.

Table 1: VRS Vendor Bandwidth Requirements

Vendor / Country	Minimum Upload / Download Speed	Recommended Upload / Download Speed At Least	Maximum Latency or Other Requirements
Ace Relay Service (Australia)	512 kbps up/down		Using Skype
American VRS (United States)		512 KB up/down	
AT&T Video Link (Software) (United States)		400 kbps up/down	
MMX / nWise (used by several EU providers)	Determined by individual implementation		
New Zealand Relay (New Zealand)	256 kbps up/down		
Purple – HoVRS (United States)	128 kbps up/down	256 kbps up/down	
Purple MVP videophone (United States)		256 kbps up/down	
Sorenson (United States)		256 kbps up/down	
Sprint (United States)		256 kbps up/down	
Tadeo (France)	512 kbps up/down		
Telus (British Columbia VRS Trial)	1.5 Mbps down[24]		
ZVRS (United States)	1.5 Mbps up/down	512 kbps up/down	Less than 100 ms latency

3.2.3. Skype

Although not a VRS provider, Skype is utilized heavily by consumers including those in the Deaf community for point-to-point video communication. VRS services are also provided over Skype such as Ace Video Relay Service in Australia.

Skype has been at the forefront of Internet video technology, and was one of the first commercial companies to bring free video communication to consumers.

While recognizing Ace Video Relay's minimum VRS requirements above, Skype's bandwidth recommendations are as follows:

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[24] Application for Participation in Telus Video Relay Service Trial on DeafBC.ca, http://deafbc.ca/wp-content/uploads/2010/06/VRS-Trial-Info.pdf.

Table 2 - Skype Bandwidth Recommendations[25]

Video Call Type	Minimum Download/Upload speed	Recommended Download/Upload speed
Video Call (low quality)	128 kpbs / 128 kbps	300 kbps / 300 kbps
Video Call (high quality)	400 kbps / 400 kbps	500 kbps / 500 kbps
HD Video Call	1.2 Mbps / 1.2 Mbps	1.5 Mbps / 1.5 Mbps
Group (3 people) Video Call	512 kbps / 128 kbps	2 Mbps / 512 kbps

3.2.4. Canadian VRS Trials

In Canada a VRS trial is currently being conducted in British Columbia and Alberta by Telus, with Sorenson as the contracted VRS provider. Telus required that participants in the trial have Telus ADSL service at a minimum of 1.5 Mbps download speed.[26] The minimum appropriate Telus service plan is the Telus "High Speed" plan; which has an advertised download speed of 1.5 to 6.0 Mbps, an upload speed of "up to" 1.0 Mbps, and a 75 GB/month usage cap (with an overage fee of $2 per additional GB used). The cost for this plan is the responsibility of the trial participants, and is currently published as $34 per month.

The Telus VRS trial also allows participants to make point-to-point calls between Sorenson provided video equipment users, without using a relay operator.

3.3. Advertised Versus Actual Broadband Speeds

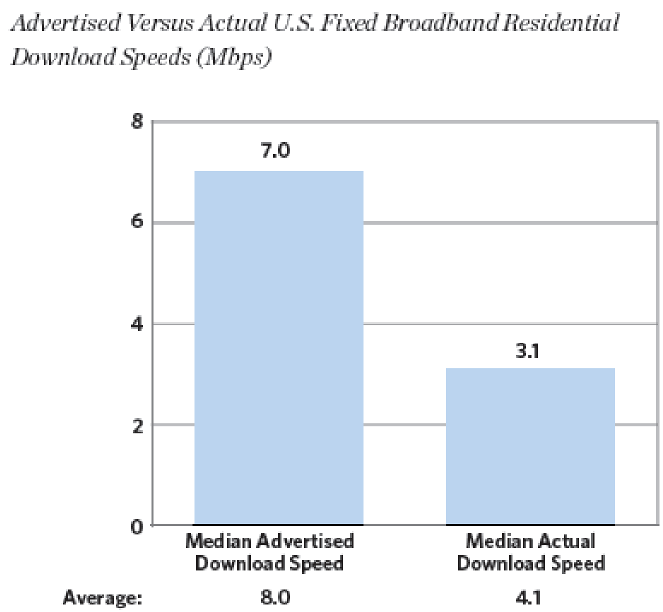
Most consumers do not actually connect at the speeds advertised by their Internet Service Providers, and in fact are frequently connecting at half the advertised "up to" or maximum speed.

The United States FCC published the following graph in its 2010 National Broadband Report, showing the differences between advertised and actual download speeds:

[25] https://support.skype.com/en/faq/FA1417/How-much-bandwidth-does-Skype-need

[26] The Telus application for participation in its Video Relay Service trial does not specify the minimum upload speed. See http://deafbc.ca/wp-content/uploads/2010/06/VRS-Trial-Info.pdf.

Figure 2: Advertised Vs. Actual U.S. Fixed Broadband Download Speeds



While speeds vary significantly from one technology to another, the significant differences between actual and advertised download speeds have been shown to be "consistent and prevalent across all types of connection technologies."[27] The United States National Broadband Report further states that this performance gap has been documented not only in the United States, but in other countries as well. "A study in the United Kingdom found that average actual speeds were typically about 57% of average advertised speeds. Studies in New Zealand, Australia, Italy and Ireland have shown similar results.[28]"

Ofcom, the United Kingdom Office of Communications, indicated in an August 2010 Consumer Bulletin that while average actual broadband speeds in the UK had increased by over 25% in the previous year, the gap between advertised and actual speeds has increased more. Ofcom's response to this research was to push ISPs to agree to "strengthen the Voluntary Code of Practice on Broadband Speeds," introduced by Ofcom in 2008.[29]

Ofcom stated in their draft Annual Plan 2011/2012 that many consumers complained that "they felt they had been mis-sold broadband services, as the speed they were experiencing was lower than advertised.[30]" Ofcom has made it a priority for future years to require service providers to provide clear, accurate information to consumers.

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[27] US National Broadband Report 2010, Chapter 3, page 21, http://www.broadband.gov/download-plan/.

[28] Ibid, page 21-22.

[29] UK Ofcom Consumer Bulletin, Issue 13, August 2010.

[30] Section 2.24 of U.K. Ofcom Draft Annual Plan 2011/2012, January 7, 2011, at http://stakeholders.ofcom.org.uk/binaries/consultations/draftap1112/summary/ap201112.pdf.

The CRTC has recognized this disparity, and in its 2011-291 decision regarding targeted goals for broadband access in Canada by the end of 2015, the Commission stated that "the target speeds are to be the actual speeds delivered, not merely those advertised.[31]"

3.4. Transmission Speeds Necessary for VRS

As discussed in the sections above, there are many factors that impact a definition of the minimum transmission speeds necessary to support VRS to the user. Not only would Individual usage vary dependent on how frequently VRS calls are made, the actual bandwidth used per minute of VRS call depends on a great number of factors such as:

- The VRS provider's proprietary compression methodologies
- Codecs and transfer protocols in use
- Network equipment in place at the call center
- Consumer equipment in place, including:
    - Videophone device or webcam type/specs
    - Videophone software in use
        - Utilities such as HCO, VCO, text/chat might add to bandwidth usage
    - Consumer cable modem or DSL router type/specs
    - Consumer firewall/antivirus software in place
        - Is packet inspection occurring?
        - Is data throttling taking place?
    - Consumer's ISP traffic management policies, including data throttling
    - Network congestion
        - Congestion may cause more transmit/receive activity on a video call
        - Device or network errors will cause more transmit/receive activity on a video call

Basic data calculation can be made based on particular videophone device's configuration, for example a videophone with bandwidth from 40kbps up to 512kbps. Obviously, device and network configuration will play the largest roles in these calculations. For example a camera capturing data at a very high rate will need to pass significantly more data through the network than a camera capturing data at a low rate.[32]

[31] CRTC 2011-291, http://www.crtc.gc.ca/eng/archive/2011/2011-291.htm

[32] . For example, a Cisco representative posted the following at http://gigaom.com/2010/06/08/why-the-iphone-4-made-att-change-its-pricing/, regarding mobile bandwidth usage in the iPhone. This illustrates how differences in cameras (on the same device) can result in twice the bandwidth needed to support video: "The front-facing camera resolution is 640×480. At 30 frames per second, with H.264 encoding, this would result in 5 MB per minute video. The back-facing camera resolution is 1280×780. At 30 fps and H.264 encoding, this would be 12.8 MB per minute video (note that H.264 is generally more efficient at higher bitrates) Livestreaming a 5-minute video shot with the back-facing camera requires 64 MB, or 32 percent of the cheaper plan."

The above considerations mean that there is no simple definition of a specific minimum bandwidth speed that is necessary in order for VRS to adequately function.

4. Broadband Availability to Canadian Consumers

Consumer access to broadband Internet service is required for VRS. Fortunately, almost all Canadians have access to broadband Internet services, as reflected in the CRTC's 2011 Communications Monitoring Report (CMR):

> *Approximately 98% of Canadian households are located within a 1.5 Mbps broadband footprint, consisting of either landline or mobile (i.e., HSPA+) facilities. On a provincial basis the footprint encompasses all households in the following 5 provinces: Alberta, Ontario, New Brunswick, Nova Scotia, and Prince Edward Island. For the remaining provinces it encompasses at least 89% of the households. With respect to Canada's mobile network, 97% of Canadians are within the mobile broadband footprint.*[33]

The above availability is reflective of a continuing shift from older technologies to new, and continuing competitive changes in service providers and offerings, as affirmed in the CMR:

> *In 2010, approximately 48% of residential customers subscribed to service bundles that consisted of local telephone service and one or more of the following services: Internet access, video, and mobile. Approximately 91% of telecommunications revenues were from TSPs [Telephone Service Providers] operating in all of the telecommunications market sectors and 68% of broadcasting revenues were from companies operating in all of the broadcasting sectors.*
>
> *The alternative TSPs‟ share of total wireline telecommunications revenues remained relatively unchanged at 37% in 2010. The alternative TSPs‟ market share included the incumbent telephone companies‟ operations outside of their traditional territories. The incumbent telephone companies‟ operations outside of their traditional operating territories decreased from 8% in 2009 to 7% in 2010, other facilities-based TSPs such as cable companies and hydro utility companies with telecommunications activities increased from 23% in 2009 to 25% in 2010, and resellers remained relatively unchanged at 6%.*
>
> *The cable companies were major providers of high-speed Internet service, as they had approximately 57% of high-speed residential Internet subscribers in 2010. In 2005, these companies started to provide local telephone service generally over a managed IP network, and by year-end 2010, had captured approximately 31% of local residential*

[33] The Communications Monitoring Report (CMR) published July, 2011 shows data for 2010 and earlier. Quoted from page i at: http://www.crtc.gc.ca/eng/publications/reports/policymonitoring/2011/cmr2011.pdf.

lines to become major competitors of the incumbent telephone companies in residential markets.

The competitors of the incumbent telephone companies, which include incumbent telephone companies operating outside their traditional territories, maintained their share of telecommunications revenues. Competitors, essentially cable BDUs, had strong growth in their number of residential local lines, which increased by 15%. Competitor business lines increased 4%.

New wireless entrants collectively captured approximately 2% of the wireless subscribers and 1% of revenues in 2010. Overall, the new entrants stimulated the market as the number of wireless subscribers increased by 8.5% in 2010 compared to 7.8% in 2009. The average revenues per subscribers decreased 1.6%, from $58.81 to $57.86 in 2010 due in large part to the lower prices for service by new entrants.

The number of mobile phone subscribers increased 9% in 2010 from the previous year. As well, Canadians continued to embrace technologies including broadband access to the Internet as the number of residential subscribers to high-speed Internet services increased by 5%. In 2010, approximately 70% of Canadian households had broadband Internet service and 74% had high-speed Internet service..[34]

The above CMR comments portray a cross-industry competitive market, extremely high levels of broadband availability, with Canadians enrolling in broadband via an assortment of service providers and technologies.[35] An overview of Internet and broadband availability is also provided in the CMR:

The *Internet access industry consists of an estimated 500 entities.*

Incumbent TSPs provide Internet services using mainly dial-up, DSL, fibre optic, satellite, and fixed wireless facilities. Cable companies provide Internet services using cable modem, fibre optic, and fixed wireless facilities. Utility telcos, municipalities, and other TSPs provide Internet services using dial-up, DSL, fibre optic, satellite, and fixed wireless facilities. Resellers essentially rely on facilities-based TSPs to provide them with facilities on a wholesale basis. Resellers provide mainly dial-up Internet access service, as well as high-speed Internet service, generally using leased DSL facilities and, to a lesser extent, cable modem and fibre optic facilities. [36]

[34] Ibid, page i – iv.

[35] The CMR also confirms the blending of telecommunication and broadcasting services and markets, including increasing use of the Internet to access broadcast programs. For example, see the CMR at page iii, table 3.1.3 at page 19, and table 5.1.11 at page 121.

[36] Ibid, pg 137

Table 3: 2010 Internet and broadband availability at a glance[37]

Broadband availability (excluding satellite)	
National:	96%
Urban:	100%
Rural:	85%
Penetration [actually signed up for service]	
All speeds:	77%
High-speed:	74%
Broadband (1.5 Mbps and higher):	70%
Broadband (5 Mbps and higher):	52%

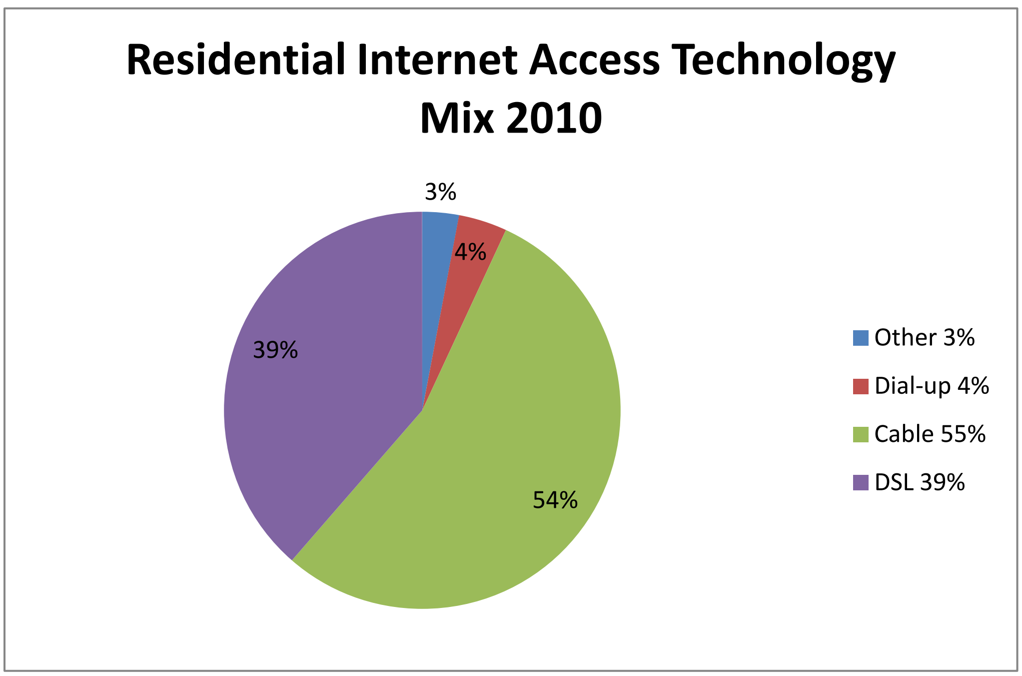
This broadband environment is illustrated in more detail in the charts and graphs of the next sections.

4.1. Current Statistics

4.1.1. Coverage

Among cable, DSL and dial-up, the CRTC indicates the following availability of Internet access to residential households.

Figure 3: Canadian Residential Internet Access Technology Mix, 2010[38]



[37] Ibid, from data on page 137

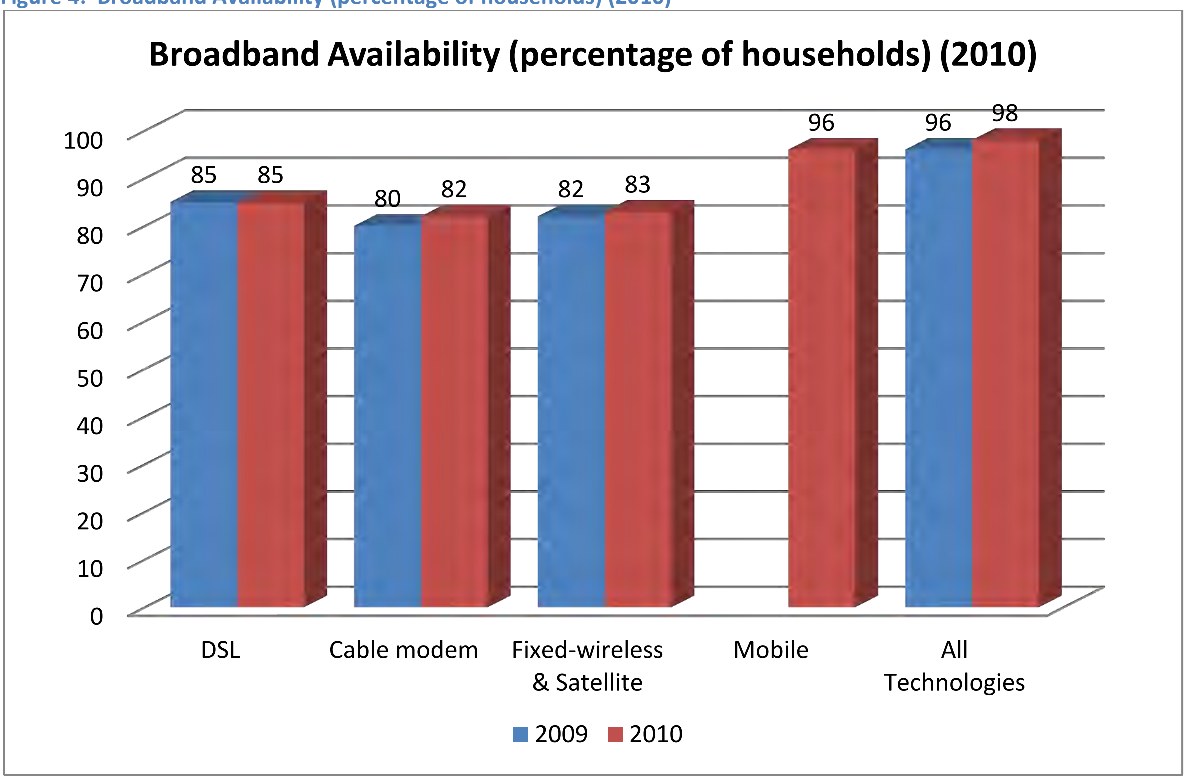
[38] Ibid, figure 5.3.3, page 142.

Broadband availability including wireless is depicted below.

Table 4: Broadband Availability by Technology (percentage of households)[39]

Platform	Availability, 2010
Mobile 3G or equivalent	98%
HSPA+	97%
DSL	85%
Cable Modem	82%
Fixed Wireless	82%
IPTV (as of 31 December 2010)	22%
Digital Satellite	National

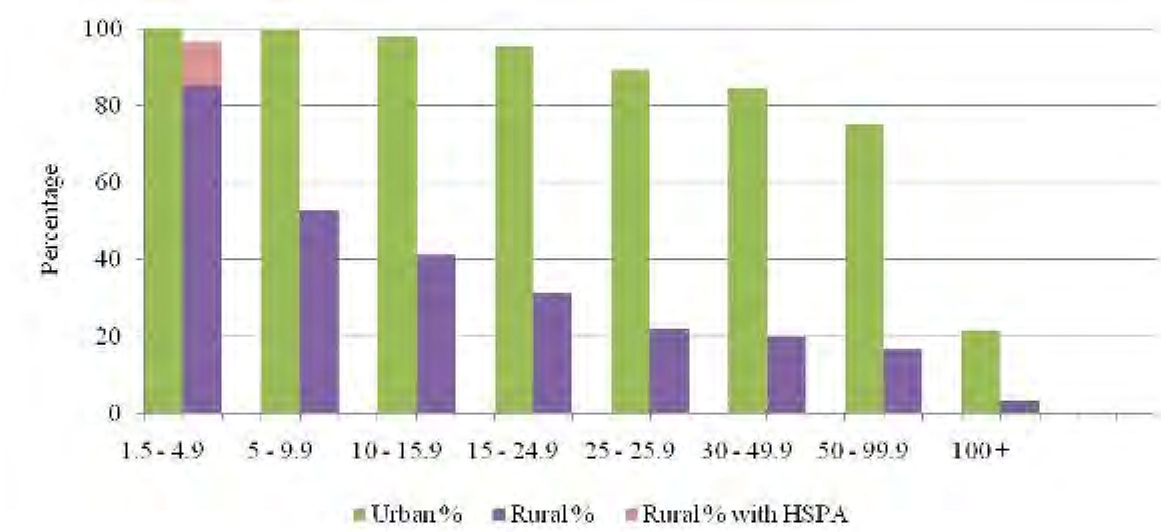
Figure 4: Broadband Availability (percentage of households) (2010)[40]



[39] Ibid. Data from table 5.3.4, page 144.

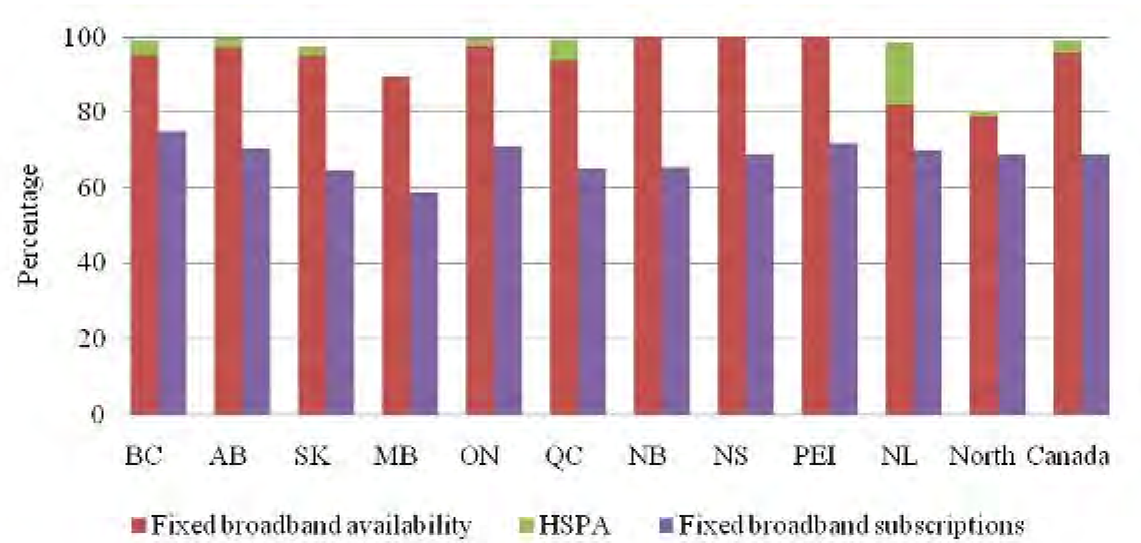
[40] Ibid, figure 5.3.6, page 144.

Figure 5: Broadband Availability - Urban v. Rural (percentage of households) (2010)[41]



The following chart, *Figure 6: Broadband Availability v. Broadband Subscriptions (2010)*, illustrates the difference between broadband *availability* statistics and actual broadband *subscriptions*.

Figure 6: Broadband Availability v. Broadband Subscriptions (2010)[42]



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[41] Ibid, figure 5.3.8, page 145.

[42] Ibid, figure 5.3.9, page 146.

4.1.2. Wireless Networks

According to the CRTC's CMR:

> *The wireless network covers approximately 20% of Canada"s geographic area and is available to 99% of Canadians. The advanced wireless network which supports handsets such as smartphones and turbo sticks, is available to 97% of Canadians. Wireless market sector revenues are the largest component (43%) of total telecommunications revenues.*
>
> *The wireless market sector consists of three large facilities-based national WSPs, a number of smaller regional facilities-based WSPs, and a small number of MVNOs [MobileVirtual Network Operators].*
>
> *A number of new facilities-based WSPs have recently entered, or have announced that they plan to enter, the wireless market sector.*[43]

Figure 7: Wireless TSP's subscriber market share, 2010[44]

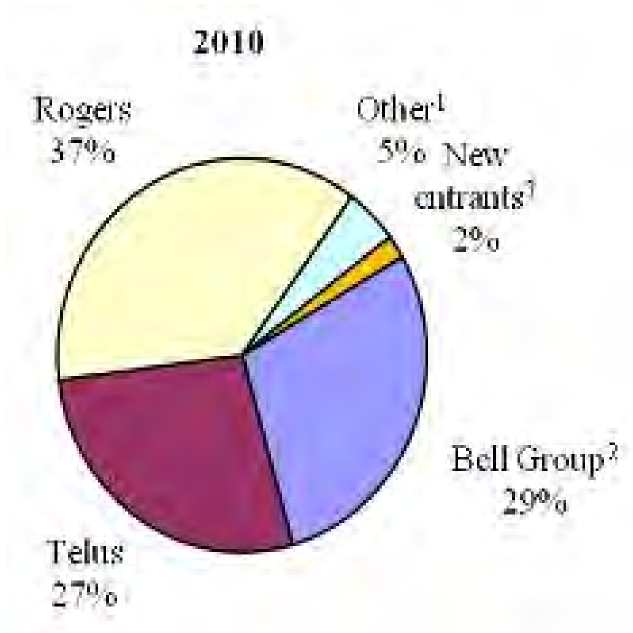

Chart notes:
1. "Other" includes MTS, Allstream, SaskTel, and smaller WSPs.
2. "Bell Group" includes: Bell Canada, Northwestel Mobility, Bell Mobility, Télébec, NorthernTel, Skyterra, Virgin, and Latitude Wireless.

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[43] Ibid, page 155.

[44] Ibid, figure 5.5.7, page 160.

3. “New entrants” refers to the new wireless entities that acquired spectrum in Industry Canada’s 2008 AWS spectrum auction.

As indicated in the figure below, the three dominant WSPs are competitive coverage in almost all provinces:

Table 5: Wireless subscriber market share, by province (2010)[45]

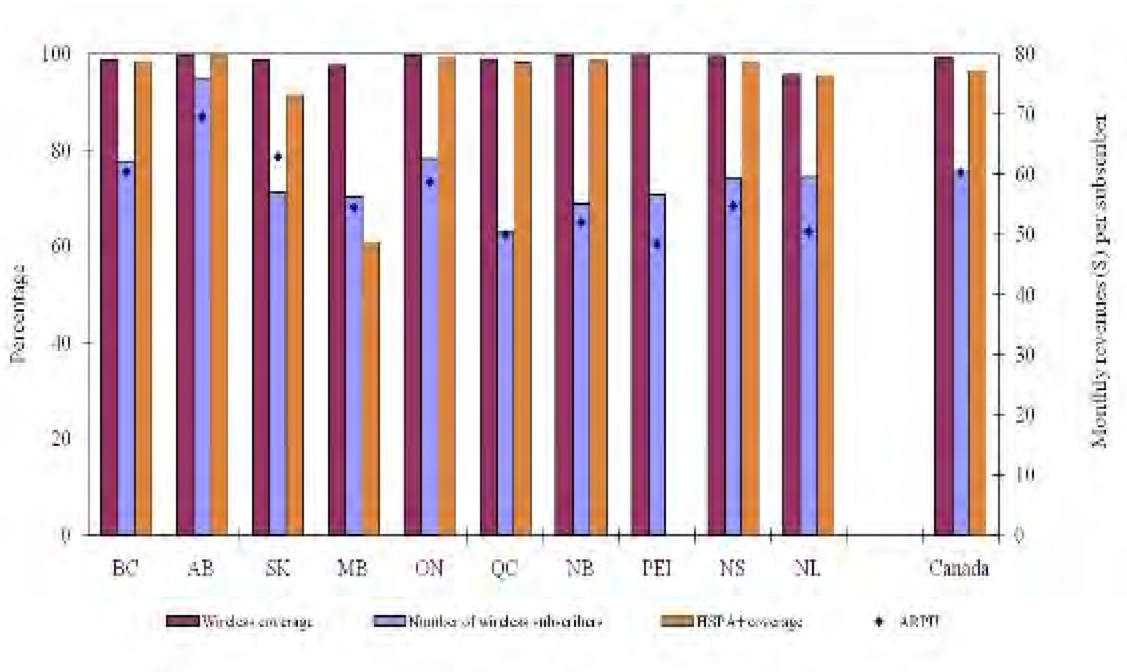
Province	Bell Group[2]	Telus	Rogers	New entrants[3]	Others
British Columbia	17%	40%	42%	1%	0%
Alberta	22%	50%	27%	1%	0%
Saskatchewan	4%	5%	13%	0%	78%
Manitoba	3%	10%	29%	0%	57%
Ontario	30%	20%	47%	2%	1%
Quebec	37%	27%	33%	3%	0%
New Brunswick	61%	18%	20%	0%	0%
Prince Edward Island	62%	21%	17%	0%	0%
Nova Scotia	56%	24%	20%	0%	0%
Newfoundland and Labrador	76%	21%	3%	0%	0%
The North[4]	90%	0%	0%	0%	10%

1. “Other” includes MTS Allstream, Sasktel, and smaller WSPs.
2. “Bell Group” includes: Bell Canada, Northwestel Mobility, Bell Mobility, Télébec, NorthernTel, Skyterra, Virgin, and Latitude Wireless.
3. “New entrants” refers to the new wireless entities that acquired spectrum in Industry Canada‟s 2008 AWS spectrum auction
4. The North includes Yukon, Northwest Territories, and Nunavut

Of significance for VRS, is the high rate of availably of wireless 3G service per province depicted in the chart below. However, the generally higher cost of wireless data usage can be a deterrent to usage; and lower wireless broadband speeds and data caps compared to fixed broadband access (DSL and cable) make fixed broadband a more affordable alternative where available.

[45] Ibid, table 5.5.4, page 161.

Figure 8: Canadian Wireless Population coverage and Penetration, 2010[46]



4.1.3. Coverage Maps

Canada's government web site has very detailed National Broadband Maps for cable and DSL coverage.[47] These maps illustrate both the served areas as well as identify unserved or underserved areas across Canada as of January 1, 2010.[48] Given the maturity and prevalence of digital television services in Canada, much of consumer broadband Internet access is delivered through cable Internet access, as well as DSL services, which these maps illustrate. The online versions of these maps can be viewed by region, and can be magnified to allow for very detailed geographic/data analysis.[49]

Wireless coverage maps provided in the Communications Monitoring Report published July, 2011 shows data for 2010 and earlier. [50]

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[46] Ibid, figure 5.5.9, page 162.

[47] Available at http://www.ic.gc.ca/eic/site/720.nsf/eng/h_50010.html.

[48] Even though the online title is "Canada's Unserved Area", the maps illustrate both covered and non-covered areas. Individual maps may be more recently dated than 1/1/2010.

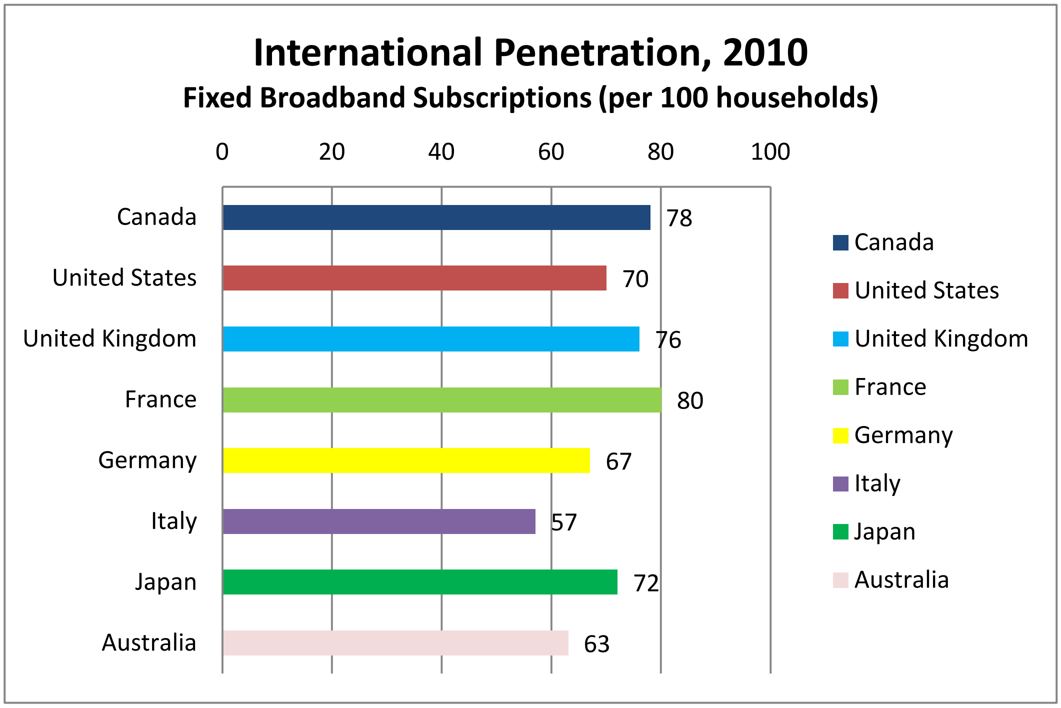
[49] Unfortunately there are no maps showing demographics of Deaf and hard of hearing populations in Canada, nor of people who use sign language. The Canadian government has been asked by advocacy groups to include such information in the design of future census programs.

[50] http://www.crtc.gc.ca/eng/publications/reports/policymonitoring/2011/cmr2011.pdf, map 5.5.1, page 165.

4.2. Comparison with Other Countries

Of significance to potential implementation of VRS is a comparison of Canada's broadband availability, penetration and speeds to that of other countries, particularly those that have implemented VRS. The charts below demonstrate that Canada currently has better broadband coverage, adoption rates and transmission speeds than some other countries that have VRS, such as the United States.

Figure 9: Fixed broadband subscriptions – International penetration, 2010[51]



[51] Ibid, from figure 6.1.5, page 171.

Figure 10: Average measured broadband speeds, 2009 and 2010[52]

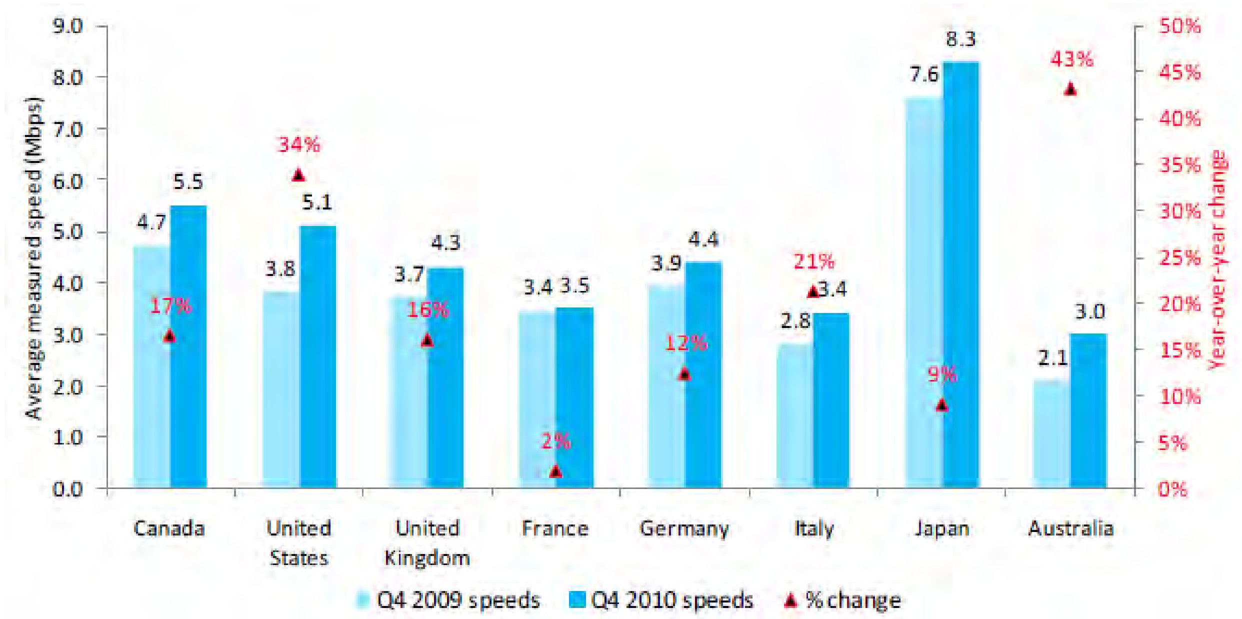
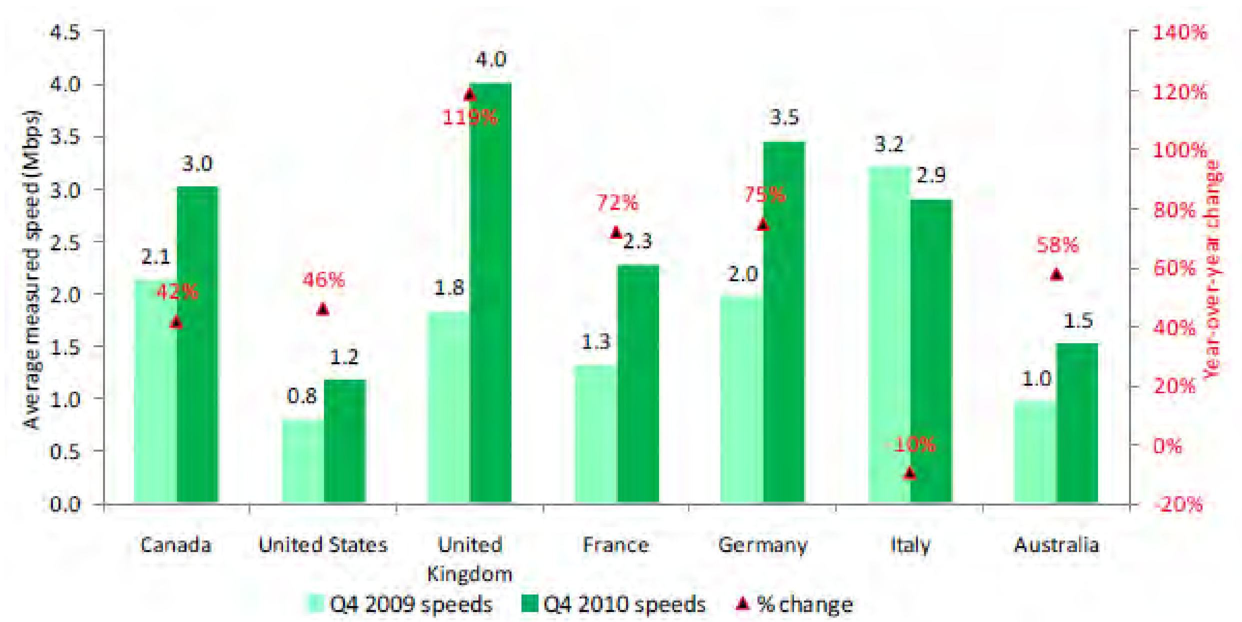


Figure 11: Average Measured Mobile Broadband Speeds, 2009 and 2010[53]



52 Ibid, from figure 6.1.7, page 172.

53 Ibid, from figure 6.1.8, page 173.

4.3. Broadband Expansion Initiatives

Development of further broadband coverage via new technology services and expansion of current broadband technologies continues throughout Canada via industry initiative and government sponsorship. In decision 2011-291, the CRTC established the goal that broadband access at speeds of 5 Mbps down and 1 Mbps up should be available to all Canadians by the end of 2015[54].

4.3.1. Broadband Canada: Connecting Rural Canadians

In January 2009, in response to the global financial crisis and recession, Canada implemented its Budget 2009 with a three-year economic stimulus plan titled "Canada's Economic Action Plan".[55] Of the almost $60 billion designated in the Economic Action Plan, $225 million was set aside to be used by Industry Canada for a nation-wide broadband expansion initiative. [56] The bulk of this funding is being used to expand access to broadband to unserved and underserved households in Canada through the "Broadband Canada: Connecting Rural Canadians" program. The first three rounds of this program will reportedly bring broadband connectivity to nearly 250,000 rural households in northern Canada.[57]

This program is supporting the installation of network infrastructure equipment to provide broadband access in areas where there was no "business case for the private sector" to do so. Broadband infrastructure in these areas is being installed through several different technologies, including fixed wireless, satellite, wireline/wireless, fixed and mobile wireless over satellite, and DSL technologies. Approved expansion projects with confirmed funding as of February 17, 2011 are detailed at the program's Industry Canada website.[58] A summary of project activity from the site's program data is provided below.

Figure 12: Funded broadband expansion projects

Province(s)	Number of Projects	Approximate Households Served
Alberta	11	40,915
British Columbia	26	13,810
Manitoba	11	33,735
Newfoundland & Labrador	1	207

[54] CRTC 2011-291, http://www.crtc.gc.ca/eng/archive/2011/2011-291.htm

[55] http://www.actionplan.gc.ca/eng/index.asp

[56] http://www.actionplan.gc.ca/eng/feature.asp?featureId=18

[57] http://www.ic.gc.ca/eic/site/ic1.nsf/eng/06045.html

[58] http://www.ic.gc.ca/eic/site/719.nsf/eng/00050.html

Province(s)	Number of Projects	Approximate Households Served
Northwest Territories	2	1,234
Nunavut	1	11,938
Ontario	13	13,505
Quebec	26	114,381
Totals:	**91**	**229,725**

Maps of proposed broadband expansion may be accessed online at the same web address. The online maps may be selected by for Canada overall or by regions of each province, may be filtered by layered information, and may be magnified for closer review.

4.3.2. Quebec Initiative

Of notable significance is a special initiative undertaken in Quebec to expand or improve broadband access throughout the province. The Quebec government announced in April 2011 that the government would spend $900 million by 2020 to provide high speed "next generation" Internet to all of Quebec. Twenty percent of the funds will reportedly be spent in suburban areas and the remainder in remote areas.[59] This initiative is not reflected in the above table, project lists or maps of the *Broadband Canada - Connecting Rural Canadians* program or website.

Additionally, the CRTC has, in various decisions such as CRTC 2006-9, mandated that ILECs should spend significant portions of deferral account funds to expand broadband services to rural areas within their territories. The CRTC has further directed various ILECs to use specific dollar amounts of their deferral funds to expand broadband services via certain technologies; such as in decision 2010-805, in which the CRTC approved the use of funds by Bell Aliant and Bell Canada to expand broadband access to rural communities in Ontario and Quebec using HSPA (high-speed packet access) wireless technology.

[59] See http://free-fiber-to-the-home.blogspot.com/2011/04/quebec-announces-900m-for-provincial.html, and page 96 of http://www.budget.finances.gouv.qc.ca/Budget/2011-2012/en/documents/BudgetPlan.pdf.

4.4. Alternative Community Broadband Networks

Another type of Internet access available in many communities is a “community” or “municipal” network. Traditionally these types of networks were developed in rural areas where there was no competitive market for large-scale Internet service providers to offer services to consumers. The community broadband networks can be run by local governments, colleges or universities, or even utility companies. These agencies traditionally provide robust services at competitive prices, even when other traditional service providers later enter the local market.

Community broadband networks are regionally restricted and available only to local consumers. Some of these services are based on specific needs, such as rural Internet access, or based on new technology and/or “green” technology initiatives – such as Ottawa’s “Green Broadband” Fibre-To-The-Home project.[60]

Other community networks are run by cities or other local governments with the goal of providing free Internet access to members of the community. These community networks are generally non-commercial and non-profit, and are supported by community members, sponsors and/or grants.[61]

5. Average Consumer Broadband Usage and Costs

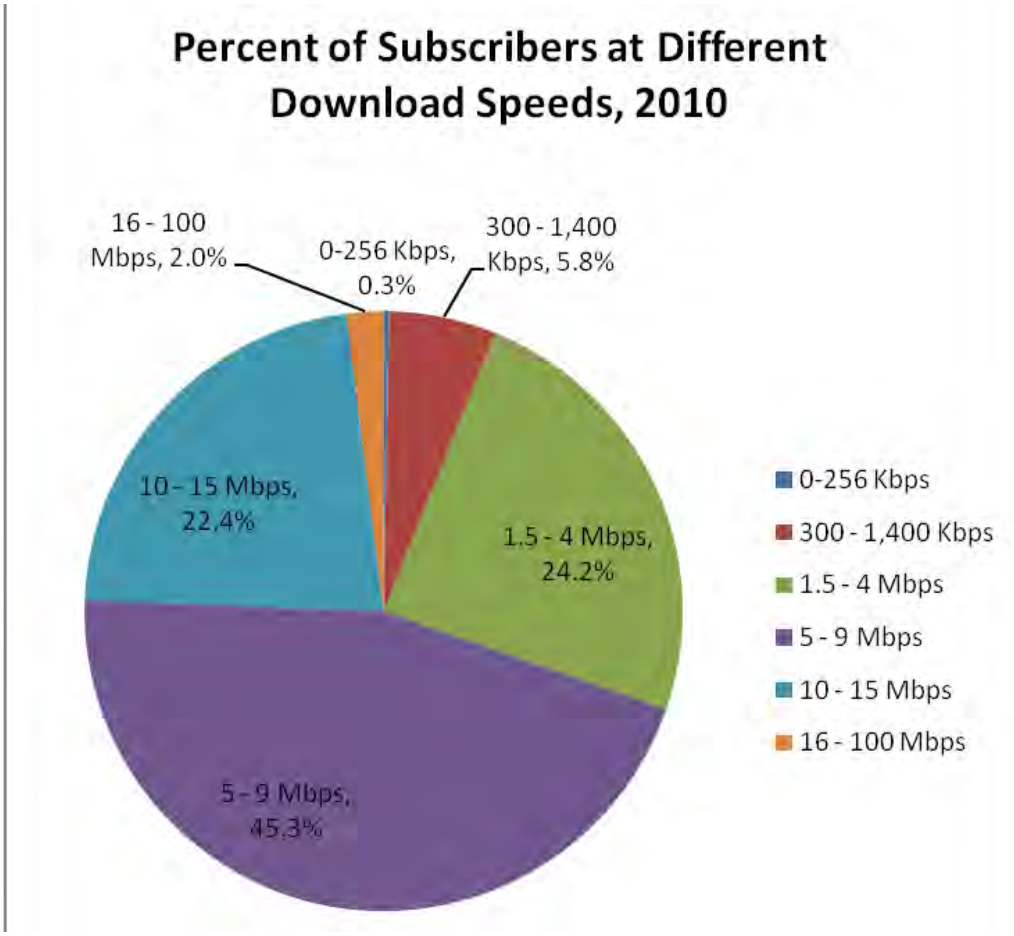
5.1. Average Broadband Usage

Canadian residential Internet usage in 2009 was dominated by usage at relatively high speeds. Less than one percent of subscribers were at a download rate of 256 Kbps or lower:

[60] See http://www.cbc.ca/news/story/2008/12/01/tech-fibre.html.

[61] An example of a Community network in Ottawa is the National Capital FreeNet, at http://www.ncf.ca/.

Figure 13, Fixed Line Residential Internet Usage 2010[62]



[62] Data from the 2011 Communications Monitoring Report, table 5.3.3, page 141.

For each of the above tiers of download speeds, consumers averaged significantly less upload speed:

Table 6, Average Upload Speed per Download Tier[63]

Download Tier	Average Upload Speed
0 - 256 Kbps	209 Kbps
300 to 1,400 Kbps	352 Kbps
1.5 to 4 Mbps	584 Kbps
5 to 9 Mbps	870 Kbps
10 to 15 Mbps	797 Kbps
16 to 100 Mbps	1,735 Kbps

In 2010, the average downloaded per month by Canadians with Internet access was 14.8 GB per user; an increase of 23% from the previous year. Average monthly upload in 2010 was 3.7 GB, a 9% increase from 2009.[64]

5.2. Average Broadband Costs

In 2010 the average monthly fee for broadband services in Canada was $38.96[65]. A breakdown of average rates by speed tier is shown below:

Table 7: Average Monthly Fee per Canadian Broadband Subscriber (2010)[66]

Download Speeds	Average Subscriber Rate
300 to 1,400 Kbps	$28.87
1.5 to 4 Mbps	$33.57
5 to 9 Mbps	$42.23
10 to 15 Mbps	$39.67
16 to 100 Mbps	$53.71

[63] Ibid, data from table 5.3.3, page 141.

[64] Ibid, page 137.

[65] Ibid, data from table 5.3.3, page 141.

[66] Ibid, data from 5.3.3, page 141. Excludes terminal rental costs

The above rates can be further broken down to the following comparison of wireline, wireless, broadband, and mobile Internet service plan average monthly prices:

Table 8: Average Internet Access Plan Pricing, by Type[67]

Service Type	Average Monthly Rate
Wireline Service	
Level 1 (low-volume use)	$32
Level 2 (average use)	$50
Level 3 (high-volume use)	$60
Wireless Service	
Level 1 (basic user)	$34
Level 2 (average user)	$51
Level 3 (premium user)	$100
Broadband (fixed technology)	
Level 1 (~1.5 Mbps, 2 GB/month)	$35
Level 2 (1.5 – 9 Mbps, 10 GB/month)	$50
Level 3 (10-20 Mbps, 25 GB/month)	$63
Level 4 (20+ Mbps, 50 GB/month)	$78
Mobile Internet (3G)	
Speed ~1.5 Mbps, data usage 2 GB/month	$52
Bundled Services	
Wireline-Wireless-Broadband	$134
Wireline-Broadband-Digital TV	$123
Wireline-Wireless-Broadband-DTV	$168

A more detailed analysis of broadband usage and costs, and cost structures, will be addressed in this VRS Feasibility Study, under Phase 10, Cost Variables and Forecasts.

[67] Data from CRTC 2011 Communications Monitoring Report, table 6.1.1, page 168.

6. VRS End-User Solutions

6.1. Diversity and Choice

Potential VRS users reflect individuals with a diversity of communication preferences, as is reflected in equipment and the user-interface offerings of current VRS providers and equipment in other countries. There are several different devices and software used for video relay services. At the most basic level, the Deaf end user will need a device capable of capturing, transmitting, and receiving video images over the Internet with a VRS provider (as well as with other users in point-to-point conversations, although that may not be a strict requirement for VRS). Transmission of video can occur via a standalone videophone device, or through a computer or mobile device equipped with a webcam and a provider's software. Some countries have implemented VRS models where it is a requirement that VRS hardware and software must be interoperable with any other VRS provider's systems. In an interoperable environment, the user may obtain a device and service from one provider and if the service is later contracted to a different provider, or if the consumer has the option and later decides to use the device with another provider's service, the investment in the initial equipment is not lost. The European Union has taken this open, interoperable concept even further, with a "total connect" methodology, which, beyond VRS communication from any device or software meeting basic functionality requirements, also requires VRS providers to provide and utilize software and hardware that allows the users to choose their desired communication modes – e.g. sign language with VCO, or sign language with text chat alongside, etc.

The choice of what kind of *device* to use for VRS may be very personal based on individual preferences, computer knowledge, and ease of use. Some users may not be aware they have access to other types of devices, or they may live in an area served by a monopoly VRS model with only one VRS vendor which only offers one video device option. Some users may have multiple devices (e.g., mobile and fixed, or devices at home and work, each with its own telephone number and/or IP address), and may also use more than one VRS service provider. Others uses may prefer only one device (or have more than one of the same kind of device) for ease of use, and familiarity or availability of features.

Experienced VRS users expect a VRS system that can accept calls from multiple devices and communications methodologies. When choosing an end-user *device* or *software*, knowledgeable consumers will seek basic features and functionality in the end-user interface, such as:

- Clean, simple interface
- Easily navigable buttons or menus
- Tiltable screen and/or camera
- Direct button access to call preferred VRS provider
- Direct button access to call or email VRS provider support
- Device interoperability (with other devices, other VRS providers)
- Configurable environment settings (lighting, contrast, etc.)
- Configurable communications options (VCO, HCO, text chat, etc.)
- Availability or potential inclusion of features such as:

- Video mail
- Contacts/Address book
- User profiles
- Notification features (flashers, screen pops) for incoming calls/messages

If multiple VRS providers are available to consumers, many factors can influence consumers' choice of *provider*, including ease of use, special features, perceived overall quality of the video interpreters, speed of answer, good customer service, and special promotions. User-selectable basic functions that contribute to the quality of the conversation include choice of preferred communication mode such as ASL or LSQ, contact language (sign supported English or French), VCO, HCO, lipreading, and/or close-up signing.[68]

6.2. End User Variables Affect Functionality

There are many factors that affect the functionality of VRS. These include proprietary compression algorithms, bandwidth issues, and the systems displaying and transmitting the video. Device-specific hardware and software component considerations include screen size, resolution, frames per minute, memory, display drivers, processor speed, etcetera.

Two different devices or software programs can provide very different results with the same VRS system, and therefore two different users can have different results with any given VRS provider. For example, if two consumers use the same vendor's supplied VRS software for their home computer, and both have a broadband internet connection, with download speeds of 3.0 Mbps, and upload speeds of 1.5 Mbps, their VRS experiences may still be different. This will be the case if one user has a new computer with an Intel i5 processor running at 3.2GHz, 6GB RAM, a discrete graphics card with 1GB RAM, and a 21" high definition LCD monitor, while the other user has a five-year old laptop with a Pentium 4 processor running at 2.8GHz, 1GB RAM, and onboard graphics with shared memory. The second user will have a very different experience with VRS, with the video on the laptop screen appearing significantly less clear, and will likely experience jitter or stuttering in the video. While VRS vendors can list recommended minimum requirements for their hardware and software, many VRS consumers are not technical and may need assistance to select, set up or troubleshoot their devices.[69]

In addition to device, software, and vendor considerations, there are factors in the end-user's home or work environment that will affect VRS functionality and perception. Beyond the basics of hardware and software compatibility there are issues such as the possibility that connectivity through a cable

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[68] These types of functions are dependent upon the VRS provider services offered, as well the degree that they may be supported by the end-user's technology. However, there are no inherent technical barriers to offering these service functions. These functions will be discussed in study phase 3, Consumer Interests and Perspectives, and phase 8, Potential Related Services.

[69] Some VRS vendors in the U.S. list very low minimum requirements in order to try to capture higher market share, even though higher requirements may provide a significantly better relay experience.

broadband service may be slowed as a result of congesting during peak usage periods. Also, consumers who have never used a web camera or videophone might not know that environmental factors, such as glare from windows, fluorescent lighting, "busy" backgrounds, etcetera, will affect not only the usability of the VRS system for them, but will affect the quality of their image being transmitted. Even though VRS users see their own image and most devices and software have several settings which can be adjusted to improve video quality, these types of environmental and video quality settings may not be evident to a new or non-technical user. These factors go beyond basic "technical" support, but with the introduction of VRS many VRS consumers may need to be educated on these matters. Any company providing VRS services must, therefore, provide technical and user support which goes beyond the basics of which cable to connect to the videophone or webcam. VRS support must be competent and knowledgeable in a variety of factors affecting VRS functionality. Additionally, when a VRS solution is initially implemented, the VRS vendors will need to be partners in the communication and education efforts in order to ensure that consumers have access to information about the technology, and also to general information about what VRS is and how it can and cannot be used.

User perception is an additional factor to consider when discussing VRS technologies. One of the examples above illustrated the potential experience of two different users with computers of varying hardware capabilities. Given the same hardware configuration, however, users may have individual opinions about the design and functionality of the VRS software or device from a user interface perspective, or differing opinions about the accessibility and support from a VRS provider.

6.3. Videophone Devices

6.3.1. Videophone History and Technology

"Videophone" is a general term for a standalone device with a video camera and screen capable of transmitting and receiving video motion images. Videophones are, by definition, full-duplex devices capable of transmitting and receiving audio and video at the same time, and are not only used in point-to-point communication (i.e. two individuals with videophone devices communicating to each other), but also in videoconferencing and video telephony scenarios (including VRS).

Webcams were a technological evolution of videophones, allowing users to add a hardware video camera to their desktop or laptop computer, and to utilize software on their computer to transmit and receive video and audio through their computers, rather than through a stand-alone videophone. A webcam, therefore, may be considered the video/audio capture component of a videophone, but one which must be used in combination with specialized software and a computer with display.

The earliest videophones were propriety network-dependent, and point-to-point. Although videophones which could communicate point-to-point over plain old telephone lines (POTS) were

Figure 14, Bildtelefon T-View 100 ISDN Videophone

developed and commercially available, consumer usage of videophones did not become affordable and more common place until communication methodologies such as ISDN became available.[70]

Most modern videophone devices, however, now communicate using Internet Protocol (IP) over the Internet, and as such require a broadband Internet connection to the device or computer via a network cable or wireless (e.g., Wi-Fi) connection. The bandwidth required for a videophone device or software is directly dependent on the transmission protocols being used, such as SIP, H.323, or H.324, or 3G-324M for 3G mobile networks; along with the video and audio codec (compression) used, such as H.263 or H.264.[71] Different protocols have different compression requirements and capabilities, and therefore are designed for or function better on various communication mediums (e.g., the H.324 protocol combines call setup and video compression, and is therefore generally the protocol used by videophones that work on POTS lines.)[72]

Most VRS providers use proprietary software and/or hardware in which the compression algorithms have been specifically formulated to provide better focus on the signer's face and hands, and background area is given less emphasis or focus. This is a complex process and involves not only the technical engineering aspect of the compression algorithms, but also the end-user's preferences – especially in low-bandwidth or smaller screened devices. In the United States, the University of

[70] Video over POTS produces a significantly delayed image refresh rate resulting in motion that appears as a series of sequential static pictures.

[71] H.263 is widely used but does not include audio handling, and therefore a separate audio codec, such as G.711 must be used.

[72] Video over a POTS line still does not offer high enough quality to support sign language.

Washington and Cornell University are involved in a project to investigate the technology and effects of various video compression methodologies affecting ASL communication on wireless mobile devices.[73] However, research projects aside, VRS provider solutions are not open-source technologies.

Many Deaf users communicate point-to-point with non-VRS specific software, such as Skype, iChat, Google Chat, etc. While these technologies are heavily used and have been extremely beneficial in providing communication tools to the Deaf community, the common perception seems to be that the compression methodologies are superior in VRS-specific software and hardware, thus providing a better video image for sign language users.

6.3.2. Videophone Device Configuration

Videophone devices sometimes require users to make configuration changes to their Internet router, in order to allow the necessary protocols to communicate over the Internet, or may require a Public (or Static) IP address in order to communicate properly over the Internet.

Some software and devices will function with no configuration changes, especially the web-based clients, but others may require specific ports to be opened on the user's firewall. Generally this is more of a concern for users in corporate or office environments, where the company networks are protected by robust firewalls. The configuration changes for these environments can be quite complicated and usually require a network administrator with access to the firewall.

Technical configuration is another area in which the VRS providers must be able to provide their users support, whether it is providing a home user with assistance with simple configuration changes, or providing detailed "pinhole" configuration for more complex firewalls.

6.3.3. Videophone Device Types

Videophone devices can be stand-alone devices which contain a screen built into the device, or separate components that require connection to an external display.

Videophones with built-in displays can have small very high resolution screens, or larger screens. Many have displays that can be tilted, which can be essential for best viewing angle as well as minimizing glare. Some videophone devices utilize touch screen technology, others use device buttons and menus, while others use remote controls.

Representative examples of videophones are depicted below, simply to provide a better idea of the range of devices available. General and technical information about these videophones are available at their referenced websites.

[73] See http://mobileasl.cs.washington.edu/.

Figure 15: Tandberg E20 Videophone (ZVRS Z20)[74]

Figure 16: Grandstream GXV-3000 IP Videophone[75]

Figure 17: Visiontech ONYX[76]

Figure 18: Visiontech 640D[77]

[74] http://www.zvrs.com/z-series/the-z-products/z-20; manufactured by Tanberg at http://www.tandberg.com/.

[75] http://www.grandstream.com/user_manuals/GXV3000_User_Manual.pdf

[76] All-in-one unit by Visiontech AB of Sweden; used with a remote control. Supports data transfer up to 640 Kbps full duplex. Data sheet at http://www.visiontech.se/docs/onyx.pdf.

[77] Supports data transfer up to 640 Kbps full duplex. Data sheet at http://www.visiontech.se/docs/vt640p.pdf.

Figure 19: Creative inPerson (ZVRS z-340)[78]

Figure 20: Sorenson VP-200[79]

Figure 21: *OJO Personal Video Phones (PVP) (ZVRS Z-OJO)*[80]

[78] http://inperson.creative.com/product/welcome.aspx?id=Information and http://www.zstoreonline.com/VP_Z340_p/vp-z340.htm

[79] The Sorenson VP-200 is the videophone currently being used in Telus VRS Trial in conjunction with a separate display and Sorenson VRS. Sorenson publishes a VP-200 user guide, but does not publish the VP-200's technical specifications: http://www.sorensonvrs.com/assets/pdf/VP-200_User_Guide.pdf

[80] http://www.ojoservices.com/_files/pages/Ojo-1000-Spec-Sheet.pdf and http://zvrs.com/uploads/Image/specsheet/zojo_specsheet.pdf

Videophone Accessories

In addition to the actual videophone device, accessories or software applications may be added or used in combination to enhance videophone and VRS functionality. For example, "flashers" are separate devices that can be attached to a videophone to provide visual notification of an incoming videophone or VRS call. Other methods of notification include on-screen popup windows used with computer-based VRS software, the ability to have a text or pager alert sent to a user's cell phone, pager, or an email to notify the user of an incoming call. An example of a VRS generated text message is shown below.

Figure 22: VRS alert on a BlackBerry phone[81]

```
------Original Message------
From: VRS Call
To: Jane Doe
Subject: Incoming call now from 678-555-5555
Sent: May 6, 2011 6:14 PM

A caller at 678-555-5555 is trying to reach you at 916-555-1234 through
Purple VRS right now.

You can answer this call on your P3 or other videophone, or your caller
may be directed to leave you a Video Mail message.

For more information please log in to your Purple account.

Thank you for using VRS.

Sent via BlackBerry from T-Mobile
```

Other common VRS utilities include:

- Video Mail, which allows a VRS interpreter (or point-to-point caller) to leave a video message for a user who is not available to accept a video call;
- Address Book or other means of storing contact information and numbers,
- User Profiles, to allow users who share the same device to quickly access their personal settings and content.

These accessories are used not only with videophones, but also with computer-based VRS client software, and will be discussed in the Phase 8 report, Potential Related Services.

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[81] Purple Alert message sent to a Purple VRS user. Name and phone number have been changed for privacy.

6.4. Desktop Computer Software

In combination with a webcam or other compatible video camera, desktop or laptop computers may be employed to access VRS services. VRS providers generally supply free software application which can be downloaded and installed to the VRS consumer's computer for use with the VRS providers' services. Some VRS providers offer web-based VRS client services, wherein the user simply logs into the VRS provider's website and access VRS completely online. One advantage to a web-based client is that many people have more than one computer, or they access VRS from multiple locations. Having the VRS service completely web-based, allows the users' contacts, VRS mail messages, and other customized settings and applications to be available on any computer with a webcam that can access the VRS provider's website (although some software allows access to these features from any computer).

Whether VRS access is software application-based or web-based, most VRS providers offer clients that can be installed or run on most home or office computers operating systems, including Microsoft Windows, Apple's Mac OS, or Linux. Software-based VRS services are functionally identical to using a videophone device, but the interface is generated from the software, rather than from the physical videophone. Two examples of VRS software shots are illustrated below.

Figure 23: myMMX screen shots

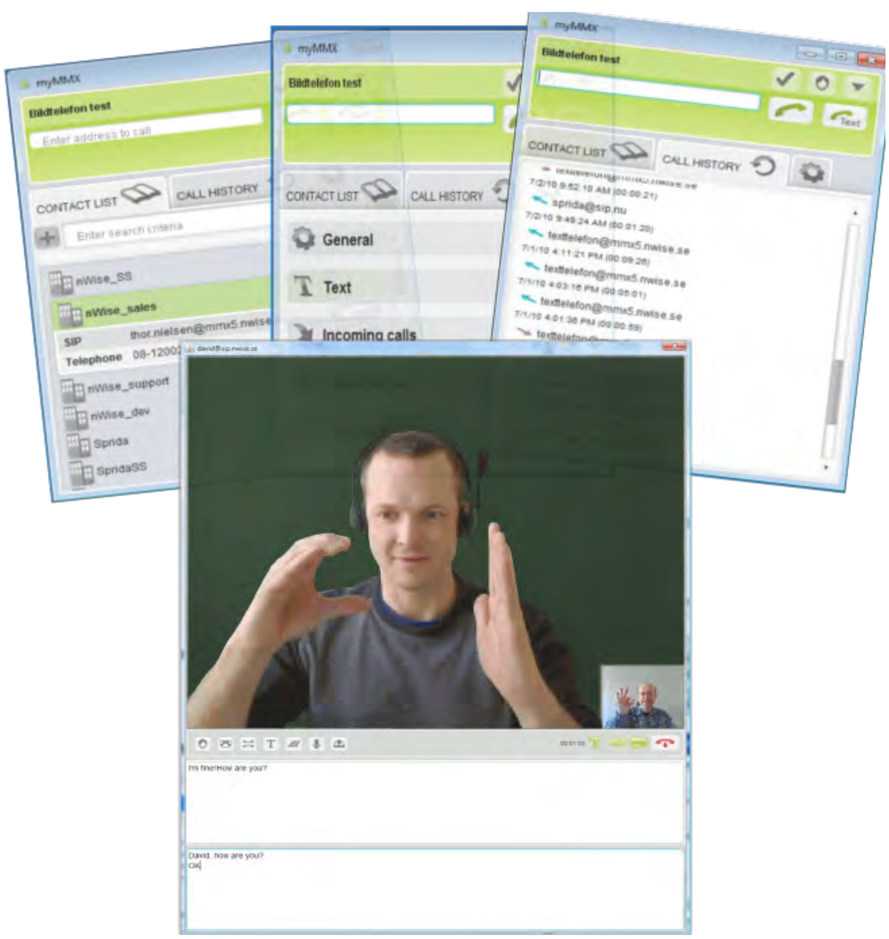
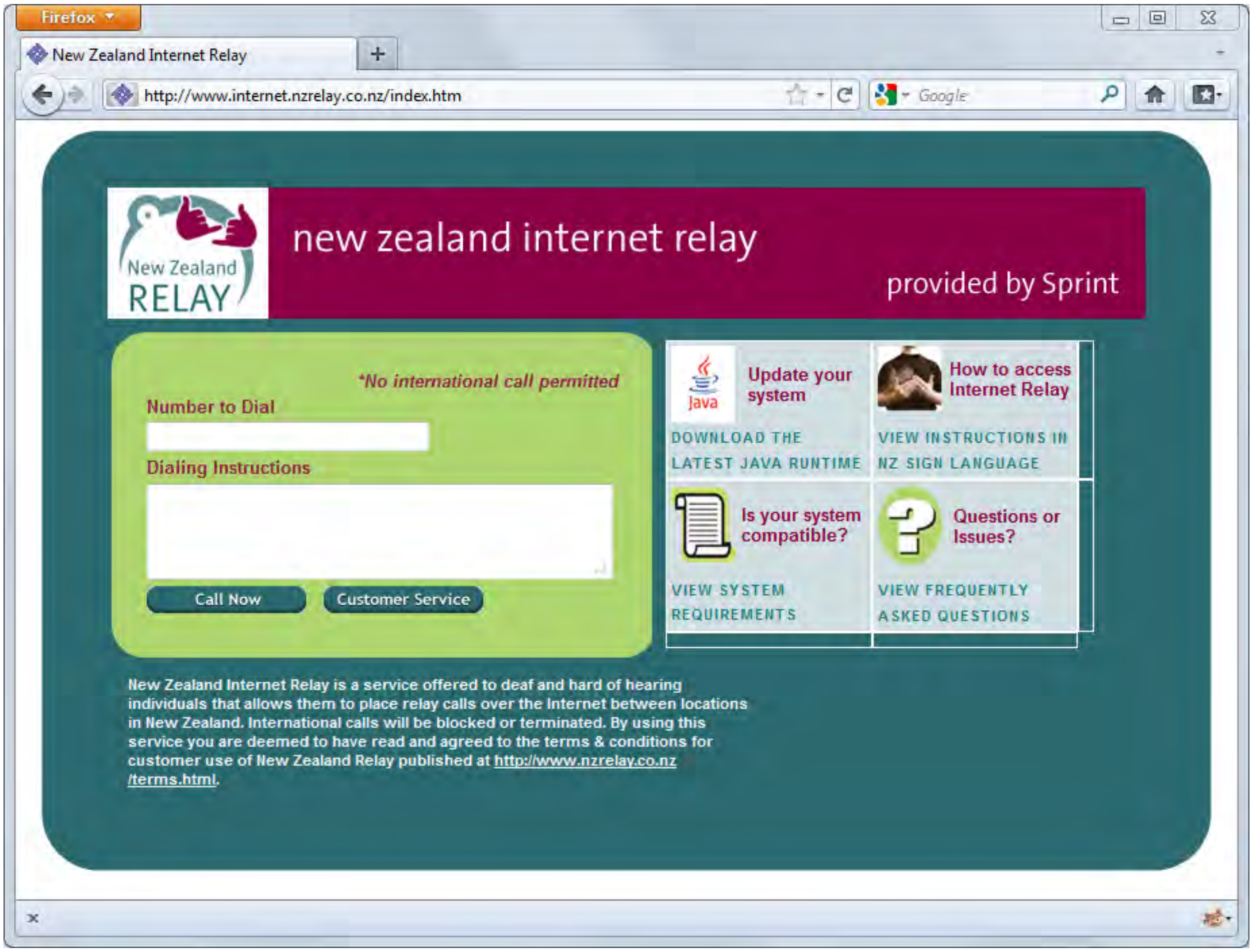


Figure 24: New Zealand Web-Based Relay Sign-On Screen



6.5. Tablet and Other Mobile Device Software ("Apps")

When pagers and text-capable (i.e., SMS) cell phones first became available in the consumer market, Deaf users were some of the earliest adopters of these technologies. These devices allowed Deaf users to communicate anywhere, anytime with similarly equipped mobile or computer text system. In some instances, users activated Baudot signalling on their mobile device to enable communication with TTYs. The introduction of smartphones and tablet devices capable of recording, transmitting, receiving and displaying two-way live video over cellular signals has similarly heralded a revolution in communication technology. With live video-capable mobile devices, Deaf consumers can use sign language to communicate point-to-point and through video relay services from anywhere with a cellular signal with sufficient bandwidth. The merging of technologies and the trend toward IP-enabled services also means devices that have both cellular and wireless (Wi-Fi) capabilities can connect through either signal.

As indicated in section 4.1.2 and Appendix C, 3G Cellular connectivity has become available to almost all Canadians. As demonstrated in other countries, 3G has proven to provide sufficient speed for limited

VRS functionality. For example, since 2004 Sweden has had technology in place to allow 3G mobile users to use VRS services. As previously mentioned, various agencies and institutions have developed or researched improved compression algorithms to enhance sign language and especially lip-reading comprehension over 3G signals. However, the prevalence of advanced smartphone and tablet devices along with the promise of rapidly expanding 4G coverage is driving the demand for increased video communication capabilities with mobile devices. Whether 3G or 4G, smartphone usage is growing worldwide. The CRTC reports in their 2010 Annual Communications Monitoring Report that smartphone growth in Canada from the fourth quarter 2008 to the fourth quarter 2009 was 32%, while the overall growth of mobile devices was 15%.[82]

Deaf users already have the ability to communicate point-to-point with various smartphone devices, and in many countries other than Canada, VRS providers are beginning to deploy applications to allow smartphone users to make or accept VRS calls. As smartphone and tablet costs continue to drop and/or as their capabilities increase without an increase in cost, users will increasingly adopt these technologies and use them for VRS.

It is important to note that access to mobile devices is not equally available to all users at all income brackets. Smartphones, while becoming more common, are still expensive devices that require cellular service plans with “data” access. The software (generally called an ”App” on a mobile device) used for the video communication is usually free, but payment for the data access and usage minutes are the responsibility of the consumer.

While some video-capable smartphones can be obtained relatively inexpensively with the addition of a multi-year cellular service contract, some popular smartphones can cost hundreds of dollars, even with a multi-year contract agreement. In addition to the phone purchase cost, the user must have a cellular plan with data access in order to use the advanced features of the smartphone.

New “tablet” devices are becoming popular, and some now have front-facing cameras which enable live video communication. These devices, like their smaller smartphone predecessors, have Wi-Fi and cellular network connectivity, and offer a larger screen for better sign language and lip-reading comprehension.

Modern Video-capable tablet devices are still somewhat new on the market, and as such are fairly expensive. The communication methodology (from a network and IP perspective), however, is identical to that of smartphone devices, so VRS providers who are prepared to allow mobile VRS communications will easily be able to provide mobile tablet video relay services.

Some VRS providers have offered video relay services on Wi-Fi tablet or netbook-sized devices for many years. These may be single-purpose devices designed for video communications only, or may be small laptops or tablet computers which can also run VRS (such as the iPad) with or without specialized downloaded VRS applications. See following figures for examples.

[82] CRTC 2010 Communications Monitoring Report, page 168

Figure 25: TM-9000 Tablet Videophone[83]

Figure 26: Oplink Tablet Videophone[84]

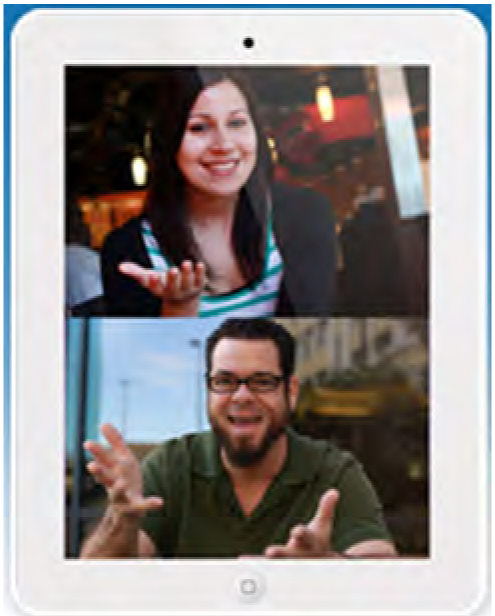
Figure 27: Viable VPad+[85]

[83] TM-9000 (Sweden); http://www.tmeeting.net

[84] http://www.oplink.fr/oplink.html

[85] http://www.viable.net/product/vpad

Figure 28: IPad2[86]



6.6. Other IP-based Devices Such as IP Televisions, Video Game Consoles

As analog technologies such as television and radio signals are being converted to digital, and as home access to the Internet becomes a worldwide standard, many new types of IP-based devices are being purchased by consumers for home entertainment purposes. For example, with Digital TV becoming a standard in most countries, television "sets" are now becoming blended video and computer devices. The explosion of Internet gaming has bought associated Internet-connected gaming devices (PlayStation, Xbox, Wii, etc.) into many consumers' homes. Many of these devices have integrated web cams and communication technologies, thus enabling them to potentially be used as VRS devices. While the requirements for the use of these types of devices with VRS will vary from system and vendor, open access VRS systems which accept calls from any IP-based device may well be able to offer users VRS access through their web-cam equipped IP TV or gaming console.

6.7. Consumer Technical Assistance

The above review of VRS equipment and software reveals a range of complexity involved in the installation and/or configuration of VRS terminal equipment, and its use. This poses questions regarding the degree of technical support that VRS consumers will require during implementation of service. A review of the user guides or installation/configuration instructions available from the VRS vendors and

[86] https://www.zvrs.com/.

device manufacturers demonstrates significant potential complexities.[87] Some installation configurations may be as simple as "plug and play", while other situations will require knowledgeable technical support. As with any population of users, Deaf consumers represent a cross section of technical competence, with many young people often more knowledgeable about the latest details of computer and network interfaces than their elders. In general, vendor technical assistance to consumer products is usually provided in written product user guides and set up instructions, augmented by help desk call-in and/or web chat access. For many Deaf consumers, however, written English or French are not their primary language. Additionally Deaf consumers are often restricted to vendor help desk services via traditional relay or via chat access if provided. Thus technical issues that are complex to the consumer or that use a specialized technical vocabulary, are usually not be available for explanation and discussion in the Deaf consumer's native language, e.g., ASL or LSQ. This is a significant barrier to trouble-free adoption of VRS technology.

To overcome this barrier, some level of technical support to the VRS consumer will be required during implementation. In the United States different VRS vendors have adopted different strategies of support. While some offer comparatively minimal end user support, some provide complete personal support by delivering equipment, setting it up, and personally explaining and demonstrating its use using Deaf installers fluent in sign language. This latter approach was successfully used by Sorenson to acquire approximately 85% of the U.S. VRS market, and is being used by them in the current Telus VRS trial.

The extent and type of personalized support that will be needed will be dependent in part upon the type of equipment and VRS model selected. Multiple vendors with multiple devices and software solutions will require a variety of approaches, each tailored to the vendor systems and devices employed. However even a single VRS solution will face a variety of implementation and usage issues when deployed over a variety of computer, smartphones, mobile tablets and other popular devices. Therefore, some level of effective technical support to the consumers will be necessary.

7. Average Terminal Equipment Costs

End-user equipment hardware and software costs vary depending on the technology and the VRS model implemented. Client software, either downloaded on a consumer's existing computer or as a website function, is usually provided by VRS vendors at no charge. When considering a standalone videophone, costs can vary from a couple hundred dollars to a thousand or more. In some countries' VRS models equipment costs are subsidized in whole or in part, either by the VRS vendors or by a government agency. However, most VRS models cannot provide end-users with a computer or laptop on which to install the VRS software. Similarly, smartphone devices or mobile tablets, and their associated cellular and data service plans, are usually the financial responsibility of the Deaf user.

[87] For a sample of user guides with installation instructions, refer to the vendor websites referenced in this document's footnotes.

In most competitive VRS models, users can choose their preferred VRS provider based on services as well as by the choices of equipment offered by the providers. In a non-subsidized VRS environment, however, or if a user prefers a different device from the one provided by the VRS provider, the user would need to purchase their own videophone device.

While videophone devices will vary in cost depending on features and functionality, the average consumer costs for a few videophone devices are listed in the table below.

Table 9: Estimated Videophone Device Consumer Costs

Manufacturer	Model	Estimated Costs
D-Link	DVC-2000	$350
Grandstream	GXV-3000 or similar	$150 - $200
Ojo	Ojo PVP	$190 - $240
Sorenson	VP-200	Provided only to Deaf users in subsidized VRS model
Tandberg	E20 (business class videophone)	Provided at a discounted rate to users in subsidized VRS model.
VisonTech	VT82 /VT640D	2 Devices provided free to Deaf users in subsidized VRS model (Sweden)

Although videophone devices have often been provided to end-users on a free or subsidized basis, device accessories usually are not free or discounted. Examples of hardware accessories that typically require purchase are notification devices (such as flashing light indicators), or the physical equipment to enable pager or smartphone notification of incoming calls or messages.

Notification devices can be as simple as a small $20 USB LED device that flashes when an incoming call or alert is received, or can be as complicated as a system connected to multiple devices to provide notification alerts throughout an individual's home or office. More complex systems will begin in the hundreds of dollars range, and some may require professional installation.

8. Other Technical Considerations

In addition to technical considerations for functional VRS, such as available bandwidth, user hardware, mobility and software, the overall design of VRS for Canada may consider other technical capabilities to enhance the operations or management of VRS. Examples discussed below are interoperability, fraud detection, demand and service reporting, and consumer data base services. These considerations will only be discussed at a high level, as their definition would normally be part of a detailed VRS procurement request and contract documents.

8.1. Interoperability

In the early days of VRS, communications technology was often limited to whatever network the VRS provider had invested in internally. Current communications technology, however, trends toward open, IP-accessible devices and software. Although individual VRS providers may continue to utilize proprietary devices, software, or systems, these proprietary methods do not necessarily have to limit the communication options for Deaf and disabled users in either their point-to-point communication or their video relay communication. Thus both the user devices, client software, and the VRS system design can be designed for either exclusive (non-interoperable) communications among their own kind, or can be designed for shared (interoperable) communications with other types of devices, software, or VRS providers. For example, the United States had a model that was open only to the degree volunteered by the VRS providers. Since the dominant provider (with about 85% market share) elected to have a closed non-interoperable system, the model was effectively non-interoperable for many years until the FCC ordered interoperability for all. Sweden adopted the "Total Conversation" model, demonstrating that proprietary systems can function in an open environment with multiple choices available for the end user.[88]

Interoperability needs to be considered not only from the device-to-device functionality, and multiple VRS provider interoperability and administration and billing considerations, but also at the features and functionality level. Deaf users' communications options such as VCO, HCO, text chat, language choice, and other modes of operation need not necessarily be limited by a single VRS vendor or provider.

Interoperability will be discussed in study phase 11, Potential Canadian VRS Models.

8.2. Fraud

As has been experienced in the United States, fraudulent usage and costs can be an expensive and pervasive blight on VRS. The potential for fraud is enhanced or diminished with different VRS reimbursement or cost models, which in themselves will have other benefits or drawbacks. However, depending upon the reimbursement model selected, the VRS system technology and the VRS end user hardware and/or software may also incorporate functions that may assist in mitigating the occurrence of fraud. For example end user devices or software could incorporate independent account tracking and usage reporting to oversight entities responsible for auditing relay provider's reimbursement claims. Likewise, third party user registration (e.g., user ID and account authentication) could help ensure that costs were not accrued by non-Canadian or unauthorized (unregistered) users. All technical

[88] Note that the "Total Conversation" technology requires significant end-user equipment specifications for optimum performance, e.g., processor speed, memory, etc.

considerations for mitigation against potential VRS fraud will need to be assessed against non-technical considerations such as end-user privacy, potential barriers to ease of access, and overall increase in system complexity and costs.

Fraud will be a topic in subsequent VRS feasibility study phases.

8.3. Quality of Service

Quality of service will be a topic of discussion on its own under study phase 7. From a technology perspective, data capture of call attempts, denials and wait times from end-user software and/or from VRS provider system software could potentially provide ongoing assessments of VRS vendor quality of service. Such measures would, like those for fraud, need to be assessed against other non-technical considerations such as end-user privacy, potential barriers to ease of access, and overall increase in system complexity and costs. [89]

8.4. Consumer Options

Typically VRS consumers are able to make personal choices regarding their VRS call handling and supporting information. These choices include but are not limited to language and modality of interpreting (e.g., LSQ, ASL, close up signing, signed English or signed French, hearing carry over, voice carry over, etc.), personal address books, and potentially even special topics or vocabulary (e.g., for calls to a medical environment, legal, or other speciality). These types of consumer options or preference choices can be the purview of the VRS providers, or such choices could be maintained within national or regional databases. If the data were maintained by non-VRS vendors, the data could be made available to all serving vendors, perhaps at the option of the individual consumer. Such preferences would also be maintained when and if vendors are changed out as a result of periodic bidding for award of VRS provider(s), or the possible withdrawal of a contracted service provider. While a central database is technically feasible, it would impose its own design constraints on the VRS model architecture for Canada. A central database of this type has many advantages as well as significant drawbacks, and will be discussed in study phase 11, Potential Canadian VRS Models.

8.5. Central Versus Local Call Distribution

As implied above in sections 8.1 through 8.4 there will be significant technical considerations involved with the choice of VRS architecture for Canada. Models that are regional by telephone company for example will have different technical challenges compared to a national architecture, whether or not such models involve a single vendor or multiple vendors. An architecture may have all local calls going to a regional provider, while another may have all calls going to a single point from which calls are

[89] Non-technical means of acquiring quality of service information can include customer surveys, vendor reporting, and measurement and assessment of consumer complaints.

distributed to VRS call centers based on availability of interpreters, language choice, regional or cultural issues, and other consumer choices.

9. Future Technology Trends

9.1. The Technological Progress Enabling VRS

This report has described a range of technological considers for VRS, beginning with the original technology that enabled communications access to the Deaf and hard of hearing (the TTY). The evolving development and use of the computer, the videophone, the broadband infrastructure, and VRS provider technologies have created an environment that can potentially enable Deaf consumers to freely communicate in their native sign language with non-sign telephone users through VRS.

The latest developments in portable technology, wireless access, video-enabled smartphones and tablets have created a new level of accessibility not possible a very short time ago. Only four years ago a presentation was given by Omnitor, a technology company in Sweden, regarding the use of 3G cellular service for VRS.[90] In this presentation they described a "3G Signing Revolution" in which a large percentage of Sweden's Deaf population were switching to wireless as their preferred technology: "70% of signing Deaf Swedes use 3G video calls as one of their favourite communication means." The presentation described acceptance and penetration in spite of the fact that the then current wireless technology was less than adequate for this purpose. For example:

- "Picture frequency varies largely between models. The best can make 15 fps. 15 is possible to use [for sign language] but jerky, 20 is smooth and good.
- "For a long time, only one videophone gave usable performance (NEC 616). All others had too low frame rate."
- "Still screen size, camera angle and camera low light sensitivity are common problem areas."
- "The current 3G phones give very limited quality. Only usable for short conversations on easy topics."
- "Now and then during a signed call, there is a need for exact spelling. Especially with current 3G videophones fingerspelling is hard."[91]

Just a few years later, 4G phones and wireless devices with software programs such as 'Facetime' have enabled the technological fine tuning to make mobile sign language and wireless VRS a reality. In fact, mobile phones of today provide many additional communication tools that can enhance the experience of the Deaf and hard of hearing consumer outside of the VRS environment. For example:

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[90] Omnitor's self-description is to: "Improve Deaf communication and bring modern telecom development to the benefit for all."

[91] Gunnar Hellström; Omnitor; The 3G Signing Revolution; TDI-2007 Presentation

- ☑ Cell phones can use video for checking signed video mail messages.
- ☑ An application for subtitles can be used to follow dialogue while watching films in a movie theater.
- ☑ An application can enable the cell phone vibrate and flash to provide an alert when loud noises are present near the phone.
- ☑ An iPhone application amplifies sound around the user and turns it into a hearing aid device that can even adjust frequencies according to the user's preferences.[92]

However, just because the technology is available does not mean it is accessible. As reported in this study's phase 4 report, many countries that have VRS have not yet made it available via wireless technologies, e.g. the UK, Switzerland, Czech Republic and Australia.

Thus, although a new technology may not be currently viable, this does not necessarily imply that it will take a long time to be developed. As demonstrated with mobile video, the technological evolution took only a few years to perfect. Since most MRS contracts last many years and are sometimes extended, their ability to enable new technologies should receive significant consideration.

9.2. Developments in Sign Automation

A new technology being researched is one that one day may potentially enable automation of video relay services. The European Union of the Deaf (EUD) is currently funding a three year "SignSpeak" project to "eventually" create software capable of translating between sign language and text or synthesized speech.[93] The stated goal of the project is to "develop a new vision-based technology for recognizing and translating continuous sign language to text (i.e. provide Video-to-Text technologies), in order to provide new e-Services to the Deaf community and improve their communication with hearing people."[94] This technology could have significant implications for the Deaf in that it could, "possibly allow the Deaf community to communicate with hearing people without having to use a relay service." While similar research has been conducted in the United States in the past, the advances in computer graphics (CGI) and faster more powerful computers provide greater possibilities than in the past.

The SignSpeak project started April 1, 2009. In addition to the EUD, whose involvement is to represent the needs of the Deaf community, the project is a collaboration of various research entities from Spain, the Netherlands, Germany and Belgium. Telefonica is the main industrial partner in this consortium.

Currently in its second year, the project is studying the "linguistic understanding of sign languages" from the perspective of machine recognition. It is creating a system to track the dominant and non-dominant hand, as well as facial expressions and body posture. In addition, it is creating the context for the translated sign by taking into account the signs performed before and after the sign. SignSpeak is using

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[92] www.leimobile.com; LEI Mobile; Facetime; Useful iPhone Apps for the Deaf; page 3

[93] http://www.signspeak.eu/

[94] SignSpeak Consortium; SignSpeak Annual Public report; 2nd year; Abstract

the same approach found in text-to-speech and speech-to-text technologies and applying them to sign language recognition. Development of this technology is a first step towards solutions that can understand and translate sign language with an acceptable degree of accuracy found in these other technologies.

The SignSpeak project outlines some of the difficulties it expects to encounter in creating efficient software capable of translating sign language. Some of these challenges include:

- "Multimodal language": sign languages involve many simultaneous channels for communicating (hands, facial expressions, head movements, etc.)
- "Need to be more natural": The signer needs to be understood by the machine without wearing gloves or other types of sensors or markers
- "Robustness and self-adaptation to the changing ambient conditions": Developing automated detection and tracking techniques to minimize problems with clothing, lighting, viewpoint angle, background clutter, etc.
- Signer-dependency vs. signer-independency: First phase of the project is to work with training a SignSpeak signer for reliability and further stages will support a random signer
- Contextual translation: System needs to carry out continuous translation and not just identifying isolated signs
- Multilingual: A scientifically challenging task to be overcome by modeling and statistical methods is that there are many different sign languages and only a few grammar patterns
- Spatial reference handling: Analysis of the "spatial information containing the entities created during the sign language discourse (Considered by the Project team to be too challenging for a three-year objective and therefore not considered part of the project)
- Software integration: the need to integrate the different prototypes developed for multimodal visual analysis, sign language recognition and translation will be accomplished using a common framework
- Real time factor around 20: Initial project goal not to be a 'real time translator'. 'Real time factor of 20 means that 6 seconds of video will take 2 minutes to provide the translation
- Vocabulary size: Initially limited to around 4,000 words.[95]

The above challenges indicate that the technology delivered by the SignSpeak project will be far from complete and will not be able to replace the human Interpreter in a Video Relay Service any time soon.

France is also experimenting with a Virtual Sign Language technology. There is a consortium of Academic, Industrial and Research partners working on the "SignCom Project" which is funded by the Agence Nationale de la Recherche (ANR), the French National Research Agency.[96] The basic goal of the

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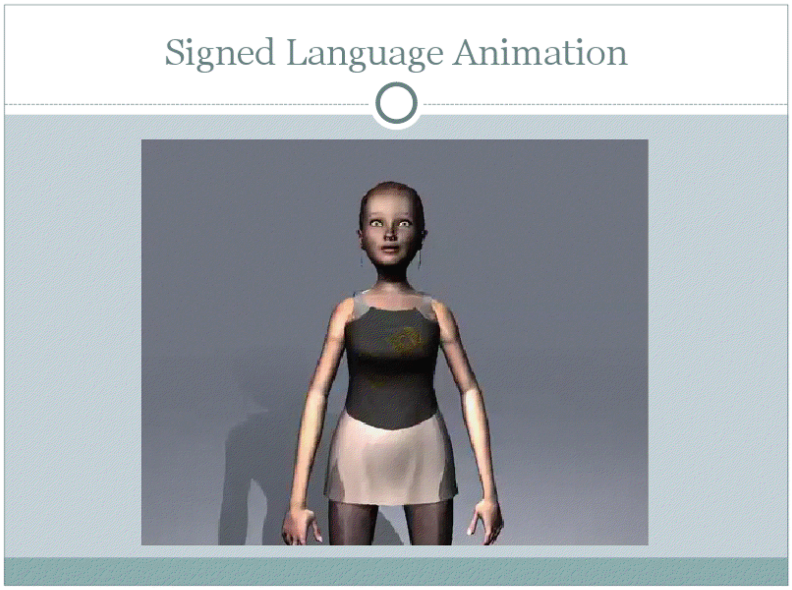
[95] SignSpeak Consortium at http://www.signspeak.eu/en/partners.html; SignSpeak Annual Public report; 2nd year at http://www.signspeak.eu/deliverables/SignSpeak%20-%20Annual%20Public%20Report%20-%20year%202-v1.pdf; SignSpeak Specifications at http://www.signspeak.eu/en/specifications.html.

[96] http://www-valoria.univ-ubs.fr/signcom/en/.

project is to “improve the quality of real-time interaction between humans and virtual agents.” By using motion capture data and building a comprehensive database of multiple repetitions of the same sign in many different contexts, the team is able to animate a virtual French Sign language (LSF) signing avatar.[97]

Figure 29: The SignCom LSF virtual interpreter avatar[98]



The project has oriented its goals into: 1) sign language analysis, and 2) sign language animation. The data collection for analysis included motion capture (mocap), video and annotations. They created the “vocabulary” for the avatar by initially using 12 cameras placed around a laboratory sign language interpreter to capture the motions of body markers placed on the subject. [99] Once the vocabulary database is built, they can be used to animate the avatar in various applications, although the research “will be valuable for the creation of multiple ‘intelligent and expressive’ interfaces for people who use signed languages”. The SignCom project listed two main applications:

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[97] Corpus Design for Signing Avatars; by Kyle Duarte and Sylvie Gibet; Université de Bretagne-Sud, Laboratoire VALORIA, Vannes France; Author manuscript , published in “Workshop on Representation and Processing of Sign Languages: Corpora and Sign Language Technologies, Valetta: Malta (2010)

[98] http://www-valoria.univ-ubs.fr/signcom/en/index.php?a=avatar.

[99] The markers included: 41 facial markers, 43 body markers and 12 hand markers (six per hand). Language resources and Evaluation Conference (LREC); Valletta, Malta; May 22-May 23 2010; Kyle Duarte and Sylvie Gibet; Université de Bretagne-Sud, Laboratoire VALORIA, Vannes France; Heterogeneous Data Sources for Signed Language Analaysis and Synthesis: The SignCom Project

- Interactive kiosk: "making public announcements accessible for Deaf and Hard-of-Hearing people is recognized as a [French] national priority. With the interactive kiosk, users' gestures are captured by cameras and recognized by the system; then, responses are provided through a virtual expressive character, giving information and advice. In this case, the dialogue is guided by restrictive scenarios."

- Virtual Reality: "LSF signs, previously recorded with motion capture (mocap), are used to drive a virtual character's animation. Interaction is guided by the progressive construction of a 3D virtual space shared by the human user and the humanoid character."[100]

There are no indications of when these applications would be commercially available. However, in a July 22, 2010 update to the Corpus Abstract, they conclude: "Having collected our data, we believe that we have an excellent base with which we can create convincing animations of French Sign Language, due in large part to the intentional way we built the SignCom corpus."[101] In addition to the referenced presentation at the LREC conference in Malta in May of 2010, the project team has shared their experience and results at many other venues. These include: Proceedings of the Colloque A3DM 2010 in Poitiers, France June 17-18 2010; Proceedings of the Workshop Traitement Automatique des Langues des Signes (TALS 2010), Montreal, Quebec, Canada, July 23 2010; and the First International Workshop on Sign Language Translation and Avatar technology in Berlin, Germany, January 10-11, 2011.[102]

There are other examples of technologies attempting to replicate the sign language translation abilities of an interpreter.

A company called iCommunicator states that although they are developing similar technology, the goal of their product is to augment not replace human sign language interpreters: "The iCommunicator is not intended as a replacement for sign-language interpreters, but as an alternative when an interpreter is not available: Classroom Settings, Daily Communication, Ad hoc Meetings, Emergency Situations."[103]

As time progresses, these technologies will be refined and supplanted by new technologies that have yet to be imagined. In the context of preparing for the possibility of deploying VRS, advancements in automated technologies such as computer generated interpreting of sign language and converting it to speech, or the use of animation and avatars, may hold the promise to provide

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[100] www.valoria.univ-ubs.fr/signcom; Valoria University website; The SignCom Project: Sign-Based Communication Between Real and Virtual Agents; Overview; Applications

[101] Corpus Design for Signing Avatars; by Kyle Duarte and Sylvie Gibet; Université de Bretagne-Sud, Laboratoire VALORIA, Vannes France; Author manuscript , published in "Workshop on Representation and Processing of Sign Languages: Corpora and Sign Language Technologies, Valetta: Malta (2010); hal-00505182, version 1 – July 22, 2010

[102] www.valoria.univ-ubs.fr/signcom; Valoria University website; The SignCom Project: Sign-Based Communication Between Real and Virtual Agents; Dissemination; Publications and Events

[103] www.icommunicator.com; Product information

additional video and sign language interpreting options in the future, but it is uncertain that these technologies will be robust or accurate enough to satisfy the personal interaction generally required in relay services.

10. Conclusion

Developments in technologies directly pertinent to VRS have in recent years have progressed in many areas. New highly capable technical products such as computers, mobile devices and videophones offer consumers unprecedented communication capabilities. These together with the very high availability of wired and wireless broadband to almost all Canadians, and advances in VRS provider services, all indicate that there are no technical barriers to implementing VRS in Canada.

The primary challenges to selecting and implementing the technical VRS solutions will be non-technical, such as consumer education and training, cost considerations, and other policy and program issues, which will be explored in other phases of this VRS Feasibility Study.