7 Technical Future Needs

7.1 Introduction

The aim in this chapter of the Assessment is to predict how much bandwidth will be required in the Arctic, by community, to meet the future needs of government.

These projections are based on information gathered from the workshop discussions and responses to the ACIA survey, and simply provide a starting point for projecting bandwidth needs in the future. The data gathered during the short phase of this Assessment does not represent every initiative planned across the Arctic.

Predictions depend on accurate data being entered into a prediction model that will provide a guideline for planning. Of course, because predictions are based on assumptions in the future that may or may not turn out to be true, they are, by their very nature, inexact. But they do provide a starting point for discussion.

Section 7.2 describes the ACIA bandwidth prediction model developed for this part of the Assessment, in detail. It indicates the assumptions made in the many variables and explains the data input values.

Section 7.3 provides charts, divided by territory, indicating the specific amount of bandwidth required by community, based on the inputs to the ACIA Predictive Model.

One can easily see from Section 7.3, the gap between what is available now, by community, and what will be required in the future.

7.2 ACIA Predictive Bandwidth Model Development

In order to develop a model that can be used to estimate the amount of bandwidth required for a given community there are several components that need to be calculated or estimated. The next section called "defining variables" provides a complete list of each variable used in the model. Then each variable is described in detail, and provides the data used in the prediction model.

Defining variables

Knowing what applications people will use, how often they will use each application, where they use it, what time of day, and how long each application is used are just some of the variables that go into predicting how much bandwidth will be required to serve a specific community.

This section (7.2) of the report will provide an explanation for each of the variables used to predict the bandwidth that will be needed by each community.

If governments wish to refine their bandwidth predictions further based on additional data, the ACIA predictive model tool is posted at www.aciareport.ca.

The following table describes each of the parameters used in the ACIA predictive model including the variable name and whether the value is estimated or calculated. The remainder of this model explanation is provided throughout this section.

Parameter Description	Variable	Calculated/ Estimated
Inbound bandwidth required for a given application category	Bai	Estimated
Outbound bandwidth required for a given application category	Bao	Estimated
Number of applications for a given application category by user base	A	Calculated
Number of concurrent sessions for a given application category	C = n*L/T	Calculated
Length of the average day that an application category is used in minutes	T	Estimated
Average length of a given session for a given application category	L	Estimated
Number of users utilizing a given application category on a typical day	n=U*Pu	Calculated
The total number of users of a given type of application within a given community	U	Estimated
Percentage of users using a given application category on a given day	Pu	Estimated
Percentage of applications of a given category used on a given day	Pa	Estimated
Inbound bandwidth required for a given application category for a given user type within a community	IB	Calculated
Outbound bandwidth required for a given application category for a given user type within a community	OB	Calculated

Variables "Bai and Bao": Defining inbound and outbound values by application categories

Some applications like email, are not particularly sensitive to latency or heavily loaded networks, while other applications are very sensitive to any interruptions in the flow of data, such as videoconferencing.

In order to better predict the network resources required to support planned applications, the ACIA predictive model categorizes each application according to a common set of criteria. Each application is categorized as either 'casual' for less sensitive applications, 'critical' for more sensitive applications, or 'additional service categories' for specific applications.

Each of the inbound and outbound values listed beside each category of application represents the minimum Quality of Service (QoS) required per concurrent session. This provides us with all of the required values for ***Bai*** and ***Bao***.

The Casual Category includes applications such as email, web browsing, instant messaging, and other similar applications. Each of these "casual" services has an underlying design that can deal with uneven bandwidth, and can do so without truly impeding function or usability. To ensure some base level of functionality for casual services a "QoS" value of 128Kbps has been used.

'Casual' Category	Inbound (Kbps)	Outbound (Kbps)
Intranet	256	
Internet (work)	256	128

The Critical Category includes voice connections, live business video, and business related media streaming or file transmission, not including email. These categories require a minimum Quality of Service (QoS) level in order to function properly.

For critical services, QoS must be provided at all times, even during peak loads. For each of these services a QoS value for inbound and outbound bandwidth has been assigned based upon industry published standards. The following table describes the QoS for each of the critical services.

'Critical' Category Service	Inbound(Kbps)	Outbound (Kbps)
VoIP	90	90
Streaming video	256	
Video conferencing	512	512
Client/Server	256	256

These values represent the QoS bandwidth requirements per concurrent session. To estimate the total inbound and outbound bandwidth needed at any given time for a critical service the values above must be multiplied by the expected number of concurrent sessions.

Additional service categories (in addition to 'critical' and 'casual') were also used in the ACIA predictive model:

- Education – applications used to deliver rich content to students.
- eHealth – this is the eHealth application that would be deployed to remote communities to be used for remote diagnostics and examinations. This is a single application.
- Internet (population) – Internet browsing and email for the population of the community. (While public users were not part of this Assessment, in predicting community usage, it is important to include the public as a draw on the networks servicing the community. The model uses the 256 kb/s inbound and 128 kb/s outbound for end users – a low figure that will surely rise.)

'Additional Service' Category	Inbound (Kbps)	Outbound (Kbps)
Education	512	512
eHealth	512	512
Internet (population)	256	128

Variable "A": Number of applications for a given application category by user base

Specific data was collected from a wide range of government participants in this Assessment. Various departmental representatives were asked to submit information about the actual applications they were currently running and planned to run in the next 3 to 5 years.

Data was submitted by federal, NWT and Yukon government participants. In Nunavut, application data for all departments was provided directly by Community and Government Services. A summary of these applications are in Appendix C.

These counts are not an exhaustive list of every single application, but are used to provide a starting point based on data collected as part of this Assessment.

All applications identified through the completed surveys and workshops were captured into a consolidated dataset. Each application identified was then grouped by which government planned to use the application. Four user groups were identified:

- Government of Canada
- Government of Nunavut
- Government of Yukon
- Government of Northwest Territories

A count of applications within each category, separated by user group is below.

To predict needs in the future, this table includes both applications being used now plus applications planned for the near future. Note: the number below only include applications that were identified in the course of this assessment -- it does not reflect every application being run or planned in the Arctic.. This provides us with all of the required values for ***A***.

Category	Application Count			
	Federal	**Nunavut**	**NWT**	**Yukon**
Intranet	28	4	64	11
Internet (work)	1	1	1	1
VoIP	1			
Streaming Video	1	1	2	
Video Conferencing	2			1
Client/Server	32	35	70	17
Education				1
eHealth		1	1	1
Internet (population)		1	1	1

Variables "C = n*L/T": Calculating concurrent sessions by application category

The next calculated parameter is the estimated number of concurrent sessions for a given application category. In order to calculate this we assume a Poisson distribution for members of the user community connecting to a given application category over a given time period. The formula for the Poisson distribution is:

C = n*L / T

In order to calculate the number of concurrent sessions, ***C***, we first estimate the average length of a session, ***L***, and the length of a typical workday that the application category will be utilized, ***T***. The following table provides the ***T*** and ***L*** values, in minutes, for each of the application categories used in our model:

Category	L	T
Intranet	10	480
Internet (work)	10	480
VoIP	3	480
Streaming Video	10	480
Video Conferencing	30	480
Client/Server	10	480
Education	60	300
eHealth	10	720
Internet (population)	20	960

As indicated these are estimates and as such are relatively subjective. Manipulating these numbers will impact the number of concurrent users and bandwidth requirements.

Variables "n=U*Pu": Calculating user base and percentage of users utilizing a given application on a given day

Calculating the number of users utilizing a given application category on a typical day is by multiplying the number of users (U) by the percentage of users likely to access a given application category on a typical day, expressed in the parameter table as ***n=U*Pu***.

U is the number of users in a given user base with in a community. In order to obtain values for ***U*** the following data was entered into the ACIA predictive model for all communities:

- Total number of Federal government employees
- Total number of Government of Nunavut employees

- Total number of Government of Northwest Territories employees
- Total number of Government of Yukon employees
- Total number of students
- Total population

The charts listing this data are included in Chapter 3 of this Assessment.

Not every user in a user base in a given community will access a given application category every day so we estimate a percentage of users that will likely access a given application category on a typical day (***Pu***).

Additionally, not every application within a category will be accessed every day and so an estimate is also required for the number of applications within an application category that will be accessed on a typical day (***Pa***). The following table provides estimates for the ***Pu*** and ***Pa*** values for each of the application categories:

Category	Pu	Pa
Intranet	50%	50%
Internet (work)	80%	100%
VoIP	80%	80%
Streaming Video	30%	50%
Video Conferencing	1%	100%
Client/Server	10%	50%
Education	80%	50%
eHealth	1%	100%
Internet (population)	80%	100%

With all required parameters defined the consolidated table of values is below

Category	In-bound (Kbps)	Out-bound (Kbps)	L	T	Pu	Pa	Federal	Nunavut	NWT	Yukon
Intranet	256		10	480	50%	50%	28	4	64	11
Internet (work)	256	128	10	480	80%	80%		1	1	1
VoIP	90	90	3	480	80%	80%	1			
Streaming Video	256		10	480	30%	50%	1	1	2	
Video Conferencing	512	512	30	480	1%	100%	2			1
Client/Server	256	256	10	480	10%	50%	32	35	70	17
Education	512	512	60	300	80%	50%				1
eHealth	512	512	10	720	1%	100%		1	1	1
Internet (population)	256	128	20	960	80%	100%		1	1	1

Variables "IB and OB": Calculating inbound & outbound requirements by community

With all of the required parameters we can now calculate the required inbound (***IB***) and outbound (***OB***) bandwidth for a given application category for a given community using the following set of equations.

n = U * Pu

C = n * L / T

IB = C * Bai * Pa * A

OB = C * Bao * Pa * A

To calculate the total inbound and outbound bandwidth required we would sum the ***OB*** and ***IB*** values for each application category. This will provide us with the required QoS for a given community in order to adequately meet the expected demand.

The three territorial capitals require an additional level of consideration. As they host the Intranet and client/server applications, local traffic for these application categories would not leave the community and therefore should not be included in the bandwidth requirement. However, the aggregate bandwidth from all of the other communities in the territory for these two application categories will arrive in the territorial capital, excluding the federal government employees.

For the three territorial capitals the values for the Intranet and client/server application categories are the sum of the inbound and outbound bandwidth calculations for all of the other communities in the territory.

IB = sum(OB)

OB = sum(IB)

Architecture, hosting and routing impact on bandwidth requirements

The bandwidth numbers expressed by the provided predictive model are intended to be guidelines only - not final numbers.

In order to provide more accurate bandwidth predictions for network requirements a number of considerations must be included, including the network architecture, hosting decisions and routing of data.

Network architectural decisions, such as where the community's bandwidth terminates will have an impact upon the bandwidth required from a given community. As an example, bandwidth from a community may terminate in another community in the North or may travel out of the North bound for the Internet or another service hosted in the South.

Hosting more services in the North will reduce the bandwidth required with the South but increase the bandwidth required between communities in the North. Similarly, services hosted in the North that need to be accessed from the South will increase the bandwidth required between the North and the South. Careful consideration should be paid when considering where to host services based upon where the largest user base of the service will reside.

Traffic routing also affects bandwidth projections. The network architecture dictates how the traffic is routed. Routing all traffic through a centralized hub will increase the bandwidth required for the hub specifically and the overall bandwidth required across the network as traffic must first travel to the hub and then to the final destination.

Given the nature of land based communications and the realities of the North some of this may be unavoidable as the cost or feasibility renders the creation of any sort of land based meshed network impossible. Again, paying careful consideration to where services

are hosted in conjunction with the network architecture can have a dramatic impact on bandwidth requirements for a given community.

The cost of bandwidth and physical realities of the North must be considered when deciding on where to host services. The closer a given service can be to the largest user base the less bandwidth will be consumed routing traffic between the user community and the service. Additionally, the lower the number of hops required between the user community and the service the lower the amount of bandwidth that will be consumed. Consuming less bandwidth translates into lower costs and improved performance.

Adjusted Mbps

In the bandwidth projections on the next pages, we have provided a column titled "Total Mbps".

The 'Total Mbps" are the calculated Committed Information Rate (CIR) values required to support the expected applications and activities. The Total Mbps is not the final total that is necessary to support applications properly.

The next step is to calculate the "Adjusted Mbps" to allow for a reasonable amount of burst space, and an allowance for overhead. Using a rule of thumb that CIR should not account for more than 35% of available bandwidth the calculated Mbps was adjusted to arrive at the Adjusted Mbps by community.

7.3 Bandwidth Projections by Community

Yukon Bandwidth Prediction

Community	Federal Gov't		Yukon Gov't		Students		Population		Total (Mbps)		Adjusted Total (Mbps)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Out-bound	Inbound	Outbound
Beaver Creek	0	0	2009	1716	256	128	956	734	**3.2**	**2.6**	**9.20**	**7.37**
Blanchard	0	0	583	498	256	128	512	512	**1.4**	**1.1**	**3.86**	**3.25**
Burwash Landing	0	0	389	332	256	128	956	734	**1.6**	**1.2**	**4.57**	**3.41**
Carcross	0	0	4408	3764	256	128	2351	1431	**7.0**	**5.3**	**20.04**	**15.21**
Carmacks	0	0	4537	3875	444	222	2581	1547	**7.6**	**5.6**	**21.61**	**16.12**
Dawson City	0	0	15167	12952	802	401	8538	4525	**24.5**	**17.9**	**70.02**	**51.08**
Destruction Bay	0	0	1296	1107	256	128	713	612	**2.3**	**1.8**	**6.47**	**5.28**
Drury Creek	0	0	259	221	256	128	512	512	**1.0**	**0.9**	**2.94**	**2.46**
Eagle	0	0	519	443	256	128	512	512	**1.3**	**1.1**	**3.68**	**3.09**
Faro	0	0	3241	2768	256	128	2176	1344	**5.7**	**4.2**	**16.21**	**12.11**
Fraser	0	0	389	332	256	128	512	512	**1.2**	**1.0**	**3.31**	**2.78**
Herschel Island	0	0	259	221	256	128	512	512	**1.0**	**0.9**	**2.94**	**2.46**
Haines Junction	0	0	8426	7196	559	279	3964	2238	**12.9**	**9.7**	**37.00**	**27.75**
Klondike	0	0	648	554	256	128	512	512	**1.4**	**1.2**	**4.05**	**3.41**
Marsh Lake	0	0	0	0	256	128	2462	1487	**2.7**	**1.6**	**7.77**	**4.61**
Mayo	0	0	5056	4317	260	130	2385	1449	**7.7**	**5.9**	**22.00**	**16.85**
Old Crow	0	0	1750	1494	256	128	1506	1009	**3.5**	**2.6**	**10.03**	**7.52**
Ogilvie	0	0	389	332	256	128	512	512	**1.2**	**1.0**	**3.31**	**2.78**
Pelly Crossing	0	0	2009	1716	256	128	1877	1195	**4.1**	**3.0**	**11.84**	**8.68**
Ross River	0	0	3565	3044	260	130	2014	1263	**5.8**	**4.4**	**16.68**	**12.68**
Stewart Crossing	0	0	454	387	256	128	512	512	**1.2**	**1.0**	**3.49**	**2.94**
Swift River	0	0	454	387	256	128	512	512	**1.2**	**1.0**	**3.49**	**2.94**
Tagish	0	0	65	55	256	128	1557	1035	**1.9**	**1.2**	**5.37**	**3.48**
Teslin	0	0	3500	2989	256	128	2487	1500	**6.2**	**4.6**	**17.84**	**13.19**

Community	Federal Gov't		Yukon Gov't		Students		Population		Total (Mbps)		Adjusted Total (Mbps)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Out-bound	Inbound	Outbound
Tuchitua	0	0	519	443	393	196	512	512	**1.4**	**1.2**	**4.07**	**3.29**
Watson Lake	0	0	11408	9742	474	237	7019	3765	**18.9**	**13.7**	**54.00**	**39.27**
Whitehorse	25240	14742	60886	71300	17446	8723	114101	57986	**217.7**	**152.8**	**621.92**	**436.43**

NWT Bandwidth Prediction

Community	Federal Gov't		NWT Gov't		Students		Population		Total (Mbps)		Adjusted Total (Mbps)	
	Inbound	Out-bound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Out-bound	Inbound	Outbound
Aklavik	0	0	6266	3622	623	311	3319	1916	***10.2***	***5.8***	**29.17**	**16.71**
Behchoko	0	0	18579	10738	2577	1289	9387	4949	***30.5***	***17.0***	**87.27**	**48.50**
Colville Lake	0	0	989	572	256	128	1186	849	***2.4***	***1.5***	**6.95**	**4.43**
Deline	0	0	4398	2542	572	286	2931	1722	***7.9***	***4.5***	**22.57**	**13.00**
Detah	0	0	0	0	256	128	1621	1067	***1.9***	***1.2***	**5.36**	**3.41**
Enterprise	0	0	1539	890	256	128	930	721	***2.7***	***1.7***	**7.79**	**4.97**
Fort Good Hope	0	0	4398	2542	499	250	3038	1775	***7.9***	***4.6***	**22.67**	**13.05**
Fort Liard	0	0	4507	2605	521	260	3017	1764	***8.0***	***4.6***	**22.98**	**13.23**
Fort McPherson	0	0	5937	3431	832	416	3904	2208	***10.7***	***6.1***	**30.49**	**17.30**
Fort Providence	0	0	7036	4066	836	418	3785	2148	***11.7***	***6.6***	**33.31**	**18.95**
Fort Resolution	0	0	4617	2669	435	218	2620	1566	***7.7***	***4.5***	**21.92**	**12.72**
Fort Simpson	0	0	23197	13406	1071	535	5931	3221	***30.2***	***17.2***	**86.28**	**49.04**
Fort Smith	0	0	54309	31388	2564	1282	11106	5809	***68.0***	***38.5***	**194.23**	**109.94**
Gamèti	0	0	1539	890	350	175	1796	1154	***3.7***	***2.2***	**10.53**	**6.34**
Hay River	0	0	31112	17981	3179	1589	16410	8461	***50.7***	***28.0***	**144.86**	**80.09**
Hay River Res.	0	0	2419	1398	303	151	1911	1212	***4.6***	***2.8***	**13.24**	**7.89**
Inuvik	0	0	54419	31451	2846	1423	15667	8090	***72.9***	***41.0***	**208.38**	**117.04**
Jean Marie River	0	0	220	127	256	128	815	663	***1.3***	***0.9***	**3.69**	**2.62**
Kakisa	0	0	220	127	256	128	747	629	***1.2***	***0.9***	**3.49**	**2.53**
Lutselk'e	0	0	2529	1461	346	173	1779	1146	***4.7***	***2.8***	**13.30**	**7.94**

Community	Federal Gov't		NWT Gov't		Students		Population		Total (Mbps)		Adjusted Total (Mbps)	
	Inbound	Out-bound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Out-bound	Inbound	Outbound
Nahanni Butte	0	0	660	381	256	128	1024	768	***1.9***	***1.3***	**5.54**	**3.65**
Norman Wells	0	0	12863	7434	597	299	3994	2253	***17.5***	***10.0***	**49.87**	**28.53**
Paulatuk	0	0	2419	1398	354	177	1946	1229	***4.7***	***2.8***	**13.48**	**8.01**
Sachs Harbour	0	0	989	572	256	128	1084	798	***2.3***	***1.5***	**6.65**	**4.28**
Trout Lake	0	0	1319	762	256	128	939	725	***2.5***	***1.6***	**7.18**	**4.62**
Tsiigehtchic	0	0	880	508	256	128	1037	774	***2.2***	***1.4***	**6.21**	**4.03**
Tuktuoyaktuk	0	0	4617	2669	849	425	4420	2466	***9.9***	***5.6***	**28.25**	**15.88**
Tulita	0	0	3958	2287	589	294	2918	1715	***7.5***	***4.3***	**21.33**	**12.28**
Ulukhaktok	0	0	3408	1970	414	207	2526	1519	***6.3***	***3.7***	**18.14**	**10.56**
Wekw eèti	0	0	770	445	256	128	1114	813	***2.1***	***1.4***	**6.11**	**3.96**
Whati	0	0	2968	1716	614	307	2633	1572	***6.2***	***3.6***	**17.76**	**10.27**
Wrigley	0	0	1429	826	256	128	994	753	***2.7***	***1.7***	**7.66**	**4.88**
Yellowknife	114721	67006	152872	264510	14532	7266	86439	43928	***368.6***	***382.7***	**1053.04**	**1093.46**

Nunavut Bandwidth Prediction

Community	Federal Gov't		Nunavut Gov't		Students		Population		Total (Mbps)		Adjusted Total (Mbps)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Arctic Bay	0	0	1089	781	947	474	3695	2103	***5.7***	***3.4***	***16.38***	***9.60***
Arviat	0	0	3842	2756	3618	1809	10492	5502	***18.0***	***10.1***	***51.29***	***28.76***
Baker Lake	0	0	2238	1605	2526	1263	8887	4700	***13.7***	***7.6***	***39.00***	***21.62***
Cambridge Bay	0	0	4397	3153	1702	851	7450	3981	***13.5***	***8.0***	***38.71***	***22.82***
Cape Dorset	0	0	2317	1662	1566	783	6515	3514	***10.4***	***6.0***	***29.71***	***17.02***
Chesterfield I.	0	0	574	412	422	211	2146	1329	***3.1***	***2.0***	***8.98***	***5.58***
Clyde River	0	0	1149	824	1306	653	4446	2479	***6.9***	***4.0***	***19.71***	***11.30***
Coral Harbour	0	0	1069	767	1216	608	4224	2368	***6.5***	***3.7***	***18.60***	***10.69***
Gjoa Haven	0	0	2000	1435	1412	706	5367	2940	***8.8***	***5.1***	***25.09***	***14.52***
Grise Fiord	0	0	317	227	256	128	1169	841	***1.7***	***1.2***	***4.98***	***3.42***
Hall Beach	0	0	693	497	755	378	3575	2044	***5.0***	***2.9***	***14.35***	***8.34***
Igloolik	0	0	2891	2074	2125	1062	7706	4109	***12.7***	***7.2***	***36.35***	***20.70***
Iqaluit	15009	8766	32528	45352	5717	2859	30421	15467	***83.7***	***72.4***	***239.07***	***206.98***
Kimmirut	0	0	634	455	567	284	2453	1483	***3.7***	***2.2***	***10.44***	***6.35***
Kugaaruk	0	0	951	682	1067	533	3661	2086	***5.7***	***3.3***	***16.22***	***9.43***
Kugluktuk	0	0	2693	1932	1246	623	6601	3556	***10.5***	***6.1***	***30.11***	***17.46***
Pangnirtung	0	0	2555	1832	1613	806	6810	3661	***11.0***	***6.3***	***31.36***	***18.00***
Pond Inlet	0	0	3010	2159	1788	894	6763	3637	***11.6***	***6.7***	***33.03***	***19.12***
Qikiqtarjuaq	0	0	852	611	465	233	2790	1651	***4.1***	***2.5***	***11.73***	***7.13***
Rankin Inlet	0	0	8377	6008	3183	1591	12160	6336	***23.7***	***13.9***	***67.77***	***39.82***
Repulse Bay	0	0	871	625	1327	663	4245	2379	***6.4***	***3.7***	***18.41***	***10.48***
Resolute Bay	0	0	396	284	256	128	1600	1056	***2.3***	***1.5***	***6.43***	***4.19***
Sanikiluaq	0	0	1030	739	1126	563	3968	2240	***6.1***	***3.5***	***17.50***	***10.12***
Taloyoak	0	0	792	568	1088	544	4314	2413	***6.2***	***3.5***	***17.70***	***10.07***
Whale Cove	0	0	614	440	610	305	2219	1365	***3.4***	***2.1***	***9.84***	***6.03***