FY 2010 Capital Request Broadband Internet

FY10 Capital Project Request Form for District: C HD 05

Grant recipient name (ie. Name of Municipality, School District, or Organization): **City of Gustavus**

Physical location of project (community name): **Gustavus**

Project Title (should clearly state what the project is): **Community-wide broadband network**

Brief Description of Project (1 or 2 sentences): This project will create a last-mile wireless broadband network covering all Gustavus populated areas of the city except Bartlett Cove and capable of delivering at least 3 Mbps both up and down (but limited by upstream Internet service). The new wireless network will connect to the Gustavus Community Network (GCN, the existing self-sustaining municipal Internet Service Provider) and will deliver fast, reliable, affordable Internet access and community networking to Gustavus homes and businesses.

Total Cost of Project from Inception to Completion: (Total should equal the funding request from the State and funding sources secured, requested or needed listed below): **$193,000**

State Fiscal Year 2010 Funding Request from the State: $183,000

If your project is funded this year, will you be requesting state funding again? (Y/N): No.

Funding Plan

Please list any funding **already secured**, as well as the year it was secured:

Funding Source	Amount Secured	State FY
Federal Funds		
State Funds		
Denali Commission		
Rasmusson Foundation		
Local Funds	$10,000	FY09
Other Funds (explain)		

Please list any non-state funding currently **requested but not yet secured**:

Funding Source	Amount Requested	State FY
Federal Funds		
State Funds		
Denali Commission		
Rasmusson Foundation		

Local Funds
Other Funds (explain)

If you need additional funding to complete this project, please indicate below from whom you intend to secure that funding:

Funding Source	**Amount Needed State FY**
Federal Funds	
State Funds	
Denali Commission	
Rasmusson Foundation	
Local Funds	
Other Funds (explain)	

Please provide a detailed description and project justification

(approx. a one page summary, attach all other project back up with this form)

Overview and Benefits

This project will improve community health and safety and promote economic development and curb out-migration by delivering affordable, reliable, low-latency broadband Internet access, improving coverage and reliability for the city's emergency services, and allowing other advances in communications such as improved cell phone coverage. It builds on the success of the Gustavus Community Network (GCN), which has been completely self-sustaining since 1996. GCN reserves from subscriber fees will provide the $10,000 in local funds for this project.

The importance of broadband Internet access for economic development and health and safety (i.e. telemedicine) has been well documented. Currently, the best Internet access available in most of Gustavus is satellite service such as StarBand or Hughes Net. These services, however, suffer from high latency, high cost, and low performance and reliability. Due to their slow upload speeds they do not meet the original FCC definition of "broadband" (256 Kbps both up and down), much less the current definition (750 Kbps both ways). This project will deliver true broadband Internet service to the entire community with the exception of the Bartlett Cove area.

A few parts of Gustavus already have high-speed connections to the Gustavus Community Network (GCN), a non-profit Internet Service Provider that has been self-sustaining since 1996, now owned and operated by the City of Gustavus. For example, GCN delivers high-speed Internet access to the Gustavus Public Library, City Hall, and customers in the Salmon River meadow area, but the rest of town has only dial-up connections to GCN, many of which are hampered by sub-standard phone lines, or their own satellite dishes. By the end of FY09 GCN will have low-latency broadband Internet access from AT&T Alascom. This project will allow GCN to share that excellent broadband Internet service with the entire community -- service they cannot get any other way.

Additional benefits of the communications tower provided by this project include better coverage for City of Gustavus emergency communications, better coverage for public radio, and potentially better cell phone coverage and other advances in communications should providers wish to use the new tower facility.

Project Description

This project will erect a multi-purpose 40' communications tower east of Gustavus at an elevation of approximately 550 feet. An equipment hut donated by the Coast Guard will be installed at the base of the tower. This site, part of the Falls Creek hydroelectric project area, has a clear view of Gustavus. Testing conducted during the summer of 2008 demonstrated usable data connections between the site and most parts of Gustavus using 900 MHz radios manufactured by Trango as recommended by Borealis Broadband in its Gustavus wireless design study.

A 900 MHz base station with high-gain sector antenna will be installed on the communications tower and a wireless link established to Gustavus Public Library, the current GCN network center. Then the wireless link for Internet access from AT&T Alascom's facility will be re-aligned to connect to the Falls Creek tower and the network re-configured so the library and GCN gets its Internet access from the tower.

Finally, 900 MHz client premises radios will be installed at homes and businesses throughout Gustavus. Some customers will need external directional antennas. Some customers in westernmost Gustavus will still not have direct access to the base station so repeater stations will have to be installed. Bartlett Cove will not receive a high-speed connection under this project; that will require an additional future effort. This project funds connecting all current GCN subscribers plus about 20 more. GCN has historically had as many as 158 subscribers so there will likely be additional customers wishing to connect after this project is complete. They will pay for the installation themselves, be funded by GCN proceeds, share connections with other customers using inexpensive wi-fi, or be paid for from other grant funds.

The Gustavus Volunteer Fire Department will relocate its base station to the tower to improve coverage for its emergency communications. The facility will be made available to other providers and Juneau public radio station KTOO has already expressed strong interest in siting its repeater there.

Detailed budget

Item	Qty	Price	Amount
Site permits and fees			$500
Site preparation			$1,000
Communication tower package			$4,000
Communication tower shipping			$1,500
Communication tower erection			$2,000
Communication tower and equipment hut wiring and finishing			$1,000
Uninterruptible power system for equipment at tower site			$1,500
Communication tower project management			$2,000
Broadband base station with shipping Trango M900S access point			$2,100
High-gain sector antenna for base station with shipping			$1,400
Broadband base station and antenna installation, configuration, and testing	20 hr	$100	$2,000

Internet backhaul reconfiguration (20 hours to move radio to new tower site and re-configure Alascom P-P link and network routing. Includes estimated Alascom fee of $800)			$2,800
Client premises radios, including shipping: Trango M900S subscriber unit	100 ea	$750	$75,000
Client premises external high-gain antennas for marginal areas with shipping	20 ea	$60	$1,200
Client radio mounting hardware, outdoor installation, configuration, and testing	100 ea	$200	$20,000
Project management for wireless network deployment			$40,000
Administration of CIP grant, purchasing, and accounting, approximately 5%			$8,000
Contingencies allowance: approximately 15% of $178,900 for inflation and other unexpected expenses			$27,000
Project Total			**$193,000**

Please describe the project time-line and when expenditures will occur:

December, 2008 through March, 2009: Final design work, obtain site permit(s).

April, 2009: Order tower using local matching funds

July, 2009: Project manager hired, tower arrives, contract awarded for tower installation

August, 2009: Tower installed, base station and first few client premises radios ordered

September, 2009: Project manager hired for client premises installation. Client premises radios ordered. Base station installed and tested, library connected, Internet backhaul re-configured

October, 2009: Tower installation signed off as complete. First 20 client premises radios arrive. First installations take place.

November, 2009 through May, 2010: Client premises radios installed. Repeaters set up as needed.

June, 2010: This project completed.

July, 2010 and beyond: Pre-existing wireless infrastructure removed. Additional client premises radios installed using GCN, subscriber, or other funds.

Who will be responsible for providing the ongoing maintenance and operation costs?
City of Gustavus dba Gustavus Community Network will manage the new network as they manage the existing network. Revenues will be higher and costs lower (cheaper Internet backhaul, no leased line to city hall, more reliable network, fewer lines for dialup). Administration may be contracted out as it currently is to a computer consulting company.

Grant Recipient Contact Information:

Contact Name: Kapryce Manchester, City Clerk, City of Gustavus

State Tax ID Number: 27-00-85777
Phone Number: 907-697-2451
Mailing Address: PO Box 1, Gustavus AK 99826
E-Mail: clerk@gustavus-ak.gov

Has the project gone through a public review process at the local level and is it a community priority by resolution or other official action by the governing body?

(Y/N): Yes. There have been years of public GCN committee meetings where the current broadband plan was discussed and developed. Broadband Internet access is a high priority in the city's Strategic Plan. This CIP request has been the subject public hearing at a city council and has been supported by a resolution of the city council (attached).

You must provide documentation (ie. Copy of resolution and/or appropriate letter(s) of support)

If your project request has not gone through a public and/or governing or appropriate review process for your community or school district then it may not make it through the Legislative process of approval.

If this form is missing information that is not provided in a timely manner, your request will not be able to be included in the FY10 capital project funding requests as we will will not have the information needed to fully support your project should there be questions our office may be asked to answer regarding your project.

City of Gustavus, Alaska

Resolution No. 2008-29

A RESOLUTION IN SUPPORT OF THE PROPOSAL TO 'CONSTRUCT A COMMUNITY-WIDE BROADBAND NETWORK' FOR FUNDING THROUGH THE STATE OF ALASKA CAPITAL IMPROVEMENT PROGRAM

WHEREAS, the Gustavus Community Network (GCN) has successfully provided internet service to the community of Gustavus since 1996 and has a solid record of creativity and self-sufficiency;

WHEREAS, existing dial-up internet service provided to the majority of GCN subscribers is plagued by sub-standard telephone lines, hampering service and resulting in a substantial decline in GCN subscribers;

WHEREAS, private satellite internet services available in Gustavus suffer from high-latency, high cost, low performance and do not meet the FCC definition of 'broadband";

WHEREAS, upgrading the community internet service to broadband has been identified as a critical infrastructure need for the City of Gustavus and received 'strong positive' support as a capital infrastructure project in the 'City of Gustavus Strategic Plan 2005';

WHEREAS, 84% of respondents to the DCRA sponsored 'Gustavus, Alaska: 2008 Community Survey Report' identified improvement of internet connectivity as an important infrastructure project, placing second only to a new dock in importance on a list of 25 infrastructure projects;

WHEREAS, AT&T Alascom will be able to make available low-latency broadband internet service to Gustavus in 2009;

WHEREAS, with proper equipment GCN can link to the AT&T Alascom service to provide true broadband internet service to the large majority of the community, while also providing capacity for enhanced emergency services and other advances in communications such as enhanced cell phone coverage;

NOW THEREFORE BE IT RESOLVED, the Gustavus City Council, in an effort to promote economic development, curb out-migration and improve community health by providing low-latency broadband Internet service,

supports for submission the proposal 'Construct a Community-wide Broadband Network' for a CIP grant.

PASSED and APPROVED by the Gustavus City Council, this 11th day of December, 2008.

_____	_____
William Unkel, Mayor	Paul Berry, Vice Mayor
_____	_____
Wayne Howell, Council Member	Sandi Marchbanks, Council Member
_____	_____
John Nixon, Council Member	Joe Lassiter, Council Member
_____	_____
Louis Cacioppo, Council Member	Attest: Kapryce Manchester, City Clerk

Borealis Broadband

Project Proposal For

City of Gustavus

Wireless Broadband Infrastructure

March 25, 2008

Revision 2.0

NOTICES PAGE

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Accuracy and Completeness:

Every effort was made to ensure the accuracy and completeness of the information in this document, including descriptions, parts, pricing, formulas, numbers, spelling, etc.

We believe this document to be accurate and complete as of the date shown on the cover page.

We expressly reserve the right to correct or adjust for errors or omissions, if any, throughout the term of this project. Any adjustments or corrections made under these circumstances will conform with best-practice procedures and/or published pricing and be coordinated with the City of Gustavus or its assigned representatives.

Revision History:

Document Revision Number: Version 2.0

1. The availability of an Internet feed from AT&T via terrestrial wireless has changed our recommendation for the source of the Internet feed and greatly increased the economic viability of the project by providing a higher capacity feed for a lower price than is currently possible over satellite.

2. An additional supplier-funding source has been identified and is listed under funding sources.

3. The possible introduction of a new 900 MHz client unit in the near future by a well-known, quality manufacturer has been identified (Ubiquity Networks).

4. Additional documentation has been added to the appendix.

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For questions or comments regarding this project document, please contact:

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Gustavus Requirements

This project document intends to address the following requirements for a Gustavus Wireless Broadband network:

- ✓ The City of Gustavus would like to deploy a wireless broadband network infrastructure as a commercial enterprise to serve its residents with broadband Internet services.
  - This needs to be a self-supporting business
- ✓ Although there are clear areas, a significant portion of Gustavus is heavily forested.
- ✓ Gustavus already has an active ISP service and trained personnel.
  - ISP Servers and head-end are located at the Library
- ✓ The City of Gustavus still requires access to funding in order to complete this project.
- ✓ An initial installation of 60 client units is planned.

As we address the requirements, wherever possible, we will outline our reasoning for a particular decision so that the reader will get an understanding of “why”, along with the “how”.

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System Description

The overall broadband communication system consists of two major parts:

1. The Internet Feed
2. The Wireless Local Loop

The Current Satellite System

This is the long-haul communication system which is tasked with providing Satellite connectivity to the Internet. Bandwidth is delivered in an asymmetric fashion, meaning that the downlink bandwidth (to the City) is typically much higher than the uplink bandwidth (from the City). The bandwidth delivered also includes access to the Internet and related services.

Recommended Internet Feed

With the recent availability of terrestrial wireless service delivery through AT&T to the Gustavus area, we recommend that the current Satellite link be discontinued and the Internet feed instead be drawn from AT&T.

A 3 Mbps x 3 Mbps (In/Out) Internet feed can be obtained from AT&T for roughly the same price as a 1.5 Mbps x 512 Kbps satellite feed.

Therefore, for about the same monthly cost, you can add twice the bandwidth, eliminate satellite latency and gain the additional benefit of a symmetric link to the Internet.

Attached to the Appendix of this document is a quote for this service from AT&T. It has an expiration date by default but AT&T has been notified that the project timeline will be longer than the expiration date in the quote.

We recommend that Gustavus switch its Internet feed link to AT&T, to be delivered via Terrestrial Wireless to the AT&T tower in Gustavus.

In order to take advantage of the AT&T feed link, a separate wireless link needs to be installed to bring the Internet from AT&T's tower in Gustavus to the Gustavus City Network; either to a tower or to the library.

This will require the purchase of a point-to-point link as well as operational costs in the form of leasing space and power on the AT&T tower and facility.

Alternatively, the entire circuit can be delivered to the location of choice in Gustavus via AT&T for additional local-loop charges. However, leasing space and power at the AT&T facility for a point-to-point wireless link may be more operationally cost-effective than paying the additional local-loop charges, as well as having better quality control capabilities when deploying your own gear on the local-loop.

Unless a local-loop copper connection via AT&T is more economical, we recommend that Gustavus install a wireless point-to-point link from the AT&T Tower to its own infrastructure for its Internet feed.

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The Wireless Local Loop System

Once the Internet bandwidth is available it needs to be distributed throughout the community. This will be accomplished via a Wireless Local Loop system.

Specifically for Gustavus' requirements, this WLL system will initially consist of one cell site, utilizing an omni-directional antenna, with a serviceable radius of up to seven (7) miles (near-line-of-sight) and a capacity of up to 300 wireless clients. This would then deliver a maximum throughput of 2.8 Mbps system-wide, including up to 2.8 Mbps to an individual client, if so desired.

Because wireless clients can support multiple computers behind them, with the addition of a common, consumer-grade Firewall Router, this system is capable of supporting thousands of individual computers.

To accommodate growth, this same system can be scaled upward by utilizing additional channels and sector antennas, essentially slicing up a 360 degree circle into "pie slices", with one sector per slice. For example, by adding another Base Site radio and replacing the Omni antenna with two 180 degree sector antennas, the system can effectively double its capacity.

The system can be scaled even higher over time by adding new cell site locations. In the same manner, radio "shadow" areas can be addressed by building a new base site closer to the shadow area.

Because of Gustavus' heavy forestation, the 900 MHz ISM band was chosen for deployment. The following pages will provide details on the wireless system itself.

The Wireless Infrastructure

Gustavus is densely forested in many areas. This is the most critical of all requirements in determining the type of technology to be deployed and therefore is our first task.

To gain perspective, we can summarize the most commonly used frequency bands in the unlicensed spectrum as follows:

Unlicensed National Information Infrastructure (UNII) 5.15-5.35 GHz and 5.725-5.825 GHz
For outdoor applications, this band is typically used for high capacity data communications at short to medium ranges. Radio technology in this band is offered in Proprietary as well as standards-based 802.11a format. The typical range for clear line-of-sight multipoint links in this band are two to 10 miles. At ranges longer than 2.5 miles, a dish antenna is preferred at the client. Bandwidth can go up to 54 Mbps at very short range but is typically delivered at 10 Mbps at a range of 2-5 miles. This frequency band, because of its short wavelength, is highly susceptible to obstructions in the beam path and clear line-of-sight is a requirement.

The Industrial, Scientific and Medical (ISM) 2.45 GHz
Probably the most well-known frequency in the unlicensed spectrum is the ISM band operating at the 2.45 GHz range and using 802.11b/g/n standards for transmission. Most of the consumer-grade Wi-Fi units operate in this frequency band. When deployed outdoors in a multi-point configuration, this frequency band can deliver up to 15 mile range with actual throughput up to 6-10 Mbps, depending on equipment manufacturer and deployment configuration. There is a wide range of equipment available in this band for outside multipoint deployment with increasingly mature functionality. Deployment in this band prefers clear line-of-sight for optimum performance but most equipment can tolerate a small amount of obstructions.

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The Industrial, Scientific and Medical (ISM) 900 MHz
The ISM band operating at 900 MHz has the lowest throughput of the three technologies, but it more than makes up for that weakness with its exceptional capability to penetrate natural line-of-sight obstructions. At this frequency, obstructions such as trees are more transparent to the signal because of the longer wavelength. Assuming clear line-of-sight, range at this frequency can approach 20 miles on a multipoint infrastructure with throughput typically reaching up to 3 Mbps, depending on manufacturer and deployment configuration. It is important to note that at this frequency, trees are more transparent to the signal energy but ***not*** invisible. Deployment expectations should be kept reasonable and proper radio installation practices should be maintained.

The tree cover in Gustavus dictates that a low frequency band be used. Anything higher than 900 MHz will have extreme difficulty penetrating the forest and will result in unusable signals or extremely complicated, fragile installations. Neither of these scenarios are desirable.

Because parts of Gustavus are heavily forested, the 900 MHz ISM Band is the optimum choice for this area.

A Side Note - Capital versus Operating Expenses

An important factor in our reasoning behind the design of any commercial wireless infrastructure is the requirement that operational costs must be kept to an absolute minimum.

Capital costs must be kept reasonable and will determine the size and scope of any initial deployment. Capital costs will also determine how fast a network can grow and who can afford to pay for the installation. Therefore, obviously, capital costs are important to manage and plan for as part of the project.

However, the ***Operating Cost*** of the network is the single most important factor in determining whether the venture succeeds or not. This is a very, very important point to keep in mind.

Optimally, once a base site is installed, it should require little to no maintenance. Likewise, once a client unit is installed, it should require little to no maintenance. Further, the system should be capable of remote management and troubleshooting and ideally, traffic management should be configurable per client.

Every truck roll after the initial installation costs money. A significant part of our design criteria is focused on preventing truck rolls except for new installations. The drawback is that the capital costs are not as low as they could be.

A lot of organizations will make their critical mistakes at this point. They will choose the lowest-cost system possible, sometimes also mixing a variety of technologies and/or manufacturers and then hope for the best. More often than not, the lowered capital cost will drive up the operating costs significantly, which in turn can make the overall enterprise fail over time.

With this in mind, we'll examine our equipment choices.

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The Hardware

Now that we're focused on the 900 MHz ISM band for deployment, we have a few choices for equipment to purchase. We'll summarize them here. Please see the appendix for more detailed specification sheets.

Motorola Canopy 900 MHz

A fine product from a well-respected manufacturer. The Motorola Canopy series delivers up to 2.1 Mbps throughput to any individual client, with an overall aggregate throughput of approximately 4 Mbps per sector. The system provides for three non-overlapping channels. Receiver sensitivity can go as low as -90 dBm (very good) and the units are reputed to be able to process a signal that is only 3 dB over the noise floor (exceptional). They are also priced well.
Pros: Outdoor installation, large manufacturer, proven technology, good pricing.
Cons: Users have reported annoying firmware problems. Motorola's licensing scheme may require future payments for upgrades.

Base Station Price:	***$1,700.00***	***(quantity pricing)***
Client Unit Price:	***$400.00***	***(quantity pricing)***

Mikrotik 900 MHz (Hybrid)

Mikrotik is well-known for its exceptional wireless router boards. A hybrid unit can be assembled that will incorporate the Mikrotik router/client functionality along with a 900 MHz radio system by ZCom or Ubiquity. This is a proprietary system and can deliver connectivity solutions under extreme conditions (i.e. trees and challenging line-of-sight conditions). Receiver sensitivity can go as low as -95 dBM with the highest claimed throughput in the 900 MHz band.
Pros: Extreme range, highest throughput, exceptional configuration flexibility, many features supported, including traffic shaping.
Cons: Indoor unit only (requires separate external antenna), configuration is more complex, custom assembled.

Base Station Price:	***$725.00***	***(includes PoE and Surge Suppressor)***
Client Unit Price:	***$425.00***	***(includes PoE and Surge Suppressor)***

Trango Broadband 900 MHz

Trango Broadband is a well-known wireless broadband equipment manufacturer. Their equipment is easy to deploy, rugged and reliable. At 900 MHz the units will deliver up to 3 Mbps of throughput per sector (or to an individual subscriber) and were designed specifically for challenging environments such as non-line-of-sight scenarios. They are self-contained, outdoor mounted units. In addition, these units use ARQ for noise rejection as well as supporting vertical and horizontal polarized operation, providing additional flexibility in deployment.

This summer Trango will introduce a new 900 MHz radio that will support up to 12 Mbps of throughput and will be backwardly compatible with the current 900 MHz units.

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Pros: Specifically designed for harsh, non-line-of-sight environments, dual-polarized antennas, traffic shaping, easy configuration and installation, -98 dBm receiver sensitivity, smart-polling, proven deployment in Alaska.
Cons: Expensive

Base Station Price:	***$2,200.00***	***(individual pricing)***
Client Unit Price:	***$675.00***	***(quantity pricing)***

Any of the three technologies listed above are suitable for Gustavus and there are others also available of varying quality.

The Motorola system has been adopted by a number of ISPs and is priced quite well in quantity. However, their licensing scheme can result in additional charges to the ISP over the life of the product. This is not beneficial to the ISP.

The Mikrotik Hybrid radio router is also very attractive because it marries the best of Mikrotik technology with very high quality radios by Ubiquity Networks. However, these are indoor only units and therefore installation is more involved due to the need for antenna cable and separate outdoor antenna. Because of their extensive capabilities, their setup configuration is also more involved.

The Trango radios are the most expensive of the three technologies. However, they do have some significant advantages in that they are easy to install and have built-in dual-polarity antennas (horizontal and vertical) which ultimately results in twice the number of available channels. The next generation units due to be released in summer of 2008 will boost throughput to 12 Mbps – an impressive benchmark for 900 MHz radios as well as backward compatibility with the existing technology.

Most importantly, the Trango units have a track record of at least three years of proven operation in Alaska, even in harsh Alaskan climates such as McGrath where the temperature dips to -55 degrees in the winter. During this time the Trango units have required almost zero maintenance.

Although all three technologies are suitable for Gustavus, Borealis Broadband favors Trango Broadband due to its overall performance, reliability, ease-of-installation and proven performance in Alaska. These attributes contribute to a very low operating cost for this technology.

The following section describes how to put the nuts and bolts together. The descriptions will apply to any of the technologies mentioned.

Revision 2.0 addition: There is the possibility that Ubiquity Networks will have equipment available in the 900 MHz ISM band by the time this project is ready to start that is based on its current 2.4 GHz radio client system (i.e. they will run similar software). If so, it would be worth the time and effort to test this equipment as an option for cost-effective deployment.

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Building The System

The first step in deploying the wireless broadband system is to pick a suitable location for the base site and decide on an initial deployment configuration. Ideally, the base site should be on a tower in an area relatively clear of trees but still next to a building. It is best if the signal does not encounter an obstruction for the first fifty feet.

City Hall has been identified as one possible tower location. The following map of Gustavus shows the areas most suitable for tower deployment. However, most points within Gustavus that are not obstructed by a hill are also well within the operating range of the base site, so there exists a lot of flexibility on where the tower can go. Assuming the Airport would have no objection, the tower could even be placed near the Library.

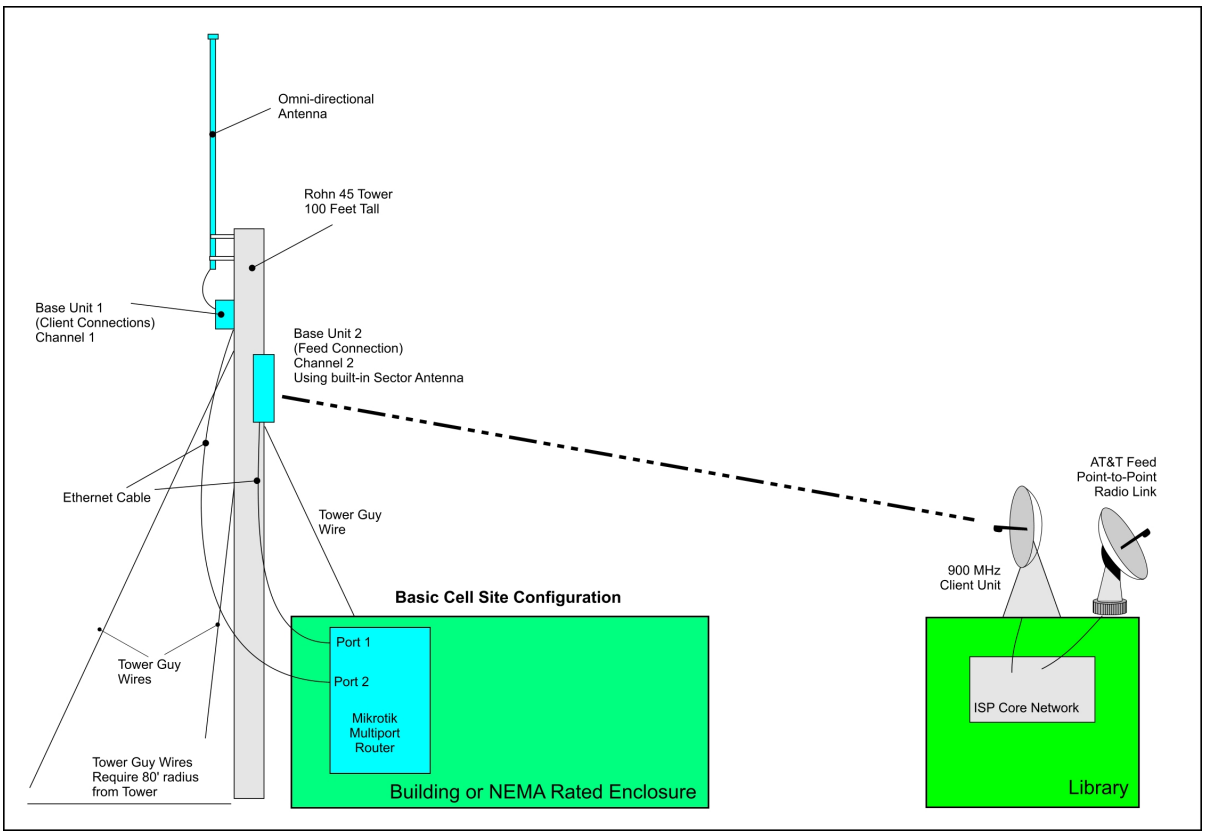
For the initial installation, a single base unit with an omni-directional antenna can be used for client connections, along with a second base unit with a directional antenna to connect with the network core and the satellite feed at the Library. This will create a tower structure with two antennas and assumes that the tower will be placed somewhere other than at the Library.

A separate feed link on a separate channel is used to connect to the Library so that the over-the-air data traffic does not have to repeat itself. Otherwise, system throughput can be negatively impacted by as much as 50-60%.

The Initial Base Site installation will be an Omni-Directional antenna and one base unit. This will provide capacity for up to 300 clients and can be scaled upward by implementing sectors in the future.

We recommend the installation of a Rohn 45 tower at a minimum, to a height of 100 feet. A ten foot diameter concrete pad will be required along with space to deploy three guy wires from the tower at a distance of 80 feet from the tower base. Tower sections come in 10 foot lengths and are stacked on top of each other and capped with a top assembly. All tower installations should be accomplished by experienced professionals.

A power source also has to be near the tower. Therefore, erecting the tower near a building is optimum. As the following diagram shows, the amount of equipment required at this location is minimal, so as long as power is present, the equipment can even be mounted in an external NEMA-rated enclosure, eliminating the need to be near a building.



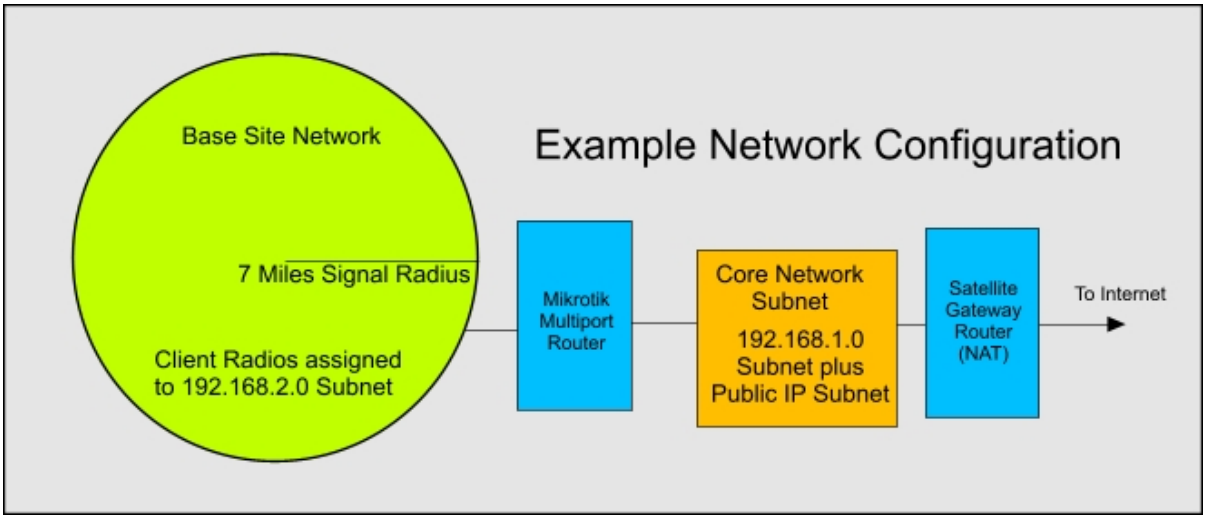
Both Base Site units are connected to each other via a Mikrotik Multiport Router. The router can be configured to bridge both ports or route them, depending on the desired network results.

This creates a very simple network configuration for the broadband portion of the ISP network. The Base Site has a subnet assigned to it to which all the radios will be configured. This will allow the operator to access each radio remotely for administration.

Because the radio clients act as a media bridge, the actual customer IP address can be assigned to a second Subnet which is assigned to the Base station port on the Multi-port router. Therefore, the radio IP addresses would be on one subnet, the customer IP addresses on another subnet, both of which are assigned to the router port which has the Omni-Directional base station attached to it.

Customer IP addresses can be statically or dynamically assigned, as desired by the ISP. Static IP addresses can aid in the administration, traffic analysis and management of the clients.

Traffic Shaping is accomplished directly on the client radio and is configured at the Base Site. This will shape all client traffic as soon as it enters the radio network. Therefore, access to the Internet and even local system servers is dictated by the client's assigned service level.



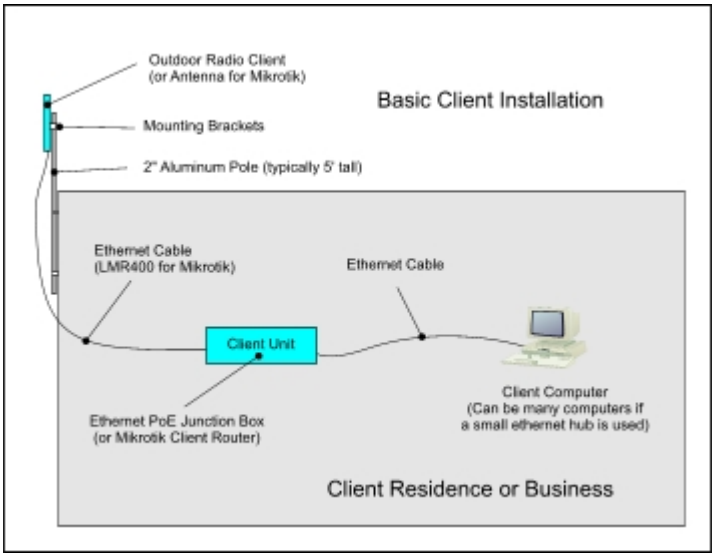
Client Installation

The client installation is straightforward. The radio unit is mounted outside (except for Mikrotik version) and an Ethernet cable is run into the premises and attached to a Power over Ethernet junction box. The customer is then presented with a simple Ethernet port for connectivity.

This also allows the customer to add a Firewall Router or Wi-Fi unit to their residence for additional flexibility. Because the radios are connected at all times, login passwords or accounts are not needed.

If DHCP is implemented on the base site, customer connections can be as simple as plug-n-play.

There are many configuration options that can be implemented in this system and it is up to the ISP to decide which is the preferred mechanism that integrates best with their current setup.



System Performance

With this system configuration, customer service levels can be assigned anywhere from 128 Kbps to whatever the Feed link can deliver. Because the traffic shaping is assigned directly to the client unit, the customer enters the network already at their service level.

Local loop performance on the wireless network is symmetric. Bandwidth coming into the customer is the same as the bandwidth leaving the customer (can also be made asymmetric with the Trango units if desired). This allows the service operator to implement additional services in the local community

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such as Game Servers, local VoIP, websites or other types of network services that do not require reaching out to the Internet to deliver.

Latency on the local wireless network is typically as little as 20ms although the first PING may be higher latency if the radio is spooling up from idle.

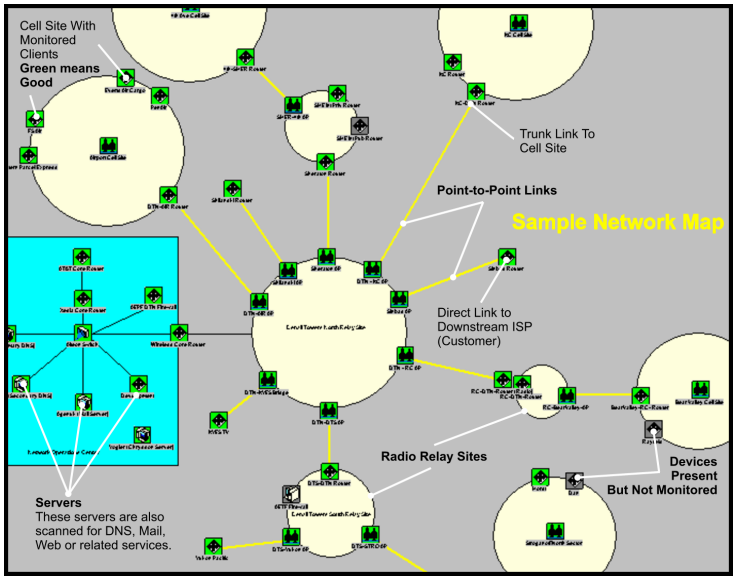
Further, with the addition of another traffic shaping router just before the Internet Feed, the operator can actually create separate service levels – one type of service level for local network access, another type of service level for Internet access.

Important Note: It is critical that customer installations and all other radio installations are done to specifications (depending on manufacturer) and utilizing proper installation practices. A radio unit that is properly and carefully installed may never need to be touched again. This is the desired result of any installation and it is well worth the effort.

Network Visibility

Part of the process of network and systems management is knowing how the network is doing, what it's doing and if there are any current problems. Knowing this in real-time is a significant factor in maintaining a smooth-running network.

There are several reasonably inexpensive management tools available that allow the system or network administrator visibility into the network. These tools can be implemented on a modular level so that the network administration, maintenance and monitoring functions can be done at a central location.



Managing in Real-Time

Real-time management means knowing what your network is doing at all times. It also requires knowledge of what the network has done in the past. There are two very important, very basic functions for managing the network in real-time:

1. Watching all devices to ensure they are up and running
2. Recording traffic patterns to generate baseline data

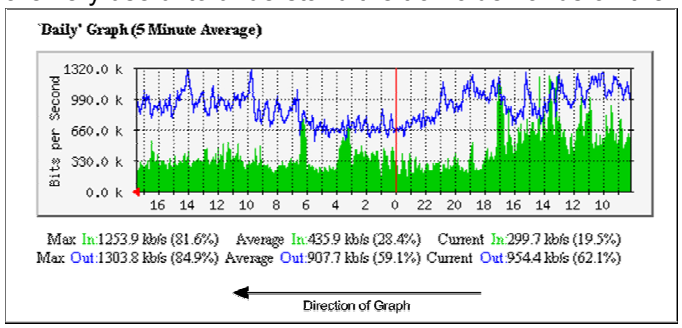
Watching the devices on a regular basis to ensure they are functioning is actually quite simple and software is available for that function. In most cases, a simple PING test or, in the case of servers, checking the availability of specific ports is all that is required to ensure a system is operating (but not necessarily an all-inclusive guarantee of operability).

Borealis uses a management system from IPSwitch called "What'sUP". This management tool allows us to view a network in graphical format as well as test for device availability. In addition, the software can scan servers to verify that services are available (such as Web, Mail, DNS, etc.). Should a device go offline or for some other reason not respond to a management packet, an alarm will be generated at the monitoring station as well as on pager, email and other methods.

How quickly an alarm will sound can be configured into the software and is based on the type and reliability of the link being monitored. In most cases, sounding an alarm when a device is down for approximately 3 minutes is sufficient.

The second important function is knowing what kind of traffic levels are present on the network over time. This will help generate a "baseline" for the network (i.e. a traffic pattern history).

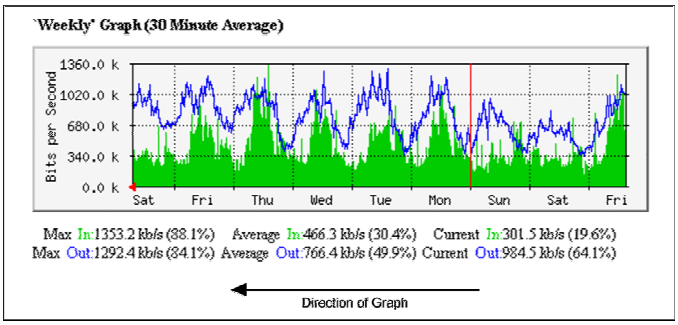
Traffic graphs are typically grouped into Daily, Weekly, Monthly and Yearly categories. The graphs are very useful to understand the traffic demands on the network at any point in time. They can also be used to forecast system growth as well as track abnormal system events.



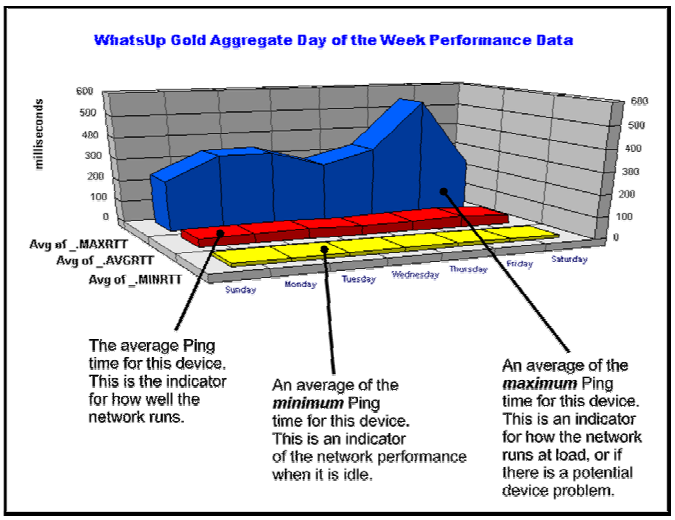
Borealis uses the MRTG graphing utility for Linux to monitor traffic levels on its own as well as client networks. It is important to note that these graphs only look at the level of traffic, not what is actually inside the packet.

In the Daily Graph example above, the green bars represent *incoming* bandwidth to an interface and the blue lines represent *outgoing* bandwidth out of the interface. If we assume that the graph shown here represent a router interface connected to the Internet, then we can see that the outgoing traffic (sent to the Internet) is approximately 990 Kbps and the incoming traffic (received from the Internet) is approximately 300 Kbps. We can therefore deduce that the attached network (or company) sends out about 3 times more data to the Internet than it receives, on average.

The data is further compiled into a Weekly and Monthly graphs as well. This allows the operator to understand historical traffic levels on the network by looking at longer term graphs. These graphs can be made available via web browser for viewing and can also be secured so they can only be viewed by authorized personnel. The information is collected and formatted automatically and is vital to the proper operation of a network over time.



This data can then also be reported over time, in various formats. Shown here is a sample report graph that maps out the PING times for a particular device on a network over a period of one week. Reports such as these can be important indicators of the health of the network if used properly.



What'sUP! Gold Standard (100 devices)
$1,995.00

Source: http://www.ipswitch.com

Equipment Lists

Trango – Motorola - Mikrotik

Equipment List

Utilizing Trango Technology

Item	Price Each	Qty	Total	Source
Tower Construction				
Rohn 45 Tower Segments	$310.00	10	$3,100.00	
Rohn 45 Base Segment	$150.00	1	$150.00	
Rohn 45 Top Segment	$310.00	1	$310.00	
Guy Wire	$200.00	1	$200.00	
Total Tower Material Cost			**$3,760.00**	Frigid North, Tamsco, Borealis
Tower Installation Budget (Includes concrete)			**$8,500.00**	If installed by Borealis
Total Tower - Installed (Does NOT include freight charges)			**$12,260.00**	
Base Site Construction				
Trango Base Unit	$2,200.00	2	$4,400.00	Trango Broadband, Borealis
Spare Base Unit	$2,200.00	1	$2,200.00	Trango Broadband, Borealis
Omni Antenna (Vertical Pol. at 9dBi +)	$600.00	1	$600.00	Hutton, Borealis, Wisp Router
Radio Patch Cable	$40.00	1	$40.00	Frigid North, Borealis
Mikrotik Multiport Router	$300.00	1	$300.00	Wisp Router, Borealis
Trango 900 MHz Client (Library)	$675.00	1	$675.00	Trango Broadband, Borealis
Ethernet Cable	$300.00	1	$300.00	Frigid North, Borealis (Roll)
Mikrotik Multiport Router (Library)	$300.00	1	$300.00	Optional but recommended
Total Base Site Radios Material Cost			**$8,815.00**	
Installation Budget for Base Site Radios			**$5,000.00**	If installed by Borealis
Total Base Site - Installed (Does NOT include freight charges)			**$13,815.00**	Assumes building is nearby for equipment
Client Units				
Trango Client Radios	$675.00	60	$40,500.00	Trango Broadband, Borealis
Tripod, Pole, Tilt-mount Brackets	$65.00	60	$3,900.00	Wisp Router, Borealis
Ethernet Cable, Connectors	$300.00	6	$1,800.00	Frigid North, Tamsco (Rolls)
Total client Cost			**$44,400.00**	
AT&T Wireless Point-to-Point Link				
AT&T Internet Installation Cost			$1,300.00	AT&T
Local-Loop Wireless Link			$5,890.00	Equipment & Installed (see appendix)
Total AT&T Link Cost			**$7,190.00**	
Totals				
Borealis Training (2-days)	$2,000.00	1	$2,000.00	Training in Anchorage
Grand Total for Project			**$79,665.00**	If installed by Borealis

Please note that it is expected that local technicians will be trained by Borealis to install the client radio units. This quote does not include Borealis technicians installing client units.

Freight varies depending on where supplies are purchased. Many of the commodity supplies such as cable, connectors, poles, etc., can be purchased locally. Budget approximately $4,000 for freight costs.

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Equipment List

Utilizing Motorola Technology

Item	Price Each	Qty	Total	Source
Tower Construction				
Rohn 45 Tower Segments	$310.00	10	$3,100.00	
Rohn 45 Base Segment	$150.00	1	$150.00	
Rohn 45 Top Segment	$310.00	1	$310.00	
Guy Wire	$200.00	1	$200.00	
Total Tower Material Cost			**$3,760.00**	Frigid North, Tamsco, Borealis
Tower Installation Budget (Includes concrete)			**$8,500.00**	If installed by Borealis
Total Tower - Installed (Does NOT include freight charges)			**$12,260.00**	
Base Site Construction				
Motorola Base Unit	$1,700.00	2	$3,400.00	DoubleRadius, Borealis
Spare Base Unit	$1,700.00	1	$1,700.00	DoubleRadius, Borealis
Omni Antenna (Vertical Pol. at 9dBi +)	$600.00	1	$600.00	Hutton, Borealis, Wisp Router
Radio Patch Cable	$40.00	1	$40.00	Frigid North, Borealis
Mikrotik Multiport Router	$300.00	1	$300.00	Wisp Router, Borealis
Motorola Client (Library)	$450.00	1	$450.00	DoubleRadius, Borealis
Ethernet Cable	$300.00	1	$300.00	Frigid North, Borealis (Roll)
Mikrotik Multiport Router (Library)	$300.00	1	$300.00	Optional but recommended
Total Base Site Radios Material Cost			**$7,090.00**	
Installation Budget for Base Site Radios			**$5,000.00**	If installed by Borealis
Total Base Site - Installed (Does NOT include freight charges)			**$12,090.00**	Assumes building is nearby for equipment
Client Units				
Motorola Client Radios	$450.00	60	$27,000.00	DoubleRadius, Borealis
Tripod, Pole, Tilt-mount Brackets	$65.00	60	$3,900.00	Wisp Router, Borealis
Ethernet Cable, Connectors	$300.00	6	$1,800.00	Frigid North, Tamsco (Rolls)
Total client Cost			**$30,900.00**	
AT&T Wireless Point-to-Point Link				
AT&T Internet Installation Cost			$1,300.00	AT&T
Local-Loop Wireless Link			$5,890.00	Equipment & Installed (see appendix)
Total AT&T Link Cost			**$7,190.00**	
Totals				
Borealis Training (2-days)	$2,000.00	1	$2,000.00	Training in Anchorage
Grand Total for Project			**$64,440.00**	If installed by Borealis

Please note that it is expected that local technicians will be trained by Borealis to install the client radio units. This quote does not include Borealis technicians installing client units.

Freight varies depending on where supplies are purchased. Many of the commodity supplies such as cable, connectors, poles, etc., can be purchased locally. Budget approximately $4,000 for freight costs.

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Equipment List

Utilizing Mikrotik Technology

Item	Price Each	Qty	Total	Source
Tower Construction				
Rohn 45 Tower Segments	$310.00	10	$3,100.00	
Rohn 45 Base Segment	$150.00	1	$150.00	
Rohn 45 Top Segment	$310.00	1	$310.00	
Guy Wire	$200.00	1	$200.00	
Total Tower Material Cost			**$3,760.00**	Frigid North, Tamsco, Borealis
Tower Installation Budget (Includes concrete)			**$8,500.00**	If installed by Borealis
Total Tower - Installed (Does NOT include freight charges)			**$12,260.00**	
Base Site Construction				
Mikrotik Base Unit	$725.00	2	$1,450.00	Wisp Router, Borealis
Spare Base Unit	$725.00	1	$725.00	Wisp Router, Borealis
Omni Antenna (Vertical Pol. at 9dBi +)	$600.00	1	$600.00	Hutton, Borealis, Wisp Router
LMR900 Radio Cable	$1,500.00	1	$1,500.00	Frigid North, Borealis
Mikrotik Multiport Router	$300.00	1	$300.00	Wisp Router, Borealis
Mikrotik Client (Library)	$425.00	1	$425.00	Wisp Router, Borealis
Ethernet Cable	$300.00	1	$300.00	Frigid North, Borealis (Roll)
Mikrotik Multiport Router (Library)	$300.00	1	$300.00	Optional but recommended
Total Base Site Radios Material Cost			**$5,600.00**	
Installation Budget for Base Site Radios			**$7,500.00**	If installed by Borealis
Total Base Site - Installed (Does NOT include freight charges)			**$13,100.00**	Assumes building is nearby for equipment
Client Units				
Mikrotik Client Radios	$425.00	60	$25,500.00	Wisp Router, Borealis
Tripod, Pole, Tilt-mount Brackets	$65.00	60	$3,900.00	Wisp Router, Borealis
External Antennas (Grids)	$160.00	60	$9,600.00	Wisp Router, Borealis
LMR400 Cable, Connectors	$150.00	60	$9,000.00	Frigid North, Tamsco
Total client Cost			**$29,400.00**	
AT&T Wireless Point-to-Point Link				
AT&T Internet Installation Cost			$1,300.00	AT&T
Local-Loop Wireless Link			$5,890.00	Equipment & Installed (see appendix)
Total AT&T Link Cost			**$7,190.00**	
Totals				
Borealis Training (2-days)	$2,000.00	1	$2,000.00	Training in Anchorage
Grand Total for Project			**$63,950.00**	If installed by Borealis

Please note that it is expected that local technicians will be trained by Borealis to install the client radio units. This quote does not include Borealis technicians installing client units.

Freight varies depending on where supplies are purchased. Many of the commodity supplies such as cable, connectors, poles, etc., can be purchased locally. Budget approximately $4,000 for freight costs.

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Bonus - Relay Connections (*Without Direct Line-of-Sight*)

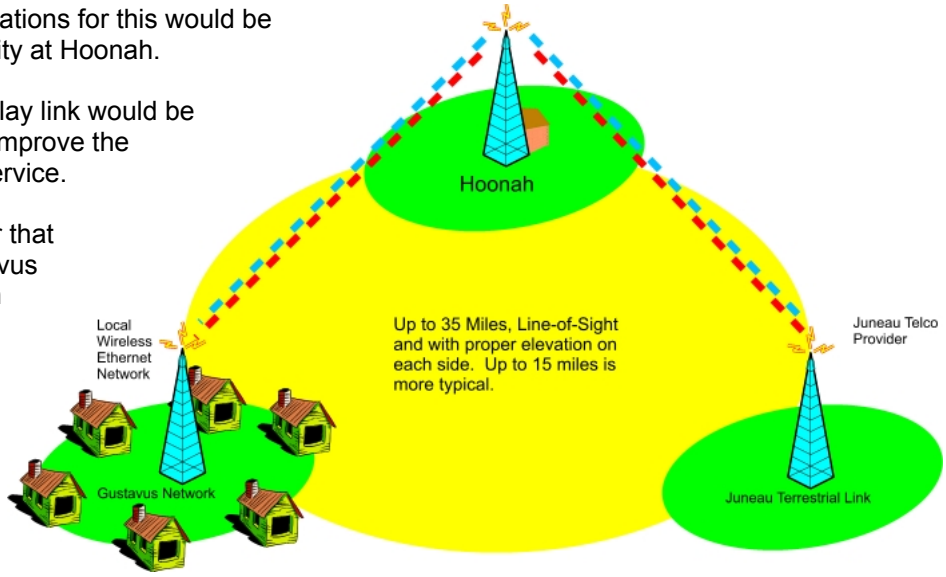
A relay link to Juneau may also be possible. For such a connection to be feasible, there should be a geographic point at significant elevation (depending on distance) relative to each location that is also visible from each location.

One of the identified locations for this would be the AT&T Alascom facility at Hoonah.

The benefit of such a relay link would be to reduce the cost and improve the quality of the Internet service.

Utilizing the same tower that deploys the local Gustavus wireless network, a dish antenna can be mounted and pointed at the AT&T Alascom site in Hoonah.

At the AT&T Alascom site, a dish antenna is pointed back to Gustavus to complete the initial leg of the link.



This link is then duplicated between Hoonah and the Telco facility in Juneau.

Item	Price Each	Qty	Total	Source
StarOS Wireless Router	$725.00	4	$2,900.00	Borealis Broadband
Dish Antennas (2.4 GHz)	$500.00	4	$2,000.00	DoubleRadius, Wisp, Borealis
LMR900 Radio Cable	$500.00	4	$2,000.00	Frigid North, Borealis
Connectors	$60.00	8	$480.00	Frigid North, Borealis
Total Relay Equipment			**$7,380.00**	
Installation Budget			**$6,500.00**	If installed by Borealis
Total Relay Link - Installed (Does NOT include freight charges)			**$13,880.00**	

Depending on the price difference between a terrestrial feed and the current satellite feed, such a relay link may pay for itself in less than a year in saved costs. This will need to be researched by Gustavus with their preferred Internet vendor to determine if it is feasible.

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Bonus – Potential Funding Source

One of the requirements for Gustavus is that the city still needs to obtain funding for the project.

We recommend the following organization as a potential funding source for your project. This organization also has networks that may be complementary to your own.

We have already discussed your project with them and they are interested in speaking with you.

Starlight Capital
Attention: Bryan Emerson
1800 West Loop South, Suite 475
Houston, TX. 77027
(713) 225-3028 Office
(713) 385-0302 Mobile
http://www.starlightinvestments.com
emersonb@starlightinvestments.com

Revision 2.0 Addition: DoubleRadius is an equipment supplier that also offers lease financing.

DoubleRadius
2022 Van Buren Ave.
Suite 100
Indian Trail, NC 28079
(704) 927-6100
www.doubleradius.com

Supplies Source List

Supplies can be ordered from the following vendors as mentioned in this document:

Borealis Broadband, Inc.
2550 Denali Street, Suite 512
Anchorage, AK 99503
(907) 563-3278
www.borealisbroadband.net

Wisp Router
1123 S Broadway
Pittsburg, Kansas 66762
(620) 230-5862
www.wisp-router.com

DoubleRadius
2022 Van Buren Ave.
Suite 100
Indian Trail, NC 28079
(704) 927-6100
www.doubleradius.com

Frigid North Company
3309 Spenard Road
Anchorage, Alaska 99503
(907) 561-4633 or (800) 478-4633
www.frigidn.com

Motorola Inc.
1301 E. Algonquin Road
Schaumburg, IL 60196
1-866-515-5825
http://motorola.canopywireless.com/products/advantage/

Trango Broadband, Inc.
14118 Stowe Drive, Suite B
San Diego, CA 92064 USA
(858) 391-0010
http://www.trangobroadband.com/

Hutton Communications
2520 Marsh Lane
Carrollton, TX 75006
(972) 417-0100
http://www.hol4g.com/mk/index.aspx

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Appendix Documents

Specifications Sheet

Motorola Canopy
900 MHz AP

Canopy Part Number	9000AP
Description	900 MHz AP
Market Availability	North America, South America, Asia
Signaling Rate	6 Mbps maximum
Typical LOS Range	40 Miles (64 km)
Typical Aggregate Useful Throughput	4 Mbps maximum
Frequency range of band	ISM 902-928 MHz
Non-overlapping Channels	3
Channel Width	8 MHz
Modulation Type	High Index 2-level and 4-level Frequency Shift Keying (FSK) optimized for interference rejection
Channel Spacing	1 MHz
Encryption	DES capable
Latency	< 15 msec
Carrier to Interference ratio (C/I)	~3dB @ 3 Mbps, ~10dB @ 6 Mbps at -70dBm
Nominal Receiver Sensitivity (dbm typical)	-90 dBm
Antenna Gain (dBi)	12 dBi
EIRP (dBm)	36 dBm
Equivalent Isotropic Radiated Power (EIRP)	4 W
DC Power (typical)	0.3 A @ 24 VDC = 7.2 W
Antenna Beam Width	60 degree beam width azimuth and 35 degree elevation ~12.5 dBi
Mean Time Between Failure (MTBF)	40 yr
Temperature	-40° C to +55° C (-40° F to +131° F)
Wind Survival	190 km/hr (118 miles/hr)
Dimensions	19.5 H x 12 W x 4.75 D (50 cm H x 30 cm W x 12 cm D)
Weight	5.4 kg (12.5 lb)
Access Method	Time Division Duplexing/Time Division Multiple Access (TDD/TDMA)
Interface	10/100 Base T, half/full duplex. Rate auto negotiated (802.3 compliant)
Protocols Used	IPV4, UDP, TCP, ICMP, Telnet, HTTP, FTP, SNMP
Network Management	HTTP, TELNET, FTP, SNMP Version 2c
FCC ID	ABZ89FC5809
Industry Canada Certification Number	109W-9000

Specifications subject to change without notice.

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trangobroadband® WIRELESS

M900S Series™

900 MHz

NLOS Broadband Wireless System

The M900S Series point-to-multipoint wireless broadband platform utilizes the advantages of the 900 MHz license-exempt spectrum and delivers up to 3 Mbps to the subscriber. Ideal for non-line-of-sight (NLOS) deployment, this fully integrated outdoor system includes internal dual polarized antennas as well as connectors for optional external antennas.

Product Highlights

- **New Low-cost EXT-model SU**
- **Superb NLOS Performance**
- **Up to 3 Mbps**
- **Robust interference rejection (ARQ)**

- **900 MHz NON-LINE-OF-SIGHT PERFORMANCE**

  The M900S Series was designed for deployment in areas where foliage and other obstructions obscure line-of-sight between the access point (AP) and subscriber unit (SU). The system offers excellent receiver sensitivity and best-in-class overall system gain for outstanding non-line-of-sight (NLOS) range. The subscriber can expect typical NLOS performance of up to 6 miles or beyond*. Use of external antennas increases range and fade margin even farther. In addition, Spread Spectrum modulation promotes resistance to multipath fading. Combining Trango's state-of-the-art SMARTPolling™ with Spread Spectrum modulation results in maximum cell performance.

- **ANTENNA FLEXIBILITY**

  The M900S AP and SU each include an integrated 10 dBi dual polarized patch antenna as well as a connector for optional external antennas. The lower cost M915S-SU-EXT features only a connector for an external antenna. External antenna options include omni antennas for the AP and yagi-style antennas for both the AP and SU. The auto-sensing feature on the M900S SU allows the firmware to choose the antenna with the strongest signal, or the user can manually select either the internal or external antenna.

- **CHANNEL FLEXIBILITY**

  The system is configured with four channels, each 6 MHz apart. The user can redefine channels by selecting frequencies in single MHz increments. The SU scans all channels until it associates with a properly configured AP. This allows redundancy of APs as well as a simple and quick method to switch channels on an entire sector.

- **INTERFERENCE MITIGATION**

  The M900S Series offers powerful resistance to interference with the Automatic Repeat Request (ARQ) feature which automatically retransmits packets to mask RF errors to higher layer protocols. In addition, the system includes interference mitigation tools such as software selectable dual polarity antennas, automatic SU power leveling, and threshold control.

- **MANAGEMENT FEATURES**

  The system offers remote and local management via Telnet, SNMP and HTTP via browser. Powerful tools such as site survey and upstream/downstream CIR/MIR controls allow operators total control and flexibility in managing their network.

* Non-line-of-sight range and throughput may vary due to antenna height, leaf density, moisture content, and other environmental factors.

M900S Series™ Specifications

COMPATIBILITY / RANGE CHART			
Part Number	**Model Type**	**Antenna**	**Range / Fade Margin**
M900S-AP	Access Point w/ integrated & external antennas	Internal, 10 dBi, External	Up to 6 miles NLOS* / 10 dBi
M900S-SU	Subscriber Unit w/ integrated & external antennas	Internal, 10 dBi, External	Up to 20 miles LOS / 18 dBi
M915S-SU-EXT	Subscriber Unit Connectorized	External only	Depends on external antenna selection

* Non-line-of-sight performance may vary due to antenna height, leaf density, moisture content, and other environmental factors.

RADIO PARAMETERS	
Frequency of Operation	902 - 928 MHz
Channels	4 non-overlapping, software selectable
Channel Spacing	6 MHz, software selectable
RF Power Output	M900S AP & SU: +26 dBm Max Setting, -4 dBm Min Setting M915S-SU-EXT: +26 dBm Max Setting, 0 dBm Min Setting
Modulation Format	Direct Sequence Spread Spectrum (DSSS)
Certification / Compliance	FCC Part 15.247
Receiver Sensitivity (BER 10-6)	-90 dBm typical
DATA AND OPERATIONAL PARAMETERS	
Access Method	TDD with SMARTPolling™
User Data Throughput	3 Mbps
Upstream/Downstream Throughput	Dynamic, automatically adjusts to suit demand
Bandwidth Control	CIR and MIR upstream/downstream control by AP
Maximum Number SUs per AP	126
Auto Repeat Request	Continuous ARQ with Selective Repeat
Security	Trango proprietary authentication method, based on MAC address and alphanumeric base ID; over-the-air data scrambling.
Configuration & Management	Telnet, SNMP, TFTP, HTTP
ANTENNA PARAMETERS	
Internal Antennas	M900S AP & SU: Integrated 10 dBi 60° X 60° patch dual polarized (HPOL/VPOL)
External Antenna Connection	Reverse Polarity SMA (RP-SMA)
*Omni Antenna** (Optional)*	8.5 dBi 360° X 10° (VPOL) - Comtelco Part # BS915XL7** (Requires N-SMA RP adapter)
*Yagi Antenna*** (Optional)*	15 dBi 30° X 30° (VPOL or HPOL) - Cushcraft part # PC9013N*** (Requires N-SMA RP adapter)
POWER PARAMETERS	
Power Method	Power-over-Ethernet (PoE Injector JBox included)
Voltage Input	24 VDC
Standard Power Supply	120VAC to 24VDC
PoE Cat-5 Max Cable Length	300 feet on 24 AWG STP Cat-5 cable
PHYSICAL AND ENVIRONMENTAL	
Ethernet Interface	RJ45, 10/100BaseT, auto sense, auto negotiate
Antenna Connector	SMA reverse polarity
Reset Button	Resets unit to factory default settings
Radio Enclosure	M900S AP & SU: All-weather, powder coated, cast aluminum with polycarbonate radome M915S-SU-EXT: All-weather ABS
Temperature Range	-40° to 60° C (-40° to 140° F)
Radio Weight	M900S AP & SU: 4 lbs. M915S-SU-EXT: 1.5 lbs.
Radio Dimensions	12.5″ x 8″ x 2.75″ (AP), 15″ x 7.4″ x 6.1″ (SU)
Mounting Hardware	M900S AP & SU: Mounts to pole or wall (2 V-mounting brackets, 4 threaded rods, 4 lock washers and 8 kepnuts) M915S-SU-EXT: Mounts to pole or wall (L-mounting brackets, U-bolt, nuts, hex-head bolt, kepnut and lock washer)
User Interfaces	RJ45 (shielded)

Features and specifications are typical and subject to change without notice.

** Available from Comtelco (www.comtelcoantennas.com) and Comtelco distributors

*** Available from Cushcraft (www.cushcraft.com) and Cushcraft distributors

trangobroadband® WIRELESS
A division of Trango Systems, Inc.

15070 Avenue of Science, Suite 200
San Diego, CA 92128
Phone: 858-653-3900
Fax: 858-621-2725
E-mail: sales@trangobroadband.com

www.trangobroadband.com

XTREMERange9

TECHNICAL SPECIFICATIONS

Frequency Freedom™

Think Outside the Band

CARD INFORMATION	
Chipset	Atheros, 6th Generation, AR5414
Radio Operation	Proprietary 900MHz
Interface	32-bit mini-PCI Type IIIA
Operation Voltage	3.3VDC
Antenna Ports	Dual MMCX
Temperature Range	-45C to +90C (extended temp version up to +95C)
Security	WPA, WPA2, AES-CCM & TKIP Encryption, 802.1x, 64/128/152bit WEP
Data Rates	6Mbps, 9Mbps, 12Mbps, 24Mbps, 36Mbps, 48Mbps. 54Mbps
TX Channel Width Support	5MHz / 10MHz / 20MHz / 40MHz
RoHS Compliance	YES

REGULATORY INFORMATION	
Wireless Modular Approvals	FCC Part 15.247, IC RS210

RADIO OPERATING FREQUENCY 907-922MHz

TX SPECIFICATIONS				RX SPECIFICATIONS			
	DataRate	TX Power	Tolerance		DataRate	Sensitivity	Tolerance
DSSS	1Mbps	28 dBm	+/-1dB	DSSS	1Mbps	-95 dBm	+/-1dB
	2Mbps	28 dBm	+/-1dB		2Mbps	-93 dBm	+/-1dB
	5.5Mbps	28 dBm	+/-1dB		5.5Mbps	-91 dBm	+/-1dB
	11Mbps	28 dBm	+/-1dB		11Mbps	-90 dBm	+/-1dB
OFDM	6Mbps	28 dBm	+/-1dB	OFDM	6Mbps	-92 dBm	+/-1dB
	9Mbps	28 dBm	+/-1dB		9Mbps	-91 dBm	+/-1dB
	12Mbps	28 dBm	+/-1dB		12Mbps	-91 dBm	+/-1dB
	18Mbps	28 dBm	+/-1dB		18Mbps	-88 dBm	+/-1dB
	24Mbps	28 dBm	+/-1dB		24Mbps	-84 dBm	+/-1dB
	36Mbps	26 dBm	+/-1dB		36Mbps	-81 dBm	+/-1dB
	48Mbps	25 dBm	+/-1dB		48Mbps	-75 dBm	+/-1dB
	54Mbps	24 dBm	+/-1dB		54Mbps	-72 dBm	+/-1dB

900MHz FREQUENCY CHANNEL SUPPORT

Frequency	5MHz	10MHz	20MHz	Frequency	5MHz	10MHz	20MHz
907 MHz				917 MHz			
912 MHz				922 MHz			

CURRENT CONSUMPTION INFORMATION

TX CURRENT CONSUMPTION				RX CURRENT CONSUMPTION			
	DataRate	Current	Tolerance		DataRate	Sensitivity	Tolerance
DSSS	1Mbps	1.10 A	+/-100mA	DSSS	1Mbps	300 mA	+/-100mA
	2Mbps	1.10 A	+/-100mA		2Mbps	300 mA	+/-100mA
	5.5Mbps	1.10 A	+/-100mA		5.5Mbps	300 mA	+/-100mA
	11Mbps	1.10 A	+/-100mA		11Mbps	300 mA	+/-100mA
OFDM	6Mbps	1.10 A	+/-100mA	OFDM	6Mbps	300 mA	+/-100mA
	9Mbps	1.10 A	+/-100mA		9Mbps	300 mA	+/-100mA
	12Mbps	1.10 A	+/-100mA		12Mbps	300 mA	+/-100mA
	18Mbps	1.10 A	+/-100mA		18Mbps	300 mA	+/-100mA
	24Mbps	1.10 A	+/-100mA		24Mbps	300 mA	+/-100mA
	36Mbps	1.00 A	+/-100mA		36Mbps	300 mA	+/-100mA
	48Mbps	0.90 A	+/-100mA		48Mbps	300 mA	+/-100mA
	54Mbps	0.80 A	+/-100mA		54Mbps	300 mA	+/-100mA

RANGE PERFORMANCE	
Indoor (Antenna Dependent):	Up to 400meters
Outdoor (Antenna Dependent):	Over 50km

DRIVER INFORMATION	
Operating System Support	Linux MADWIFI, WindowsXP, Windows2000
Advanced Mobility / QuickHandoff	WindowsXP/2000 Utility with Enhanced Mobility Driver from Ubiquiti
Cisco Support	CCX 4.0 Supported Driver/Utility also available from Ubiquiti

For help with MADWIFI or other Special Driver Support, Please e-mail support@ubnt.com

City of Gustavus

Alascom Internet Service (AIS) Basic Service

Prepared By:
Richard Carl
Data Network Account Executive
AT&T ALASCOM
TF Voice: 907.264.7729 TF Fax: 907.777.2658
April 11, 2008

City of Gustavus

April 11, 2008

Basic AT&T Alascom Internet Service	MONTHLY	1 Year DISCOUNT	2 Year DISCOUNT	3 Year DISCOUNT	INSTALL ONE TIME
DESCRIPTION	**MRC**	**15%**	**17%**	**20%**	**NRC**
T1 (1.5M) IP Port	$ 434.00	$ 368.90	$ 360.22	$ 347.20	$ 1,000.00
ACCESS CONNECTION	$ 20.00	$ -	$ -	$ -	$ 20.00
IOC Gustavue to Juneau 34 Miles**	$ 1,479.00	$ 754.29	$ 754.29	$ 754.29	$ -
TOTAL	**$ 1,933.00**	**$ 1,123.19**	**$ 1,114.51**	**$ 1,101.49**	**$ 1,020.00**

This quote is valid for 30 days from the date of issuance.
This quote does not include any taxes or surcharges.
Service is always based on facility availability at the time the order is placed.

Basic Offer - allows customers to access the Alascom Internet Platform via dedicated local access facilities.

Customers will see TWO charges on their bill, one for the Internet Port and one for the dedicated Local Access Circuit.

Monthly AC and ACF and their install waived with term contract.

***** IOC BACKHAUL DISCOUNT 49% *****

AT&T ALASCOM PROVIDED COMPONENTS:	CUSTOMER PROVIDED COMPONENTS:
Internet Port	Router with CSU/DSU
Primary and Secondary DNS Administration	
Network Usage Reports	
Dedicated Local Access Circuit	
Pro-active monitoring of your network	
Modem	

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City of Gustavus

April 11, 2008

Basic AT&T Alascom Internet Service	MONTHLY	1 Year DISCOUNT	2 Year DISCOUNT	3 Year DISCOUNT	INSTALL ONE TIME
DESCRIPTION	**MRC**	**15%**	**17%**	**20%**	**NRC**
2xT1 (3M) IP Port	$ 900.00	$ 765.00	$ 747.00	$ 720.00	$ 1,200.00
ACCESS CONNECTION	$ 20.00	$ -	$ -	$ -	$ 20.00
IOC Gustavue to Juneau 34 Miles**	$ 1,479.00	$ 754.29	$ 754.29	$ 754.29	$ -
TOTAL	**$ 2,399.00**	**$ 1,519.29**	**$ 1,501.29**	**$ 1,474.29**	**$ 1,220.00**

This quote is valid for 30 days from the date of issuance.
This quote does not include any taxes or surcharges.
Service is always based on facility availability at the time the order is placed.

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AT&T ALASCOM PROVIDED COMPONENTS:	CUSTOMER PROVIDED COMPONENTS:
Internet Port	Router with CSU/DSU
Primary and Secondary DNS Administration	
Network Usage Reports	
Dedicated Local Access Circuit	
Pro-active monitoring of your network	
Modem	

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Answers to Follow-Up Questions

Nate,

--------- Tower Sites ----------

Out of the sites you mentioned, I would lean toward the DRC site, where the existing building and power is located. I would also strongly consider two 120 degree sectors for multipoint operation.

That would leave a single 120 degree wedge for future fill-in if the community grows in that direction. Assuming Trango gear, that would also give you enough channels in each polarization to accomplish all of it at 900 MHz (i.e. 4 non-overlapping channels).

Remember also that you may want the link from AT&T. Therefore, your point-to-point link would go from that tower to AT&T's tower (or delivered by wire, depending on what you guys work out). The library would then become just a 900 MHz client to the infrastructure. If you could re-locate your servers to the tower building that would be an extra bonus. If not, that's no worry either. If you get a lot of server activity, the originally specced point-to-point link from a separate sector would provide you maximum throughput.

From that location you might also be able to implement Wi-Fi mobile Internet to the dock area directly from the tower. Further, you could point a Wi-Fi sector over the water and if a laptop (or client unit) is equipped with a small external antenna, you could maintain Internet connectivity quite far out there. An example would be a boat outfitted with a small client unit and an omni-directional antenna. Range would depend on configuration and atmospheric conditions over the water.

Caveat: Keep in mind the guy wires. Towers have been brought down by a loader or backhoe driving through a guy wire before . Guy wires will be deployed in a triangle shape so we'll want to keep any potential industrial traffic in mind when installing them.

I would avoid anything near the airport if possible. Save yourself the hassle.

The actual range of the Trango 900 MHz is 20 miles in stock configuration (integrated 60 degree sector). We can expect range to be shorter with their newest units coming out that deliver 12 Mbps of bandwidth and of course range is lower when cutting through trees. Our 4 to 7 mile range statement is conservative and taking into account your area.

That makes the Falls Creek Hydro location also a possibility. However, because the infrastructure for power and housing is not there, it would be lower on my list. Further, you might find yourself adding external antennas to a lot of your client units, which drives

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up installation cost. There are also additional benefits for having a tower closer to clients:

1. Maintenance is easier. Long drives through a blizzard to swap a UPS or refuel a generator during a power outage suck. Running off the road during that drive sucks even more.

2. The closer to "stock configuration" you can keep your client installs, the cheaper the install. Having the tower closer aids that process. Please note that having a tower TOO close to your clients can sometimes have an adverse effect too (i.e. less than a quarter mile or so) and is dealt with appropriately.

3. Longer range towers in multipoint configuration can leave you more vulnerable to interference issues along the path, now or in the future.

You could always add a tower (or a small, stub tower) up there in the future if you decide it's worth it.

--------- NEMA Enclosure ----------

Attachment: I've attached a PDF that describes a Relay Connection in the boonies. It will give you a good idea of what to do for standalone sites, including pictures. It is expensive to do though.

--------- Tower Type ----------

The lowest sized tower you could use is a Rohn 25G. We recommend a minimum Rohn 45 because you're located close to water, you're raising it to 100 feet and we expect you'll have winds and this tower will be more stable in that environment.

Attachment: I've attached a PDF describing the various Rohn towers.

--------- Tower Height ----------

The "minimum" comment also applies to the tower height.

The Rohn 45G Tower can be raised up to 300 feet. When using 900 MHz gear, you'll want about 20 feet of vertical separation between the sectors, so for a 100 foot tower the first sector would be at 100 feet and the second one at 80 feet. With the dual-120 degree-sector tower scenario described above, the top sector would point to the heavily forested area and the lower sector would point toward the NE.

A 100 foot tower is much easier to erect than a 150 foot tower and easier to climb when maintenance is required (you'd be surprised at the difference in just those extra 50 feet). However, you could easily add another 50 feet to the tower, bringing it to half its rated height. Your guy wires will also require a larger ground radius, the higher up you go, so there's something to keep in mind.

My guess is that the original height would work out for your scenario but it certainly wouldn't hurt adding another 50 feet if you're ok with the expense (additional tower legs,

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additional guy wiring, additional concrete, larger footprint, more shipping) and in any case, you can add segments to the tower at any time.

However, the potential of high winds and snow/ice loads makes me want to keep any towers around half their rated height. Also, in most cases, you'll want to engineer it so that your base transmitters will remain pointed parallel to the ground or at most, with a small downtilt. Too big of a downtilt and you may introduce problems with ground splatter (our slang term for signal reflections added to the area by pointing a transmitter toward the ground rather than letting the signal attenuate into the distance). Ground splatter can drive you nuts.

Because of the distance the Falls Creek tower would be away from Gustavus, a 500 foot elevation probably wouldn't cause you a concern with Ground Splatter, just as an FYI.

--------- Tower Install Budget ----------

We normally don't quote freight costs for these projects, because projects usually have a long timeline between quote and implementation. Freight charges can vary considerably in between, which is especially true with the current rising fuel prices. Also, because a different installer may choose different sources for the equipment, freight charges may vary between sources.

It includes the concrete but a prepped site is assumed, with the exception of the hole digging for the concrete. Since your tower site is as yet undetermined, we have no way to quote a site prep charge. Our quote is determined primarily on manpower/materiel and time spent. Anything Gustavus can provide that speeds this along can result in a lower bill.

Also, it would be understood that any supplies that could be purchased in Juneau at an equivalent or better price would be purchased there.

I'm not sure where the tower segments themselves were coming from but I'll pop a message to our Tower Installer and ask him. He's currently doing his tower thing in the lower 48. To my knowledge the guy wires are stainless steel with crimp collars, but I'll check on that with him too.

--------- Overall Budget Notes ----------

I'll make a note of this on the second version but please keep in mind that the budget prices quoted are subject to change with the market. Rising fuel prices can affect more than just transportation costs. We may want to refresh this information when you're ready to proceed. However, since we provide sources, you can keep track of any price changes along the way.

We are not equipment resellers though, even for Trango gear. The only exception to this is when we custom build or program equipment prior to delivery.

At 10:46 AM 5/3/2008 -0800, you wrote:

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Hello Horst,

As promised/warned I have some followup questions to the March 25 Borealis Broadband Gustavus Wireless Broadband Infrastructure proposal [http://tinyurl.com/3jwckq]. Since you delivered the proposal GCN committee members have met and identified a list of action items and have been working on them, particularly funding, tower location, and equipment choice. Funding is a local problem and we are working on it. You and I have discussed equipment choice and will continue to do so. The subject of this message is tower location and design, discussed on pages 9-10 of the proposal.

LOCATION, LOCATION, LOCATION

GCN committee members Fritz Koschmann and Jim Martell have looked at the criteria for tower location in the proposal and checked out various potential sites in the community, starting with property over which the city has management authority (see attached "Tower site" message). We would appreciate your analysis of one option which is to place the tower at the city's Disposal and Recycling Center (DRC). Location is 58.4043° -135.729°; see the attached updated Google Earth placemark file. This location is outside the circled "optimal" area in the proposal but you did say we have considerable flexibility. The trees in this area are few and relatively short so the tower could easily overtop them; it would be about .2 miles before the signal encountered the first trees. There are essentially no residences South of this location so perhaps a 180 sector antenna could be used instead of an omni for greater gain and range? There is a building and power on the site. One concern about the DRC site is that it is farther from the library than City Hall is (1.28 mi vs. 1.18 mi). Can we be sure of a reliable NLOS link back to our network center from the DRC?

The other site Fritz considered is shown in the Google placemark file as "Glen's Road parcel." I note this is quite close to the end of one of the runways. I have not yet heard anything definitive about the restrictions FAA imposes on towers; I think Fritz and Jim are working on that.

Have you considered the site labeled "Falls Creek Hydro" in the Google Earth placemark file? It offers a commanding view of Gustavus. I speculate its 500' elevation would result in a down-angle and thus fewer trees for the signal to penetrate. It is about 6.5 miles from the most distant customer (me!) but the entire area to be covered is within about a 30 degree wedge from that site so a high-gain antenna could be used. That location now has power. There could be permitting issues but if there were a strong technical reason to choose this location it could probably happen. There is no building there; how big a NEMA enclosure would we need? It seems to me the equipment to be housed would be a power meter and breaker panel, a surge suppressor and battery backup unit, and possibly a router, which if a Mikrotik indoor unit is not very big. One more consideration about this site might be its shot at Hoonah Mountain which is better than anywhere in central Gustavus which is more or less behind Pleasant Island.

DESIGN

For tower construction you recommend "installation of a Rohn 45 tower at a minimum, to a height of 100 feet." Does the "at a minimum" recommendation relate to the Rohn 45 type of structure or to the 100' height? One of our questions is whether we can gain

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additional fade margin by going higher, and at what point we get diminishing returns for additional height. Some parts of town have trees over 120' high; should we make our tower taller than they are? As you can see from all these questions we are still concerned about range since we did not have the facilities here for you to demonstrate the 4 to 7 mile coverage described in your proposal. So we want to build something we can be sure will work, not the minimum.

BUDGET

I understand the $8,500 tower installation budget you present includes concrete but not freight. Does the budget include site prep and tower pad prep for the concrete pour? Are the tower guy wires budgeted for galvanized or stainless steel and are you using wire clamps or crimp collars?

Would the tower be shipped from Anchorage or Seattle? Most of our freight comes through Juneau from Seattle by barge.

OK, that should be enough for now. I hope to get our antenna shortly so I can conduct the Trango/Mikrotik testing and give you those results shortly.

Nate
Received: (qmail 11533 invoked from network); 10 Apr 2008 16:04:08 -0000
Received: from unknown (192.168.1.107) by filter7.cesmail.net with QMQP; 10 Apr 2008 16:04:08 -0000
Received: from loki.catalog.com (HELO loki.onesite.com) (209.217.36.101) by mx70.cesmail.net with SMTP; 10 Apr 2008 16:04:06 -0000
MIME-Version: 1.0
Content-Type: multipart/mixed;
boundary="----_=_NextPart_002_01C89B24.81DE0C00"
Received: (qmail 13223 invoked by uid 10000); 10 Apr 2008 16:04:03 -0000
Received: (qmail 13145 invoked by uid 0); 10 Apr 2008 16:04:03 -0000
Received: from unknown (HELO mx4.webhero.com) (192.168.1.193) by 192.168.1.76 with SMTP; 10 Apr 2008 16:04:03 -0000
X-MimeOLE: Produced By Microsoft Exchange V6.5
Received: from webmail-outgoing.us4.outblaze.com (webmail-outgoing.us4.outblaze.com [205.158.62.67]) by mx4.webhero.com (Postfix) with ESMTP id 710DB10AC3DC for <nate@borson.net>; Thu, 10 Apr 2008 11:03:50 -0500 (CDT)
Received: from wfilter.us4.outblaze.com.int (wfilter.us4.outblaze.com.int [192.168.9.180]) by webmail-outgoing.us4.outblaze.com (Postfix) with QMQP id 9D39F18007CE for <nate@borson.net>; Thu, 10 Apr 2008 16:03:49 +0000 (GMT)
Received: by ws1-9.us4.outblaze.com (Postfix, from userid 1001) id 85CE3BE406B; Thu, 10 Apr 2008 16:03:49 +0000 (GMT)
Received: from [72.5.97.66] by ws1-9.us4.outblaze.com with http for fritzdfk@mail.com; Thu, 10 Apr 2008 07:03:49 -0900
Content-class: urn:content-classes:message
Subject: Tower site
Date: Thu, 10 Apr 2008 08:03:49 -0800
Message-ID: <20080410160349.85CE3BE406B@ws1-9.us4.outblaze.com>
X-MS-Has-Attach: yes
X-MS-TNEF-Correlator:
Thread-Topic: Tower site

Thread-Index: AcibJIHeqnUIG2xnTUi1tLai9CC2Bw==
From: "Fritz Koschmann" <fritzdfk@mail.com>
To: "Nathan Borson" <nate@borson.net>,
"CityGCN" <GCN@gustavus-ak.gov>

If you already received this I am sorry. I sent it a few days ago but didn't receive a copy myself and Nate said I was now on the list. I'll try once more.

I have been researching potential sites for the tower. The city only has management authority over a few parcels. There is other land that will be under city control in the future but there is no reliable time-frame for that to happen. It seems to me that we should concentrate on land that is usable now.

With that in mind I have selected two potential sites that the city controls now. One is the landfill area both on the south side of the Boat Harbor rd and the north side of the road. See attachments. On the south side there would be power and a building. I have talked to Paul and he supports siting a tower there. The probable site at the landfill would be on the north side of the existing fenced in area. Across the road there is plenty of space but we would have to bring in power and build a s tructure. I don't think that the cost of power and a structure would be prohibitive. I would think it would only add a few thousand to the overall cost.

The other site is the triangle with Glen's road on the NE side and the Main road on the NW. Again see attachment. This site again would require power and a structure. I talked to Joe Vanderzanden and he roughly guessed the cost to be below a couple thousand. A structure would have to be built but it could be very simple. The structure would have to be secure of course and might require a fence.

fritz

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ROHN™ Products

GT Series Towers

Products for a Growing World of Technology

GT Series

Multi-Use Towers Built to Last

The GT Series is a line of towers designed for efficiency, strength and versatility. The products in the GT Series include the 20G, 25G, 45G, 55G, and 65G towers. These durable towers are entirely welded and fabricated with precision equipment and are suited to meet a variety of needs.

Designed For Efficiency and Strength

All towers in the GT Series are constructed with high strength steel tubing and feature ROHN's exclusive Zig-Zag ® solid rod bracing to provide exceptional strength. All GT Series Towers are hot dip galvanized after fabrication. In this process, each section of the tower is totally immersed in molten zinc, allowing every square inch of the tower, inside and out, to be completely covered. Hot dip galvanizing protects all points of welding and construction against rust and corrosion while providing an attractive finish.

25G

The 25G is available in the standard 10' section length and as a 7' length which is UPS shippable. This tower uses double bolted joints which are proven to be the best method of joining tower sections for sturdiness and dependability. Featuring a 12-1/2" equilateral triangular design, the 25G is constructed of extra heavy duty 1-1/4" steel tubing side rails with continuous solid steel rod bracing. Each 10' section is shipped containing all required nuts and bolts inside one leg.

The 25G tower can be used guyed, self-supporting or bracketed configurations according to specifications in the ROHN catalog. As a guyed structure, it can rise to a maximum of 190 feet. Self-supporting and bracketed heights depend on loading and are also specified in the ROHN catalog.

20G

The 20G is an ideal tower for home TV installations. It's designed and engineered for 2 square feet of antenna surface and will handle most home TV installations. Should a larger antenna be used, we recommend the 25G Series. The 20G tower is intended for bracketed installations only.

All accessories for the 20G tower are the same as the 25G tower – they are completely interchangeable. The 20G is built with a 12-1/2" equilateral triangular design and has high strength tubular legs joined by Zig-Zag ® cross members. Each 10' section is shipped containing all required nuts and bolts inside one leg.

45G

The 45G is a true multi-use structure that provides excellent strength for applications up to 300 feet. It's offered with either heavy steel tube or solid steel rod legs to satisfy a wide variety of needs under varied conditions. When properly installed, the standard tower will support loads as shown on various guyed and self-supporting information sheets in the ROHN catalog.

Featuring an 18" equilateral triangular design, the 45G utilizes 1-1/4" outside diameter, 14 gauge special quality steel. The Zig-Zag ® cross bracing is formed from a continuous 7/16" solid steel rod electrically welded every 15-3/4" on the side rails. Each 10' sleeve is joined to the other and double bolted for extra strength.

55G

Because of its rugged design, the 55G lends itself well to a wide variety of uses in the communications field, particularly where unusual wind loading and height requirements exist. The 55G is designed to provide excellent strength in heights up to 400 feet. When properly installed, it will support loads as shown on various guyed and self-supporting information sheets in the ROHN catalog.

It features an 18" equilateral triangular design and utilizes high strength steel tubing side rails. The Zig-Zag ® cross bracing is formed from a continuous 7/16" solid steel rod electrically welded every 15-3/4" on the side rails. Each 10' sleeve is joined to the other end and double bolted for extra strength.

65G

The 65G is designed to provide excellent rigidity and strength in applications up to 500 feet when guyed, and 80 feet when self-supporting. Its high strength design covers a wide variety of communications uses. The 65G is completely prefabricated in welded sections allowing for quick and convenient installation.

This tower features 2" outside diameter high strength steel side rails and is built using a 26-1/4" equilateral triangle design. The Zig-Zag ® cross bracing is formed from a continuous 5/8" solid steel rod electrically welded every 22" on the side rails.

Notes