

# Installation of a 900 MHz Ethernet Bridge

*How to link two facilities together through trees and buildings*

## Executive Summary

### IP Data Corporation

- Small service and software firm in Florida, specializing in intellectual property products and services
- www.ipdatacorp.com

### The Challenge

- Two facilities two miles apart
- Wetland forest in between
- Secure high speed data link needed
- No DSL or Cable Internet access

### The Solution

- 900 MHz Wireless Ethernet Bridge
- Directional antennas
- Moderate towers

### Results

- Reliable 1 Mbps link established
- \$7200 per year in T1 charges saved

### Follow Up

- Newer AvaLAN xTR technology makes it easier
- Free software tools from the Internet

## The Challenge

Richard Burgess of IP Data Corporation in Edgewater, Florida was faced with a rather difficult and potentially costly internet connection problem when his company expanded into a new facility a couple of miles away. IP Data is in the business of providing intellectual property information (patent documents, manuals, etc.) from their self-hosted website. Because their location is (or was) in the “Internet sticks” with no cable or DSL access, their connection to the Internet was via leased T1 lines.

They moved their T1 lines to the new facility, but wanted to retain access at their old facility to allow some work to be done there and to provide off site backup for their valuable data. The first thought was to keep one T1 line connected to the old facility, but this solution had two serious issues: about \$7200/year for the additional T1, and bogging down their new T1 whenever they wanted to move large files from one facility to the other, disrupting service to customers from their website.

Mr. Burgess knew that a wifi link would not work because he had seen the 2.4 GHz signal from an inexpensive wifi blocked by a couple of dense trees. To connect his two facilities, he needed to penetrate a mile of dense Florida wetlands.

## The Solution

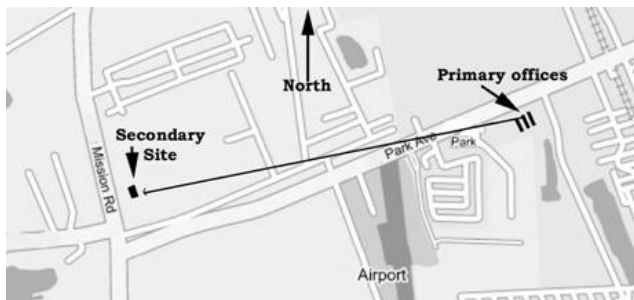
After searching the Internet for any information on real-world installations of the new unlicensed 900 MHz NLOS (Non Line Of Sight) 802.x Ethernet devices (bridges, point to point, point to multipoint, etc.), Mr. Burgess discovered that there was very little information to be had. The technology is fairly new and he found more questions than answers.

Because of his RF engineering background, he realized that the 900 MHz band offered the greatest chance of making his link work, given the amount of vegetation in the path. The lower the frequency, the greater the ability of RF to penetrate obstacles.

Avalan's AW-900 seemed to be just what he was looking for to save money, reduce commercial bandwidth consumption, and provide good security over a link between his two offices. AvaLAN's wireless link operates at the same raw data rate as a T1 line, about 1.5 Mbps. With link overhead, the delivered data rate is about 1 Mbps or 120 kilobytes per second. After the initial installation cost, their data could be exchanged with no \$7200 annual fee and no loss of bandwidth on their T1 lines to the Internet.

#### HOW MANY TREES ARE "TOO MANY" TREES?

Mr. Burgess was unable to find definitive information about the penetrating power of the 900 MHz signal. He knew there was no hope for a 2.4 GHz wifi, having experienced complete loss of signal by a couple of dense trees. The 900 MHz frequencies were reportedly much better, but he had to get through a mile of very dense woods. He asked a lot of questions of unbiased people, and got basically the same answer from everyone, which was: "No two sites are alike, you'll have to experiment to find out what works." A friend of his in New Jersey said "I am quite sure that you will have to get over the densest parts of the trees, but the tree tops won't bother you at all, and the farther the trees are away the less affect they have."



This map and satellite photo shows the path between the two buildings (black line in the map and yellow line in the photo). The distance between the two points is 1.55 miles. Note that the entire left side of the path is wooded and totally undeveloped.



Oaks, palms, maples, and just about every other variety of tree you'll find native to central Florida is in this wooded area nearest to the Secondary Site, and they are all mature trees. The area is undeveloped original Florida "Wet Lands" and woods. The very tallest trees top out at about 70 to 75 feet and the tallest trees appear in every direction at about 100 to 200 feet intervals. Another 25% to 30% of the trees along the path top out at about 45 feet with the rest at about 20 to

30 feet. The underbrush is also quite dense with short palms, ferns, saw grass, and many other varieties of plants. A good many of them are broadleaf and wide fronds - all excellent signal eaters.

Sometimes one can use a directional antenna and go "under the tree canopy" for a half mile or more if there is little or no underbrush or lower branches, but that certainly was not the case here. You can't see 10 yards in any direction in that swamp. Adding to the vegetation problem were power lines at about 50 feet and another set

at about 35 feet that run along the entire length of Park Avenue. They usually don't attenuate or interfere with the signals too much, but they can cause some serious interference if a 4,000 or 15,000 volt line has a bad (cracked) insulator near your location. Arcing in a cracked insulator can cause horrible wideband RF noise as high as 2 or 3 GHz. Mr. Burgess used an inexpensive police scanner that can tune the band from 896MHz to 960MHz and discovered that the band was relatively clear except for something near the upper end. The Avalan units ability to automatically change and select channels to avoid interference for maximum signal strength and data throughput made potential interfering signals a non-issue.

### INDOOR & OUTDOOR AW-900 UNITS

There are indoor and outdoor (sealed) versions of the AW-900, and AvaLAN also has high gain Yagi antennas available for the 900 to 928 MHz ISM band (Industrial, Scientific and Medical) band which these units can use. High antenna gain has a two-fold benefit, allowing the low power transmit signal to reach farther in one particular direction and increasing the receiver sensitivity in that same direction. Avalan has an entire "arsenal" of antennas for the 900 MHz band, some indoor, and many outdoor. Mr. Burgess opted to use a pair of 15 dBi parabolic antennas that he already owned instead of purchasing Yagis from AvaLAN. [Note that FCC requirements make it illegal to operate a radio in the unlicensed band with an antenna that has higher gain (thus higher EIRP) than what the manufacturer used in obtaining their certification.] He wasn't sure if he would need high gain antennas, but had already guessed that he would have to get up above some of the trees and his first round of experimenting confirmed this.

When he purchased the AvaLAN units, Mr. Burgess opted for the indoor version of the AW-900. The outdoor sealed version is more expensive and he wanted to keep the electronics indoors to make it easier to see the LED signal indicators. Having decided on the indoor units, and also knowing that he might need to elevate one or both of the antennas, he located (with some difficulty) low-loss cable with the right connectors on each end (RP-TNC). He suspected manufacturers of collusion to prevent a customer from using someone else's antennas and was partially correct. FCC "Unique Connector" rules were established to prevent using a different antenna from that used in certification testing. Low loss cable is important because of the loss of both transmit and receive signal. He used LMR-400 with loss of 4 dB /100 ft. Compare this to RG-58A which has 20 dB/100 ft loss at 900 MHz.

Mr. Burgess recommends purchasing and installing lightning arrestors for the cable. They plug inline right at the pigtail of the antenna and are clamped to the tower. With adequate grounding, these will help a great deal to protect the sensitive electronics.

### THE FIRST TEST

He stuck the 2.5db gain flexible antenna of one unit out of his office at about 17 feet above ground, and got an inverter for his car and powered up the other unit there. [Note: he also could have used an AvaLAN AW-12VA Auto Adapter.} He started driving west on Park Avenue (see the map) to see how far he could get at ground level with the 2.5 dB omnidirectional antennas included with the AW-900s. He got just short of 1 mile (right past the airport headed west on Park) and the signal dropped to zero from the 5 or 6 lit LEDs it had been on since he got into the car at the office. There are 6 signal level LEDs on each radio that indicate relative signal strength. He got out of the car and tried to move the antenna around, but the signal remained at zero. A mile range with small antennas at almost ground level was encouraging. There was a large steel building in the path at this point, so he didn't try to go any further.

### THE NEXT TEST

Next he hooked up the 15db gain parabolic dish antenna and put it in the back of his car and headed west from the office again. Periodically he stopped and took out the antenna and aimed it toward the office. This time he had good signal (5 to 6 lights) at the point where he last lost it. Aiming the antenna was very critical and not easily done holding it over his head “(not to mention some mighty strange looks from people passing by).” He then turned north on Airport Road (it crosses Park Ave going north and south just west of the airport - see the map) and drove up to the next corner (not more than 250 yards) and tried to aim the antenna to get a signal. There was a thick strip of trees and underbrush now between him and the office. He got absolutely nothing even with the 15 db gain antenna.



### TOWER TIME

Mr. Burgess wanted a small tower for other reasons at his original building and was intent on installing one. He didn't want to waste more time and effort to determine the minimum requirement to get the signal through, so he went directly to a solution that he was relatively certain would be sufficient. So, up went five 10 foot sections of Rohn model 25 triangular tower next to the building. He guyed it at the 35 foot point. The parabolic dish antenna went up on the tower mounted on a 10 foot 1.25" pole insert. The top section of the tower is designed for an antenna rotor which also allows you to insert and clamp a single 5 to 10 foot pole through a hole at the top. At left is a picture of the tower with the dish at the top. The picture is deceiving because most of the trees are higher than the antenna (including the tree directly to the left of it in the picture - the antenna is much closer to the camera).



The second dish was installed on three sections of galvanized TV mast (courtesy of the local Radio Shack). Using the maps and a GPS unit, Mr. Burgess and his helper aimed the dish antennas. However, even with 15 dB gain antennas, one side at 55 feet and the other side at about 26 feet, there was no signal.

### NOT THE PROBLEM HE THOUGHT IT WAS

How depressing! He immediately thought: “The tops of those trees are eating all of my signal!” However, as he was standing there holding the AvaLAN radio at the base of the 50 foot tower, he saw the signal lights flicker. He moved the box again and they flickered again. He discovered that he had an intermittent connection between the radio and the antenna! Once repaired, he had all 6 signal LEDs lit up rock solid. Finding this problem was pure luck. Once he repaired the connection, Mr. Burgess realized that his earlier automobile tests probably failed when they did because of the same problem.

### THE FINAL TEST

So, just as a test, he lowered the antenna at his new building and got it almost to ground level before the signal decreased. The tower on the heavily wooded side is probably 10 to 15 feet higher than it needs to be, but he’s sure he had to get over most of the trees to get maximum signal strength, and he does have 6 solid signal lights, 24 hours a day. He had originally planned on 20 to 30 foot poles on both sides, but is glad he put the taller tower up on the heavily wooded side to get above the heaviest vegetation.

## The Results



IP Data's Computer Closet



Closeup of AvaLAN Radio Installation

Here are pictures of the main AvaLAN radio in the equipment closet in the back of the IP Data Corp. computer room at the main office. You can see the rounded curve of the LMR-400 cable going into the bottom side of the unit. The LMR-400 is not very flexible and in fact, you do not want to kink this cable at all. Even a minor kink and too tight a bend can dramatically increase signal loss.

As a final test, Mr. Burgess measured the bandwidth by copying a 10 megabyte file across the link and it took 84 seconds. That is one megabyte approximately every 8 seconds, or 1 megabit/second (maybe just a wee bit less).

### BOTTOM LINE

IP Data Corporation now has a rock solid one megabit link between two offices almost 2 miles apart (including a mile of dense woods) and it has been running 24 hours a day. They had to reset one of the units after a very bad thunderstorm one afternoon when they took a hit close to the tower, but other than that it has run continuously and flawlessly and Mr. Burgess is absolutely thrilled with it (not to mention the fact that he is saving \$7200/year with this link).

## Followup



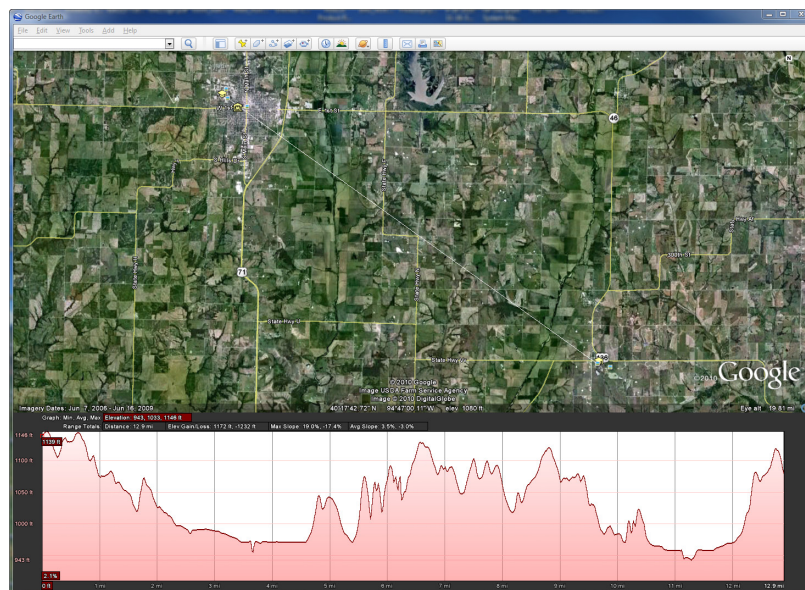
## NEW RADIOS

Mr. Burgess set up his AvaLAN wireless bridge several years ago. As we all know, technology moves so rapidly that information is often obsolete as soon as it is written. He used the AvaLAN AW900i radio and it has now been replaced by the AW900iTR. The primary difference is that this newer radio has a built-in browser interface and this allows configuration of the radio over the Ethernet connection.

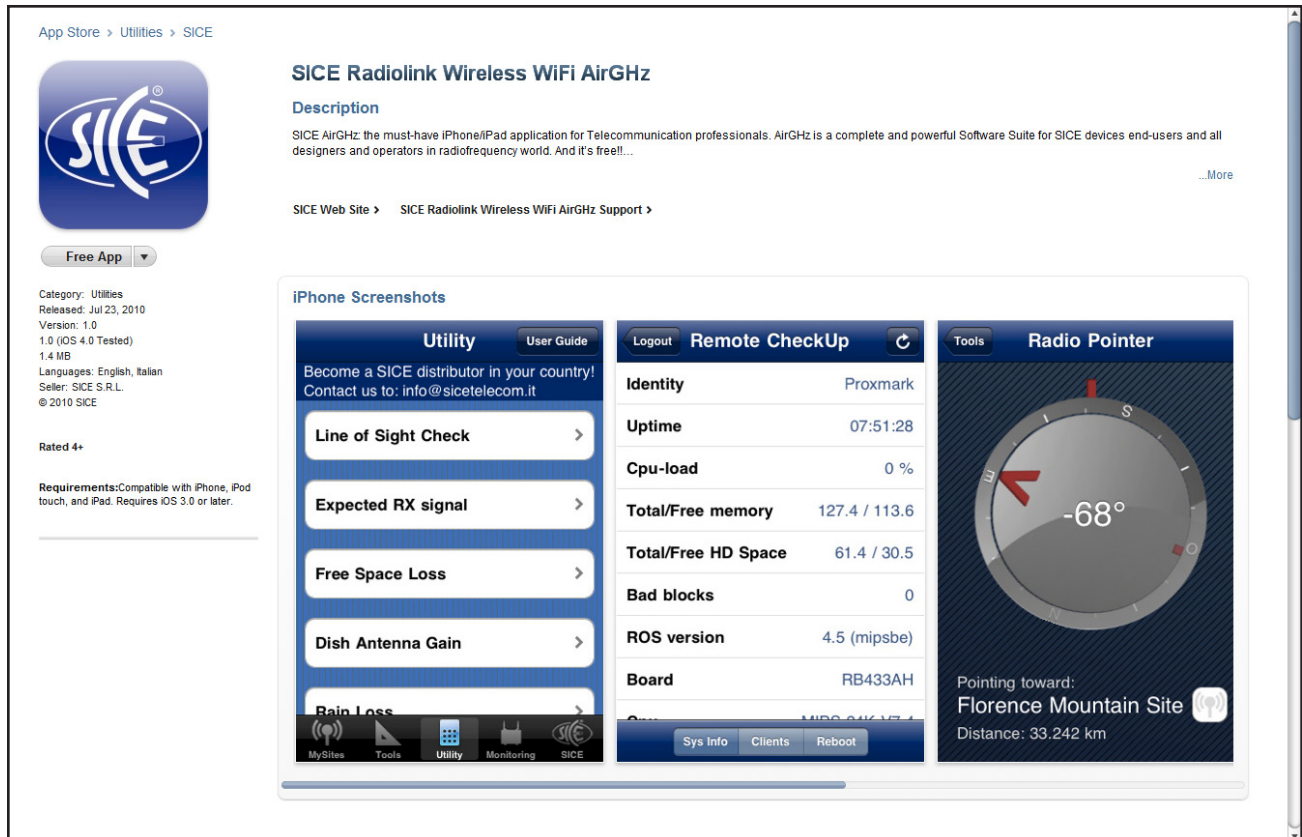
Because you no longer need to see the LEDs or move the DIP switches, many users opt for the external version, the AW900xTR because it provides a rugged outdoor enclosure that can be mounted atop the tower next to the antenna. Instead of expensive RF cable with its attendant signal loss, the cable run up the tower can be an inexpensive outdoor-rated CAT-5 Ethernet cable. The Power Over Ethernet (POE) Injector provided with the radio allows you to place the power supply at a convenient location and avoid a separate power cable to the top of the tower.

## NEW TOOLS

There are many excellent hardware and software tools now available that simplify the job of designing and implementing a long distance wireless link. At the writing of this Case Study, Google Earth was one of the best (and free) tools for plotting an elevation profile. Here is an example screen shot:



For those of you who have iPhones, there is an exciting free app from SICE Telecom in Italy called AirGHz. This amazing tool can help point the antennas, tilt them properly and calculate parameters such as antenna gain vs. diameter and expected receive signal strength.



Before going too far with either of these suggestions, we suggest that you do an Internet search for “topographic profile tools” or “antenna alignment tools” or visit [www.avalanwireless.com](http://www.avalanwireless.com) for our latest recommendations.