

RadioResource

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C O M M U N I C A T I O N S

Have you Checked your NOISE FLOOR Recently?

By Gary Hartman

Does the following scenario seem familiar? Your municipality's communications infrastructure is 20 years old ... Portable radios are barely audible in some parts of town, and even the mobile radios have issues in some areas. And this is just when the radios are working ... Much of the time, they're in shop getting fixed.

You know almost all your equipment needs to be replaced, but how do you ensure that your town will get a system that functions adequately for the large amount of money you will probably spend?

For years, operators in the highly competitive cellular world have known the value that propagation software provides for solving basic coverage concerns. The land mobile radio world has begun to apply the technology when factoring system coverage; however, users must be aware that the software is only as good as the data placed into it. In other words, GIGO (garbage in, garbage out).

Two important parameters need to

Table 1: Typical UHF Base Station (Outbound) Link Budget

Network Element	Gain/Loss	Antenna System Gain/Loss (dB)	Power (dBm)	Power (Watts)
Base Station TX Power	--	--	50.0	100
Coax Cable	Loss	-2.0		
Jumper	Loss	-1.5		
Lightning Protector	Loss	-0.5		
Antenna	Gain	9.0		
System Gain/Loss	Gain	5.0	5.0	
Effective Radiated Pattern (ERP)	--	--	55.0	316

Table 2: Typical Mobile Link Budget

Network Element	Gain/Loss	Antenna System Gain/Loss (dB)	Power (dBm)	Power (Watts)
Mobile Unit Power	--	--	47.0	50
Coax Cable	Loss	-1.0		
Antenna Gain	--	0.0		
System Gain/Loss	Loss	-1.0	-1.0	
Effective Radiated Pattern (ERP)	--	--	46.0	40

be established before using propagation software. First, the "link budget," the sum of all system gains and losses in the transmit power, needs to be defined and checked against reality. The second parameter is the target sig-

nal strength required to achieve reliable coverage within the coverage area.

For cellular carriers, these factors are well known and readily understood. For the two-way radio world, there appears to be very little research

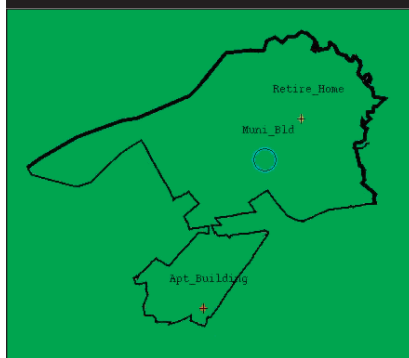
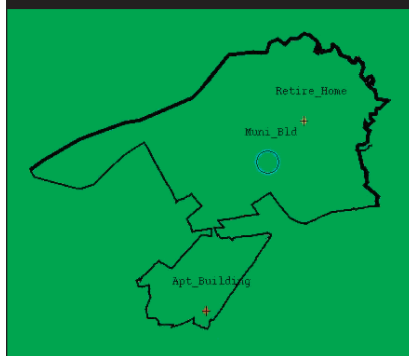
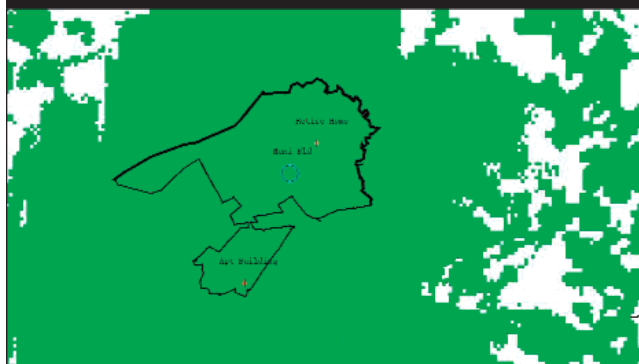
Table 3: Typical Portable Link Budget

Network Element	Gain/Loss	Antenna System Gain/Loss	Power (dBm)	Power (Watts)
Portable TX Power	--	--	36.0	5
Coax Cable	Loss	0.0		
System Gain/Loss	--	0.0		
Effective Radiated Pattern	--	--	36.0	5

Table 4: Noise Floor RSSI

Number of Points Examined	Average Noise Floor RSSI	Standard Deviation of Points	Highest RSSI Measured	Lowest RSSI Measured
492	-101 dBm	3.79	-90.0	-112.2

that addresses either of these important parameters. Engineers have extended their cellular expertise to the public safety environment, examining what the parameters for this sector.

Figure 1: Low Noise Talk-Out**Figure 2: Low Noise Mobile Talk-In****Figure 3: Low Noise Portable Talk-In**

Define the Link Budget

Determining a radio system's link budget is the first step to developing an accurate coverage model. The link budget is simply the transmit power adjusted by all passive gains and losses between the output connector of a transmitter and the input to a receiver.

The propagation software should determine the path loss between a transmit antenna and a receiver antenna; it's up to you to determine the other parameters such as cable losses and antenna gains. The goal is to determine the actual power radiated by the antenna toward the radios in the field. Table 1 is an example of the typical UHF link budget. For convenience, the link budget uses dBs for gains and losses and dBms for actual power levels, which allows you to add and subtract gains and losses directly.

One size does not fit all in the land mobile world. The majority of mobile two-way systems are limited by the inbound (talk-in) path. And the difference between the mobile talk-in vs. the portable is also very pronounced.

Since the portable has the lowest power, portable coverage almost always becomes the limiting factor of

coverage. Typical UHF link budgets are indicated in Table 2 for a mobile transmitter and in Table 3 for a portable transmitter. When you compare Table 2 with Table 3, there is almost a 10 dB difference between the talk-in capability of a

mobile vs. portable radio.

Given the imbalance between the talk-out and talk-in paths, receive-only receivers (satellite receivers) can be deployed in a system design where the best quality received signal is "voted" for receiving and/or repeating through the base station's transmitter.

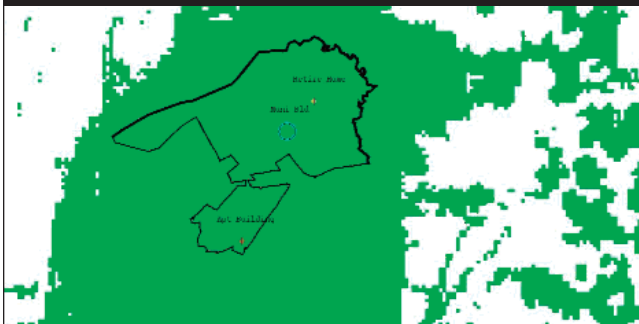
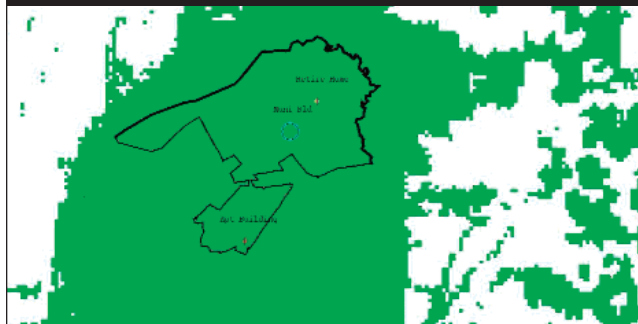
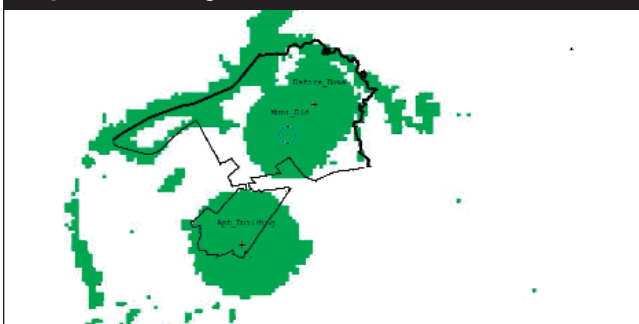
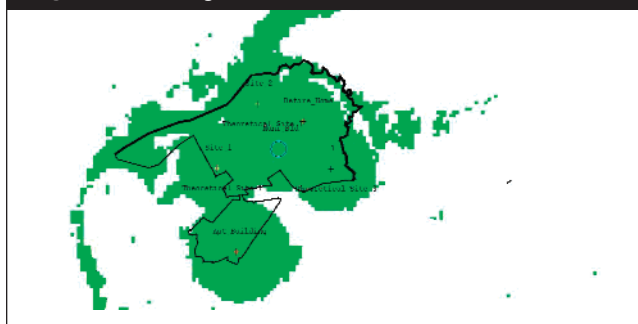
Target Coverage Levels

Exactly what minimum coverage level is needed to achieve reliable communications? It is well known that most modern radio receivers have good sensitivity (or at least 12 dB SINAD operation) down to a -120 dBm input. So, one might think that a target level of -110 dBm, which provides a 10 dB margin would provide reliable communications.

With this assumption mind, consider the following example: A township located next to a large city in the Northeast operates a UHF repeater system. The township's terrain is relatively flat and covers a 12-square-mile area. A full repeater is located at the public safety building, with two additional satellite receivers at either end of the township.

Using -110 dBm as the target level for acceptable coverage and the base station outbound link budget in Table 1, mobile link budget in Table 2, and portable link budget in Table 3, coverage maps were generated for low-noise talk-out (Figure 1), low-noise mobile talk-in (Figure 2), and low-noise portable talk-in (Figure 3). According to the maps, the township should have complete portable talk-in coverage well beyond its borders. Unfortunately, this was *not* the experience that the township was having with its communications. Clearly, there were other factors at work.

To better understand the environment, a trial in the township was performed using a computer-controlled communications receiver and a GPS unit. This data was useful in two ways. First, data collected while the transmitter was keyed was used to tune the propagation software to better model the actual levels achieved in the field. Second, data recorded while the transmitter was not keyed proved to be the most valuable. This data represented the noise floor of the environment.

Figure 4: Average Noise Floor Talk-Out**Figure 5: Average Noise Floor Mobile Talk-In****Figure 6: Average Noise Floor Portable Talk-In****Figure 7: Average Noise Floor Portable Talk-In, 3 New RX Sites**

The trial identified 492 points in close proximity to the actual transmitter where the signal level could clearly be separated into keyed and non-keyed values. The average of the non-keyed values was taken to establish the actual noise floor environment of the area where the system is in operation. This data is shown in Table 4.

The average noise floor in this area turned out to be a whopping -101 dBm. Now, the target receive level needed to be adjusted to -90 dBm, to achieve 10 dB over the noise floor, which produced very different plots for average noise floor talk-out (Figure 4), average noise floor mobile talk-in (Figure 5), and average noise floor portable talk-in (Figure 6).

What a difference 20 dB can make. These plots clearly showed coverage issues in several areas of the township for portable talk-in that correlate to actual reported communications failures. This paints a more accurate picture of the communications environment in this township. So, three new satellite receiver sites were added to the model, creating a system design

that provides reliable coverage within the township borders. The additional receivers (for a total of six receivers, a receiver density of two square miles per receiver) produced the plot in Figure 7, which indicates there is reliable portable talk-in coverage for most of the township's borders.

In this example, if the area had been located in a low-noise environment where the equipment sensitivity of -120 dBm would be the limiting factor for reception, a single base station could provide reliable coverage well beyond the township. Since the noise floor environment was in close proximity to a major urban area, however, the noise floor environment is the overriding factor for reliable reception.

Conclusion

To accurately predict coverage with propagation software requires complete knowledge of the proposed system's operating environment. Precise link budget and noise floor numbers are a must to produce accurate coverage predictions. Without

knowledge of these parameters, any propagation plot must be viewed with suspicion. In many cases, the process used to arrive at these numbers is beyond the capabilities of not only the organization purchasing the system but also the expertise of the two-way vendor supplying the equipment.

Hiring a seasoned engineering consultant can be worth the additional expenditure, considering the cost of purchasing a completely new system designed and installed with false coverage assumptions. ■

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