Chapter 38 of the Society of Broadcast Engineers
SBE
EL PASO - LAS CRUCES - JUAREZ

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NEWS

Back to Basics: Spectrum 101

By Doug Lung June 26, 2015

Why This **Matters** The FCC is designing an auction to reduce broadcast TV spectrum by up to 40 percent.

This article originally appeared in the print edition of Radio's sister publication, TV Technology. We share it with readers who will be interested in spectrum management issues.

THE BIG ISLAND—To understand the concerns about spectrum availability and the value of spectrum, it's worth taking a look at the history of spectrum usage, how spectrum is valued, and what the impact of the demand for greater wireless data bandwidth and associated spectrum needs will have on broadcasting.

WHAT SPECTRUM IS MORE VALUABLE?

The UHF TV spectrum at 600 MHz has been called "beachfront property" for wireless carriers but before buying that property, it might be worth asking if today's "beachfront property" might be underwater tomorrow. Looking at the history of spectrum usage, could this spectrum be worth less in 2020 than it was when the National Broadband Plan was released in 2010? This month I'll present some historical data and some technical arguments that support my assertion that, as demand for data bandwidth increases, the value of higher frequency spectrum increases and that of lower frequency spectrum decreases.

It may be hard to believe, but at the dawn of the 20th century frequencies below 1 MHz were considered the best ones for communications. Large RF alternators were used to generate high power RF signals at frequencies below 50 kHz. One is still operational on 17.2 kHz (Fig. 1). Amateur radio operators were disappointed when the Radio Act of 1912 restricted private radio transmission to wavelengths above 200 meters (1500 kHz), but found the higher frequencies actually allowed longer range contacts.

In the last 100 years, amateur radio operators have found their higher frequency allocations, well into the GHz bands, limited or shared as other users discovered the value of their previously undiscovered higher-frequency spectrum.

I got my first job in broadcasting more than 45 years ago and at that time AM radio (540–1600 kHz) was king and FM radio (88–108 MHz) was a stepchild that got little respect. Today, except for a few stations in larger markets, listeners tuning into AM radio are likely to hear the same programs (usually sports talk) delivered nationwide by satellite. Programming has moved to FM, and even all-news AM stations are finding outlets on FM radio, if not as the primary service, as a digital HD-Radio subchannel.

After the transition to digital TV, even the FCC recognized that UHF spectrum was at least equal to VHF spectrum. Based on the incentive auction rules, UHF TV spectrum is now valued significantly higher than VHF TV spectrum. History shows that through time, higher frequency spectrum becomes more valuable, although the technical and economic reasons for that vary.

KTSM-TV

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KRWG-TV

KBNA-AM/FM & KAMA-AM

KHEY-AM/FM, KPRR-FM & KTSM-AM/FM

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THE LIMITS OF SHANNON

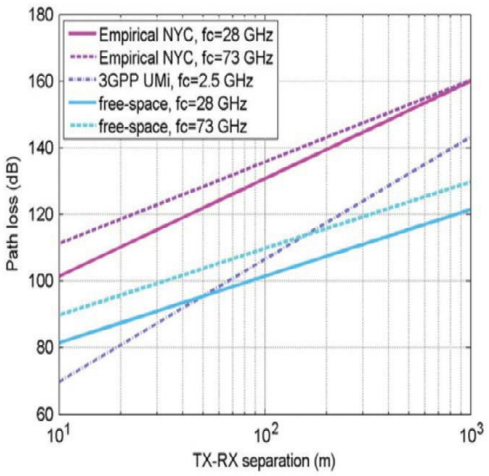

Fig. 2: Comparison of distance-based path loss models with unity gain antennas. The curves labeled "Empirical NYC" are the experimentally derived mmW models based on the NYC data. These are compared to free space propagation for the same frequencies and the 3GPP UMi model for 2.5 GHz.

Let's look at the technical reasons first. In my article **"Reviewing Next-Generation Error Correction Codes**," I explained the "Shannon Limit," the maximum error-free data rate that could be sent over a given amount of bandwidth for a given signal-to-noise ratio (SNR). The obvious conclusion is that more bandwidth provides a greater data rate for a given SNR. The lower the frequency, the lower the available bandwidth. Designing RF systems that can use bandwidths more than 5 percent of the center frequency is difficult. At 600 MHz this equates to 30 MHz; at 5 GHz this equates to 250 MHz—more than eight times the bandwidth and eight times the data rate for a given SNR. This makes higher frequencies more useful. If someone tried to put a 200 kHz-wide FM signal in the medium wave AM band, there would have only been room for five stations! Wider bandwidths and higher speeds demand higher frequencies.
Some of you may be asking, "What about MIMO and directional antennas?" The advantage again goes to the higher-frequency spectrum. The rea-

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EL PASO, TX SBE CHAPTER 38 MEETING MINUTE

DATE 6/9/2015 LOCATION: COMO'S ITALIAN REST.

MEETING CALLED TO ORDER: 12:26 PM, BY ANTONIO CASTRO, THERE WERE 8 MEMBERS.

REPORT OF THE SECRETARY: MINUTES IN THE MAY NEWSLETTER. ACCEPTED BY CARLOS SOSA, SECOND BY MICHAEL GIERE.

REPORT OF THE TREASURER: $ 10,334.75 IN THE BANK. ACCEPTED BY DAVID GRICE, SECOND BY MICHAEL GIERE.

REPORT OF THE CERTIFICATION COMMITTEE: WAITING FOR TWO CTO FOR EXAM.

REPORT OF THE MEMBERSHIP COMMITTEE: NO REPORT.

REPORT OF THE FREQUENCY COORDINATOR COMMITTEE: NO REPORT

REPORT OF THE SCHOLARSHIP COMMITTEE: ONE APPLICATION FOR REVIEW, VOTED UNANIMOUS FOR GRANTING. CIERRA BUSTAMANTE IS THE RECIPIENT.

REPORT OF THE WEBSITE COMMITTEE: 1879 HITS LAST TIME, NOW 1895. (16).

REPORT OF THE EAS CHAIRMAN: MONTHLY FROM TEXAS CAME FINE, NEW MEXICO EQUIPMENT IS DOWN..

REPORT OF THE PROGRAM COMMITTEE: INVITATION FROM SPONSOR TO LUNCH AT THE LAS CRUCES KRWG, INCLUDING CHAPTER MEETING

UNFINISHED BUSINESS: NONE.

NEW BUSINESS OR ANY ITEMS FOR THE CHAPTER INTERES: THE ENNES WORKSHOP WAS A SUCCESS. READED THE SURVEY RESULTS.

NEXT MEETING DATE AND LOCATION: TUESDAY, JULY 14TH 2015, AT NOON @ KRWG, LAS CRUCES. NEW MEXICO.

MEETING ADJOURNED: AT 12:52:00 PM.

CONGRATULATIONS TO **BRUNO CRUZ**, UNANIMOUS WINER OF THE 2015 CHAPTER 38 ENGINEER OF THE YEAR. NOW, HIS NAME IS AMONG SEVERAL CHAPTER WINNERS COMPETING FOR THE NATIONAL "ROBERT E. FLANDERS" 2015 AWARD.

JULY PROGRAM

There was no presentation for last month of JUNE, just our regular meeting, held at the Italian restaurant "COMO'S" where with a minimal attendance, BRUNO CRUZ was elected the " 2015 Chapter Engineer of the Year".

For this JULY, we have this invitation to a presentation from TRIVENI DIGITAL who is hosting a lunch right at the installations of KRWG TV. This is in Las Cruces, NM. and it is the perfect opportunity for us to know the place and have a tour in the installations that Mario Jimenez and his engineering crew will show. Directions in how to get there will be e-mailed to everyone in the next few days.

WHEN? Tuesday July 14, 2015
WHAT? Meeting and presentation
TIME? 12:00 PM (NOON)
WHERE? KRWG TV/FM, NMSU
HOST? Ruben I. Araza, Trevini Digital.

The reason is that the directivity of an antenna is related to its size in wavelengths. For MIMO to be effective, it requires at least two receive antennas isolated from each other. The longer wavelengths (lower frequencies) in the UHF or lower bands make it more difficult to isolate antennas, especially in the confined space of smartphones and even tablets compared to higher-frequency spectrum. One wavelength at 600 MHz is about 20 inches, while at 5 GHz, the wavelength is less than 2.4 inches.

One of the advantages of lower frequencies is that they can travel great distances. I regularly receive KNX (1070 kHz) from Los Angles after dark while driving in Hawaii. Properly designed UHF and VHF stations, assuming no terrain obstructions, can provide a decent signal all the way to the radio horizon. Lower frequencies are also passed through foliage and through windows.

This ability to get indoors, to get through the trees, is one reason 600 MHz spectrum has attracted the interest of wireless carriers. However, Shannon's Limit still applies, limiting the number of users a site can support. As the number of users grows it will be difficult to increase the bandwidth, and thus the data rate, enough to accommodate them, even after using directional antennas to provide sector coverage.

FREQUENCIES OR SITES?

As cell sites become overloaded, wireless carriers increase capacity by adding more sites, so each one serves a smaller number of customers. As the service area of each site is reduced, the long-range coverage of UHF frequencies becomes less important and limiting interference more complicated. We've already seen Verizon shift traffic from its 700 MHz LTE spectrum to its 1700 MHz spectrum in urban areas. As demand for bandwidth grows, even reallocating the entire UHF TV band for wireless broadband won't be sufficient.

With a large number of closely spaced cell sites, there is no advantage in using UHF spectrum (500–800 MHz) for wireless broadband. As sites become denser, it is easier to move to higher frequencies with wider RF bandwidth. More bandwidth equals higher data rates and more users. At much higher frequencies with shorter wavelengths, it's possible to use massive MIMO with very directional beams. Researchers at NYU Wireless (an academic research center focusing on wireless, computing and medical applications), have successfully tested wireless links in New York City using 28–60 GHz spectrum. Last fall, Samsung tested 5G technology in New York as well, delivering data rates more than 1 Gbps over distances up to 2 km using 28 GHz spectrum.

Who will be the winner in the battle for wireless bandwidth? Look at companies developing technology for spectrum well above that commonly used today. The need for more base stations will benefit those companies with the ability to inexpensively deliver very high data rates to antennas on roof tops and light pole tops.

Cable companies are in a great position to move their business from delivering fast, wired Internet to delivering wireless Internet just as fast or faster. It isn't surprising CableLabs has joined NYUWireless.

Another option—if some data bandwidth can be sacrificed—is a mesh network, where base stations connect to each other to move data across the network. Such a network could be built inexpensively using unlicensed spectrum, similar to Metricom's 900 MHz Ricochet network that, until it shut down in 2001, provided higher data rates than most cellular companies could provide.

What about broadcasters? The maximum frequency allocated for conventional TV broadcasting is 698 MHz and that may drop to 608 MHz or less after incentive auction repacking. Being limited to 6 MHz of bandwidth, the only way broadcasters will be able to deliver higher data rates and prettier pictures to viewers will be to move to a new transmission standard. ATSC 3.0 will allow broadcasters to trade-off robustness for and increase in the data rate and that loss in robustness can be offset by building single frequency networks—multiple transmitters using the same channel—to deliver a stronger signal to viewers unable to get a strong signal from the main transmitter. Such coverage could still be useful after 5G technology allows essentially unlimited wireless Internet.

I welcome your comments. Email me at **dlung@tran**