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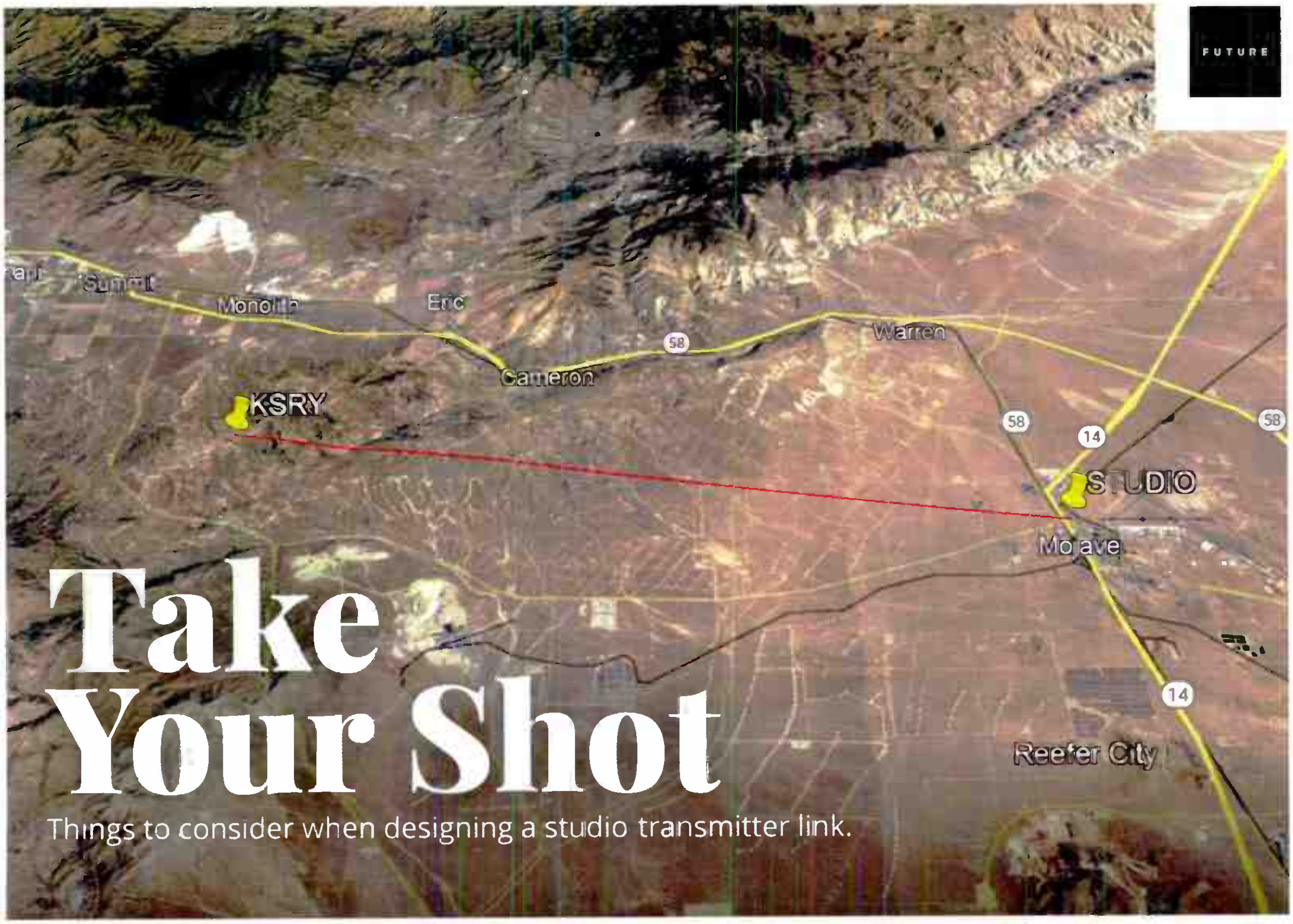

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Things to consider when designing a studio transmitter link.

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A link from outside the box

Over-the-air STLs can be a challenge

Cris Alexander
CPBE, AMD, DRB
Technical Editor

Not long after I came to work for Crawford Broadcasting in 1984, I was introduced to our most recent acquisition, KBRT in Los Angeles. The station was unique in that the transmitter site for the three-tower 10 kW 740 kHz AM was located on Santa Catalina Island, some "26 miles across the sea ..." as described in the song "26 Miles" by the Four Preps, circa 1957.

The infrastructure for the station was different than anything I had ever seen. There was an audio feed from the Century City studio by an equalized "phone line," which actually made the hop from mainland to island on a C-band terrestrial microwave link operated by the phone company.

The problem was the several miles long run of copper from the phone company facility in Avalon to the site, which was up near the Airport in the Sky. Whenever it would rain, the overhead line would develop a hum and sound terrible.

As a backup to the phone line (or maybe it was the other way around, I forget), there were not one but two Part 74 STL links. One was from a bluff at Ranchos Palos Verdes (RPV) to a hilltop at the KBRT site, and the other was from the Queen Mary, which was moored permanently at Long Beach. Both sites were fed with equalized phone lines from our studio. I remember that those STLs operated on grandfathered 930 MHz frequencies, which we kept for most of our remaining tenure on the island.

Between those three STLs, the station could generally keep program audio on the air. We had a full-time engineer living in company housing at the site, and it was a big part of his job to monitor and make sure we had a clean program feed at all times, switching as necessary and as conditions changed.

At some point, we lost the site at the Queen, and I moved that link to the top of Signal Hill in the Long Beach area. Then, when we moved our studios from Century City to Costa Mesa in 1987, I rented tower space from a cable

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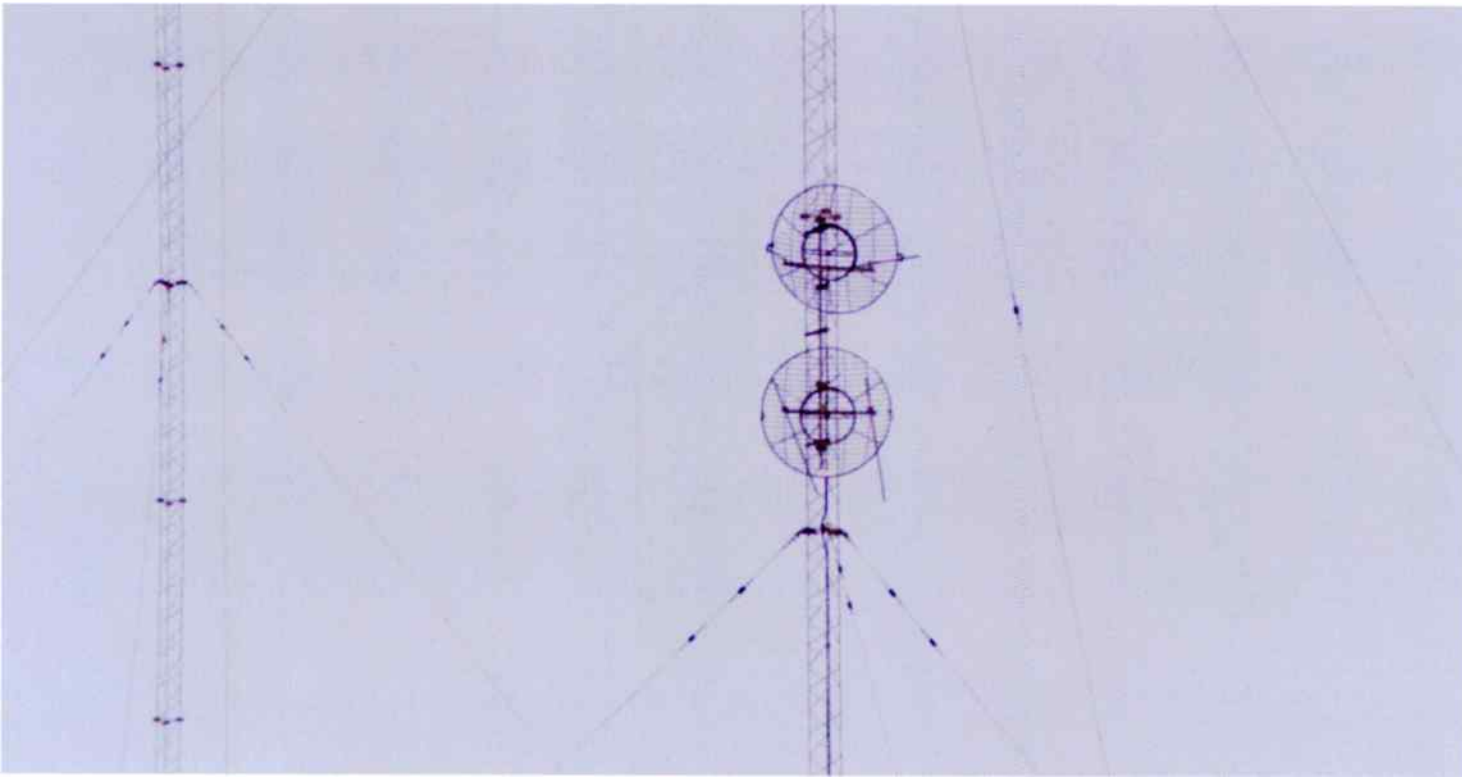


Above
These 10-foot grid antennas were used in the 930 MHz diversity array for KBRT on Catalina Island. We hung them at an elevation where there was no view of the water but we still had a clear shot to the mainland end of the path. Still, knife-edge propagation let enough multipath through that digital never would work.

TV head end a couple of blocks from the new studio and employed an "IF repeater" STL to get from studio rooftop to cable TV tower to the island.

As you can imagine, all those paths were clear. Nothing but oil derricks and ship traffic between the mainland and island antennas. The island transmitter site, by the way, was some 1,300 feet above sea level with a clear view of the mainland. Our typical receive signal was full scale, over 1,000 uV.

And yet, the over-the-air STL link was not all that reliable. When we would get marine layer over the Santa Barbara Channel, we would get deep fades and the recovered audio would get noisy or would squelch altogether.

My experience to that point was all with over-land 950 MHz STLs, so I really didn't understand what was happening other than that there was maybe some refraction taking place that was "bending" the signal up or down so that it would miss the receive antenna. Or was it something else?

I talked to some very smart people who suggested that we try a diversity receive system, with two antennas spaced a significant distance apart on one of the AM towers.

So that's what I did. We hung two 10-foot grid antennas on one of the towers. I don't recall the vertical spacing, but it was significant. Each antenna fed a separate receiver, and we put a "voter" between them that monitored the AGC voltage from each receiver and selected the one with the higher signal.

Fingers crossed, I fired that system up and on a foggy day (marine layer over the channel made fog on the island), watched it work. I saw the signal on one receiver start to dip, dropping from over 1,000 uV to the bottom of the scale. At the same time, I saw the signal meter on the other receiver rising. At a certain point, I heard a "click" as the relay in the voter routed the signal from the receiver with the better signal. The audio stayed steady and noise-free!

We used that system for many years, eventually transitioning to a T1 when the cable company jacked the tower rent up out of reach.

At one point, we tried a digital add-on to the 930 MHz STL, but it didn't work at all, despite the strong signal. The reason: multipath from water reflections. As I recall, there was a UHF TV transmitter on the island trying to serve the Southern California mainland, and they had water multipath issues, too.

I learned a lot in those island years about STLs and UHF propagation. I learned that in some situations, innovation was required. And it was gratifying to see the application of "out of the box" thinking actually work.

In this issue of RWEE, Dennis Sloatman will educate us on some of the principles at work in the STL world. This is a followup to an article we published about a year ago. I trust that you will be enlightened by Dennis as I was.

Also, some months back Crawford Broadcasting experienced a strange phenomenon with our Buffalo, N.Y., superpower FM. We may see more of this kind of thing as stations upgrade their HD facilities; James O'Neal reports in this issue. I think you'll find it's an eye-opener.

Our goal in these pages is to give radio engineers tools that they can use in their everyday work. I'm confident that you'll come away with something of value from this issue. If you have topic suggestions, I'd love to hear from you. Email me at *rweetech@gmail.com*.

Writer

Dennis L. Sloatman

CSRE, AMD, CBNT, BSEET

Factors that affect your STL performance

Things to consider when designing a studio-transmitter link

In an earlier article we discussed microwave theory for STLs. You can read that story in the Oct. 19, 2022 issue at *radioworld.com/digital-editions*.

In the prior article, we discussed factors on which we have some influence: antenna size, transmitter power, type (and associated loss) of transmission lines, etc.

Now let's consider aspects of the microwave system over which you have no direct control but can predict and work around using accumulated knowledge.

To review, we have learned that there is no direct "loss" due to distance, it's just that as we move farther from the source terminal, the signal is more diffuse, and therefore, you can capture only a smaller sample.

However, that's loss in "free space," which is nothing like the real world. In our world, we have atmospheric disturbances, temperature inversions (which affect "K Factor," to be discussed later) as well as interference from other sources, destructive signal polarity inversions when a path is over a body of water, among other concerns.

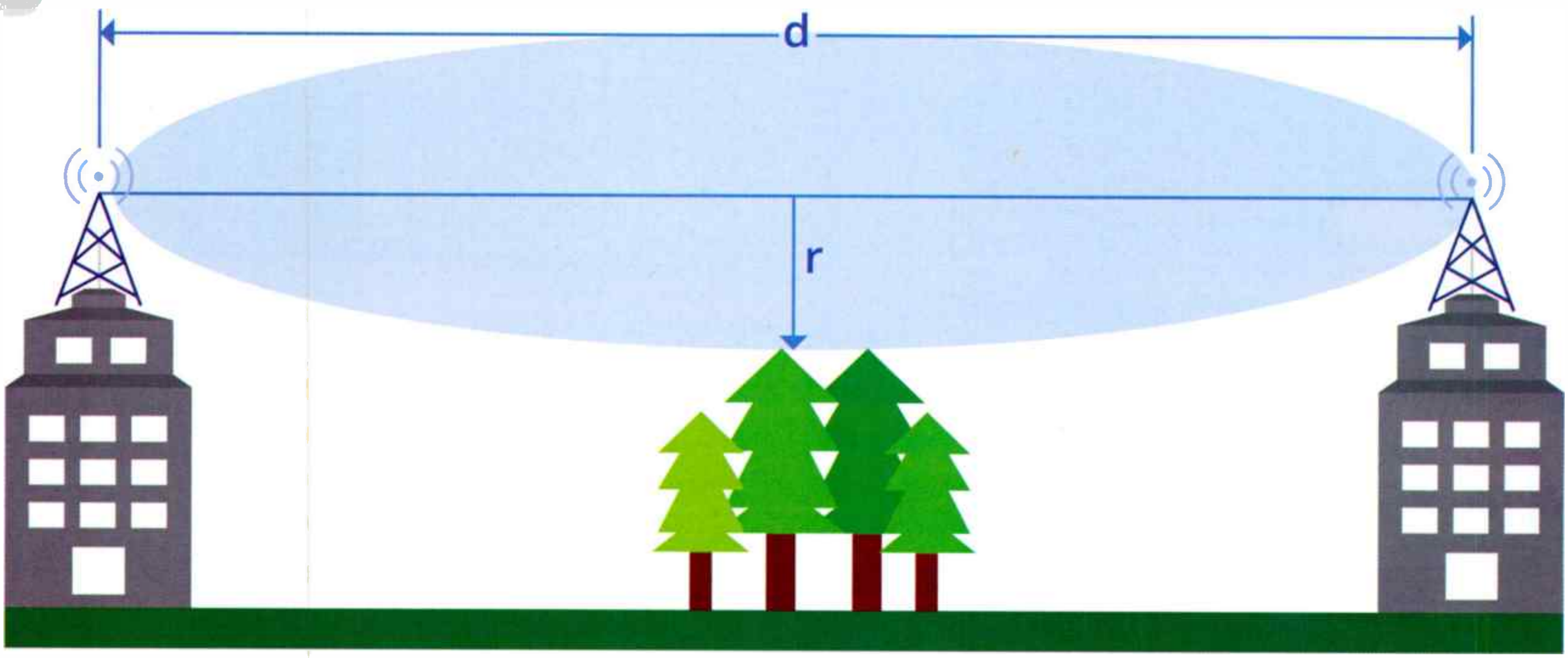
Among the worst issues an engineer may experience with the microwave path, aside from equipment failure, are interference from another transmitter (sometimes at seemingly random times); atmospheric effects such as tropospheric ducting, temperature inversions or polarity reversal of the wave front due to a reflective surface; and objects inserted into the path without prior knowledge such as a new office building.

So we open a toolbox of mitigation methods that are proven to be effective in the design of microwave systems.

Types of diversity

Frequency Diversity: The idea is to have more than one frequency (or "channel") in the system design (here

Below
Fig. 1: Fresnel zone diagram



$$r_{(in\ mts)} = 17.32 \times \sqrt{\frac{d_{(in\ km)}}{4f_{(in\ GHz)}}}$$

$$r_{(in\ ft)} = 72.05 \times \sqrt{\frac{d_{(in\ miles)}}{4f_{(in\ GHz)}}}$$

by "system," I mean the entire collection of transmitters, transmission line, antennas, receivers, filters, isocouplers, etc. that comprise your design as a whole).

This type of diversity, implemented properly, provides for robustness. If one channel is experiencing atmospheric anomalies, the other channel(s) may not be so affected.

In the section of 47 CFR Part 74 that deals with rules for 950 MHz STL systems, the channel spread is likely not enough to materially be of use for this type of diversity (that is to say, the entire channel spread is likely to be affected by the self-same disturbance). However, this can still be of good use if there is an interference issue that may affect only one channel, and not another.

Use of an entirely different band such as 6, 11 or 23 GHz along with a 950 MHz band radio can be of tremendous benefit by virtue of frequency diversity (and is also a form of technological diversity, covered below).

Hawaii suffers from periodic destructive interference during military RIMPAC activities, which lead to unusable 950 MHz links. The "price of freedom," we are told. In this case, multiple 950 MHz channels are affected.

Space Diversity: Here, the aim is to separate two receive antennas in such a manner as to receive the transmitted signal via multiple paths with some vertical separation. Empirically, a vertical separation of some 200 wavelengths has proven effective. It just so happens this works out to about 200 feet at 950 MHz. So, if you have a receive antenna (which we'll call the "main antenna") at 700 feet AGL on the tower, then another antenna ("aux. antenna") might be at 500 feet of elevation.

I had such an arrangement in Orlando, which performed very well during early morning temperature inversions during which the transmitted signal was diverted downward. I would observe the receiver signal connected to the main antenna begin to drop rapidly while at the same time, the received signal of the receiver connected to the aux. antenna would rise.

In this case, the RSSI as indicated on the receiver connected to the main antenna, which normally would hover around 1100 µV, would drop below 200 µV! This form of diversity worked very well in this system. We'll discuss the cause of this shortly.

Technological Diversity: This method is my personal choice for almost ultimate robustness. Here, we mix technologies to achieve almost 100% reliability.

Several choices are available to us in 2023. For example, we can use a 950 MHz STL and an audio over IP device such as an Intraplex IP100/200 or a Comrex Bric. Another option is a 6 GHz data link (using an IP200 as the audio codec) as well as a 950 MHz link (a form of frequency diversity discussed above). Further, dedicated fiber from the studio to the transmitter site is an almost ultimate solution.

From a fault tolerance standpoint, if the redundant, diverse systems each have "5 nines" reliability or 99.999% uptime, this means the probability of failure is 1–0.99999 or 0.00001.

This implies the probability of both systems failing at the same time is a remote 0.0000000001 or 1 in 10 billion.

Propagation and path

Now let's focus on propagation and the path itself.

In general, we need a clear, line-of-site path from the microwave transmitter to the receiver antenna (clear of obstacles). We determine this using a terrain profile by using Google Earth or other suitable software. From this we can plot the "Fresnel Zone" (pronounced "Fray-nell"). See Fig. 1 on the facing page.

$$r = 17.32\,x\sqrt{\frac{d}{4f}}$$

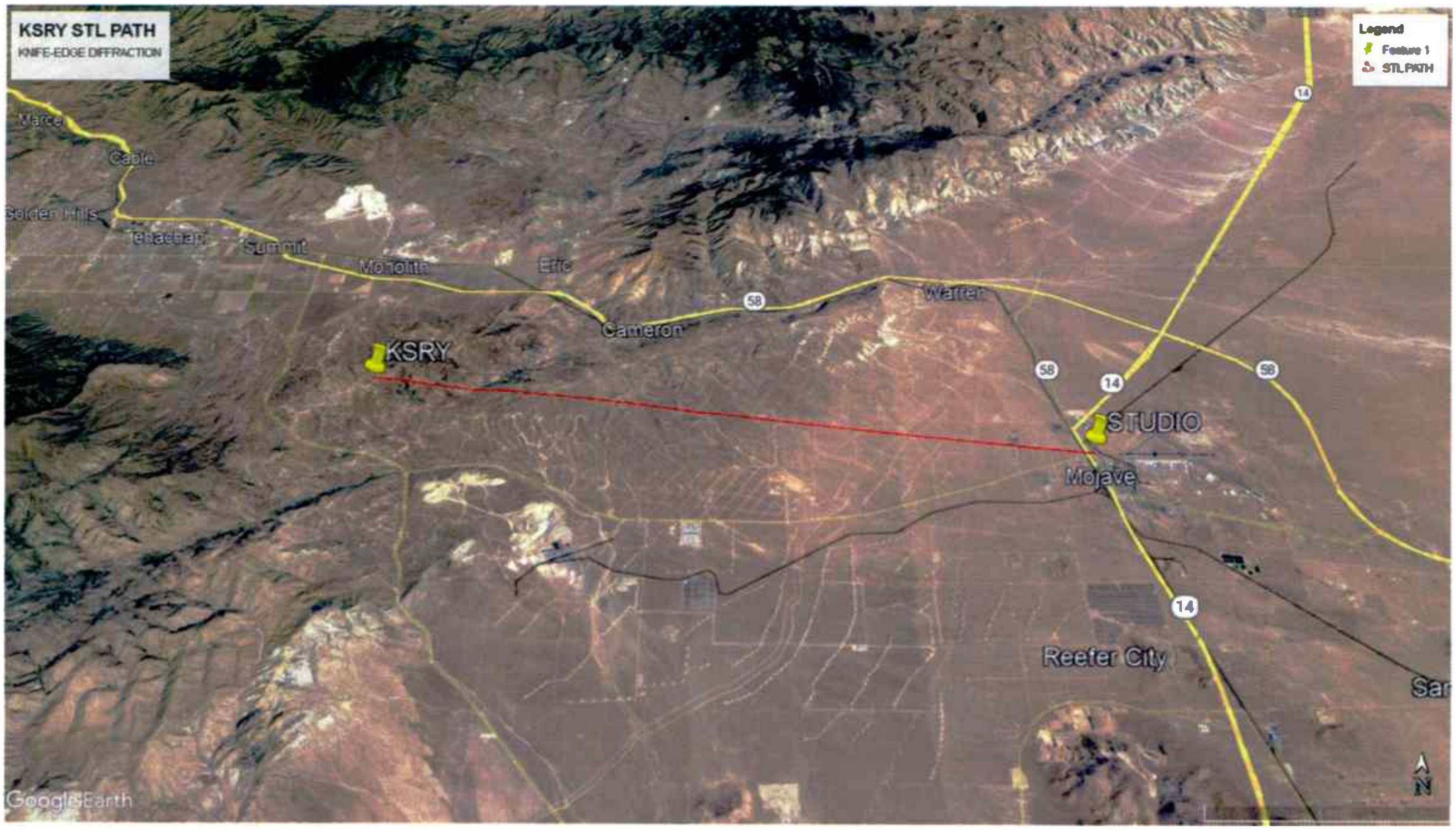
Where: *r = radius in meters*
d = distance in km
f = frequency in GHz

Typically, 40% intrusion by an object (this was empirically derived) into the Fresnel zone is acceptable, so one can use 0.6 as a constant multiplier. Any further intrusion into the zone is considered a grazing path. If under those circumstances the path has line of site considering the intrusion, add 6 dB to the free space attenuation to compensate.

> **"No way in the blue blazes would an actual engineer even have attempted this system given the terrain blockage."**

It is well known that microwave paths that traverse bodies of water (lakes, bays, etc.) can be problematic due to the incident wave striking the water surface and thence being reflected out of phase or reversed in polarity. A larger fade margin and a form of diversity are often the only remedies available to the design engineer.

Brewster's angle is an advanced topic, but for our purposes there exists an angle at which the incident wave is partially refracted into the water and polarized in the reflected wave because of the difference in density of the air/water interface. This can cause a wave front to the receive terminal being compromised by a



Above
Fig. 2: KSRY Google Earth path profile

polarized wave not of the same polarity as that of the transmitted signal.

K factor and "Flat Earth"

K factor is a relationship of the radio horizon to the true earth radius as a result of tropospheric bending and generally considered to be 4/3 or 1.33. the distance under these conditions is given by:

$$horizon_{meters} \approx 3.57 \, x \sqrt{height_{meters}}$$

However, *normal* isn't always the case. During temperature inversions in which the overlying air layer is warmer and therefore less dense (common on summer early mornings after the earth has cooled more than the overlying air), K factor can become 1.00, which is known as the "flat earth condition" in which the wave front can travel for a very long distance.

This phenomenon also can lead to FM stations hundreds of miles away booming into your market, inspiring your PD, OM or GM telling you that there's "something wrong with our signal" or "The station in Colorado must be running 'super high power,' call the FCC."

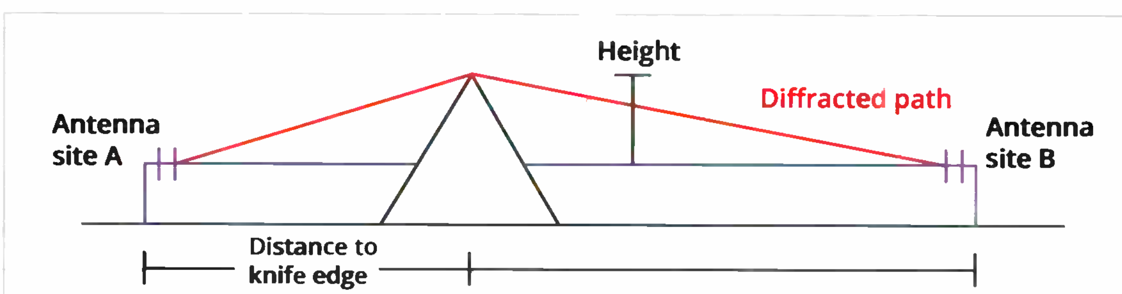
Generally these issues clear up around 10 a.m. after the sun warms the ground and atmospheric conditions normalize. I experienced this particularly in Central Florida during the summer months.

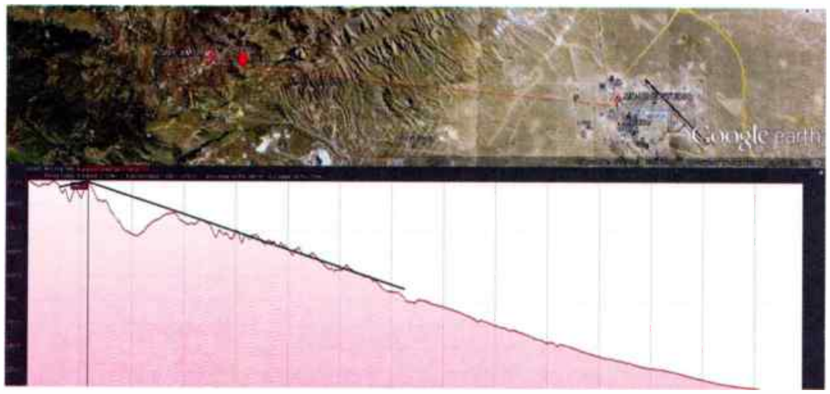
Knife-edge diffraction

When I was working in Southern California a few years ago, we had a site on a windfarm in Tehachapi (wind turbines by the hundreds) to which the previous engineer attempted a 950 MHz "shot" from the Mojave "main studio."

No way in the blue blazes would an actual engineer even have attempted this system given the terrain blockage (see Fig. 2). Yet against all odds, it worked after a fashion; the RSSI as indicated by the receiver would vary wildly from 150 to 300 µV continuously (think of a VU meter), but by

Below
Fig. 3: Idealized knife-edge diffraction





running the STL system in mono, the system produced a marginally usable audio source.

The only plausible explanation I and my knowledgeable colleague Doug Irwin could come up with is the phenomenon of knife-edge diffraction.

Above
Fig. 4: Actual knife-edge diffraction

Fig. 3 is the idealized depiction of a knife-edge diffraction scenario. This is the same phenomenon that allows you to hear sound from around the corner of a building (even in absence of reflective surfaces (remember, 1 Hz to beyond X rays are all on the EM spectrum).

Fig. 4 shows the KSRY path plane view.

Note that the STL transmitter in Mojave is at the extreme right of the illustration and the KSRY site (receiver) is at the extreme left. Note the "knife edge" peak less than a mile from the receiver. This is well beyond a grazing path!

Conclusion

The proper design of a microwave system requires some minimum knowledge of the topics we've discussed. Fortunately, a multitude of online calculators exist to assist you. Even with the aid of such calculators, you can make better use of such helpers if you have a basic understanding of the entire system.

Marketplace

A Shure SM7 With Active Preamp

Shure's SM7 microphone family has a new member. Called the SM7dB, it is a dynamic vocal mic with cardioid polar pattern like the SM7B but adds a built-in active preamp that can be bypassed with a switch.

"The SM7dB provides creators and audio engineers with the exact rugged construction and legendary audio quality of the SM7B, with the addition of a phantom-powered, built-in preamp designed by Shure," the manufacturer says in its press release.

"This integrated preamp provides a supplementary +18 or +28 decibels (dB) of clean gain, eliminating the need for a separate preamp, and freeing users from the hiss and noise introduced by many audio interfaces when their preamps are driven to the levels necessary to provide enough gain for the SM7B."

Shure says the added gain brings the sensitivity up to a level optimized for most audio interfaces. "This guarantees users enough gain on hand for their audio to be heard with maximum clarity in a recording, on a broadcast or while streaming, regardless of their audio interface."

The mic also the same EQ controls as the SM7B, with bass roll-off and presence boost. Retail price is $499.

Info: *www.shure.com*

Telos Updates Z/IPStream Line

Telos Alliance announced updates to its line of streaming audio encoders and processors.

The Z/IPStream R/20 is a dedicated 1RU encoding and processing hardware appliance with AES/EBU, Livewire and AES67 I/O. It replaces the Z/IPStream R/2 in the Telos product catalog.

And Z/IPStream X/20 is a streaming audio encoder and processing version implemented in software for deployment on Windows PCs and servers. The user interface of the X/20 is shown.

Telos said current X/2 and R/2 users may choose to upgrade their products to X/20 and R/20 at no charge through October of next year.

"Z/IPStream X/20 and R/20 continue to provide all of the same high-quality codecs and versatile encoding features you've come to expect, including Adaptive Streaming to support Apple HLS and Microsoft Smooth Streaming formats," the company said.

The encoders are available with optional Omnia Forza processing, Nielsen/Kantar watermark encoding and Déjà Vu surround sound upmixing.

Info: *http://telosalliance.com*

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Writer

Eric Smith
Founder and President, Auralex

Acoustics 101 for radio environments

Regardless of format or content, Job One in radio should be to put out quality audio

In the beginning there was perfect sound. Then man invented rooms.

I'm Eric Smith, founder and president of Auralex, the 46-year-old global acoustical products and consulting company. I've have been asked to write a series on acoustics and sound-related construction concerns for radio environments.

I know firsthand the acoustics and sound-isolation issues that often plague air and production studios. I not only wear an acoustical consultant hat but I worked at top radio stations in multiple markets in the '70s, '80s and '90s as an air personality, production director, fill-in talkshow host, producer and more. I appreciate the opportunity to pay forward some of my accumulated knowledge.

I'll talk about room acoustics and products and methods that can make a space sound better, in-room and on-air, as well as how to construct sound-critical spaces and address common issues such as HVAC noise, sound leakage and more. There's a lot of false information out there, so my job is to give you lab-verified, time-tested knowledge to build or treat your spaces in the fastest, least involved and least expensive ways possible.

The two modalities of acoustical optimization — in-room treatment and sound isolation — work synergistically.

Above
Auralex Studiofoam T absorption panels installed in podcast studio.

Either can help you, but when used together, 1+1 can equal 3. Plus, a properly constructed space inherently sounds better, doing some of the acoustical heavy lifting for you.

The document that inspires this series is my Auralex booklet "Acoustics 101," which you can download for free as a PDF at *http://auralex.com*, and which a number of notable people have called their studio-construction bible. Feel free to refer to it as well as my ever-expanding companion document "Real-World Acoustics."

Regardless of format or content, Job One in radio should be to put out quality audio. Unfortunately, whether from DJs, newspeople, traffic reporters or talk-radio hosts, and whether in-studio, remote or a work-from-home voice-tracking setup, poor acoustics often degrade audio quality by generating excessive room-tone noise. This screams "unprofessional" and distracts the listener from bonding with the content.

With so many platforms vying for their attention and with listeners often consuming our content while driving, working, studying, cleaning house, etc., it's critically important to put out clean audio that doesn't tax the person by causing their ear-brain mechanism to work hard to separate important audio content from noise introduced by poor acoustics.

When their brains have to devote "CPU cycles" to separating the aural chaff from the wheat, listeners aren't drawn in by the content being conveyed. We lose them. No one wants to tucker out from struggling to decipher our content.

In addition, air-chain processing can accentuate excessive room ambience, so we must start with as clean an audio signal as possible. Compression pulls up the ambience and noise-gating can sound unnatural when used with an excessively ambient space. Phil Collins drum-sound, anyone?

Listener vs. mic vs. talent

We care about how the listener perceives our content. But the way we convey that content is via one or more microphones, some of which don't have as tight a pickup pattern as needed to reject off-axis room ambience. As such, we need to build sufficiently sound-isolated facilities and implement a sufficient degree of, and proper type of, acoustical treatment in our studios so that the microphone conveys the cleanest possible spoken or performed audio.

We also have to remain cognizant of how the talent (solo or group) perceives the degree of sound isolation and the in-room acoustics. We need to balance what the mic hears with what the talent hears; the acoustics must be transparent to the talent and not distract them or keep them from performing their best. Further, in a group, they need to be able to hear each other well to facilitate seamless interaction. And, with multiple mics open at once, poor in-room acoustics can really trash your audio.

No talent wants to pot open a mic and hear a version of their voice that sounds as if they're in a cave. Everyone wants to sound tight, present and authoritative, but that will simply not occur in an insufficiently controlled environment — be it in your facility, a home studio or a remote environment such as a client's office. We want listeners to hear voices that emanate from a dead-silent background.

For example, when the late legend Don LaFontaine was voicing movie trailers in his Auralex-treated studio, you heard his magnificent voice come from a black, noiseless place, thus allowing his nuance to create the best possible emotional connection with the listener.

I gave a lecture on acoustics at the Don LaFontaine VO Lab in the SAG building in Los Angeles. In the talk, I stated that if Mr. LaFontaine had said his trademark expression "In a World ..." in the highly reverberant hallway that leads to the lab instead of in his well-designed studio, his trailers wouldn't have been nearly as successful. This concept applies to your audio, too.

I once worked as the production director at a 50 kW market-leading station where the production room was large and insufficiently treated, and I went round and round with management over the need for acoustical treatment. Spots that I and the air talent cut were far too ambient, which I felt undermined the station's credibility in the minds of the listeners.

Invisible enemy

With our acoustical treatments and construction, we're working to control room modes, which are reflection patterns, based on physics, that cause peaks or dips (cancellations) in the frequency response of the room. There are three types of modes: axial (between two surfaces), tangential (touching four surfaces) and oblique (touching six surfaces). Axial are the strongest and most offensive.

Now, given today's glass-everywhere air-studio designs, there's often a limit to what acoustical treatments we can implement, and where. Production rooms tend to have less glass, so we can generally do a better job of treating their boundaries properly. At Auralex we have recording studios designed for the biggest names you can imagine. In these rooms we implement physical and acoustical symmetry, whereas that's often impossible in a radio air-studio. Thus, we have to work smarter, not harder, and seek the maximum amount of control out of the space that's available for treatment. But fear not; the cavalry is coming.

In work-from-home voice-tracking environments, we generally have better access to the areas where acoustical treatments can be most effective, but sometimes stand-mounted treatments are called for due to room layout, windows, doors, trimwork, etc. Home studio environments have gained prominence in the pandemic era, and the stand-mounted portable treatments they often require can in some ways be even more effective than boundary-mounted treatments. These voice-tracking environments may not be purpose-built, so we often also consult on how to best shore up the construction for maximum sound isolation with the least amount of disruption, work or expense. Don't fret, though; there's always something that can be done to improve a space's sound isolation and acoustics.

Tools of the trade

Let's hit some basics on which we can build (literally).

Sound can be absorbed, reflected or blocked. It can also be attenuated by physically isolating one thing from another; this is sort of a subset of the "blocked" category and we'll dig into this in the series, as this method can sometimes be enormously beneficial and less expensive to implement than other modalities.

When I refer to isolating things from each other, I'll sometimes mention "floating" them, which means that we're keeping one thing from contacting another, thus attenuating the frequencies we desire to and precluding sympathetic vibration and flanking transmission, which is the travel of sound through the physical infrastructure. This will come into focus later but pay particular attention to that discussion if you have concerns about noise from traffic, aircraft, trains and other intrusive sources such as salespeople in the hallway. There; I said what you were thinking.

Absorbers can be narrowband, which means they primarily absorb mids and highs, or they can be broadband, which means they absorb all frequencies, including the lower ones, which are stronger and more difficult to attenuate.

Mid-high absorbers are generally thinner and go on walls and ceilings, while broadband absorbers can be thicker and can be used in these locations and/or in dihedral and trihedral corners, which are where two surfaces meet or three surfaces meet, respectively. In plain language, that means wall-wall or wall-ceiling junctures for the former, and wall-wall-ceiling junctures for the latter.

> **"A properly constructed space inherently sounds better, doing some of the acoustical heavy lifting for you."**

Just taming the mids and highs can leave a room sounding bass-heavy and imbalanced, both to the talent and the mics, so we aim for broadband treatment whenever possible, as it sounds more linear and natural. Sometimes we accomplish this with broadband absorbers; sometimes with a combination of bass traps and mid-high absorbers; and sometimes by taking the room's features and construction materials into account to a greater degree and working as much as possible with what's there, adding as little additional construction material or acoustical material as possible.

You may have heard about sound diffusors, which, in a perfect world, would evenly reflect sound waves in all directions. As you may have also heard, though, we don't live in a perfect world, so there is no perfect diffusor. Some come close (wink) and certain designs function as both diffusors and bass traps (wink), thus yielding a more-broadband, even-sounding sonic signature.

(BTW, you want to absorb excess low-frequency energy, not diffuse it as mud. The spaciousness people attribute to diffusors comes from the dispersion of the mid and high frequencies only.)

Here are two diffusion- and reflection-related factors about which you should be aware. First, every time a soundwave interacts with a surface or an object, the soundwave is altered in the frequency domain and in the time domain. There is no perfect reflector, meaning one that won't filter a soundwave as it's reflecting the sonic energy.

Second, in a radio environment, our goal is to absorb ambient sound in the studio, not keep the waves bouncing around, which would create the detrimental ambience I've talked about. I generally discourage the use of diffusors in broadcast environments where spoken-word content originates, especially if your studio contains a lot of glass and/or cubic volume. There are exceptions, based on what your space presents us, but generally remember that linear absorption is our best friend.

Ratings! We need ratings!

When we assess the effectiveness of various acoustical treatments and construction methods, we look at numerical ratings.

In the case of absorbers, we look at their NRC, which stands for Noise Reduction Coefficient. This is an official, lab-verified rating of the overall effectiveness of an absorber (or should be; some people fudge their numbers or even make them up; seriously).

A specified number of square feet of material is submitted, then positioned per protocol in a fastidiously constructed, certified test chamber that will yield valid results at all the center frequencies included in the test: 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz. Interestingly, though, when you calculate a product's NRC, you discard the 125 Hz and 4 kHz numbers and just average the remaining values, then round up or down to the nearest .05.

If you see an NRC quoted as a number such as .47, you'll know that it's an invalid number and may be suspect, as it doesn't conform to the standard. NRCs can be a fraction of 1 or greater than 1, such as 1.50, which is the quite-high NRC of the Auralex LENRD ("Leonard") Bass Traps.

Typical, relatively thin wall- and ceiling-mounted mid-high absorbers — plus cheap ceiling tiles — can have NRCs as low as .25 or less, or perhaps as high as 1.10 or more. In general terms, you prefer that your acoustical treatments be as broadband as possible, have the highest NRC you can afford and can fit into the available spaces.

When assessing sound barrier material, an important component of sound-critical construction, we look at its

STC, which stands for Sound Transmission Class. There are other ratings pertaining to how barriers and construction methodology affect footfall and other types of intrusive noise, but we'll ignore those ratings and focus on STC. Again, you test at specific center frequencies, throw some out, average the rest and end up with a rating of how well that material performs as a sound barrier. An effective sound barrier material (which can be as skinny as 1/8-inch thick, but more effective than a commensurate sheet of lead) will yield an STC of 27, which denotes a significant reduction of sound transmission that's well worth the effort and investment to implement it.

The good news is that significantly upping your sound isolation does *not* require walls that are 3 feet thick or studios on springs that go all the way down to bedrock. There are affordable, less space-eating products and methods that are time-proven to yield exceptional sound isolation and with absolutely the least amount of angst possible. The real beauty is, you don't have to reinvent the wheel each time you build or retrofit a space; the performance of the recommended products and methodology we'll cover in future articles has been proven potentially millions of times over the preceding decades, including in quite-notable facilities. Don't sweat it; the heavy lifting's been done and there's no guesswork or finger-crossing needed.

Now, the devil's absolutely in the details, and attaining the sound isolation you desire is a game of inches, with each facet contributing to the overall success — or sabotaging it, if gotten wrong.

Tune in next time, as we begin to put all this into context. We'll start to talk about the types of products and methodologies that can yield the great-sounding, sound-isolated spaces you require in order to put out high-quality, natural-sounding, engaging audio over the airwaves. The accountants and talent won't hate you, I promise. In fact, you can be their hero.

Writer

James E. O'Neal

Longtime contributor and broadcast engineer is editor-in-chief of the IEEE's Broadcast Technology publication and former technical editor of TV Tech.

An unintended consequence of digital radio

Is inadvertent HD Radio capture a problem?

We've heard about hijackings of broadcast signals, in which a disgruntled former employee or someone trying to get across a political message jams a signal or breaks into an STL feed.

The subject of this story is a different kind of undesirable signal capture in which the signal from a local FM station is replaced by that of an HD Radio signal from a distant station. This unintentional displacement appears to be a consequence of physics and the growth of in-band on-channel digital broadcasting.

One such inadvertent capture occurred last December, affecting operations at a Buffalo, N.Y. station, WDCX(FM), which is part of Crawford Media Group.

"This was right after Christmas," recalled Chief Engineer Brian Cunningham. "We started getting calls almost immediately — at least a couple of dozen — with listeners saying they were hearing a Canadian station on our frequency. I also heard about the Canadian signal from our station manager."

A quick database search of Canadian FMs operating on WDCX's 99.5 MHz frequency and with sufficient power to capture FM demodulation circuitry in car radios in the Buffalo metro area showed such possibilities were slim, but the calls kept coming.

As WDCX operates with an ERP of 110 kW it would indeed take a hefty amount of co-channel signal to "commandeer" local area radios via the FM demodulator capture ratio phenomenon.

Cunningham realized that the appearance of the foreign signal coincided with a temporary cessation of WDCX's MP1 HD Radio signal due to an equipment failure in the audio processing chain feeding it.

"Both main and backup audio processing systems for the HD channel failed," said Cunningham. He noted that the failure occurred at a time when heavy snows had hit the Buffalo region, delaying restoration of the processing.

It's difficult to term this "interference," as the HD radios were doing what they were supposed to do by switching from analog to digital reception whenever a digital signal is sensed. But the phenomenon seems to be relatively new.

North Carolina

Is it happening in other markets? It appears to have affected a low-power FM farther south, as described by Michelle Bradley, founder of REC Networks, an advocacy group and consulting engineering firm for LPFMs.

"This occurred with a North Carolina station several years ago," said Bradley. "It was never resolved."

The station is WPVM(LP) in Asheville. General Manager Davyne Dial said that she was not aware of the potential for this sort of capture until she purchased a car equipped with an HD Radio in 2021.

"My Mini Cooper has a screen that shows call letters and frequency," said Dial. "The text screen confuses us with a Charlotte, N.C. station, WSOC(FM)."

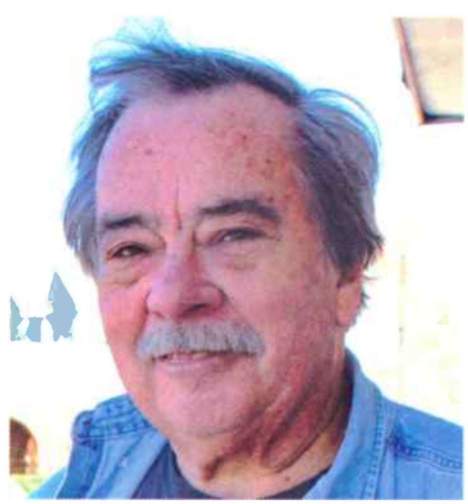
That Class C station shares WPVM's 103.7 MHz frequency and transmits an HD signal. The stations are separated by almost 100 miles, but WSOC operates with 100 kW ERP while WPVM radiates but 100 Watts.

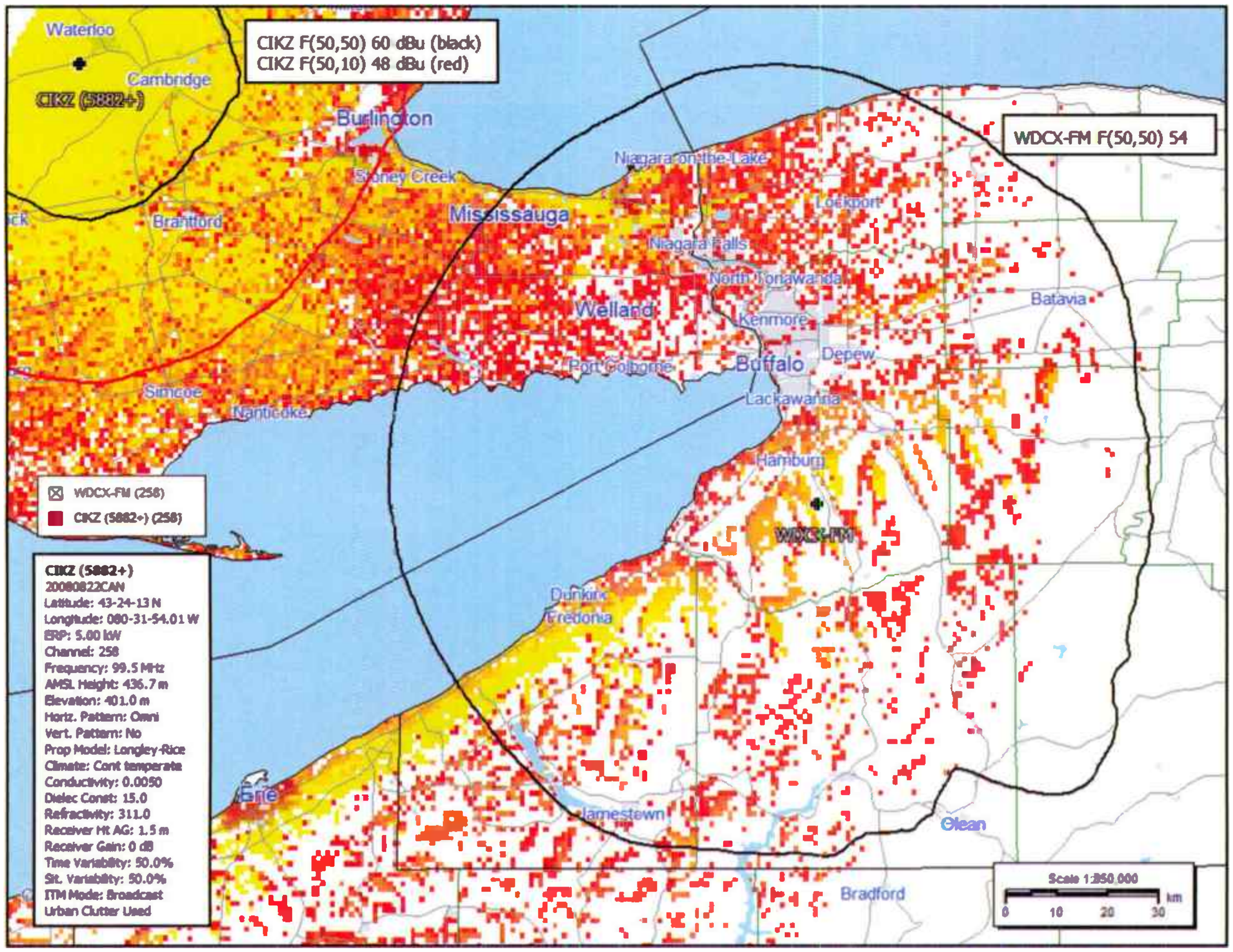
Dial said that analog reception of the Asheville LPFM is normally not affected by the Charlotte station. She has not received calls from listeners but speculates that with the growing number of HD Radio receivers in cars, some potential listeners may not be aware of the existence of the noncommercial community station.

"I was able to figure out what was happening and go through the Mini Cooper's setup menu and disable the HD reception," she said. "I think a lot of people might not be that tech savvy and don't realize what's going on." She worries that other listeners are not hearing what they intended to listen to.

While the Buffalo full-power FM regained its temporarily lost audience once a processor could be rigged up and the HD

Below
Brian Cunningham and Chuck Conrad





Courtesy John Kean

Left
WDCX(FM) coverage with signal overlap from potential Canadian co-channeled station.

operation restored, that's not an option for Dial's small station, which has no plans or budget for adding HD service. Bradley at REC Networks said the cost of HD implementation is prohibitive for most LPFMs.

East Texas

Radio World contacted Xperi.

"Your outreach is the first we have heard of this concern," a company spokesperson said.

"Xperi has not heard from the station or received an official report on this issue and is unable to comment without receiving an official FCC inquiry, per their established reporting protocols."

So is this a widespread issue?

A possible third instance surfaced at an east Texas Class A FM. KZQX is licensed to Tatum, Texas, and serves the Longview/Marshall/Kilgore market. Owner Chuck Conrad said, "I had a listener call me and tell me that they were listening to my 100.3 station, but there was artwork on the radio display that didn't match the station."

Right Davyne Dial became aware of the distant HD signal penetration in her Asheville market after purchasing a Cooper Mini and trying to listen to her low-power FM station on 103.7 MHz. She found that the HD signal from a Charlotte station some 100 miles away "commandeered" the receiver, making it impossible to hear her LPFM unless the HD feature was defeated.

Conrad said neither he nor anyone else in east Texas operates with HD, so an informational display of the type described by the listener would have had to come from a broadcaster outside of the area.

In his region the terrain is mostly flat and the Gulf of Mexico is at hand. Out-of-area VHF propagation is common, he said. However, such "freak" reception doesn't usually occur in December.

"It's not unusual to pick up a Dallas station here," he said. "It's not unusual to have them blasting in here in east Texas when ducting rears its ugly head several times a year. [But] the December instance was very unusual, as usually [such occurrences] are in the spring and continue into the latter part of June."

After learning about the cases described earlier, Conrad believes this was what his listener experienced. He planned to monitor for further out-of-area intrusions.

"Almost everything I've got is co-channeled with a 100 kW station on an 1,800-foot tower, and this could be a real issue, as local people like to hear local stuff," he said.

"Most people keep their cars for eight or 10 years. So this may not be a problem now, but as more and more cars become equipped with HD radios, this could become an issue, especially if they (HD broadcasters) increase the power of the digital carrier."

Most consumers, he said, wouldn't know how to get into the menu structure to shut off the HD Radio if they wanted to listen to a local channel.

Conrad also worries about the possible impact on FM translators (he owns six). He notes that his advertisers are all local small businesses that want to reach local audiences. If these inadvertent captures were to become more common, it could be harmful to his business.

During the initial research in connection with this article, the above cases were the only ones that came to light; since then, others have surfaced and will be described in a subsequent article.

What's happening?

In adding LPFMs and translators to the FM band, the FCC uses spacings to avoid co-channel interference; they should

> **"I think a lot of people might not be that tech savvy and don't realize what's going on."**

be sufficient to avoid a broadcaster "stepping on the toes" of another. But hybrid digital radio is a different animal than the analog FM service the commission has been authorizing for more than 80 years.

Told of the findings above, engineering consultant John Kean offered to crunch some numbers to determine how this sort of capture might be possible even with proper spacing of stations.

"Since HD Radio receivers are agnostic to the FM host — the analog host need not even be present — the IBOC signal capture could be at a relatively low field strength," said Kean.

"According to official ITU-R documents for HD Radio planning factors, a field strength of 18.4 dBμV/m is indicated as the median threshold for the primary mode of digital reception, MP1, or fixed reception.

"This is for IBOC alone, and doesn't account for the analog FM signal hosting the digital carrier. With the specified –20 dBc injection level, there could be a field strength that's 20 dB greater, or 38.4 dBμV/m. However, this does not adjust for the Rayleigh fading and availability that would be encountered in mobile reception, so a solid lock would likely require a greater amount of signal."

Kean said there are other considerations that figure into the field strength levels.

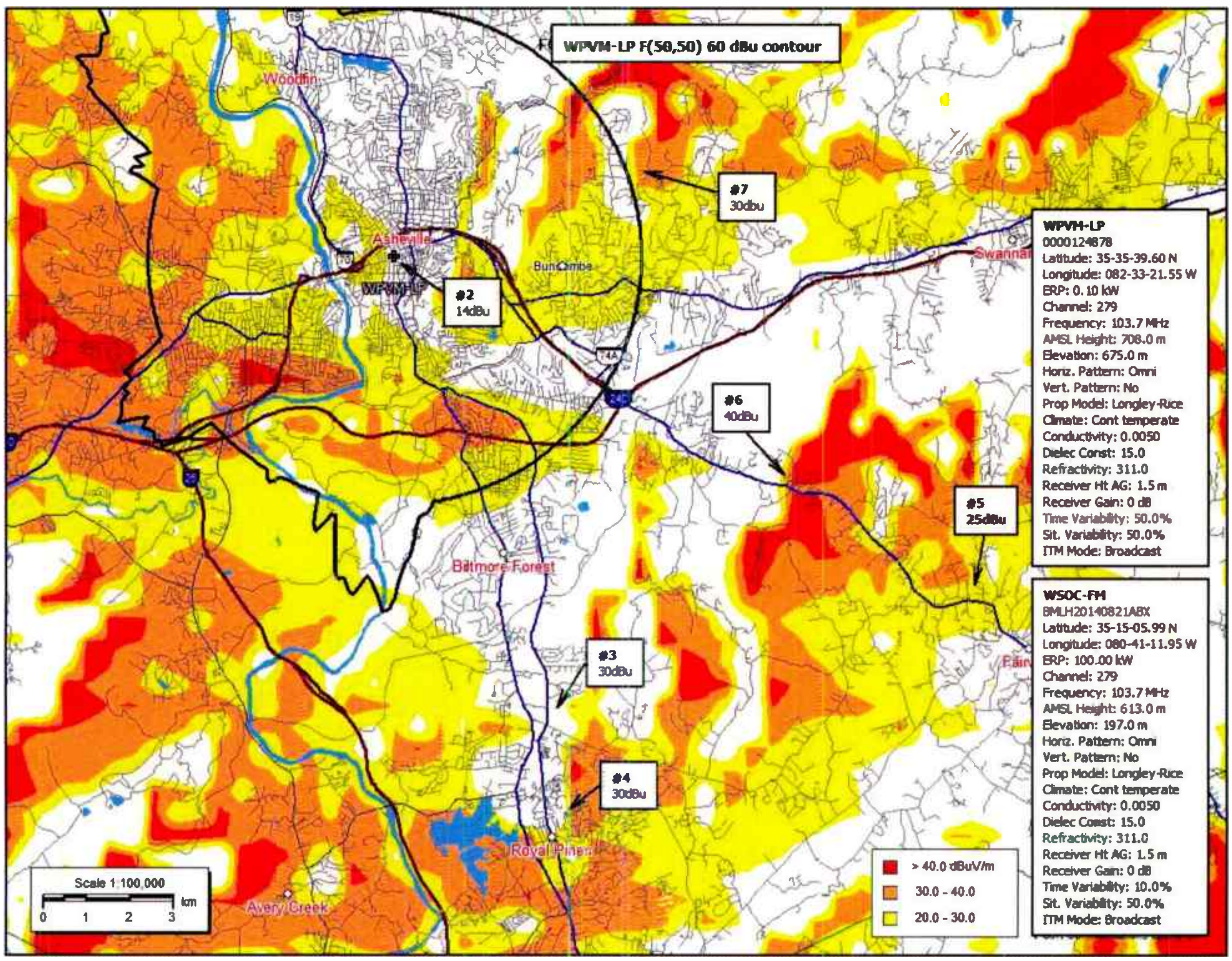
"Under current FCC rules, the IBOC digital power radiated may be up to –10 dBc relative to the analog FM 'host' signal. This would lower the field strength of the hybrid host by as much as 10 dB, or as little as 28.4 dBμV/m, based on the ITU planning data.

"This would indicate that under ideal conditions — no interfering signals —an FM 'host' field strength intensity of some 35 to 40 dBμV/m may be all that's needed to capture the car radio's HD circuitry when you represent this as a function of the IBOC host's field strength."

He said the capture would also depend on the actual ratio of digital signal to the FM's main analog carrier.

Kean noted that FCC rules mandate geographic separation of FM stations operating on a common frequency, with the 40 dBu signal contour of the interfering station (the one granted the assignment on a secondary basis) not interfering with the other station's service contour, which is 60 dBu in most cases.

"As usable FM analog reception for car radios is possible at field intensities of less than 40 dBu, it's conceivable that with the automotive receiver located within the desired station's



Left
Colored areas in this computer-modeled map represent field strength of a Charlotte, N.C., 103.7 MHz Class C FM station at locations around Asheville, indicating where the station's HD Radio digital component might be able to capture HD-capable receivers. The licensed service contour of Ashville's co-channeled WPVM(LP) is indicated at the upper left. Numbered squares indicate locations where the distant signal captured Davyne Dial's car receiver.

Above Reception of Dial's WPVM(LP) is not possible in many parts of its community of license unless her car radio's HD reception capability is switched off. The distant HD signal capture even occurs in front of her station's studio and transmitter location, an eight-story office building in downtown Asheville.

F(50,50) 50 dBu contour, a 35 to 40 dBμV/m signal from a minimally-spaced co-channel station could capture the receiver's IBOC circuitry and inadvertently 'hijack' reception in absence of a digital carrier from the desired local station."

Kean said that in the case of the Buffalo incident there are co-channel Canadian stations sufficiently close to Buffalo to activate digital decoding in a mobile receiver.

Is there a solution?

It's not clear from these few instances that a problem exists, though as noted by the Asheville operator, there may be individuals with HD-capable radios who are listening to an out-of-market HD station and assume that there is no local station on that particular frequency.

If the phenomenon is happening as described and if more cases turn up, the industry should at least understand what's happening and discuss whether steps to address it are necessary.

The best way to resolve such capture issues would be for all stations to operate in HD mode; but that's not a likely scenario in the current radio marketplace.

As Dial noted, consumers experiencing problems also could drill down into setup menus in many car radios and lock out HD reception, but this is neither practical nor desirable for a number of reasons. Nor is it likely that radio stakeholders would want to see an "HD disable" switch installed or mandated in cars.

Another possible solution that would not require intervention — or even awareness on the part of the radio owner — would be to equip such radios with comparison circuitry or a software algorithm for comparing the station ID transmitted in RDS information for analog-only receivers with a similar ID sent with the IBOC digital content. If the two IDs matched, HD decoding would be enabled; if there was no match (indicating the presence of an out-of-market or otherwise undesired digital signal), the digital audio decoding mode would be blocked.

But that too would be complicated to implement, and it presumes that the industry perceived a problem in the first place.

REC Networks' Michelle Bradley opined that a solution could come through universal implementation of HD broadcasting.

"I would love to see an 'all-channel' act applied to manufacturers ... to include HD capability, as well as AM analog and digital reception. I would love to see low-cost HD for everybody. Unfortunately, the nature of the system that we chose [for HD Radio] isn't for everyone due to the implementation expense involved. It would be nice to see more low-power stations go HD; unfortunately, only low-powers with big budgets can afford to do this."

Cris Alexander, director of engineering for Crawford Broadcasting as well as technical editor of RW Engineering Extra, said the only current redress for unintentional audience "hijacking" is through complaints to the FCC.

"For full-power stations that have protection, there is a procedure for dealing with this, even though it's not 'traditional interference,'" said Alexander.

"The FCC will contact the interfering station and have them to cut back on power or shut down HD." In such cases, he said, the interfering station might have to pay to equip the station being interfered with to convert to HD if it wanted to continue its own HD operations.

In the case of WDCX, Crawford did not complain to the FCC because the out-of-market HD capture was temporary and ended with restoration of HD operation at WDCX.

We've described the physical possibility of an out-of-market digital signal intrusion when an HD Radio receiver "locks on" to the digital carrier of a distant co-channeled station instead of the analog program stream of a local station.

It might be advisable for broadcasters, especially operators of LPFMs and translators, to check periodically for distant HD signal capture within their service areas. Also, any calls and emails from listeners reporting programming "switches" or other anomalies should be taken seriously and evaluated for validity. In any event, thorough documentation is important in all cases.

Radio World would be interested in hearing from any broadcasters who may have experienced such interference, or have not experienced it where it might be expected. Email *rweetech@gmail.com*.

Consultant John Kean modeled several other markets where potential HD Radio capture by out-of-area broadcasters existed; but initial field testing in these markets has not borne out such projections. These cases will be discussed in a followup installment of this story.