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Maximizing your AM infrastructure

Paul McLane
Editor in Chief

Without question, AM broadcasters face daunting challenges due to various business factors and listener demographics. Many of those are beyond the control of an AM station manager and engineer, but are there strategies and tactics that can help today's AM broadcasters get the most out of their station infrastructure? What technologies are available? What can be learned by developments among international broadcasters or from the early adopters of all-digital MA3?

In this ebook we explore these questions with Jeff Welton, regional sales manager and "fixer of problems" for Nautel; David Layer, vice president, advanced engineering at the National Association of Broadcasters; Joshua King, president/CEO of Kintronic Labs; Dave Kolesar, senior broadcast engineer and program director for Hubbard Broadcasting; Ben Dawson, senior consultant to Hatfield & Dawson Consulting Engineers; Mike Pappas, vice president of business development for Orban Labs; and Cris Alexander, director of engineering for Crawford Broadcasting and the technical editor of RW Engineering Extra.

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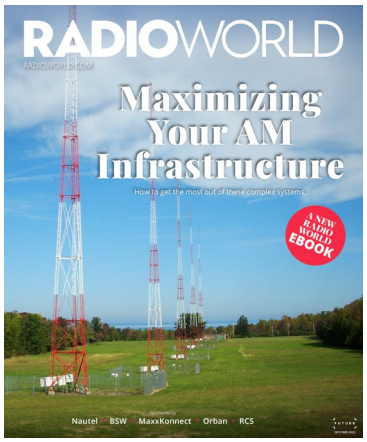

Learn about the facility on the cover on page 20.

THIS ISSUE

Above
Jeff Welton shares one of his many stories at the 2023 Broadcasters Clinic of the Wisconsin Broadcasters Association.

Welton: Don't neglect your antenna system

Protect your investment by optimizing its delivery platform

Jeff Welton has been with Nautel for 33 years, spending the first half of his tenure in technical support roles. A recipient of several engineering awards, Jeff writes or gives dozens of articles, presentations and webinars a year on topics relevant to broadcast engineering.

RW If an AM manager wishes to protect or improve their station infrastructure, where should they start?

Jeff Welton: The first step is to do an audit — take an inventory of the entire facility from microphone to antenna. With respect to savings, electricity is almost always the biggest single expense after labor, and the transmitter the biggest single consumer of electricity; however there could be other areas for improvement, and until they know what they have, the owner doesn't know what items could be improved.

What role are Modulation Dependent Carrier Level technologies playing at this point?

Welton: MDCL has played a significant role. For stations running 10 kW or higher, the power savings will quite frequently cover the cost of upgrading to incorporate it, and after the payout period, it's money in the bank. For lower-power stations contemplating a transmitter upgrade, it makes sense to ensure that any new system considered contains the technology, again reducing cost as part of the evolution of the station.

Are there opportunities for AM broadcasters to address noise floor challenges through the use of audio processing?

Welton: Well sure — denser audio, with higher average power, will cut through higher noise floor better. It has the side benefit of driving MDCL algorithms harder, so that savings on the electric bill are maximized also. Keep in mind, though, that there's no free lunch — everything is a trade-off, and that is the case here. More heavily processed audio will have less dynamic range, and that can impact listener fatigue. So spend some time talking to your processor guru and your supplier about the best setup for your particular station, format and audience.

Is it realistic to think the FCC will ever be able to do anything about spectrum noise from non-broadcast sources?

Welton: I suspect that horse has long left the barn. There is so much gear generating noise outside of acceptable limits and so much less ability to enforce from a field perspective that it's unlikely we'll see any changes in that regard. The challenge is so overwhelming I don't think there's anything that could be done anyway.

I'd suspect this situation will continue to get worse in the AM band, not better. About all we can do is look to options (such as digital radio) where we can send the audio without being as subject to environmental noise — although the laws of physics do still apply... if my signal doesn't get there, it doesn't get there, no matter what transmission format. The only difference is how free from distortion it is when I listen. Again, tradeoffs — low-bitrate digital audio brings its own distortions (artifacts) as compared to analog with the noise floor and environmental distortion. What works best for one station may not be ideal for another.

How realistic is it that U.S. AM broadcasters would adopt all-digital (MA3) HD Radio? What lessons have been learned from the early adopters, and why haven't more put it on the air?

Welton: The biggest challenge is that, at the moment, the stations who would stand to benefit most — lower-power stations who are running FM translators already and don't have a huge listenership to the existing analog AM signal — don't have the budget to convert to MA3. Add to that the very limited options, and it makes it challenging. For example, no manufacturer currently produces a 1 kW AM transmitter capable of operating in MA3 mode.

What best practices should AM stations be aware of, to deliver the best audio quality to listeners?

Welton: The biggest one — and one that has been resoundingly ignored for decades — is the antenna system. It's like the speakers to a home stereo. You can have the best, cleanest, highest-fidelity stereo on the market, with 0% THD, oxygen-free cables, gold-plated AC connectors and everything (I'm being facetious), but when you connect it to a $10 pair of discount-bin speakers, it's still going to sound terrible. The same is true for AM antenna systems — if attention hasn't been paid to optimizing bandwidth and phase rotation, it's not going to cover as well, nor sound as good when it gets there.

That was one unintended benefit of hybrid HD Radio (MA1 mode); it forced us to start paying attention to the antenna systems again, in order to make it work at all. We had the same bump of attention with AM stereo, because it also required the antenna be optimized for best performance.

Until that's addressed, the rest is basically lipstick on a pig. There are obvious low-hanging fruits, such as noisy items within the studio, adjusting processing to best fit your particular situation, upgrading transmitters and consoles, etc., but ultimately the antenna system is one of the biggest overlooked items in the system.

How can stations find out if they are getting the best performance from their ground system?

Welton: The best indicator is coverage — if it's changing, whether becoming more directional or reduced, and there

> **"If attention hasn't been paid to optimizing bandwidth and phase rotation, it's not going to cover as well, nor sound as good when it gets there."**

are no indicators of any environmental change (nearby structures or cell towers that haven't been detuned), the ground plane is the first thing to check. A field strength meter can be used to verify radial integrity. Here's a link to a helpful article.

What strategies of collocation might help an AM broadcaster?

Welton: Obviously, the largest is minimizing footprint, allowing the gains from selling the less desirable site — less desirable from a broadcast, not real estate, perspective! While it's been more common to see sites owned by the same group consolidated, there are plenty of instances of non-related stations pooling resources, whether engineering, studio facilities or transmitter sites. If it can be done economically, it could potentially reduce costs for all parties.

With AM, especially directionals, the biggest challenge is determining whether a specific existing site could handle a specific pattern and/or what changes might be required to make that happen — a good consulting engineer will be worth their weight in #6 soft-drawn copper when it comes to figuring this out!

Common wisdom says that at many AM stations, the land under the towers is worth more than the station. Has that trend continued, and what implications does it have?

Welton: Sure it has — real estate values continue to rise, and that will be a continuing challenge. Where it becomes a big issue is when an owner trying to realize some income sells or leases a portion of the antenna field and a portion of the ground system ends up getting chopped up, directly impacting coverage. In some cases, it might be best to look at minimal ground plane antennas, like the whips or high-efficiency broadband designs. These will also almost certainly come with an impact to coverage, but if primary listenership is on a translator and the AM is only used to provide a source for the translator, coverage may be less a consideration. In which case, why not benefit from any real estate revenue that can be derived?

Tips n Tricks for AM Sites

Click here to watch a Jeff Welton webinar on care and feeding of an AM site, including grounding, security and maintenance.

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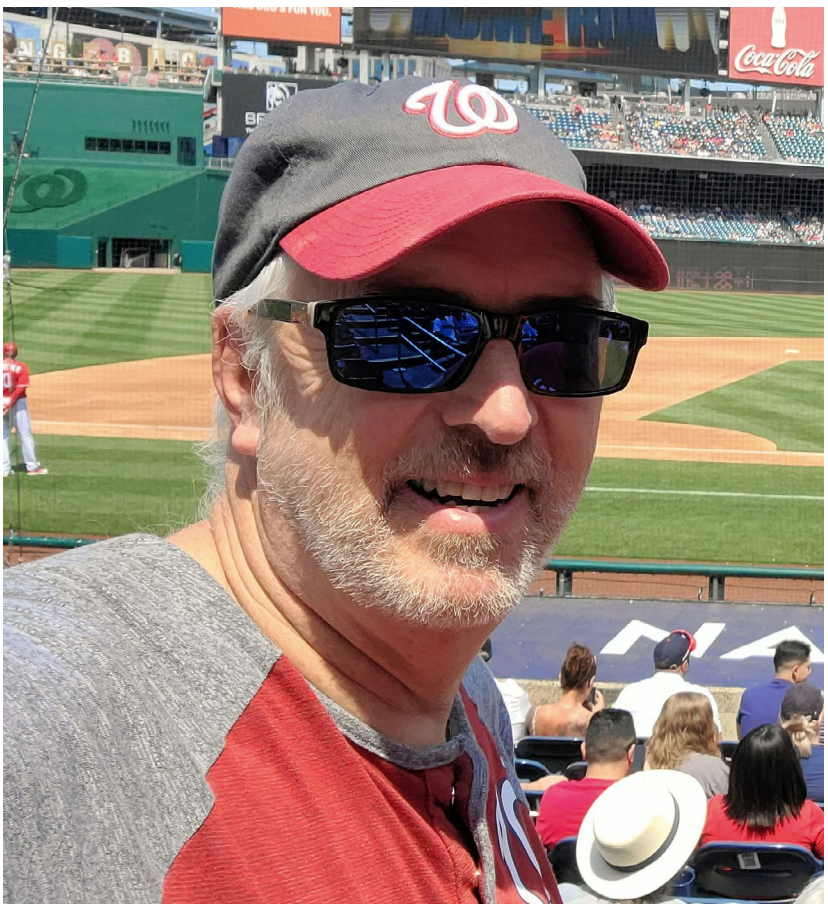
Time to get on the metadata bandwagon

While analog AM does not support metadata, other signals in use by AM broadcasters do

David Layer is vice president, advanced engineering in the NAB Technology department. Now in his 29th year at the association, he focuses on radio technology and radio technical standards setting. He serves as a project manager for technology projects conducted by NAB's PILOT innovation initiative and is principal administrator of the NAB Radio Technology Committee.

What new types of products or other technologies have become available recently to help AM broadcasters improve their systems or their product?

David Layer: AM broadcasters need to get on board the "metadata bandwagon" if they haven't done so already.



While analog AM signals do not support metadata, other signals in wide use by AM broadcasters do. These include re-broadcasts of AM content on FM-band HD Radio multicast channels and FM translators, as well as the streaming audio versions of AM programs (and most AM broadcasters make streaming audio versions available to listeners). In many markets, use of metadata by broadcasters is too low (50% or less) and this needs to change for AM radio to compare more favorably with other audio services with respect to use of metadata — station logos, program information, etc.

Is it realitic to think that U.S. broadcasters would adopt all-digital HD Radio?

Layer: Certainly the MA3 adoption rate has been slow, and conventional wisdom holds that this is primarily due to not enough digital receivers in the marketplace to make this a compelling service for broadcasters. While some markets have higher digital receiver penetration — for example, according to Xperi, over 40% of all vehicles in NYC have digital radio — most markets are at 30% or less. What this means is that stations going all digital would lose access to the majority of AM radios.

One way to lessen this impact is for the all-digital AM station to broadcast their programming on an FM translator signal which, while not in the AM band, will be receivable on analog-only radios. Currently, about six out of 10 new cars sold in the U.S. have factory installed HD Radio, so penetration is slowly rising as older cars are replaced. There could be an inflection point for more broadcasters at some point in the future to make the decision to broadcast all-digital MA3 Radio when penetration rates are higher.

What can be learned from how AM radio is used in other countries?

Layer: AM services outside of the United States are by and large on the decline with some exceptions, most notably Canada and Australia, which like the U.S. have millions of listeners who rely on AM.

This creates challenges in the automotive entertainment sector as automakers build cars for global markets and the demand globally for AM radio is on the decline. This is why NAB has as part of its auto initiative mission to engage with automakers and make sure they realize the importance of AM.

Digital can make AM radio worth investing in

"DRM adoption in other countries can give U.S. station owners a look into what's possible here"

Joshua King was named president/CEO of Kintronic Labs in 2022. An electrical engineering graduate of Clemson University, he joined the company in 2018. Now as its leader he is continuing the legacy of his father Tom King and grandfather Louis King in AM radio antenna systems.

RW What lessons have been learned from early adopters of all-digital AM HD Radio, and why haven't more put it on the air?

Joshua King: It is great to see the market penetration of receivers in cars and I'd love to see more stations, especially in population dense cities, promote their transition to all-digital, then commit to running it. In my opinion I don't think stations focused on talk radio stand as much to gain, but stations with a music format could benefit from the sound quality that can be realized through all-digital.

I always laugh when I'm tuning through the AM band and land on some thumping (this is hyperbole, there is actually very little bass) rap and R&B jams. Usually I turn it up, roll my windows down and see if I get any funny looks as I'm driving by. Stations like this are clearly just using the FM translator and should look into running all-digital MA3 HD Radio, because they will only gain listeners in the AM band.

RW What can be learned from AM developments in countries outside the United States?

King: DRM adoption in other countries can give U.S. station owners a look into what's possible here. The message should be that AM radio is still seen by many countries as worth investing in. The number of countries adopting plans to roll out DRM is growing quickly. An effective and high-quality AM signal is possible even in today's high RF noise environment thanks to the advances a fully digital signal can offer.

RW What has been the impact on your clients of soaring real estate values at many tower sites?

King: As cities have expanded, many AM stations that at one time were surrounded by open fields are now surrounded by apartments, developments or suburbs. Since AMs generally require several acres for a non-directional, and tens of acres for a directional, the land they are on can be worth an incredible amount of money. I think this speaks more to the skyrocketing value of real estate than the decreased value of some AM stations. The interest rate increases have slowed land sales driven by developers and in turn may reduce the value of the real estate, but we expect this trend to continue for AMs, which will likely mean more multiplexing to combine multiple AM frequencies. This also leads to more complex antenna system designs, which we thrive on.

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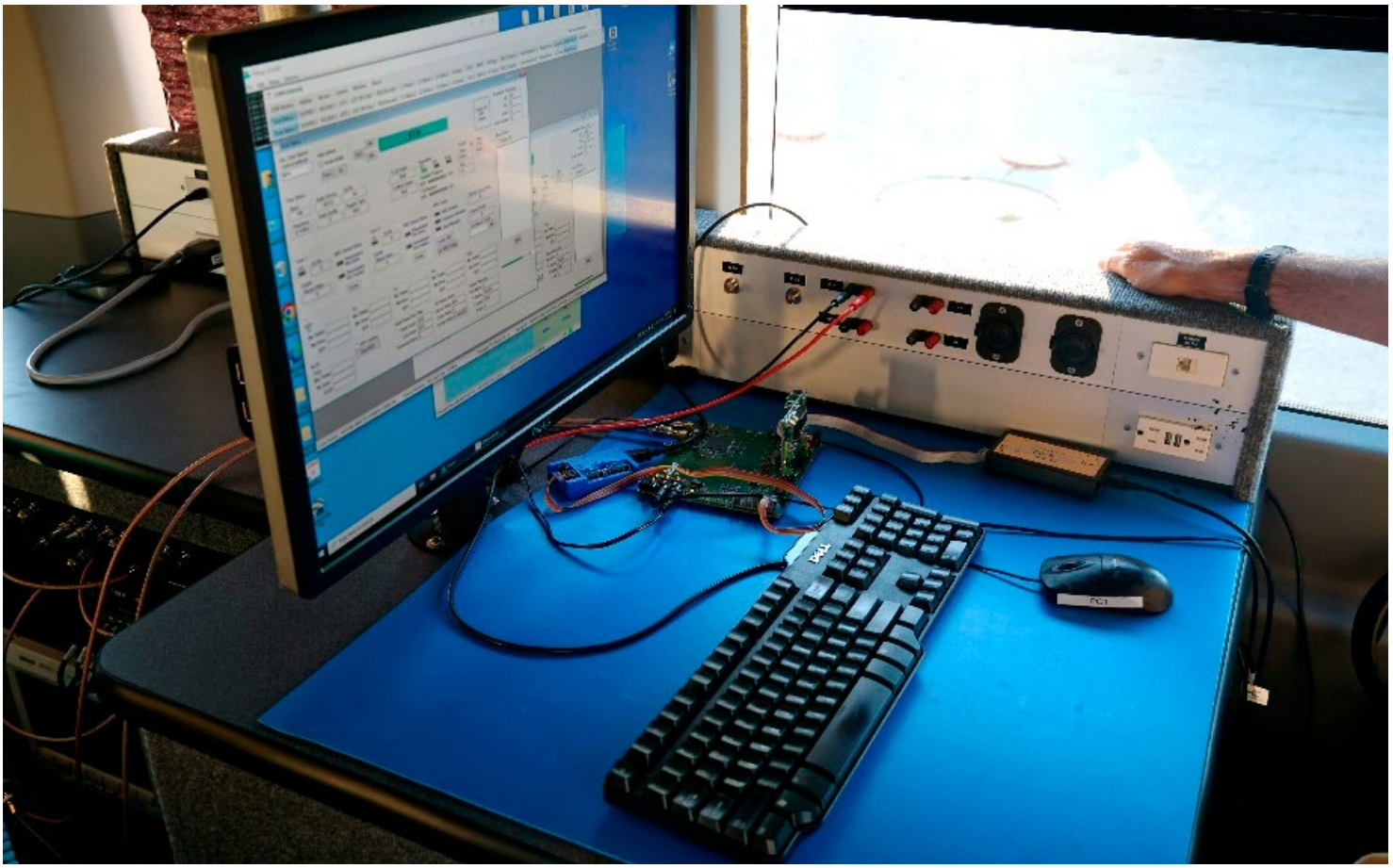

Writer

Dave Kolesar
Senior Broadcast Engineer, Hubbard Broadcasting

WWFD concludes AM digital test phase

Dave Kolesar summarizes results of five years of testing

WFD in Frederick, Md., recently concluded the experimental phase of its MA3 HD Radio operation. It has notified the FCC that after five years, it will now continue operate as a full-time all-digital AM operation as is allowed under commission rules.

The author is a senior broadcast engineer, and program director for Hubbard Broadcasting. He provides an update for Radio World readers on the experimental work that has been done at the station.

With apologies to Star Trek, this summer WWFD (820 kHz, Frederick, Md.) completed its "five-year mission" of testing the all-digital HD mode of AM broadcasting known as MA3.

On July 31, we submitted a Digital Notification to the FCC, transitioning the station from digital operations under Experimental Authority to normal licensed operations. Up to almost the very last day, WWFD was working with Xperi Corp. to support as much field testing as possible.

So what were we doing?

In a few of our papers and presentations at the NAB BEIT Conference, Mike Raide of Xperi and I have noted that the Reference Carrier in the MA3 waveform accounts for approximately 38% of the transmitted power in the waveform.

While this carrier is necessary for coherent reception of the signal constellations in the OFDM (Orthogonal Frequency Division Multiplex) signal, could power savings be achieved by reducing the level of this carrier, and at what cost? Would fringe coverage or fast receiver acquisition (the ability of a receiver to lock on to an MA3

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The test van setup.

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Above
The Xperi test van.

signal and output audio within one frame, or about 1.4 seconds) be compromised?

These are issues best examined in field trials, and WWFD's proximity to the Xperi offices in Columbia, Md., make it the logical platform for drive tests.

Jeff Baird and Paul Peyla of Xperi created some RF recordings of WWFD, and modified them to reduce the Reference Carrier level by 6 dB. (Theory and laboratory tests indicate that this value would offer the maximum benefit of power savings with the minimum amount of signal degradation.)

Retransmitting these RF recordings required some creativity, and a solution was devised: A PC would play back the recordings into a sound card with a high AES sampling rate (near 200 kHz), and the output of that card would be fed into the AES3 audio input of the main transmitter (Nautel NX-5). This bypasses the Exgine card and demonstrates a new method of MA3 signal generation, as not only can a previously recorded RF signal be played back (retransmitted), but new RF vectors can be (and were) generated for transmission using this same method. Design engineers, imagine the possibilities!

With the MA3 signal generation question resolved, it was time to go out into the field and do drive tests.

WWFD's coverage area makes an excellent test bed for signal characterization: There are mountains (the Appalachians) to the west, a fertile valley with excellent ground conductivity to the northeast in Pennsylvania, the urban core of Frederick (its city of license), flat open terrain to the east, and two major metropolitan areas in its fringe reception area (Washington and Baltimore).

Such varied conditions provide many options for testing signal robustness and receiver acquisition. The best way to compare different test scenarios is to use the same driving route (with similar conditions: time of day, weather, etc.) and log the audio availability as a function of distance covered. This "percent audio availability" could then be used to compare the reliability of each Reference Carrier level scenario (including a normal MA3 signal) on each predetermined test route.

The test results will be presented at the 2024 Broadcast Engineering and IT Conference next spring, and are very promising: In all test runs, Core reception (Primary Carriers) was reduced by no more than 5.8%, and Enhanced reception (Secondary and Tertiary Carriers) was reduced by no more than 4.3%.

While this is a measurable effect, and the power savings would be modest, why would a station go through the trouble of reducing the power of its Reference Carrier?

A high-power (50 kW) station may see a reduction in its power bill, which may be beneficial and worth the slight reduction in coverage. However, I would argue that there may be another reason to consider a reduction in the Reference Carrier level, at least for short durations. For this, we must revisit the idea of peak power levels in AM broadcasting.

It is well-known that an AM transmitter needs enough headroom to accommodate power peaks of 6 dB. For WWFD, this means that in its days of analog operation, its 4.3 kW daytime signal would occasionally peak at 17.2 kW.

This translates into a corresponding transient power draw (plus overhead to account for transmitter efficiency). This matters when on emergency generator power: WWFD's generator, an old Onan 20 kW rig, barely handled the analog AM transmitter when on day power. With MA3 operations, even with Peak To Average Power Reduction (PAPR) algorithms in place, the 6 dB overhead figure still becomes 8.2 dB.

That means that the peak (transient) power of our digital transmissions hits just above 28 kW! The generator becomes unstable, and we have had to cut to night power (our next lower preset) just to stabilize the generator during utility outages.

With a modified Reference Carrier level, we may be able to find a "sweet spot" where we would only have to modestly reduce our digital carrier power so as to make the generator happy once again. Generators are capital expense items, and I'm going to have a much easier time setting up a "genset preset" for the transmitter, actuated by the remote control, than I would be trying to convince management to invest in a new generator. The reduction in coverage under such a scenario may be barely perceptible, and such a scenario may demonstrate the utility of (temporarily) reducing the Reference Carrier.

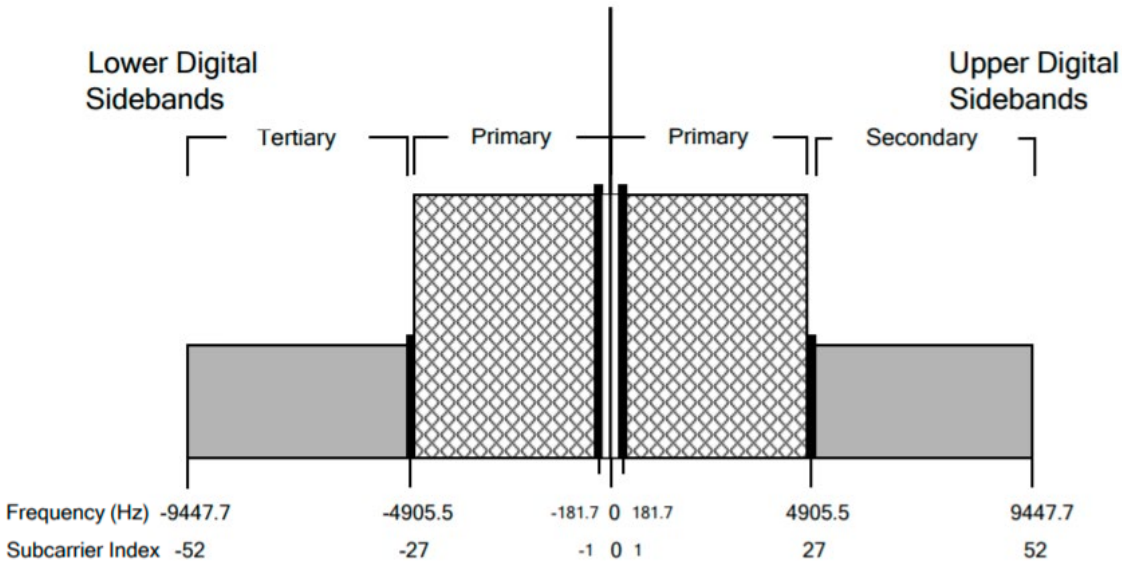
At this point, it may be useful to ask: If we can successfully reduce the Reference Carrier power without significantly compromising signal coverage, can we trade that for power increases for the Core or Enhanced carriers?

Such an idea would be subject to the restrictions of NRSC emissions masks, but the idea should not be overlooked. MA3 coverage has already been shown to work better than analog in most Electric Vehicles (EVs), but any enhancements to the robustness of AM reception in these vehicles of the future should be seriously considered. Such testing would once again require WWFD to operate under Experimental Authority, and I would be totally in favor of doing that. I have a strong personal belief that if the AM band is going to stay relevant for years in the future, it has to get to digital.

MA3 operation solves the dual problem of poor audio quality and the lack of metadata that all analog AM users experience. You can mandate that cars have analog AM tuners, but that doesn't mean that anyone has to listen to them. It's the same with digital, but at least that puts AM on a more even playing field with other services in the car dashboard. In fact, pairing digital AM with connected car platforms such as DTS AutoStage solves the "curb appeal" problem of AM: You tune by swiping through tiles on a screen, and it doesn't matter if the underlying program source is AM digital, FM, satellite or streaming. (Analog-only AM stations, lacking any metadata transmissions, don't get to play.)

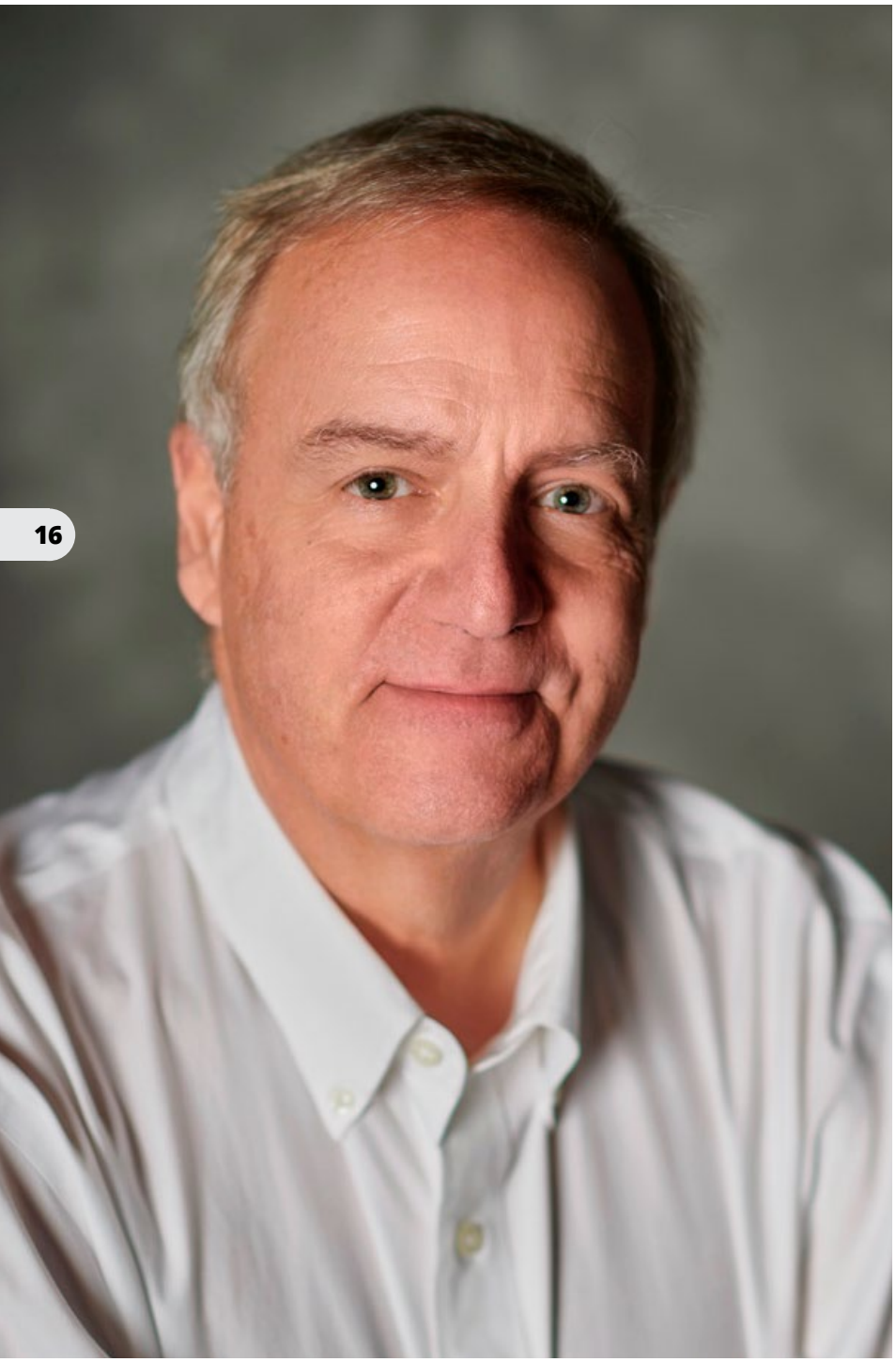
The idea of taking WWFD all-digital occurred to me around Christmastime 2016. I had not anticipated that seeing that project through would raise new possibilities for improving the AM service as a whole, and be a viable technical solution for reception in EVs. I'm happy to have had the station be used as a test platform for ideas on improving digital transmission and AM broadcasting in general, and welcome its continued role in that discussion.

The MA3 Carriers for AM HD Radio



Embrace the unique robustness of AM service

Pappas says, "FEMA has spent millions hardening AM for a reason"



Mike Pappas is a veteran radio engineer and consultant. He is vice president of business development for Orban Labs and former longtime engineering manager of KUVO(FM) in Denver.

If a manager seeks to protect or improve their AM infrastructure, where should they start?

Mike Pappas: From an audio standpoint, take a look at the whole air chain, from mics to transmitter. We have found lots of things in air chains that were severely affecting audio quality, such as multiple cascaded analog compressors prior to a digital STL, clipped IP-based STLs, bad DAs, bad board operator training, bad mic processing, broken transmitters, 30-year-old processing, to you-name-it.

Take a long listen to your audio. Hum, noise, distortion and inappropriate processing need to be resolved. A hard look at everything in the air chain will go a long way to making a better product for listeners — and that can also significantly impact PPM numbers.

One station we consulted to and cleaned up with multiple air chain problems saw a 20% increase in their PPM numbers the week after we finished. That was 18 months ago and the ratings improvement still stands.

How helpful has MDCL turned out to be?

Pappas: For those unfamiliar with the acronym, MDCL is Modulation Dependent Carrier Level. Sixty-six percent of the power consumption of an AM transmitter is the carrier, which provides no useful information. MDCL reduces the carrier level based upon the amount of modulation. Developed by the BBC back in the days of analog-controlled transmitters and pre-DSP audio processing, it had a reputation for negatively impacting fringe coverage.

That doesn't have to be the case now.

With today's digitally modulated transmitters and advanced DSP audio processing, you can run MDCL with up to 6 dB of carrier suppression using Amplitude Modulation Companding with little to NO impact on fringe coverage. Running MDCL also provides significant power savings. We have seen upwards of a 77% reduction in power costs going from non-MDCL to MDCL with 6 dB AMC. For a 50 kW station at $0.15 kW/h, the potential savings are in the range

of $40K to $60K a year. Going from 3 dB to 6 dB AMC can result in a 40% decrease in power consumption. You need the proper audio processing, though, to keep your fringe coverage area intact.

On that subject, are there opportunities for AMs to address noise floor challenges through the use of audio processing?

Pappas: You have to be able to generate density without killing your TSL to get above the noise floor, and a 30-year-old analog processor and a 25-year-old transmitter probably won't be able to do that.

Processing can improve the apparent signal to noise by upwards of 15 dB, which can make a big difference in the listener experience — not to mention better PPM decoding.

What are the implications if U.S. broadcasters were to adopt all-digital HD Radio on AM?

Pappas: There are a half-billion AM radios in the USA, and that's a lot of radios that won't receive anything but noise with MA3 all-digital broadcast. Does your listener base have sufficient numbers of HD Radios to make this work? That's the number one question you need to ask yourself before throwing the all-digital switch.

What can be learned from what's happening outside the United States?

Pappas: AM radio developments in other countries are flourishing because receivers are inexpensive and the coverage is good — and those countries want to reach listeners both in good times and bad.

Keep in mind that figure of a half-billion AM radios in the USA. It's shortsighted to turn off or abandon AM stations when you consider their unique ability to provide robust service in emergencies.

The survivability of other services is always questionable. Cellular carriers have problems on an alarmingly regular basis and have put millions of customers "off the air." The same applies to internet service providers and, to a lesser extent, FM broadcasters.

When the Four Horsemen of the Apocalypse arrive, it's going to be me, the cockroaches and AM that survive. FEMA has spent millions hardening AM for a reason.

Is it realistic to think the FCC can do anything about all that spectrum noise from non-broadcast sources?

Pappas: We can only hope. The next big noise issue will be inductive EV charging. If you thought the AM band was noisy before, wait until you have 10 kW inductive chargers running in the 79–90 kHz band in residential garages. Those are only 96% to 94% efficient, which means 400 watts to 600 watts will be dissipated as heat and RFI.

Initial testing of those chargers by CEPT ECC in Europe showed they killed everything including the FM band and the aircraft band for upwards of 30 yards around them. Hopefully those test results will be sufficient to chloroform the whole project, but you never know.

Broadcasters will have to be vigilant to protect the spectrum they use or they will be driven off their bands by these types of endeavors.

What tips can you offer or common mistakes to avoid?

Pappas: We have seen a lot of air chain problems that have been detrimental to the audio, and some are the result of equipment being added on top of other equipment.

One that had me running down a rabbit hole for a couple of days was an IP-based STL whose analog input was spec'ed at +4 dBv and had an undocumented brick-wall limiter that kicked in at +9 dBv. That was being fed from an analog facility with a nominal +4 dBv, with a +24 dBv max output level. It was kind of OK with talk, but at night the station ran music and that sounded like Satan's ShopVac. It took a couple of days and a bunch of calls to the vendor to finally get them to fess up; a 20 dB H pad was needed to make all of that happy.

Another one had an Ariane driving a Compellor, running a total of 35 dB to 40 dB of compression into an Orban 9400. The results of that were ugly! Even worse, both of those were hiding in the back of a rack, and no one currently at the station engineering department knew they were there.

A pair of good headphones and some quality time listening at every stage in the air chain can help pinpoint these types of problems.

If you are using a 25-year-old modulation monitor that hasn't been calibrated in a decade, it might be time for a calibration or replacement. We have seen more than a few stations running 80% positive due to a bad modulation monitor. If you are running MDCL, you will absolutely need a modulation monitor capable of working with MDCL.

Keep that transmitter maintenance going as well. Older transmitters may need to have all of their capacitors replaced (usually every 10 years or so) and any bad PA modules should be repaired.

So there are lots of areas that need to be looked at.

What new types of products have become available to help AM broadcasters improve their systems or the quality of their product?

Pappas: Not to blow our own horn too much, but the Orban XPN-AM has pretty much revolutionized AM processing in the last four years. In 2022 40% of our U.S. processing sales was XPN-AM. Especially when combined with the latest solid-state transmitters, we've turned out stellar results in power savings, audio quality, TSL and fringe coverage.

The FCC has not resolved our basic allocation problems

Ben Dawson calls on the commission to take more action

Ben Dawson is former managing partner of Hatfield & Dawson Consulting Engineers and now a senior consultant to the firm. He is a recipient of the Radio Engineering Achievement Award from the National Association of Broadcasters.

What technical changes could the FCC make to help U.S. AM stations that it has not already made? Is it realistic to think the commission will ever change nighttime and critical hours protection of Class A AMs?

Ben Dawson: The FCC has simply been derelict in not moving forward with most of the allocation changes proposed in the AM improvement rulemaking. FM translators are nice, but they don't solve the basic allocation problems of AM stations attempting to make improvements or lower operating costs by changing sites or antenna configurations.

The change from 0 dB to 6 dB first-adjacent-channel protection in the previous rulemaking created enormous amounts of overlap, and using the 1 mV/m rather than 0.5 mV/m as the protected contour had already been the case under the previous version of §73.37, not to mention the power increase for Class C (Class IV to us old-timers) to 1 kW.

FEMA's concerns for the Class A allocation standards were nearly paranoid, given the federal government's powers in true emergency situations. But even if the Class A standards aren't changed, the standards for all other stations should be.

Parenthetically, once digital transmission on the "medium-wave" begins to proliferate, the implications for allocation standards need study as well.

It became easier for U.S. broadcasters to deploy MDCL 10 or 15 years ago. How widely has it been adopted?

Dawson: A modest percentage of users of modern high-power transmitters — 10 kW and above — have begun to employ MDCL. In the United States, the use of Amplitude Modulation Companding (AMC) with either 3 or 6 dB compression is essentially universal.

Although a few companies have discontinued its use at some stations based on putative fringe-area coverage issues, many others report no coverage issues. One user did make field tests and comparative recordings in a very low-signal area with important demographics and discontinued AMC as a result.

Modern audio processing has proven to be very

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In a challenging era, AM stations still have options

Let's consider some of them

Cris Alexander
CPBE, AMD, DRB
Technical Editor

Several years ago, Cris Alexander wrote about options available to AM stations and licensees that needed to move or wanted to maximize their facilities. Radio World asked him to update that useful article for this ebook.

I have in recent years had discussions with several individuals about AM siting issues. Stations frequently lose their land leases or have to sell their land for economic reasons. Landlords and station owners find that the dirt under the AM tower or towers is worth far more for another purpose than as an AM site.

Many times, this news comes with little warning, and stations don't have a lot of time to find another site. The other side of this double-edged sword is that it isn't easy to build a tower anymore, even out in the middle of nowhere.

Tight ASR regulations requiring public notice and environmental processing, in addition to NEPA (National Environmental Protection Act) and NPA (Nationwide Programmatic Agreement) compliance, can add *years* to the tower approval process. Add to that the state and local environmental, zoning and land use regulations that many venues have in place, and you may find that it will take three or four years just to get all the approvals needed to build — if you can get them at all.

None of that regulatory compliance is cheap. The cost can easily exceed the cost of the tower or towers. Or even the whole radio station. The sad economic reality can well be that it's just not worth it. The earnings potential of the AM station over five or 10 years may not come close to paying for development of the new site. All of that pushes AM station owners to look at other options, one of which may be shutting the station off and turning in the license. We've done that very thing at Crawford Broadcasting in recent years.

Fig. 1 These cabinets contain diplex filters, ATU and prematch components to allow two 15 kW AM stations to share the tower.

COLLOCATION

"Collocation" is a word that has gained popularity with local regulatory bodies since the start of the cellular boom. I have found that some local planning bodies have the word written into policy or even codified into statute. If an applicant comes to them wanting to build an antenna support structure of any kind, their first question is whether it can be collocated on an existing site. The bar is often set fairly high for this, making collocation a much more attractive route than new construction.

Of course, these rules and policies were written mostly to address the cellular proliferation of the past close to 30 years. AM (or any broadcast) use was not even a factor; but a tower is a tower, so AMs get lumped in with the rest and have the same burden of proof as to why they can't simply hang their little antenna on the side of the 60-foot 5G monopole behind the Wal-Mart.

That being said, it's a pretty rare thing for an AM station to be the only broadcast outlet in a town, especially in urbanized areas, and that opens up the possibility of some kind of collocation.

AM WITH AM

The easiest kind of collocation to do is with another AM station. If the tower is tall enough to present a reasonable impedance and the stations are sufficiently far apart in frequency (>120 kHz), diplexing two AM stations together is a fairly simple matter of using pass/reject filters on each frequency. Fig. 1 shows cabinets enclosing the needed components.

Just a little over a year ago, I did a "DIY" diplex project that was chronicled in the pages of Radio World Engineering Extra. Give that a look for an example of what can be done in some circumstances.

Even if a tower might otherwise be considered too short for the frequency of the station to be collocated, there are often things that can be done to make it work. Reactance can be resonated with shunt components to raise the impedance, and broadbanding networks can sometimes be used to produce a better VSWR bandwidth.

Until February 2016, stations didn't often have this option. The FCC's minimum antenna efficiency standards required in most cases for an antenna to produce at least 282 mV/m per kilowatt at 1 km. Fifty-five electrical degrees was about as short as you could go and still meet the standard.

In the FCC's initial AM Revitalization effort, the minimum antenna efficiency standard was reduced to 215 mV/m per kilowatt at 1 km. Curve A in §73.190, Figure 8 only goes down to about 18 electrical degrees (0.05 wavelength), and that corresponds to about 214 mV/m, so presumably a 19-degree antenna would meet the minimum antenna efficiency standard. That really gives stations some options. The lower efficiency could be made up for with transmitter power (and electricity usage).

A station on 600 kHz could, for example, diplex with a station on 1550 kHz that uses a 90-degree (158-foot) tower and still easily meet the minimum antenna efficiency standard.

Of course, we're talking about non-directional daytime operation here. At night, the vertical plane radiation pattern comes into play, known as the "function of theta." Short towers are notorious "cloud burners," radiating a lot of energy well above the horizon. A full-time non-directional AM station that moves from a quarter-wave tower to one that's 30 or 40 degrees tall will have to reduce power at night to keep from raising the night limits of all the other stations on frequency, particularly those within a few hundred miles.

Can directional stations diplex together? Certainly, if the tower lines and spacing are right for putting the lobes and nulls in the right places.

Years ago, I had a 5 kW 1290 kHz station in Portland that diplexed into all three towers of a 50 kW 1520 kHz station. The tower line and spacing were just right and it worked. At present I have a 5 kW 970 kHz station in Buffalo that diplexes with a 5 kW 1270 kHz station using all five towers of our directional array, and it works well for both stations day and night (see Fig 2). That kind of thing is rare, however.

How about a non-directional AM diplexing on one tower of another station's directional array? That's fairly easy to do, although pass/reject filters and detuning components will be required at the unused towers for the relocated station. It's also possible to use as a directional antenna just a few towers of another station's array that has more than that, again provided that the tower line and spacing are right, and again with

Fig. 2
This five-tower inline array is home to WDCZ and WHLD, both 5 kW stations, in the Buffalo market. That's Lake Erie in the background.

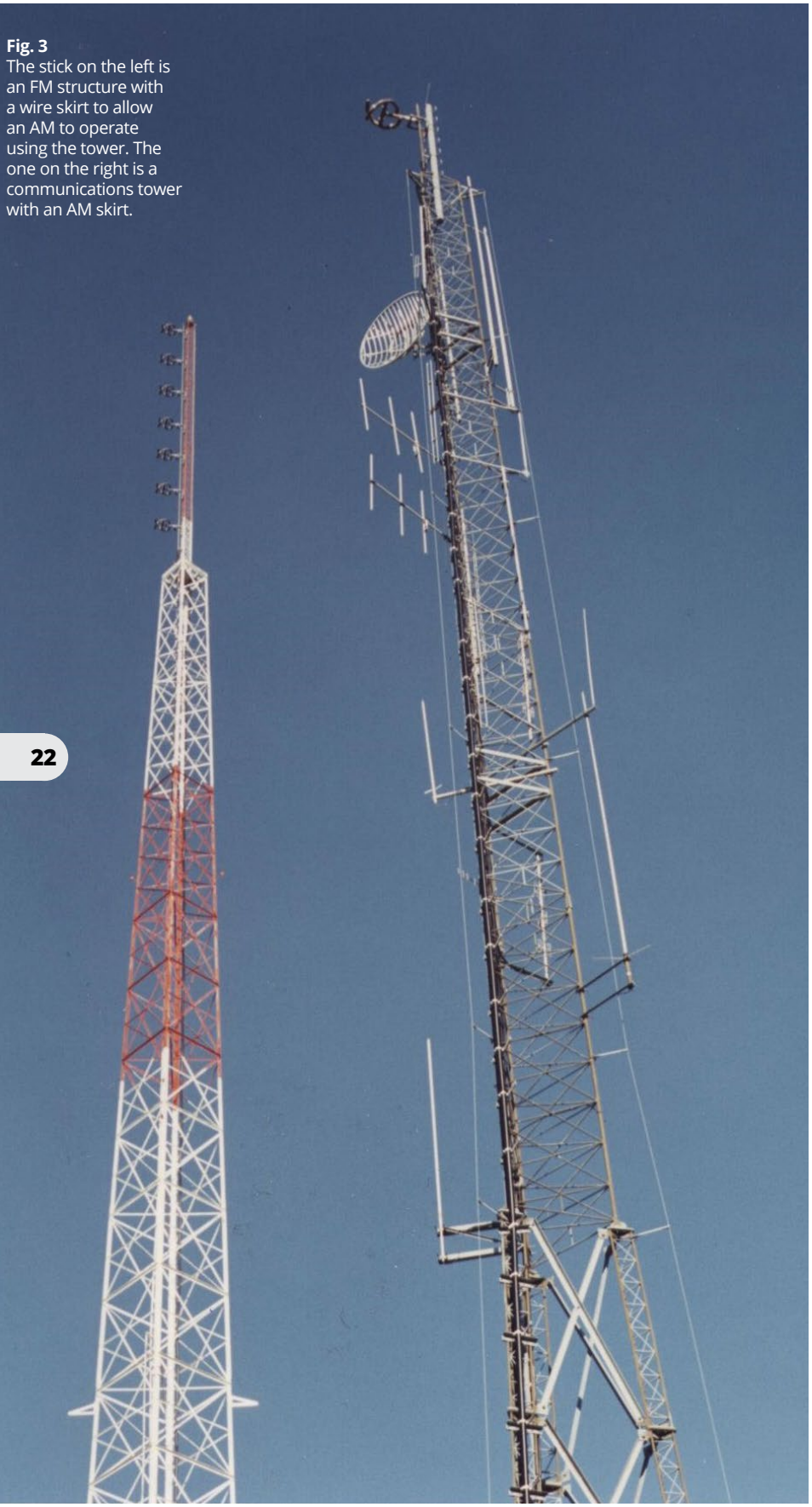

Fig. 3
The stick on the left is an FM structure with a wire skirt to allow an AM to operate using the tower. The one on the right is a communications tower with an AM skirt.

the understanding that pass/reject filters and detuning components will be required on all the unused towers.

AM ON FM/TV

It's also possible for an FM or TV (or communications) tower to be used as an AM radiator. The easiest way to do this is to add a set of skirt wires to the tower, insulate the guy wires and plow in a radial ground system. If the tower is fairly tall, the skirt wires may need only go up part of the way, leaving the top part of the tower unencumbered for antenna mounting. Fig. 3 shows two adjacent towers "wearing" a wire skirt.

For many years, I have used Greater Media's 1,000-foot "Motower" in Detroit for a nighttime site for our 560 kHz station there, seen in Fig. 4 on the next page. A set of skirt wires runs some distance up the tower and shorts to it at a spot that provides a reasonable impedance at the bottom of the skirt.

Only three ground radials are used for this antenna because of structures and parking lot that occupy what would be the antenna field. Field measurements were made to prove the efficiency of the antenna and determine the input power.

That's sort of an extreme example, but the point is that it works very well, and we have seldom seen any base impedance change as a result of antenna and transmission line changes on up the tower.

NON-TRADITIONAL ANTENNAS

I would be remiss if I did not mention non-traditional antenna options such as the Kinstar from Kintronic Laboratories (Fig. 5) and the Valcom whip.

> **"If the tower is fairly tall, the skirt wires may need only go up part of the way, leaving the top unencumbered for antenna mounting."**

The Kinstar uses an array of five short support poles instead of a tower and has been shown to provide good results, an inverse distance field of 300 mV/m/kW, and it is short enough that it may not require any special zoning or local regulatory approval.

The Valcom Whip antenna is a 75- or 85-foot (depending on model) fiberglass whip that's good for 2 kW input power below 1,000 kHz and 5 kW above. in 2008, the FCC approved use of the 85-foot Valcom Whip above 1,200 kHz, stating in the public notice that it met the minimum antenna efficiency standard in effect at the time. Presumably, the Valcom could be used on lower frequencies now that the minimum efficiency standard has been lowered.

Either of these options would require a ground system, and a full quarter-wavelength radial system would be best. Still, a low-profile antenna would likely find an easier (and faster) path through the regulatory labyrinth than a full-sized tower.

GROUND SYSTEMS

What happens when an existing station moves to the tower(s) of a higher-frequency station and the ground system is short on the lower frequency? The short answer, no pun intended, is that this is largely taken care of in the new antenna efficiency standards.

The FCC has an unpublished (as far as I know) algorithm that it uses to calculate the inverse distance field of an AM tower with a shortened ground system, based on the average length and number of radials. For example, a 55-degree tower with a full 90-degree 120-radial ground system has an efficiency of 282

> **"If the tower is tall enough to present a reasonable impedance and the two stations are sufficiently far apart in frequency, diplexing two AMs is a fairly simple matter of using pass/reject filters on each frequency."**

Fig. 4
WRDT feeds a skirt on the 1,000-foot Motower in Detroit. Note the insulated guy wires.

mV/m at 1 km per kilowatt. Change the average radial length to 60 degrees and the Curve A efficiency drops to 257 mV/m/kW.

The bottom line (again, no pun intended) with these things is that measurements trump everything (as they did with the Motower example), so if in doubt, if on the edge or off the bottom of the chart, request an STA or experimental authority, temporarily feed the tower on the new frequency and go out and make some measurements in accordance with §73.186. You can then submit those with your application. Measurements would almost certainly be required with a Kinstar or Valcom antenna.

COMMUNITY COVERAGE

I should mention the changes in the community coverage standards that were also enacted in 2016. Before the change, AM stations had to produce 5 mV/m coverage of 80 percent or more of the principal community during the day and interference-free coverage in the same percentage of the community at night. That was a real problem for siting AM stations, especially as community boundaries have often grown and available sites are many times a good distance from the town.

The new rules, which require only 50% principal community coverage with the daytime 5 mV/m contour and 50% (area or population) nighttime principal community coverage with the higher of the night interference-free contour or 5 mV/m, give existing AMs that are forced to move a lot of options.

If you're faced with the prospect of an AM site move, keep these options in mind.

The author is technical editor of Radio World Engineering Extra. He has been director of engineering for Crawford Broadcasting Co. since 1984 and oversees the technical operations of 23 radio stations. He is managing partner of Au Contraire Software Ltd., which produces AM-FM allocations and engineering software.

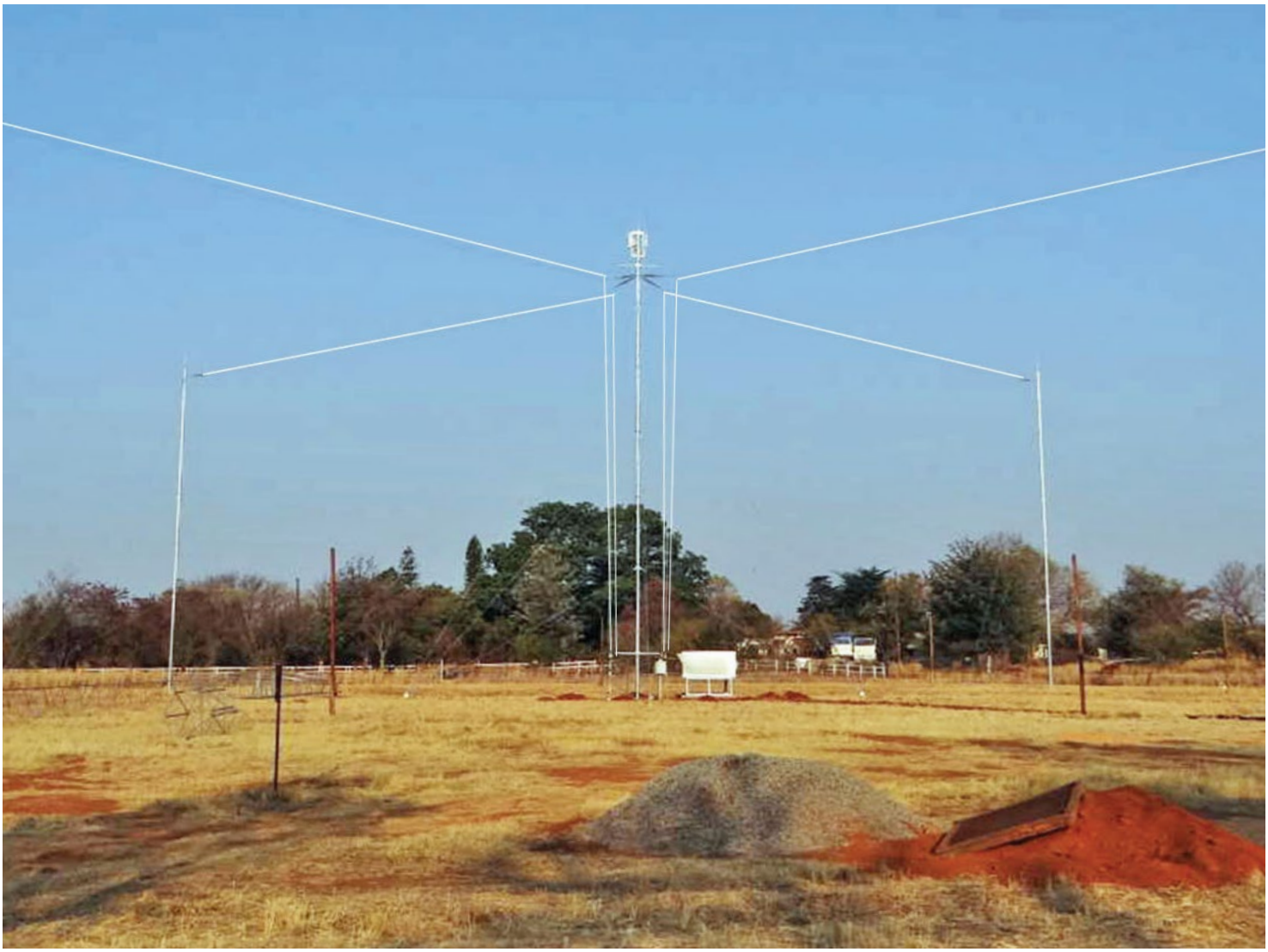

Fig. 5
The Kinstar antenna is a non-traditional, low-profile AM radiator that may work in height-limited situations.

Joshua King
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What strategies of collocation might help a broadcaster?

King: If broadcasters have multiple AM stations covering the same market, they should consider selling the land at one site and diplexing on their other site.

We've built a lot of equipment in the past couple of years to enable the installation of telecoms on AM towers. Working with an experienced company that can review the design will help prevent unnecessary degradation of the AM performance when an additional revenue source is added to the tower. An experienced company will avoid the pitfalls that can plague such a project otherwise.

What can diplexing or combining offer a station to improve its circumstances?

King: Consideration of the tower feed method for a diplexed or triplexed operation can open opportunities to enhance the performance of the original station(s). A flared skirt feed, for example, can enhance bandwidth significantly versus using a series feed or a standard folded unipole feed. Strategic choices in the filter designs can then preserve the bandwidth. Multiplexing can be a very tricky engineering challenge that can yield a good outcome for all stations involved. Extensive experience is necessary to ensure a good outcome for all the stations.

Any other tips to share?

King: If broadcasting in analog, stations should optimize their audio processor for the audio bandwidth of the average receiver in cars. If the station's audio processor is optimized using speakers in the studio or headphones, which have a much wider dynamic range, and then they take those same settings for on-air broadcast going to receivers with much narrower audio bandwidth, then the sound is not truly optimized for the listener, and that bandwidth is then wasted.

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Ben Dawson
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beneficial to users of AMC, according to the reports we've received. And of course in areas where AC power is very costly, it results in significant savings.

In a few cases, MDCL has been used to reduce or eliminate voltage stress on old antenna systems (arcing and other VSWR cutbacks), since peak voltages with AMC are the same as peak carrier, substantially reduced from peak DSB modulation values.

[Here's a link to the National Radio Systems Committee usage guidelines for AM modulation-dependent carrier level technology. –Ed.]

What impact have you seen on AMs from increases in the land value of their tower sites?

Dawson: For the past decade or more, many licensees have found that AM antenna site real estate had substantial value and that the rate of return on that value was not competitive with other investments. This has led to consolidation by diplexing (and triplexing) operations of multiple stations on a single site, and to turning in the licenses of once significant AM stations. It has also led to sales of antenna towers and sites to tower management and development companies.

We expect these activities to continue, and it may be an industry benefit. Some stations have been able to make improvements in facilities because others have gone dark or reduced their frequency allocation footprint.

How can stations determine if they are getting the best performance from their ground systems?

Dawson: It's not well known, but it's important information that many AM station ground systems are overkill.

The "120 ninety-degree radial" specification does not properly consider the actual requirement for a given ground system loss. The original ground system study from the 1930s that led to the erroneous specification was not evaluated properly by its authors but was taken as gospel without any corroboration.

Particularly at the low end of the AM band, where the radials would normally be physically long to meet the quarter-wave requirement, substantially less ground system is fully adequate in many cases. This is clearly shown in at least one standard reference "Radio Electronic Transmission Fundamentals" by Whit Griffith.

Determination of the condition of an existing ground system can be made by careful field strength measurements and analysis of them, and conditions around tower bases can be determined with a sharp shovel. A field strength meter can also be used to locate ground radial wires.

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> **"FM translators are nice, but they don't solve the basic allocation problems of AM stations attempting to make improvements or lower operating costs by changing sites or antenna configurations."**