Radio World
ENGINEERING EXTRA
February 21, 2007

WHITE PAPER

New Generation of HD Radio Systems Brings More Options, Complexity

Integration and Delivery of MPS, SPS and PAD Are Among Questions Raised by Digital Implementation

by Richard Hinkle

The author is vice president of engineering and technical services for Broadcast Electronics.

HD Radio provides broadcasters with a way to deliver programming digitally, but that's just the beginning. In addition to main program audio, the underlying design of HD Radio allows for a variety of additional advanced application services, most notably the ability to deliver additional channels of programming using the same signal — an application called multicasting. Listeners with HD Radio-enabled receivers can listen to a station's main program service, which is delivered concurrently with the conventional analog FM signal, or adjust their receivers to listen to the secondary program services, commonly referred to as HD2 and HD3.

By the time an HD Radio signal reaches a listener's iver, the complete payload is made up of multiple parts:

ıPS: Main Program Service. This is your main HD ladio signal. This will carry the same audio as analog 'M.

PS: Secondary Program Services. These are your addi-onal channels of audio programming, commonly alled multicast channels.

ΛD: Program-Associated Data. Data associated with rogram playing on air, including artist/title informa-on. PAD can be specific to either the Main Program ervice (MPS PAD) or to a Secondary Program Service ;PS PAD).

dditionally, the HD Radio specification allows for the ery of other types of data including traffic information. In the following, I discuss the integration and delivery of MPS, SPS and PAD and the common questions and issues facing broadcasters as they prepare to "go HD."

I. ARCHITECTURE CONSIDERATIONS

While MPS audio can be delivered from the studio to the transmitter site by conventional means as AES serial digital audio, SPS and PAD are delivered as data-only over an Ethernet connection. This transition to the world of data as opposed to audio forces engineers to at least venture into an arena normally consigned to network and IT specialists. Discourses in Information Technology are beyond the scope of this paper, but you will need to know some basic terms to carry on a conversation:

Duplex: Bidirectional communication, used to describe a link between devices that allows for two-way, back-and-forth communication.

Simplex: Unidirectional communication, used to describe a link between devices that limits data flow to one-way, send-receive communication.

User Datagram Protocol (UDP): A protocol that is part of the Internet Protocol Suite, UDP is a broadcast protocol that lacks provisions for guaranteed packet delivery or the ability to request packets to be resent. UDP communication can be bidirectional (duplex) or unidirectional (simplex). Broadcast protocol as described here means that the packets can be sent to all devices on a network, not just the one intended.

Transmission Control Protocol (TCP): A connection-based protocol that allows for more reliable communication between devices. TCP sends data to a destination in numbered packets, and requires the destination device to acknowledge delivery of each packet. The trade-off is in overhead and speed as TCP is slightly costlier in bandwidth and slower than UDP.

Bandwidth: In this context, bandwidth refers to data transmission rates or capacity when communicating over certain media between devices. In this paper, we will differentiate between *average bandwidth*, which is the actual average bandwidth the HD Radio payload

SEE HD PAYLOAD, PAGE 8

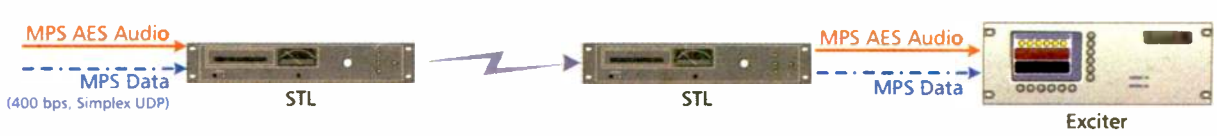

Fig. 1: Basic HD STL Configuration, No Multicast

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FROM THE TECH EDITOR

by Michael LeClair

Overnight Projects Yield The Most Rewards

You might think me a bit strange for it; but I admit that working overnights was one of the things that drew me into broadcast engineering.

I don't mean the kind of overnight shift where you spend the time reading "just in case" you are needed for something technical. When I was in college I worked overnights as a lonely security guard one summer and I can't imagine doing that for the rest of my life.

The kind of overnight work I enjoy involves a critical project that just can't be done in the daytime because you have to take the station off the air. I look on these projects as a challenge that keeps me on my toes. If you aren't organized and operating at a high mental capacity, you might end up exhausted and frustrated at around 4 o'clock in the morning, searching for the way to get things back together in time for morning drive.

I think most of us have been there before and don't really want to go there again. You always have to be thinking creatively about how to get the station back on the air when the time comes, even if it means cobbling together a backup system on the spot.

HOOKED ON A FEELING

I remember the first time I was invited to work on a transmitter with one of my early mentors, electronics wizard John Graham. Up until that point I was an enthusiastic but unschooled technician with an interest in studios and PA equipment. For me a transmitter was a large and mysterious object that hummed with power and sent out signals that could be received many miles away in perfect clarity by what was essentially a magical process.

The transmitter was a 1 kW Collins FM with a pentode power amplifier and automatic power control. The first time I was allowed to tune it, I remember I worked with an absurd caution. I was afraid that the transmitter would sense my uncertainty or lack of knowledge, let out a prodigious *CRACK* and then go permanently, horribly silent.

John invited me to join a late-night maintenance session where I would learn the basics of keeping this creature in good operating condition. We were going to change out an aging tube and clean the entire inside of the transmitter.

I recall we were joined by another friend who was more experienced than I was, and the three of us met at a college campus sometime around when most of the students were getting ready to go to bed on a Sunday night. It was from this moment that I was hooked on the idea of working in radio as a career.

The three of us worked as a team, each taking on one aspect of the transmitter cleaning and testing. With the doors open and the high voltages safely shorted with the grounding stick, I finally was able to learn more about what was inside and how it worked. I learned how to work safely on equipment that could kill people.

I also learned that diligence and craftsmanship were as important to making a transmitter go as the electronic theories of amplifiers and radio frequency signals. We checked *every* wiring connection and cleaned the entire inside of the cabinet. Then we moved to the power amplifier cavity and I got my first view of what was actually happening when I adjusted the tuning controls. I also got my first explanation of tuned cavities, which was completely over my head and made no sense to me at all.

I was only 19 and up to that point I had never done work that was as interesting or rewarding. I also had never worked as part of a team to accomplish a practical goal. The companionship was just as important as the work.

BREAK FROM THE NORM

I was working an overnight project just recently — replacing a remote control unit at an AM directional array — and again it was a team of three of us working at a steady but careful pace in order to get the project done before the morning. We were disassembling a transmitter interlock system I had built years before but which needed to be redone completely because of the arrival of a new transmitter and an old one going away. Definitely something to tackle at night since even the slightest mistake will take down the transmitter.

> It was a good time to tell stupid jokes or talk about sports or whatever keeps everyone loose and working well.

I still find overnight sessions a fine opportunity to get away from the office for a while and the nearly constant interruptions that define office work these days. The three of us were concentrating on our assigned tasks straight through the night. When I have this kind of time to focus it is sometimes possible for me to reconnect to the joys of working as a craftsman to complete a job well — a job that will last for many years before it has to be redone.

I find this a welcome relief to the daily routine of a broadcast engineer. So much of our work these days is responding to problems with temperamental and poorly built computers. By its nature, programming computers is the most temporary of arts because their operating systems are designed to be replaced every three or four years.

It is hard to feel that any project using a computer is ever done. At best a computer is enjoying a short spell of operation between constant software updates and system upgrades. I take great satisfaction when I finish up a transmitter project and know that it should run for many years without anyone having to change anything if I designed it right.

Although we ran into some difficulties at one point, no one lost their temper or composure. It was a good time to tell stupid jokes or talk about sports or whatever keeps everyone loose and working well.

By the time we were getting close to our 4 o'clock deadline, we had the job complete, although there were still some things that remained for us to finish up during the daytime or later on in the week. Another overnight done and a sense of accomplishment that we get important work done that no one else can do.

STORIES TO TELL

We have a great issue of Engineering Extra this month, including a feature article from Richard Hinkle of Broadcast Electronics about the architecture of the latest generations of HD Radio. Multicast is beginning to sprout up in many markets, and with it new opportunities as well as new ways to build your HD. I know I've been enjoying multicast in our market on my new (Christmas present) Boston Acoustics Recepter.

Our interview is with Mike Patton, a veteran of the rebuilding efforts in the New Orleans area after hurricane Katrina nearly wiped out all the region's broadcasters. Patton has interesting stories to tell.

Guy Wire brings you his predictions for the coming year, Cris Alexander talks about proposed changes to the process of "proofing" and AM directional, and yours truly has contributed a Project Profile on the replacement of a directional FM array. We round out the issue with a piece from Wes Keene on preparing for data delivery over HD and Barry Blesser talks about the way the Internet has changed broadcast engineering.

Don't forget that we want this paper to be an open forum for ideas, and I welcome any comments you may have, good or bad. Am I crazy to like overnights? Please write to me at *rwee@imaspub.com*. ■

IN THIS ISSUE

by Steve Callahan

Patton's Pride Evident in Katrina Response

Engineer Has Seen Radio's Bad, Good and Ugly; Cites Katrina Crew as Best in the Business

When I visited New Orleans on the one-year anniversary of Hurricane Katrina, I was amazed at the devastation that remained. And at every radio station I visited, I was told to "talk to Mike Patton."

In the storm's aftermath, Patton helped restore stations that had been damaged by violent winds and flooding.

Patton, owner of a broadcast systems integration and facilities contracting firm that bears his name, calls himself a "field engineer." He is proud that he works in the field and not at a desk. Born in Jackson, Miss., now based in Baton Rouge, La., he is known at many stations along the Gulf Coast.

Like many in the industry, Patton is self-taught and came to radio engineering by a path that included various jobs. More than 20 years ago he started work as a contract engineer and hasn't looked back. He shared a few stories from Katrina and thoughts about the field of radio engineering today.

'I will never forget WWL acting like some small-town 1 kW AM and airing unscreened calls from people trying to find their lost family or friends anywhere in the country.'

What was it like getting stations back on the air after Hurricane Katrina?

It was hell. And it was a high point of my career too. The human misery we were so close to was frightening, but the work we did helped to alleviate much of that too. My crew did some extraordinary things for the stations of New Orleans.

Katrina came through on a Monday, and on Tuesday at 9 p.m. we returned to New Orleans. We were stopped at a state police checkpoint and I told the officer we needed to get in because "radio will save lives." We were lucky and he let us in.

Entercom later arranged for us to get "all access" passes. One thing that struck me was a city of 2 million people in total darkness. The stations that had working generators had fuel storage that was good for two, maybe four, days. Entercom's WWL(AM) was lucky enough to have generator fuel to operate 30 days at half power. After 20 days, there were still no commercial power or fuel deliveries.

Finally on Day 28, a military helicopter airlifted a portable fuel bladder to WWL and just as the helicopter was pulling away, the commercial power was restored. Now that's cutting it close.

I will never forget WWL acting like some small-town 1 kW AM and airing unscreened calls from people trying to find their lost family or friends anywhere in the country — and it kept working too, over and over. A call seeking lost loved ones would come in, and a few minutes someone else would call in from half the country away in response. Truly radio at its finest; you didn't see that on CNN.

We had just moved the studios of WSHO(AM) from the 43rd floor of the 44-floor Plaza Tower to a new facility on Canal Street before the storm. After Katrina hit, we learned that the storm had twisted the Plaza Tower enough to prevent the use of the elevators. We still have some equipment there.

WSHO was one of the lucky ones. They stayed on the air by remote control from the owner's vacation home in North Carolina.

A station that was not so lucky was a station in Delacroix. The transmitter building was picked up off its foundation, tossed on its side, and we never did find the transmitter.

There are still some stations either off the air, or operating at reduced facilities. One four-tower array lost two-and-a-half towers and will take some time to rebuild because the towers are in a swamp.

Some New Orleans television stations are still at low power, but surprisingly none of them lost any towers. My crew and I had a small part in keeping stations on the air, and we are fiercely proud of it.

What do you do for fun when you're not working?

When I'm not working? When is that?

Mostly I eat and sleep when I'm not working. If any time at all is left, I try to spend it with my kids. I have five total: three are grown and the last two (boy and girl twins) are almost 14. I'm trying to show them a bit of the U.S., so I often take them with me on jobs or arrange for my family to meet me for a weekend in whatever locale I find myself.

Where did you go to school or get your initial training?

I was given the great gift of working for a custom electronics firm while in high school. By the time I graduated I already knew how to design and make PC boards, troubleshoot and operate machine shop equipment. While I went to Mississippi State to study electrical engineering, I dropped out after a year and went to work, first as a two-way radio tech, then in broadcasting.

What was your first job in broadcasting?

I fixed a broken Harris TE-3 exciter for a Jackson, Miss.-area station. It had a shorted .01 uF cap on the 24 V power supply. Never got paid for it, either. Funny how we remember stuff, eh?

Was there a mentor or an early influence in your career?

Tom Brown of Jackson, Miss., who is out of broadcasting now, was the finest bench technician I ever knew, including now. He taught me how to think with a scope probe in my hand. Charles Ellis, a consulting engineer from Lafayette, La., is one of the smartest engineers I ever met and taught me AM RF and AM DAs.

I learned good wire harness work from the oilfield, where I worked for several years in the early '80s. Wiring standards in broadcasting were — and still are — terrible compared to most other industries. I learned a lot of ways not to do things from the many corner-cutting, so-called engineers I met along the way.

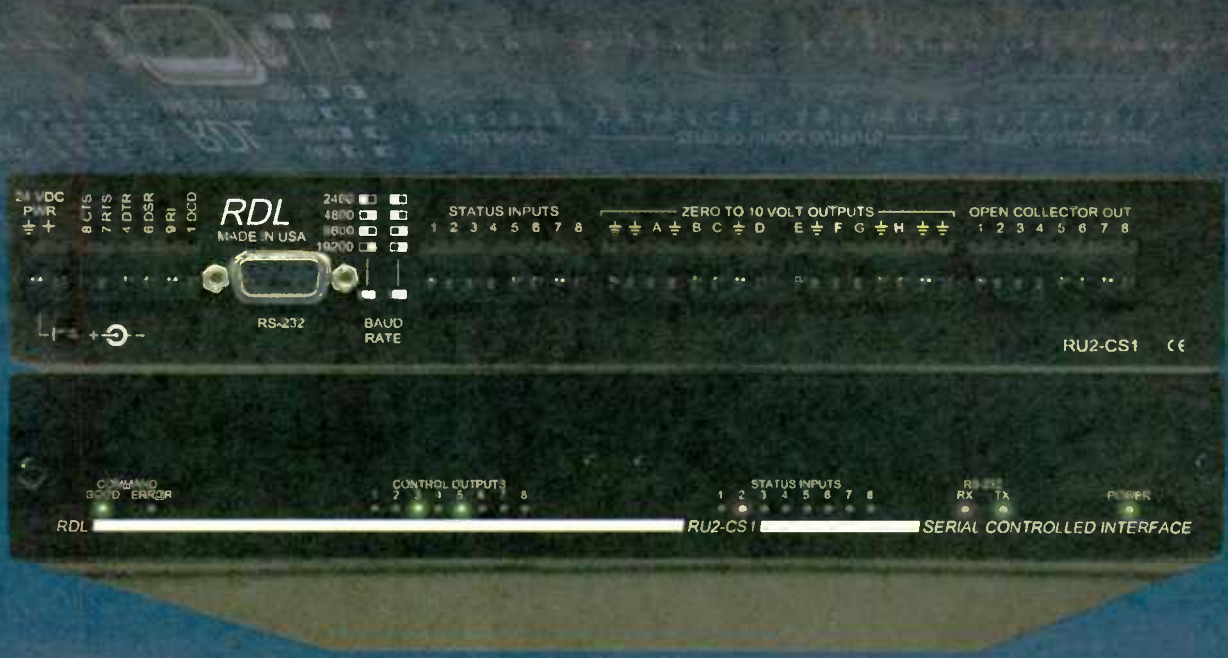
When and how did you decide to open your own business?

The engine in my van had to be rebuilt in the summer of 1981, when I was working in the oilfield and I didn't have the money; so I put out the word to my friends in radio that I needed to hustle some side jobs, and the phone never stopped ringing.

Soon I quit my oilfield job and went

SEE PATTON, PAGE 6

GET EVERYTHING UNDER CONTROL



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  Examples include sensing contact closures from satellite receivers or from RDL audio or video detection modules.
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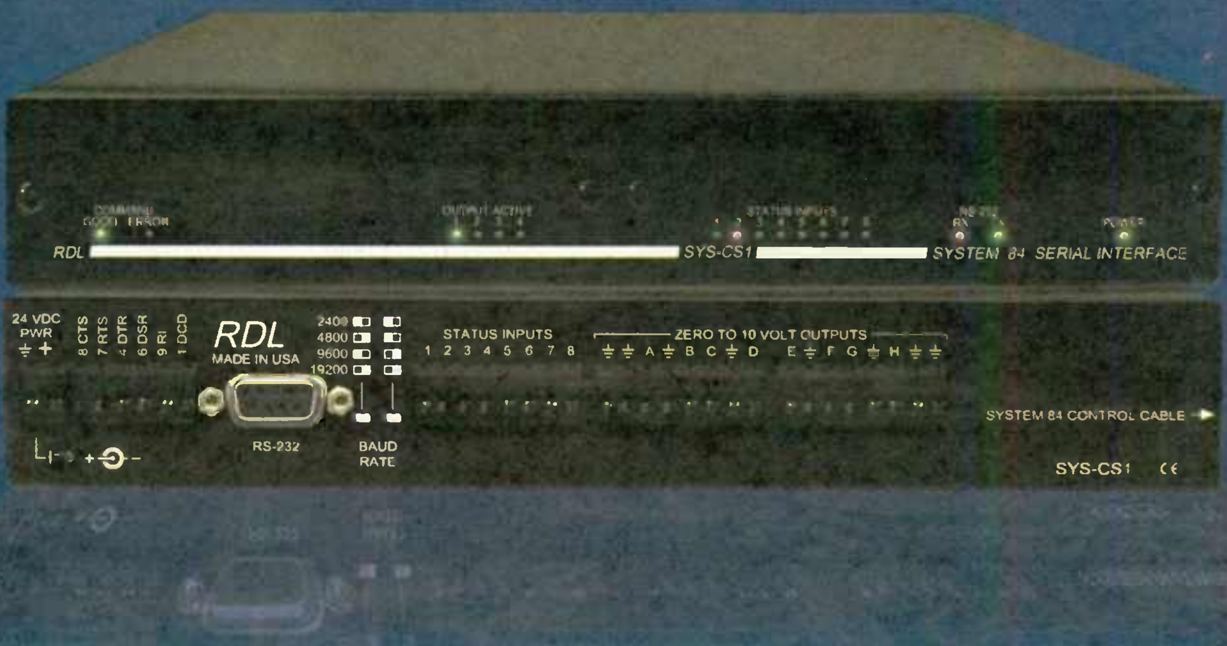

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Patton

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into contract work full-time, and as I got older and more experienced, my firm morphed more into consulting and project work. We don't do hardly any conventional contract work any more — and that's just fine with me.

Are there any other particularly memorable projects you've worked on?

I built the first 50 kW AM in Honduras, and I designed and built an island-wide chain of linked FM transmitters in Jamaica. I had the honor to be tapped by Ron Rackley to help him tune up a nine-tower DA in Detroit — WDFN(AM) — several years back. I helped build the Senior Road multi-FM site in Houston.

Whatever project I'm on at the moment is most important to me.

What problems do you see over and over when you visit stations?

Engineering personnel are overworked and just let management keep piling it on — which it seems more than happy to do. The concept of routine scheduled maintenance is almost completely gone; all we do is put out fires. Long-range planning is a joke almost everywhere. There is no pride of facility among corporate management. The FCC's decision to allow giant broadcasters has made us all slaves to Wall Street and the next quarterly report. Quality is a lost concept.

Patton and Company. From left: Frank McIntyre, IT head and office manager; Eric Blevins, IT tech; Randy Young, field engineer; Jonathan Chellette, intern; Dave Calhoun, logistics coordinator; Dane Robinson, senior field engineer; Mac Dula, senior field engineer/repair shop manager; Leo Rabelais, fabrication shop manager; Mike Patton; and Jane Patton, his daughter and company intern last year. Blevins and Calhoun are no longer with the firm. Not pictured: Velise Valerie, office assistant, and M. E. Patton, daughter and bookkeeper.

What is the worst problem you've seen in the field?

Because it's so fresh in my mind, the worst problem I've ever seen was the day after Hurricane Katrina when we first drove to New Orleans and we realized that no one was on the air except for WWL and WWL(TV). We were overwhelmed by the magnitude of the damage.

Our crew worked 60 to 70 hours a week for two months alongside the full-time and contract engineers of New Orleans and engineers from across the country. We did the basic things — and some heroic things — to get the stations of New Orelans back on the air and functional.

What was the most creative solution you've seen?

Again, the most creative solution was Katrina-related. After it became clear that WWL and the other Entercom stations were going to have to abandon their downtown New Orleans studios because of limited diesel fuel and other issues, we were part of a solution that brought many of the stricken stations together in a unique emergency STL.

Here's how we did it. At the Baton Rouge Clear Channel studios, we took a small room and installed a Mackie mixer and a spare Prophet Systems audio workstation. It was wired into their backbone audio router, which gave it access to their ISDN codecs.

A month before, my firm had just finished new studios for the Louisiana Network and they had a C-band uplink with a spare channel and the needed ISDN codecs. We started scrounging C-band dishes and non-penetrating mounts from around south Louisiana. Many of them were abandoned on roofs of former studios that had to be moved, and we spent several days disassembling and hand-lowering large and heavy dishes from multi-story buildings.

Within 48 hours we had a cobbled together an STL chain that went from Clear Channel in Baton Rouge, to the Louisiana Network via ISDN, then up to the bird via C-band and back down to a 3.8-meter dish we installed after midnight at the West Jefferson Parish Emergency Operations Center, which was in the hardest-hit area of New Orleans. WWL had a pre-existing emergency studio there, so we aimed a 950 MHz STL antenna on the fourth floor toward WWL's transmitter a couple of miles away. We also ended up installing C-band dishes at several other Entercom sites.

This collaboration, the "United Radio Broadcasters of New Orleans," continued to broadcast news and emergency information for several months after the storm. It was its live mic that caught Mayor Ray Nagin publicly accusing FEMA and the U.S. government of negligence in their response. I cannot tell you how proud I was that the nuts and bolts of this were put together by the local engineers of Clear Channel and Entercom and my associates — the hardest-working crew in show business.

What projects have you been working on, and what are you looking forward to?

I just finished an antenna proof for a station near the Port of Galveston. It was tricky because the four-tower array was within a kilometer of the shipping cranes, and the ships were constantly moving in and out of the port. No way to detune those guys. Some of the radials cross-crossed ship channels and a nuclear waste dump.

When a Baton Rouge AM station lost its transmitter site, I applied and got an STA from the FCC to operate it with 250 watts from a long wire in my backyard. I used a Nautel 1 kW transmitter, a spare processor that I had and we built up an ATU from parts that I had. Sometimes you just have to "git 'er done."

> **'I learned a lot of ways not to do things from the many corner-cutting, so-called engineers I met along the way.'**

I'm looking forward to working on a project in Shreveport with Clarence Beverage. It's a center-fed, half-wave dipole using a self-supporter with no ground system and an FM at the top. Did I mention that it's a tall tower and the top half has to be skirted and detuned?

We're constructing a lot of custom phasors and ATUs. There's a company nearby that builds our aluminum cabinets and we're cost-competitive with the big guys. We are getting ready to market a phasor controller that utilizes a color LCD touch screen and is packed with features.

What will you be doing five or 10 years from now?

I've still got two more kids to put through college, so I imagine that I'll still be doing what I'm doing for at least another 10 years. After that, I may kick back and teach electronics or broadcast engineering somewhere. I like to teach and I'm good at it. It would be nice to not be on the road all the time, to be able to coach little league or play volleyball or in a band, things like that.

Steve Callahan is a frequent contributor to Radio World Engineering Extra. ■

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HD Payload

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requires as measured over a 24-hour period, and *provisioned bandwidth*, which is the maximum bandwidth peak including data, data bursts and overhead.

II. HD RADIO FUNDAMENTALS

When HD Radio was first introduced, broadcasters were limited to Main Program Service audio at 96 kbps, broadcasting the same programming as the FM analog signal. The HD Radio specification also included provisions for very low 400 bps worth of MPS PAD, which was primarily limited to artist/title information.

Main AES audio and this small data payload were delivered to the transmitter site where the exciter handled all the HD Radio generation. Today, almost all standard studio-to-transmitter links can handle this implementation.

STL requirements for basic HD Radio systems are quite simple, and practically unchanged from pre-HD Radio requirements:

AES Audio Transport Capability:
- 44.1 kHz AES Audio = 1.411 Mbps (uncompressed)
- 32 kHz AES Audio = 1.024 Mbps (uncompressed)

Ethernet Data Transport Capability:
- MPS PAD – 400 bps Simplex (unidirectional) UDP

Network requirements for these original systems are practically nonexistent. In most cases the studio automation data interface connects directly to the STL, but even in cases where the data interface connects to the STL using existing/shared network connections, impact on other network traffic is negligible because of the low data rate.

As HD Radio evolved and multicasting was introduced, the structure of the HD Radio signal became more flexible and more complex. Currently, there are three modes of HD Radio operation:

MP1: Standard Hybrid HD Mode of Operation: 96 kbps available to partition between main and multicast channels

MP2: Extended Hybrid HD Mode of Operation: 108 kbps available to partition between main and multicast channels

MP3: Extended Hybrid HD Mode of Operation: 120 kbps available to partition between main and multicast channels

There are two different ways to implement multicasting: I2E (Importer to Exporter/Exciter) and E2X (Exporter to Exgine), the primary difference being the location of the individual hardware components. Link and network requirements are different for each approach, with benefits and tradeoffs for each.

III. MULTICASTING I2E: HD GENERATION AT TX SITE

When multicasting was first introduced, engineers were working within a framework that placed all HD Radio generation equipment at the transmitter site. The introduction of multicasting increased the flexibility of HD Radio, but also increased the complexity.

To allow for multicasting, a piece of equipment called an Importer was added to the system, which required a duplex (bidirectional) link.

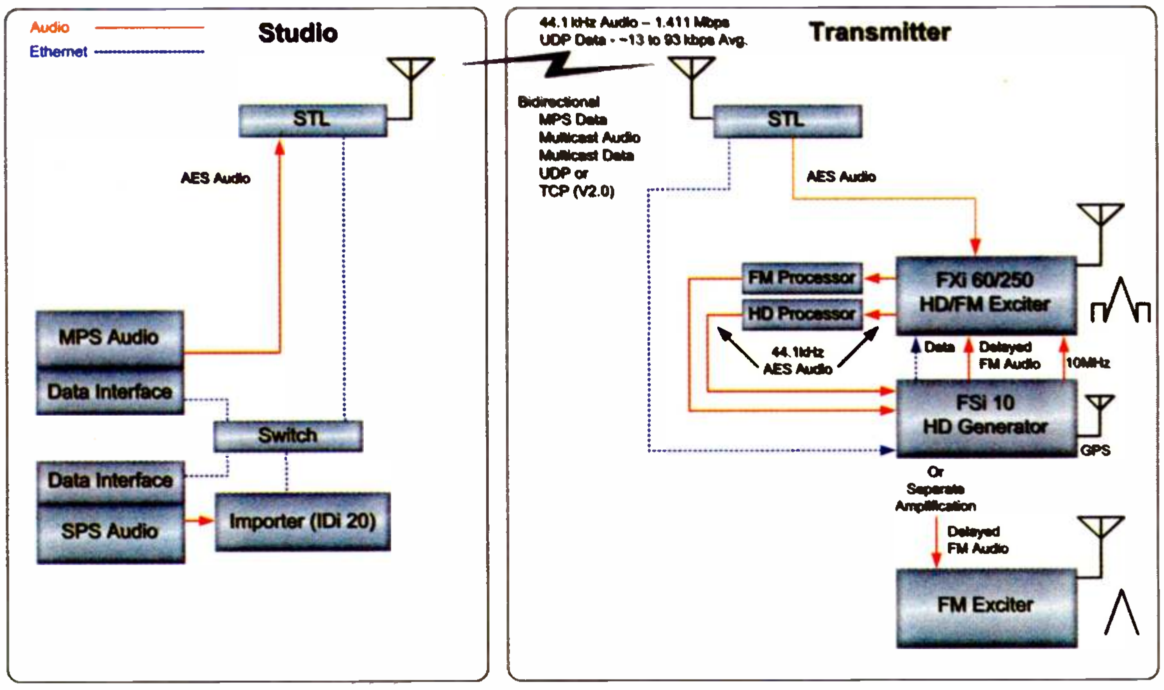

Fig. 2. Multicast Architecture, HD Generation at Transmitter Site

Studio Site Equipment: Importer

An Importer is a Windows-based computer that:
- converts secondary program audio to a data stream
- multiplexes all secondary audio data and program associated data into a single data stream
- sends that data stream to your Exporter/HD Radio signal generator

The Importer allows the further introduction of MP2 and MP3 modes. It adds the capability to adjust the bandwidth allocation of MPS and multicast audio, a process called bandwidth provisioning. MPS audio can be scaled to between 48 kbps and 96 kbps, and up to two multicast channels can be added, between 12 kbps and 48 kbps each. The Importer is the point of control for the HD Radio bandwidth provisioning process.

Transmitter Site Equipment: HD Generator

After the Importer integrates multicast audio and data into a single Ethernet stream, the coded data stream is delivered to the HD Generator, such as BE's FSi 10 or an XPi 10 depending on system architecture (other manufacturers may have different products that serve a similar purpose). The data stream is sent over a duplex link using either UDP or TCP (coming in version 2.0). The HD Generator encodes the main program audio, which is delivered to the transmitter site as AES audio, and integrates it with MPS PAD and the combined multicast data stream from the Importer, which includes multicast audio and PAD. This process creates a single, properly provisioned HD Radio signal payload.

The HD Radio Generator also delays your conventional FM audio, so as listeners switch between analog and HD Radio the audio is synchronized.

Transmitter Site Equipment: Exciter

Also at the transmitter site is the HD Radio/FM exciter. The exciter digitally upconverts the complete HD Radio payload to the FM band and corrects for non-linearities in the transmitter. The FXi series of exciters from Broadcast Electronics is capable of HD Radio-only, FM-only and simultaneous FM+HD Radio operation.

Data Rates and Provisioning Required for Modes and Services (Importer to Exporter or HD Generator)					
Interface	Direction	IP Protocol	Service Mode	Average Bandwidth kbps	Provisioned Bandwidth kbps
Importer to Exporter (XPi 10) or HD Generator (FSi 10)	Bidirectional (Duplex)	UDP	MP1, SPS1 = 12 kb	13.0	17.3
			MP1, SPS1 = 32 kb	34.9	46.6
			MP1, SPS1 = 48 kb	43.5	58.0
			MP2, SPS1 = 12 kb	21.5	28.7
			MP2, SPS1 = 32 kb, SPS2 = 12 kb	57.0	76.0
			MP2, SPS1 = 48 kb, SPS2 = 12 kb	65.2	87.0
			MP3, SPS1 = 24 kb	36.5	48.6
			MP3, SPS1 = 32 kb, SPS2 = 24 kb	69.4	92.5
			MP3, SPS1 = 48 kb, SPS2 = 24 kb	77.7	103.6
		TCP	MP1, SPS1 = 12 kb	16.3	27.2
			MP1, SPS1 = 32 kb	37.6	62.7
			MP1, SPS1 = 48 kb	53.8	89.6
			MP2, SPS1 = 12 kb	29.8	49.7
			MP2, SPS1 = 32 kb, SPS2 = 12 kb	65.2	108.7
			MP2, SPS1 = 48 kb, SPS2 = 12 kb	80.6	134.2
			MP3, SPS1 = 24 kb	42.3	70.4
			MP3, SPS1 = 32 kb, SPS2 = 24 kb	78.2	130.3
			MP3, SPS1 = 48 kb, SPS2 = 24 kb	93.3	155.5

Table 1: Data rate requirements of multicast data, sent by the Importer to the transmitter site.

STL Considerations for I2E

STL transport capability requirements for I2E systems are more demanding than pre-HD Radio requirements.

In systems where the main HD coding is taking place at the transmitter site, you *must* have an STL capable of a duplex Ethernet link between the Importer at studio site and the HD Generator/Exporter at the transmitter site. Today, that bidirectional link must support UDP, but with the 2.0 release of the Importer software from Ibiquity this will change to TCP.

Only the MPS PAD, SPS Audio and SPS PAD are sent via this bidirectional link, meaning that if the Ethernet connection is lost, only PAD and multicast services are lost.

The Ethernet data capabilities of the STL should be capable of at least the provisioned data rate which ranges from ~17 kbps to ~156 kbps depending on the specific configuration. Keep in mind that much higher data bursts are inherent to the process.

Table 1 shows the data requirements of just the multicast data sent by the Importer to the transmitter site. The average bandwidth column indicates (in kbps) the average requirement to deliver the multicast data. The provisioned bandwidth column provides some guidelines that indicate the required capability to pass the multicast data without losing packets. If other traffic is being delivered over this link, that bandwidth should be taken into account as you plan your system.

Provisioned bandwidth for multicast data is calculated using the following formula:

X * (HD + Other) = P

X = Protocol overhead constant: 1.33 for UDP; 1.67 for TCP
HD = Combined average measured multicast bandwidth in kbps
Other = All other WAN traffic in kbps
P = Minimum bandwidth recommendation in kbps

Audio also should be considered when calculating the necessary overall bandwidth capacity of your STL. Bandwidth for AES audio can be calculated with the following simple formula:

(C x R) S = B

C = Number of channels; for stereo, this is 2
R = Resolution in bits; standard AES audio resolution is 16 bits
S = Sample rate in bits per second
B = Bandwidth

Using this formula, stereo 44.1 kHz audio would require 1.4112 Mbps:

(2 x 16) 44100 = 1411200 bps = 1.4112 Mbps

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HD Payload

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Summary of STL Bandwidth Requirements for I2E:

AES Audio Transport Capability:

- 44.1 kHz AES Audio = 1.411 Mbps (uncompressed)
- 32 kHz AES Audio = 1.024 Mbps (uncompressed)

Ethernet Data Transport Capability:

- Multiplexed PAD and SPS Audio: ~17 to ~155 kbps duplex (bidirectional) UDP
- "Other" Ethernet capability as demanded by system configuration

Data Transport Considerations for I2E

Data transport considerations are far more important with the addition of multicast services because of the increased data that is transported via the network. Encoded data is sent from the Importer in 1.48 second intervals, with each data burst referred to as a "frame."

Fig. 3 graphically captures the nature of these data bursts as captured by the Ethernet sniffer software EtherReal. Bursts are delivered every 1.48 seconds, so your network must be capable of properly spooling and transmitting the data while waiting for the next burst.

Currently, all traffic is sent using duplex (bidirectional) UDP. Care should be taken when designing your network. When considering the data requirements of the system, include all anticipated traffic, not just the HD Radio component. Factor in at least an additional 33 percent capability to allow for overhead related to UDP communication. Provisioned bandwidth entries in Table 1 include this overhead calculation.

Additionally, the Bit Error Rate of your STL should be 10^{-5} (0.001 percent) or better. Higher packet loss will result in multicast service dropouts. Network link latency should be less than 100 ms. Latency can be measured using the Windows PING command (see Fig. 4).

With the anticipated release of version 2.0 of the Importer software, TCP will be supported instead of UDP. A duplex link will still be required, but TCP has some distinct advantages over UDP. Unlike UDP, TCP is not a broadcast protocol, which means it includes the provisions for verified packet delivery and buffering. TCP allows for higher packet loss, but requires higher bandwidth allocation.

Factor in at least an additional 67 percent capability to allow for overhead related to TCP communication and be sure to include all anticipated traffic when considering the data requirements of the system, not just the HD Radio component. Provisioned bandwidth entries in Table 1 include this overhead calculation.

When using TCP, network latency should still be less than 100 ms, but use of TCP allows for a higher STL BER, up to 10^{-3} or 0.1 percent. Higher packet loss will result in multicast service dropouts.

Network Considerations for I2E

Networking is as important as the data capacity of your design. UDP is a broadcast protocol. It can easily interfere with other components on a network, and other

SEE HD PAYLOAD, PAGE 12

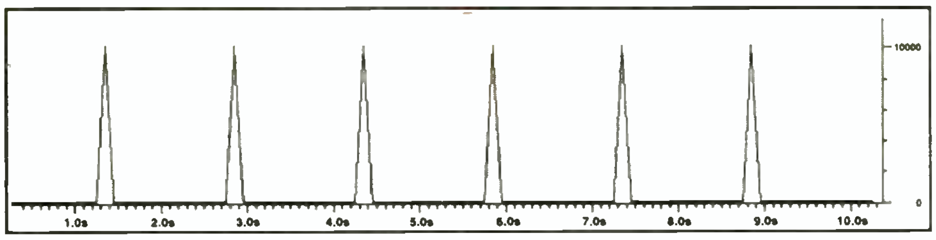

Fig. 3: Importer to Exporter/HD Generator Data Bursts

Ping with 64 bytes of data (while running traffic) 20 times using this command line:

ping –l 64 –n 20 [address of HD generator]

```
C:\WINDOWS\system32\cmd.exe
C:\>ping -l 64 -n 20 10.2.4.9

Pinging 10.2.4.9 with 64 bytes of data:

Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=13ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
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Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60
Reply from 10.2.4.9: bytes=64 time=4ms TTL=60
Reply from 10.2.4.9: bytes=64 time=5ms TTL=60

Ping statistics for 10.2.4.9:
    Packets: Sent = 20, Received = 20, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 13ms, Average = 5ms
```

Fig. 4: Network link latency is measured using Windows PING command.

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CONTINUED FROM PAGE 10

devices on the network can interfere with your transport capabilities.

One solution is to put the transport devices on a different subnet. Installing a layer 2 switch, you can create separate virtual networks, and isolate their traffic. It also is possible to put HD Radio components on a separate network that connects to the automation network through the use of a managed router.

As you design your network, here are some basic guidelines to follow:

- Use Static IP Addresses for Importer, Exporter and exciter
- HD Equipment should be on own subnet
- Subnet *must* be separate from rest of facility through use of VLANs or physically separated networks
- Use a switch or a router for communication between VLANs or network segments
- Utilize IT resources in system planning
- Utilize shielded CAT-6 cable at the transmitter site

Summary I2E

As you plan your I2E HD Radio system, evaluate your STL for data just as critically you did for audio. Remember to allow an extra 33 percent overhead when using UDP, and if possible prepare for TCP implementation by allowing for an extra 67 percent overhead. Don't forget to include "other" network traffic demands when putting together your numbers.

With the I2E configuration, audio processing, HDC audio coding and HD carrier generation remain at transmitter site. In the event of an Ethernet link failure, only PAD and multicast services will be affected. Link failure will *not* affect main FM audio or main HD audio in the I2E configuration.

HD equipment should be networked on a subnet or separate network, with each device assigned a static IP address. High-quality CAT-6 cable and managed switches or routers should be used.

IV. MULTICASTING E2X: EXPORTER TO EXGINE

E2X (Exporter to Exgine) allows multicasting in cases where bi-directional communication with the transmitter site is not an option and works well if the simplex connection to the transmitter site is exceptionally stable. Under this architecture the HD coding for multicast *and* primary audio is done at the studio site. This means that failures or deficiencies of the network connection can affect your main audio programming, not just the multicast programming as with I2E. All of the same basic capabilities of I2E (MPS, multicast, etc.) are available with the E2X architecture.

In addition to audio processing moving to the studio site, key changes in this architecture are the addition of the Exporter and the Exgine card installed in the HD exciter. The Exporter serves double duty, not only multiplexing multicast programming into a single data stream, but also HD encoding audio for delivery over an Ethernet connection to the transmitter site. This is the only architecture allowing you to send HD Radio data to the transmitter site over a simplex (unidirectional) UDP connection.

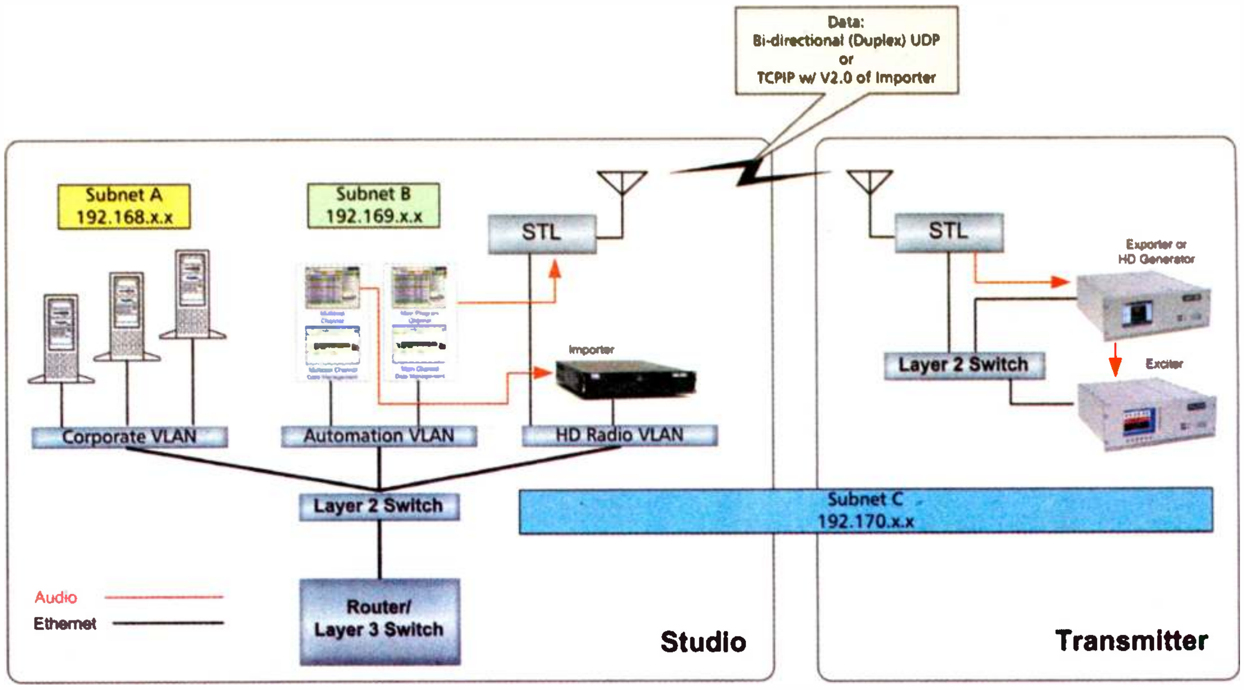

Fig. 5: Multicast Architecture With HD Generation at Transmitter Site

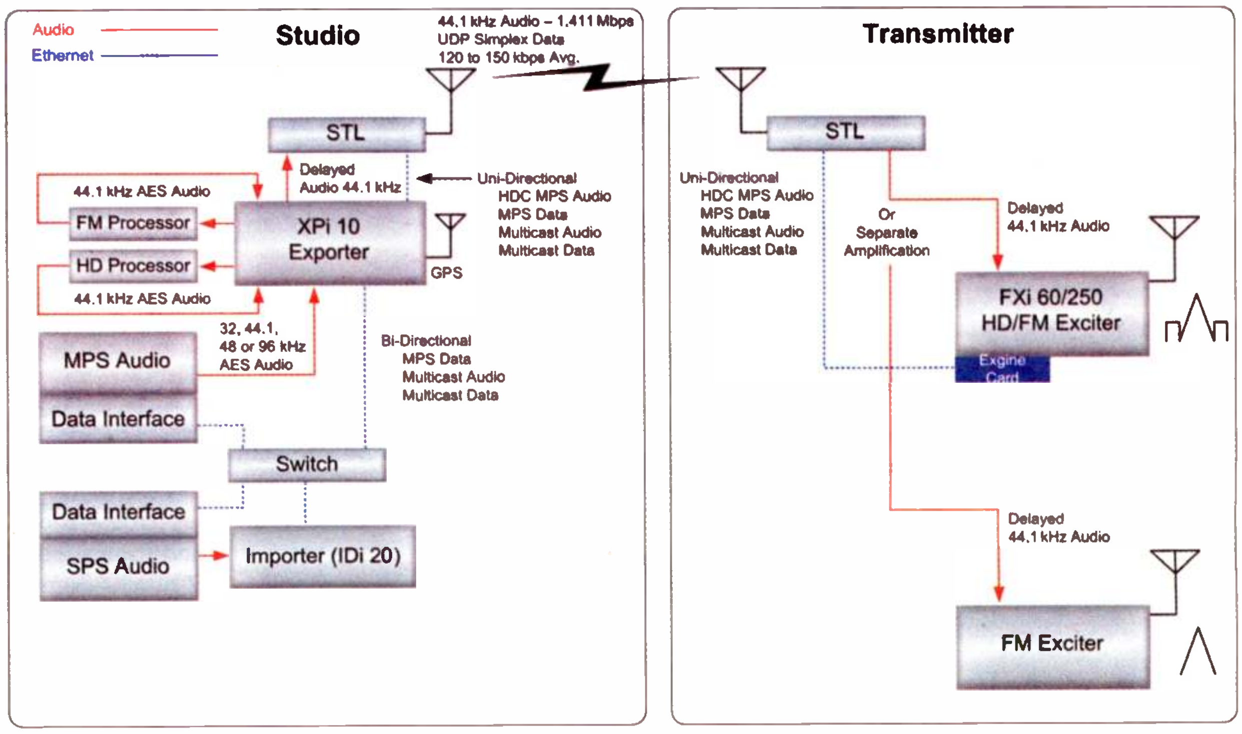

Fig. 6: Multicast Architecture With HD Generation at Studio Site

Data is still sent out at 1.48 second intervals, but the data rate is higher. The average simplex UDP data stream increases with E2X to approximately 120–150 kbps due to the addition of the main HD Radio programming to the data stream. Analog audio goes to the transmitter site as before. In fact, analog audio can be transmitted by a second STL, as long as the audio reaches the transmitter site at approximately the same time.

Studio Site Equipment: Importer

The function of the Importer is identical in both I2E and E2E implementations. The Importer:

- converts secondary program audio to a data stream
- multiplexes all secondary audio data and program associated data into a single data stream
- controls the HD Radio bandwidth provisioning process

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HD Payload

CONTINUED FROM PAGE 12

Instead of sending the multiplexed data stream directly to an HD Generator, in this configuration the data stream is delivered to an Exporter.

Studio Site Equipment: Exporter

The Exporter codes main program audio, delays FM analog audio and integrates HD Radio audio and data into a single, simplex UDP Ethernet stream. This complete HD Radio payload is then sent to the HD Radio exciter at the transmitter site.

Transmitter Site Equipment: Exciter

Enabling simplex communication with the Exporter based at the studio site requires the simple installation of an Exgine card in the exciter. Once properly upgraded, the exciter digitally up-converts HD carriers to the FM band, corrects for non-linearities in the transmitter and generates the Orthogonal Frequency Division Multiplex HD carriers.

No GPS signal is required at the transmitter site in this configuration. GPS timing is integrated at the studio site into the multiplexed signal that is transmitted to the exciter.

STL Considerations for E2X

When the main HD coding is taking place at the studio site, your STL must be capable of a stable simplex Ethernet link between the Exporter at studio site and the Exgine-enabled exciter at the transmitter site.

MPS audio, MPS PAD, SPS Audio and SPS PAD are sent as a combined data stream via this unidirectional link, meaning that if the Ethernet connection is lost all HD Radio services are lost. The Ethernet data capabilities of the STL should be capable of at least the average provisioned data rate, which ranges from ~160 kbps to ~280 kbps depending on the specific configuration.

Keep in mind that high data bursts are inherent to the process. Audio also should be considered when calculating the necessary overall bandwidth capacity of your STL.

Data Rates and Provisioning Required for Modes and Services (Exporter to Exgine)

Interface	Direction	IP Protocol	Service Mode	Average Bandwidth kbps	Provisioned Bandwidth kbps
Exporter (XPi 10) to Exgine (FXi 60/250)	Uni-Directional (Simplex)	UDP	MP1	119.7	159.5
			MP2	132.1	176.1
			MP3	149.3	199.0
	Bi-Directional (Duplex)	TCP	MP1	139.3	232.0
			MP2	155.6	259.2
			MP3	167.8	279.5

Table 2: Data Rate Requirements, Exporter to the Transmitter Site

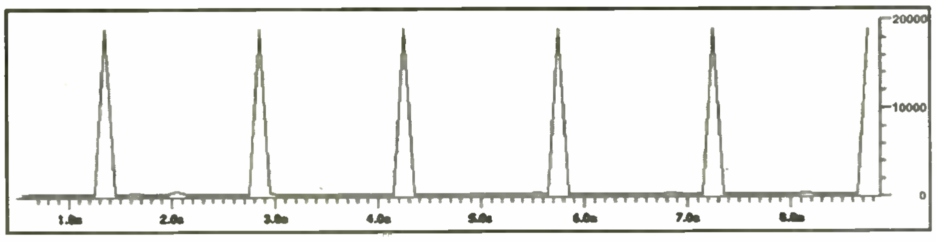

Fig. 7: Exporter to Exgine Data Bursts

Table 2 shows the data requirements of the HD Radio data sent by the Exporter to the transmitter site. The average bandwidth column indicates (in kbps) the average requirement to deliver the combined payload. The provisioned bandwidth column provides some guidelines that indicate the required capability to pass the data without losing packets. If other traffic is being delivered over this link, that bandwidth should be taken into account as you plan your system.

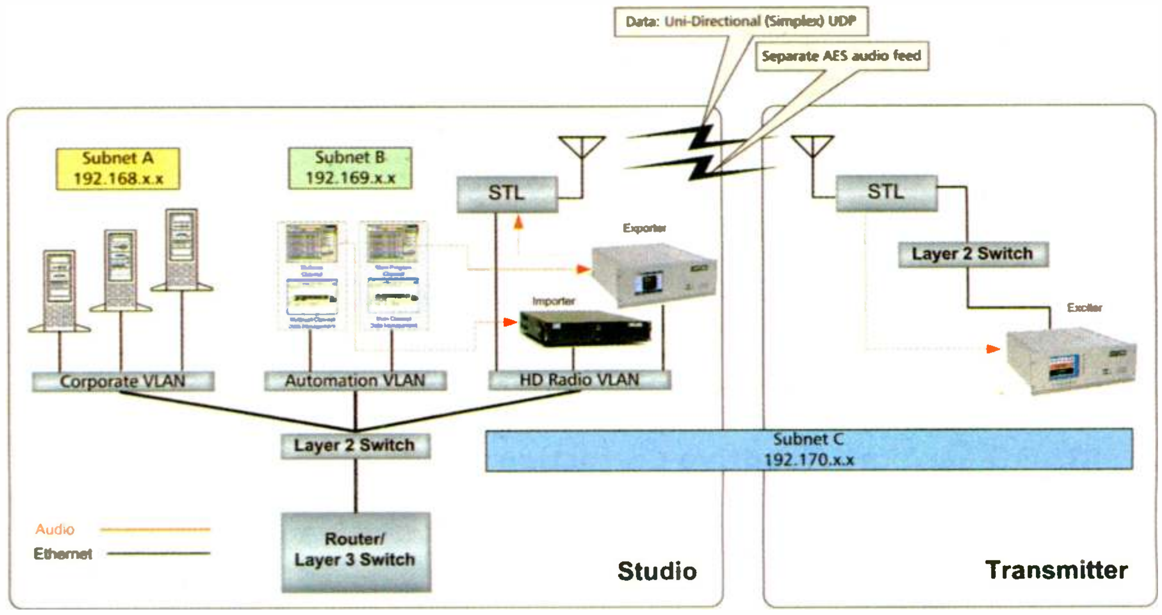

Fig. 8: Multicast Network Architecture, HD Generation at Transmitter Site

Overall, STL transport capability requirements for E2X systems focus on Ethernet transport since in this configuration, all HD Radio services are delivered as a single data payload.

Data Transport Considerations for E2X

The reliability and data transport capacity of the STL is far more important with the addition of multicast services because of the increased data that is transported via the network. Encoded data is sent from the Exporter in 1.48 second intervals, with each data burst referred to as a "frame."

Fig. 7 captures graphically the nature of these data frames as captured by the Ethernet sniffer software EtherReal. Data bursts still occur at the same rate, but the impact is greater due to the increased amount of information being transmitted.

Even operating at peak efficiency, the 1.544 Mbps capability of a T1 is not sufficient to transport all HD radio data *and* digital audio for the analog channel. If you are transporting 44.1 kHz audio (which requires 1.411 Mbps), that leaves only approximately 137 kbps — lower than the lowest recommended provisioned bandwidth recommendation.

Currently in the E2X configuration, all traffic is sent using simplex (unidirectional) UDP. Care should be taken when designing your network. When considering the data requirements of the system, include all anticipated traffic, not just the HD Radio component. Factor in an at least an additional 33 percent capability to allow for overhead related to UDP communication.

Additionally, the BER of your STL should be 10^{-6} (0.0001 percent) or better. Higher packet loss will result in complete service dropouts. This is a slightly higher specification than with I2E; if you have a simplex link, the reliability must be better.

Network Considerations for E2X

As with the I2E configuration, physical or virtual separation of network segments is recommended. Since data bursts in this configuration are even more extreme, it is more important to properly plan and manage your network to minimize the risk of overloading your network and risking packet loss (see Fig. 8). The same network guidelines as explained for I2E systems should be followed. HD equipment should be networked on a subnet or separate network, with each device assigned a static IP address. High-quality CAT6 cable and managed switches or routers should be used.

As you plan your E2X HD Radio system, evaluate your STL for data just as critically you did for audio. Remember to allow an extra 33 percent overhead when using UDP,

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Who are these guys? • Why buy a console from Axia? Element was designed by Mike Dosch and his team of ex-PR&E renegades (who know a bit about consoles). And Axia is a division of Telos, the DSP experts.

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Stage hook • This button activates the emergency ejector seat. OK, not really. It's the Record Mode key: when you press it, Element is instantly ready to record off-air phone bits, interviews with guest callers, or remote talent drop-ins. One button press starts your record device, configures an off-air mix-minus and sends a split feed (host on one side, guest on the other) to the record bus. Like nearly everything about Element, Record Mode is **completely configurable** — its behavior can even be customized for individual jocks. Sweeeet.

How many? • How many engineers does it take to change these light bulbs? None... they're LEDs.

Talk to me • Need some one-on-one time with your talent? Talk to studio guests, remote talent, phone callers — **talk back to anyone** just by pushing a button.

The Busy Box for jocks • Element comes standard with a lot of cool production room goodies you'd pay extra for with other consoles, like per-fader EQ, aux sends and returns and custom voice processing by Omnia, enabling you to quickly build and capture compression, noise gating and de-essing combinations for **each and every jock** that load automatically when they recall their personal Show Profiles. Context-sensitive SoftKnobs let production gurus easily tweak these settings while simultaneously satisfying their tactile fixations. Don't worry: for on-air use, you can turn off access to all the EQ stuff.

Missing features • Did we forget something? Program these **custom button panels** with any macro you want, from recorder start/stop to one-touch activation of complex routing and scene changes using PathfinderPC™ software. You could probably even program one to start the coffee machine (black, no sugar, thanks).

Mix-plus • If constructing a complicated mix minus on the fly brings a big grin to your face, you're excused. But if you're like us, you'll love the fact that Element does mix minus **automagically**. Forget using all your buses for a four-person call-in, or scrambling to set up last-minute interviews. When you put remote codecs or phone calls on air, Element figures out who should hear what and gives it to them — as many custom mix-minuses as you have faders.

Great Phones • With Element, jocks never have to take their eyes or hands off the board to use the phones. Element works with any phone system, but really clicks with the Telos Series 2101, TWOx12, and new NX-12 that connects four hybrids plus control with a **single Ethernet cable**. StatusSymbols™ (cool little information icons) tell talent at a glance whether a line is in use, busy, pre-screened, locked on-air, etc. Even dial out with the built-in keypad.

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Shown: 16-position split-frame Element, nicely equipped, $12,558.00 U.S. MSRP. Not shown but available: 4-, 8-, 12-, 16-, 24- and 28-position Element. Dual exhaust and whitewalls optional at extra cost.

by Cris Alexander

AM Antenna Modeling Is a Step In the Right Direction

Author Supports the FCC's Reconsideration of a Change in AM Directional Array Certification

Cris Alexander is director of engineering for Crawford Broadcasting Company, Denver.

I've been doing AM field work for a long time now. The truth is, I don't do much myself anymore. My role these days is limited mostly to the stuff I can do behind a desk — design work, phone consultation of the troops in the field and the analysis of measurement data when it comes in. But all that aside, I have tuned up my share of directional arrays and made my share of field-strength measurements over the years.

It was my privilege to be taught how to tune, measure, analyze and proof directional arrays by one of the old masters. In my case it was Charlie Gallagher, now long retired from the broadcast consulting engineer field.

Charlie had learned the trade from industry legends Everett Dillard and Gautney & Jones. I have no doubt that what Charlie taught me was entirely reflective of what the original "old masters" taught him. So for a lot of years I've carried on the traditions of AM field work in basically the same way as the two generations before me.

MATHEMATICAL MODELING OF ARRAYS

In the mid-1990s, I obtained some method-of-moments modeling software, a matrix inversion program designed for AM directional array modeling. At the time I was starting on a new 50 kW AM directional antenna construction project in Denver. I thought it might be interesting to model the antenna and see how the model stacked up to the real world, so that's what I did.

The model gave me predicted voltages, currents and phases on the different segments of the towers including the driving points, so in the initial setup I carefully calibrated the sample system, then adjusted the phasing and coupling system so the antenna monitor displayed the modeled driving-point ratios and phases. I was pleasantly surprised when we went into the field to make some directional field-strength measurements to find that the pattern was very close to what it should be. In fact, just a couple of tweaks and we were there.

Since then, I've modeled several arrays and tuned them up to the model parameters, each time with similar results. I've also talked to others who have done the same thing. Over the past 10 years or so, a good bit of information has been garnered about numerical modeling of AM antennas, both by broadcasters and the consulting engineer community. My own experiences have made a believer of me. If that isn't enough, the experiences of several respected consulting engineers are more than convincing.

A number of years ago, some from the broadcast and consulting engineer communities got together to discuss the whole issue of modeling. At issue was the accuracy and worth of magnetic field measurements for directional antenna performance verification.

According to consulting engineer Ben Dawson of Hatfield & Dawson, "The problem is that the measurement program traditionally used does not work well in anything except very uniform smooth high conductivity terrain … This results in the analysis and presentation of magnetic field measurements in a manner that is so simplistic that it is thoroughly ambiguous in a very large percentage of instances."

What Ben says here is nothing new; we've known since Marconi that a lot of stuff out there affects the instantaneous field intensity at any given point. Stuff such as vegetation, surface geology, bodies of water, topography, diffraction, scatter, reradiation and absorption all contribute to the variation. To get around this, we make a lot of measurements and graphically analyze them. We throw out data that doesn't fit the curve. In the field, we seek out points where the measured fields do fit the curve.

INACCURATE DATA

It has always seemed to me that there is a certain amount of dishonesty in this process. Sure, you can make the case that some of the collected data is contaminated and should be thrown out. You also can make the case that it is legal and accepted practice to treat the data in such a way. But scientifically speaking, how is one to know which of the data points represent an accurate picture of the inverse distance field on the radial and which do not? Isn't it possible to pick enough bad points on a radial to make the analysis say what you want it to?

So back in 1989, a group of consulting engineering firms including duTreil, Lundin & Rackley; Hatfield & Dawson; Silliman & Silliman; Moffet; Larson & Johnson; and Lahm, Suffa and Cavell paired this acknowledgement that radial magnetic field measurements are a flawed indicator of antenna performance with the growing consensus that numerical modeling of arrays can and does produce operating parameters that result in proper pattern shape and size.

It took a dozen years for the FCC to get around to considering the rather omnibus proposal, but in 2001, as part of the AM technical rule overhaul that got rid of base-current monitoring and brought us eight-point-per-monitored-radial partial proofs, the concept of method-of-moments modeling was considered.

Evidently the time wasn't right just then because the FCC omitted it from the final

SEE AM DA, PAGE 18

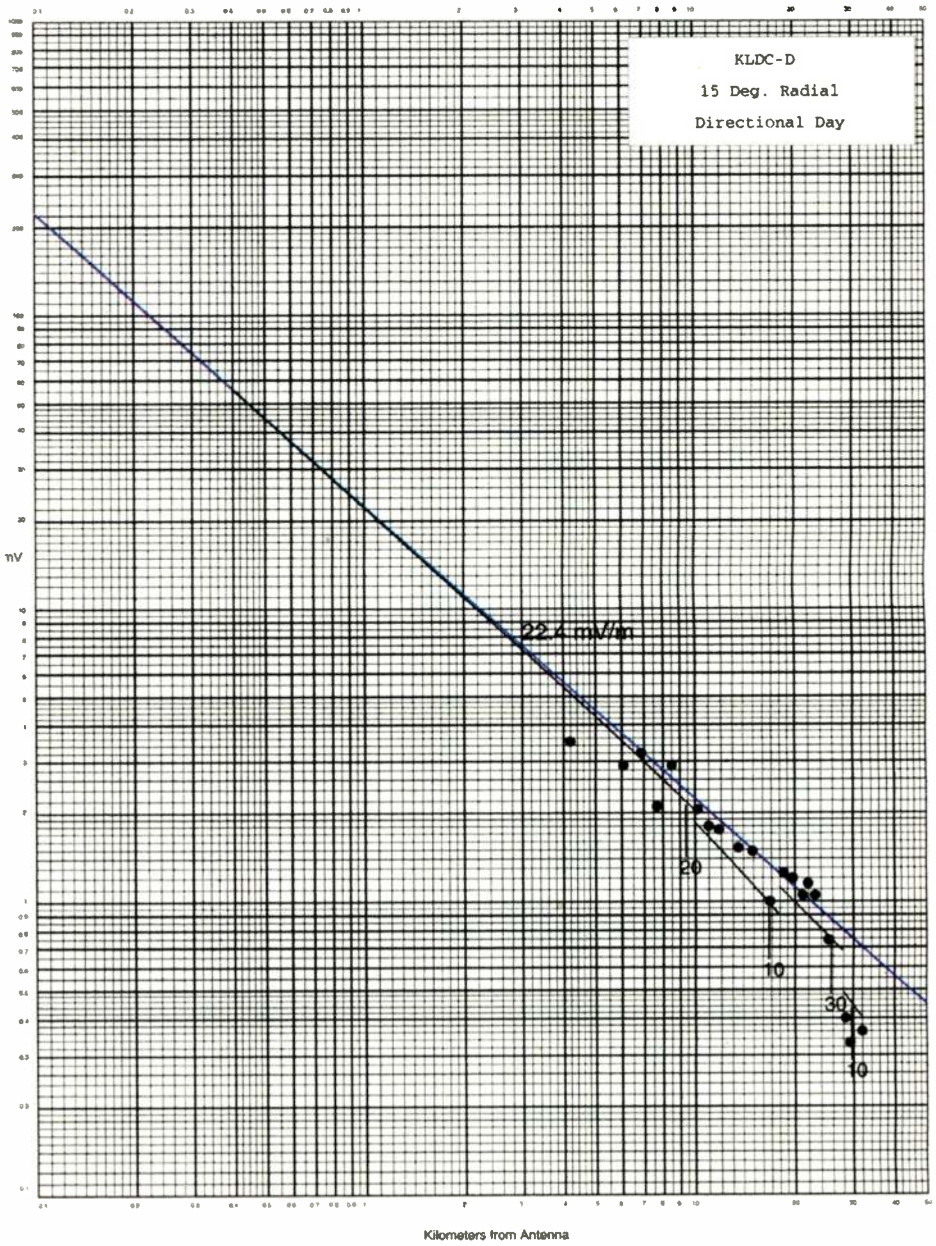

Fig. 1: Conventional radial field strength measurements are analyzed graphically for inverse distance field (IDF) and conductivity.

HD Payload

CONTINUED FROM PAGE 14

and if possible prepare for TCP implementation by allowing for an extra 67 percent overhead. Don't forget to include "other" network traffic demands when putting together your numbers.

With the E2X configuration, audio processing and HDC audio coding takes place at the studio site while HD carrier generation remains at the transmitter site. In the event of an Ethernet link failure, all HD Radio services will be affected. If only the data link fails it will not affect main FM audio in the E2X configuration as it may be transported separately. If both the audio and HD services are sent over a common link and that entire link fails, it will, of course, affect both services.

A word or two about point-to-multipoint requirements for large translator networks or multi-feed satellite systems: you can use one Exporter to send to multiple exciters due to the broadcast nature of UDP. At the transmitter site, the incoming UDP stream can be sent to two exciters allowing for implementation of a backup solution.

It also is possible to split the outbound payload at the studio site between two different STLs to send your data to two separate transmitter sites. STL and network requirements are similar as with the more common I2E and E2X configurations, but it becomes even more necessary to isolate sub-networks as the Exporter broadcasts the UDP payload to all devices on the subnet. Due to the broadcast nature of the stream, the HD Radio payload would be identical on all receiving exciters.

When planning for these larger systems as well as the point-to-point network, it's always a good idea to consult an IT expert. HD, particularly the multicasting piece of it, adds a layer of complexity to the radio operation and transitions your stations into the world of data. This is a world markedly different than that of the audio world historically occupied by radio engineers. Knowing all the options will help you determine the ideal architecture (I2E or E2X) and ensure you have built in enough bandwidth and reliability to handle the extra payload required of HD and multicasting for the foreseeable future.

In the April Radio World Engineering Extra, I will continue the discussion on radio's transition into the IT world with a primer on networking basics for HD and multicasting. ■

Meet The New Innkeepers

(they're a very functional family)

We've refined our innkeeper 1(x) line, gussied it up, gave it some great new features, expanded its family AND lowered the cost!

Why take a successful line like the innkeeper 1 and change it? Because we knew we could make it better AND lower your cost!

For starters, we've combined the features of the innkeeper 1 and the innkeeper 1x into a single hybrid that's more than the sum of its parts. As with the original, the new **innkeeper 1x** is a full-featured phone line interface which uses a proprietary dual-convergence echo canceller algorithm. It's designed to achieve excellent separation without any setup, and without sending a noise burst down the line. Plus, we've added an RS-232 connector for remote control applications and made them globally-compliant.

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Innkeeper 1x is more than a facelift. More than an upgraded feature set. It's a comprehensive, streamlined hybrid environment that gives you the tools you need to control it from anywhere. Visit us on the web or give us a call to learn more about innkeeper 1x.

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AM DA

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rulemaking. The agency did, however, issue in connection with that report and order a Notice of Further Proposed Rulemaking specifically addressing the method-of-moments issue. The group of engineers and broadcasters got together and carefully crafted a set of parameters within which method-of-moments modeling would be allowed in lieu of a full radial proof-of-performance.

These parameters were based on the collective experience to date and the state of the modeling art at the time. But again, the time evidently wasn't right. The FCC never did act on its notice of further proposed rulemaking and the whole issue of modeling fell by the wayside. Until recently, that is.

Late last year, another ad-hoc committee was formed to deal with the modeling issue. A meeting was held in Washington and there was a crowd there, a "Who's Who" of radio engineering. The FCC sent three of its top Media Bureau engineers as well. We spent the day discussing the issues and the current state of the modeling art. Clearly things have progressed in the past seven years. Another meeting was set for early 2007. The hope is to draft a set of rules that the FCC can propose and enact, possibly this year.

So, what's the big deal about method-of-moments modeling of AM antennas? How can a computer model help "prove" that a directional antenna is working properly?

The shape and size of a directional pattern ARE determined by a mathematical formula that is based on the relative current magnitudes and phases in the array elements (towers). Given a set of theoretical parameters, it is a fairly simple matter to calculate the instantaneous inverse-distance field on any given azimuth. In the real world, the challenge for the engineer constructing and tuning up the array is to adjust the relative currents and phases so the pattern produced is the desired pattern.

NOT SO FAST

Sounds easy, right? I mean, just adjust the phasing and coupling system so that the antenna monitor indicates the theoretical phases and ratios and we should be really close, right? Sorry. Most of the time it doesn't work that way.

The reason for this is that the current distribution on the tower, assumed in calculations to be sinusoidal, really isn't sinusoidal. Mutual coupling and the currents induced into a tower from other towers in the array disturb the sinusoidal current distribution. What method-of-moments modeling does for us is tell us what the real-world current distribution on each element is likely to be. The wealth of experience catalogued by those employing modeling in their array designs and tune-ups has shown us that the models, when properly set up, can be trusted.

The models tell us what the current and phase at the driving point of each element should be, and it's most often not the familiar phase and ratio values on the construction permit. If we adjust the array to those model-predicted parameters, the pattern will be the correct shape.

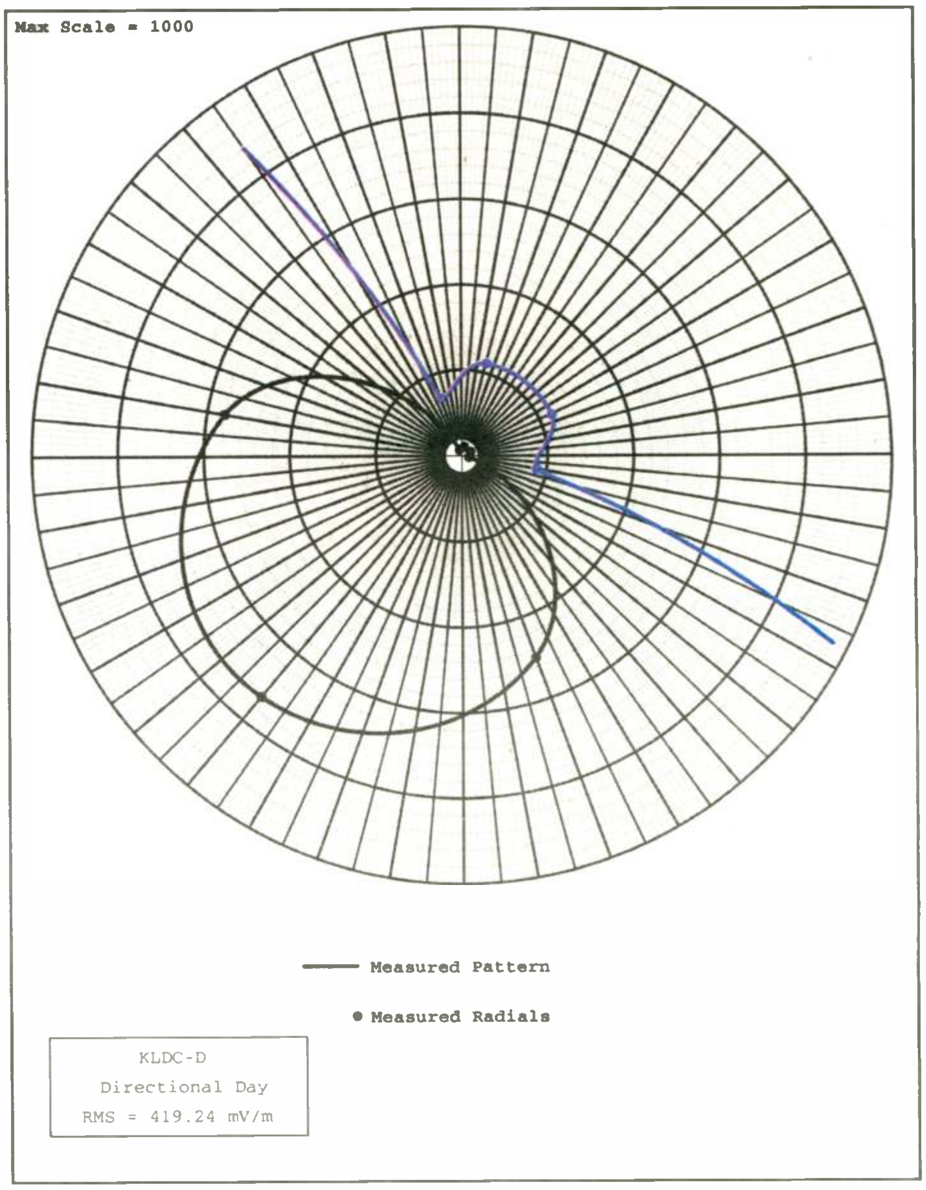

Fig. 2: Radial measurements are analyzed to show that the measured pattern does not exceed the standard pattern.

So if the model gives us correct values, what's the big deal? Can't the engineer just crank those values in on the antenna monitor and walk away? The answer is no because there's still one variable to be solved in the equation: the calibration of the sample system.

ANTENNA CALIBRATION

Antenna monitors are factory calibrated and certified to a certain level of accuracy, so we can reasonably assume they can achieve that accuracy in the field. The sample system, however, is a different story. It is composed of either tower-mounted loops or the familiar toroidal base current transformer (TCT), which measures the amplitude and phase of the RF current flowing in an RF conductor passing through it.

TCTs come from the factory certified for a certain output voltage (volts per amp) and phase accuracy. Two TCTs placed in series with one another and immediately adjacent to each other on the same RF conductor will have closely matched outputs for both amplitude and phase.

Loops, on the other hand, can have considerable variation. Not only will even minuscule variations in size have an effect on the sensitivity of the loop but the mounting location — vertically and horizontally — has a significant impact as well.

The biggest variable of all is the sample transmission line. Even relatively small variations in electrical length — and remember that velocity factor has a good bit of leverage over the electrical length of a line — can have a significant effect on the phase accuracy of the sample system, particularly at higher frequencies.

Loss is another variable. One would think that identical lengths of the same type of transmission line would have identical loss characteristics, but lines get kinked or dinged, they have connectors (sometimes improperly) installed on them and sometimes the dielectric gets wet. Clearly we must make frequency domain measurements to match sample line lengths and ensure that their losses are uniform from line to line.

The sample system in its entirety — loops or TCTs and sample lines — is part of the test equipment complement that we use to set up a directional array, so we must calibrate the sample system. That is the key item as we consider modeling as a means of directional antenna performance verification. If the sample system is not precisely calibrated, the parameters indicated on the antenna monitor are just numbers without precise relationship to the pattern shape.

As such, most of the questions that must be resolved before the FCC will allow method-of-moments modeling of AM antenna systems as part of the proof process revolve around how to go about calibrating the sample system. Calibrating at the outset is no big deal. We can do it in a few minutes in most cases with a network analyzer. On the other hand, keeping the system calibrated for the years, or even decades, that the array is in operation is a harder question.

I have no doubt that we will come up with reasonable compromises on these questions. So at some point in the future, chances are that those who are faced with the prospect of tuning up a new array, tuning up an array modification or doing array rehabilitation will have a choice. They can stick with traditional radial field-strength measurements (the traditional proof) or they can model the array, calibrate the sample

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JUST ENOUGH TEST

Is your bulky bench analyzer more test than you use and more weight than you want?

Sophisticated Minstruments from NTI give you just enough test capability, plus functions not even available on their larger siblings...
and these flexible instruments fit in the palm of your hand

ML1 Minilyzer
Analog Audio Analyzer

The ML1 is a full function high performance audio analyzer and signal monitor that fits in the palm of your hand. The comprehensive feature set includes standard measurements of level, frequency and THD+N, but also VU+PPM meter mode, scope mode, a 1/3 octave analyzer and the ability to acquire, measure and display external sweeps of frequency response generated by the MR1 or other external generator.

With the addition of the optional MiniSPL measurement microphone, the ML1 also functions as a Sound Pressure Level Meter and 1/3 octave room and system analyzer. Add the optional MiniLINK USB computer interface and Windows-based software and you may store measurements, including sweeps, on the instrument for download to your PC, as well as send commands and display real time results to and from the analyzer.

- Measure Level, Frequency, Polarity
- THD+N and individual harmonic measurements k2→k5
- VU + PPM meter/monitor
- 1/3 octave spectrum analyzer
- Frequency/time sweeps
- Scope mode
- Measure signal balance error
- Selectable units for level measurements

DL1 Digilyzer
Digital Audio Analyzer

With all the power and digital audio measurement functions of more expensive instruments, the DL1 analyzes and measures both the digital carrier signal (AES/EBU, SPDIF or ADAT) as well as the embedded audio. In addition, the DL1 functions as a smart monitor and meter for tracking down signals around the studio. Plugged into either an analog or digital signal line, it automatically detects and measures digital signals or informs if you are on an analog line. In addition to customary audio, carrier and status bit measurements, the DL1 also includes a sophisticated event logging capability.

- AES/EBU, SPDIF, ADAT signals
- 32k to 96k digital sample rates
- Measure digital carrier level, frequency
- Status/User bits
- Event logging
- Bit statistics
- VU + PPM level meter for the embedded audio
- Monitor DA converter and headphone/speaker amp

NEW! AL1 Acoustilyzer
Acoustics & Intelligibility analyzer

The AL1 Acoustilyzer is the newest member of the Minstruments family, featuring extensive acoustical measurement capabilities as well as core analog audio electrical measurements such as level, frequency and THD+N. With both true RTA and high resolution FFT capability, the AL1 also measures delay and reverberation times. With the optional STI-PA Speech Intelligibility function, rapid and convenient standardized "one-number" intelligibility measurements may be made on all types of sound systems, from venue sound reinforcement to regulated "life and safety" audio systems.

- Real Time Analyzer
- Reverb Time (RT60)
- High resolution FFT with zoom
- Optional STI-PA Speech Intelligibility function
- THD+N, RMS Level, Polarity

MR1 Minirator
Analog Audio Generator

The MR1 Minirator is the popular behind-the-scenes star of hundreds of live performances, remotes and broadcast feeds. The pocket-sized analog generator includes a comprehensive set of audio test signals, including sweep and polarity signals which work in conjunction with the ML1 Minilyzer.

- Sine and square waves
- Pink & white noise
- Polarity test signal
- Stepped sweep for response plots
- Balanced and unbalanced outputs

MiniSPL
Measurement Microphone

The precision MiniSPL measurement microphone (required for the AL1 Acoustilyzer and optional for the ML1 Minilyzer) is a precision reference mic for acoustics measurements, allowing dBSPL, spectrum and other acoustical measurements to be made directly.

- 1/2" precision measurement microphone
- Self powered with automatic on/off
- Omni-directional reference microphone for acoustical measurements
- Required for the Acoustilyzer; optional for the Minilyzer

MiniLink USB interface and PC software

Add the MiniLINK USB interface and Windows software to any ML1 or DL1 analyzer to add both display and storage of measurement results to the PC and control from the PC. Individual measurements and sweeps are captured and stored on the instrument and may be uploaded to the PC. When connected to the PC the analyzer is powered via the USB interface to conserve battery power. Another feature of MiniLINK is instant online firmware updates and feature additions from the NTI web site via the USB interface and your internet-connected PC.

- USB interface fits any ML1 or DL1
- Powers analyzer via USB when connected
- Enables data storage in analyzer for later upload to PC
- Display real time measurements and plots on the PC
- Control the analyzer from the PC
- Firmware updates via PC
- MiniLINK USB interface is standard

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system, tune up the array to the model parameters and certify the array to the FCC.

The former method involves hundreds of individual field measurements and perhaps months of parameter tweaking as the attempt is made to "tune out" the effects of re-radiators and other error vectors affecting the pattern. This method is open-ended; there's no way to know how much it will cost or how long it will take.

Modeling offers the advantage of a closed-end project. We can know at the start how long it will take to construct and run the model, install and calibrate the sample system and adjust the array parameters to match the model. We don't worry about re-radiators and other producers of error vectors; the pattern will be correct leaving our site.

How is one to know which of the data points represent an accurate picture of the inverse distance field on the radial and which do not? Isn't it possible to pick enough bad points on a radial to make the analysis say what you want it to?

How many arrays are out there with their parameters out of tolerance and the owner unwilling to invest in the open-ended money-pit that array rehabilitation so often is? How many of those owners would be willing to invest a reasonable, fixed sum to fix their broken arrays? It wouldn't be all of them — there are always those who are willing to run the risk of an FCC inspection to avoid spending any money on compliance — but I'm betting a good number would be willing to make the investment. And that would result in reduced interference on the AM band.

So which would you rather do? Tromp around in the ice, snow or mud and make hundreds of repeated field-strength measurements to determine the effect of many small changes made to the operating parameters, or spend a few hours with a network analyzer in the relative comfort of the transmitter building?

Method-of-moments modeling isn't right for every array, but if we can get a set of rules hammered out, it offers clear advantages for those situations in which it is appropriate. I very much look forward to the day when it is an option for us. Stay tuned.

THE HD REBOOT

Since converting our stable of stations to HD Radio, we've noticed that occasionally the HD exciters will "freeze up." The early symptom is a semi-frozen display, i.e., the display does not update and appears frozen until the mouse or touchscreen is actuated. As soon as mouse or stylus motion stops, the display again freezes.

The exciter continues to produce drive, however, and if you weren't standing in front of the exciter looking at the screen, you would not know anything was wrong. But the semi-frozen display is a precursor to a full lock-up of the exciter, one in which output ceases and the station will be off the air. A hard reboot is required to fix this condition, and that means a trip to the transmitter site. Bad news. Better make sure that auxiliary transmitter is working.

This problem is evidently related to the Ibiquity-produced Digital Up-Converter, its drivers or the Ibiquity software because it occurs in both Nautel and Broadcast Electronics HD Radio exciters, for both AM and FM implementations, and the DUC is the only common hardware element. My guess is that it also occurs in Harris exciters.

Broadcast Electronics has come up with a temporary work-around. It is, in essence, an "activity monitor" that watches for processor activity. If there is no activity for a full second, the unit is assumed to be locked up, a bypass relay is actuated and the unit is automatically rebooted.

This is probably a good failsafe solution to what BE has recognized as a problem it cannot solve on its own, but it is somewhat of a Rube Goldberg approach. The better approach in my view would be to fix whatever software/hardware bugs are producing the freeze-up problem in the first place.

In our stations, I have instructed the engineers to proactively reboot the HD-R exciters at opportune times of their choosing rather than waiting for the exciter to choose what's bound to be a most inopportune time. Periodic rebooting seems to stave off the freeze-up problem.

I think it's just a little ironic that we have "advanced" to the point where we must "reboot" our transmitters to keep them working.

E-mail the author to suggest topics for this column. Write to crisa@crawfordbroadcasting.com. ■

```
KLDC daytime 3-tower array

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire   caps Distance     Angle        Z              radius      segs
 1     none 75.9         220.         0              .228         7
            75.9         220.         77.
 2     none 0            0            0              .228         7
            0            0            77.
 3     none 75.9         40.          0              .228         7
            75.9         40.          77.

Number of wires             =  3
          current nodes     =  21

                         minimum                    maximum
Individual wires       wire      value            wire  value
segment length          1        11.               1    11.
radius                  1        .228              1    .228


ELECTRICAL DESCRIPTION
Frequencies (MHz)
     frequency                        no. of  segment length (wavelengths)
 no. lowest          step             steps   minimum         maximum
 1   .81             0                 1      .0305556        .0305556

Sources
source node     sector  magnitude       phase           type
 1      1        1      53.8335         217.            voltage
 2      8        1      644.09          293.1           voltage
 3      15       1      466.962         40.2            voltage

IMPEDANCE
normalization = 50.
freq      resist    react    imped     phase    VSWR     S11      S12
(MHz)     (ohms)    (ohms)   (ohms)    (deg)    dB       dB       dB
source =  1; node 1, sector 1
.81       8.8109    -4.1485  9.7387    334.8    5.7151  -3.0712   -10.52
source =  2; node 8, sector 1
.81       16.639    -48.148  50.942    289.1    5.9563  -2.9444   -10.827
source =  3; node 15, sector 1
.81       4.8149    -65.448  65.625    274.2    28.237  -.61546   -23.298

Parallel combination of all sources.
.81        6.24132    -4.81579  7.88327   322.3   8.0866  -2.1593 -13.147

CURRENT rms
Frequency   = .81 MHz
Input power = 2,200. watts
Efficiency  = 100. %
coordinates in degrees
current                                     mag       phase   real       imaginary
no.     X          Y          Z             (amps)    (deg)   (amps)     (amps)
GND    -58.1428   48.7876    0              4.60286   242.2   -2.14555   -4.07221
 2     -58.1428   48.7876    11.            4.4857    241.8   -2.11816   -3.95411
 3     -58.1428   48.7876    22.            4.17449   241.6   -1.98528   -3.67219
 4     -58.1428   48.7876    33.            3.67606   241.5   -1.75575   -3.22968
 5     -58.1428   48.7876    44.            3.00436   241.4   -1.43821   -2.63775
 6     -58.1428   48.7876    55.            2.1756    241.4   -1.0423    -1.90968
 7     -58.1428   48.7876    66.            1.19995   241.4   -.57469    -1.05338
END    -58.1428   48.7876    77.            0         0       0          0
GND    0          0          0              10.5281   4.1     10.5017    .744981
 9     0          0          11.            9.89556   3.3     9.87958    .562041
 10    0          0          22.            8.9907    2.7     8.98071    .423818
 11    0          0          33.            7.76803   2.2     7.76206    .304506
 12    0          0          44.            6.24849   1.9     6.24522    .202026
 13    0          0          55.            4.46296   1.5     4.46143    .116858
 14    0          0          66.            2.43136   1.2     2.43085    .0498398
END    0          0          77.            0         0       0          0
GND    58.1428    -48.7876   0              5.92507   126.    -3.4799    4.7955
 16    58.1428    -48.7876   11.            5.48703   125.7   -3.20317   4.45502
 17    58.1428    -48.7876   22.            4.93218   125.5   -2.86427   4.01527
 18    58.1428    -48.7876   33.            4.22242   125.3   -2.43885   3.44686
 19    58.1428    -48.7876   44.            3.36834   125.    -1.93419   2.75765
 20    58.1428    -48.7876   55.            2.38722   124.8   -1.36209   1.96049
 21    58.1428    -48.7876   66.            1.29086   124.5   -.731419   1.06365
END    58.1428    -48.7876   77.            0         0       0          0
```

Fig. 3: A method-of-moments model predicts impedances and segment currents and phases.

by Randy Hoffner

Audio Meter Confusion Yielded VU Meter

A Look at the Origins and Rationales Behind the Two Types Of Standardized Analog Audio Meters: VU and PPM

Randy Hoffner is a veteran broadcast engineer.

It is unarguably true that one of the thorniest issues broadcasters have had to deal with is that of audio metering. This is probably no less so today than it was in the early days of broadcasting.

In my previous article ("Digital Audio Metering Not as Easy as It Looks," Dec. 13) we saw that a digital audio meter may accurately indicate the level of each individual audio sample while failing to indicate the peak level of the waveform that was digitized, because the peaks themselves were not sampled.

The Nyquist rule holds that if at least two samples are taken per cycle of a waveform, it may be perfectly reconstructed, without knowledge of what happened between samples. If the samples taken by the digitizer happen to fall at points below the waveform's peaks, a digital audio sample meter will not indicate the peak level of the waveform, although the waveform will be perfectly reconstructed, peaks and all, by a D/A converter.

In the analog audio world, two types of standardized meter have been used. It is instructive to look at the origins of these meters and the rationales behind them. In the United States, the confusion caused by the lack of a standard audio level indicator led the Columbia Broadcasting System, the National Broadcasting Company and Bell Telephone Laboratories to develop a new audio metering standard in 1939.

The result was the standard volume indicator, or SVI, which is frequently called the VU meter. We note that the 1939 standard and its successors refer to units of volume measurement as "vu," written in lowercase, but nowhere in that document or its successors do we encounter either the term "volume unit" or "vu meter."

ORIGIN OF SVI

The SVI arrived before the dawn of tape recording, and was in fact developed to prevent overload of tube-type audio amplifiers, and to assure that the level readings of two different groups in two locations could be correlated. Tube amplifiers, unlike digitizers, are not brick-wall clippers, but overload much more "softly," so that a true peak indicator was not required for this application. When analog audio tape recording arrived, its overload characteristics were similar to those of tube amplifiers, producing a rounded overload curve, not a square wave.

One of the first decisions to be made when writing the 1939 standard was whether a peak or an average-responding type of meter should be developed. Average-responding meters typically were found in broadcasting networks and general telephone use in that era in the United States, while peak-responding meters were used for transmitter monitoring, which required observance of specific peak limits.

Peak-responding meters generally were used in Europe, and this led to the standardization of peak program meters there. The U.S. standard writers found no significant advantage in using PPMs to monitor levels for the amplifiers then in use.

Extensive research in recent decades has in fact shown that when either a VU meter or a peak program meter is used, a maximum of about 15 dB of peaks occur that are not indicated on either type of meter. Because the 1939 engineers found no operational advantage to peak meters, and because average-responding meters could be built as passive devices, while peak meters required some bulky electronics to accompany them, the average-responding type of meter was standardized.

The confusion caused by the lack of a standard audio level indicator led the Columbia Broadcasting System, the National Broadcasting Company and Bell Telephone Laboratories to develop a new audio metering standard in 1939.

The standard volume indicator or VU meter was developed and implemented as a passive metering device with full-wave rectification, designed to bridge a 600 ohm audio line. When this is done, it has specific ballistic characteristics.

A real SVI is somewhat expensive, and many meters have shown up over the years that look like VU meters, but do not come close to exhibiting the proper ballistic characteristics. When VU meters are realized electronically, their driving electronics must mimic the VU meter's mechanical ballistics.

The VU meter has a response time (the time required for the indicator to rise to 99 percent of its steady-state deflection after the application of a reference-level tone) and a fallback time (the time required for the indicator to drop after removal of a reference-level tone) of 300 milliseconds. The indicator responds so that syllables or words may be discerned in its movements. Any peaks of briefer duration than the response time will not be fully indicated, so several dB of fast, transient peaks will be missed by this meter.

PPM BALLISTICS

There are several PPM ballistics, but the EBU PPM standard, developed for program interchange metering, is the one most frequently encountered, and its ballistics are also standardized in the most recent U.S. ANSI/IEEE program audio level metering standard.

Its ballistic characteristics are specified somewhat differently from those of the VU meter. It has a delay time (the interval between the application of a sine wave 9 dB above test level and the time when the indicator reaches the point 8 dB above test indication) of less than 150 milliseconds, and a return time of 2.8 seconds for the indicator to drop 24 dB after removal of a tone.

It has an integration time (the duration of a 5 kHz burst of tone that would cause a steady state indication 9 dB above test indication, that produces an indication 7 dB above test indication) of 10 milliseconds.

It rises more quickly and falls back much more slowly than the VU meter, giving it a "jumpier" response to peaks, while the indicator tends to float at a higher overall level in the presence of audio program material. Its 10 millisecond integration time fully registers peaks of much shorter duration than does the VU meter. The integration time is not zero, however, so it is not a true peak meter.

The three meters have distinct applications; VU and PPM meters are best used to monitor audio mixing levels in broadcasting and recording applications, while digital audio meters are designed to be used to avoid digital clipping. Now, we need a digital audio meter that will indicate true peaks, rather than sample peaks. ■

by Michael LeClair

Tricky FM Directional Array Challenges Engineers

Use Project Management Tools to Achieve Success in Complex Technical Projects

Michael LeClair is technical editor for Radio World Engineering Extra.

The replacement of an FM antenna is an interesting case of technical project management. For most FM stations there is only one antenna, and if it is unavailable the station must go off the air. Even those stations with auxiliary antenna systems are often confined to complex changeover procedures, reduced power or older transmission sites with equipment two to three generations older than their main site.

While radio engineers oversee the project, the physical work of antenna replacement is a mechanical task that is accomplished by craftsmen who are concerned mostly with putting the pieces together correctly. Antenna work generally is done at high elevations that are inaccessible to any but the most physically fit, ruling out the opportunity for most radio engineers to make direct visual inspections of the installation site. For this kind of project, radio engineers can develop the design but they must act as managers of a team of contractors in order to get the final installation done.

Since the 1980s, limitations on exposure to radio frequency radiation have added additional complexity to tower work. Before the first line is rigged or the first person has climbed it is necessary to plan out how this can be done without causing potentially dangerous and illegal conditions for the tower workers.

Added to these RFR restrictions is the reality that more and more tower sites are shared amongst a number of stations. Zoning regulations that limit new tower construction have gained force since the 1970s to the point where new tower construction for broadcast facilities is a rare event. This has forced most project managers to consider locating their new or upgraded transmission facilities on existing towers rather than risk an open-ended tower construction process, which has no guarantee of success. Consolidation of tower ownership also has encouraged collocation of stations at the premium sites.

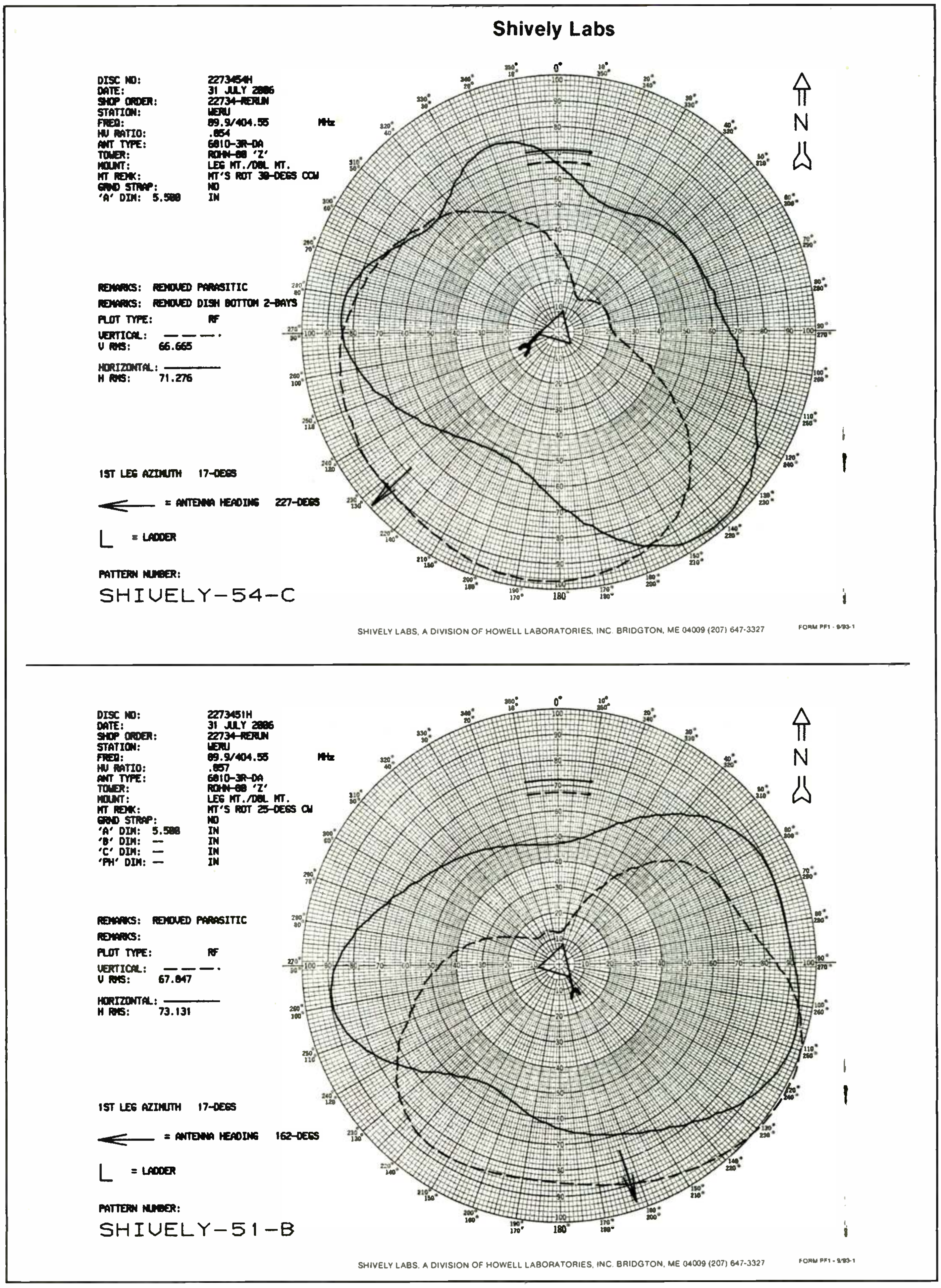
The result of these restrictions is that at a given tower the RFR conditions can require extensive study and the voluntary reduction of power by multiple users in order to allow a project to proceed. Although the radio engineering community might be cooperative with one another this is no guarantee their management will acquiesce to reduced-power operation, particularly if you are planning work during a measured ratings period. This can make the process of antenna replacement far more complicated because of the presence of "stakeholders," whose concerns must be met but who do not stand to benefit from the completion of your project.

These limitations make antenna replacement a task that must be accomplished in the shortest possible time on the tower. It is essential to plan each step in advance to achieve the best possible efficiency. Antenna projects should all be undertaken with a detailed project plan and a realistic schedule or timeline.

I recently completed the upgrade of an FM station that included the replacement of a directional FM antenna. The upgrade allowed an increase of almost 100 percent in effective radiated power and a loosening of the pattern envelope, which would substantially increase this station's coverage area. The 1996 rule changes that loosened the protection ratios for non-commercial FM stations were the basis for allowing these improvements. The project involved replacement of a 20-year-old FM directional antenna with a new one that used a different pattern.

Whenever a directional FM antenna is replaced it triggers an extra level of regulatory complexity in addition to the considerations of coordinating tower work and maintaining an on-air signal. Directional FM antennas are required by design to "prove" they operate within their pattern limitations before they can be placed on the

SEE REPLACEMENT, PAGE 26



For a side-mounted antenna the mounting angle can have a profound effect on the pattern of radiation. These two plots show the difference when an identical antenna was measured at a mounting angle of 162 degrees and then rotated to 227 degrees azimuth. Note also the differences between the vertical and horizontal polarizations.

Millenium RS-18D Console

CT-2002 Large Wall Clock

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Replacement

CONTINUED FROM PAGE 24

air. This additional requirement adds a number of steps to the process.

PLAN EARLY

The first step in designing a new or modified directional FM is done on the testing range by your antenna company. Taking the pattern limits provided by your engineering consultant, the antenna company must develop a model for the exact antenna mounting conditions on your tower. The complete model is then certified on the range to provide a pattern that does not exceed the limitations specified by the construction permit from the FCC. FM directional arrays must complete this certification in order to be licensed by the commission.

But before any of this can be done it is essential to get an accurate picture of the conditions at the precise location where the new antenna will be mounted. Any conductive metal that is within about 10 feet of the radiating elements must be considered because it can affect the final pattern developed by the antenna. This means obtaining the original tower construction drawings and the location of any other antennas or equipment on the tower.

If the tower has been around for a long time and documentation is inaccurate, this can mean a physical climb to verify what is actually on the tower where the new antenna is supposed to mount. In our case we were lucky that a mechanical engineering company had recently surveyed the tower as part of an upgrade to strengthen the tower for more antennas. The new tower drawings provided us with the information we needed to plan out the antenna location and the mechanical structure of the tower for modeling.

There are two ways that range testing can be done. The antenna company essentially can build a chunk of your actual tower using the same or functionally identical tower pieces, mount your new antenna on this tower chunk and then take carefully calibrated measurements. As long as all the details are correct, such as size of the tower leg, number of braces, presence of other station transmission lines or conductive elements that could affect the pattern and mounting angle, the antenna can be certified to produce a pattern that in its final installation should correspond closely to the range measurements.

The alternative way is the use of scale models to do essentially the same thing. One advantage of using scale models — with an appropriately scaled frequency of operation — is that a number of mounting options can be tested fairly quickly due to the smaller and more manageable size of the antenna and tower elements involved. In our case we chose to work with Shively Labs in Maine, which uses the scale model approach.

Note that it is generally impossible to design an antenna that will completely "fill-in" signal to the exact limit on your construction permit. Particularly when there are multiple limits to protect a number of other stations, the physics involved can only be coaxed to produce variations that are similar to the petals on a flower; the patterns will look like the combination of either broad or narrow lobes of signal.

Limits are met by putting signal cancellation nulls in the direction of the protected station. These nulls can end up reducing signal below the FCC limit in certain directions as a condition to meet the limit in others. Both the vertical and horizontal components of the radiated signal must be considered when limits are considered and these can be quite different from one another.

As in most areas of engineering, the design of the directional antenna involves a trade-off — you must make decisions on where you want to put undesired nulls while still serving the greatest potential population, or a specific population area of critical importance that you have identified. If you have the software, or the budget to pay someone, you can look at estimated population within the service contours to help out with this decision-making process.

There is no guarantee management will acquiesce to reduced-power operation, particularly if work is planned during a measured ratings period.

In most cases it is possible to make educated guesses based on local knowledge of the region. For example, it is usually more desirable to throw your nulls over the lake rather than the city beside it.

On our directional antenna project, we looked at a wide number of possibilities for our new antenna, considering various mounting locations and angles. Shively was patient with us as we came to the realization, after investigating a number of possibilities, that there was only one possible location on our tower that would work well for side-mounting a directional antenna. But without the range tests it would not have been easy to know this from just looking at the tower.

This type of design work takes time and it pays to begin early. We looked at close to a dozen patterns before discovering one that really stood out as the best.

PLAN YOUR TASKS TO BUILD A SCHEDULE

With the antenna selected and order placed, the next step to consider was the actual installation. The goal was to accomplish the replacement of the existing directional antenna in less than one reasonable day's work. This meant we would need the services of our tower crew for at least one full day, and prepared to go a bit long if necessary.

The antenna included a fine match transformer, so we also needed to leave time for a field engineer from Shively to assist in the adjustment of antenna tuning to compensate for whatever variations in tuning might happen in the actual antenna mounting.

Beyond the need to have your directional antenna pattern certified by the manufacturer, the FCC requires you to certify that the antenna is mounted exactly as specified in the design. The station engineer, or consultant, must provide a statement that the mounting conditions of the antenna manufacturer have been met. Happily, this statement can be written in advance, and copies made, so it is only necessary to add the signature on the day of the actual installation.

However, the FCC also requires that a professional surveyor sign off that the antenna is mounted in the proper direction. This means that you need to add another person to your list for installation day: a surveyor who has been briefed on the project requirements and has come up with a satisfactory method to certify the final mounting azimuth of the antenna. This may not be a trivial task if the new antenna is being mounted at a significant height. Few surveyors are willing or qualified to climb towers.

Additionally, before you can begin operation on the new antenna the FCC requires that you file all the necessary paperwork for your new license (Form 302). This meant making sure our Communications Counsel was standing by on the day of the installation and ready to file electronically for us.

The FCC allows stations to begin using their new FM directional arrays at half power if the Form 302 is filed and the necessary certifications are provided. This meant we could be on the new antenna that evening if we did everything right.

ASSEMBLE WITH CARE

To summarize, here are the final members of the team assembled to handle the final installation:

Tower Company: provided a crew of three plus a foreman to handle the removal of the old antenna and installation of the new one. One of the tower riggers was selected to help with the adjustment of the fine match transformer once the new antenna was mounted.

Field Engineer: measured the performance of the antenna from the ground with a network analyzer and worked with the tower riggers to make sure fine matching transformer was adjusted correctly.

Surveyor: ensured that antenna was pointed in the correct direction according to the terms of the construction permit, and certified this at the end of the installation work day.

Lawyer: electronically filed 302 at the completion of antenna work so we could start using the antenna immediately.

Project Manager: coordinated the efforts of the team and made sure the project was completed with acceptable quality and according to plan. Don't forget this part — he/she will need to be on-hand for the critical day and not at a remote broadcast.

For a project of this kind, you have to build a team using a group of experts who may not know each other at all. They are brought together for the purposes of completing this project, and then move on to other clients.

You should take extra care in working with this type of group because they are only assembled on a temporary basis and your project depends on everyone working together smoothly. If even one of your team drops the ball the entire project could fail or become stuck in costly delays. The team has to trust one another to stay on schedule. The

SEE REPLACEMENT, PAGE 28

READER'S FORUM

Guy Wire and AM Improvement

I have read with interest your story on help for AM radio, i.e. translators (Guy Wire, "Let's Have AM Improvement With Clout," Oct. 18).

I have written the commission on several occasions with my recommendations. I have suggested that a good start would be for many of the AMs that have to reduce power from 1 kW to (in our case) 67 watts or less be allowed to maintain 1 kW unlimited. I had a station at 1340 kHz and ultimately was allowed unlimited but had to agree to accept interference. I also suggested the translators and the possibility of 30 watts at less than 100 feet. This would provide a great service to our community.

You are absolutely correct as to where the listeners go in severe weather: AM radio. This little station is fighting for survival in the midst of Clear Channel, Citadel and Emmis dominance. Agencies will not buy any station not in the top 10 of a market. We can't cover the entire market so ratings are nonexistent. High school sports are big business for us but a high school football game after sunset is a killer. Local businesses won't buy because the station can't be heard; replay is unacceptable. I'm sure you have heard all of this before.

I was told that, once all of us little guys are gone, the commission will be much happier; don't know if that is true or not but I do know we don't get near the preferential treatment the big guys get. The commission has all of the tools available to allow for a *simple* application process. Use the commission search engine for a frequency search, advise the commission of the intent, location, equipment, send $750 and sign an agreement that the LPFM/translator is 100 percent simulcast and can *never* be sold leaving the AM to standalone again; simply stated no AM, no FM, no sense in reliving the 80-90 debacle.

I even suggested a novel idea to a commissioner. How about coming down and sitting with me in front of the station on our "main street" and let's just talk about what a little station in a little town means to the people? I haven't received a reply on that one.

I even suggested that the field agents make appointments with us little guys to stop in and ask what can be done to help us. The commission used to do that quite often 30 years ago; I had one field agent help me adjust a modulation problem.

I asked the commissioner if he could explain the need for digital radio. The farmers and working people around here say they'd just quit listening to radio as opposed to spending a couple of hundred of dollars for a radio in a combine, tractor, work truck, etc. Just more worthless junk to buy because the big guys and the manufacturers have a love affair going.

Anyway, great story. Hope the commission reads it.

Harry Hoyler
KKAY(AM)
Donaldsonville, La.

More Guy Wire letters pages 34-35

AP Opens Calibration Lab

Audio Precision opened its accredited calibration laboratory, located at its factory in Beaverton, Ore.

The company says the lab meets ISO's "general requirements for the competence oftestingand calibrationlaboratories" as defined in ISO/IEC 17025:2005. The accrediting agency is the American Association of Laboratory Accreditation (A2LA).

Steve Reeck, manufacturing engineer for Audio Precision, calibrates an AP2712 audio analyzer.

AP says its accredited status means audio engineers and manufacturers can use AP instruments as part of an ISO-defined quality system within their own companies, and added that this is a key requirement for many AP customers who are subject to a traceability requirement by their customers.

Supported models of AP audio analyzers ordered after Jan. 8 — which include the 2700 Series, ATS-2 and Apx585 audio analyzers — will be calibrated before shipping. Supported instruments in the field can be sent to the factory for calibration. Instruments sent in for warranty service within one year of purchase will be calibrated as party of the warranty service.

Calibrations are performed using a dedicated test system designed by AP, and are overseen by AP technicians familiar with AP instruments. If the instrument does not meet specification, it can be repaired or adjusted on-site.

For more information, contact Audio Precision in Oregon at (503) 627-0832 or visit http://audioprecision.com.

MR-PRO Plays Back WAV-Based Test Signals

NTI has debuted its Minirator MR-PRO portable signal generator, which provides sweeps and fast chirps in addition to test signals, and offers playback of WAV-based test signals. The company says it offers minimal residual distortion of greater than –96 dB, a maximum output level of +18 dB paired with continuous monitoring of the impedance, signal balance and phantom power.

Signal functions and parameters include sine, pink noise and white noise, logarithmic stepped sweeps, gliding chirp signals, polarity test signal and delay test signal for use in conjunction with NTI's AL1 Acoustilyzer.

Test signals may be stored as WAV files in the internal memory and looped. Data exchange is simplified via the USB port, which the company says enables the MR-PRO to generate complex test patterns such as the NTI STI-PA signal, or simply act as a line identifier in a broadcast chain.

MR-PRO continuously monitors the impedance of the connected load, the line signal balance and phantom power. An integrated cable testing function promotes the MR-PRO to the level of a cable analyzer, easing troubleshooting tasks.

Additional features of the MR-PRO include a shock protector, scratch-resistant display and multi-function rotary wheel.

NTI also is offering the Minirator MR2 audio generator, which replaces the MR1. It has a range of analog test signals for calibration, maintenance and repair of professional audio equipment.

For more information, contact NTI Americas in Oregon at (503) 684-7050 or visit www.nti-audio.com.

Replacement

CONTINUED FROM PAGE 26

team must also be comfortable working with you as a client, and trust you to stay on track with your plans.

Communicate with everyone thoroughly and frequently. Even a minor change in the project should be communicated to all team members in case it has an impact in another area of the project.

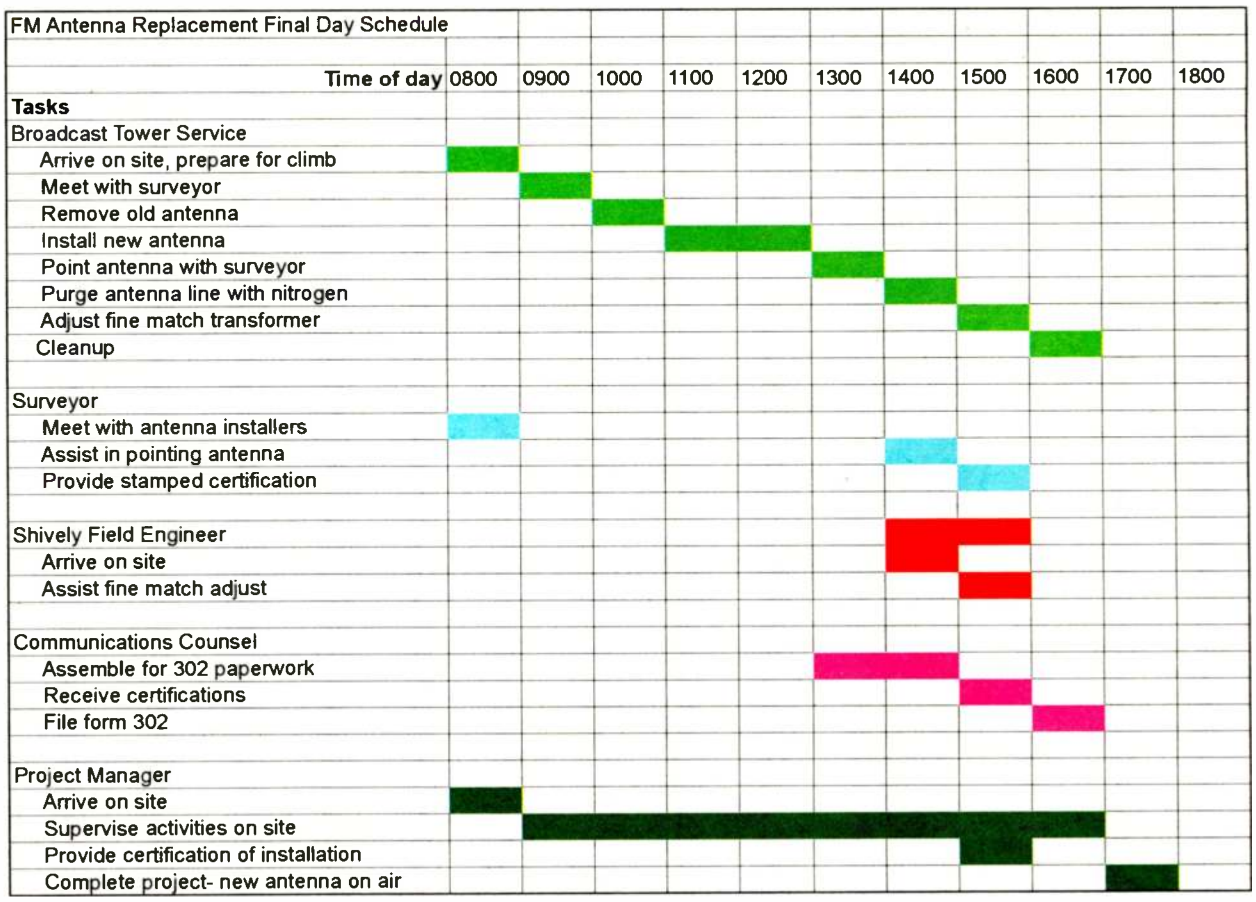
Ideally, the best way to do this is to bring together all the members of your team so they can meet everyone and get an idea of whom they are working with. Unfortunately because this can be costly, it isn't always possible for all projects. In this case I decided we would use e-mail to communicate and that I would send out updates weekly, toward the end even daily, to every team member so they would be ready for the big day.

In addition, I provided a schedule to each team member showing how the installation day would proceed. The schedule showed how each contractor fit into the project and when their services would be required so they would not have to tie up a valuable day waiting on site if they could not begin work until some other critical task was completed first. This allowed the contractors to time their portion of the project, make themselves available only at the time required and then move on once their portion was complete.

In the language of project management this is known as a Gantt chart and it combines a list of *tasks* and the *resources* required to complete those tasks with a *timeline* defining the order in which they must be completed.

There are expensive and complex computer software packages that allow the creation of Gantt charts in detail. These are great tools for planning large and complex projects. But in many cases a spreadsheet program like Microsoft Excel is adequate.

No surprises came up because we had looked at the project details in advance, down to the last mounting bolt and adapter cable.



A Gantt Chart for the Antenna Project in Excel

For the installation day I built a spreadsheet using the columns to represent individual hours of the day and rows to represent tasks that needed completion. You can change the cell colors to help keep tasks straight. The team members working on each task can be written in the cell.

Spreadsheets are fairly easy to read and can be less intimidating for those not familiar with project management. If your timeline is so complicated that your team members can't read it, you are causing more harm than good. Keep things easy to read, task assignments clear and completion times straightforward.

BUT WAIT, THERE'S MORE

With the contractor team assembled and a schedule set, I was able to set a date for the work based on Shively's delivery date. This was an outdoor project so I set aside two days for the project: one scheduled and the second as a contingency for poor weather. Everyone was asked a few weeks in advance to keep both these days available with the understanding that once we got closer to the project date the final call would be made based on the immediate weather forecasts.

However, there was one more wrinkle to be considered in this project. There were other *stakeholders* who needed to be persuaded to help us complete this project. Stakeholders are anyone who will be affected by the project or whose cooperation is required to complete it.

In our case, the other tenants on the tower were essential stakeholders because some of them needed to reduce power to allow us to work on the tower. And I was pushing for everything to be done during daylight. In order for my tower crew to reach the area where our new antenna was to be mounted, we needed to climb past both an FM and a digital TV antenna operating at high power. Luckily the tower was equipped with an elevator to keep this transit time short and provide a certain amount of RF shielding.

The situation again called for proper communication, but in this case we needed to make sure we had the right information to pass along. Each of these stations needed to know exactly how our project would affect their operations, whether a reduction in power was necessary and for how long. To satisfy these questions, we had our tower riggers do a quick survey of the RF levels two weeks in advance of the project, using a Narda meter borrowed for a day from the tower owner.

This advance survey showed that RF exposure could be kept within legal limits for controlled exposure by a reduction of power to half during the time that the elevator went past the individual antennas. In total a given station would need to reduce power for at most two minutes to satisfy this requirement, once on the way up and once more on the way down.

Because this was a very limited need to step back in power, the affected stations agreed to let us do the work during the day. It didn't hurt that we had been cooperative and moved to our auxiliary site in the past when these other stations needed access to do tower work.

Another benefit of this advance climb was that the riggers could make precise measurements of the transmission line lengths involved. The antenna must be mounted in precisely the location that was used during the range measurements, so a custom length piece of rigid transmission line was needed. Instead of having to do a field cut, we were able to order this custom line section from Dielectric and have it on site by the day of the antenna installation.

SMALL DETAILS MATTER

Project planning sometimes resembles an exercise in controlled paranoia, as you have to consider the possible ramifications of something going wrong even if it is unlikely. Because we were operating on our auxiliary for an extended time period, I had to consider what we would do if that site chose that moment to fail. Once the old antenna was removed from the tower it would be impossible to use our main site for at least a few hours while the new antenna was lifted into place and mounted.

I moved a spare exciter up to the auxiliary site with the necessary adapter to allow it to be patched into the auxiliary antenna in an emergency. Although this would only provide about 200 watts of effective radiated power, our downtown location would ensure that this would still provide signal to about half our audience.

I also brought a small portable generator to the auxiliary site rooftop on the off chance that we could experience a power outage, since this site does not have backup power.

I would be at the main transmitter site working on the antenna replacement all day, so I spent an hour with my assistant chief engineer making sure we both knew how to get this backup on-line as part of our last-minute preparations a few days before the Big Event. This kind of practice is necessary to prevent fumbling with unfamiliar equipment in an emergency situation.

THE BIG EVENT

I made the final schedule announcement the day before the installation work began. The tower company was on site a couple days before to uncrate the new antenna, verify that necessary parts were on hand and do any last-minute assembly. The weather smiled on us and we were able to use the first of our planned workdays in clear, calm and sunny weather.

The day was a busy one, with the tower riggers arriving early to get ready before the 9 a.m. start of the climb. The surveyor arrived before they started to have a quick meeting about how we would point the antenna to meet the terms of our construction permit. The old antenna emitted its last radio waves somewhere around 9:30 a.m. as we moved to our auxiliary site antenna until the new antenna was ready.

As the day progressed we met our target deadlines in good order. The new antenna went into place before noon, giving us an hour or so to purge the transmission line and antenna with pure nitrogen so that we knew everything was dry inside. When the field engineer from Shively arrived we were ready for a sweep of the transmission line and antenna. The field engineer worked with the tower rigger to adjust the antenna fine match transformer using his network analyzer fed into the transmission system on the ground at our Dielectric RF switch.

Meanwhile, the surveyor provided me with his stamped certification around 2 p.m., which I immediately faxed to our communications counsel along with my own signed certification. Our lawyer had the application for license filed by 3 p.m. and we were ready to go on the new antenna at half power.

The extensive preparation that went into this project paid off on the critical day. Everyone knew where they were supposed to be, when to arrive and what they needed to accomplish in advance. No surprises came up because we had looked at the project details in advance, down to the last mounting bolt and adapter cable.

We also were fortunate that weather was ideal for outdoor work and our auxiliary site held up just fine for the duration, although we had planned for these contingencies as well.

Critical projects like antenna replacement demonstrate the power of project management tools to achieve success. This type of engineering project requires detailed and careful planning. But the effort is worth it and allows the station engineer to demonstrate the value of good engineering to the overall success of the station.

In our case the benefits were an increase in power and potential audience, the foundations of a successful station. ■

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by Wes Keene

Get Ready for HD Data

Best to Prepare for New Capabilities of Digital Radio; Widespread Access to Data Delivery Tools Imminent

Wes Keene is manager of systems design engineering for Prophet Systems.

HD Radio clearly is in the process of changing how we work. If your station isn't transmitting its main carrier in HD yet, it's probably a just matter of time before you will. For most of you, getting HD1 up and running was just the first step, and many of you have even passed the hurdle of adding an HD2 channel to your station.

We deservedly give HD Radio a lot of attention because of its ability to deliver more programming choices that add to our mix of free-to-air broadcast content, and help us to better serve America's diverse musical tastes and growing ethnic population.

However, one important aspect of Ibiquity's system often gets lost when we talk about the mechanics of putting a new HD2 channel on the air: It's often forgotten that we're dealing with a full-fledged *data* pipe delivered right to *every* radio in our coverage area that tunes a station in.

We're dealing with a full-fledged *data* pipe delivered right to *every* radio in our coverage area that tunes a station in.

For many of us, this concept isn't very far from home when dealing with other devices. My BlackBerry is far more than a phone. When I'm using its phone capabilities, I am well aware of the fact that it can receive an e-mail at the same time I'm on that call; I could receive an IM from someone; and I might even choose to browse a web site, all without leaving my phone call — though some would question my sanity for doing all of that at the same time.

Today's radio consumer is accustomed to thinking of the radio as a "single-function device." Of course they would think that because many in our audience grew up with a Sony Walkman, or similar type of device. You turn it on, pick the programming you want to listen to and then turn it off when you're finished.

I believe we need to challenge that way of thinking as it pertains to the modern radio device. We need to move ourselves, and then our listeners, well beyond the technical perceptions of the Walkman, and move them into a technical perception more closely associated with PDAs, modern wireless phones and even iPods.

The FM HD Radio you have today is capable of receiving data at 120 kbps in hybrid mode. In the future that limit is raised to 286 kbps when a station leaves hybrid mode and becomes fully digital. That probably doesn't sound like tons of capacity, but in the context of a satellite radio channel, cell phone or other portable devices, it isn't shabby at all.

A couple of notes: Although in the all-digital future the data capacity will be much greater, the FCC does not currently authorize this type of operation. The current generation of receivers is limited to a bandwidth no greater than that afforded by the hybrid mode. This is due to a receiver limitation mostly and will, of course, be fixed in the future.

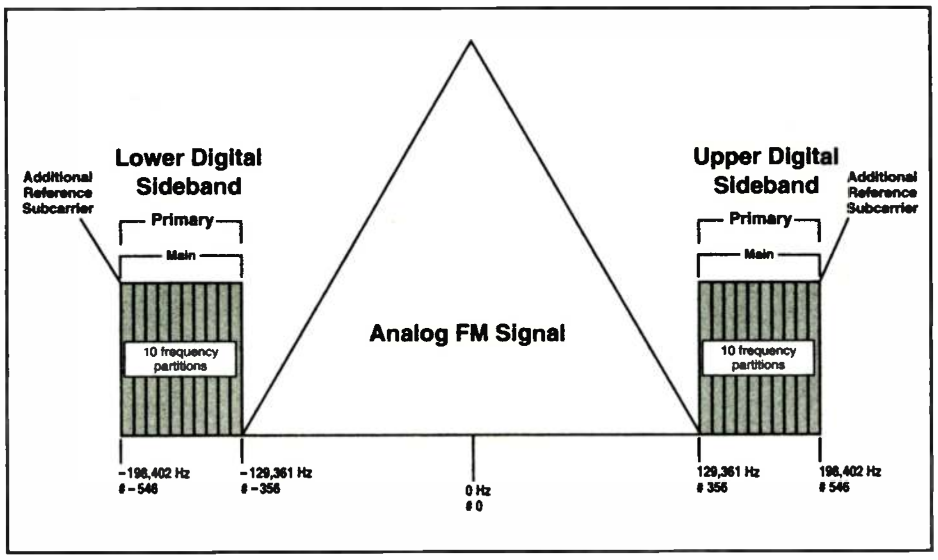


Fig. 1: HD Radio Spectrum

The second note relates to that asterisk next to 120 kbps. Many of you may be more familiar with 96 kbps. The difference comes down to modes. Most Importers I've seen operate in a mode that opens up the P1 channel, but not the P3 channel for digital use. This P3 channel is physically located closer to the center carrier frequency than P1, and allows us another 24 kbps of data … today!

Now, before you run off and adjust your Importer to glean another 24 kbps for your audio, let's discuss a couple "gotchas:"

The 24 kbps provided by the P3 channel can *only* be used for a separate audio channel. You cannot add that 24 kbps to your existing audio services in order to raise their bit rates. You also cannot create a new 32 kbps audio channel, for instance, and use 8 kbps from your P1 channel.

Stations wishing to use this "extended hybrid" mode currently must also request a Special Temporary Authorization from the FCC.

In summary there can be no crossover whatsoever between services using your P1 channel and your P3 channel. However, if you had a new speech-only application, for instance, P3 might be a good choice, and it wouldn't cost you anything from your existing audio services to launch it.

LOT HAPPENING NOW

A decent-looking picture can be created that takes less than 20 kB of space. Such an image would look perfectly acceptable on a small radio display. If a station allocated just 10 kilobits for the data service, that picture could be delivered in about *16 seconds*.

Clearly, 10 kbps isn't a very high data rate, and pictures can be made smaller than 20 kB and look acceptable at small screen sizes, so this is a bit of a worst-case example. It serves as a starting point though, and you can certainly choose a more generous allocation for data if you anticipate doing this frequently.

From a technical perspective, audio streams and data files are different mostly in that a file reaches an end at some point in its delivery, whereas a stream does not. For these two purposes, Ibiquity developed optimized mechanisms for delivery. Streams use something called RLS or Radio Linking System.

Files use a technology called LOT, or Large Object Transfer. All data being sent today, including traffic data over HD, is sent using RLS. That's because LOT support is not yet complete. The integrated circuits inside the radio know what it is, but no receivers have been designed to cope with LOT yet. This is one of the hurdles we will have to overcome before generic transfer of storable files will be possible.

Once LOT is implemented fully in the receiver and the Importer core, transmission of nearly any file to a receiver will be a simple task. We can expect to see our first glimpse of LOT in Importer 2.1.

These "non-audio" services, along with streams of audio from HD2, HD3 and so on, go a long way toward creating that perception of a multifunction data device that happens to deliver my favorite audio programming.

Being able to deliver a LOT object is just one half of the solution, though. Once I can deliver a storable object to the receiver, it needs to be able to actually do something with it.

The Ibiquity system provides developers with a flexible way of transmitting data though the HD Radio "pipe." Several data types are intrinsic to the Ibiquity system; these are mostly image and video types. An unlimited number of new types can be added for receivers designed specifically to receive them, through a special "generic" data type.

What does it mean for a data type to be "intrinsic" to the Ibiquity system? And what's the difference between data types Ibiquity recognizes and ones it doesn't? Basically, a data type's existence in Ibiquity's software development kit provides licensees of HD Radio equipment a strong hint that these types may be transmitted from an HD Radio station either now, or in the future.

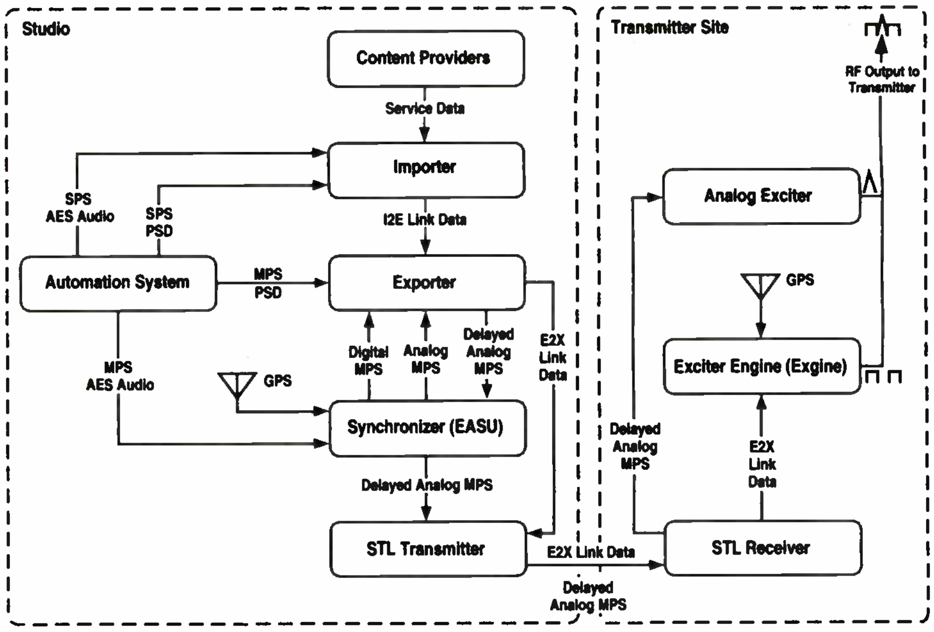


Fig. 2: Block diagram of HD Radio system with Importer and Exporter at the studio. Data services are fed to the Importer.

Do manufacturers *have* to implement those types? Of course not, but these are common sense data types to transmit to a user, so it's conceivable there may be demand for those types in the future. The presence of certain types in the Ibiquity SDKs also clearly tells application vendors that those types should probably be given consideration, and that those types may be supported by radios in the future. As with most new technologies, the service needs to exist before the receiver or client will.

The first step for Importer manufacturers is to look at the Ibiquity-sanctioned data types, and implement basic support for moving that data across the system. This is a relatively simple operation, espe-

SEE GET READY, PAGE 37

Guy's Predictions for 2007

Among Them, Adoption of HD Standards, First HD Portable Sets, Possible Satellite Merger

As I write this in January, it seems obligatory to reflect on 2006 and extrapolate industry trends while peering ahead to make predictions for the coming year. Our industry has been grappling with critical issues that will influence what we'll be doing as broadcast professionals in the near future.

Let's take a closer look. What does your intrepid masked soldering soldier of radio see happening as the year unfolds?

ADOPTION OF HD TRANSMISSION STANDARDS

Sometime during the year, probably after the commission deals with media ownership limits and other less controversial issues, we should finally see the long-awaited Ibiquity HD transmission standards written into the rules.

The FM HD service will continue to grow and add HD2 channels at an impressive pace. While most HD2 stations will be fully automated offerings, unique live programming will appear on a few trailblazing, standalone HD2 pioneers like WHUR-HD2 in Washington.

Proactive radio companies will be enlisting help from partners like Microsoft and Cisco, looking to harness all they can from HD. Witness Clear Channel's recent partnership with Microsoft to develop new HD text and data opportunities.

The nighttime prohibition of AM HD operations will be lifted, with the caveat that interference complaints be appropriately handled. I don't see a rapid increase in the number of new AM HD operations during the year as existing HD stations go full-time and deal with the first wave of complaints. The majority will come from listeners outside protected contours and DXers, in addition to station licensees and their operatives.

The industry will be watching closely but the aftermath will reveal a more muted response to interference than many had been expecting — a bit of a wake-up call that AM radio listening at night is not a topic of concern for most listeners. Those who remain are simply too used to interference, and tolerate it.

The sad reality is that many stations will lose much of the bonus fringe area coverage they've enjoyed during the analog era as HD adoption accelerates. The commission will only grant relief to qualifying "real" interference so the AM service will mostly lose whatever is left of previously established expanded coverage.

Digital Radio Mondiale could provide some mitigation to the shortcomings of the AM HD design but Ibiquity will not be moved to change its standard without sufficient pressure from the industry to consider an improved AM digital solution.

I'm not hopeful improvements to AM HD will happen in 2007 or the foreseeable future. Full-time AM HD will roll out slowly amid mixed complaints about interference primarily because the owners of most of the significant AM properties have resigned themselves to accept the new interference in exchange for the opportunity to go digital with hi-fi stereo.

AM stations gradually will shift resources to developing their Internet presence as much or more than deployment of HD, if they choose to add it. Many will place their AM programming on a sister FM HD2 channel as added insurance.

AM IMPROVEMENT, ANYONE?

We can only hope the commission will move quickly this year to approve the NAB's proposal to allow FM translators on AM. This will allow many stations crippled with interference problems and marginal nighttime coverage their first real opportunity to provide better service. Daytimers will finally gain at least some measure of full-time status.

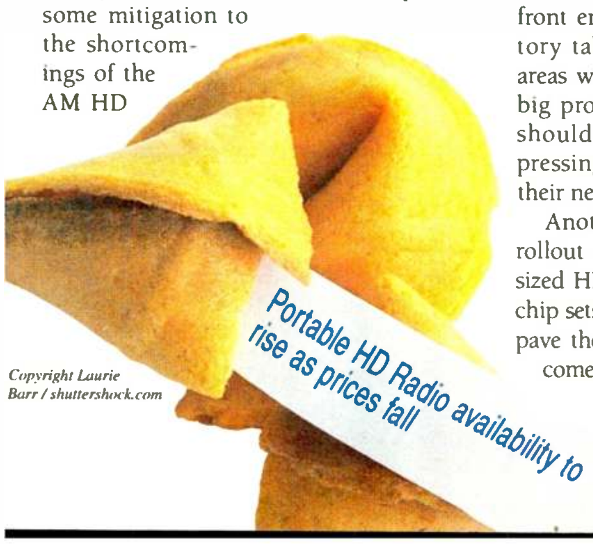
Unfortunately I do not see any sign the NAB is interested in providing leadership to advance any proposals to help clean up the AM band. Fewer stations and less interference would obviously give AM HD a much better chance of succeeding. It would seem that both the NAB and the commission are content to sit on the sidelines and let market forces dictate the survival and future makeup of the AM band.

Natural attrition of weaker stations is not going to make this happen until it's much too late for AM. It's a missed opportunity. Are you listening, David Rehr? I challenge you to prove me wrong.

MORE AND BETTER RECEIVERS

The two early shortcomings of most HD Radios have been high prices and their deaf front ends. Making many of the introductory tabletop models play well in many areas without external antennas has been a big problem. The receiver manufacturers should be working hard to address the pressing need for better RF sensitivity in their new offerings.

Another missing ingredient in the HD rollout is the lack of portable and pocket-sized HD Radios. Smaller and more efficient chip sets with lower power consumption will pave the way here. As the cost of chip sets comes down and more models are introduced, prices will continue to fall.



Look for the first battery-powered HD portable sets and the first retail priced tabletop under $100 to appear in 2007. Another breakthrough appearing this year will be the first model with store and play-on-demand, i.e. Radio TiVo. Many tout this as the real killer-app for HD.

The advent of IP Internet "radios" is for many the harbinger of what will happen to radio broadcasting. The fledgling wireless Internet companies like Clearwire will continue to expand and WiMax systems will be constructed in various markets in 2007, making this service more feasible.

Portable IP-based wireless audio players might become tomorrow's pocket radios but its going to be many years before such devices will be able to duplicate the ease of use, affordability, reliability and range of service that traditional radios provide.

AM stations gradually will shift resources to developing their Internet presence as much or more than deployment of HD, if they choose to add it.

Nonetheless, the IP radio will begin to draw attention in 2007, especially with the under-25 demo. If your station is streaming on the Web with compelling and local content, you have much less to fear from this development.

THE INTERNET IMPERATIVE

That segues nicely into the new, quickly emerging radio reality. With every passing month, it's becoming abundantly evident that radio stations need to focus more than ever on content creation and stream it via their Internet Web sites to ensure themselves a home base in tomorrow's IP world. But the on-air program streams will not be the only important offering.

Downloadable podcasts of archived shows, video clips of concerts and other special events, links to other interesting Web site content plus interactive games are becoming popular features on many of the more impressive station sites already. Radio will increasingly become contributors to the video experience of its Web-based audiences.

Many of the new-generation wireless and portable media players include video. Those who adapt quickly and learn how to create such new content well will have a big advantage.

Encoding algorithms are getting better and the price of providing streaming and Internet content is getting cheaper all the time. There is no reason even small stations should not be able to justify ramping up in 2007 with a high-quality program stream and an engaging up-to-date Web site to attract new audiences.

Some stations in areas with high broadband use may discover that especially during office hours, they may actually have more Web than radio set listeners. You may doubt that happening this year, but the trend is in that direction.

A recent J.P. Morgan Internet research study revealed that terrestrial radio stations now account for over a third of all audio streaming being consumed via the Net. Of that total, about 45 percent comes from Clear Channel stations alone. Unique visitors to the terrestrial sites are up more than 110 percent year over year, while the Internet-only sites are up about 25 percent year over year.

In the less than five years in which most terrestrial stations have decided to step up and stream over the Net, that's remarkable.

BIRDS MIGHT BE MERGING

We continue to hear and see a lot of hoopla about the satellite services merging to save either from possible extinction. Sirius boss Mel Karmazin recently dropped more hints about that as investors severely punished the stock prices of both XM and Sirius in 2006.

From a financial standpoint, it would make sense. The companies have so many things in common, especially massive debt and duplicated services. It only stands to reason millions could be saved by consolidating.

The XM folks haven't shown much interest in getting together with their archrival, but if Mel can twist the appropriate arms at the commission to change the rules so that a merger could be legalized, it just might happen. To do that, the commissioners and the Congress would have to ignore the original intent and wisdom of creating two competing services to ensure lower pricing and a better product for consumers.

It probably won't happen this year but if a

SEE PREDICTIONS, PAGE 34

Predictions

CONTINUED FROM PAGE 33

merger does happen, the commission should require that the new public ownership and control structure be required to be spread and balanced across diverse component interests. Those should include existing broadcasters, automobile companies, program content and distribution services and other key businesses that have a stake in this venture.

The rules that keep satellite a national service rather than allowing local content also need to be retained.

As wireless distribution gravitates towards the IP-based Internet model, the satellite services will be rendered less attractive, especially in populated WiMax-served areas. This will put a huge damper on the growth of satellite subscription totals. The lifespan of this technology might be much shorter than many experts were expecting, especially the Wall Street analysts, who have been big proponents of satellite.

CELL PHONES AND PLAYERS

It seems that every few days a new model cell phone is introduced with more features. Sometime this year it will probably be hard to find one that does not include a camera, a speakerphone, color display and Internet access.

BlackBerries and Treos feed the voracious e-mail habit and are used everywhere. The newest do-everything models now appearing, like the Cingular Blackjack and Apple i-Phone, include e-mail and PDA functions, media player with video, audio and flash storage. Stratos Audio expects to unveil a combo cell phone with media player, FM radio and RDS text this year.

How many more apparently desirable features can cell phone makers stuff into these small handheld devices and still make them user-friendly before we hit "overload"?

Engineers and geeks love it but combining too many functions into a small package like a cell phone increases its cost and complexity, making it harder for many to use beyond its primary function. Will the public will buy into this concept and make it an enduring success?

The marketplace will decide that for us. Especially in the arena of consumer electronics, almost any gadget that might be useful to human beings will be made and marketed, at least for a while. Remember the Kerbango? Unveiled with heavy hype in 2000, it disappeared in less than two years.

Early stats are showing that about 20 percent of cell phone sales are combo units with media players, but only 8.5 percent of their users are actually using them for OTA- and PC-transferred music downloads.

HEARING A DEATH RATTLE

Many of my colleagues are predicting the impending demise of broadcasting and radio. They say it will give way to the world of IP-based Internet connected devices, like the multi-function cell phone. Many think this is unstoppable and will happen much sooner than later. Some say that by 2010, it will be over for radio.

Predicting the future is an endeavor prone to easy failure. I won't go there, but I will predict that while IP devices will certainly be a big part of our future, it will be a long time before they completely replace broadcasting as we know it.

RESCUING EAS

Let's throw some parting light on EAS, the embattled government-mandated emergency alert system that has always had good intentions but all too often fails to deliver properly.

In spite of the best efforts of its architects, the system has stumbled under the weight of a largely dysfunctional communications structure. Its ability to provide effective and reliable early warning alerts to the public continues to disappoint in many areas.

The FCC decided to take another look at EAS last year in the context of new and developing technologies. It appears they have made a first-step decision, releasing a new report and order proposing to set aside spectrum for a nationwide broadband IP emergency communications public safety network. Located in the 700 MHz band, the network would be assigned to a single private sector licensee designated by the FCC to set up and operate it.

How this proposed system will be integrated into the existing EAS broadcast structure is yet unclear. At a minimum, the new network should be a more seamless and efficient conduit for dissemination of emergency warnings and information to be used by government agencies as well as broadcasters. It is essential that the present scheme with its incessant over-the-air testing, fragile transmission and monitoring chain structure and the vulnerability for false alarms be cleaned up and modified.

I predict we'll see a sweeping proposal to enhance and shore up EAS this year. We'll probably be stuck with the EAS "duck farts" and some form of testing for a while, but look for streamlined emergency alerting mechanisms to be implemented in analog as well as the HD transmission protocols.

Dramatically more efficient wireless IP communications and better coordination among emergency management centers, National Weather Service, Department of Homeland Security and broadcasters give the FCC a realistic chance to forge a new and improved EAS. We can only hope this is the year they will finally put the misadventures of Conelrad, EBS and the old EAS behind us and lay the groundwork for a better system. ■

We can only hope the commission will move quickly this year to approve the NAB's proposal to allow FM translators on AM. This will allow many stations their first real opportunity to provide better service.

READER'S FORUM

Guy Wire and WiMax

Guy Wire is trying to hold still in a world that is moving fast ("Radio Makes Room for WiMax," Dec. 13) His comments miss the mark altogether.

Mr. Wire argues for the longevity of conventional radio and TV in a news magazine whose lifeblood depends on things like HD Radio and the possibility of multiple audio streams through one radio carrier — the harbinger of a "multiple pipe" WiMax world. There may be less fog in Mark Krieger's crystal ball than Guy Wire realizes.

C'mon, get real. Fifteen years ago only a few executives and well-heeled people had cell phones. Today they are the bane of elementary school classrooms and the highways throughout America. Cell phones do almost everything imaginable in terms of communications: e-mail, photography, imaging and Internet browsing. How much of a leap is it to think in a year or two WiMax and similar technologies will unclog the bandwidth pipeline to bring radio and TV into the cell phone without the need for a conventional radio or TV carrier? Don't like the small cell phone screen? Bluetooth will "share" your phone video on the huge flat screen in your front room. That is about as far-fetched as a microwave oven that will warm you meal in three minutes!

WiMax is changing our world whether we like it or not. When that happens — and trust me, Mr. Guy Wire, it will — you will need a new pen name. Perhaps you could use some contemporary Instant Messaging slang word for a name, like "JK" for "Just Kidding," or "TTFN" for "Ta-Ta for Now" as you readjust your mindset to enter the new century. I'm older every year myself, and I've been working in radio for more than 40 years, but my inability to keep up with it all isn't stopping technology's advancement.

So is WiMax the demise of radio and TV? Probably not. But there will be nothing "conventional" about radio and TV in a few short years, including how its spectrum is used. The smart money is adapting to a new broadcasting paradigm. Time marches on.

Carl E. Gluck
Vice President, Technical Research
Salem Communications
Camarillo, Calif.

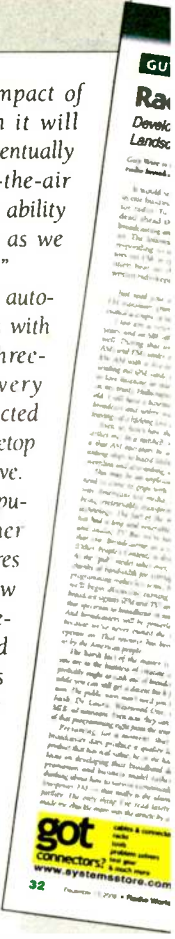
Guy Wire replies:

Carl,

Neither I nor anyone I know in this business who is successful and wants to be successful in the future is holding still. Everybody realizes technology is changing the playing field. That's been going on since radio was invented. I'll grant you that this change is probably moving at a faster clip in recent years. The industry has always adapted to change and continues to do so.

I am fully embracing the reality that the Internet is changing our industry and that WiMax will be part of our future. I'm wondering why you chose to ignore that observation in my discussion, as well as perhaps my key point about radio and WiMax: We have always been and always will be in the content creation business.

Whether that content is distributed over the air or via the Internet won't matter that much as time marches on. Radio is the major contributor to online audio streaming listening right now. Check the stats. Clear Channel and CBS combine for about 40 percent of the total. Radio is not just depending on HD and over-the-air carriers for its long-term "survival." Where you and I disagree regarding the impact of WiMax is the speed at which it will become a viable and perhaps eventually a preferred alternative to over-the-air broadcasting … particularly its ability to fully displace radio listening as we know it "in just a few short years."



Advances in technology do not automatically replace an old process with a new one. You mention the three-minute microwave oven. Every kitchen I see still being constructed has a conventional oven with stovetop burners, in addition to a microwave.

Cell phones became wildly popular because they simply untether telephone conversations from wires for the masses. Cell phones now have built-in Internet access, e-mail clients, text messaging and cameras that are add-on features which a distinct minority of their users actually use on a regular basis. If you don't believe that, check the average user stats from any cell phone carrier. Texting has become a big hit for the under-25 crowd and might be in its own category in this arena.

As you have observed, Carl, more features are being added to cell phones over the next few years. Soon we will see FM radio receivers with data and audio players with MP3 and iPod capability. Whether consumers will want and be willing to pay extra for those add-ons on a large scale is not yet known. I have a sneaking suspicion the majority of folks will want to keep using their cell phones for the primary task of making and receiving phone calls.

Many also will check e-mail or perhaps their favorite Web sites. Using it as a substitute pocket radio or iPod and running down the batteries much faster may not be all that attractive or appropriate for many.

Listening to streaming audio via the Internet on WiMax is the same cat of only a slightly different color. The advent of cell phones did not make folks stop using wired phones or render that infrastructure obsolete. WiMax and WiFi will not render wired broadband or LANs any-more less useful than portable radios made wired sets.

As WiMax rolls out in the years ahead, it will merely add more choices and flexibility to an already dizzying array of consumer entertainment resources. But I still think it's going to be a long time before WiMax delivers the same ease of use, reliability, range of service and quality of reception as over-the-air broadcasting, especially for the automobile and portable devices.

I also disagree that WiMax will force some kind of fundamental change in how the present radio and TV channel spectrum is used in "just a few short years." I predict WiMax will be granted a new band or group of bands somewhere in the UHF spectrum, while existing radio and HD TV channels will essentially stay as they are for many years. The "new broadcasting paradigm" will certainly include the successful stations already streaming, available via WiMax, but not at the expense of turning off all the over-the-air transmitters and repurposing those channels for WiMax.

Let's revisit this exchange in maybe 10 years and see who's right.

Thanks for the alternate pen name suggestions, but I think Guy Wire is just fine for now and for as long as my brain and fingers still work.

— GW

Guy, I still remember being about 13 in the early 1960s living in upstate New York and waking my mom about 3 in the morning after picking up Vin Scully signing off the Dodgers broadcast on KFI(AM), Los Angeles.

I was stoked. My mom did not share the enthusiasm. I'm sure you can relate.

Thanks for a thoughtful analysis. The sky isn't falling ... it's always been all around us!

Steve Gimbert
Toccoa Falls, Ga.

Guy, many thanks for your contributions to RW Online. I've been a big fan of radio all my life and "discovered" your Web site about 18 months ago. As my interests cover many aspects of radio, RW Online has become one of my favorite sites on the Internet.

I'm not involved in the radio industry. Though I was a radio amateur in my teens and have been a shortwave listener for over 30 years, by profession I'm a computer systems administrator. I've been working in the information technology field since 1980.

Mark Krieger's comments and sentiments regarding the future of radio broadcasting closely mirror my own. Though it may take several years, I do believe that the popularity of AM/FM broadcasting has likely reached its peak and is now beginning a gradual downturn. This is not something I am wishing for. It is simply the reality of technological changes now taking place.

My own listening habits have already been drastically affected by the presence of the Internet. With wireless broadband in my home, I've got access to literally tens of thousands of stations, all in various degrees of digital quality.

For instance, as a big fan of classical and film music, I often tune in to various stations that offer audio streaming of these genres. Some of these stations also are regular broadcasting stations: WFMR(FM) Milwaukee, WGUC(FM) Cincinnati and KUSC(FM) Los Angeles. Others are "net only" stations via Shoutcast, Live365 or from several Web sites across Europe.

National Public Radio's "All Things Considered" and "Morning Edition" are two news programs that I enjoy listening to. I used to make it a point to tune in to these broadcasts on my commutes to and from work. Occasionally I still do. But now, thanks to the Internet, I can check out these programs at any time from home and skip over any individual stories that I find not of interest.

Several shortwave broadcasters, such as Radio Netherlands, also offer their programming via audio streaming. Why should I struggle tuning in via shortwave when a far better signal is available via the Net?

You may think I have to be at my computer console to hear these stations, but that is no longer the case. I bought a small laptop that I use for "tuning in" to these stations. Most of the time I feed the laptop into my home stereo system or into a subwoofer/satellite speaker system for better sound.

My daughter bought a reconditioned Fujitsu tablet PC from eBay earlier this year for about $150. Its dimensions are roughly 9 x 12 inches and about an inch thick. It runs a full version of Windows 2000 and thus works great as a portable "net radio." Slowly yet surely, more and more products are coming out that allow one to tune in to Internet audio streams much as one tunes a station on the radio.

I live in a mountainous area about 100 miles north of Seattle. Perhaps if my AM/FM reception was better, I'd be less apt to use the Internet so much. But the fact is, for home listening, Internet radio has become my primary means of listening to "the radio." Even for local stations, I often find that the Webcast stream provides superior audio vs. the "over the air" signals I receive.

Though it may take five to 10 years or more, I can easily see the day when WiMax will be as commonplace as cell phone coverage is today. It isn't hard for me to imagine that we'll one day have car radios that can tune into Internet audio streams with the same ease as we tune into AM/FM stations today. Why will I want to tune in to my local NPR affiliate if I can get a far better signal via WiMax?

I do believe that some local broadcast radio will survive and even thrive well into the future. My local talk radio station — KGMI(AM), Bellingham, Wash. — is excellent in its coverage of local news and events.

But overall, I do not believe that AM/FM stations have a bright future. As for HD Radio, I feel it is too little, too late.

Chris Kantack
Bellingham, Wash.

Guy, are you kidding?

The stance taken in your rebuttal to engineer Mark Krieger reflects an approach consistent with what we've been hearing from radio execs: "Radio is used by the vast majority of people who think highly of it, so the boat's not sinking."

Unfortunately, it also discounts the abundant evidence of a shift towards other audio entertainment devices is well underway. Radio won't disappear, but it will lose its audience's time spent listening — a negative almost as dramatic as being replaced.

You make a few points that don't address fact:

1) "It's not too surprising to hear comments like Mark's coming out of a university environment where MP3 players, cell phones, laptops and WiFi internet are the mass media staples." You may also add, where nobody has a radio in their dorm room. Or: where tomorrow's targeted demos are developing their audio listening habits.

2) "Furthermore, students and teachers alike generally have little interest in the affairs of their surrounding communities and are narrow focused on their own pursuits." I'd like to see the research that backs this up; the psychographics of this audience makes it ripe for discovery of new things delivered by media.

3) "Content, content, content." In a word, laughable. Radio station "content" is bad. Programmers have been fired, talent has been cut back and the expense of producing quality programs is avoided. Besides a few syndicated programs, how many top-flight personalities can you name that work radio today? One, maybe two, in each market? Content is not a radio strong point.

4) "Perhaps the most underestimated aspect of broadcast radio that Mark overlooks is the burgeoning commitment to develop Web site and streaming resources to extend its reach and appeal to broadband and Internet users." Please, show me any combination of radio station Web sites that satisfy an online user's needs. The one element required for a successful site is the one radio won't pay for: consistent updates with quality information.

There are a number of station Web site links through this link: *www.audiographics.com/agd/122106-1.htm*. View them. Then send me those station URLs you feel contradict what's stated. Radio is doing a cheap imitation of "online." It won't ever pay to do it right.

I'm in agreement with you on WiMax and its potential harm. WiMax is a lifetime away from being used by the masses. But it's not simply a "shift towards other audio entertainment devices" that has caused those 30 and below to seek audio via sources other than radio. That damage was done by radio lowering the amount of quality programming, beefing up its commercial counts, dwindling the playlists, cutting its news rooms and adding voice tracking.

Your reference to the "Mercury Radio Wake-Up Call" is an urging to listen to the same style of "rah rah, we're not as bad off as they say" reports that the radio industry has dragged out many times before. All jaded recounts of a changing world.

When the industry decides to adapt to new technology, instead of forcing new technology to adapt to it, progress will be made. That didn't happen in 2006. I'm not hopeful it will occur in 2007.

Ken Dardis
President, Audio Graphics Inc.
Cleveland

Note: Guy Wire replies to the letter from Ken Dardis in the Guy Wire Mailbag online.

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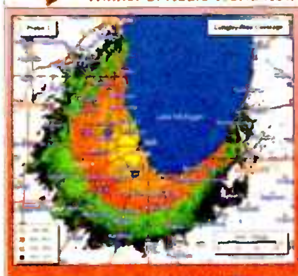

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Get Ready

CONTINUED FROM PAGE 30

cially with the new Importer 2.X SDK. It's also an easy way for the station to get their feet wet delivering images (for instance) to the receiver.

IMPORTER IS THE KEY

All the data I've mentioned so far would fall under the category of "Multimedia Support." There are other uses for the data we can pass to a receiver. For example, we can transmit something the listener doesn't consume directly like an image, but rather something that gives the radio itself additional functionality, like an Electronic Program Guide. The EPG under development will provide a guide similar to what is used on digital cable and satellite television. The data stream also will be used to provide the infrastructure for Conditional Access.

The Importer is the station's funnel for getting these advanced data types to air. In the past, Importers may have been regarded as those pesky boxes getting between your second audio source and your exporter. In the future they will become critical data aggregators for each of your call signs. All data, audio or otherwise, comes in through the Importer.

It's worth considering that not all data sent to your listeners may be originated by your station. There will more than likely be a point in the future where data clients outside your enterprise will connect to your Importer and deliver real time services. Plan your networks accordingly.

Data clients use the following protocol: Let the Importer know the data client exists, which data service it provides data for, wait for the Importer to ask it for data and respond on a socket connection with that data. Then repeat the last two steps indefinitely. This relatively simple architecture is powered by a standard Extensible Markup Language, or XML, meaning that all commands and responses are delivered as text that can be parsed on any platform.

Because XML delivers commands in plain text, any system such as Linux, Windows, Mac or even a handheld device, can deliver data and commands to the Importer.

In the future, I believe the production of data clients will expand well past the application vendors who are building Importers today. It's not too hard to picture an environment where multiple parties develop data clients for specialized uses, the way plug-ins are developed for software today. With the Ibiquity SDKs, anyone with a vision — and a competent development department — can create data clients, and (with your stations authorization) provide data directly to your audience. Is that amazing? I absolutely think it is.

In the analog age, we worked long hours before a remote, to get things ready. Tomorrow's "remote" could be a data stream, provided by a company half-way around the world, or right in your hometown. Either way, it's an IP connection, and it makes little difference who is originating it. Because it is TCP/IP, we don't even need to be concerned with it being a great connection, to boot.

I'd like to offer some closing thoughts on data and bandwidth: It's clear that your bandwidth is extremely valuable as a digital station. While the bandwidth we have is sufficient, it's not a lot. There are new uses for data allocations coming, and they'll all chip away at your bandwidth. If you want a single 10 kbps data service, and also deliver full EPG data for your market, you would be out 18 kbps right away. That's 18 kbps in an environment where we struggle with whether to give our second channel 32 kbps or 48 kbps.

Eventually, business drivers will have to influence that use of bandwidth, and in some cases audio services may not end up in the lead. That's the beauty of this system; some stations will place emphasis on audio services, while others super serve data service needs and they can both coexist in one technology.

The exact date you will have widespread access to data delivery tools is still up in the air, but their eventuality is not. If you haven't already, meet with others in your stations management team and discuss contingency plans for allocation of bandwidth in the future. What if a well-known brand name approached your station tomorrow about leasing bandwidth? You'd want a plan ready that maximized revenue for your facility while retaining as much audience as possible. ■

The Last Word

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answer was a perfect person to learn from. Also, a fragment of a social lunch turned into an article and a learning lesson.

"Tools for Analyzing Your Future" (Dec. 14, 2005) discusses how our careers depend on how new technologies change the nature of business. The Internet is important for your career in ways that are hard to predict.

"Chaos Theory and Radio's Possibilities" (Feb. 22, 2006) emphasizes the need to take advantage of the randomness of technical branches, in this case the Internet providing focused e-mail lists.

"Broadcasters Depend on Open Gates" (April 5, 2006) shows that individuals will not close their gates when they want to receive selected messages from colleagues.

"CDs Prove Secondary Features Matter" (Aug. 23, 2006) shows we must always be on the lookout for derivative properties of the Internet.

The implications of this story are still broader. Many listeners voluntarily subscribe to lists managed by radio stations, which post messages about upcoming programs and events. E-mail broadcasting and terrestrial broadcasting fuse into meta-broadcasting. WBUR is such a broadcaster that uses e-mail lists to maintain contacts with listeners, providing information on upcoming show topics as an example.

Most important, "New Audio Villages Challenge Radio" (Oct.18, 2006) emphasizes that we actually live in small virtual communities that are connected by the Internet. For Michael to have received the help of his colleagues, he had to have been an accepted member of the village of broadcast engineers, both contributing and profiting from membership. You help me today, and I will help you tomorrow. We are socially and emotionally dependent on our friends in the villages we create.

Being asked to do more and more with less and less, it is comforting to know your colleagues are out there, willing to help you today. In the "good old days" you might have met a colleague at a trade show who knew the answer to your problem, but that depended on luck. In "bad new days" the process of finding the right person can be very efficient if you know how to use these tools. But that also is a learned skill that takes time. Add e-mail lists to your toolbox. ■

MARKETPLACE

MDR-7509HDs Handle DSD, PCM Frequency Response

Sony says its MDR-7509HD headphones address the frequency response presented by DSD and High Sampling PCM recording technologies, as well as the closed-type monitoring feeds of sound professionals working with higher resolution digital audio recording and playback gear.

"The MDR-7509HD headphones feature new HD driver units capable of 80 kHz ultra-wide range reproduction," said Paul Foschino, senior manager for professional audio in Sony's Broadcast and Production Systems Division. "With their tonal balance and extended frequency range, they can take advantage of the 24 bit/96 kHz expanded bandwidth achieved by products like the PCM-D1 portable recorder." He added that the Auranomic circumaural driver units eliminate pressure on the ear during periods of extended use.

Features include 3,000 mW power capacity for high-level sound monitoring, and 360 kJ/m^3 neodymium magnets that enable driver units to reproduce clear midrange.

Sony says the MDR-7509HD headphones will be available in March for a list price of $265.

For more information, contact Sony Electronics at (800) 686-SONY (7669) or visit www.sony.com/professional.

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by Barry Blesser

Lists Have Become Educational Communities For Engineers

E-mail Lists, or 'Groups,' Enable Engineers to Connect With Each Other Online to Offer Help, Tips

Dr. Barry Blesser is director of engineering for 25-Seven Systems.

As I was driving back to my office after having lunch with our technical editor, Michael LeClair, I suddenly realized that one of his anecdotal stories happened to contain some very important ideas. Always keep your ears open, because you never know what kind of hidden gold there is to be discovered.

Michael told me about a listener who complained that his high-end radio in his high-end automobile randomly stopped receiving WBUR as he was driving through a particular suburb of Boston. Was there something wrong with the audio chain? Was there something wrong with RF propagation in this region of Boston? Was there something wrong with the listener's radio? Was the listener some kind of nut case? With so little data, it is easy to generate many hypotheses that are consistent with the problem.

To an engineer, these questions present a wonderful challenge; and engineers love to demonstrate their problem-solving skills by rising to such challenges. What was the explanation for the listener's complaint? How should a broadcast engineer find the answer? And most important, were there bigger implications to approaching the task?

But before I answer these questions, I need to digress to a completely unrelated topic: e-mail lists. To participate in such lists, individuals who share a common interest provide their e-mail addresses to some central computer that administers the list for everyone in the group. E-mail messages on a particular topic are sent to everyone on the list.

HELP FROM YOUR (UNSEEN) FRIENDS

I came across these lists while publicizing my new book "Spaces Speak." They provided an efficient way to send information about it to selected individuals. I had not realized that there are literally thousands and thousands of them floating around the Internet.

Lists vary in size from a few individuals who are interested in a narrow topic, such as how to create icons for computer interfaces, to large numbers of people interested in a broad topic, such as religion. In all likelihood, you can find a list on any topic that interests you. Michael posted information about his problem to a list targeted to broadcast engineers.

Very shortly he received the complete explanation for the problem. The listener was driving a one-year-old Lexus with an upgraded sound package installed by the dealer. WBUR had just begun broadcasting RDS in order to take advantage of the nearly universal availability of RDS in new automobile receivers.

As unlikely at it might have initially appeared, the listener's problem was directly related. This particular radio had a latent design flaw that would only manifest itself when receiving an RDS-enabled broadcast.

The problem was known to a small group of broadcast engineers who were more than happy to share their knowledge with their colleagues. A problem that could have been intractable took only an hour to solve. More likely, with so little data and the inability to reproduce the failure, an engineer may never have solved the problem. As time went on, there would have been more complaints from other listeners with the same radio. It might have taken months, and hundreds of hours, before the pattern would have been recognized.

Except for the one broadcast engineer who did the hard work of collecting and analyzing field data, and who then created and tested multiple hypotheses, nobody else required any technical knowledge to solve the problem. For everyone else, finding an efficient solution only required knowledge of the social dynamics of the Internet.

The solution was already known and the task was to find the person with the answer. Before the Internet, it would have been nearly impossible to find that person; engineers would have had to solve it the hard way.

The solution was already known and the task was to find the person with the answer. Before the Internet, it would have been nearly impossible to find that person, and hundreds of broadcast engineers would have had to solve it the hard way.

MAKING THE LIST

Automated e-mail lists are proliferating because the social and technical tools are readily available. A company, L-Soft, makes a software package that automates the handling of e-mail lists; a large number of organizations have installed it on their servers. One package can handle hundreds of lists. This company also provides a list of lists for those who want to search for one of interest.

To make lists even more accessible, Yahoo, which calls its e-mail lists "groups," provides an open resource for anyone who wants to either join or create a new e-mail list. Visit *http://groups.yahoo.com*.

Like all communities, lists and groups require some kind of governance. A list can be fully public with no moderator managing membership or content. These sometimes, but not always, have a large amount of spam and other junk.

Lists also can require permission of the moderator to join, which raises the likelihood that unwanted individuals would not clutter your mailbox with unrelated junk. Moderators in more restricted lists will check each posting for relevance and focus. And finally, some lists are completely closed; only the owner can post messages.

Internet e-mail lists and terrestrial radio are two manifestations of broadcasting using different technology and different rules for messages. They do, however, share the goal of providing social connections. Broadcasting now becomes a generic word: sending out data to multiple recipients. The Internet technology that now challenges terrestrial radio with streaming programming also provides new services to the same industry that it threatens.

FAMILIAR THEMES

Michael's story unifies many themes I have discussed in many of my *Last Word* columns. The principles can all be applied, directly and indirectly, to this story.

"The Psychology of Technical Quality" (Oct. 27, 2004) explains that we need to frame our questions carefully: how to make contact with engineers who might have a solution was a better question than what is wrong with the listener's radio.

"The Deadly Psychology of Schedules and Deadlines" (Feb. 23, 2005) examines the difficulty in allocating a fixed amount of time to solving problems with big unknowns: the time to find a solution for the listener's problem could have varied from one hour to never.

"The Paradox of Learning" (Oct. 19, 2005) presents efficient ways of learning from others: the engineer who had the

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