RADIOWORLD

Getting Data up the Hill

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From the Publishers of Radio World

FUTURE

The Tools Are Limited Only by Your Imagination

Let's explore trends in how radio stations are "getting their data up the hill" in 2018

Cover Art: Ingram Publishing

By **Paul McLane**

The payloads that radio broadcasters must move to and from their transmitter sites have grown dramatically in the 21st century. The technology industry has kept pace, offering a broadening array of data transport options to carry those loads.

How should technical managers take advantage of increased bandwidth for digital content, monitoring and control while doing so reliably and economically? What new solutions are available? How can engineers assess cost, reliability, audio performance and suitability for single-frequency networks? What are the IP connections involved; how are engineers sending composite baseband at low bandwidth? What role do HD Radio secondary channels play?

This eBook explores such questions and more. Much of the information here is based on discussion in a recent Nautel-led webinar that you can find at [www.nautel.com/webinar/getting-content-transmitter-site,](www.nautel.com/webinar/getting-content-transmitter-site) though this ebook contains additional information as well.

DIGITAL STLS

Bill Gould, broadcast sales manager for equipment manufacturer Moseley, has worked on perhaps more STL projects than anyone active in the United States. Asked to identify the major types of systems he recommends, he first mentions a *950 MHz digital STL system*.

A prime advantage of such a system is faithfulness to your content. "Digital STLs can deliver you a bit-identical copy of the input to the output — and that means no noise, no noise buildup, no noise distortion as you will get in any analog circuit," he said.

Additional benefits are a relatively moderate purchase cost — perhaps $12,000 to $15,000 total, plus the cost of readily available grid antennas — as well as no recurring payments to third parties, because your station owns, maintains and controls the link. And you can expect it to last for a quarter-century if necessary.

These systems are less prone to "backhoe fade" or network outages caused by others. Rain fade is rarely an issue, and your channel is licensed and reasonably secure from interlopers thanks in part to its point-to-point nature.

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— Bill Gould, Moseley

There's negligible delay in uncompressed audio; and with modern compression, configurations of four, six and even eight channels are possible. Data channels for HD Radio, RDS or several µMPX feeds (discussed later) are available.

Digital 950 STLs are well suited too for use in single-frequency networks, having "almost unmeasurable" delay and no jitter; so the timing stays in sync.

EXTEND YOUR LAN

Gould describes 950 digital STLs as "a well-built-out and seasoned technology." They are, however, inherently "one-way only" — by nature it is a one-way link.

To send data back down, it's easy enough to add a 900 MHz data radio link that shares the antennas used by the STL; these unlicensed systems essentially allow you to extend your LAN to the transmitter site.

"This lets you extend your network to the transmitter site — effect transmitter control; put a computer there for email and internet. You can look up a manual at midnight without driving back to the station; you can even

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put a cheap webcam on it and keep an eye on your transmitter and the front door," Gould said.

Data radios are easy to deploy and generally cost less than $5,000. Security is good, because a hacker would need another identical radio and know both the spread code and the password. A limiting factor is capacity; a typical system might have 1 Mbps throughput. "But you can get an awful lot done with a megabit," Gould noted.

Another option, Gould said, is a *digital composite 950 STL*, similarly differentiated from analog composite in that it's digitally sampled. These offer most of the advantages of a 950 digital STL including moderate cost and negligible recurring expense, and they allow you to locate audio processing at the studio.

Performance specs are much greater than their analog predecessors'; and they work well for single-frequency networks — you can use common processing and then split the multiplex signal to create identical audio streams to each transmitter and booster.

Well, what about *T1/E1 packages*? "Yes they're still around," Gould said. "Cost is moderate, less than RF — but you've got the recurring T1 costs. Reliability is great, they just work forever; but they're susceptible to network failure or backhoe fade."

These systems carry much the same payload as the 950 packages, though they're inherently bidirectional, so the Ethernet networking possibilities open up. "Any IP applications you can run over a network are available to you there."

Gould added that T1/E1 systems are suitable for SFN applications, thanks to their low and very predictable latency, and lack of jitter.

SUPER-HIGH OPTION

Getting more attention these days for microwave STL, especially for users with big payloads, are the *super high*

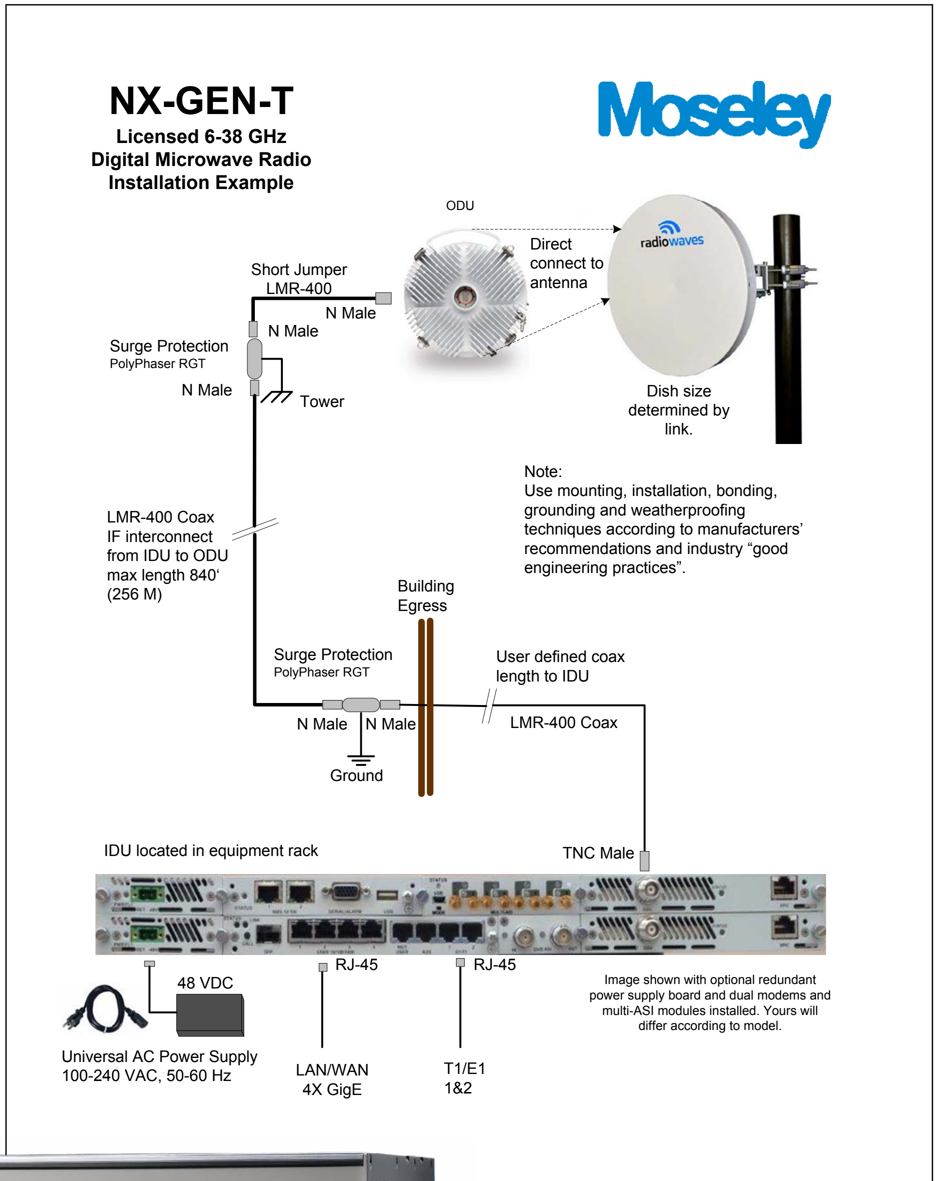

Fig. 1 (above): An installation example from Moseley of a licensed 6–38 GHz digital microwave radio installation.

Fig. 1a: Moseley SL9003QHP8SLAN Six/Eight Channel Digital STL with LAN.

frequency or SHF systems at 6, 11, 18, 23 and 26 GHz. (You can also get 5.8 GHz unlicensed.)

These cost more — perhaps $20,000 to $25,000 including antennas — but these are generally licensed systems offering high-bandwidth bidirectional operation, up to 100–155 Mb backbones depending on channel allocation, and negligible latency. "We see these new deployments used primarily for multi-station clusters transporting multiple radio stations."

They also are suitable for AES192 over IP and Ethernet network applications. "Any AoIP studio applications that require a node, you can put the node at the transmitter site and stay in your native audio format," Gould said. "You can have a network with off-premise mirrored servers, you can run video or run anything you want that fits in 100 Mb of bandwidth." They're also well suited for single-frequency networks, if perhaps a little bit of overkill.

Gould advised that broadcasters use caution when choosing a SHF microwave link because they come in many types. Noting that one of the options is 5.8 GHz unlicensed, he said, "All bands work well in their own right. However stations have no recourse when another entity lights one up on your path and obliterates your link. Licensed links need to be coordinated and stations are protected for interfering signals."

He also says the quality of radios can vary a lot.

"Data radios use a single frequency and operate half-duplex, or 'ping ponging.' Ping pong radios are subject to latency and jitter issues that can make the codec used unstable."

He said true full-duplex carrier-class radios such as the one Moseley offers use two frequencies and have a TDM backbone, ensuring data is passing in both directions simultaneously and uninterrupted. "These provide negligible latency and jitter and are ideally suited for audio transport."

SERIES OF CHOICES

No one system is right for all applications, Gould said. "Planning an STL involves a series of choices. How many stations? HD or not? Future expansion? How long is the hop? Tower space? Terrain? Bidirectional? Remote control? Data? Engineers and programmers have personal preferences about processer location, digital or analog, compression, sample rates, etc."

All these questions, he said, determine whether a conventional 950 MHz STL or SHF microwave link is the most cost-effective choice.

"A Moseley Starlink/LanLink combination provides all the functionality many stations need. But when you increase the number of stations transported on a high-capacity SHF microwave link, the per-station cost becomes much lower than with individual STLs."

Gould feels that the 950 MHz STL is and will be for the foreseeable future the workhorse STL for small- and medium-market, single- or two-station facilities looking for outstanding on-air sound, perhaps along with the addition of HD Radio.

"A 900 MHz data link piggybacking on the antenna system provides sufficient data throughput for remote control and metering, RDS and an internet connection at the transmitter site. This may be the best choice for a single- or two-station facility." He noted that Moseley recently introduced an eight-channel Starlink model that concentrates four radio stations onto a 500 kHz STL channel.

"How many unnecessary trips to the remote transmitter site can be saved by the ability to diagnose and even correct a problem remotely from the studio or the engineer's personal smartphone, and how much off-air time can be saved as well?"

Gould feels it is important to build using equipment designed specifically for broadcast audio transport from a seasoned equipment manufacturer. "Less-expensive alternative methods may seem like a good idea, but when they start sputtering on the air, the boss will be all over you like a cheap suit. And it's your phone that will be ringing in the middle of the night."

He emphasizes that IP-based, off-the-shelf applications and appliances save money and protect valuable station assets.

"How many unnecessary trips to the remote transmitter site can be saved by the ability to diagnose and even correct a problem remotely from the studio or the engineer's personal smartphone, and how much off-air time can be saved as well?" he asked.

"Add an inexpensive webcam and you can observe the transmitters and provide security for the plant. A remote mirrored server located at the transmitter building can get a station back on the air quickly after a disaster at the in town studio complex. The tools are only limited by the imagination."

FIELD-TESTED CODECS FOR STL

Fifteen years ago, the idea of using an audio hardware codec as the main studio-transmitter link for a broadcast radio station might have seemed foolish.

Chris Crump, director of sales and marketing at Comrex, recalls when the manufacturer received its first call from an engineer using the company's Access IP codec —

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Fig. 2: Hardware codecs can move linear or compressed audio with very low delay over a range of IP links. Shown is the Comrex BRIC-Link II.

which had been introduced with remote broadcasts in mind — as an STL link over a VSAT satellite. "Our engineering department just about had a stroke."

But it became apparent to codec manufacturers that a rethink of assumptions was in order and that they could expand the role of hardware codecs to include broadcast-reliable, full-duty appliances meant to be operating 24/7/365 as backups or primary STLs.

"We have made many huge technological leaps since then, and the performance of most professional broadcast IP audio codecs has been field-tested and proven for more than a decade," Crump said.

Among the advantages of this approach is cost efficiency, since not all stations can afford to build out digital 950 or similar systems.

Crump offers five tips to get the most out of your hardware codec:

1. Always used a wired, dedicated circuit when possible;
2. Get the best circuit you can afford;
3. Ask your service provider for a Service Level Agreement, because "you want to make sure that circuit has an uptime that's better than four 9s if possible";
4. Employ network redundancy/wireless backup;
5. Research the "secret sauce" that each manufacturer uses to make a given IP codec STL-ready.

As an example of the latter, Comrex highlights an offering it calls BRUTE, an offshoot of its Broadcast Reliable Internet Codec technology. BRUTE stands for UDP Transmission Enhancement.

"It sounds like an oxymoron," Crump said, "to make UDP more reliable. Basically there are two modes, there's a UDP reliability mode that will retransmit packets to make sure they get through in the event they get lost in a network; and a congestion avoidance mode that has the ability to throttle the encoder."

Most codecs being considered for STL use, he said, will employ some kind of dynamic buffer management and high-quality, low-delay algorithms to make sure the audio is 20 Hz to 22 kHz, better than broadcast quality. All have some kind of error-correction techniques; the ability to deal with network address translators on routers; and some kind of SIP-based interoperability, which helps different codecs talk to one another, though this is not usually a big consideration in an STL context.

NOT JUST ENCODE/DECODE

Another perspective on the benefits of this class of STL comes from Tieline Technology, which makes STL and audio distribution solutions over IP, with options to connect or backup to ISDN or POTS. "Tieline also delivers multiple layers of IP backup to an alternative connection, Icecast streaming, audio files and bypass of inputs to outputs," said Jacob Daniluck, technical sales specialist Americas, Tieline.

He said broadcasters can use a single codec to configure flexible multi-unicasting and multicasting IP streams, or establish multiple bidirectional peer-to-peer connections, to feed IP streams around a network or to affiliates. "STL-grade" audio codecs from Tieline include features like automated program scheduler, SNMP capability, integrated alarms and file playback.

"It's not just about encoding and decoding anymore," he said. "When you purchase a hardware codec you also get a suite of IP technologies to improve broadcast streaming reliability and flexibility. From a transport perspective, professional audio codecs offer a wide range of encoding options, auto adaptive network jitter buffering, forward error correction, dual redundant streaming and network bonding technologies."

He cautions against open-source streaming options, which he says don't offer the same flexibility or redundant streaming options over Ethernet and wireless technologies, file playback or alternative network backups over ISDN and POTS.

"Also what sort of security features do they offer? Using open source streaming options could be like leaving the front door of your broadcast network open and inviting

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Moseley

HIGH CAPACITY
STUDIO TRANSMITTER LINKS

TAKE ADVANTAGE OF MICROWAVE HIGH PAYLOAD STL/TSL CAPACITY

Moseley EVENT and NX-GEN-T STL/TSL systems provide up to 155 Mpbs combined IP, T1/E1 payloads. Multi-station clusters can convey multiple linear uncompressed audio pairs for a truly cost-effective STL/TSL link. Connect your existing T1/IP audio hardware directly into the system, or use Moseley Rincon for your audio payloads. An optional DVB-ASI mosule is available for full duplex video.

EVENT and NX-GEN-T systems are fully bi-directional including a Software Defined Indoor Unit (SDIDU) and Outdoor Unit (ODU), eliminating the need for costly waveguide.

- EVENT 5800 is available in the license free 5.8 GHz band.
- NX-GEN-T is available in 6, 11, 18, or 23GHz licensed bands.

outdoor unit

indoor unit (rear view)

INTELLIGENT SYSTEM DESIGN

Spectrum-scalable digital radios with user-selectable data rates enable broadcasters to have greater flexibility in STL planning and future growth.

IP APPLIANCES AND APPLICATIONS

Offer IP transmitter control, surveillance security, and site monitoring to reduce downtime, and protect valuable station assets while saving travel time to the site.

REMOTE MIRRORED SERVERS

Offers backup of business records and programming content to get you back on the air quickly in the event of a studio outage.

EMAIL AND INTERNET ACCESS FROM THE TRANSMITTER SITE

Saves engineers time accessing manuals or technical support from manufacturers during maintenance sessions.

SNMP AND WEB BROWSER INTERFACE

Full SNMP package with GUI provides easy monitoring and configuration changes.

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anyone in to have a look around."

Traditional microwave technologies, he acknowledges, still play a role, though he notes that they may have distance or line-of-sight limitations. "Shoutcast and Icecast are useful for online streaming, however you still need to transport audio in all manner of ways depending on a site's location and network access. We are still many years away from ubiquitous availability of data everywhere, and until then, audio codecs will have a place in radio."

SMART SECURITY

Like others contacted for this eBook, Crump of Comrex is ardent about the importance of security best practices, starting with changing the default profile of the unit's software as soon as you start it. "Make it as safe as possible by [choosing] a hard-to-guess password."

> *IP is IP …It doesn't matter if it's public internet or ISM band radios, the 2.4 and 5.8 Gig bands, or even BAS band radios — making sure that your transmission is as reliable as possible on the codec end is what we care about.*
>
> *— Chris Crump, Comrex*

He shared additional tips: Don't put the codec on an internet port with a searchable URL. Secure the Web Interface (TCP port 80) behind a firewall with VPN. Use the Connection Password functionality so that only your codec can connect to your codec. If not using these, disable SIP/EBU 3326, HTTP, SSH and RTP functionality. (Comrex Technical Director Tom Hartnett summarized this advice as follows: "If an IP address is all that's needed to hack, something's wrong. The codec needs secure passwords and unnecessary ports locked down.")

Also, Crump said, change the SIP port. "One of the things we've learned is that if you change the SIP port, if you use the SIP functionality, instead of using the standard 5060 UDP, change it to 5061 or 5062. There are a lot of SIP bots out there; a lot are auto dialers from other parts of the world that are going to log onto your device and lock it up."

You can also use a virtual private network on both sides of your codec, whether it's IPsec53 or some kind of AES countermode encryption.

Be aware that Flash exploits, Crump said, seem to be getting more common; you can fight this by using a dedicated non-Flash app and not use the Flash interface at all.

Daniluck of Tieline echoes the recommendation to use secure username and password login credentials. "Some other features we have incorporated include the ability to install SSL security certificates in codecs to ensure they are trusted devices within your network. Tieline codecs also have the ability to configure SIP filter lists, which provide filtering of SIP URIs and User Agents to provide greater security when using SIP. Also, we offer firewall settings to enable or disable a range of firewall-related network services and have implemented CSRF protection (Cross-Site Request Forgery) which avoids unwanted attacks on web applications."

As an example of how hardware codecs continue to improve, Crump said Comrex introduced CrossLock VPN, which allows simultaneous use of multiple networks to increase bandwidth and improve reliability. Among its features is an "adaptive management" engine that can monitor multiple data networks so you can have multiple wired connections on each end. It'll monitor each, figure out how much data you can send across each, and then apply the appropriate error correction protection techniques on each one.

It also offers a bonding mode that bonds data channels together — suitable for unreliable networks like 4G — and a redundancy mode for reliable, high-bandwidth networks that employs techniques including ARQ, FEC and throttling as necessary.

What else should you keep in mind when considering IP codecs for STL applications?

"Dedicated fiber connections are best," said Tieline's Daniluck, though he said his company's codecs are designed to operate full-time with STL reliability over the open internet.

"Having said that, an IP codec is only as good as the connection it is using. We can mitigate against lots of stuff like lost packets and variable bandwidth with strategies like SmartStream Plus dual redundant streaming, automatic jitter-buffer adjustment, Fuse-IP network bonding and FEC; but if the networks you are using are unreliable, then it's likely your connection will be too."

He encourages users to select a Tier 1 service provider because their infrastructure makes up the internet "backbone" and will be most reliable.

"Also don't try to squeeze too much out of the prevailing connection bandwidth; and always select encoding to suit the bit rate that is reliably available. Ensure you allow some overhead of around 20 to 25 percent as network bandwidth will always vary over internet connections," Daniluck said. "Never share the connection with other devices that could use data and lead to dropouts."

Overall, Chris Crump said, "IP is IP … It doesn't matter if it's public internet or ISM band radios, the 2.4 and 5.8 Gig bands, or even BAS band radios — making sure that your

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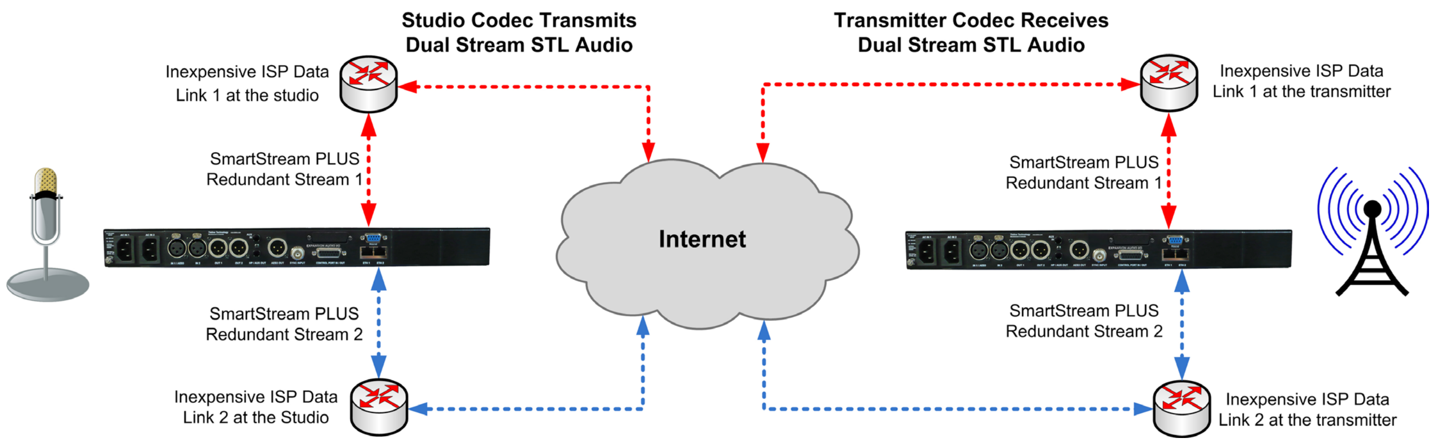


Fig. 3: A Tieline graphic depicts the use of STL-grade IP audio over affordable IP.

transmission is as reliable as possible on the codec end is what we care about."

IP STL

Jeff Holdenrid, sales manager for DoubleRadius, designs and installs radio-based IP STL packages that he describes as akin to stretching an Ethernet cable to the site using radio waves.

"We're a carrier," he said. "We're no different than a leased line; we're just over the airwaves."

Holdenrid points out that everything is bidirectional when working with IP. "All we're doing is extending your Layer 2 network or your existing LAN to your transmitter site."

It doesn't really matter what you carry across Layer 2 traffic. "We can do audio for radio. We can do video for TV. We can do video security, voice over IP, remote control data — if you want to put a camera or a VoIP system out at your transmitter site, we can carry that along with your audio."

There are variations within this category including licensed, unlicensed and "piggyback" variations.

Unlicensed systems are cost-effective, perhaps just hundreds of dollars, and can be useful for high capacity. "We're seeing unlicensed systems carry multiple hundred megabits of throughput," he said. "Latencies are usually 5 to 10 milliseconds. But the one thing you have to be careful about is interference." Since you don't own the frequency, anybody can use it.

What if your transmitter site is in the middle of nowhere? Isn't that fairly safe from interlopers? Holdenrid said think again.

"There are 7,000 wireless internet service providers in the country that are bringing internet access to houses of underserved areas, and they're using these 5.8 GHz bands, 2.4 bands, the 900 MHz band to do this." So be aware that interference may crop up where you wouldn't normally expect it.

Licensed systems are available under Part 101 of the FCC rules at 6, 11, 18, 23 and 26 GHz. The primary options for longer STL shots are at 6 and 11 GHz. These are high full-duplex throughput systems, so if you have 100 Mb going out you have a 100 coming back; if you have 1 Gb going out you have a Gb coming back. The latency is very low, less than 1 millisecond and typically more like 100 microseconds.

"And you own the frequency, you're licensing this for 10 years. You can't control someone illegally putting a channel up, but you own the frequency."

Holdenrid also described an option called a *piggyback*, also known as a 950 underbuild, or a 902 to 928 radio piggybacking on your 950. These too are bidirectional; Holdenrid has achieved throughputs of 5 and 20 Mb max on this system, but latency will be higher, roughly a 40 millisecond latency. "But they can still carry your audio, your remote control and other services at the same time."

DEPLOYMENTS

What about deployment options? An *all-outdoor* system offers your lowest cost of ownership for deployment; the radio is mounted with and integrated to the antenna. All the ports — Ethernet, fiber, TDM ports — also are on the tower, and you have to run those connections down.

"Ethernet is the first thing to spike on a surge, it's not very resilient," Holdenrid said. "Try to use fiber and DC connections if you can."

Fig. 4 shows a typical outdoor system. If using Cat-5 around an FM signal, Holdenrid recommends taking care.

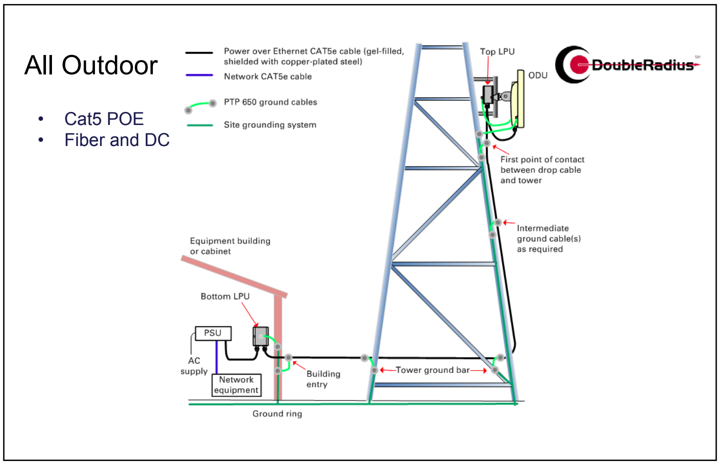
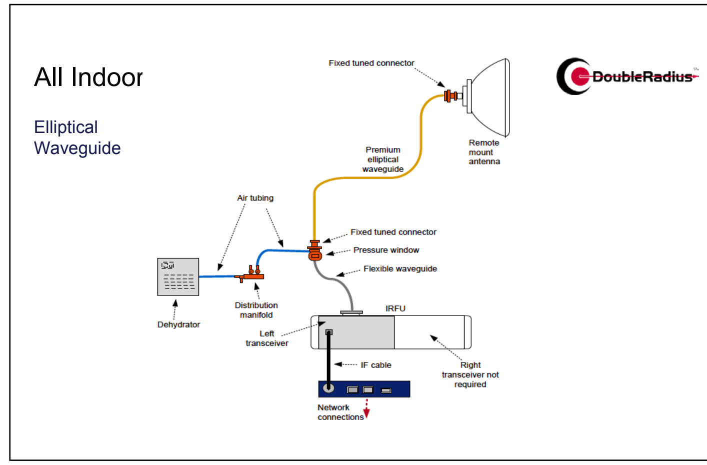


Fig. 4. *Click on the "Click to Expland" button to view larger.*



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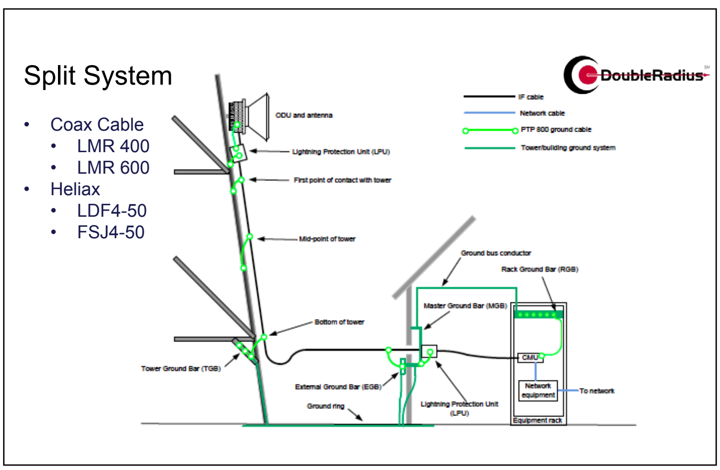

Fig. 6. *Click on the "Click to Expland" button to view larger.*

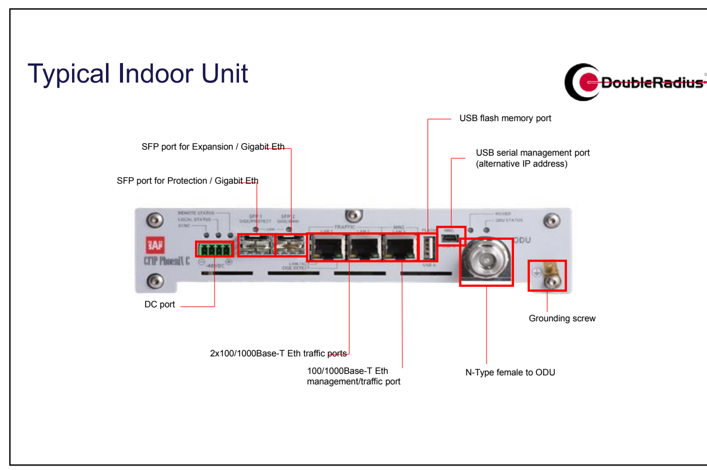

Fig. 7. *Click on the "Click to Expland" button to view larger.*

In a typical trouble call, he said, the main station signal is interfering with the Ethernet cable.

"Ethernet transmits data at 100 MHz, so you put that next to a radio station at 99.7 with 25,000 watts, all of a sudden you're interfering with the Ethernet cable. The radio is working fine, the data just isn't getting to it. You can run a fiber and DC system; just make sure you protect it, because it can easily be destroyed on the tower."

By comparison, an *all-indoor system* is the most expensive. Everything is located inside your doghouse or at the studio, and you run elliptical waveguide up the tower directly to the antenna.

He deems this approach the most reliable. "You don't have to tower climb for an equipment failure. If you have a problem with your line, that's a different story; but your hardware being indoors makes it a lot easier to troubleshoot."

Fig. 5 shows an indoor arrangement. The IRFU and the network connections are in the rack, occupying five or six rack units. "We run everything into your dehydrator, and you run your elliptical waveguide up the tower."

These systems usually use higher-powered radios to make up for some of the loss; the longer the cable run, the higher the loss and thus the lower the output power, so take that into consideration.

His preference is for a *split system*, a medium-priced option in which the radio is mounted at the antenna but the Cat-5, TDM, SFP and ASI ports are on the ground.

"Internet, T1s, ASI, fiber connections are all located inside. You run a 1/2-inch or heliax cable up the tower to the RF unit, which is mounted directly to the antenna. This gives you the best of both worlds. The Ethernet, which is going to pop first, is on the ground, so it's less likely to get that spike from a static discharge or a surge." Fig. 6 shows a split system.

Holdenrid uses 1/2-inch cable in this installation. "A lot of people like coax, LMR 400 or LMR 600; I recommend a Heliax LDF4 or an FSJ4 because it's got a longer life cycle on the tower."

The indoor unit has IP ports, SFP ports, power supply, N type female connection (which runs up the tower to the antenna) and grounding lug. The SFP ports can be used for expansion. "With this system (Fig. 7) we can

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Flexible IP Streaming with Tieline Genie Distribution

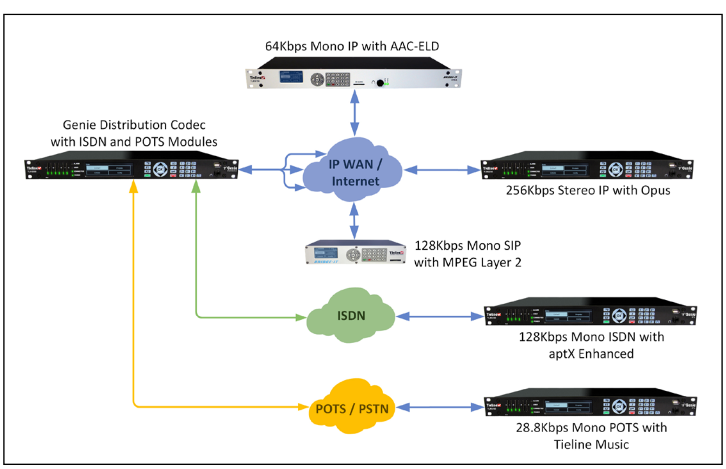
Genie Distribution is the world's first multi-channel and multi-network 1RU codec, capable of connecting up to six simultaneous bidirectional connections over IP, SIP, ISDN and POTS.

Tieline IP Delivers Flexibility

IP has been a mainstream technology at Tieline for 15 years and Genie Distribution delivers rock solid and cost effective program distribution solutions to replace expensive satellite, ISDN and MPLS IP infrastructure. Stream over IP for STLs and affordably distribute regional content or syndicated programming to national and international destinations. Solutions include:

- 3 bidirectional stereo connections.
- 2 stereo and 2 mono bidirectional connections.
- 1 stereo and 4 mono bidirectional connections.
- 6 mono bidirectional connections.
- 2, 3 or 6 simultaneous mono/stereo multi-unicasts (max. 60 endpoints).
- 2, 3 or 6 simultaneous mono/stereo multicasts.

Stream multiple algorithms at different sample rates and bit-rates, over all network transports! Plus, integrate asymmetric encoding for bandwidth flexibility over IP connections.



Multiple Backup Options

Genie Distribution features dual Gigabit Ethernet ports, dual internal power supplies, and multiple layers of IP network backup to ensure you stay on the air. Automatically switch between up to 4 backup audio sources to maintain program output at transmitter sites, including automated silence detection fail over to backup audio files.

The codec features SNMP and automated network monitoring, plus fail over to backup ISDN or POTS connections.

SmartStream PLUS Saves Thousands

SmartStream PLUS is acknowledged as the industry standard for broadcasting over the public internet. It has revolutionised IP broadcasting by streaming simultaneous redundant data streams to maintain rock solid audio over inexpensive IP networks. Some other manufacturers charge thousands for competing software as if it's an optional extra, however Tieline delivers its renowned SmartStream PLUS software for free!

Remote Control from Anywhere, Anytime...

Manage an entire fleet of codecs in real-time from the studio with Tieline's Cloud Codec Controller. Monitor and control an entire IP codec network, select and load programs and view and manage alarms, and much more!

Interoperability and Compatibility

Genie Distribution supports 6 EBU N/ACIP compliant SIP connections using different SIP accounts, plus IPv4/IPv6 protocols and a huge range of algorithms, including Opus and aptX ® Enhanced.

Tieline's Genie Distribution with WheatNet-IP interfaces seamlessly with the WheatNet-IP Environment and is fully AES67 compatible.

Save Money and Transition to IP Today

Partner with Tieline to replace expensive satellite, ISDN and MPLS infrastructure and the money you save can pay for new IP codecs in just months! Don't delay, contact **sales@tieline.com** to learn more.

Tieline®
The Codec Company

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expand to T1s if you're still using TDM technology, or we can even put ASIs on there and do native ASI if you're a TV/radio split or if you just need to do ASI across the system."

Fig. 8 shows a 1+1 frequency diversity application. "We have the ability to put two RF units on a single antenna, and this can be as a 1+1, or we can use both polarities and run a 2+0 scenario to double throughout or to keep things flowing at the same time."

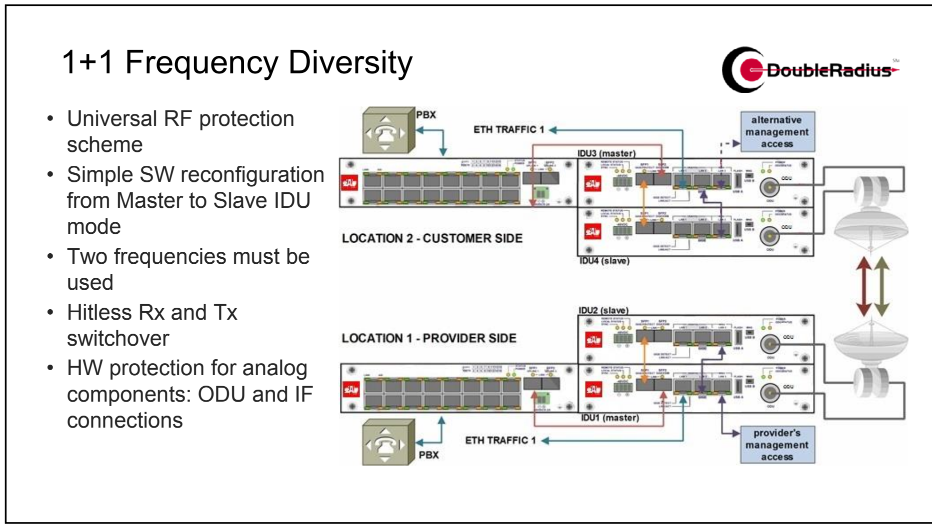

Fig. 8. *Click on the "Click to Expland" button to view larger.*

Because antennas very rarely fail, frequency diversity can be a welcome option that doesn't add much wind loading to your tower other than from extra cabling.

WHAT NEXT?

Radio-based IP STL packages like these have grown in popularity since the FCC opened the use of Part 101 services to broadcasters in 2011; but what should we watch for next in this area?

"Other than higher modulation schemes and higher output powers, nothing is really changing at this moment," Holdenrid replied. "The radios are going faster and farther than they ever have before — though we don't recommend the highest-speed solutions because they're not as reliable; we recommend gear that's been out there for two or three years and is proven."

Anyway, the speeds possible in Part 101 systems are already many times greater than broadcasters need today, even with the greater payloads that radio creates today. "You think about people using the old Moseley LanLinks? Those did 750 or 512 kpbs. We're talking 100 Mb. The latest gear can go to 1.2 Gig!" Even if someone is putting in a full-bore AoIP system, they may only need 20 Mbps per channel.

"The gear is a lot faster than the market needs. We're already 10 years ahead of the market when it comes to speed."

One emphatic piece of advice from Jeff Holdenrid is to perform path calculations, because there is no stock formula that you can rely on just because you know the frequency and antenna model. "Do it on your own, call everybody you know to do it, doublecheck your work. Have them do it from scratch." And consider regional factors too; stations in the southeastern United States for example should be aware that humidity and rain fade will be more of a concern than in, say, Arizona.

Make sure whatever program you use to make path calculations accounts for ground cover such as trees and foliage. For example, the path calculator in Nautel's RF

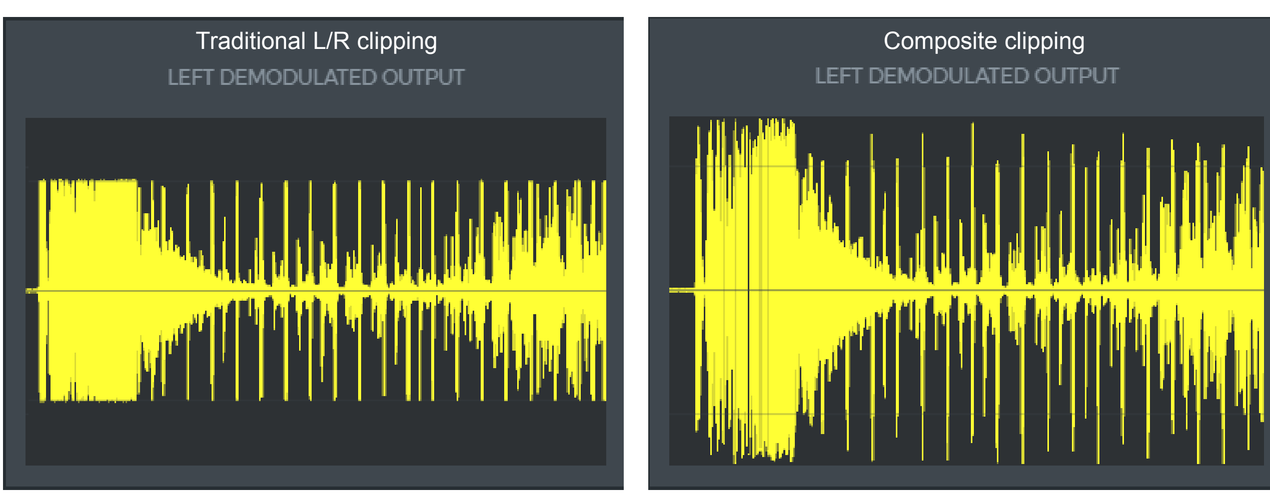

Fig. 9: This Thimeo slide demonstrates benefits of composite clipping. Louder and more dynamic, typically 2 to 3 dB more highs, and the clipper can optimize the multiplex signal for better reception and less multipath.

Coverage Tool provides the ability to turn ground cover on and off (see www.nautel.com, click on Support, then Free RF Toolbox).

COMPOSITE FM CODEC

A relatively recent addition to available STL choices is a composite FM codec made by Thimeo Audio Technology called µMPX, or microMPX.

Explaining the rationale behind it, CEO Hans Van Zutphen starts by noting that FM clippers have improved a great deal. Using composite clipping, knowing what the pilot and RDS look like, a station can put up to 140 percent of L/R audio into 100 percent modulation. "This gives you 2 to 3 dB more highs and a lot clearer and more open, dynamic sound."

The left half of Fig. 9 shows traditional clipping, the right shows composite clipping, in both cases on the demodulated left channel. The composite clipping delivers much more loudness, more dynamics and, indirectly, more clarity thanks to increased headroom.

"Because we know what the full MPX signal looks like, we can optimize it for better reception and actually make the RF bandwidth smaller," he said. "So you get fewer multipath issues and better fringe reception."

Thus it's desirable to feed the transmitter with your full multiplex signal. But can't you use an analog connection for that?

"It turns out that the quality of the signal that you broadcast has a big effect on the reception quality," he said.

"You might think, 'Well, FM is noisy anyway, so nobody is going to notice a bit of extra noise from an analog link in between.' [But] we got feedback from people who were using our own processor to replace an older analog processor and suddenly reported, 'Hey, our stereo reception area has increased by up to 20 miles.'"

Van Zutphen said that although such reports at first baffled the company, "We figured out that modern car radios are using all kinds of tricks to determine how good the reception quality is, and [will] blend to mono if they decide that it's bad."

Noise, he reminds us, adds up. Adding more noise — around the pilot, above the RDS and in the quadrature signal — will cause receiver chips to perceive that reception is worse, so they will just blend to mono sooner, which Van Zutphen said will cause your station to lose stereo reception. That, he said, is the case if you use an analog STL.

OK, so a digital signal to the transmitter is desired. But to do that with PCM audio at 128 kHz and 16-bit audio would require 2 Mbps data, not counting error correction data and network overhead. Cut bits to save data, and your noise floor goes up.

COMPOSITE LINK, LOW BIT RATE

All this, Van Zutphen said, was the context of his company developing a composite FM codec, which is intended to give the benefits of a full composite link but at 320 kilobits per second. RDS and pilot are included, peak control is provided and you still achieve L/R channel peaks up to 140 percent.

"It's a low bit rate connection, it's just an IP stream; you can send it over any IP connection including satellite. You can send multiple µMPX streams over a single 950 MHz connection."

Among the other benefits to a composite connection is in the creation of single-frequency networks.

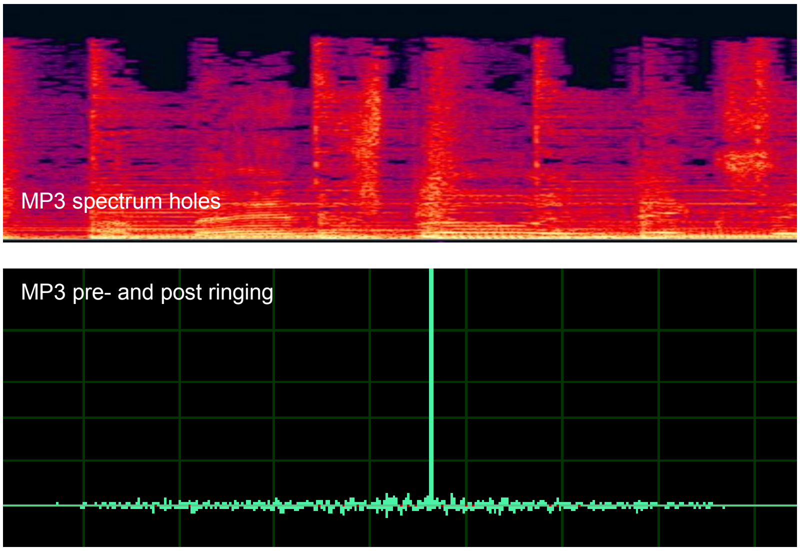

Fig. 10: Van Zutphen said the microMPX codec "doesn't have the compression artifacts associated with lossy systems" like those shown.

"For SFNs, you don't really have much other choice unless you can guarantee that the clipper/pilot/RDS is generated exactly the same on all the transmitters," he said. So µMPX will soon support GPS receivers with the SFN application in mind.

"Besides that, there are quite big differences in quality between clippers, not just in audio quality but also in how they affect reception. Fortunately, these features survive encoding with µMPX, which means that you don't really have any disadvantages compared to just sending a full-bandwidth signal."

He says other codecs typically can't encode a full MPX signal; but even if you send left/right audio, he said, there

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Comrex — Broadcast Reliable

the early 2000s, Comrex was deep in development of our IP audio codec technology. We were bringing to the table decades of experience in leveraging widely deployed data networks and transmitting high quality audio over public switched telephone network services like ISDN and POTS. We knew IP technology offered tremendous possibilities but also tremendous challenges. Most importantly, Comrex felt the need to create an IP-based product that delivered both quality and reliability which would meet the expectations of our customers. So, Broadcast Reliable Internet Codec (BRIC) technology was born. We felt so strongly about the term Broadcast Reliable that we made it our tagline and even added it to our logo.

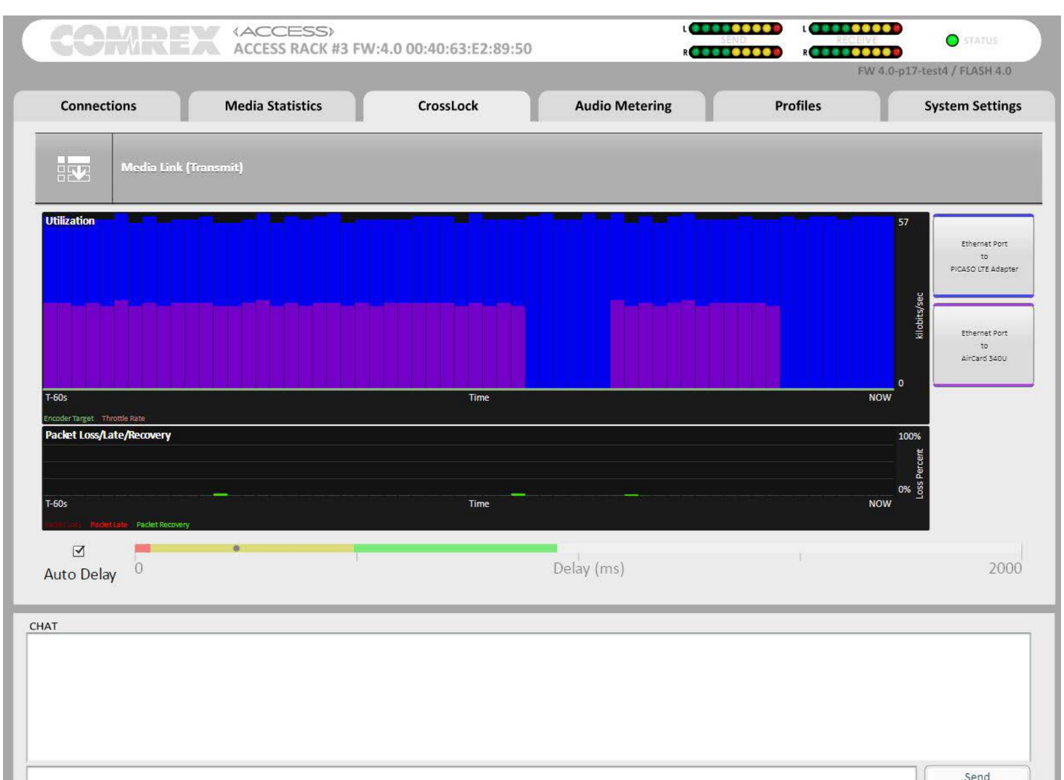
We believe that a great codec is one that you don't have to think about. Comrex builds codecs that connect easily and deliver high-quality audio over IP networks with low delay. To make sure our codecs provide stable connections even under the worst conditions, we've developed some highly-specialized tools. These ensure that your broadcast stays solid, even if your networks don't.

What is CrossLock?

When audio is streamed over the Internet, it is packetized into data, and the packets are sent to an IP address (that belongs to a computer, or a codec, or your smartphone, etc). If you've got a solid, wired connection, the packets will arrive in the order they were sent and you'll have a solid stream. But what if the connection isn't very good?

Throughout the course of extensive testing and user feedback, Comrex has found that most network impairments are due to congestion - routers may become overloaded with incoming data and create queues of packets waiting to be sent, making them late rather than lost entirely. We have also found the type of occasional parity-based FEC used by some codec manufacturers to be fairly ineffective overall for anything other than the shortest errors, which are not typical on IP connections, thereby needlessly increasing bandwidth (and potential congestion) further.

To most efficiently deal with these network issues, Comrex developed CrossLock -- a "smart" ARQ-based (packet-resend) error protection, along with FEC (if requested) and redundancy or bonding on multiple net-



CrossLock demonstrated through the ACCESS Rack web GUI. In this instance, CrossLock is being utilized in "bonding" mode, aggregating Ethernet and a cellular modem.

works. Our testing shows resending packets only when required offers the proper balance between bandwidth and delay without risking additional congestion. CrossLock also offers a choice of simple redundancy (most useful in the case of networks with no data rate constraints) or aggregation (bonding) which sums the capability of networks together. Bonding is very useful on networks like wireless, where data rates may be severely constrained.

Multiple Network Connections

The default bonding mode goes even further, employing a sophisticated algorithm to determine how best to allocate packets across each network, even going so far as to quarantine networks that are significantly underperforming. Networks that suddenly get constrained, which is common on wireless data connections, are detected quickly and more packets are immediately dedicated to the good network. In most cases, this results in seamless audio without the "bandwidth hogging" that would happen on competing systems.

This is best illustrated using the statistics page of the codec's user interface. Using color-coded graphs, you can see that CrossLock likes each of its networks equally, and has applied about half of the data load to each network. Users can even adjust target latency for both transmit and receive streams in real-time using the delay slider tool.

"Backhoe Fade" Protection

For STL applications, Comrex ACCESS and BRIC-Link codecs have been used by broadcasters for over a decade with great results. The addition of CrossLock technology in 2016 has provided an even greater level of reliability especially when combined with multiple wired broadband data connections. But even the most robust wired data connections are susceptible to interruption if, for example, an errant backhoe rips through the bundle of fiber connecting your station to your transmitter site.

To provide a safety net in case of network failure, Comrex ACCESS and BRIC-Link II codecs can now provide a "Hot" wireless backup by adding a Comrex Connect Modem to the USB connector on the device. CrossLock will continually monitor the status of the connected networks. If CrossLock detects bandwidth degradation and a failure threshold is triggered, the 4G LTE modem will take over to maintain the link. The 4G LTE modem is always on in the background but only sending a very small amount of data (approximately 256MB per month) but, in the case of primary network failure, will start transmitting at the selected bitrate to maintain the connection. Simultaneously, an alert is sent via contact closure on the studio side to notify that the backup network is active, and will remain on until the primary is restored.

"It just works"

"I'm at a loss as to what I should say," said Frank Alwine of Vermont Public Radio in an interview with Comrex about the BRIC-Link codecs he uses for his station's STL. "It's kind of boring — our BRIC-Links simply work, and that's pretty much all there is to it."

"As I'm thinking about it, I realize that "boring" is the best endorsement I could give," said Frank. "I don't have to worry about these things — they just plain work all the time. Since we purchased them in 2010, not a single unit has failed. That means 24/7, every single day, for the past seven years, these units have just been working. From a broadcast engineer's standpoint, you can't get much better than that."

A sample of the more than 30 Comrex BRIC-Links handling all of the STLs for VPR News and VPR Classical. Photo supplied by Frank Alwine at VPR.

COMREX
BROADCAST RELIABLE

Learn more about Comrex codecs at www.comrex.com.

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are changes in the spectrum and in the timing of sounds that can cause issues for reception and PPM encoding.

At 320 kilobits, isn't his system lossy? Yes, says Van Zutphen, but it doesn't have the compression artifacts associated with lossy systems. "We designed µMPX specifically for FM. It doesn't use an existing codec, it's the first codec made especially for FM. It does not have the holes in the spectrum that you would get with traditional codecs; it does not have pre and post ringing."

The codec will only add white noise, but it still provides more than 100 dB pilot protection and a clean RDS signal. In tests of the codec, he said, the level of the artifacts was more than 6 dB lower than that of MP3 at the same bit rate — even with the full signal including pilot and RDS, and with solid peak control, all of which is not the case with MP3.

The current version of µMPX includes forward error correction; it also provides redundant links via multiple connections.

"So for example if you have a satellite link and a fiber link, or a satellite link and a normal ISP, you can send the same signal through both connections, and as long as every packet arrives somehow, via at least one of the two connections, reception will be perfect." It also supports unicast and multicast.

As to the connections required, anything that can carry around 320 kbps would suffice for this. "Of course it's also possible to run multiple connections over a single link. You only need one-way communication, so even sending the signal via satellite is an option," he said. "Multicasting is also possible, so you don't need a big pipe to the studio either, even if you want to send the signal to many decoders at the same time. If you want network redundancy, you'll need multiple connections from studio to decoder. (You don't need that for Forward Error Correction)."

The software, he adds, also has a backup file player in case all connections drop out.

For security and hacking protection the company soon will add stream password protection; and it is working on even lower bit rates, which would be especially useful for satellite applications, among others.

Each decoder and encoder is available as software for $395 list price. If you make your own hardware the total package can be very inexpensive; Van Zutphen knows of one station that has been running it for two years on air on a Raspberry Pi 3 and a sound card that together cost less than $100. But µMPX is also available in packages with processors from partner company Omnia. The latter is also planning its own hardware encoders and decoders in future, and there's talk of possibly building it directly into transmitters.

Jeff Welton of Nautel calls µMPX "another tool in the box," one more option for delivering a good quality audio signal over a bandwidth-limited pipe.

Fig. 11: IP STL links, said Alex Hartman, offer users more control, cost efficiencies, bidirectionality and other benefits of IP design. Ubiquiti Networks image shown.

WEIGHING OPTIONS

Alex Hartman is owner and partner of Optimized Media Group, and has worked with many forms of STLs. He offers something of a summary take on the various options discussed above.

He said that when broadcast engineers are instructed to design an STL system, management typically has five expectations:

- It must work at all times, with "seven 9s of reliability";
- It must not introduce coding artifacts that the listener can interpret as a problem with the station, because you *will* hear about it from everybody;
- It must be easily serviced;
- It must have some form of redundancy;
- And security is paramount.

However, Hartman said, the reality is that you'll usually only be able to meet three of those requirements at a time. Choosing among available options will always require tradeoffs.

For instance, while traditional T1s, E1s and ISDN still exist and offer good security, Hartman said, "The phone guys aren't there anymore. They've all retired and moved on. It can take weeks to get a T1 repaired today. It's absolutely flabbergasting that a simple reliable connection has gone to this level."

Even if available, those solutions are costly and offer you little to no control; you're pretty much at the whim of the phone company.

A familiar 950 MHz STL offers you more control as well as secure, proprietary coding without recurring fees — but there's no return path.

IP-based links are inexpensive and bidirectional. "You can shove anything with an Ethernet cable into it — audio, control, phone lines; my favorite is remote file storage. Emergency backup stuff. Studio-to-studio links. Anything IP just works."

A downside is that unlicensed options can suffer from random interference from household WiFi or other point-to-point links from wireless internet providers, while licensed options can be cost-prohibitive for smaller stations. These systems also require some IT knowledge, more than just setting up a Windows computer.

INTERNET-BASED

So which is right? There is of course no universally correct answer.

Hardware solutions built around AoIP plans or traditional codec boxes require minimal configuration. They're standalone, they have tons of factory support; they work very well with network and SFN applications; and most have built-in failover link detection systems for redundancy.

The cons? Interoperability may be a problem; getting a Tieline to talk to a Comrex, for instance, can be a challenge. "Interoperability between brands is limited to 'standards-based' codecs — maybe," Hartman said. "It depends on implementation."

Other observers though argue that the need for interoperability is an accepted fact of life in the radio environment today, and that if a user understands Session Initiation Protocol and configures codecs correctly over SIP, it's usually simple to connect codecs from various manufacturers. There's a lot of technical support information available from manufacturers to help. Also, as noted, interoperability may not be a concern in an STL situation.

Hartman said codecs also can be expensive depending on how you implement them. Also, firmware updates may not address specific issues such as timing concerns over SFNs.

And security concerns require factory intervention. "Protocols get broken into all the time, and then [manufacturers] have got to spend the next six months updating their firmware to patch that hole," he said.

What about software-based solutions? He counts in this group a range of offerings including OpenOB, uMPX, gstreamer, VLC, OBS, Dante, Livewire, Wheatnet and Shoutcast/Icecast.

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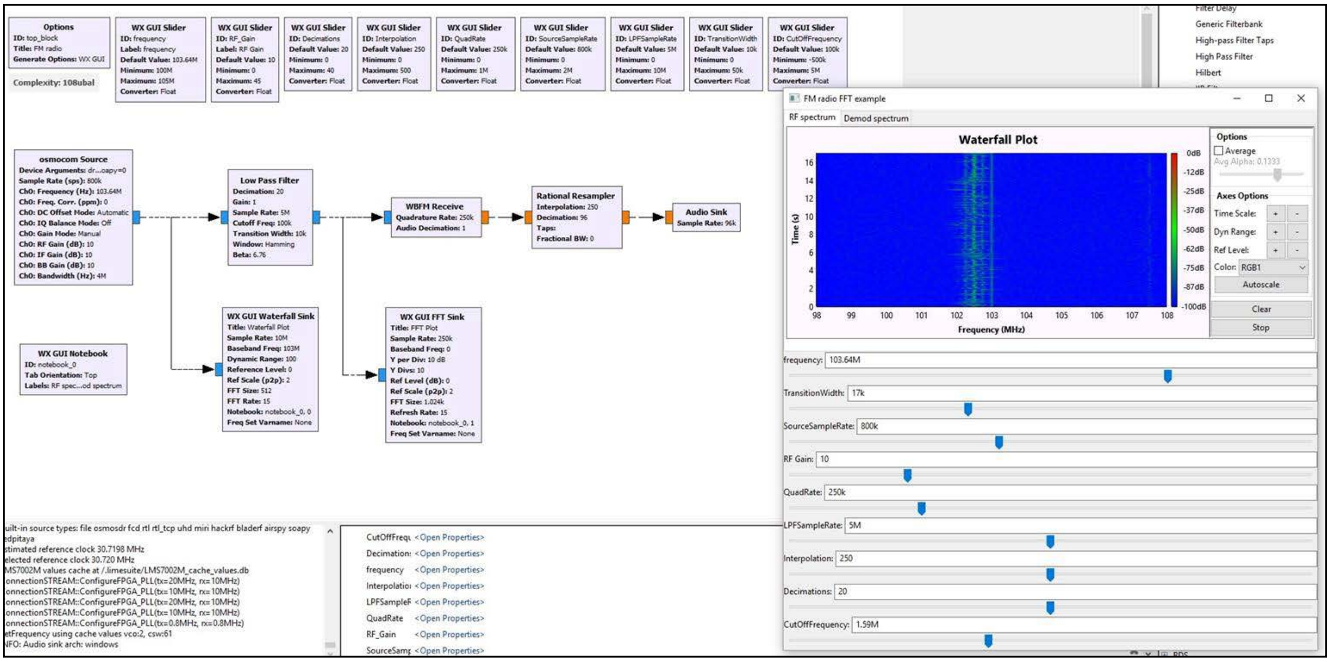

Fig. 12: An image of a software-defined receiver for STL bands as created in GNU Radio, an open-source software development toolkit. *Click on the "Click to Expland" button to view larger.*

❱ Continued from page 19

This class itself could merit its own eBook and it includes very different types of solutions, so generalizations can be difficult.

"Software can be very inexpensive or even free. There's usually a user community, so you can get a lot of help in that respect," Hartman said. Software solutions often run on commodity PC hardware; you can even use something out of the junk pile. Redundancies can be built into N+1 based on hardware, CDN, cloud or virtualization operations. You can run your entire radio stations out of the cloud for redundancy.

"What this means is that you can have multiple units (N+1) transmitting the same data in case of failure from multiple points," he said. "I can have my codec at the studio feed a CDN, say Akamai, or Amazon AWS cloud encoders, and my transmitter sites can look to those instead of a direct point-to-point to mitigate failures along the way in a standard 'internet-based' dependent setup," he said.

Believe me, VPNs are not difficult to set up today. The hardware has these little wizards; you just click the button and it does it.

— Alex Hartman, Optimized Media Group

"If those fail, the transmitter site units know to look to other sources for their data — much the same way streaming works, just 'closed circuit.' You can also do this in point-to-point fashion as well with offerings like the Worldcast SureStream, 'bit splice' from N+1 sources to mitigate any data loss. This can easily be done in software as well, not just hardware."

These systems may lend themselves to PtMP or point-to-multipoint systems, as from one studio feeding a satellite that supports hundreds of stations with the same data. "In a software-based solution, they could use local internet as a backup to the satellite, again using the technology above, should the satellite uplink fail for any reason without missing a beat."

On the other hand, software systems can be complex to set up and implement.

"You are the support for that," he said, "and this leads to the next point: Support can be nonexistent, or even 'abandonware.'"

There's little risk of that when you're dealing with established brands and manufacturers; but in other cases, "A lot of the stuff that's out there, the guy that beta'd it doesn't want to deal with it anymore." Security and buffering issues may also render certain software useless.

Asked about software options, Tom Hartnett of Comrex said the key element of pro-grade internet-based codecs is a proper balance between reliability and delay. "The listed options are designed to address one but not both of these factors," he said. "Also, keeping your STL off a Windows machine, or any PC in general, seems like a good approach to us."

Hans Van Zutphen said that at least at Thimeo, dropping support is "not gonna happen."

"We've spent multiple years on developing this. We're also working with other companies to implement it in their solutions. The whole idea is that this becomes a standard which is supported by many manufacturers." He also argues that dropouts happen in hardware as well as in software.

"The biggest challenge for any solution is to get all the packets through the network or networks — it doesn't really matter if you use hardware or software."

THE PROBLEM WITH ALL OF THEM

All parties seem to agree that security is a crucial consideration; Hartman calls it "the problem with all of them."

Best practice, if using a public internet or other non-direct link such as a T1 or microwave link, is to use a VPN appliance/router and ensure the link is obfuscated from the public world. Lest you think that's a big obstacle, Hartman said, "Believe me, VPNs are not difficult to set up today. The hardware has these little wizards; you just click the button and it does it."

VPNs though do add latency overhead due to their encryption. This can be an "X factor" for HD Radio or SFN delay settings you have to maintain.

But do change the default password even if you use a virtual private network. "A VPN obfuscates your link; it does not protect you from the program director bringing in an infected laptop." Don't use default passwords anywhere, even if you have a VPN.

There are more security concerns to track.

"Shodan.io knows about you and your equipment," Hartman said, referring to the search engine that lets users find types of computers connected to the internet. "Broadcasters have become the low-hanging fruit because we trust intrinsically all these devices.

"Default passwords and public IPs from poking holes in firewalls or foolishly assigning static public IP address to equipment leave you wide-open to having these guys come and play in your house. Hackers can take over your station, set off EAS machines, change hardware settings

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Data Transport Considerations for HD Radio™ Technology

by **Jeff Detweiler**, Broadcast Business Development, XPERI

As HD Radio™ technology has come of age, so too have the peripheral system technologies to support the digital radio ecosystem. Today, engineering managers have many data transport options that simply weren't available or cost effective a few years ago.

When HD Radio technology was first introduced, broadcasters had to cobble together disparate systems to accomplish the transport of analog and digital programming from the studio to the transmitter site. These early implementations offered no visibility into the time relationship between the analog and digital audio program paths. Today both RF and Telco based solutions are available offering the coherency needed between the analog program audio transport and the digital program IP path to maintain diversity delay alignment.

System Considerations

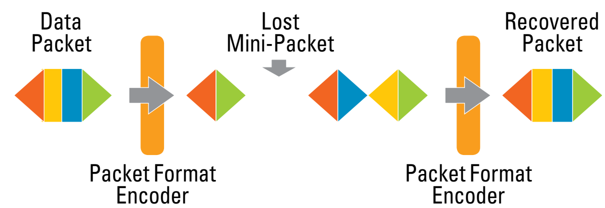
HD Radio transmission hardware is most stable when all components share a common time-base for synchronization. Typically, this is most readily accomplished by co-locating the Exporter and Exgine components. The Importer may be collocated with the Exporter and Exgine as well, but will require the multicast audio channels be delivered along with the main analog programming. If a station elects to place the Importer at the studio for the convenience of program delivery, it will require a bi-directional TCP/IP connection between the Importer and Exporter.

Many early implementations located the Importer and Exporter at the studio to reduce the payload burden on the STL. However, this configuration has two drawbacks: the challenge of common synchronization of the Exporter and Exgine and a high burst rate of data on the Exporter-to-Exgine (E2X) Link. The bulk of the HD Radio frame is sent in an initial burst at the beginning of the frame. This initial burst can contain nearly 20,000 bytes of data sourced at near wire speed. As this nature was understood, engineers deployed their networks with additional throughput apportioned to the E2X link to help mitigate loss. This was unfortunately expensive and usually didn't totally eliminate the problem.

If the deployment requires this split configuration of Exporter and Exgine, one should consider a link option that provides for the leveling and encapsulation of the E2X data. Moreover, it is suggested to independently GPS lock both the Exporter and Exgine to a GPS derived 10 MHz clock. This will minimize data loss as Exporter and Exgine are in theory locked to the same source. In practicality, no two independent clocks remain synchronized indefinitely and data will eventually be dropped affecting the diversity delay. Automated time-alignment products are worth considering as well if you are forced to implement with the Exporter and Exgine in separate locations.

Exporter-Exgine Interface with Distributed Data

Exporter to Exgine Interface with Distributed Data



Consideration for the Future

Digital radio is in a great position to become the backbone for one-to-many Connected Car and Internet of Things (IoT) data applications using the cost effective and secure distribution of the HD Radio broadcast. As one considers the total capacity of data transport links, give thought to scaling throughput to accommodate these future needs.

Many of the top-rated radio markets have HD Radio receiver penetration approaching 30%. Nearly half of all vehicle sales are now coming equipped with HD Radio technology. As these numbers continue to grow, so too does the importance of consistent digital program and availability. Hardware redundancy, path diversity and security should be topics for discussion as investigating these new data transport options.

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and lock you out of your own hardware. Or even worse — ask any accountant who doesn't want their checkbook seen — they can penetrate your network and give you a very very bad day."

The risks don't stop there. Hartman said broadcasters need to pay attention to RF hacking. "It's a real thing. Common SDRs are available for a couple hundred dollars, even one that you can use the RTL SDR that's 10 bucks on Amazon, that will let you in and sniff the air nearby, even miles away if you know what you're doing with a direction antenna, to decode passwords."

The WPA (WiFi-Protected Access) security standard was recently deemed to be insecure due to a protocol flaw. "It's broken; so everybody gets new WiFi devices."

He noted that wireless data product maker Ubiquiti uses a different modulation scheme called AirMax, which is harder but not impossible to break into.

MOM WAS RIGHT

Hartman emphasizes that as Mom told you, the world's a dangerous place.

"Nothing's perfect; nobody has it completely right. They're getting closer, but hackers will always have a bigger hammer than you. If they don't they will make one."

Also forget the idea of achieving "seven 9s" worth of uptime. "You'll never see it again, those days are gone."

Don't count on the phone companies, many of which don't even want to be phone companies anymore. "Here in Minnesota, the Public Utility Commission has allowed CenturyLink to not be a phone company; they can abandon the copper plant as early as 2019. So no more tariffs — and they love that because your price goes up and their margin goes up."

Backups only work if you test them regularly, he said. "Unplug things. Pull the Ethernet cable and see what happens and how fast it reacts. Test those redundancy connections. Unplug both of them; plug them both back in. What happens?

"You need to be prepared for the eventuality that things will fail."

IP STLs, Hartman concludes, can do a lot more than traditional systems of yesteryear. "This is the way of the world," he said. "But 1-2-3-4-5 is still a bad password for your luggage — and your transmitter. So go change those right now."

THE VIEW FROM THE HILL

As noted in the introduction to this eBook, Nautel conducted a webinar last fall on the topic of getting content to and from a transmitter site, and much of the information we've cited derives from that source. Nautel does not make STLs, but Regional Sales Manager Jeff Welton said engineers at the company enjoy working with such links. Also, if there's a problem with audio in an air chain, a transmitter company often gets the first support call, so it's helpful to educate users about the available options.

So given that engineers can choose among multiple technologies including microwave IP, digital UHF, hardware codecs and composite codecs, is there one approach that Nautel favors? Welton said no, it's about what is appropriate in a given situation. "The two things I look for if asked to make a recommendation are reliability and redundancy — if you have a lot of one, you can get by with a bit less of the other, so that also can affect the decision."

> *Between Facebook engineering groups, engineering email lists including the SBE Roundtable and the industry contacts we all make, there's a wealth of information at our fingertips that was not nearly so accessible even 10 years ago — don't be afraid to use it.*
>
> *— Jeff Welton, Nautel*

The creation of single-frequency FM networks does involve special STL considerations. What should broadcasters be asking?

"The biggest things are latency, or delay through the system; and dither, how much the delay varies from one moment to the next," Welton said.

"Latency can easily be accommodated when it comes to adjusting audio delay, but dither presents much larger challenges if it's more than a few samples or microseconds. Any variation of the phase of audio as received in two different places would have a direct impact in the location of the interference zone(s) in an SFN."

What about sending composite baseband at low bandwidth?

"At low bandwidth, one of the most important tools is to have a router that can assign QoS to specific signals," Welton said.

"For example, I have a customer with a low-bandwidth path who had discovered that whenever he accessed the AUI for his transmitter, his HD audio started hiccupping and dropping out — the AUI when loading is fairly bandwidth-intensive if unrestricted. Setting the router to provide top-level QoS to the path from Exporter to Exgine helped resolve this issue."

Always keep such considerations in mind, Welton said. Be sure that the signals in any specific network path are prioritized in some way. "Even on a high-bandwidth path, it's good to have this done ahead of time — in case, for example, your fiber suffers backhoe fade and you have to go to a backup path."

HD Radio secondary channels offer another twist, but Welton downplays their impact.

"They do add a bit to the bandwidth requirement; but again, setting QoS to prioritize an audio signal over, say, internet capabilities at the transmitter site is a good idea. In general, if I'm looking at an HD signal overall through a limited-bandwidth connection, I'd be more inclined to look at adding our NRHD package to help assure reliable transmission of the HD data," he said.

"As always, every situation is a bit different, with regards to what tools fit best and what infrastructure is available. Knowing that HD channels are present may have an impact on the overall configuration; that comes back to making sure that you've got all the information available to make the best decisions for your situation."

A WEALTH OF INFORMATION

So what's the takeaway to this entire discussion?

"The moral is that there are a lot of options for content delivery out there," Welton said. "It's important to look at each situation independently, rather than trying to assume a 'one size fits all' solution.

"In the station I co-engineer, with no line-of-sight from studio to transmitter, our best option turned out to be fiber end to end. Given the choice, an IP STL would have been preferable, since we're in a very RF quiet area, but a big ridge and height restrictions ruled that out," he said.

"In a more RF dense market, licensed vs. unlicensed for an IP STL would be a huge factor. I think the first thing is always to look at your specific situation — is there a clear path, what is the RF environment and (obviously) what's the budget available, along with how do we 'future proof' it?

"After that, make a list of the options available: licensed/unlicensed, WiFi, DSL, fiber, etc. Also look at existing infrastructure — sometimes changing something just because it can be changed may not add enough benefit to justify the cost."

Welton concludes by encouraging engineers to work with their manufacturers on any new project, especially an SFN, to see what they recommend and why.

"Don't be afraid to call their competitors and ask for second opinions, or to network with other engineers to see what's working in their specific situations. Between Facebook engineering groups, engineering email lists including the SBE Roundtable and the industry contacts we all make, there's a wealth of information at our fingertips that was not nearly so accessible even 10 years ago — don't be afraid to use it."

Ultimately, he said, the question to ask is always, "Will this benefit the station and/or the listener experience enough to validate the cost of doing it?" ■

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