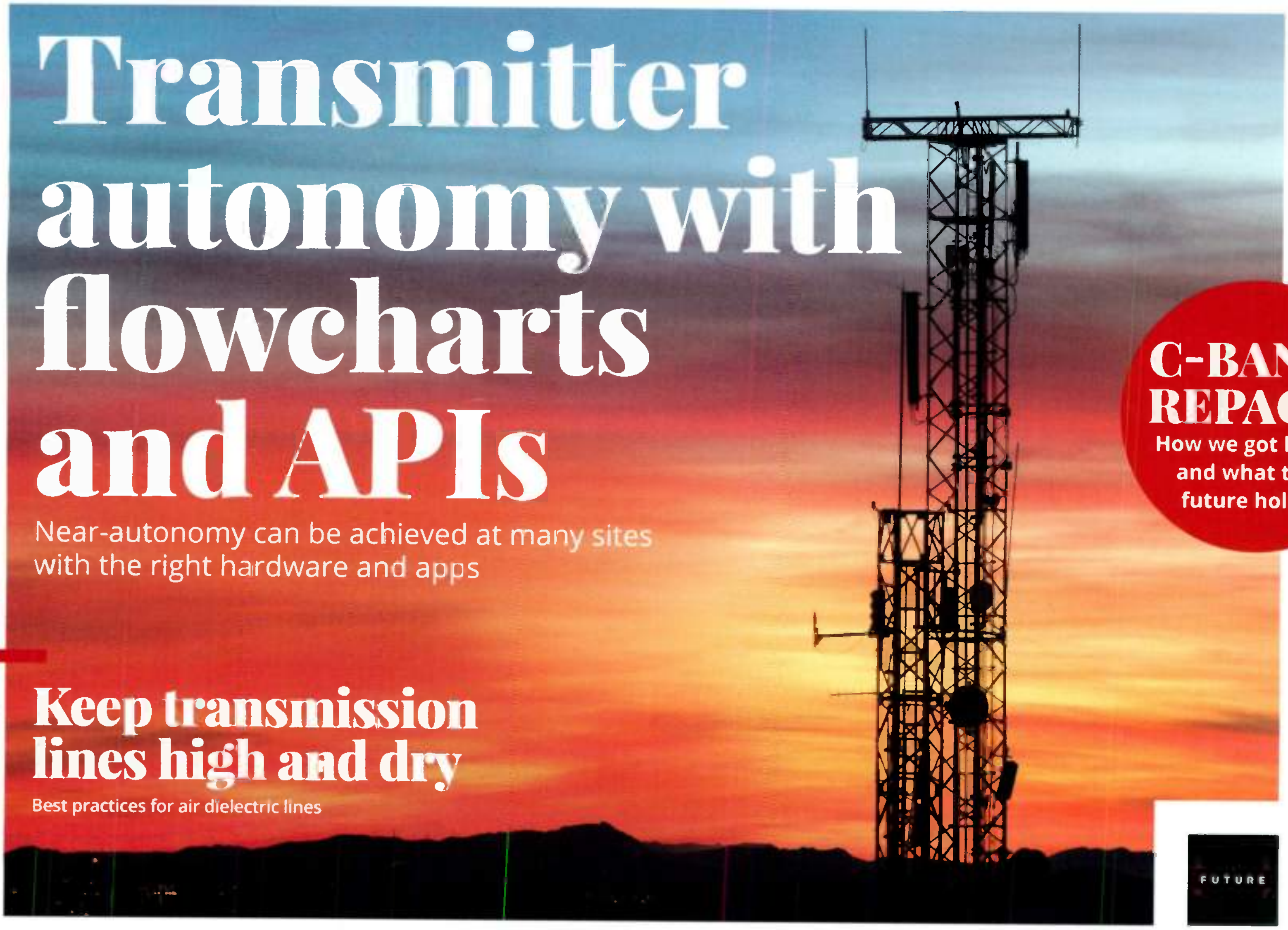
In-depth technology for radio engineers

radioworld.com | April 21 2021 | $5.00

RADIOWORLD engineering extra



Transmitter autonomy with flowcharts and APIs

Near-autonomy can be achieved at many sites with the right hardware and apps

Keep transmission lines high and dry

Best practices for air dielectric lines

FUTURE

RADIOWORLD
engineering extra

Vol. 45 No. 10 | April 21 2021
www.radioworld.com

FOLLOW US
www.twitter.com/radioworld_news
www.facebook.com/RadioWorldMagazine

CONTENT
Managing Director, Content & Editor in Chief Paul J. McLane, paul.mclane@futurenet.com, 845-414-6105
Senior Content Producer — Technology Brett Moss, brett.moss@futurenet.com
Technical Advisors Thomas R. McGinley, Doug Irwin
Technical Editor, RW Engineering Extra W.C. "Cris" Alexander
Contributors: Susan Ashworth, John Bisset, James Careless, Ken Deutsch, Mark Durenberger, Charles Fitch, Travis Gilmour, Donna Halper, Craig Johnston, Alan Jurison, Paul Kaminski, John Kean, Peter King, Larry Langford, Mark Lapidus, Jim Peck, Mark Persons, Stephen M. Poole, James O'Neal, Rich Rarey, Jeremy Ruck, John Schneider, Randy Stine, Tom Vernon, Jennifer Waits, Chris Wygal
Production Manager Nicole Schilling
Managing Design Director Nicole Cobban
Senior Design Directors Lisa McIntosh and Will Shum

ADVERTISING SALES
Senior Business Director & Publisher, Radio World
John Casey, john.casey@futurenet.com, 845-678-3839
Publisher, Radio World International
Raffaella Calabrese, raffaella.calabrese@futurenet.com, +39-320-891-1938

SUBSCRIBER CUSTOMER SERVICE
To subscribe, change your address, or check on your current account status, go to www.radioworld.com and click on Subscribe, email futureplc@computerfulfillment.com, call 888-266-5828, or write P.O. Box 282, Lowell, MA 01853.
Licensing/Reprints/Permissions
Radio World is available for licensing. Contact the Licensing team to discuss partnership opportunities.
Head of Print Licensing Rachel Shaw licensing@futurenet.com

MANAGEMENT
Senior Vice President, B2B Rick Stamberger
Chief Revenue Officer Mike Peralta
Vice President, Sales & Publishing, B2B Aaron Kern
Vice President, B2B Tech Group Carmel King
Vice President, Sales, B2B Tech Group Adam Goldstein
Head of Production US & UK Mark Constance
Head of Design Rodney Dive

FUTURE US, INC.
11 West 42nd Street, 15th Floor, New York, NY 10036

Radio World (ISSN: 0274-8541) is published bi-weekly with additional issues in February, April, June, August, October and December by Future US, Inc., 11 West 42nd Street, 15th Floor, New York, NY 10036-8002. Phone: (703) 852-4600, Fax: (703) 852-4583. Periodicals postage rates are paid at New York, NY and additional mailing offices. POSTMASTER: Send address changes to Radio World, P.O. Box 282, Lowell, MA 01853.

A trip down remote control lane

Remote control systems and technology have come a long, long way

Cris Alexander
Tech Editor
and director of engineering at Crawford Broadcasting

Comment on this or any story. Email *rweetech@gmail.com.*

Remote control systems have come a long way in my 45-year broadcast engineering career.

There was a time when you could call the phone company and order a "dry pair" from point to point, and over that dry pair you could connect your remote control system with its telephone dial, stepper relays and DC metering.

Those old systems were always interesting, especially when the steppers got out of sync, but somehow they got the job done.

Then came the Moseley TRC-15 types that used audio tones for telemetry. We could use those over a dry pair or just about any bidirectional telco circuit, or you could use them over a subcarrier on an STL for the outbound control functions (if I recall correctly, this used a 300-400 Hz FSK scheme for the wireline version).

Some folks used an over-the-air SCA for telemetry backhaul for the TRC-15 — if you couldn't get a reading on *anything*, the transmitter must be off! — but others used telemetry return links on one of eight discrete 450/455 MHz frequencies designated for such by the FCC. And there were no status indications.

But all in all, the TRC-15 was a huge step up (no pun intended) from the old stepper relay DC remote control systems. It was an even better platform if you installed the digital telemetry adaptor offered as an aftermarket add-on from Hallikainen and Friends.

Up in smoke

There were some digital systems from Moseley that came after the TRC-15. I remember using them in some of the TV stations at which I worked. The red LED digital readouts took away the sometimes difficult task of meter scale

THIS ISSUE

interpretation and interpolation, always a plus with busy master control operators!

Then in the early 1980s came the MRC-1600, a 16-channel digital remote control with status.

The old TRC-15 didn't seem to care much about lightning, but that MRC would go up in smoke every time the sky got cloudy, or so it seemed. I remember that the display would say OUCH! if an input channel got hit with too much voltage or if one of the multiplexers was damaged.

That sensitivity to static discharges bit me one time, too. It was always a challenge to remember to take the R/C out of "local" and put it back in remote when leaving a transmitter site. One TV station at which I worked had a red 60-watt light bulb in a porcelain socket right next to the door, and that bulb would be lit whenever the remote control system was in "local." That saved a lot of midnight trips back to the tower site.

I wanted something similar at one radio site I took care of, so I thought I would put the NC contacts of the local/remote relay in series with the alarm system door contact — it would then be impossible to set the alarm with the remote control in the "local" mode.

That worked great until the next thunderstorm. The MRC lost its mind (OUCH!) and opened that local/remote relay and set off the burglar alarm.

It was a long drive to that tower site at "Cadaver Creek" in stormy weather with the alarm wailing and the police on the way.

Talking control

In the late 1980s, Gentner Engineering came out with the VRC-1000, a revolutionary new "talking" remote control system that worked over a dial-up phone line.

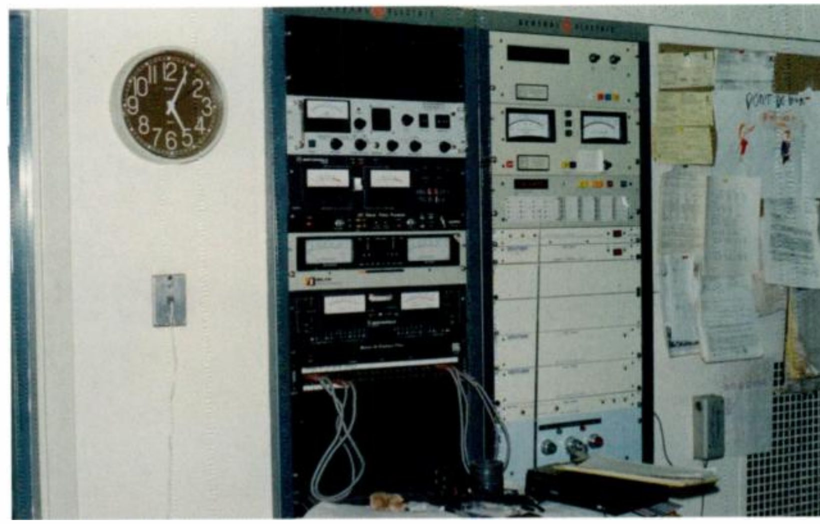
That changed everything for radio stations. No longer would they need an expensive dedicated line or dry pair for remote control, or a fussy, interference-prone telemetry return link that would blank out whenever a cab driver passed by the studio while talking on his dispatch radio.

The early vocabulary was limited, but we made it work. And the best part was that the unit would call us when something went wrong. Programming was a chore, but it was just so … cool … that we didn't care!

Later iterations of the Gentner VRC (and Burk GSC) had improved vocabulary and other capabilities, and some of these units are still in service today.

If memory serves, Gentner came out with a "sample and hold" system to interface its VRC-series systems to analog antenna monitors, and that worked pretty well except right after pattern change — you had to wait for the next sample to get an accurate set of readings.

Potomac Instruments came out with a pretty good and capable system in the late 1980s. Interfacing remote control systems to analog antenna monitors was always a difficult task, and the Potomac RC16+ had a means of doing



Top
A Gentner VRC-1000 "talker" is visible in the right rack bay. When that model came out, we thought we'd gone to radio heaven.

Above
This IP-based remote control is not the latest-greatest model from Burk but remains very capable.

that, using a scan function to constantly monitor operating parameters.

The thing that probably kept the unit from greater popularity was that it could not be programmed in the field. Need to make a change? Fill out this form and we'll burn and ship you a new EPROM.

That worked, but it was anything but convenient, and it certainly discouraged programming changes. Still, it was a rugged, reliable system.

IP all the way

The name Burk became synonymous with "remote control" in the mid-1990s, and that remains the case today.

The first Burk systems I used were ARC-16s, and they were good, rugged, reliable units that could be configured as stand-alone dial-up, dedicated studio/transmitter pairs of a combination.

These systems had RS232 capability, and you could purchase an IP-to-RS232 adaptor to link your units together over a network or even the internet. Multiple sites could be linked, a popular feature in the age of consolidation. There are a lot of ARC-16 systems still out there in service, and for good reason.

Which brings us to today and the ARC Plus and ARC Plus Touch systems, which are nothing short of amazing. These units use IP connectivity all the way, and the ARC Plus Touch has SNMP and API capability.

In our company, the last few transmitter installations we have done where we had a Touch system in place did not use so much as an "RF On/Off" wire connecting transmitter to remote control — everything was done by SNMP. Which

Further reading

For more on this topic, see "Remote Controls Have a History All Their Own" at *radioworld.com,* search "remote controls."

I should say can be a bit like drinking from a fire hose with some equipment interfaces — there are so many parameters available to monitor.

I should not fail to mention systems by Sine Systems, Broadcast Tools and others that provide a bridge between technologies and an excellent means for stations with limited resources to avail themselves of many of the features of much more expensive systems. I have used some of these systems in niche applications even within larger operations and found them very useful.

Today's remote control systems, along with companion software, can do a lot of things. Many can run scripts and macros that can make decisions. You can make the logic as simple or complex as you wish using IF/THEN statements and AND/OR Boolean operators. Actions can be scheduled based on a calendar/clock, or they can be triggered by some external input or event, even taking input from external off-site data over the internet. They can blow up our phones or drive us nuts with texts and emails. I love the mobile web page displays of some remote controls, where I program things green-good/red-bad. A busy operator or engineer can tell at a glance if all is well.

> **"I remember that the display would say OUCH! if an input channel got hit with too much voltage."**

One of the best macros that one of our engineers uses sends a text to her phone every 10 minutes whenever the remote control system is in the "maintenance" mode (the modern version of the "local" mode). That ensures that she won't get more than 10 minutes down the road before she realizes she forgot to turn that off before leaving.

Not once since implementing this macro has she had to make an emergency run to a site at pattern change time when the pattern couldn't change because the command relays were disabled! And not once has this set off the burglar alarm at a site!

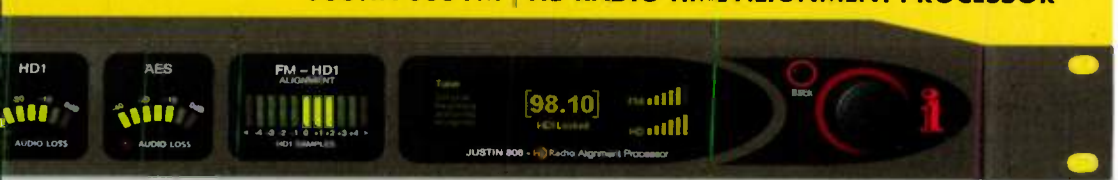
In this day and age of ultra-capable remote control systems, our transmitter sites can be almost completely autonomous, which translates to fewer of the time pressures that often accompany equipment malfunctions. Such a remote control system can react to the failure, look at multiple variables and make decisions that will get the station back operating again in less time that it would take the engineer to answer his or her phone. That's worth something.

INOVONICS SUPPORTS HD Radio WITH

UNIQUE SOLUTIONS

THE LARGEST PORTFOLIO OF HD RADIO PRODUCTS IN THE RADIO BROADCAST INDUSTRY

JUSTIN 808 FM | HD RADIO TIME ALIGNMENT PROCESSOR



100% Automatic to Within +/- 1 Sample

Precise time alignment between analog FM and HD1, Dynamic Web interface, SMS/email alarms, Data logging with graphic display.

719 DAVID IV FM | HD RADIO AUDIO PROCESSOR

Sophisticated Sound

Ultra low latency, DSP design; 5 bands of dynamic range compression and "graphic-EQ", 25 factory and 20 customizable presets, Stereo-Gen with RDS metering, easy setup and control.

AARON 655 FM | HD REBROADCAST TRANSLATOR RECEIVER

Combines Multiple Processes in a Single Box

DSP-based FM/HD Radio Receiver, Audio Processor, Dynamic RDS Encoder, and Streaming

SOFIA 568HD RADIO SITESTREAMER+™

Critical Remote Monitoring

- Displays HD Radio graphics
- Off-air outputs: Analog, AES Digital, AES67 AoIP
- Internet stream for 10 listeners
- Alarms & Notifications.

679 FM | HD RADIO MONITOR RECEIVER & 638 FM | HD RADIO SITESTREAMER

Compact and Agile

Inomini products provide powerful monitoring in reduced size & cost

INOmini 639
- Professional off-air monitoring
- Analog L/R & AES outputs
- Alarms

INOmini 638
- Remote Monitoring Via Web
- Streaming on-line
- Alarms & Notifications

www.inovonicsbroadcast.com | sales@inovonicsbroadcast.com | 831-458-0522

WHY INOVONICS?
- Quality Solutions. Competitive Prices.
- Quick to install. Easy to Program
- Three-year Factory Warranty.
- Quality after sales service.

INOVONICS BROADCAST

Jose A. Bernat Bacete/Getty Images

Writer
Peter Burk
president of Burk Technology

Transmitter autonomy with flowcharts and APIs

Near-autonomy can be achieved at many sites with the right hardware and apps

No one likes the 3 a.m. calls from the transmitter site. Even if you can fix the problem from home, it still is an unwelcome intrusion.

Instead, imagine waking up after a good night's sleep and reading a reassuring note from your transmitter site that all is well.

That's where autonomy comes in. It's the ability for the transmitter site to circumvent faults even if the control link is down.

Through autonomy, each site becomes an island of reliability.

Plan for autonomy

Planning an autonomous site starts with predicting the measurable things that might signal the need for action.

If you've been at the site for a while, you know what conditions have dragged you out of bed. At the top of the list you might include loss of carrier, loss of AC power, silence and high VSWR.

Setting alarms to detect these conditions needs to be done thoughtfully. An alarm is pointless if there is nothing you can do about it. Setting a high outdoor temperature limit is only useful if you need the information to cause a specific action.

Set your thresholds wide enough to avoid nuisance alarms. If your AC line voltage sags on Monday morning allow for it in your trip points.

Be aware of the source of the alarms on which you will depend. An SNMP fault indication from a transmitter will never occur if the transmitter doesn't have power. It is better to have external indications of failure where

possible. In this case, an RF Power Sensor connected to a directional coupler in the transmission line is preferred where available.

Alarm hierarchies

Obviously, if there is no AC power, banging on the transmitter ON button won't do any good. Similarly, silence sense is meaningless if there is no carrier. AutoPilot alarm relationships as shown in Fig. 1 can be used to suppress alarm reporting for subordinate alarms, rolling them up into the root cause alarm. Still, they must be considered within the fault monitoring functions.

Alarm Relationships

Close

Network	Site	Alarm Type	Channel	Pre-Alarm Window (sec)	Post-Alarm Window (sec)
ARC Plus Network 1	WDHH	Status	AC POWER LOSS / AC POWER OK	N/A	N/A
ARC Plus Network 1	WDHH	Meter Low Critical	UTIL V	10	10
ARC Plus Network 1	WDHH	Status	SILENCE / AUDIO OK	10	10
ARC Plus Network 1	WDHH	Meter Low Critical	STL RX	10	10
ARC Plus Network 1	WDHH	Status	PPM LOSS / PPM OK	10	10

Above
Fig. 1: AutoPilot Alarm Relationship Table showing four subordinate alarms.

Jet Active Flowcharts

Using carrier loss as an example, a status alarm can trigger the recovery function. Using Burk AutoPilot with Jet Active Flowcharts, your carrier loss recovery function might look like Fig. 2 on page 14.

Note the use of frequent messages to the log. These are very useful for debugging if something doesn't work the way you expected.

Preventing Emergencies

Autonomy requires diligent routine maintenance. Monitoring with an eye toward heading off trouble can save a lot of unscheduled trips to the transmitter by focusing attention on potential sources for degrading performance.

Virtual channels help spot issues before they take you off the air. They can include calculations from other channels to synthesize a new channel.

Simply subtracting the temperature at the input to the transmitter cabinet from the exhaust temperature gives you an early warning that there is something to look for on the next routine visit. A change could indicate something as simple as a clogged air filter or a mistuned amplifier, but almost any important change in the health of the transmitter will affect this reading. An ARC Plus virtual channel can be set up to alarm when the delta-T changes.

> **“Backup audio over a second path is great, but even a USB stick with appropriate tracks is better than dead air.”**

If you have more than one fan in the transmitter, put a temperature probe in front of the exhaust of each one. Use a virtual channel to watch for a change in temperature between the two and set it to alarm if the delta increases. A failed fan will show up quickly.

Autonomy includes more than the transmitter and associated equipment. Consider what would happen if the HVAC stopped working. Check for degraded performance by measuring the temperature at the output and compare that over time with readings at a similar ambient temperature. This can be automated with virtual channels.

You can also assign an elapsed time channel that you reset each time you change the filter. Admittedly a high-tech solution for a low-tech problem, but for some of us, more likely to get noticed.

Troubleshooting autonomous sites

Despite your best efforts, there will always be failures for which there is no automatic response.

This is where you would like to have a little more information before you get behind the windshield. If the carrier is off or there is no power at the site, you know where to go, but for audio problems a lot of time can be lost driving to the wrong site.

Consider connecting some "leaving here OK" metering at the studio or other program source and something at the transmitter that tells you that the signal entered the building. These can be silence sense units connected to the remote control at each location or SNMP from the audio gear at both ends brought into the remote control.

Backups and spares

Sometimes it may seem like you have backups for everything except what just failed. Radio is a business, and as such there are finite limits on how much redundancy makes sense. Whatever your constraints, plan for the possible failure of each piece of critical equipment.

An auxiliary transmitter should be high on the list, but if it is out of the question, work with the transmitter manufacturer to be sure you have spares for components prone to failure.

If you do have an aux, make sure it is tested regularly. This is easily automated with a flowchart that runs once a week or once a month.

Good, better, and then there is Best !!!

APEX is the most powerful and flexible radio automation system in the world, the ultimate solution for any application. Whether you are a small Internet station, or a large multi-station group, APEX has all you need, at an affordable price. Join the thousands who have chosen Arrakis for their On air automation.

Easily supports One to Ten stations...
APEX can be just a single PC or easily supports up to 10 on Air PC studios with all Air, scheduling, and reporting. Record your voice tracks, change your schedules, or manage all of your audio libraries from anywhere that you have wide band internet. Have audio files that you want to go to only one station? It'll do that. Or maybe you want a handful of files to go to 3 of your 10 stations. No problem. Powerful and versatile and easy to operate.

Custom user profiles...
The live (on-air) screen gives you complete control of how it looks. Resize, and map any module to your exact preference, and then save a special user profile for every on air personality. Easy to use and yet scales to meet your needs.

APEX
radio automation

www.arrakis-systems.com 970-461-0730

GSX...Ready To Fly

Cost Effective – The power of LXE, trimmed down, ready to go
Turnkey – Preconfigured buttons, knobs & faders
Options – Add ScreenBuilder, ConsoleBuilder, Layers, Automix, & more

wheatstone.com/gsx-rw20B

BLADE-4 COMPATIBLE

Wheatstone
BROADCAST AUDIO PERFECTIONISTS®

Backup audio over a second path is great, but if that's not possible, at least have a backup source of audio at the transmitter. Even a USB stick with appropriate tracks is better than dead air. It is best to duplicate as much of the audio chain as possible, so you don't have to switch multiple inputs to get on the backup.

Introduction to APIs

Traditional remote control was based on GPIO (general purpose input/output), which allowed the inclusion of sources that were reachable with a pair of wires. SNMP extends the reach without wires, but isn't universal.

APIs (Application Programming Interfaces) are the currently hip way to get data from one device to another. They aren't new. Salesforce famously got APIs off the ground in 2000. If you are curious, Wikipedia is a good place to learn more.

The Burk REST API provides external access to meter, status, command and macro channels, expanding the reach of the ARC Plus system to include data available on the web, a PC or IoT devices.

APIs expose the parts of a program or product that would be useful for interconnection. Two or more APIs are connected using what are commonly called "mashups." A PC runs the APIs, delivering data to the ARC Plus and routing commands and readings from the ARC Plus. A listing of about 24,000 APIs is available in the API directory at ProgrammableWeb.com.

Custom applications can be written in any script or programming language that supports HTTP GET and POST commands. The ARC Plus REST API works seamlessly alongside traditional GPIO and SNMP channels. For details, contact Matt Leland at *sales@burk.com* for the free API Tech Bulletin.

APIs as meter or status inputs

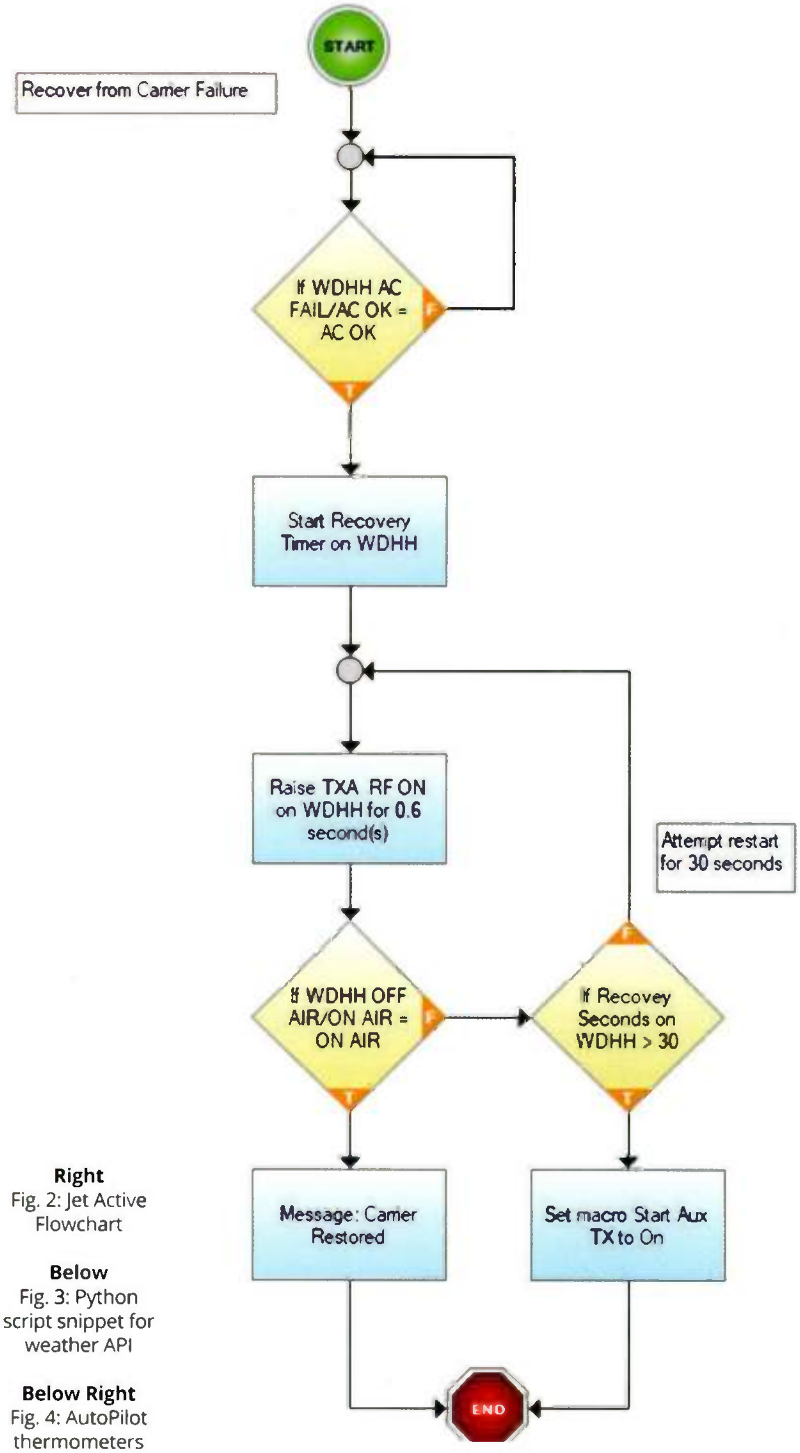
An autonomous transmitter site benefits from inputs available on the web.

Weather is the most obvious example. Rather than installing and maintaining a weather station at the transmitter site, you can monitor current conditions using one of the many weather APIs.

Each measured parameter is sent to an ARC Plus channel using a small script that runs on a PC. The PC needs access to the internet and ARC Plus but doesn't need to be co-located.

Fig. 3 shows a portion of a Python script that feeds data to the three AutoPilot thermometers shown in Fig. 4.

While the view of the data is of value, more important to our autonomy is the ability to use this data to make decisions. For example,



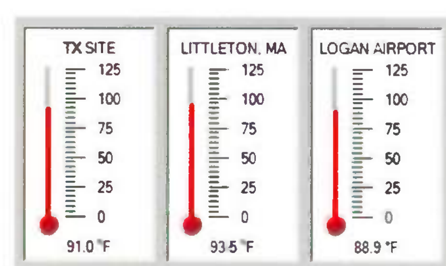
Right
Fig. 2: Jet Active Flowchart

Below
Fig. 3: Python script snippet for weather API

Below Right
Fig. 4: AutoPilot thermometers driven by API

```
# Read the current temperature in Littleton
txAmbF = weather.GetWeatherTemperature("Lat=42.6,Lon=-71.6")
littletonF = weather.GetWeatherTemperature("Littleton,MA,US")
loganF = weather.GetWeatherTemperature("Boston,MA,US")

# Store the value into the ARC Plus
arcPlus.SetMeter(1, txAmbF)
arcPlus.SetMeter(2, littletonF)
arcPlus.SetMeter(2, loganF)
```



```
C:\Test>curl "10.10.0.96/api.cgi?action=meter&token=dN70Z3jc9ieD0S5R&channel=1"
{
"result":"success",
"meter": [
{
"channel":1,
"online":true,
"name":"Temp",
"value":85.099998,
"units":"F"}]}
C:\Test>_
```

Above
Fig. 5: API call to an ARC Plus from the command line

automatically shut down the air conditioner to prevent freeze up at low temp, start deicers as temperature nears freezing, or predict condensation by comparing dew point with ambient temperature.

APIs as outputs and commands

Command APIs give you the powerful ability to bring non-traditional devices under autonomous control. Most IoT devices have user-friendly APIs so making your smart home devices or even Alexa part of your plan is completely feasible. You likely would avoid consumer devices in the broadcast chain, but for items that are not mission-critical, there are many that are easily integrated.

Getting data out of the remote control and into the PC is straightforward with APIs. Fig. 5 shows a command line result. Typically, this result would be parsed in a script and the desired data would be used as an argument of an API call to an external device.

Looking ahead

A look into the crystal ball sees artificial intelligence as a goal. Reducing trips to the transmitter sites is an aim for most major broadcasters, and not being off the air is even more important.

By keeping data on how the equipment performs at a particular site, it is reasonable to assume that we will eventually be able to generate reliable data that tells us when to repair or replace a particular piece of gear. We really have a lot of that information already, but it still depends on human interpretation. Machine learning will help us develop the most efficient ways to operate our equipment with less human intervention.

On a wider scale, data from multiple sites can be compared and analyzed to spot trends. Manufacturers of broadcast equipment are already moving in this direction, but the ability to apply the concept across an entire plant is still to be accomplished. Some of the correlations might not be obvious but we will learn to trust the data. Expect major advances in the next decade.

RFHAWKEYE - The Game Changer Solution for RF Transmission System Monitoring

The solution, based on real-time TDR-like mode, detects and locates local changes in VSWR with 8 inches accuracy allowing operators to apply corrective actions in preventing antennas failures and downtimes.

1 INTRODUCTION – WHY MONITORING IS NEEDED

As any broadcast operator knows, the major RF components outside the transmitter building – the transmission line and the antenna – are not only critical and essential in the signal transmission chain, they are also very expensive to acquire, to install and, most importantly, to repair, typically requiring skilled riggers and specialized equipment. Even though these RF components are robustly designed for unattended operation in all environments, problems can occur. Consider that a failure in the line or antenna can interrupt the broadcast service to millions of end users until the problem can be identified, located and repaired – all at significant cost to the broadcaster. It is then, perhaps, somewhat surprising that the monitoring of the condition of the line and antenna has generally been left to a reflected power or VSWR circuit in the broadcast transmitter. Such protection does protect the transmitter, but it has been unable to prevent many examples of spectacular failures of line and/or antenna components, resulting in catastrophic damage and significant off-air time. It is clear therefore that the broadcast industry is long overdue for an effective and reliable monitoring system that can identify potentially damaging anomalies early, thus minimizing downtime and protecting the operator's investment by preventing catastrophic damage.

2 WHAT MONITORING IS AVAILABLE AND ITS PROS AND CONS

As noted above, for many years the only monitoring, and therefore protection, of the RF line and antenna was provided in the transmitter by way of directional couplers and observation of reflected power (typically, although some transmitters do calculate system VSWR, providing better monitoring). The alarm levels were generally set to protect the amplifying devices in the transmitter and allowed wide variations in reflected power with no logical indication of degradation of individual RF components. Further, these methods can only measure the resultant reflected power or VSWR of the entire system at the coupler position, providing no indication of the presence of the multiple reflections along the line, caused by insulators, transformers, elbows, gas barriers and so on, as well as by the antenna. In many cases, by the time the transmitter protection activates, the damage has already occurred with no information provided on the location of the fault or the extent of the damage – not much help for the troubleshooting phase! In some cases the damage is occurring and the protection does not even activate. Regardless, that troubleshooting requires a skilled RF engineer, using a network analyzer, working in parallel with skilled riggers to even identify the source of the problem before corrective action can be defined and then deployed. Even if the observant transmitter engineer has noted some anomalous VSWR behavior before the transmitter faults, the RF engineer still has to shut-down the transmitter and break apart the line at a suitable point before looking to identify the source of the anomaly – which may disappear as the system cools.

VSWR/RL Degradation Chart

More sophisticated systems, deployed recently, install VSWR sensors in multiple locations in the transmission system, including at the antenna input and the base of the vertical line run, thus introducing the possibility to localize the faults by correlating measurements taken at different points in the system. Note that these systems are in addition to, and independent of, the transmitter monitoring, although some level of integration is generally possible.

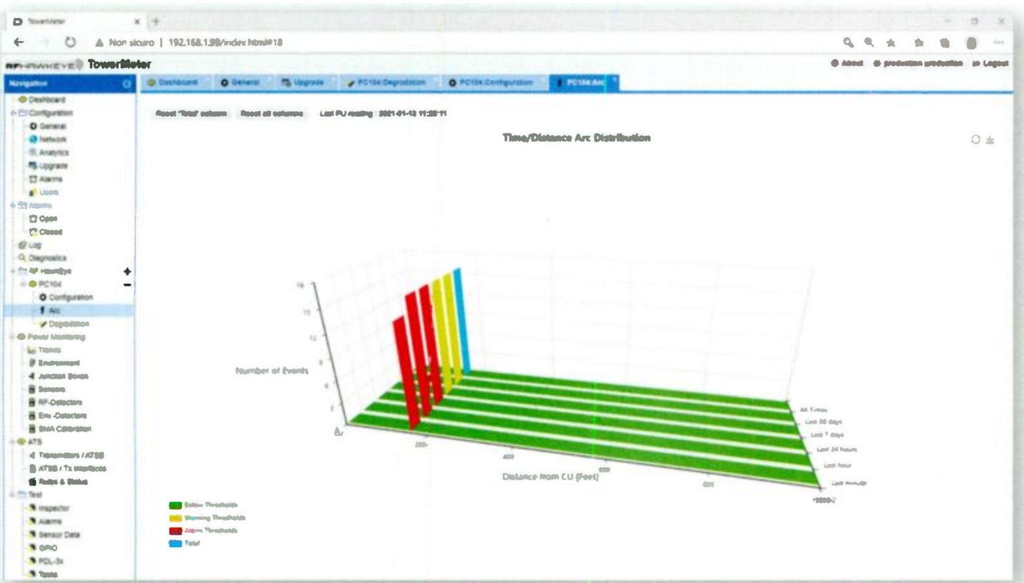
A different approach - a system with the capability of detecting and even localizing arcs in the line– has also appeared in the market recently. Although information of the occurrence and position of arcs is definitely valuable in troubleshooting, this information is provided after the degradation has deteriorated to the point of voltage breakdown. Damage to components will likely already have occurred requiring emergency action. Such a system may, however, limit the extent of the damage to the RF system if the operator reacts accordingly.

In general, all the mentioned systems share a common limitation: they are reactive i.e. a significant degradation has already occurred before the monitoring system provides an indication of the problem. Systems relying on arc detection will likely miss the small degradations in components or connections that have to occur before an arc develops. In other words, the arc is not an early indication of a deteriorating issue, but just the evidence of an issue that has been deteriorating over some time to the point of voltage breakdown.

3 WHY RFHAWKEYE?

There is a better solution – real-time monitoring of all components of the line and antenna system that can localize small changes in VSWR. RFHAWKEYE (RFH) is such a system. By monitoring the line in real-time TDR-like mode, it can detect and locate local changes in VSWR or Return Loss (RL) with a sensitivity far surpassing that of overall system VSWR detectors, also identifying when and where a potentially catastrophic arc has occurred. With 8 inch accuracy, RFH can monitor the detailed behavior of the system, identifying each single connector or elbow in the line, and identifying changes as low as 1.004:1, much earlier than would be visible in the overall VSWR. Thresholds can be set to generate warnings and alarms if the VSWR at a particular location (or locations) varies beyond acceptable limits. The operator or monitoring service can then determine if corrective action should be taken immediately, before the situation deteriorates, or whether inspection can be scheduled later.

Analysis of multiple transmission line failures, in which evidence of catastrophic voltage breakdown (arcing) was found, indicates that the arcing was not the initial failure – the arcing occurs as result of deterioration of other components through a variety of mechanisms – all of which will show up as a deterioration in VSWR before the catastrophic arcing occurs. Since, in the majority of instances, the transmitter itself is not damaged, this confirms that most, if not all, current protection systems protect the transmitter - not the transmission line and other RF components i.e. the transmitter protection may well "see" the catastrophic arcing and shut down with no indication to the operator of what actually occurred. RFH has been developed to provide operators with advance warning of the development of problems in transmission line and antenna components, such that catastrophic voltage breakdown and damage does not occur. However, since the rate and magnitude of degradation will likely be different in each case, depending on the nature of the degradation, the power level, the environment and so on, it is conceivable that a rapidly deteriorating event can occur and an operator cannot intervene on time. RFH can also identify the characteristic signature of an actual arc and display the location of that arc. As will be shown later,



Arcs Chart

an arc was simulated by introducing a probe into a section of transmission line causing an increase in VSWR at the probe location well before the voltage breakdown of the arc occurs. RFH will capture and display both the degradation leading to the arc and the characteristic signature of the arc.

Executing a continuous in-service TDR-like measurement not only enables the early detection, but also determines the exact position, of anomalies thus providing valuable, time-saving information for the rigging crew to confirm and perform necessary repairs.

The RFH system uses Internet Protocol (IP) and can be readily integrated into the operator's network, or that of a remote monitoring service, allowing the view of system status and sending timely notifications of detrimental system condition to all the relevant key people. Forward and Reflected power monitoring at the RFH coupler is integrated within RFHAWKEYE, providing rapid indication of whether the anomaly is in the antenna or the transmission line.

RFHAWKEYE is independent of the transmission system used, works with ATSC 1.0, ATSC 3.0, FM, DVBT-xx, and others.

4 EXAMPLES

4.1 TYPICAL CASE OF DEGRADATION

Consider a fully installed system with the reflection measured by a detector at the input of the transmission line reading overall Return Loss (RL) = -33dB (or VSWR of 1.046:1). This is very good. But this system value of 33dB is the result of the combination of multiple reflections from transmission line components such as Teflon insulators, flanges, elbows, transformers and gas-barriers, and each of them could be around -50dB (1.006:1). Now suppose that, for some reason, one of the Teflon insulators or bullets undergoes a minor degradation at, say, 760ft. Its RL jumps from -50 to -45 dB (1.011:1). This will have virtually no impact on the broadcast system operation - it is not a major change in overall VSWR measurement. The station will still be working perfectly and the detector value at the input will go to maybe -32.2dB (1.05:1), a 1.004:1 change. The change would most likely go unnoticed – the resolution of most VSWR or RL monitoring in use today simply won't show the change. However, RFHAWKEYE will show the magnitude and location of this change. Perhaps the change is cyclical and of no concern or perhaps the change is the first indication of the degradation of an insulator or bullet – which will only get worse. With RFHAWKEYE, the operator has been warned: "There is a change from 1.006:1 to 1.011:1 at 760ft". This change, along with any others, can now be tracked and, if it gets worse, corrective action can be initiated before a failure occurs.

4.2 FAULTY INSTALLATION

Now consider that, during installation of a transmission line, one or more connectors is not assembled properly or is contaminated. The contamination is minor and the normal system tests before operation do not raise a warning flag. Then RF power is applied and the contamination, or poor connection, starts heating up starting a potentially slow downward spiral of damage starting at the connector but progressing back towards the transmitter. RFHAWKEYE would "see" the small changes of the VSWR at the connector and would send out a warning and eventually an alarm before the connector is fully deteriorated or arcing has occurred. As mentioned in example 1, the transmitter monitoring or any other available monitoring system would most likely not react at the onset of the issue, potentially resulting in catastrophic and extensive damage to the line.

5 CONCLUSIONS

RFHAWKEYE moves the monitoring of broadcast transmission systems from a reactive mode to a proactive mode enabling better protection of the transmission system as well as increasing the overall reliability and safety of the site.

Monitoring of the entire RF transmission system 24/7 at full RF power, using RFHAWKEYE, can warn the operator of locations of small changes and send warnings and alarms when the changes exceed the thresholds, but before they could cause extensive damage. It provides historical data on the system condition allowing trends to be identified without the need for a visit by a technician to sweep the line and verify normal operation or, in the case of an alarm, determine where the issue is located thus reducing maintenance and/or repair costs and off-air time.

RFHAWKEYE is a monitoring system which operates independently of the broadcast standard in use, thus providing broadcasters with valuable information on, and protection of, their RF systems long into the future.

AUTHORS

Andre Skalina, *VP Technology*, Dielectric
Andy Whiteside, *President*, Dielectric
Daniel Glavin, *Electrical Engineer*, Dielectric
George Klauser, *Senior Broadcast Consultant - Former Kathrein CTO*
Paolo Delmastro, *CTO*, DAC System SA

Writer
Mark Johnson
CSRE
President, LinkUp Communications

The C-band repack

How we got here, where we are, and what the future holds for broadcasters

Nothing has gripped the attention of radio and television engineers and management like the FCC's mandated C-band repack. For over three years, the idea of 5G co-sharing the coveted mid-band spectrum has been speeding along, directed by Congress in the 5G Spectrum Act of 2019 and the Beat CHINA for 5G Act of 2020 to open the mid-band (or C-band) to mobile broadband.

Now the real work begins. If you're a broadcaster in one of the major markets who registered your antennas with the FCC but chose to opt-out of the all-expenses-paid mid-band spectrum repack, you need to develop a strong plan in 2021 to tackle the C-band transition at your downlinks.

How we got here

The use of C-band for radio, television and cable content delivery began nearly 50 years ago.

In fact, HBO became the first television channel in the world to begin transmitting via satellite — expanding the growing regional pay service into a national television network — in September 1975. National Public Radio and the Mutual Radio Network quickly followed, beginning their own distribution by satellite in 1979.

Below
Mark Johnson and the team at LinkUp use high-quality satellite meters and spectrum analyzers to document the performance of downlinks and 5G filters.

Prior to satellite delivery, every network affiliate, television and radio station had to maintain equalized lines from AT&T for every network source, costing broadcasters hundreds of dollars per month. With the introduction of satellite, operating costs plummeted with the elimination of monthly phone line costs by affiliates.

Another key to the C-band spectrum's popularity is its resistance to adverse weather. With a reliability of an unheard of 99.99%, coupled with extreme cost savings, C-band quickly became the critical link for radio and television programming in all 50 states and around the world.

Government involvement

As early as 2016, Congress began pushing the Federal Communications Commission to repurpose bandwidth for mobile broadband, with apparently little to no regard for the current users of the bandwidth. Like the broadcast industry, mobile broadband companies wanted to lay claim to the mid-band spectrum for its effectiveness — specifically its line-of-sight reliability in poor weather.

Their goal: to gain 500 MHz of bandwidth from 3.5 GHz to 4.0 GHz.

After noting both the desires of the broadband industry and the singular focus of Capitol Hill, satellite industry leaders SES, Intelsat and Telesat decided to form an association to promote an industry-backed solution and auction in order to share the spectrum. The C-band Alliance, or CBA, began a multi-dimensional operation to preserve C-band distribution, while making room for 5G mobile broadband usage.

A discrepancy in numbers

Misinformation about the significance of C-band delivered content to the broadcast industry and others fueled Congress and the FCC's push for 5G to gain access to the C-band spectrum. It was assumed by the FCC there were only roughly a thousand C-band users throughout the U.S., because that was the number of actual registered downlinks with the FCC.

Yet both the CBA and the broadcast community agreed that the numbers were actually much larger. Why the discrepancy? In the 1980s, AT&T began to decommission 4 GHz point-to-point microwave links, making C-band downlink registration and frequency protection superfluous.

In an effort to get a clear picture of the number of actual C-band downlinks in the country, the FCC conducted a registration drive in 2018, asking owners to register their downlinks and pay a $450 per antenna processing fee.

Since paying the fee was a stumbling block for C-band downlink users registering multiple sites, the CBA pushed the FCC to waive it. When the FCC refused, SES stepped in and reimbursed thousands of downlink owners their registration fee themselves. SES's efforts led to a substantial increase of registrations in 2018 with a total of nearly 17,000 registered C-band downlinks.

The FCC was ill-prepared for the flood of C-band registrations. The process of confirming these registrations took the commission nearly 18 months. Yet, in spite of the larger-than-expected registration turnout, many broadcasters believe as many as 50% of America's C-band downlinks still remain unregistered.

Jumping through hoops

In a study of current customers by each satellite company in 2019, the CBA was able to plan a transition that eliminated excess capacity. The launch of new satellites would allow for 200 MHz of bandwidth to be earmarked for 5G. The CBA was confident in its approach, since the FCC indicated that they were in agreement that a solution of 200 MHz of bandwidth, with 120 MHz of bandwidth being cleared in the top 46 Partial Economic Areas (PEAs) in the first 12 months, was the best way to move forward.

Yet, before the orders would be released, the FCC demanded 300 MHz of bandwidth for the broadband industry from the CBA. In a quick reshuffle, the CBA developed a plan to compress 500 MHz of satellite content delivery into 200 MHz from the same satellite arc, with the launch of at least seven new satellites. Once again, the FCC continued to signal their plan to release the order with the "industry-led solution."

At the twelfth hour, however, FCC Chair Ajit Pai went in a completely different direction. On Nov. 18, 2019, Pai announced the "FCC solution" was to repurpose the 300 MHz of satellite designated frequency from 3.7 GHz to 4.0 GHz.

The FCC would set up a Capacity Auction, a reverse auction for satellite transponder capacity. This newly freed capacity could then be used to repack the C-band incumbents who remain. Pai reasoned that the resulting revenues would be split between the auction participant and the U.S. Treasury, with the cost of relocation or protection coming from the auction participant's portion.

The FCC designated CohnReznick LLP and subcontractors Squire Patton Boggs (US) LLP and Intellicom Technologies Inc. to serve as the Relocation Payment Clearinghouse. The FCC also established a C-Band Clearinghouse Coordinator, RSM US LLP.

The lump sum

Though it was originally assumed that SES, Intelsat, Telesat and Eutelsat would handle all details of procurement, installation and documentation of the filters at registered downlinks, the FCC had still one more curveball in their playbook.

The FCC offered a lump sum buyout of $8,948 to registered downlinks. Thousands of downlinks chose the cash, once again decentralizing the process even further.

If your operation chose the lump sum, the timing, filter and documentation is completely on you. If you did not opt out, the satellite owners are still responsible for making your system whole. In some scenarios it may even include a new downlink as well as a two-tiered filter install. The Clearinghouse will be responsible to reimburse the satellite owners for those expenses.

The repack: For you, it's all about timing

Satellite owners must migrate off of all transponders below 3.82 GHz by Dec. 5, 2021 in conjunction with the FCC's Relocation Coordinators. The satellite owners must order, construct and launch more than seven new satellites by Dec. 5, 2023 to compensate for lost bandwidth by filling in empty orbital slots. The satellite owners must migrate all customers to transponders above 4 GHz by Dec. 5, 2023. All related expenses for the satellite owners will be reimbursed by the Relocation Coordinator.

Phase 1 — Dec. 5, 2020 to Dec. 5, 2021, 3.7 GHz to 3.82 GHz must be cleared from use by C-band downlinks in the top 46 Partial Economic Areas. Wireless carriers will be installing facilities in preparation to begin service transmissions as early as Dec. 5, 2021.

Phase 2 — The clearing of 3.7 GHz to 4 GHz nationwide in anticipation that transmissions of 5G wireless could begin as early as Dec. 5, 2023.

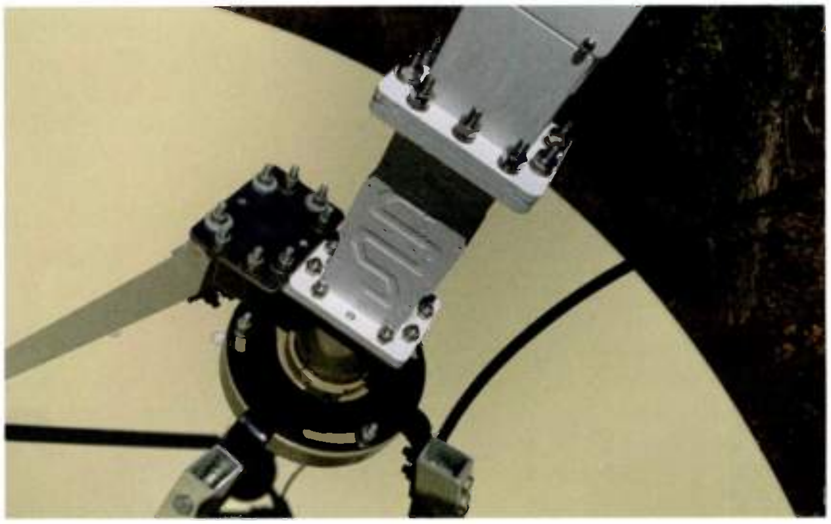
Phase 3 — Protection for downlinks expires nationwide on Dec. 5, 2025.

It's about 5G filters, too

In addition to industry, legislative and FCC outreach, the now-defunct CBA spent large sums of money on research to develop a filter to impede 5G signals. Going through countless versions and improvements, the CBA's ultimate goal was the development of a filter that had more than twice the rejection of typical WiMax or TI filters. The filter would also need to have a sharp rejection of 70 dB in just 20 MHz. Additionally, filters must produce these results and have a lower insertion loss than any filters it replaced.

The plan for the immediate clearing of 120 MHz in the top 46 PEAs made the filter development and deployment more complex. In anticipation of the multi-phase clearing, the CBA developed a two-filter solution — the same solution now on the market.

The first, called the "red" filter, is a temporary filter that allows the bandpass of transponders 7 through 24, while rejecting all 5G transmissions of 70 dB or less, below 3.8 GHz. This filter also rejects transmissions above 4.22 GHz allowing it to replace existing radar-TI filters.



Above
The new 5G filter is installed between the feed horn and the LNB.

> **"Radio broadcasters can skip the red filter completely and install the blue filter immediately."**

The "blue" filter is the permanent filter solution, allowing the bandpass of transponders 16 through 24 while rejecting all 5G transmissions of 70 dB or less, below 3.98 GHz. The blue filter also rejects transmissions above 4.22 GHz, allowing it to replace existing radar-TI filters. Once all cable, television and radio networks are migrated above transponder 16, the red filters will be replaced. All non-filtered downlinks will be outfitted with the blue filter.

The exception to the two-tiered red filter/blue filter solution: Radio.

Fortunately for radio broadcasters, SES has moved all commercial radio networks on SES-11 and religious networks on SES-2 to the higher transponders, while Intelsat has moved the Public Radio Satellite System to the higher transponders. Radio broadcasters can skip the red filter completely and install the blue filter immediately.

TV and Cable MSO are not so fortunate. They likely must start with the red filter in the top 46 PEAs. Ultimately, the installation of the blue filter would depend on the services used on the particular antenna and whether all of those services had migrated above 4.0 GHz. For these operators the monitoring of the transition periods to other satellites and higher transponders will be important.

And don't forget documentation

Don't skimp on this extremely important part of the process. Think about it: What records/receipts may the FCC require in an audit?

The FCC has given the impression that they will very likely audit some percentage of sites that are directed by the Clearinghouse and performed by contractors of SES, Intelsat and Telesat. Details on what the FCC will expect for the $8,948 that they provided in the lump sum option are even less clear.

However, consider this: If in the future there should ever be an interference issue between a downlink and a wireless carrier, the FCC will likely demand proof that your downlink was operating nominally and that 5G mitigation was carried out properly, before interference became an issue.

Whether you're conducting your own repack, or hiring a qualified technician for 5G mitigation, here are the steps that the FCC's Clearinghouse is demanding their contractors perform. You'll want document your findings, as well:

- Site registration number, screenshot of cell phone lat/long coordinates
- Pre-installation check of antenna, feed, cable and receiver
- Pre-installation proof of performance using a satellite signal and performance meter
- Post installation proof of performance using a satellite signal and performance meter
- Post installation images of antenna, feed, cable and receiver

Looking toward the future

As the mid-band frequency shrinks for the broadcast industry, available C-band space segment is at a premium. So, too, is Ku band, as some users move away from C-band to this slightly less-resilient transmission.

Personally, I expect to see content providers experiment with less-reliable distribution methods. For example, public internet is readily available but typically designed for consumer use and not for professional transmissions. However, some products are now available in the marketplace that can enhance the internet and provide a more stable transmission.

But C-band transmission for broadcast content is not going anywhere. It's still the most reliable form of content delivery for broadcasters, and it remains both cost-effective and available.

Protecting your C-band transmission is and must be your prime concern. If you have any doubts or concerns about the process of mitigating 5G interference at your site, please reach out to our qualified team at LinkUp Communications. We'll be happy to answer any questions you may have, or handle the process for you.

Writer

Larry Wilkins
CPBE
Director of Engineering Services, Alabama Broadcasters Association

Keep transmission lines high and dry

Air-dielectric lines require proper dry-air pressure to operate safely

Comment
RW Engineering Extra welcomes submissions of stories that help readers solve engineering problems. Email rweetech@gmail.com.

Every AM, FM or TV transmitter must be connected to an antenna via some type of cable, normally a coax line. Some lines are constructed with a type of foam between the inner conductor and the outer conductor, while others are hollow.

If your system has the hollow type of transmission line, it is imperative that some type of gas pressure be inside the line. Transmission lines can be vulnerable to corrosion if they are exposed to oxygen and moisture, the two main components that cause a corrosive reaction.

Properly pressurizing coaxial cables will keep moisture out and therefore prevents arcs inside the cable and it improves the power-handling capacity of the coax by increasing the breakdown voltage between the inner conductor and the shield.

Engineers often ask which is more effective, nitrogen or using a dehydrator. The answer is, "It depends."

If you will be operating the transmission line at or near the power rating of the line, nitrogen will give more protection from arc over. For lower power levels, either will work.

To keep moisture out, the transmission line must be kept at a positive pressure relative to the outside pressure. The pressure required is minimal indeed; maintaining excessive pressure can damage the line and waste energy.

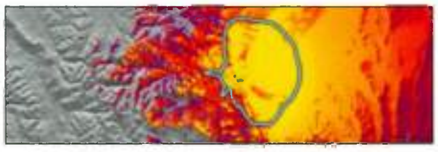
When it comes to dehydrators, proper sizing is everything. If undersized, the unit must run longer in order to maintain pressure, increasing wear on the compressor and driving maintenance costs higher. An oversized dehydrator, however, creates pressure surges in the line. This causes the unit to constantly cycle on and off, again resulting in increased compressor wear and higher maintenance costs.

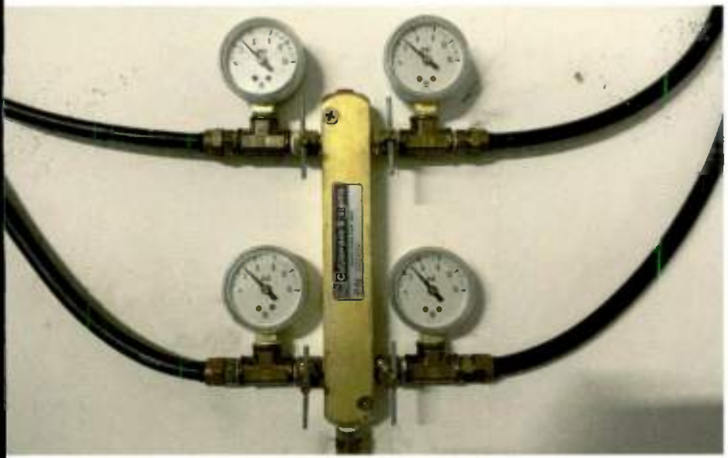
The most important takeaway point is to have a method to monitor the pressure in the line and an alarm system to notify engineering of a

> **"Engineers often ask which is more effective, nitrogen or using a dehydrator. The answer is, 'It depends.'"**

Below
A properly sized dehydrator will keep your lines dry and pressurized. Some, like this model from Kintronic Labs, have web interfaces to allow monitoring of pressures.

Thanks, ABA
This article was published in the Alabama Broadcasters Association Monday Coffee and Technical Notes newsletter. Learn about ABA's engineering training academy at *https://al-ba.com/.*





sudden loss of pressure on the line. This could be caused by failure of the dehydrator or empty nitrogen supply. It could also indicate a pending failure in the line itself caused by a major gas leak created by lightning or even a bullet hole.

When installing a new line, it is advisable first to pull a vacuum on the line. This will remove all the moisture from the line. Then fill the line with nitrogen or dry air from a dehydrator. Do not use a standard air compressor for this purpose, since it will fill the line with normal air, which is full of moisture.

This type of failure will be extremely costly and time-consuming. Don't neglect this important part of your transmission system!

Left
It doesn't take much pressure; 3 or 4 psi is more than adequate to keep moisture out of the line and antenna.


IP EXPRESS