IEEE

Broadcast Technology

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5G Wireless Broadband Continues To Roll Out: How Might It Impact Conventional Broadcasting? – p. 28

BTS IEEE

Second Quarter 2022

President's Message

Ralph Hogan, BTS President

It is time to get out and about if you have not already done so. After two years of being restricted because of the pandemic, many are ready to try to resume some level of normalcy in their life. Along with this thought some members are ready to resume social interaction with face-to-face gatherings. 2022 may be the year we start that process.

More and more face-to-face meetings and conferences are slowly starting after two years of hiatus due to Covid-19 and its variants. The following programs of interest are planned for 2022:

- IEEE International Symposium on Broadband Multimedia Systems and Broadcasting in Bilbao, Spain, June 15–17
- IBC in Amsterdam, Netherlands, Sept. 9–12
- BTS Annual Broadcast Symposium in Florida, USA, Oct. 18–20

International travel is also starting to pick up, so more international visitors may be traveling to these conferences. Some conferences keep a virtual component to serve those who can still not travel. For those that can safely travel, I encourage you to attend one of our conferences.

BTS will also have its virtual Pulse Technical Program on June 12–13, 2022. If you have missed past Pulse Events, on-demand videos are available in the BTS Resource Center (*https://resourcecenter.bts.ieee.org/*).

To make these conferences and virtual events successful it is important that individuals attend them. We have not had a good track record of attendance from BTS members. Not all events cover topics of interest to everyone, but it is important that we have a reasonable attendance. Since these events are a major source of revenue for BTS, it has an impact on successfully scheduling sponsors and retaining presenters for future presentations. I would encourage you to sign up for BTS events, they are all informative and may provide information and knowledge that you can use now or in the future.

The BTS website is currently going under an upgrade. We are looking for volunteers to help with this process. Even if you cannot help directly, any ideas that you may have on improving the site will be appreciated. If you are interested please contact Margaux Toral at *bts@ieee.org*.==

Finally, The IEEE Broadcast Technology Society is seeking nominees for the Administrative Committee (AdCom) election. Any member of the BTS in good standing is eligible for election to the AdCom. Elected officers will begin their three-year term on Jan. 1, 2023.

There are specific areas where we're looking for volunteers to serve for the 2023–2025 term including Fellows, Education, Standards and Strategic Planning. These society chair/committee roles as well as all others can be found here: *https://bts.ieee.org/about-bts/adcom-officers/society-chair-roles.html*

Serving on the AdCom is a great opportunity to become more involved in the Society and the industry. If you (or a BTS member you know) would like to actively assist in the growth of BTS and serve our members, please submit a nomination. We encourage our young members and those working in new media technologies to volunteer and become more involved in the Society. Our members are engaged in research, standards, technologies and companies that touch and impact the daily lives of virtually everyone on earth.

To submit a nomination for yourself or on behalf of someone else, please use the form in the link. The nominations will be open from March 16, 2022 through May 9, 2022.

Should you have any questions please send an email to Jennifer Barbato, Society Staff, *j.barbato@ieee.org*.

Ralph Hogan
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Cover: "Cell" sites for wireless broadband communications have been part of the global landscape for decades; now these services are being augmented with "fifthgeneration or "5G" technology. In this issue of Broadcast Technology, several experts in this field share their thoughts on how this "newcomer" may impact conventional terrestrial broadcasting.
Cover photo courtesy of Paul Shulins, Shulins' Solutions

From The Editor

More on NextGen TV's Arrival, 100 Years of Broadcasting, and Some 'Thank Yous'

By James E. O'Neal, Editor-in-Chief, BTS Life Member

In the last issue of **Broadcast Technology**, I reported on the "coming of age" of ATSC 3.0 television broadcasting in the Washington, D.C. market which serves your editor's home. Yes, we have a host station—WHUT at Howard University—which is carrying NextGen TV signals originated by the major network affiliates in Washington.

As a result of 3.0 service now being available, I began searching for the best fit for a new television receiver to replace the 55-inch Sony model I purchased more than a decade ago (it was a very large-screen model back then!). Now that there are four TV manufacturers offering sets in North America that decode ATSC 3.0, there's a lot more to evaluate and choose from than even a year ago, so I've been making the rounds of the "big box" store retailers for the "perfect" replacement for the aging Sony LCD model that has provided rock-steady performance for the ATSC 1.0 signals delivered over-the-air by area broadcasters. (There also the "SPF" or spousal approval factor to consider in making the selection, with a balance that has to be achieved between the bigger screen size that I'd like and "something that doesn't completely dominate the room."

As the selection process for a new TV continues, I would like to report on some heartening news, and also comment on something that needs improvement.

First, as I mentioned in my last editorial, the groups behind the ATSC 3.0 U.S. rollout have been running TV announcements about the availability of NextGen TV and some of its attributes. While the messages were apparently discontinued after the 2021 holiday period, they must have worked. As reputed recently by **Broadcasting And Cable** writer Jon Lafayette, American consumers are becoming more aware of NextGen TV, with some 40 percent of the U.S. population now aware of ATSC 3.0, which is up from 25 percent this time a year ago. He also reported that the study, which was conducted by the Magid research organization, in conjunction with Pearl Tv and Dolby Laboratories, revealed that 74 percent of those who viewed the NextGen TV promotional ads said they were likely to purchase a receiver for the new DTV standard.

It's also encouraging that most of those I've spoken with in the TV and appliance stores are aware of NextGen TV and are able to answer at least some of my questions (even though this might necessitate a little Internet research on their part before they could provide an answer).

That's the good side.

On the negative, the salespeople I spoke with agreed that while some progress is being made in making the general public aware of ATSC 3.0 and what it can offer them, they also agree that while virtually everyone coming into their stores has at least heard about 5G, the number of those who've heard of NextGen TV or ATSC 3.0 pales in comparison. (Message to Pearl TV and Dolby: start running those ads again, and while you're at it, buy some space on the pages of consumer magazines and newspapers, and also make it a point to invite some newspaper "entertainment section" editors to lunch and fill them in on NextGen TV's attributes over a meal. Maybe even offer to let them try out an ATSC 3.0 set in their home for a while.)

Another item that needs improvement in the area of NextGen TV awareness and education is to get the "NextGen TV" logo out in front of consumers as soon as they enter a big box or other retailer's store. I couldn't help but notice that the NextGen TV logo is stamped very prominently on receiver boxes from Sony, but this seems to be absent on those of the other three manufacturers who offer 3.0 sets for the U.S. market (at least on the new set boxes that I inspected). I really don't know why this little bit of consumer awareness generation, is being ignored, as these manufacturers—along with Sony—very prominently proclaim the "4K UHD, HDR, Roku, AirPlay, Google Assistant, Alexa, and similar attributes of their TV product boxes.

Actually, this sort of subtle marketing (including feature sets on shipping containers) is nothing new. I recall that back in the early 60s when color TV was a "hard sell" to many due to its price and scarcity of programs in color, that set manufacturers tried to stimulate things a bit by printing a color TV screen image—color bars or other artwork—on the cardboard shipping boxes. This drove home that a family had purchased something rather special and unique then. I recall too seeing these boxes being prominently placed at the end of driveways—long in advance of the scheduled rubbish collection day—so that others in the neighborhood would take note that one of their neighbors had taken the color plunge. This amounted to a bit of low-key and very ephemeral advertising (as well as display of a status symbol of sorts), but it did encourage conversation between neighbors, as well as hints about an invitation to watch the next "big game" being televised in color.

So, let's get that NextGen TV logo stamped in large letters on those TV boxes! (It would also make it easier for shoppers like me to quickly identify what is and what is not an ATSC 3.0 set when roaming the stores in search of a new TV.)

'The Little Engine That Could'

While I'm on the subject of NextGen TV, I'd like to report on one of the latest implementers of 3.0 service, this time in the largest U.S. television market, New York City. In this case a low-power broadcaster, WNYZ-LD, beat the full-power operations to the punch by initiating a NextGen TV service on March 22. While the Ch. 6 station operates with a directional antenna (necessary to reduce the possibility of interference to a full-power Ch. 6 station operating in Philadelphia) and offers a niche service (Korean language programming), it was first to make the 3.0 plunge in the "Big Apple." Congratulations are extended to its operating company, Sound of Long Island, Inc., for moving out with this very 21st century mode of broadcasting. We wish them well. (And at the same time, we hope that it's not too much time passes before full-power NextGen TV broadcasting comes of age in New York City).

Saluting Some Significant Anniversaries

While late 1920 marks "ground zero" for the birth of modern wireless one-to-many broadcasting in most history books (I'm speaking, of course, of the Nov. 2 continuing coverage of presidential election returns by Westinghouse station KDKA in Pittsburgh, Pennsylvania), broadcasting did not burst into bloom in any big way for another year or so. Actually, it was not until 1922 that the transmission of speech and music into homes occurred in any big way.

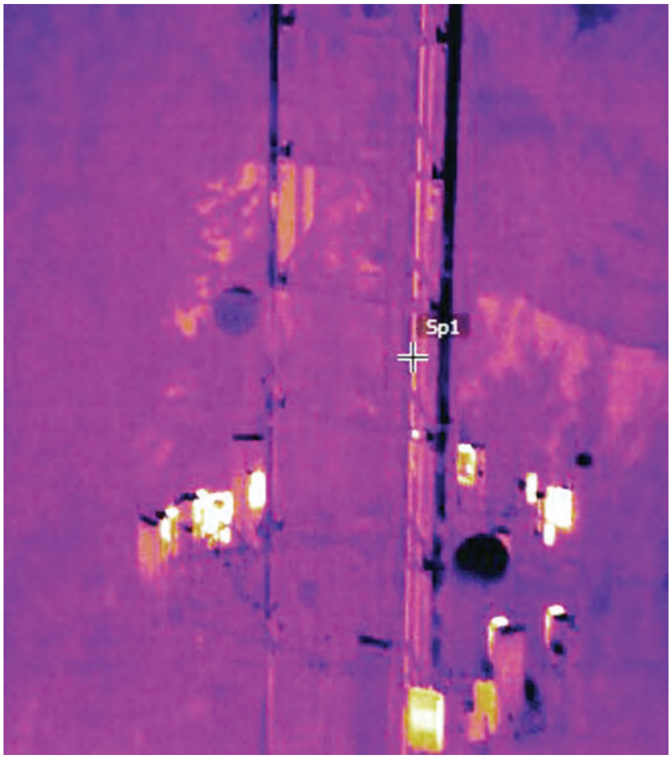
U.S. stations taking to the air for the first time (and still broadcasting 100 years later) include: Atlanta, Georgia's WSB; New Orleans, Louisiana's WWL; New York City's WOR; Schenectady, New York's WGY; Charlotte, North Carolina's WBT; Cincinnati, Ohio's WLW; Ft. Worth, Texas's WBAP; Salt Lake City, Utah's KSL; and a number of others.

Of course, radio broadcasting has been around in other parts of the world for 100 years also; however, it appears that historic documentation is on the "light side" in most areas outside of North America and the United Kingdom. I was recently introduced by BTS member Peter Siebert to Hugo Wyss, who is involved in Swiss IEEE goings-on. Hugo notes that 2022 marks the birth of broadcasting in his country, and is trying to piece together more of its early history.

He observed: "*The Anglo-Saxon environment of early radio broadcastings is thus well covered, but I still lack historical sources on early broadcastings on continental Europe, more specifically in France, Germany, Italy and the former Austro-Hungarian Empire, which collapsed in 1919, just few years when civil public radio broadcasting started in Europe.*"

I have to admit to somewhat of a dearth of information regarding early broadcasting history in this part of the world; however, I was able to pass on a little information. So, if any of our members have additional information that would like to pass along, please let me know and I'll put you in touch with Hugo.

Also, as I noted, broadcasting is now 100 years old in many parts of the world. I'd welcome information on early stations in all parts of the world from our readers outside of the United States and the United Kingdom. If you'd take time to put together a story about seminal broadcast activity in your nation or region, I'd welcome publishing it in the pages of **Broadcast Technology**.



Shulins' Solutions

Wireless broadband communications or 'cell' towers are ubiquitous in the 21st-century world. BTS member Paul Shullins provides a rather unique look at one of these by using a combination of drone and infrared imaging technologies.

Some Acknowledgements

In past issues of **Broadcast Technology**, I've frequently appealed for our Society members and other readers to provide content to help fill the pages. As this issue came together, I was pleased to receive several contributions—several dealing with 5G wireless broadband technology—and it's gratifying to be able to present multiple viewpoints on its place in the broadcasting arena. In connection with this, I'd like to thank member Peter Siebert who assisted in the delivery of one of these (from authors Les Sabel and Peter Walop), and David Gomez-Banquero who provided assistance in connection with the submission from Mohamed Aziz Taga. A big "thank you" also needs to be extended to Emeka Okoli

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NAB Photo

2022 NAB Show: You Look Better In Person

In-person event brings broadcasters back to Las Vegas

By Phil Kurz

It's been more than 1,000 days since the broadcast industry gathered in Las Vegas for what was—and appears to again be—its annual pilgrimage to the largest U.S. gathering of technology leaders, product innovations and technology presentations.

In spite of strong Covid-19 headwinds that shuttered the in-person gathering in 2020 and 2021, the 2022 NAB Show picked up where the gathering left off, offering attendees a better sense of where technology trends are headed—but with a few noteworthy changes.

Among the most obvious was show attendance. NAB reported 52,468 registered attendees of which 11,542 came from outside the United States. The total represents about 60 percent of the 91,460 registered attendees for the 2019 gathering—the last in-person NAB Show—and about 48 percent of the 24,096 international registered attendees that year.

It should be noted that in either case, the reported numbers reflect how many people registered; not necessarily the number of those who actually attended the show.

The number of exhibitors was also down. More than 900 showed their wares versus the 1,600 that exhibited in 2019.

Another difference this year was the LVCC itself. Unlike past years, the massive two-story South Hall was not used. In its place, the show took over a large portion of the 600,000-square-foot exhibition space in the newly opened West Hall—west of Paradise Road. As in the past, the North and Central Halls were used as well.

Officially opened in June 2021, the $1 billion, 1.4-million-square-foot expansion is a sleek, architecturally interesting building as compared to the rather boxy North, Central and South Halls, and is connected to the convention complex by a skyway over Paradise Road and a tunnel system put in place by Elon Musk's Boring Company and traversed by Tesla electric cars.

Another new feature of this year's show was related to Covid-19. Attendees were required to show proof of vaccination or a negative Covid test prior to being admitted to the convention for the first time and picking up their credentials. There were also Covid testing stations for rapid tests of those who suspected they may have contracted the virus during the show.

On With The Show

Regardless of the possibility or presence of Covid, the mood of the show was upbeat. Quoting a popular tag line for the show that contrasted the Zoom-culture that's emerged since the start of the pandemic, Madeleine Noland, president of the Advanced Television Systems Committee, noted "you look better in person," during an interview at the ATSC 3.0 Pavilion where there were nearly a dozen presentations on the NextGen TV standard and new technology showings.

At the pavilion, Pearl TV highlighted its collaboration with consumer electronics manufacturers on NextGen TV receivers and antennas, including the Zinwell ZAT-6000L 3.0 gateway, the ADTH 3.0 USB TV receiver and 3.0 gateway receiver, and three new NextGen TV-optimized antennas from Televes. Other highlights included the MediaTek Reference Platform that offers consumer electronics manufacturers a fast and easier way to introduce NextGen TV-compatible products; RUN3TV, Pearl TV's web platform that enables broadcasters to deliver new hybrid TV services that offer interactivity to over-the-air viewers; and Gaian Solution's Mobius Marketplace, a NextGen TV monetization platform that offers AI-driven 3.0 spectrum use planning and which was a winner of the 2022 NAB Show Product of the Year Award.

Elsewhere in the West Hall at the Futures Pavilion, the ATSC 3.0 Korean Alliance featured a wide variety of NextGen TV developments. One involving CAST.ERA and KBS highlighted a test in Seoul and Jeju Island scheduled for May of mobile ATSC 3.0 reception with location-based, targeted ad replacement. The test vehicle will use a film-type UHF antenna attached to the vehicle's windshield and an ATSC 3.0 set-top-box drawing power via a plug-in connection, along with 5G tablets attached to the vehicle's headrests for display.

Another exhibit showcased SpectraRep's EduCast distance learning, which relies on DigiCap's NextGen TV gateway. (This is part of a remote learning application in Washington, D.C., being delivered by Sinclair Broadcast Group's WIAV-CD television facility.)

One of the more interesting exhibits was Munhwa Broadcasting Corp.'s (MBC's) real-time kinematic (RTK) technology that relies on ATSC 3.0 to deliver precision positioning data down to the centimeter level, which is the broadcasters says is much more accurate than what's available with conventional GPS.

NAB Photo

The 2022 NAB Show marked its first-ever use of the newly-constructed Las Vegas Convention Center' West Hall.

Applications for the technology include autonomous vehicles, drone delivery and precision agriculture. In addition to the informational display in the pavilion, MBC demonstrated RTK in a drone delivery application outside the convention center.

South Korea's Electronics and Telecommunications Research Institute (ETRI) also demonstrated two technologies for enabling 8K content delivery via ATSC 3.0. Using Multiple-Input Multiple-Output (MIMO) OTA transmission and reception, ETRI showed how it's possible to sustain about 100 mbps data throughput over the air using horizontal and vertical antenna polarization for 8K broadcasting. ETRI also demonstrated scalable high-efficiency video coding (SHVC), combining an OTA 4K base layer transmission with and OTT-delivered enhancement layer to deliver 8K service.

Off the show floor, Sinclair announced at a press conference that it was working with USSI Global to trial an ATSC 3.0-based datacasting application the station group hopes will one day lead to a new revenue stream. Initially, the companies will deploy two electric vehicle (EV) charging stations equipped with 3.0 receivers and displays in the West Palm

NAB Photo

Xperi Corporation's Ashruf El-Dinary (left) was awarded the 2022 NAB Radio Engineering Achievement Award for Radio and Capitol Broadcasting Company's Pete Sockett (right) was the recipient of the this year's NAB Television Engineering Achievement Award.

Past Presidents William Meintel and William Hayes meet with current President Ralph Hogan and BTS Member at Large Guy Bouchard at the 2022 BTS booth at NAB.


NAB Photo

The NAB's new president and chief executive officer, Curtis LeGeyt, delivered his inaugural State of the Industry address during the NAB Show Welcome event.

Beach, Florida market. Repurposed local programming reformatted for a vertical display will give EV drivers something to watch—including local advertising—while charging their vehicles. Content will include video and data. It's undecided as to whether audio will be part of the offering.

Expressing the belief that 3.0-based datacasting will add a new revenue stream for local broadcasters, Sinclair president and CEO Chris Ripley observed that: "Our industry has reinvented itself to have a seat at the data distribution table."

Going Beyond ATSC 3.0

While the television industry was rightly focused on the three years of developments in NextGen TV technology that have occurred since the last gathering in Las Vegas, the NAB Show also gave broadcasters a smorgasbord of other technology developments to ponder.

"I think what surprised me most was how much there was of a change in the focus of the technologies, leaving the nuts and bolts and getting into new business models and new platforms," said Pete Sockett, Capitol Broadcasting Company's director of engineering and operations during a post-show interview. Sockett noted that the West Hall contained technology "that barely existed 10 years ago."

Among those technologies were the cloud, streaming, artificial intelligence (AI)/machine learning (ML) and even the metaverse, tools for which Veritone showed and discussed behind closed doors at its booth.

(Sockett was awarded the 2022 NAB Engineering Award for TV, and the 2022 NAB Engineering Award for Radio went to Ashruf El-Dinary of Xperi Corp.)

The 2022 NAB BEIT Conference

During the four-day Broadcast Engineering & IT (BEIT) conference, many of the new developments mentioned by Sockett were part of the agenda, as well as the latest trends in ATSC 3.0, HDR, 5G, cybersecurity, IP-based facilities and a range of radio topics, including AM and FM HD Radio, NABA Radio in-car user experience and radio transmission technologies.

BEIT sessions on AI included "Real-World Use of AI for Better Video Compression," in which presenter Tony Jones, principal technologist at MediaKind, explored how AI processing implemented across neural networks can optimize bitrates versus quality.

Other AI applications examined during the BEIT conference included the use of AI-based video compression to ultimately optimize energy consumption devoted to compression and reduce carbon footprint, as presented by Harmonic vice president of video strategy Thierry Fautier; the ways in which targeted TV advertising can be optimized using AI, which was presented by Guillaume Lossois, TV solutions architect at Viaccess-Orca; and how AI can assist in the automatic generation of frame-accurate segmentation metadata, which was presented by Harish Bharadwaj, lead AI scientist at Prime Focus Technologies.

A team of presenters from Firstlight Media, which included Prabu Chelladurai, vice president of management and customer success; Juan Martin, chief technology officer; and Jerald Mejarla, the company's chief architect, focused on use of a fully redundant cloud architecture for delivering demanding live broadcast video with a 99.99 percent availability.

Kirk Harnak, senior solutions consultant at Telos Alliance, discussed the use of containerized software technology to enable daily cloud-based broadcast infrastructure operations along with disaster recovery. Dominic Giambo, manager of technology at Wheatstone, discussed new IT strategies for boadcasters that leverage onsite and cloud resources. And Dan Pisarski, vice president of engineering at LiveU, offered a presentation on using new cloud-based workflows in live production.

OTT and streaming was the focus of Yuriy Reznik, technology fellow and vice president of research at Brightcove. His presentation—"Towards Efficient Multi-Codec Streaming"—addressed the problem of reaching devices with different codecs and delivering the best performance in all cases.

People, Progress And Changes

The NAB Show is always an opportunity for people to network with one another, but the hiatus since 2019 seemed to elevate those one-on-one, in-person meetings. It also offered an opportunity for the industry to say hello to new, rising luminaries and also offer a farewell to others.

In the case of the NAB itself, the 2022 Show was the first opportunity for the organization's new president and chief executive officer, Curtis LeGeyt to address the broadcast industry since taking the reins in January.

During his State of the Industry presentation, LeGeyt commended broadcasters for the role they have played in their communities since the outbreak of the pandemic, noting that they have been "striving to find common ground and common good."

LeGeyt identified four areas that are the focus of his policy efforts in Washington, D.C., including: calling for Congress to rein in the market power of tech giants "who are stifling the economics of local news;" advocating in Congress and at the FCC for modernization of media ownership laws "to reflect the realities of the marketplace;" urging the Commission to "reorient how it thinks about broadcast policy," taking a broader view that's "fundamentally premised on its economic viability;" and working for congressional support for the Local Radio Freedom Act, which opposes a new performance fee on local stations.

LeGeyt then conducted a "fireside chat" with FCC Chairperson Jessica Rosenworcel. After discussing the importance of journalism, its societal role and Congressional interest in the Local Journalism Sustainability Act, the conversation turned to ATSC 3.0.

Saying the FCC has put in place the "right framework for right now" with regards to ATSC 3.0, Rosenworcel observed that this strategy gives broadcasters a chance to experiment with the technology, and to develop use cases and try to figure out what services work at scale.

Rosenworcel commended Media Bureau Chief Holly Sauer for the responsiveness of the Bureau in helping broadcasters who have a problem with a 3.0 signal and are looking for special temporary authorizations (STAs) that can be granted to enable continued experimentation and innovation.

An announcement was also made at the show about the new executive director of The Society of Motion Picture and Television Engineers (SMPTE). David Grindle is filling the position left empty by the departure of Barbara Lange late last year. Grindle joins SMPTE after serving as the founding executive director of the United States Institute for Theater Technology.

During a press conference at the NAB Show, Grindle identified his goals for the society, which include: remaining at "the core of innovation and engineering," harnessing global membership growth, connecting "SMPTE and academia at all levels…to fill the pipeline of individuals coming out of training," guiding the organization "on the path to being a leader in inclusion," and reaching out to innovators "who use media in ways it never was intended to be used."

This year's NAB Show also will be remembered for some departures, including Gordon Smith, who served as president and chief executive officer of the NAB organization for 12 years before retiring from those roles at the end of last year. Smith was honored with the association's Distinguished Service Award during the show.

Fade To Black

The NAB Show has a way of making exhibitors and attendees happy when it's over. They can leave Las Vegas, rest for a few days, rub their aching feet and spend a little time decompressing. This year, however, there's one other post-show activity that was bound to occupy at least a few minutes of time for many of the attendees—reflecting on the importance of personal relationships formed and strengthened each year during the event.

The significance of having an annual forum in which to discuss common problems, explore solutions and rekindle friendships in person is hard to overstate. While a viable alternative that will do in a pinch, virtual shows just aren't the same as meetingin person. After three years of going without those personal interactions at the NAB Show, it's clear these are the most valuable show qualities of all.

From The Editor

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for taking time to put together the story on bonding of 4G/5G cellular "circuits" for video transmission. Also, in connection with these 5G presentations, I wish to thank BTS member Paul Shullins and his company, Shulins' Solutions for supplying some very nice aerial (drone) photos to help carry this 5G technology "theme." I also want to thank a frequent contributor, Amal Punchihewa, for his coverage of the AIBD "World Radio Day" event, as well as our regular columnists who provide information on various broadcast-related organizations and technologies. And a special thanks goes out to broadcast industry journalist Phil Kurz for putting together (on a very quick turnaround basis) a look at the April 2022 NAB Show, the first-such live NAB Show since the global pandemic began. Please keep the content coming!

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ATSC Insider

By Madeleine Noland and Jerry Whitaker,
Advanced Television Systems Committee

Latest ATSC 3.0 System Standard Published

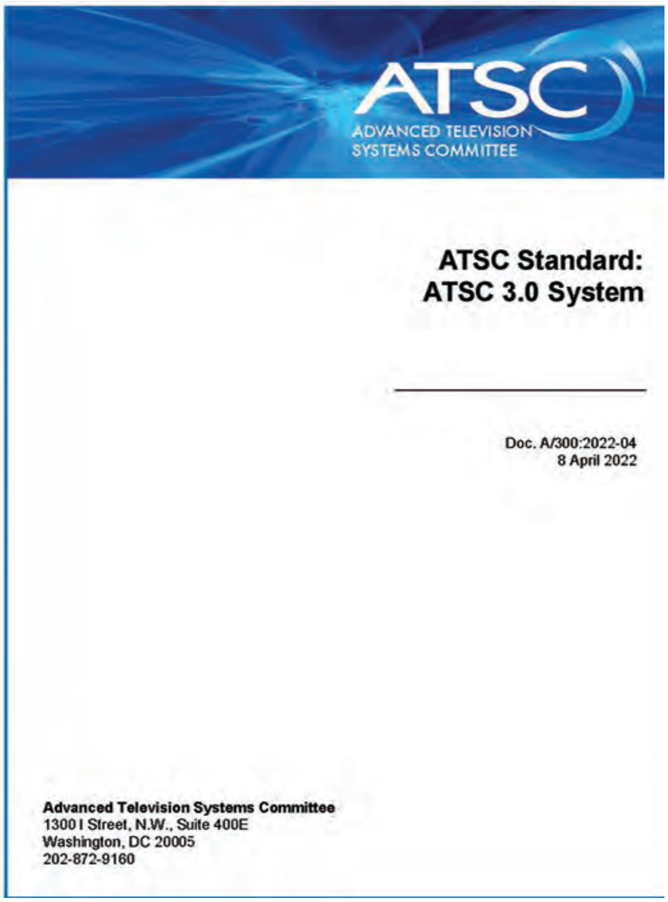
The first quarter of 2022 has seen a great deal of activity on standards development and implementation with the publication of the latest version of the ATSC 3.0 system on April 12, 2022. At the same time, the rate of stations signing on with NextGen TV is accelerating in the United States, and in Jamaica the nationwide implementation is moving forward rapidly.

A/300—The Keystone Of ATSC 3.0

One of the most important aspects of the ATSC 3.0 system is evolvability. This was emphasized in the initial set of requirements that governed development of the suite of next-generation standards. With evolvability comes a need for balance between progress and stability. On one hand, progress is necessary and inevitable, and a flexible, expandable system is needed. On the other hand, stability is required to enable product development and commercial deployment.

To facilitate evolvability, the ATSC 3.0 system is defined in a suite of 22 standards, with each describing a particular aspect of the system. The individual standards can be updated at their own pace according to technical advancements and market forces without impacting the other standards. A suite of 10 recommended practices (RPs) provides guidance for implementers of the system.

While this strategy keeps pace with developments in the market, it can create a challenge for product developers who need to clearly identify which version of which standard(s) a given product release supports. For products that are based on more than one of the standards in the suite, this can become complicated. Annual updates to document A/300, "ATSC 3.0 System," are intended to address this issue.


ATSC
ADVANCED TELEVISION SYSTEMS COMMITTEE

ATSC Standard:
ATSC 3.0 System

Doc. A/300:2022-04
8 April 2022

Advanced Television Systems Committee
1300 I Street, N.W., Suite 400E
Washington, DC 20005
202-872-9160

A/300, the ATSC 3.0 System Standard.

ATSC Standard A/300 is the central document of ATSC 3.0, presiding over the entire suite of standards and recommended practices that together comprise the full system. As such, it plays a pivotal role in managing this balance. A/300 normatively references a particular version of each of the other standards, and each referenced document is interoperable with the others. This allows product developers to address a particular version of A/300 in a given product release. This is important for communication with consumers and for interoperability with other products.

A/300 versioning also considers backward compatibility. It is expected that each version of A/300 (and the standards it references) will be backward compatible with the previous version of A/300. Since the launch of the A/300 versioning strategy in 2018, a rigorous process has been established for documenting not just the changes and additions to existing standards, but also the rationale for those changes and the potential impact on backward compatibility—if any. Every change to every standard is documented with this level of detail and made available to implementers via the ATSC website. This allows implementers to identify precisely what changed from one version to the next, and then evaluate whether to incorporate those changes into a new product release.

The ATSC expects to update A/300 annually. The balance between stability and evolution suggests that an annual cadence is a good target. This cadence is just that:

a target. More frequent updates are possible if needed, and if no changes are merited, then a given version of A/300 could run for more than a year.

The latest version of A/300 has just been published. Coincident with the approval of A/300:2022-04, all other ATSC 3.0 standards and RPs have been updated to point to the latest version of ATSC documents. A/300:2022-04, therefore, represents a watershed milestone for the overall system.

The current pace of technology requires that ATSC 3.0 keep up with new technical developments and continue to provide the most up-to-date features and tools for broadcasters across the globe. Any technology-based standard must evolve over time to be successful in the marketplace. The A/300 update strategy is designed to manage those updates to help make the rollout of NextGen TV and other services smooth and efficient for broadcasters, receiver manufacturers, and broadcast solution vendors alike. Work will continue as the ATSC both refines and expands ATSC 3.0 features and functionality over the coming years.

Jamaica Transitions From Analog To ATSC 3.0

On Jan. 31, 2022, Television Jamaica Limited (TVJ) launched ATSC 3.0 services in Kingston. With that move, Jamaica became the third country to start commercial transmission of the ATSC 3.0 digital standard, currently the world's state-of-the-art digital television broadcast standard. The country's new Minister with responsibility for Information, Hon. Robert Morgan, officially switched on the TVJ NextGen service just after 6:30 p.m. local time.

Jamaica has now joined South Korea and the United States in the adoption and transmission of ATSC 3.0 digital terrestrial television services. Jamaica is the first Caribbean nation to adopt a second-generation digital system, and is the first ATSC 3.0 nation to transition directly from analog, leap-frogging a first-generation system entirely. Like the South Korean approach, the transition in Jamaica is government-mandated, and additional RF channels have been allocated to enable simulcast of the analog system with the new ATSC 3.0 system. In the case of Jamaica, the analog services reside in the VHF bands, while ATSC 3.0 services will occupy UHF bands.

Building on the successful launch of services at TVJ, the nation anticipates as many as 20 similar transmission sites being commissioned into service, targeting an ambitious goal of 95 percent coverage in 2022. In addition, Jamaica is looking to sunset analog standard definition operations as soon as 2023.

Each nation that elects to implement a new broadcasting system has its own motivations and unique use cases for the new system. Connecting the capabilities of the technology with the needs and betterment of the lives of the Jamaican people is the central pillar behind this transition. As a very "human-driven" initiative, advanced emergency messaging and distance education opportunities are key use cases for Jamaica's rollout, together with strengthening local media.

Traditional Jamaican media companies seek to operate on a level playing field with newer technology firms such as Google, Amazon, and Facebook, which have rapidly entered the content production and delivery marketplace. These global giants have no physical presence in Jamaica and may not have the same motivation to create socio-culturally relevant content as local broadcasters. As such, one of the primary goals for the digital switchover in Jamaica is to strengthen the position of the incumbent television companies by providing new business opportunities and increasing the number, variety, and quality of programs they can deliver. Using the new ATSC 3.0 system broadcasters look to monetize content across platforms and develop new sources of revenue.

TVJ says it will now make available free to consumers, TVJ, TVJ Sports Network, Reggae Entertainment Television, and Jamaica News Network. Plans are in place to add the Public Broadcasting Corporation of Jamaica shortly. TVJ has made significant investments in upgrading to a full high-definition transmission format. TVJ is also making major commitments to its in-house resources. The installation was conducted by an all-Jamaican engineering team on the ground.

To assist with future implementations of ATSC 3.0 across Jamaica, ATSC will host a July 18-22 ATSC 3.0 Seminar and Bootcamp in Montego Bay for local engineers, government officials, and business leaders. Generously supported by ATSC members, the seminar will feature storied "road show" instructor, Gary Sgrignoli of MSW, together with a rich program of informational sessions covering a range of topics about implementing and optimizing ATSC 3.0 operations.

The adoption of ATSC 3.0 is seen by Jamaican government officials as an integral part of nation's transition to a digital society and economy. ATSC is honored to play a role in this major initiative and looks forward to working closely with the Jamaican broadcast community for years to come.

Get Involved

Work within ATSC is open to all groups with a direct and material interest in the work. Membership information can be found on the ATSC website *(https://www.atsc.org/members/become-a-member/)*. The benefits of membership are numerous, including:

- Involvement in developing and approving Standards and Recommended Practices for the digital terrestrial transmission industry
- Involvement in Planning Teams exploring new technologies and verticals that are emerging in the broadcast industry
- Develop and share information on the implementation of ATSC Standards and Recommended Practices

continued on page 51

Brazil Begins Transition To Next Phase Of DTV With 'TV 3.0' Project

A report on the country's evolving digital television landscape

By Luiz Fausto
SBTVD Forum

Background

Free-to-air terrestrial television is the main audiovisual distribution platform in Brazil, covering almost all Brazilian households and used in more than 70 percent of them. It secures to most of the Brazilian population a free-of-charge, universal and democratic access to information and entertainment, made by Brazilians for Brazilians. It is, therefore, an important social cohesion, national and cultural identity factor.

The SBTVD Forum (comprised of representatives of the broadcasting, academia, transmission, reception, and software industry sectors, with the participation of Brazilian Government representatives as non-voting members) developed the standards for the first-generation of Digital Terrestrial Television in Brazil (conventionally called "TV 2.0," as opposed to the analog "TV 1.0"). The system introduced high-definition video, surround sound, mobile reception, and interactivity. The first SBTVD standards were published in 2007, with the official opening of transmissions in the same year. Since then, the standards have been continuously revised and updated by the Forum. The technological innovations proposed by Brazil were incorporated into the International ISDB-T standard, which has been currently adopted by 20 countries.

Since 2007, the technological landscape changed a lot. Based on this new technological landscape, as Brazilian analog television began switching-off in 2016, the SBTVD Forum recognized the necessity to evolve the SBTVD. It also acknowledged that changes in the physical layer, the transport layer, and/or audiovisual coding would not be backwardly-compatible. Nevertheless, the transition to a new generation of digital terrestrial television (DTT) is a long process, based on the investments required by both broadcasters and consumers, and the expected life span of TV transmitters and receivers. It was, therefore, deemed necessary to increase the life span of the existing DTT system as much as possible through a backwardly-compatible evolution (a project called "TV 2.5"), and to start development of the next-generation DTT system (referred to as "TV 3.0").

TV 2.5 comprised two aspects: broadcast-broadband integration and audiovisual quality. The first aspect involved the development of a new receiver profile for the middleware "Ginga" (receiver profile D, also known as "DTV Play"), addressing use cases such as on-demand video, synchronized companion devices, audiovisual enhancement over the Internet, and targeted content. The second aspect was addressed through the introduction of three new optional immersive audio codecs (MPEG-H Audio, E-AC-3 JOC, and AC-4) while retaining MPEG-4 AAC main audio for backward compatibility, and through the introduction of two new optional HDR video formats (SL-HDR1 dynamic metadata and HLG "preferred transfer characteristics" signaling) while keeping MPEG-4 AVC (H.264)/8-bit / BT.709/1080i for backwards compatibility. The revision of the SBTVD standards containing both TV 2.5 aspects has already been published (available at *https://forumsbtvd.org.br/legislacao-e-normas-tecnicas/normas-tecnicas-da-tv-digital/english/*).

Phase 1—Call For Proposals

As Phase 1 of the TV 3.0 project the SBTVD Forum, after agreeing on requirements (use cases and corresponding technical specifications), released a Call for Proposals in July 2020 for any interested organization to submit its proposed candidate technologies for any of the system components

Over-the-air Physical Layer

Candidate Technology	Proponents
Advanced ISDB-T	DiBEG
ATSC 3.0	ETRI / ATSC
5G Broadcast / EnTV	Qualcomm / Rohde & Schwarz GmbH / Kathrein Broadcast GmbH
DTMB-A	DTNEL

Transport Layer

Candidate Technology	Proponents
ROUTE/DASH	ATSC
SMT	DTNEL / NERC DTV
ARIB MMT	DiBEG
ATSC 3.0 MMT	ATSC

Video Coding

Sub-Components	Candidate Technology	Proponents
Video Base Layer Codec	AVS3	DTNEL
Video Base Layer Codec + (multilayer) Video Enhancement Codec	VVC main / multilayer	DiBEG / InterDigital / Ateme / Fraunhofer HHI
	HEVC / SHVC	ATSC
Video Enhancement Codec	LCEVC (multilayer)	V-Nova / Phase / Harmonic
	Dynamic Resolution Encoding (single layer)	Phase / Harmonic
HDR Dynamic Mapping Codec	SL-HDR (1/2/3)	InterDigital / Philips / ATSC
	SMPTE ST 2094-10 (Dolby Vision)	Dolby / ATSC
	SMPTE ST 2094-40 (HDR10+)	Samsung
VR Codec	V3C (V-PCC / MIV)	InterDigital / Philips / Harmonic / Phase
Emergency Warning System manager	ATSC 3.0 AEA	ATSC

Audio Coding

Candidate Technology	Proponents
AC-4	ATSC / Dolby
AVSA	DTNEL
MPEG-H Audio	DiBEG / Ateme / Fraunhofer IIS / ATSC

Captions

Candidate Technology	Proponents
IMSC1	ATSC
ARIB-TTML	DiBEG
AVS Captions	DTNEL

Application Coding

Sub-Components	Candidate Technology	Proponents
All	Advanced ISDB-T	DiBEG
	DTNEL Application Coding	DTNEL
	ATSC 3.0	ATSC
3D object-based immersive audio interaction	MPEG-H Audio	Ateme/Fraunhofer IIS
VR support	Guaraná	CEFET/RJ
voice interaction, gesture interaction, multimodal interaction, multi-user identification support, multi-user interaction support, sensory effects	NCL 4.0	UFF

Figure 1

or sub-components. (This Call for Proposals is available at *https://forumsbtvd.org.br/wp-content/uploads/2020/07/SBTVDTV-3-0-CfP.pdf*)

Requirements included frequency reuse-1 and indoor reception with a C/N < 0 dB, MIMO 2 x 2, channel bonding, IP-based transport layer, new accessibility services (including closed signing), advanced emergency warning features, advanced sound systems, and state-of-the-art video coding (i.e., more efficient than HEVC). In addition to the interactivity functions and broadcast-broadband integration, the TV 3.0 application coding included presentation of all audiovisual content. The user television experience was considered to be "application-oriented." This means that it is no longer an audiovisual service that can contain an interactive application; rather it is an App with audiovisual content that can be provided over-the-air or via the Internet.

A total of 36 responses from 21 different organizations were received with consideration to the six system components (Over-the-air Physical Layer, Transport Layer, Video Coding, Audio Coding, Captions, and Application Coding) by the Nov. 30, 2020 Phase 1 deadline. Some of the similar proposals were merged for the sake of Phase 2 testing and evaluation and this resulted in the 30 candidate technologies listed in Figure 1.

Phase 2—Testing And Evaluation

Phase 2 tests were carried out from July 5, 2021 through Dec. 3, 2021. The "TV 3.0 CfP Phase 2/Testing and Evaluation" document (available at *https://forumsbtvd.org.br/wp-content/uploads/2021/03/SBTVD-TV_3_0-P2_TE_2021-03-15.pdf*) provided further information and requirements for Phase 2, along with the test procedures for evaluating and comparing the proposals of candidate technologies and instructions on providing Phase 2 responses. Testing was funded by the Brazilian Ministry of Communications through the Brazilian National Council for Scientific and Technological Development (CNPq, *Conselho Nacional de Desenvolvimento Científico e Tecnológico*), and involved about 70 researchers from seven Brazilian universities. These included:

Physical Layer—laboratory testing by Mackenzie Presbyterian University and coordinated by Prof. Cristiano Akamine, and field testing by Fluminense Federal University coordinated by Prof. Natalia Fernandes

Transport Layer—testing by Mackenzie Presbyterian University with coordination by Prof. Gustavo Valeira

Video Coding—testing by the University of Brasília with coordination byProf. Mylène Farias

Audio Coding—testing by the University of São Paulo with coordination by Prof. Regis Faria and Prof. Almir Almas

Captions—testing by the Federal University of Paraíba with coordination by Prof. Guido Lemos

Application Coding—testing by both the Federal University of Juiz de Fora and the Pontifical Catholic University of Rio de Janeiro with coordination by Prof. Marcelo Moreno

The Phase 2 over-the-air Physical Layer field testing required the use of MIMO indoor antennas. Proponents of the Physical Layer candidate technologies were requested to provide antennas for the test; however, the SBTVD Forum also used MIMO indoor antennas from other providers for reference purposes. The inclusion of the additional antennas in the testing was important in verifying reception performance with antennas that had characteristics closer to what would be obtained with end-user consumer electronics products. This information also assisted in determining the minimum required field strength for indoor reception of the candidate technologies.

Physical Layer – Lab Tests	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-PL-Lab-Report.pdf*
Physical Layer – Field Tests	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-PL-Field-Report.pdf*
Transport Layer	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-TL-Report.pdf*
Video Coding	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-VC-Report.pdf*
Audio Coding	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-AC-Report.pdf*
Captions	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-CC-Report.pdf*
Application Coding	*https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-AP-Report.pdf*

Figure 2

In connection with this, the SBTVD Forum also released a Call for Prototypes of MIMO indoor antennas in December 2020, as commercial product implementations are still practically non-existent, due to fact that this innovative new technology has not yet begun to be used in DTT transmission, except in research and development activities.

The Call for Prototypes of MIMO indoor antennas (available at *https://forumsbtvd.org.br/wp-content/uploads/2021/01/SBTVD-TV_3_0-CfP-MIMO_2021-01-28.pdf*) resulted in four prototype models that were used in the field tests along with antennas provided by proponents of the Physical Layer candidate technologies.

Links for Phase 2 Testing and Evaluation reports are available at the links shown in Figure 2.

Phase 2 Conclusions And Technology Selection

Considering the results of the TV 3.0 Project Phase 2 testing and evaluation, as well as market and intellectual property aspects of the candidate technologies, the SBTVD Forum forwarded its recommendations on the selection of candidate technologies to the Brazilian Ministry of Communications. The Brazilian Ministry of Communications has agreed to disclosure of these recommendations by the SBTVD Forum. The decisions presented in Figure 3 were adopted for the continuation of the TV 3.0 Project.

Over-The-Air Physical Layer

To perform additional tests. Condition for participation: to provide equipment with support for reuse-1, MIMO, and channel-bonding. Only the two best lab results go on to field tests. The technology would only be selected at the end of the second round of testing if the bitrate in the reuse-1 condition is sufficient; otherwise, the reuse-1 condition will need to be revised.

Transport Layer

To adopt the ROUTE/DASH technology as the basis of the TV 3.0 transport layer and adapt/extend it to support all the project requirements and the technologies to be adopted in the other layers, and to maintain optional support for HLS streaming (as currently available in the TV 2.5 specification) for distribution of alternative content over the Internet.

Video Base Layer

To adopt VVC for the main video (both over-the-air and over the Internet) and perform subjective video quality assessments to determine the bitrate needed for real-time encoding at different resolutions (considering base layer only and in combination with the enhancement layer), and to evaluate the most suitable video coding for transmitting a second video with a sign language interpreter. Also, to maintain support for H.264 and H.265 video (as currently available in the TV 2.5 specification) for distribution of alternative content over the Internet.

Video Enhancement

To adopt a combination of Dynamic Resolution Encoding and LCEVC.

HDR

To adopt HDR10 as the base (format already supported on all HDR TVs), with optional support for Dolby Vision, HDR10+ and SL-HDR2 dynamic metadata (both over-the-air and over-the-Internet), and to maintain optional support for HLG and SL-HDR1 (as currently available in the TV 2.5 specification) for the distribution of alternative content over the Internet.

VR Codec

To adopt V3C for inclusion in TV 3.0 standards (support will not be mandatory in all receivers; focus on content distribution over the Internet and consumption on smartphones and HMDs).

Emergency Warning System

To adopt ATSC 3.0 Advanced Emergency Alert.

Audio Coding

To adopt MPEG-H Audio for over-the-air and Internet distribution.

To maintain the other audio formats currently supported in TV 2.5 for distribution of alternative content over the Internet (including optional AC-4 support).

Captions

To adopt IMSC1 for over-the-air and Internet distribution, and to maintain optional support for WebVTT (as currently available in the TV 2.5 specification) for distribution of alternative content over the Internet.

Application Coding

To adapt and extend DTV Play, including the satisfactorily tested proposals (MPEG-H Audio, Guaraná, and NCL 4.0) and considering including parts of the Advanced ISDB-T, DTNEL Application Coding, and ATSC 3.0 proposals (depending on the results of their prototyping). Also, to fill the gaps in requirements that were not satisfactorily fulfilled by the received proposals, when necessary.

Phase 3—Next Steps

Phase 3 is currently being planned and is expected to last about two years (2022–2023). It will involve—among other activities—complementary tests for selection of the Physical Layer technology, development of the necessary adaptations and extensions to the Transport Layer specification, subjective assessment of the video coding quality (determination of the necessary bitrate), development of adaptations and extensions to DTV Play for TV 3.0 Application Coding, elaboration of ABNT technical standards for TV 3.0, development of interoperability tests, demonstrations, etc. TV 3.0 service is expected to launch in 2024 in Brazil.

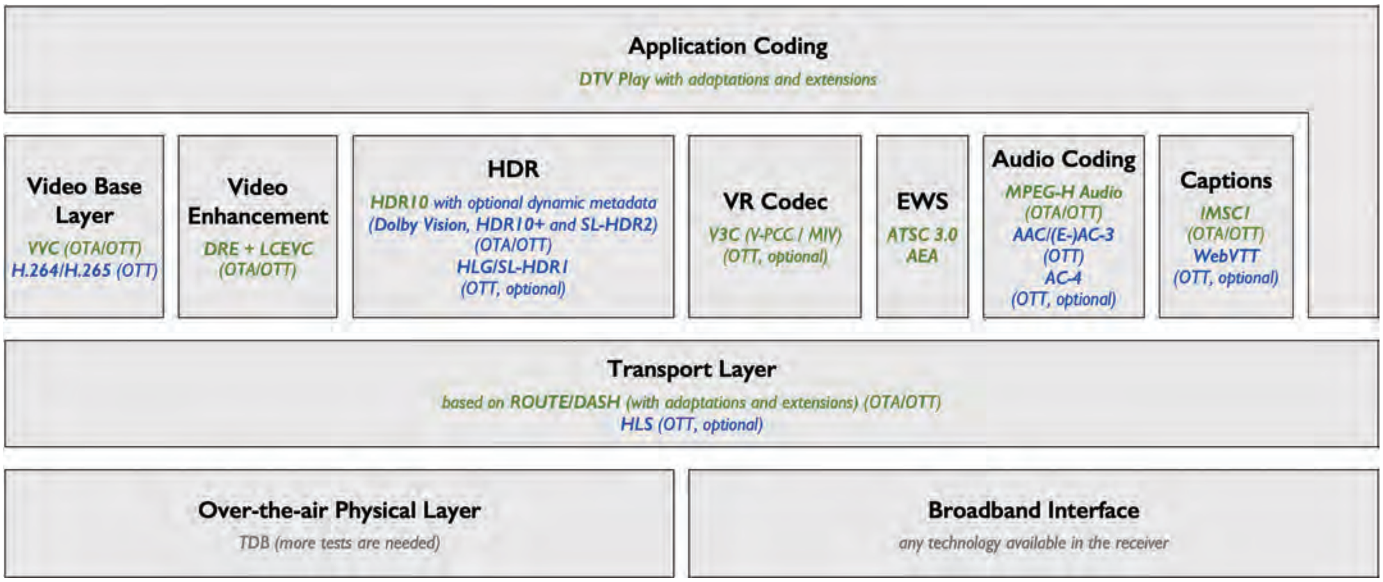


Figure 3

Additional TV 3.0 Project information may be obtained at *https://forumsbtvd.org.br/tv3_0/*.

Acknowledgments

We wish to thank the candidate technologies' proponents, the participating universities, and SBTVD Forum members for making equipment available for the lab and field evaluations. We also would like to extend thanks to the providers of equipment used in the tests, including Ideal Antenas and RFS who supplied the transmitting antenna systems used in the Physical Layer field tests, and Teletronix, who provided UHF driver amplifiers for use in the Physical Layer tests. Thanks also go to Phabrix who supplied the rasterizer used in the video coding tests, and to Proeletronic, Aquário, Advansat and Mackenzie Presbyterian University for constructing the prototype MIMO receiving antennas for the tests.

About The Author

__Luiz Fausto__ is the chair of the Technical Module of the SBTVD Forum overseeing the technical aspects of the TV 3.0 project. He is also the chairman of SWG 6B-2 (Multimedia) of ITU-R WP 6B (broadcast service assembly and access). Fausto works as a technology and regulatory specialist at Brazil's Globo TV Network. He may be contacted at luiz.fausto@forumsbtvd.org.br.

DRM News

By Radu P. Obreja
Marketing Director
Digital Radio Mondiale Consortium

Shortwave Broadcasting Revived

Background

The technological advances in telecommunications since the introduction of the Internet in the mid-nineties, and, especially, after the year 2000, have been spectacular. The array of tools for linking the world communities in the so-called "global village" seems to have no limits. The whole world seems connected.

And the traditional free-to-air analog radio devised early in the 20th century has been trying to maintain its status as the only one-to-many communication tool over the airwaves. However, some international broadcasters realized that analog shortwave radio, despite being a simple and robust technology, is sometimes crackly, very power hungry and expensive to run. It is also subject to different nighttime and daytime propagation laws, and also to atmospheric distortion. Therefore, shortwave broadcasts have been reduced over the years (the BBC in the United Kingdom, Deutsche Welle in Germany, and elsewhere) or have been ditched altogether (in countries such as Australia). Others have reduced their transmissions significantly (Radio France International and Radio Exterior de España), while quite a few have successfully maintained their broadcasts (All India Radio and Radio Romanian International). Even so, the BBC continues to broadcast in shortwave to Africa and Asia; the Voice of America still broadcasts into Latin America; Saudi Arabia into Iran and Afghanistan; Japan and South Korea into North Korea; as well as China into Taiwan and vice versa.

Shortwave antennas, Rodeador Park, Brazil.

Digital Radio

The radio industry stakeholders realized they cannot afford to let radio stay unchanged, i.e. analog. Several digital radio alternatives were devised. One of these is the Digital Radio Mondiale—the DRM standard, the only open global system that can digitize radio in all frequency bands.

Using DRM technology, radio stations can create multiple programs (as many as to three), broadcast on a single frequency, offering an excellent, undistorted sound quality, as well as an additional data channel which can offer texts, pictures, along with new key functionalities such as emergency or disaster warnings, distant education and training, traffic information.

The tragic events this year in Ukraine and Russia have proven recently how Internet in its different guises can be either destroyed by war or simply shut down. FM towers fall victim to bombardments and local radio and TV broadcast content can be manipulated or censored.

It is in this context, that our "old-fashioned," but still reliable, friend, shortwave radio, has been given a new lease on life by some reputable international broadcasters.

The crisis in Ukraine has prompted those broadcasters to resume shortwave transmissions. Radio Miami International for example has announced additional shortwave radio broadcasts to Russia, Belarus, Ukraine, and other parts of Eastern Europe (with content from the Voice of America and Radio Free Europe/Radio Liberty). They are being sent using the station's 100,000-watt transmitters. The BBC World Service has also resumed four-hour daily broadcasts in shortwave to ensure that people in many parts of Ukraine and Russia can access its news service. The BBC World Service still has as many as 40 million shortwave listeners in Africa alone, as shortwave radio never disappeared in part of the world. It has, however, faded in its most developed parts of the world that are "super-served" by newer technologies.

Reconsidering Shortwave

Shortwave signals use fairly low frequency radio waves, which reflect from the upper atmosphere and deliver radio services beyond the horizon. They travel very large distances—over thousands of kilometers—and propagate better through buildings and other obstacles than higher radio frequencies, reaching well into all corners of people's homes. The signals can come from another country or continent, remote from the zones of conflict or natural emergencies, unlike the situation with more localized solutions such as FM, TV, or mobile signals.

In addition, it is quite difficult to censor shortwave transmissions. If certain totalitarian regimes wish to jam shortwave broadcasts, they need a similar infrastructure to that of the original broadcaster and a lot more transmitter power to distort those shortwave programs; quite a costly endeavour.

Unlike the one-to-one Internet with its backchannel where every user has a footprint, there's no lasting trace of listeners of the one-to-many shortwave radio. It is difficult for occupying forces in a country to trace those listening to overseas media. Suddenly, the fact that radio listeners remain anonymous has become an asset.

Shortwaves were the first frequencies to be considered for digitization. This was actually the initial reason for the invention of the DRM standard. And DRM is the only system that can digitize shortwave transmissions.

Interest in DRM broadcasting has gradually but steadily, been rising since about 2014-15. The developing world generally does not have the level of infrastructure required for an FM installation every 10 kilometers or so outside cities, and often needs to provide services to low-density, rural populations at low costs. In such cases, digital medium wave and shortwave broadcasts for domestic transmissions are the best way to cover large countries.

Today, all modern shortwave transmitters are being manufactured incorporating all the functionalities of the Digital Radio Mondiale standard. They are "DRM-ready." It is up to the national authorities to turn an analog transmitter into a digital one. Some existing and not-too-old analog shortwave transmitters can be upgraded to DRM at a fraction of the price of a new transmitter. This is a much more cost-effective way to modernize the existing shortwave infrastructure of a broadcaster in the developing world than to set up a totally new transmitter network.

Simon Keens, sales and business development manager at Ampegon Power Electronics AG in Switzerland, one of the top global shortwave transmitter manufacturers, commented recently that "Digital shortwave is no longer a power-hungry transmission method. It is modern and efficient, using at least 40 percent less electricity. The crackly sound and atmospheric distortions typical in analog mode are gone. Thanks to digital error correction, broadcasters have the possibility to transmit crystal-clear FM quality stereo sound, with a dedicated data stream for images and videos, all within the same 10 kHz bandwidth. Such long-range broadcasts can provide enormous benefits to displaced people or populations under censorship or other emergencies."

Advantages Of The New Digital Shortwave

A major benefit is the energy savings offered by a DRM shortwave transmitter due to reduced electricity consumption. (The DRM Consortium has created a very useful tool to calculate the power consumption and the savings made by broadcasters when using the DRM standard. It's available at energyefficiency@drm.org)

As the new shortwave offerings are now in digital mode, the perfect audio quality over thousands of kilometers is now a reality. Radio Romania International's shortwave broadcasts to Latin America are a perfect example. One of the great drawbacks of analog has been eliminated.

Another key benefit of the DRM standard is the Emergency Warnings Functionality or "EWF." Though available across the DRM standard in any frequency band, it is particularly attractive in shortwave, as the special emergency broadcasts can originate hundreds or thousands of kilometres away from a disaster area.

The diagram in Figure 1 illustrates how broadcasts from outside an affected disaster area can be received by listeners in the disaster area where the communication towers have failed.

DRM shortwave broadcasts can also help communities or entire countries with distance education and information/training programs. With DRM shortwave facilities in place, and in co-operation with the ministries of education and schools in interested countries, educational programs can be created and transmitted from further afield, or from one or two points within a country, to cater to the students without direct access to schools and teachers. The educational programs (lessons) benefit from the inbuilt features of the DRM standard such as advanced texts (Journaline) in the languages or dialects of the target audiences. Those texts can be complemented by pictures and diagrams (as seen in Figures 2 and 3) to illustrate the lessons taught. (A DRM video with an example of this distance learning feature is available at https://youtu.be/lqQ-fodAH4E.)

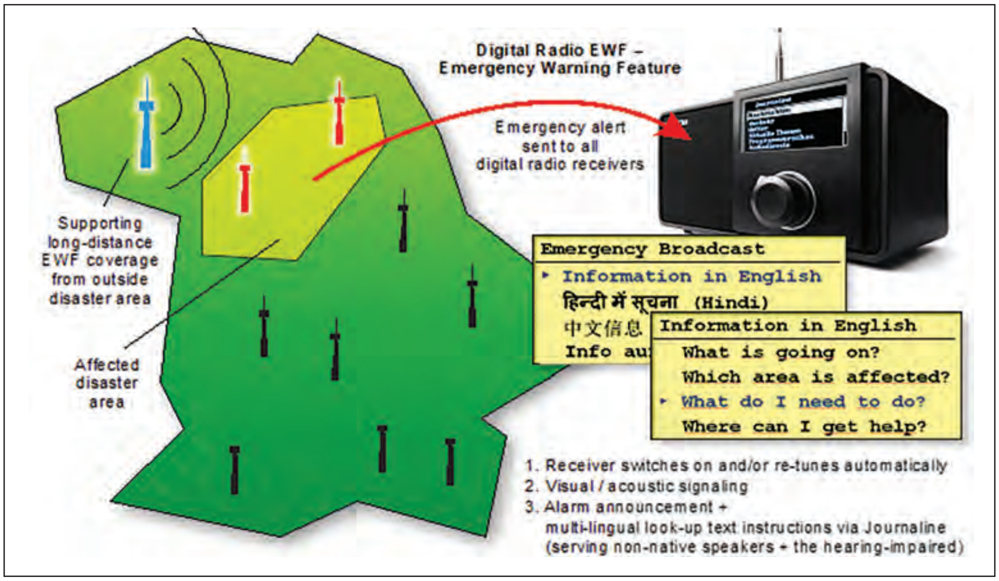


Figure 1

All of these benefits prove wrong those who have questioned the future or viability of shortwave radio, as in these times of turmoil, digital radio can be the only tool or one of the few tools for uninterrupted information.

Conclusion

The digital DRM shortwave radio is a new and worthy 21st-century broadcasting platform. The quality of audio it delivers is excellent, completely different from analog shortwave, and it also incorporates the extra benefits and all other features of digital radio while saving valuable energy.

One question always remains, though. This is the receivers for the digital broadcasts. Solutions for different kinds of DRM reception exist already (in cars, desktops, and mobile devices). Most DRM receivers can tune in to all frequencies be they digital or analog.

The software-defined radio (SDR) solutions are here as well (unlike the situation 20 or 30 years ago), the dongles are cheaper, and a shortwave digital receiver does not need to be a heavy "wooden box" any longer.

DRM receiver solutions have been demonstrated extensively by international manufacturers. They are now waiting for major orders to start significant commercial production. The more they will produce and sell, the lower their unit cost will be. This will also convince broadcasters, politicians, and listeners that there is a simple, robust communication solution in these uncertain and changeable times, digital shortwave.

About The Author

Radu P. Obreja is the marketing director of the DRM Consortium. He has extensive experience in business development, marketing and PR, having worked for large international companies in various industries, such as Visa International and Visa Europe, where he also held the position of vice president. He is a member of the DRM Steering Board, and is actively promoting the rollout of the DRM standard in Asian, African, and South American nations, as well as in some European countries.

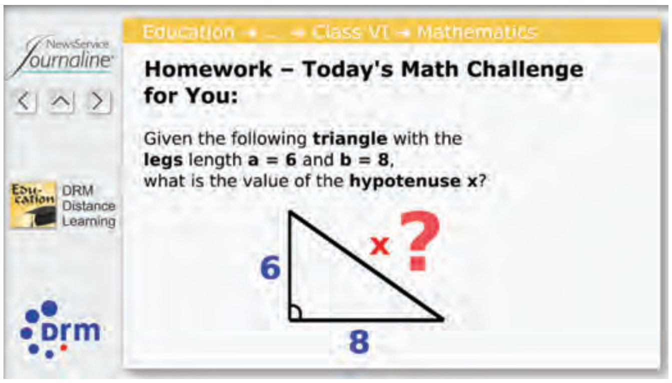


Figure 2

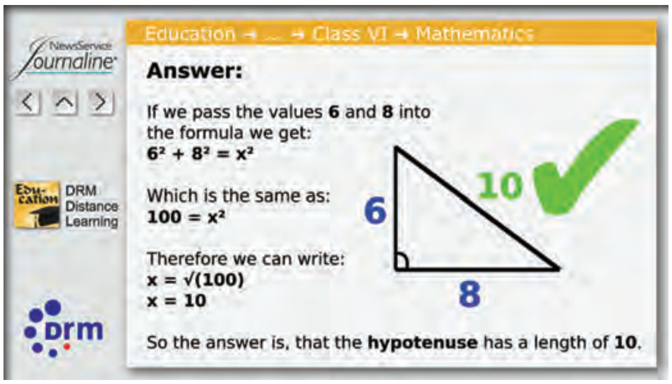
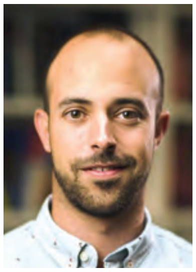


Figure 3

5G MAG

By Jordi J. Gimenez and Peter Siebert

A Report on the Joint ESA 5G-MAG Workshop


Jordi Gimenez


Peter Siebert

5G-MAG, together with the European Space Agency (ESA), organized a joint Dec. 1, 2021 one-day on-line workshop on "Reinventing Satellite Broadcasting for the 5G Era." The event focused on fostering the discussion between satellite, terrestrial infrastructure and service providers, media and other verticals representatives, in order to address the requirements and potential solutions for evolved media distribution, 5G satellite systems and service delivery chains.

Workshop Summary

The initial session began with a presentation from Matteo Ainardi, a partner of the Arthur D. Little management consulting firm, on "Future trends in media distribution and the role of satellite," in which he compared the revenue of selected media distribution infrastructure operators Eutelsat, Telesat and SES as video broadcast satellite operators, and Akamai as a CDN, and SiriusXM as radio broadcaster. He noted that the "clear winner" was SiriusXM (as indicated by the Figure 1 graph), and stated that during the last 15 years the revenue of SiriusXM has increased ten-fold, which is growth far above that of the other infrastructure operators.

Aindardi added that in 2020, the company had 35 million subscribers, with a monthly ARPU (average revenue per unit or subscriber) of $17.00 U.S. According to Ainardi, the reason for this success is the specific approach of SiriusXM on how to structure its business. He explained that the country has secured access to premium content, and as a next step the organization developed seamlessly integrated services to deliver this content to the end-user. A third step was in establishing strong bonds to all stakeholders.

He said that SiriusXM was able to orchestrate the overall user devices ecosystems (automotive OEMs, consumer devices and the like, and stated that by offering the right service at the right price point, the company was able to expand its subscriber base. For the video broadcast satellite operators, Ainardi recommended building on the three key strengths of satellite distribution: their ubiquitous coverage, the cost-

effectiveness to in reaching large audiences, and control of quality of service.

Ainardi proposed several new opportunities in using communications satellites for delivery, including distribution of 8K content, providing immersive experiences, content distribution to vehicles, and distribution of data streams to CDNs/edge servers.

Ainardi's presentation was followed by speakers from European Broadcast Union (EBU), Globecast, Südwestrundfunk (SWR, public German broadcaster) and Varnish Software. The main takeaways from these presentations were as follows:

- **The EBU**: There is the opportunity to use satellite for more than broadcast and traditional linear TV distribution. Synergies can be exploited by an integration of satellite distribution within on-line media to directly provide content to end users either at home or on vehicles. In addition, content caching at CDN servers allows distribution to the end user via a decentralized architecture.
- **Globecast:** The latest developments of satellite infrastructure such as high-throughput satellites (HTS) which are based on spot beams, or low earth orbit (LEO) constellations, provide low latency with the combining of satellite and terrestrial digital connectivity. There are two clear targets: integration of 5G capabilities for uplink contribution via satellite; and the use of 5G broadcast evolution to leverage technologies of the 5G ecosystem, such as network slicing.
- **SWR:** When it comes to the connected car there is more than just radio. New audio experiences can be created with a high degree of personalization. SWR is analyzing new use cases in their audio lab. The initiative proposes use of broadcast infrastructure and 5G Broadcast to deliver linear media into the car while making use of 5G connectivity for delivering the Mediathek and its online service offering. SWR also is considering the use of a 5G-based private network for content production.
- **Varnish:** The company provides solutions for multi-access edge computing (MEC), where the network provides services and computing functions required by users are on edge nodes. Software is the key enabler for content delivery with virtualized 5G CDN solutions powered by edge computing capabilities. 5G satellite capability could offer a direct path for content caching.

The workshop's second session began with a presentation by Qualcomm's Thomas Stockhammer who addressed "Collaboration Opportunities with 5G Media Streaming." In his presentation, Stockhammer provided an update on the current status of the 5G Media ecosystem. He observed that with 3GPP Release 14/16 the basic specifications for standalone 5G Broadcast (also known as "enhanced TV" ot "enTV") are in place. He added that the specifications support broadcast using high-power high-tower (HPHT) transmitter infrastructure and that additional functionality will be specified in the upcoming Releases 17/18. He said that this includes adding support for 6/7/8 MHz carrier bandwidths to support UHF bands, support for CMAF and low-latency broadcast distribution. In addition, he noted that work on 5G Media Streaming allows the creation of hybrid services using broadcast and unicast, and that 5G can play an important role in the overall picture of the media ecosystem. He stated that due to their ubiquitous reach, satellites will complement terrestrial networks in underserved areas, with satellite connectivity providing "global" smartphone access, as well as a backhaul channel for fixed wireless access and public safety.

Additional presentations were made by representative of Thales, SES, Eutelsat and Novelsat. The main takeaways were:

- **Thales:** The future of broadcast delivery is an integrated broadcast/broadband approach with satellite and 5G networks working closely together. The deployment options are broad, depending on use cases and other considerations in terms of terminals, satellite ground infrastructure and space segment.
- **SES:** The representative noted that satellite operator started its successful services with geostationary earth orbit (GEO) satellites, and now the organization also operates medium earth satellites (MEOs). This combination of different satellite constellations opens new opportunities for distributing content. New satellites adapted to IP Media delivery are the opportunity to migrate from traditional video delivery into the IP-based data/video space. This, along with 5G, will create favorable conditions for satellite multicast into the on-line ecosystem.
- **Eutelsat:** Technical progress such as more efficient video coding schemes and a more reliable public Internet, combined with cloud-based infrastructure and virtualization of work flows, have changed how video is produced today. On the distribution side, the traditional commercial model of satellite capacity as a commodity needs to evolve

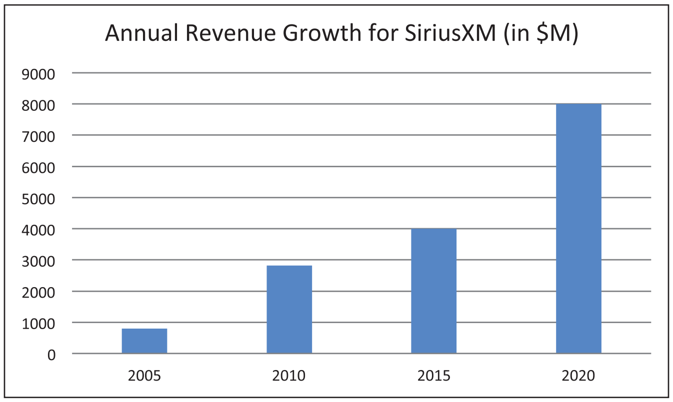


Figure 1. Annual revenue growth for SiriusXM.

to favor a new architecture where satellite connectivity becomes a "network slice" orchestrated by a "network core" that assigns network resources (including satellite connectivity) in a transparent fashion to users. In addition, the new DVB-NIP specification allows video delivery in native IP format to consumer end devices, and will also support 5G Broadcast as a Transport Layer on top of DVB Broadcast Standards.

- **Novelsat:** There is a high demand for video delivery over 5G networks using end-to-end unicast. The challenge is not so much the access network, but rather congestion in the backhaul. Novelsat sees the solution in edge-based CDNs and edge-based media distribution, where satellites play an important role in delivering content to the edge.

The topic of the third and final session focused on user devices and non-video services for 5G and satellite. Oliver Wick from the BMW automotive group started the session with a presentation on a "Non-Terrestrial Network, From Technology Radar Into The Car." He first provided an overview of all the various terrestrial networks a car is already connected now (see Figure 2). The next step could be using 5G non-terrestrial networks (NTN) based on 3GPP specifications for satellites. Wick said that BMW is preparing the roadmap from technology scouting to final implementation in the connected car, and that this roadmap is based on analyzing the space ecosystem, and the services and the use cases for the end user. He noted that 5G has the potential to bring connectivity into vehicles, enabling use cases such as autonomous driving, safety, infotainment, and entertainment, and added that this could also include augmented reality for driver information, high quality video conferencing, and in-vehicle streaming with 4k/8k videos or the car as a gaming platform.

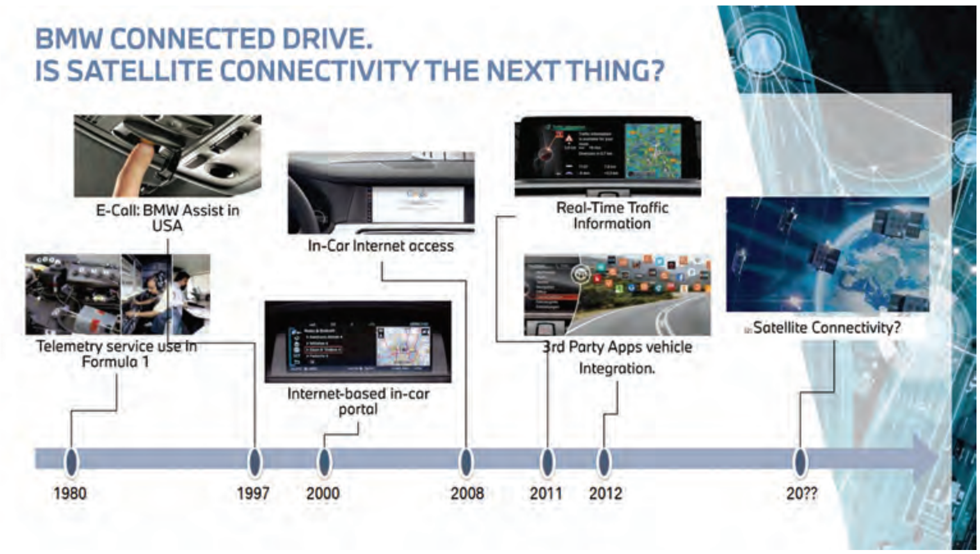


Figure 2. Connectivity in the car.

Speakers from Airbus, VirginMediaO2, Satixfy and Thales, SES, Eutelsat and ST Engineering followed Wick's presentation. Their main takeaways were:

- **Airbus:** non-terrestrial network (NTN) satellite broadcast offers an opportunity to deliver content (and not necessarily just media) with service continuity, ubiquitous coverage and scalability Advantages of combined 5G terrestrial and satellite-based NTN services include roaming between terrestrial and satellite networks, extra-territorial 5G services or a massive "Internet of Things," where satellite network element "regenerative" satellite payloads could be enablers that would benefit from the strength of satellites in the 5G era.
- **VirginMediaO2:** Current 5G terrestrial networks can be supported by existing satellite technology. The next step could be a non-3GPP satellite radio access integrated into the 5G terrestrial core network. Finally, there is the option of 3GPP-specified satellite radio access (NR) integrated into the 5G core network non-terrestrial satellite component.
- **Satixfy:** The company is working on the necessary devices, antennas and terminals to support 5G satellite reception on any platform, from aeronautics and cars to residential user terminals. This includes software-defined antennas supporting single/multi-beam modes of operation. Corresponding terminals are available for Ku- and Ka-band frequencies. The adoption of software-defined radio technologies offers a smooth and flexible path to adapt to the different needs and configuration options for satellite and mobility applications.
- **ST Engineering:** The speaker noted that the company provides products on OTT delivery integrating the satellite into the distribution chain to expand on services and use cases (video, learning, maritime entertainment, connected cars, and the like). Satellite connectivity, along with native IP technologies and multicast, can enable the distribution of OTT media content to end users by getting satellite content into the 5G network.

The various presentations and resulting discussions clearly indicated that the relevant players in the satellite industry see a great future in integrating satellite technology with 5G networks. The necessary specifications are currently being discussed in 3GPP. It will be interesting to see how these specifications will be picked up by the traditional mobile network operators.

RF Report

A Mixed Bag Of Topics

By Doug Lung

I've put together a mix of topics for this issue's article: Rust programming and a comparison of propagation models. I've started learning Rust programming, and have written a simple program that readers may find useful. It runs in both Linux and Windows. On the other topic, Oleg Sakharov at RadioPlanner has posted data on a comparison of FM radio station field measurements in different clutter environments with the signal strengths predicted by ITU P.1546-6, ITU-P,1812-4, and Longley-Rice, with both standard clutter attenuation and tuned attenuation based on measurement results, and I'll be looking at that later on in my column.

Rust Programming

If you've been reading my articles for a while, you know my main programming language is Python. I've developed a number of programs that analyze files from TVStudy to help maximize coverage, as well as programs that analyze the output from the SPLAT! Propagation modeling program. They're available at *https://www.transmitter.com/bts/Programs/*. Lately, I decided to learn Rust, a memory-safe programming language. Getting started was very easy on Linux, but a bit more complicated with Windows 10. With the Linux operating system, it was easy to install using the "Rustup" installer. Most of the required libraries were already present on my Ubuntu 20.04 LTS system. (See *https://www.rust-lang.org/tools/install*.) In searching, I found a couple of links with instructions for installing Rust on Windows along with Microsoft's Visual Studio code. (The instructions on Microsoft's site at *https://docs.microsoft.com/en-us/windows/dev-environment/rust/setup* worked best.) One tip that may not be obvious is to create a "projects" (or whatever name you want to use) folder to hold the programs that you write in Rust. The installation will create a ".cargo" folder, but I don't recommend putting the programs you create there. The book I'm using to learn Rust is available at *https://doc.rust-lang.org/book/*. There are also on-line tutorials. (See the options at *https://www.rust-lang.org/learn*.)

The first program I wrote with Rust is channel_data (channel_data.exe for Windows). The source code is shown in Figure 1. I haven't really taken time to optimize it— there may be a newer version by the time you read this— but it should run fine on Linux or Windows. No installation is needed. Just download and run the program. A terminal window will open where you enter a TV channel number. The program will return data on the channel—the center frequency, along with the FCC service area thresholds for full power, low power/Class A and translator facilities. If you do a lot of TV studies, put the application or shortcut on the desktop and click for quick info. I find it faster than searching for the data on the web or using TVStudy's ptelev program to get the dipole factor adjusted UHF signal thresholds. Figure 2 shows the program in use. You can find the latest version at: *https://www.transmitter.com/bts/Programs/*

Comparing Propagation Models

In recent columns I compared the features of the Longley-Rice propagation model used in TVStudy and most other programs that calculate TV coverage in the United States with the ITU-P1812-4 model that's used in Europe and other parts of the world. I referenced some studies comparing measurements with predicted coverage from a variety of propagation models in my last column. And I mentioned that I'd asked if it was possible to add a measurement comparison routine to RadioPlanner, similar to the one that exists in the program for non-broadcast links and available in TVStudy. I'm pleased to report that in a March 2022 update this capability is now available for FM and TV studies.

Oleg Sakharov posted details on field measurements of an FM radio station located on the Novosibirsk RTRS tower. The models used to predict coverage were ITU-P.1812-4, ITU-P.1546-6, and Longley-Rice. The signal was measured using an OPEK VH-1210 2dBi antenna mounted on the roof of a car with a phase center about 1.9 meters above ground. Other equipment used in the measurements consisted of a Signal Hound USB-SA44B spectrum analyzer/measuring receiver and Signal Hound Spike version 3.5.21 software, along with a USB GPS receiver used to track the location. His report notes: "The measurement area is the center and suburbs of Novosibirsk ([a] low-density development, mainly 5 [to] 30 meters high) and highways passing through forests of variable density. This is a hilly-flat area with absolute terrain heights from 90 [meters] to 350 [meters]."

Figure 3, which was copied from the *https://www.wireless-planning.com/blog* posting, shows the map from RadioPlanner with the routes followed for the measurements, and is labeled: "Comparison of field-strength measurements with simulation results for analog FM broadcasting." Table 1, from the posting, shows the standard deviation between the measurements using RadioPlanner's clutter attenuation settings.

I've found standard deviation to be a good way to compare predicted-versus-measured signal strength. It's useful, as it does not depend on precisely calibrated—just consistent—field measurements. The results Oleg obtained were in the same range I found when comparing my TVStudy field main.rs — KWrite

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```rust
use std::io;

fn main() {
    loop {
        println!("Input channel (2 through 36) or 0 to exit");
        let mut channel = String::new();
        let mut uhffrequency : f32 = 473.0 ;
        let mut hvhffrequency : f32 = 177.0 ;
        let lvhffreqlist: [f32; 5] = [57.0,63.0,89.0,79.0,85.0] ;
        let lvhffrequency : f32 ;
        let uhffpfs : f32 = 41.0 ;
        let uhflpfs : f32 = 51.0 ;
        let hvhffpfs : f32 = 36.0 ;
        let hvhflpfs : f32 = 48.0 ;
        let lvhffpfs : f32 = 28.0 ;
        let lvhflpfs : f32 = 43.0 ;
        io::stdin().read_line(&mut channel)
            .expect("Failed to read line");
        let channel: f32 = channel.trim().parse().expect("Please type a number") ;
        if channel >= 14.0 && channel <= 36.0 {
            println!("Channel {} is UHF", channel);
            uhffrequency = uhffrequency + 6.0 * (channel - 14.0);
            let freqratio : f32 = 615.0/uhffrequency;
            let uhffpfs = uhffpfs - (20.0 * freqratio.log10());
            let uhflpfs = uhflpfs - (20.0 * freqratio.log10());
            println!("Channel frequency is {} MHz", uhffrequency);
            println!("Full Power NL Field Strength is {} dBµV/m",uhffpfs);
            println!("Low Power Service Field Strength is {} dBµV/m",uhflpfs);
            }
        if channel >= 7.0 && channel <= 13.0 {
            println!("Channel {} is High VHF", channel);
            hvhffrequency = hvhffrequency + 6.0 * (channel - 7.0);
            println!("Channel frequency is {} MHz", hvhffrequency);
            println!("Full Power NL Field Strength is {} dBµV/m",hvhffpfs);
            println!("Low Power Service Field Strength is {} dBµV/m",hvhflpfs);
            }
        if channel >= 2.0 && channel <= 6.0 {
            println!("Channel {} is Low VHF", channel);
            let mut channelint = channel.round() as usize ;
            channelint = channelint - 2;
            lvhffrequency = lvhffreqlist[channelint];
            println!("Channel frequency is {} MHz", lvhffrequency);
            println!("Full Power NL Field Strength is {} dBµV/m",lvhffpfs);
            println!("Low Power Service Field Strength is {} dBµV/m",lvhflpfs);
            }
        if channel < 2.0 || channel > 36.0 {
            println!("Channel {} is out of range, exiting", channel);
            break;
            }
        println!("");
    }
}
```

Figure 1.

measurements after eliminating the worst outliers. When measuring an antenna that turned out to be oriented 180 degrees from where it was supposed to be pointed, the standard deviation was over 20. Re-running the prediction with the antenna oriented 180 degrees (as installed), the standard deviation dropped to the 5 to 7 range.

Looking at the data in Table 1, you can see the ITU-P.1812-4 predictions were closest to the measured values for most clutter types, particularly in the forest. Table 2 shows the clutter loss adjustment based on the measurements. You can see how Longley-Rice over-predicted signal strength in several areas, particularly trees/forest, dense urban, open areas in forest, and open areas in urban. In regards to the Open/Rural difference the study notes that the rural area wasn't really open, with the highway surrounded by forest on both sides (note the match to Open/Forest).

The study's conclusion found that for clutters with over 100 measurement points, P.1812-4 had a standard deviation range from 5.4 to 7.2 dB. ITU-P.1546-6 was close with a range from 4.7 to 7.4 dB. Longley-Rice was worse with a 4.7

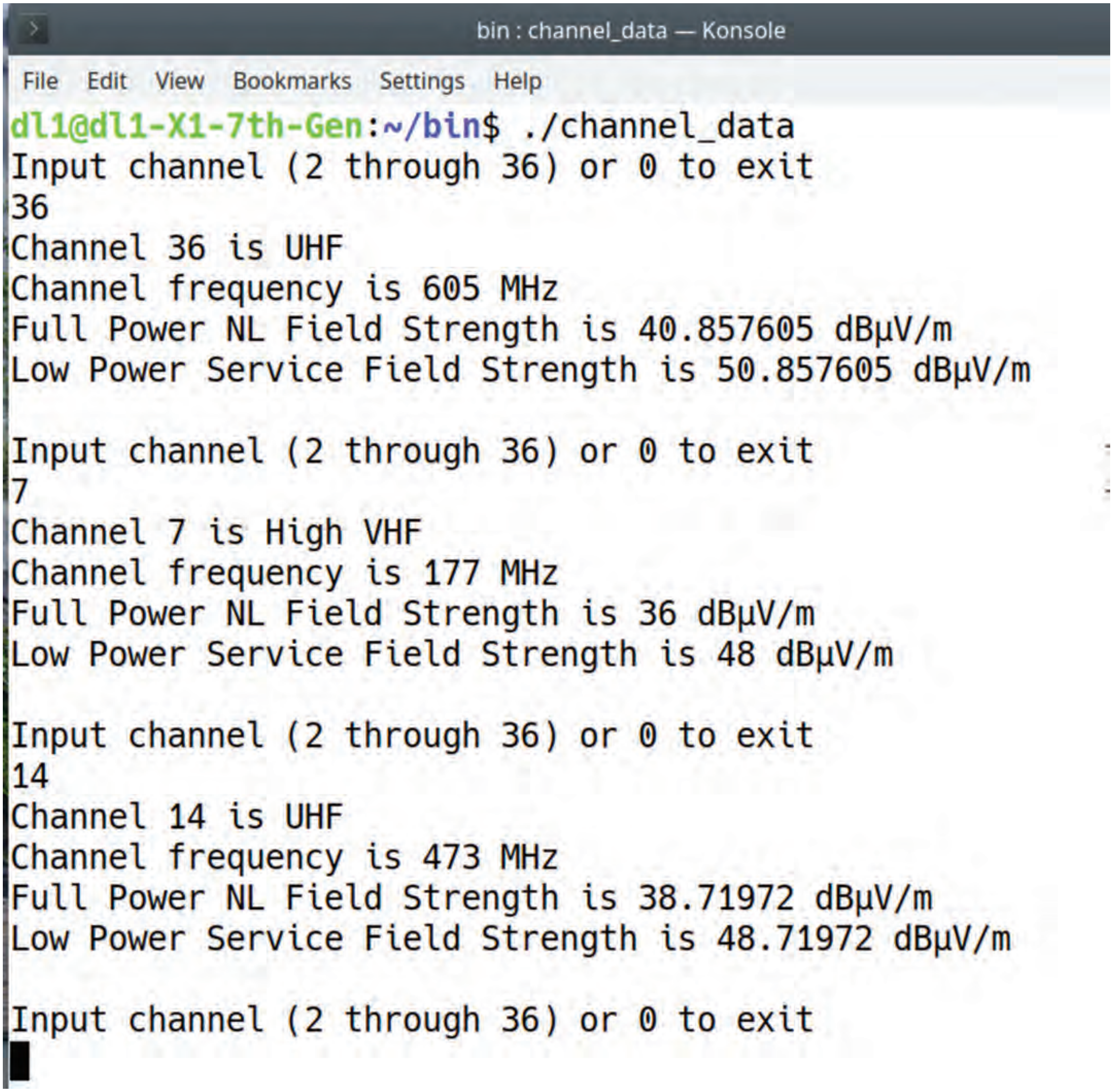

Figure 2. Channel usage date.

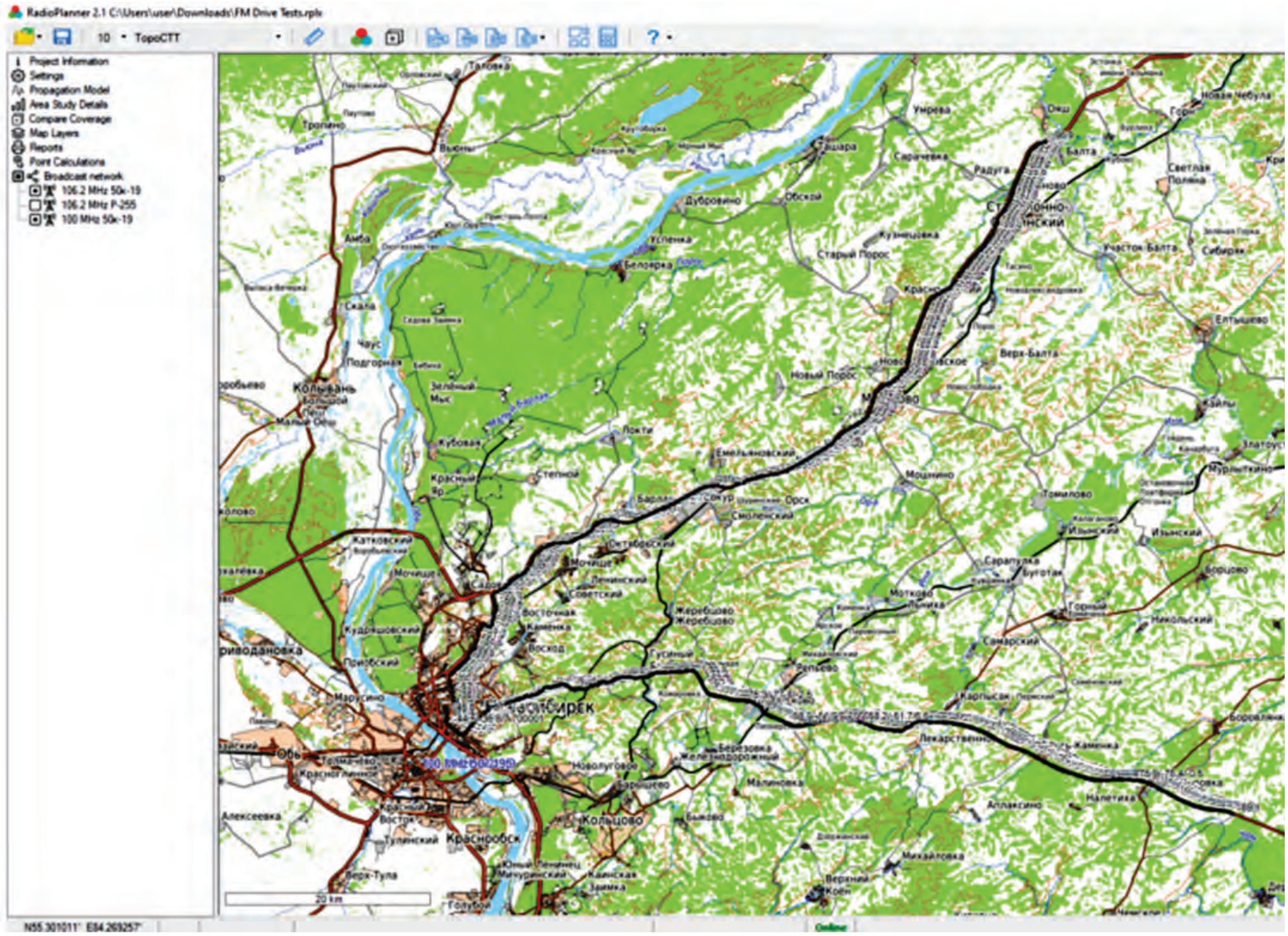

Figure 3. Measurement route map.

Table 1. Standard deviation comparison results.

	Number of Points	1812 Standard Deviation, dB	1546 Standard Deviation, dB	Longley-Rice Standard Deviation, dB
Open/rural	1797	5,6	5,6	8,9
Trees/forest	9	7,1	10,1	8,6
Suburban	108	5,4	4,7	4,7
Urban	18	4	3,7	3,6
Dense urban	6	7,1	5,8	5,8
Open areas in forest	1277	7,2	7,4	10,1
Open areas in suburban	890	6,2	7	7,9
Open areas in urban	181	6,3	6	6,4

Table 2. Tuned clutter loss comparison results.

	Number of Points	1812 Clutter Loss, dB	1812 Tuned Clutter Loss, dB	1546 Tuned Clutter Loss, dB	Longley-Rice Tuned Clutter Loss, dB
Open/rural	1797	0 (0м)	11,4	9,5	8,8
Trees/forest	9	13,2 (15м)	14,3	12,4	19,3
Suburban	108	9,6 (10м)	11,1	6,6	16,2
Urban	18	13,2 (15м)	6,1	2,7	13,1
Dense urban	6	15,2 (20м)	11,8	7,9	17,6
Open areas in forest	1277	13,2 (15м)	11,8	9,6	12,7
Open areas in suburban	890	9,6 (15м)	11	9,4	15,6
Open areas in urban	181	13,2 (15м)	12,1	8,6	17,5

to 10.1 dB range. The blog post has much more data on the study, including graphs and photos.

I hope to have time before my next **Broadcast Technology** column to compare predicted results for different propagation models with field strength measurements I've made. As part of that process, I'll look at the options for fine tuning clutter loss to get a better match.

RadioPlanner isn't the only software that allows fine tuning clutter losses. Losses can be modified in TVStudy, but there isn't an easy way to determine which form of clutter applies to which measurements without digging into the text or shapefile output files.

TVStudy's D_CelData.csv file includes a field for the type of clutter and the predicted field strength for each cell. Matching up measurement coordinates with the cell coordinates allows seeing how well measurements and predictions match for each clutter type, and thus the clutter loss adjustments necessary for more accurate predictions. Depending on the clutter data source, a single clutter type might include different types of forests, different urban densities, and different building types. As a result, any adjustments from measurements are likely to apply only to the particular area being studied.

If there are relatively few measurement points, one simple way of fine tuning clutter losses is to include the clutter loss in the shapefile output of TVStudy. Seeing the data on a map also helps to determine where the clutter data might not be accurate for the precise measurement spot, or where there are different conditions in one clutter type. Plotting the data on a map also allows adding different land-use data sources which might be more accurate than the one included with TVStudy. Many of the variations in predictions between different software using the same propagation model can be traced to variations in the accuracy of the terrain and clutter data. In future columns I'll look at these methods and the results of applying clutter data and losses to predicted results to better match measured data.

Readers may notice that RadioPlanner was developed by, and is sold by CTT, a company that's based in Novosibirsk, Russia. With the sanctions placed on Russia due to the invasion of Ukraine earlier this year, it may no longer be possible to purchase this software—at least in countries supporting these sanctions. Some tech companies and their engineers have relocated out of Russia, and perhaps CTT will do the same, but after the company's nearly 20 years of existence in Russia *(https://www.wireless-planning.com/about),* I realize that may be difficult. In the meantime, they continue to support the product, as indicated by the March update, which I was able to download and install without difficulty.

Your comments and questions are always welcome. Email me at *dlung@transmitter.com*.

Linear Television Broadcasting Over 5G Networks: Spectrum, Regulatory and Business Considerations

By Les Sabel
S-Comm Technologies
and Peter Walop
Convergence Consulting Company

Abstract

This article addresses the options for terrestrial network operators and national regulatory authorities for carrying linear television services by applying the newly released 5G 3GPP standards for 5G-based broadcasting. This article covers several technical considerations for 5G-based linear broadcasting, addresses having a supporting regulatory and licensing framework, as well as having a viable business case for 5G-based broadcasting.

It is important to note that this article focuses on the terrestrial delivery of linear television services over 5G networks. These linear television services are typically delivered by High-Power High-Tower (HPHT) networks, commonly referred to as terrestrial broadcasting networks, and are often Free-To-Air (FTA). The delivery of Video-On-Demand (VOD) services, which may also contain catch-up broadcasts of linear television services, is not addressed in this article. VOD services are commonly delivered over IP-based mobile and fixed networks, and will likely continue to expand in time.

Introduction

Renewed efforts from the telecom and broadcasting industry to deliver linear television services using mobile cellular technology networks have recently gained traction again. Dating back as far as the early 2000s, technologies such as DVB-H, MediaFlow, T-DMB and ATSC-M/H had limited business success. The capability to deliver linear television services over FeMBMS enabled LTE/5G networks, as defined in 3GPP releases 14/16 and labelled 5G Broadcast (5G BC), may be more promising. The definition of FeMBMS now includes additional 5G transmission modes and significantly larger OFDM Guard Intervals to allow networks to operate in both Multi Frequency Network (MFN) and Single Frequency Network (SFN) modes. FeMBMS or 5G BC, may provide viable business opportunities where previous attempts failed.

Current activities within the Release 17 specifications, due to be completed in 2022, include some new system features which can operate in parallel to 5G BC features. One prominent new feature is the Multicast and Broadcast Service (MBS) [1]. MBS provides switching the available carrier capacity automatically from unicast to broadcast or multicast mode. MBS minimizes the required capacity for serving users who are simultaneously streaming the same video or rich media content, including linear television services.

Currently the MBS feature within the Release 17 specification identifies the aim to provide Linear Television Broadcasting (LTB) operation. This FTA operation was also provided within the 5G BC specifications but did not provide a solution for that feature (see §5.5 of [2]). We also note that SFN operation is not discussed in [2], whereas inter-cell handover is covered, and that the MBS requires both receive and transmit communications, whereas 5G BC is designed to operate in receive-only mode.

Several experiments and studies on the structure and use of 5G BC have been carried out, such as those reported in [3]-[8]. Although this article builds on the experiences gained, it focuses on the terrestrial delivery of linear television services over 5G-based networks. The delivery of VOD services, which may also contain catch-up broadcasts of real-time linear television services, are not addressed in this article. These VOD services typically are delivered via IP-based mobile and fixed broadband networks, and are expected to continue to grow in the future.

Preparations of the ITU World Radio Conference of 2023 (WRC-23) are now well underway as the industry currently debates the possibility of migrating large parts of terrestrial television services to 5G networks. WRC-23 Agenda Item 1.5 [9] addresses possible changes to the use of the 470 to 694 MHz band in ITU Region 1 to allow 5G service. The United States in ITU Region 2 has recently re-allocated the UHF 600 MHz television broadcasting band. The 2017 incentive auction cleared 84 MHz of digital television (DTV) spectrum in the UHF 600 MHz band for mobile use. In the United States, the highest UHF DTV channel is currently television Channel 36 (602 to 608 MHz). It is noted that for ITU Region 3, the 600 MHz band is not being considered in the forthcoming WRC-23.

Given this background of new 5G technology developments and the global spectrum management agenda of WRC-23, this article is structured as follows:

1. Spectrum Demands for TV over 5G Networks
2. Regulations for TV over 5G Networks
3. Business Case for TV over 5G Networks
4. Conclusions

Spectrum Demands For TV-Over-5G Networks

In this section, we first examine what spectrum is needed to deliver linear or FTA television services, using unicast mode over 5G mobile networks. Secondly, we consider the alternative of delivering FTA services over dedicated 5G BC networks.

Table 1. Viewing scenarios.

Viewing scenario	Household viewing situation	Percentage of Households with given viewing situation in each cell	Number of unicast streams per cell, at peak hour
1	4 people, each viewing a different FTA service, at peak hour.	100%, all households	5,000
2	4 people, all viewing the same FTA service, at peak hour	As above	1,250
3	As above	50%	625
4	As above	25%	312

5G Unicast Delivery

It is important to note that in this analysis of 5G unicast delivery we do not consider the needs of other traffic. Only the spectrum bandwidth that would be required for the carriage of FTA television services at peak hour is considered.

For calculating the spectrum demands for carrying FTA services over a 5G unicast network, we first model the FTA viewing situation, followed by defining the bitrate requirements for the various types of FTA services, and then modelling the spectral efficiency of 5G services. With these three sets of assumptions, we can calculate the spectrum demands for the various scenarios.

Viewing Situations

Assuming a large city population of five million, which requires approximately 1,000 mobile phone cells, implies that on average there are 5,000 people per cell, with the major Mobile Network Operators (MNOs) in Sydney Australia being examples.

Viewing of FTA services are not equal during a day, and tends to peak in the morning and early evening when the daily news and current affairs programs are delivered, typically between 7:00 and 9:00 a.m. and 5:00 and 7:30 p.m. in most countries. Hence, we need to calculate the traffic for these peak hours. Different viewing scenarios at these peak hours are compared, as defined in Table 1. We have assumed an average household size of four people. With 5,000 people per cell this assumption results in 1,250 households per cell.

In this section, we first examine what spectrum is needed to deliver linear or FTA television services, using unicast mode over 5G mobile networks. Second, we consider the alternative of delivering FTA services over dedicated 5G BC networks.

Bitrate Requirements Per Type Of Service

For determining the required bitrates per type of service, we need to select the applied video encoding standard. A range of video encoding standards are commercially available, as well as new standards are being developed for future implementation.

To date the highest efficiency video coding scheme used in digital broadcasting is H.265/High Efficiency Video Coding (HEVC) which is more efficient than the more commonly used H.264/Advanced Video Coding (AVC) scheme. H.264 is used in DVB-T, while H.265 is used in DVB-T2 and ATSC-3.0. Recent developments in video coding have resulted in the H.266/Versatile Video Coding (VVC) standard, which claims to reduce the required bitrate relative to H.265 by 40 percent to 50 percent for UHD and 8k resolutions [10], and is slightly less around three percent for HD and SD. The VVC codec is currently being integrated into the DVB-T2 and ATSC 3.0 standards and is also gradually getting acceptance for streaming and video playback applications.

For setting the required bit rates, we use in this article the H.265/HEVC and H.266/VVC standards, noting that the latter does not have any commercial applications yet. Table 2 shows the required bit rates per FTA service type for the two encoding standards.

For the values in Table 2 we have used average bitrate values for delivering the various television services to TV screen sizes greater than 48-inches [12], [13]. It is noted that the different providers use varying bitrates, as the required bitrates are not only dependent on the picture resolution, but are also dependent on the number of frames per second, HDR/color method and encoding technology applied.

5G Spectral Efficiency

We study the bandwidth requirements of the average cell considering different modulation orders where we use the optimistic case which includes 256-QAM modulation as shown in Table 5.1.3.1-2 in [14]. The details of 5G spectral efficiency provided by different modulation and Forward Error Correction (FEC) coding are defined in [14] table 5.1.3.1 and summarized in Table 3 below, using the mean FEC rate for each modulation order.

However, we find in the ITU 5G evaluation report [15,] that under realistic conditions for mobility that the spectral

Table 2. Required bit rates per FTA service type.

Resolution		Bitrate (H.265) (Mbps)	Bitrate (H.266) Mbps
UHD (4K)	3840 x 2160	16	8
FHD (2K)	1920 x 1080	8	4
HD (HD ready)	1280 x 720	4	2
SD	720 x 576	2	1

efficiency values will generally be lower than the maximum values available. The values as provided in [15] do not include any overheads which may reduce the video payload capacity.

For our estimation of the required bandwidth for carrying FTA services, we use two scenarios. For the first case we assume a rooftop antenna and a high spectral efficiency of 6 bps/Hz which corresponds to using 256-QAM modulation and a code rate of 0.73 [14] and which is very close to the three-quarter code rate used in DVB-T2. For the second case we consider the mobile and indoor scenario assuming a more robust spectral efficiency of 3 bps/Hz, which corresponds to 64-QAM and a code rate of 0.5 [14].

We do not include any additional gain which may be provided by Multiple Input Multiple Output (MIMO) techniques due to the difficulty of implementation in the sub-1 GHz band. Finally, we use a frequency reuse ratio of three as the standard case for macro/micro cells in a cellular network.

Calculation Results

The resulting requirements for the average bandwidth (in GHz) per network cell, under the different viewing scenarios (numbered 1 to 4) and FTA service types (UHD and HD), are shown in Figure 1 for the current H.265/HEVC codec and in Figure 2 for the new H.266/VVC codec.

Table 3. Modulation orders and spectral efficiency (non-MIMO).

Modulation	Spectral efficiency using mean FEC rate (bps/Hz)
QPSK	0.71
16-QAM	2.02
64-QAM	3.92
256-QAM	6.37

For the left-hand graph in Figure 1, for delivering UHD services under viewing scenario one when using the current HEVC video codec, we see that the required bandwidth is 40 and 80 GHz respectively for rooftop and mobile reception, an amount of spectrum that even millimeter wave bands could not support. The right-hand graph in Figure 1 shows that for viewing scenario three and delivering HD services, the bandwidth requirement is 1.3 and 2.5 GHz respectively for rooftop and mobile reception. Such a spectrum demand is also highly unlikely to be supported, even by using all the sub-6 GHz frequency bands.

Given the high bandwidth requirements as discussed above, we will now examine the ability of the three individual mobile frequency bands (the sub-1 GHz band, mid bands of 1 to 5 GHz, and millimeter wave bands (typically above 20 GHz)) to deliver FTA services.

In the sub-1 GHz range, 5G can cover cells of 2 kilometer radius. There is approximately 250 MHz of paired spectrum, or 125 MHz of downlink spectrum, in the range from 600 MHz to 1 GHz (country dependent). Sub-1 GHz spectrum is very valuable for use in macro cells and rural situations. The analysis shows that even for the most lenient case of viewing scenario four, and the use of H.266/VVC codec for HD resolution video, the sub-1 GHz spectrum is unable to support the demand of 300 and 600 MHz respectively for rooftop and mobile reception.

Alternatively, the lower mid-band frequencies may also be able to cover cells with a 2 kilometer radius, and in this lower mid-band range there is around 1 GHz of spectrum available, and then a further 2 to 3 GHz in the upper mid-band range. However, it is unlikely that those frequencies will be able to provide in-building support for high bitrate services near the edge of the cell.

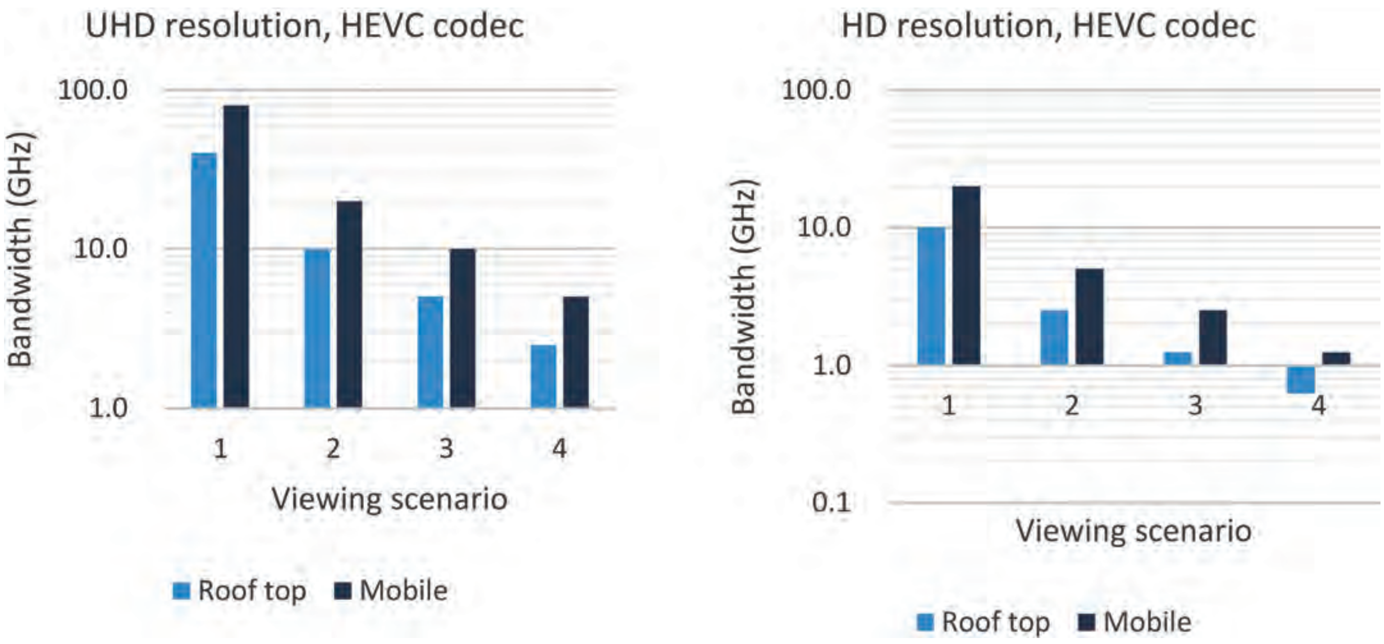

Figure 1. Total bandwidth (in GHz) per cell for unicast delivery using H.265/HEVC video coding.

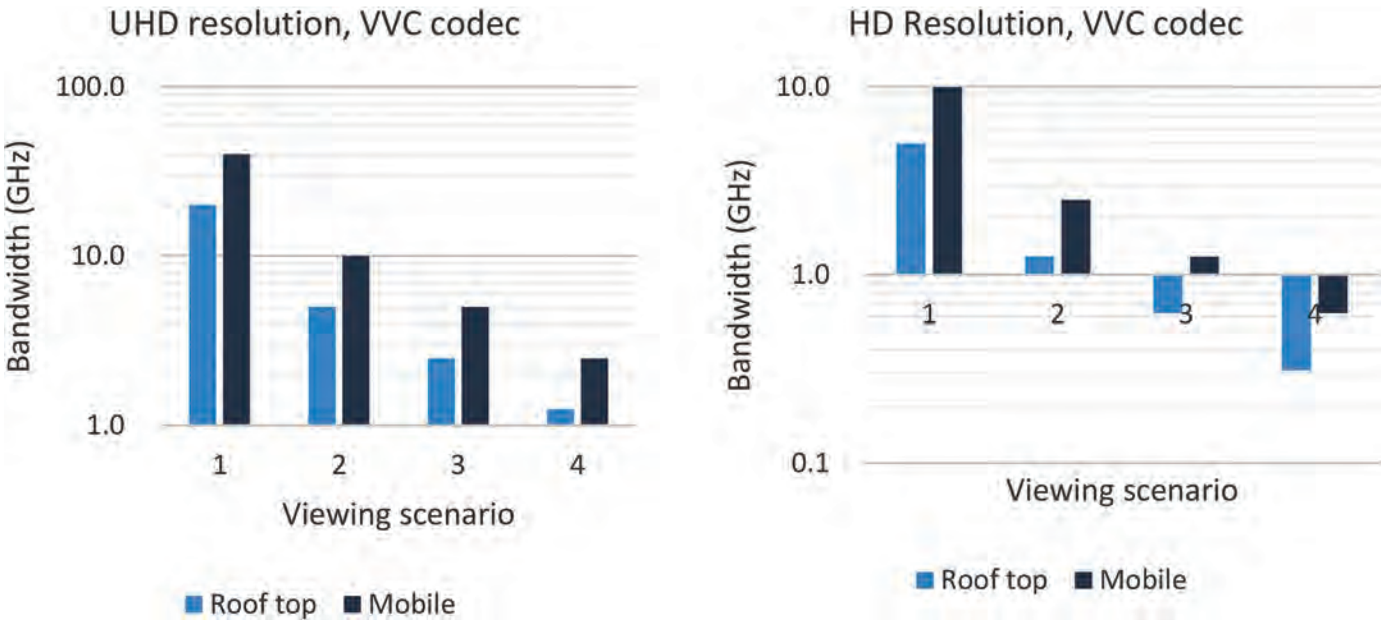

Figure 2. Total bandwidth (in GHz) per cell for unicast delivery using H.266/VVC video coding.

In both cases (below 1 GHz and mid-band) there is insufficient spectrum to support all UHD services, even when the viewing scenario is limited like in viewing scenario 4. It is likely that there will be a mix of UHD and HD/SD in various use cases including rooftop and mobile reception. However, the resulting demand at peak hours is likely to exceed the bandwidth availability in the combined sub-1 GHz and mid-range bands, even when excluding other traffic.

The high-band frequencies, typically above 20 GHz and up to 70 GHz, have substantially more spectrum. In total, up to 18 GHz could be made available in this frequency range over time. These frequencies, however, suffer from significantly higher losses, with typical cell radius of less than 500 meters with reasonable traffic loads. In other words, the use of the high-band frequencies is likely to require around 20 sites within the 2 kilometer cell radius.

In summary, even with higher operating frequencies and the latest encoding technologies, 5G unicast will struggle to deliver FTA services, and the cost to MNOs will be enormous—let alone the unsightly impact of the increase in antenna sites. Furthermore, the rollout of that many sites will take many years, if it is at all viable.

5G Broadcast Delivery

As described in the Introduction, the 3GPP introduced further changes to the 5G BC system in Releases 14/16, which provides near equivalence in spectral efficiency of 5G BC and Digital Terrestrial Television Broadcasting (DTTB) systems such as DVB-T2/ATSC 3.0. In terms of best-case reception, such as rooftop reception, both systems are theoretically close to the Shannon limit.

We note that when 5G BC is consumed in a mobile, indoor and Non-Line-Of-Sight (NLOS) reception area, which applies for most mobile use cases, then the usable Modulation and Coding Scheme (MCS) combinations move to the lower end of the spectral efficiency. Hence, applying this 5G BC technology for carrying FTA services in a 5G network, the bandwidth required will be essentially the same as it is for the current DVB-T2/ATSC 3.0 systems for rooftop reception.

These DTTB systems are commonly deployed in the UHF band. In Europe, the band 470 to 698 MHz (228 MHz) is allocated to broadcasting services, whereas in the United States, the band 470 to 608 MHz (138 MHz) is in use for terrestrial broadcasting as the 600 MHz spectrum was previously allocated to mobile services. Hence, a 5G Broadcast network would operate in the same UHF bands.

With 5G unicast, the number of simultaneous streaming sessions (at peak hour) drives the spectrum needed, independent from the number of television services. In contrast, with 5G (or DTTB) broadcast delivery, the number of television services is limited by the amount of spectrum that is available. We can estimate the maximum number of services which can be provided in the current spectrum, using a few basic assumptions.

From DTTB network planning in the various countries, we know that the frequency re-use factor ranges between three to six in deploying national services for achieving 95 percent population coverage. These frequency reuse factors can be achieved by deploying Single Frequency Networks (SFNs) as much as possible. The size of the SFN, however, is limited by the guard interval. In practical terms, the SFN size is limited by a maximum site separation distance of between 80 to 100 kilometers. We use five as a mean frequency reuse factor value as suggested in [16]. This gives us a maximum bandwidth of 45.6 MHz (228 MHz/5) per area in Europe and 27.6 MHz (138 MHz/5) in the United States.

Using the numbers in [17] Table 5 for DVB-T2 spectral efficiency, we obtain the values for the average number of services available in an area for the case of fixed rooftop antenna (256-QAM) and portable receivers (64-QAM) as shown in Figure 3 for Europe and the United States for the case of HEVC coding, while Figure 4 covers the case of VVC coding.

When using HEVC video coding, Figure 3 shows that for Europe the number of UHD services will be 14 if rooftop reception is assumed, and nine if portable reception is assumed, noting that portable indoor reception may be difficult in some situations due to building entry propagation losses. In contrast the number of UHD increases to 28 and 18 for the future case of VVC, as shown in Figure 4. The situation in the United States is similar, but scaled to lower values as less bandwidth is available.

Given that there are already significant numbers of FTA services in Europe and the United States, where second-generation DTTB is available, the options for introducing UHD services are limited because a single UHD transmission will require approximately eight times more bitrate as a SD service. As the second-generation transmission standards are already close to the Shannon limit, any technical improvement for carrying more UHD services will have to come from better video coding.

While it may be possible to improve video coding efficiency beyond VVC, the introduction of a better codec will take considerable time, considering that H.266/VVC is still in the implementation process and no receivers are commercially available yet. A further codec change beyond VVC is unlikely within the next decade.

While it is likely that there will be some limited UHD services offered for prime content such as the Olympic Games, it is also likely that there will be an ongoing mix of HD and SD services to support different service content types. As television services migrate to UHD and demand increases for these service types, even with the widespread use of H.266/VVC it is likely that programming of films and TV shows will increasingly be consumed through VOD streaming using both fixed and mobile networks. This supports the assertion that FTA TV will increasingly focus on news, sports and live events.

Regulations For TV Over 5G Networks

Regulations for linear FTA television services over MNO's 5G networks, irrespectively if unicast or 5G BC is used, will require national regulatory authorities (NRAs) to change their regulations and licensing policies. Traditionally, regulations of telecommunication markets address technical and market-related issues. Content carried over telecommunications networks has been considered a private matter—operators are supposed to just transport traffic. In regulatory terms, this is known as the "mere conduit" principle. Consequently, MNOs are unfamiliar with content requirements in their licensing and regulatory framework.

With the convergence trend and telecommunication networks also carrying broadcasting services, additional FTA regulations will have to be included in the licensing and regulations of MNOs. This would especially apply under a scenario where the traditional broadcasting networks would be (partly) replaced by 5G networks.

It is important to note that we stress that from the perspective of the MNO, regulations for FTA services are additional ones. MNOs will primarily deploy 5G networks for facilitating the unicast traffic growth as well as new Internet-of-Things applications. These additional regulations would have to address protecting the distribution of FTA services.

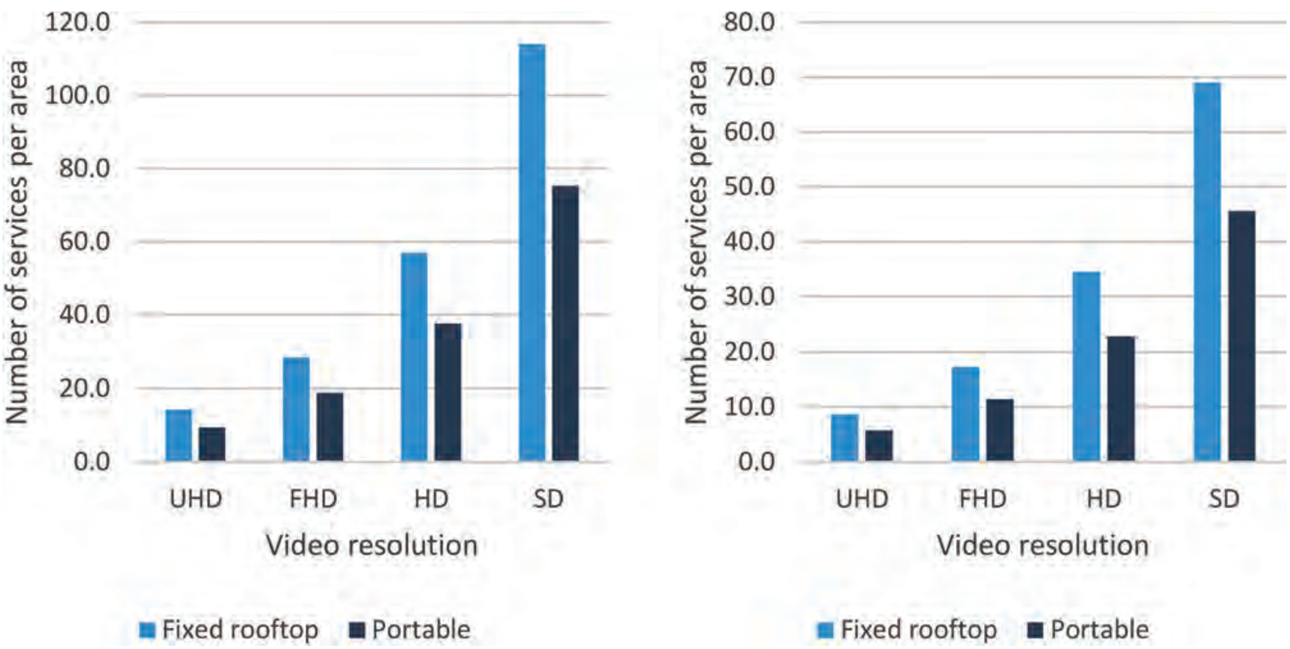

Figure 3. Average number of services per area when using the H.265/HEVC codec – left = Europe, right = United States.

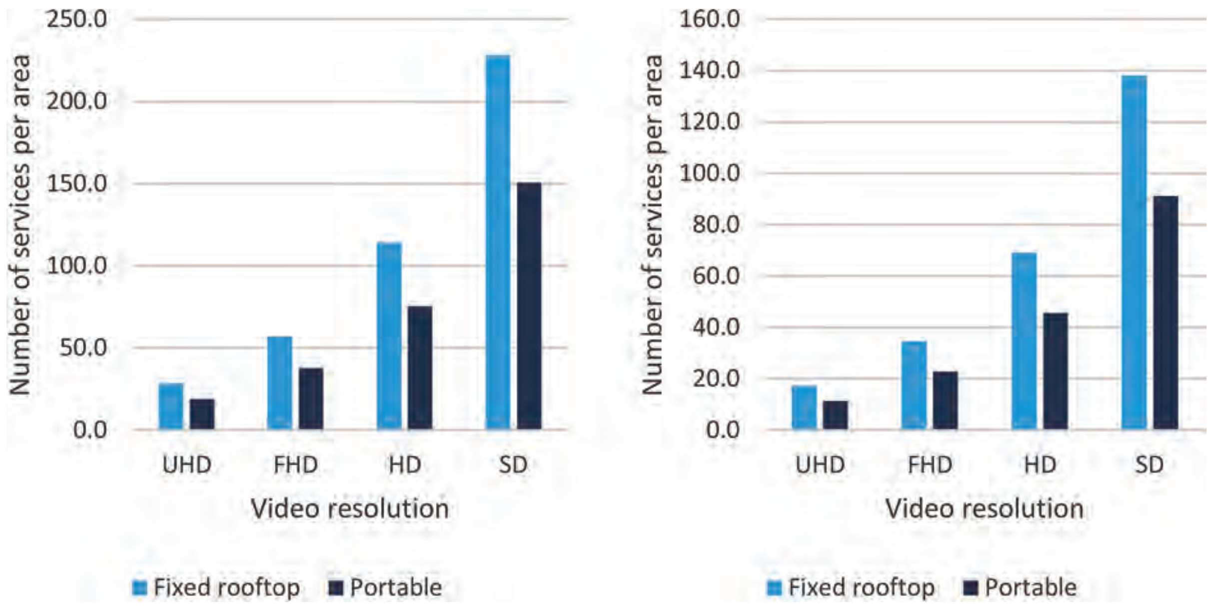

Figure 4. Average number of services per area when using the H.266/VVC codec – left = Europe, right = United States.

FTA services are often defined in a Broadcasting or Media Act (and Code of Conducts), stipulating the number of national/regional services, editorial content requirements per service, and advertising limits. Depending on the applied licensing framework, such content requirements are enforced through the terms and conditions of the broadcasting or service license for the broadcaster or service provider.

However, FTA services are also regulated in terms of their distribution, including must-carry rules (for example, public broadcasting services must be carried), encryption (for example such public broadcasting services cannot be encrypted and must be FTA), their population coverage (often nationwide), service availability (for example, 99.99 percent on a 24/7 basis), and include national emergency/disaster functionality, picture quality (SD, HD or UHD) and transmission/encoding standards (so as to protect consumers from purchasing non-compatible receivers).

For broadcasting network operators, these distribution requirements are common. However, these FTA network requirements are often not arranged for, and are also fundamentally different from the typical requirements for mobile networks. In the paragraphs below we explore these differences in more detail.

FTA 'Must-Carry'

In its day-to-day operation, the MNO is constantly balancing traffic over its networks and available spectrum. MNOs having 5G BC will also balance their traffic between unicast and broadcasting mode. Regardless of whether this rebalancing between unicast and broadcast traffic is automated (MBS), in the broadcasting mode the MNO will allocate a part of the available capacity to the broadcasting service. Consequently, the MNO will have less capacity available for unicast traffic. For event broadcasting (for sports events or in stadiums) and MBS-based traffic management such rebalancing is temporary.

Unregulated, such traffic balancing will be driven by the profitability of both services. However, for FTA services, which must be carried on a 24/7 basis, such capacity allocation to broadcasting mode is permanent.

In addition, MNOs offer access to their services through their customer management system and SIM cards. Although FTA services can be made available without payment through any customer management system, it should be checked to see if such system solutions legally comply with the definition of FTA in the relevant act or statute.

As mentioned in the introduction, in the past, MNOs have experimented with the delivery of linear television services over their mobile networks (for example LTE/eMBMS). These broadcasting services were primarily intended for delivery to handheld devices with relatively small screens. As demonstrated in the first section, the delivery of UHD services to large screens over 5G unicast is not feasible. Hence, any FTA must-carry rule including (U)HD services, will need to be delivered over 5G BC, again limiting the MNO's traffic management options.

Hence, NRAs considering 5G-based FTA broadcasting, will have to take these must-carry and FTA requirements into account and arrange for them. Clearly, such regulatory interventions are intrusive on the current MNO's business operations, especially when licenses are already running.

FTA Service Availability

FTA services delivered over 5G networks need extra safeguards to ensure these services are available in time of national emergencies or disasters. As the 2011 tsunami in Japan demonstrated, during such times of national distress, mobile network services were not available, mainly due to traffic overloading. The Japanese government relied on the DTTB networks to disseminate critical disaster news and information.

Consequently, the NRA should regulate how the FTA services needed to disseminate critical news and information are facilitated in 5G networks. A 5G network balancing traffic between unicast and broadcasting mode will not suffice, as the whole system would still be exposed to traffic overloading. Hence, the FTA services should be permanently allocated to broadcasting mode, with traffic balancing between unicast and broadcasting modes excluded.

Whether such a permanent allocation of FTA services to broadcasting mode is sufficient to warrant enough services availability during national disasters remains to be seen. From the perspective of having redundant networks, this is likely not to be the case. Especially, considering that HPHT sites have different locations from LPLT sites. HPHT sites are often located around city centers (on hill and mountain tops), whereas LPLT infrastructure is concentrated in town centers (to facilitate for the dense traffic load). In other words, DTTB networks with a HPHT network architecture are truly redundant to LPLT mobile networks.

FTA Picture Quality

As Table 2 shows, for the different picture resolutions a minimum bitrate is required. FTA services carried over 5G networks will need to meet these minimum bitrates. It is important to note that when FTA services are carried over 5G networks (or any other broadband network) in unicast mode, two market roles or parties are involved: the broadcaster/service provider and the network operator. The broadcaster may deliver its services in UHD quality to the network operator. However, the network operator may not guarantee sufficient network capacity for delivering this UHD quality at the viewer's premises or device.

In the Internet domain, such split of service and network provisioning is referred to as Over-the-Top (OTT) service delivery. Managing the Quality-of-Service (QoS) for video services is more challenging, considering that several parties are involved. These include international Tier-1 network operators, Content Delivery Network (CDN) providers, and local Internet Service Providers (ISPs). The ISPs tend to guarantee the availability of a defined transport capacity shared between the different services carried over the "data pipe," but they do not guarantee this QoS per service.

Recent developments show, however, that service providers (such as Netflix or Amazon) agree with ISPs that their services have priority over other traffic, so as to ensure a minimum broadband speed is made available to their subscribers. The ISPs receive a financial compensation for doing so. The service providers can then offer their subscribers packages with different picture quality levels. For example, "Silver" for HD and "Gold" for UHD services.

In many countries, the prioritizing of Internet traffic, including that delivered over mobile networks, is regulated under net neutrality rules. Under these regulations, network operators should manage all data-streams according to the same rules. They should not introduce any form of preferred or discriminatory treatment of content. Capacity management as such is justifiable if it is based on technical grounds and applied in a non-discriminatory way. Deliberate blocking or throttling of (audiovisual) streams of third parties is not acceptable.

Net neutrality regulations also include rulings on "zero-rating." Under "zero-rating" regimes, selected services are not counted towards customers' data plans. For example, in the United States, T-Mobile charged reduced or no additional costs for its "Music Free" audio service and "Binge On" video service delivered at a standard resolution (SD). Customers paid an additional $25 per month to receive videos in HD quality. The lawfulness of such practices was questioned by the FCC, as it surmised that throttling SD video streams and charging customers extra for not throttling HD video runs was a violation of net neutrality rules.

Hence, MNOs carrying FTA services over 5G unicast will have to comply with net neutrality regulations, as such FTA traffic would be defined as Internet traffic. MNOs managing traffic in such a way that HD or UHD quality would be guaranteed, for example by throttling other traffic, may well conflict with the net neutrality rules in their jurisdiction. In addition, offering these FTA services free of charge will also need regulatory review.

MNOs carrying FTA services over 5G BC seem to be exempt from these net neutrality regulations. However, (automatic) traffic balancing between unicast and broadcasting mode (MBS), may need to be restricted, as this traffic balancing would constantly change the traffic type between broadcasting and Internet traffic. Alternatively, the net neutrality regulations should be adjusted to facilitate 5G MBS.

FTA Transmission And Encryption

Viewers can access FTA services without a service charge, as these services are commonly financed by advertising income. Under such a business model, viewers are also able to purchase receivers independently from the service or network provider. To protect consumers from purchasing non-compatible receivers, both transmission and receiver sides are regulated.

The broadcasting network operator needs to deploy a network in compliance with a stipulated transmission standard such as DVB-T2 or ATSC 3.0, and an encoding method such as AVC (H.264) or HEVC (H.265). By means of equipment type approval, possibly in combination with import regulations, the NRA facilitates that standards-compliant receivers are sold in the various retail channels.

For FTA services delivered over 5G unicast, the transmission standards are IP-based. A wide range of IP-based streaming solutions are applied in the market such as HLS ABR (Apple) and MPEG-DASH, which can be combined with various encoding methods such as AVC, HEVC along with proprietary encoding methods. These different streaming solutions tend to lock-in the viewer to specific receiver devices (such as Apple TV) and/or service providers (such as downloadable software applications from Netflix or Spotify).

IP-based viewing of audiovisual content is mostly paid-for or subscription-based, with the service provider ensuring that the correct app and drivers are installed on the viewing device. In this way, the viewer is somewhat protected from having non-compatible devices.

Delivering FTA services, free of charge, over IP-based systems may still need additional regulations to protect viewers from device or service provider lock-in. For example, smart TV manufacturers tend to limit the apps that can run on their sets. Stipulating standardization and having an open platform for TV apps reduce the risk of customer lock-in.

From a regulatory stance, the delivery of FTA services over 5G BC is no different from having these services delivered over a DTTB platform. Consequently, the 5G BC standard and video coding (HEVC and/or VVC) should be stipulated for smart TV manufacturers to incorporate into the TV receiver. In addition, the NRA needs to decide if it would stipulate the 5G BC as an additional standard to any incumbent transmission standards (such as DVB-T2 or ATSC 3.0) in the market. Obviously, having 5G BC as an additional standard would significantly increase the cost of smart TV sets or any other television receivers.

Finally, the NRA should consider the situation of delivering pay TV services next to FTA services over 5G BC. As in the case of DTTB-enabled smart TV sets, the regulator often stipulates that the Conditional Access (CA) system cannot be embedded in the smart TV set so as to prevent the situation in which the smart TV set is dependent on the applied CA system, and hence the service provider. Similarly, the NRA should avoid the situation for 5G-based broadcasting, that the smart TV set will be MNO-dependent.

Business Case For TV Over 5G Networks

In the first section, it was concluded that 5G BC is like the second-generation DTTB systems in terms of spectrum efficiency. Also, it was concluded that unicast is not a feasible option for delivering FTA (U)HD services. Hence, this situation raises the question as to whether there is any advantage in having a single global standard (5G) for both unicast and broadcasting services.

Any substantial advantage will have to be at the network and receiver sides, with cheaper networks and receivers due to larger economies of scale. However, as MNOs and device manufacturers are free to select what part of the 3GPP standards they will implement, it is not a given that 5G BC (and MBS) will be implemented. As stated previously, 5G-delivered FTA services would be additional to MNOs. Hence the marginal costs of having 5G BC (and MBS) in mobile networks and devices should be considered, against the added value of having a television service bundle. For smart TV sets and settop boxes (STBs), it should be considered as to whether a 5G-based implementation would result in cheaper TV sets and STBs as compared to DTTB sets and STBs.

5G MBS For Mobile Devices

For delivering 5G BC to mobile devices, several studies have been conducted for the optimal network topology [5]. These studies have shown that broadcasting networks (with their main sites being HPHT) are important to reduce the overall number of sites that needed. The mobile network sites (LPLTs) are important for covering urban areas. In other words, any 5G BC deployment would result in a mixed deployed of broadcasting and MNO sites.

For the broadcasting sites, a 5G BC introduction would result in a replacement of some broadcasting equipment, mainly the exciter part of the transmitter. Such replacement costs are considered minimal. Hence, the number of MNO sites needed in the urban areas is critical in establishing the marginal costs.

As explained in the first section, a 5G unicast deployment (on a mobile network topology) in a large city of five million people could be realized with 1,000 sites or cells. Every cell (gNB) will need to include equipment that can transmit the appropriate MBS signals. This will require capital expenditures (CAPEX) to implement at both the gNB and core network levels. However, many of the required functions will be software-based, and should not require significant additional costs over non-BC capable systems.

We assess that the key CAPEX driver will be number of additional transmitters needed to generate the 5G BC signals. As this 5G BC transmitter equipment is also OFDM-based equipment, it can be assumed that 5G equipment will be comparable to low-power DTTB transmitter equipment.

CAPEX for low-power OFDM DTTB transmitters ranges between $10k to $30k U.S. (including installation). Assuming the $30k U.S. figure, and having a redundant transmitter, this would result in additional CAPEX for 1,000 cells of approximately $60 million U.S. Assuming a 10-year linear depreciation method and cost of capital of 15 percent, this would result a required annual revenue above $12 million U.S. for a single MNO.

These required additional revenues should be generated by offering linear television services, including FTA and any pay-tv services, next to VOD unicast services. Market surveys show that most content consumed with Internet-connected devices is short-form video content. Longer form content, such as linear FTA content, is relatively small. Table 4 shows the share of video views by length when consumed on internet connected devices [18]. The viewing behaviour as reflected in Table 4 is not different from the times of introducing LTE based (F)eMBMS services.

Hence, without a fundamental change of viewing behavior, the additional revenues to be realized from offering linear FTA services are expected to be small. If the various television broadcasters would select different MNOs to carry their services, and with three to four MNOs in a country, at least $36 million to $48 million U.S. in additional revenues from linear FTA services would need to be generated. Given the current viewing behaviour this seems doubtful for a city of five million people.

At this point, we have not even considered the additional costs of having 5G BC (and MBS) enabled handsets. Experiences in the past with DVB-H, MediaFlow and (F)eMBMS have shown this to be extremely challenging, even with a marginal cost of only a few dollars per device.

In other words, given that current video viewing on mobile devices is all unicast delivered, and that any future growth can still be facilitated with additional spectrum, there seems to be little business incentive for MNOs to introduce 5G based broadcasting on a large scale.

5G MBS For TV Sets And STBs

The markets for smart TV sets and STBs are very mature and global markets, with highly efficient production lines, delivering cost-effective implementations of DTTB standards. As discussed in the first section, 5G BC is not fundamentally different from second-generation DTTB standards; therefore, its implementation in smart TV sets and STBs will be at best similar in cost terms. A 5G BC implementation in smart TV sets and STBs is likely to require system changes as the 5G unicast traffic is absent or managed differently as compared to a mobile device.

As with any migration to a new transmission standard, such was the case from analog TV to DTTB and from first- to second-generation DTTB, a 5G BC introduction would require a transition period in which both the DTTB and 5G BC standards are supported in smart TV sets. This seems unlikely, as there is no technical gain for having the new 5G transmission standard. This is in contrast with the migration from analog TV to DTTB and from first- to second-generation DTTB.

Conclusions

This article has demonstrated that delivering FTA services over 5G unicast is not a feasible option, as such a solution would significantly outstrip available spectrum. FTA services delivered over 5G BC (and MBS) is technically not different from DTTB delivery in terms of spectrum efficiency, as both solutions are OFDM-based and near the Shannon limit.

Having 5G-based broadcasting as an alternative to DTTB for delivery of FTA services would require NRAs to impose additional regulations on MNOs,. These would require the MNOs to permanently allocate a part of their network capacity to 5G BC. In addition, other regulatory measures would be required to protect viewers from customer lock-in and the purchase of non-compatible receivers.

The business case of delivering FTA services over 5G BC, as an additional business to delivering VOD services over 5G unicast, seems feeble because the additional FTA revenues for MNOs are deemed to be relatively small, as most video consumption on mobile devices is the viewing of short-form video content (delivered over unicast). This viewing behavior has not changed since the introduction of LTE-based MBMS services, and therefore there is little reason to assume 5G-based broadcasting would prove a better business case at this time.

Hence, 5G-based broadcasting should not be viewed as a DTTB replacement. A better model would be to combine DTTB broadcasting with 5G network services, whereby DTTB would focus on FTA service delivery, albeit with a smaller number of services in UHD quality. 5G networks would continue to deliver VOD services, whereby 5G BC/MBS can be deployed as an advanced traffic management tool to further increase the capacity of mobile networks. 5G and DTTB can be further integrated, such as those currently in trials between SK Telecom and Sinclair Broadcast Group with 5G and ATSC 3.0 in South Korea [19].

With 5G being complimentary to DTTB, 5G-based broadcasting still requires NRAs to review and possibly change their current regulatory framework in the areas as included in Table 5.

Such changes are best addressed when they are part of a comprehensive review of the licensing and regulatory regimes for both telecommunication and broadcasting services and a converged licensing framework is developed.

Finally, 5G BC/MBS functionality can further improve spectrum management efficiency. NRAs should investigate how LPLT 5G BC/MBS can be deployed in underutilised (white space) areas of DTTB networks. Licensed Shared Access or Shared Access Licensing concepts such as developed by CEPT and Ofcom can prove to be helpful in developing a spectrum licensing regime for 5G MBS deployment [20],[21].

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Table 4. Share of video views by length (Q4 2020). (Source: Brightcove).

Content type	0-5 min	6-20 min	21-40 min	41+ min
Corporate Communications	71%	22%	4%	3%
Entertainment	71%	7%	8%	15%
Marketing and Sales	82%	8%	4%	6%
News	90%	3%	2%	4%
Retail	97%	2%	1%	1%
Sports	89%	4%	1%	6%

Table 5. Regulatory review areas and issues.

Regulatory area	Issues to address
Must-carry for TV services	• If MNOs don't have a must-carry obligation, but do offer TV broadcasting services, is there (still) a level-playing field with DTTB network operators?
TV service availability	• Can MNOs, having TV broadcasting capabilities, provide national disaster services and how to arrange for these services given 5G BC/MBS functionality?
TV picture quality	• Are MNOs, applying MBS based traffic management, compliant with net neutrality regulations or do these regulations need adjustment?
TV transmission & video encoding s	• Should type approval rules and procedures for smart TVs and STBs be changed to also include the 5G broadcasting transmission standard?

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4G/5G Cellular Bonding For Live Video Broadcast

5th-generation wireless rollout can benefit broadcasters

By Emeka Okoli
Vice President Of Customer Success
Zixi

Introduction

Cellular companies have been heavily promoting the benefits of fifth-generation (5G) cellular service over the current and more readily available fourth-generation (4G) service. For their part, cellular companies have relied on promoting the significant difference in download speed to consumers. However, in addition to increased speed—as much as 100 times faster than 4G[1]—there are two other benefits of 5G over 4G: decreased latency and enhanced coverage.

These advantages can have a significant impact on the bonded cellular technology that is being used by broadcast and media organization to send live video signals back to their production control rooms.

4G/5G Cellular Services

All cellular service works by connecting a cellular device (smartphone, tablet, etc.) to a nearby antenna as part of the Radio Access Network. The signal is then sent to the Core Network, which either routes telephone calls to an antenna located near the device of the party with whom connectivity is desired, or to the desired Internet service. The Transport Network is the intermediary connecting the Radio Access Network and the Core Network[2].

First-, second- and third-generation services use relatively low (UHF region) radio frequencies and provide a large coverage area, as frequencies in this portion of the spectrum travel farther and can penetrate deeper into structures[3].

4G uses mid radio frequencies, which brings increased capacity, but with the tradeoff of smaller coverage areas. 5G, however, taps significantly higher radio frequency spectrum for increased data capacity (at the expense of reduced coverage), but has the advantage of using lower cellular frequencies as well, thus providing enhanced data handling capacity over that of 4G service[4].

While 4G increased data capacity approximately tenfold over previous generations, in densely populated areas its capacity was not always sufficient. This is especially true as data traffic has been growing at about 60 percent per year[5]. With 5G, capacity is increased, alleviating connectivity issues in crowded areas such as at a sporting event.

With regard to coverage, cellular service providers are using different frequency ranges, service management techniques, and cellular antennas that are closer together to manage the coverage limitations of higher radio frequencies.

When latency between 4G and 5G is compared, 5G offers a very significant improvement. Latency in 4G networks is currently about 50 milliseconds, while 5G networks are expected to lower that to nearly zero—about one millisecond[6].

Bonded Cellular For Video

As the term implies, bonded cellular is the process of multiplexing two or more cellular internet connections simultaneously (via SIM cards), with timing of the video signal between each individual cellular service handled by various algorithms. This provides an increase in cellular bandwidth that is capable of handling the needs of live video for broadcast. A bonded system takes in an audio and video feed at the origination point of the connection and outputs audio and video at the receiving point.

Bonded cellular allows video contribution and/or distribution over the Internet," which uses a managed IP network to significantly lower, or even eliminate, packet loss. A well-engineered system will deliver outstanding performance at low predictable latency, superior reliability, no packet loss, and broadcast-grade video quality (SD, HD, and UHD) with no tradeoffs in video or audio delay, resolution, or "stutter."

For broadcasters or media organizations, it is significantly less expensive than using satellite transmission and does not rely on a hard-wired Ethernet connection or Wi-Fi. For newsgathering and live reality programs, bonded cellular is, literally, what makes many of the stories and programs technically and financially possible.

Benefits Of 4G/5G Bonded Video Over 4G-Only

Bonding of 4G LTE and 5G taps the benefits of both spectrums in enabling seamless and highly resilient signal uptimes. It also provides a failsafe in the case of failure of one or the other. Additional bonding back-up can be provided via the public Internet. As an example, one available technology—a software-defined video platform—allows users to enable contribution or distribution from nearly any location with 99.999 percent reliability[7].

This significantly improves high availability, thus supporting varying degrees of applications across a broad range of video streaming and live data communication verticals. While 4G does have extended frequency range advantage, it suffers from interference, unpredictable jitter, high latency and significant congestion when crowded with many users and devices.

This is a significant hurdle to overcome when servicing "new age" consumers who have increasing appetites for the highest live content quality in newsgathering, reality programming, and even sports betting. Achieving this objective requires accelerating the speed of datagram transfers, along with exceptional bandwidth with less noise.

4G/5G bonding helps expand the bandwidth bottleneck of 4G, paving the way for field production teams and content creators curating live content to deliver high video bitrate signals, whether to a television production control room or directly to a streaming service for both at-home and out-of-home mobile consumption—making use of 5G distribution as well.

A Look At 4G/5G Tradeoffs

Bonded 5G certainly does not come without risks. The service still has deficiencies and elements that can impede its benefits, such as line-of-sight impairments and shorter signal range in less dense geolocales with scarce 5G range extension repeaters and related infrastructure.

In addition, initial 5G bandwidth cannot be guaranteed to remain high over time, so it is prudent to adopt platforms that are highly efficient, yet agile enough to dynamically reduce overhead, adjust latency in real time without interruptions and reduce content bitrate, and can seamlessly pivot to 4G LTE.

These are challenges that can be solved through the use of technology available today, which in 5G, enables multiple edge computing contribution and distribution use cases, with 5G accelerating on- and off-ramp across the 5G MEC. Marrying 5G with cloud edge computing can alleviate and normalize tradeoffs between 4G and 5G services.

With on- or off-ramp distribution to 5G edge devices, cloud edge computing intelligence allows operators to receive feedback about congestion and issue instructions back to the 5G devices, dynamically throttling back bitrates when there are range or congestion limitations.

Number Of Cells Involved In Bonding

There are no limitations on the number of SIM cards that can be bonded together in a software-defined video delivery platform. A recent test with one such product using the Verizon 5G MEC and AWS Wavelength Zones with bonded 5G SIMs achieved a 5 gbps throughput over 5G.

It needs to be kept in mind that the average maximum speed for 4G is 150 mbps, while 4G LTE clocks in between 300 mbps and 1 gbps[8]. Although 5G on its own has average speeds between 1 and 10 gbps[9], there is no consideration for dropped packets or management. These are the data transmission rates received by a smart device from the cellular service tower.

Conclusion

Audiences have insatiable appetites for content, whether it be local, regional, national, or international news events, entertainment, or sports, and broadcasters and media organizations have to balance their coverage of an event against the cost of bringing that coverage to viewers.

Traditionally, news "live shots" and live programming were sent back to the production control room via microwave, satellite, or a hard-wired (copper or fiber) connection if it was available. Each of those solutions comes with a significant cost in terms of both capital expenditures (CAPEX) and ongoing operational expenses (OPEX).

4G/5G bonding for live video broadcast comes with the benefits of significantly less costs for both CAPEX and OPEX, while providing the ability to capture an event wherever such cellular services are available, with the reliability required for live broadcast use, up to and including UHD acquisition.

This new production solution gives producers the freedom to obtain the live shots they desire, without the cost constraints that the industry has traditionally been subjected to.

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5G Broadcast – A New Era Of Content Delivery

By Mohamed Aziz Taga
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For decades, mobile cellular networks have been based primarily on a unicast bidirectional communication model that provides various services to their end users. Consumers can now enjoy watching a huge amount of premium content, including a large percentage of live media services. Moreover, mobile user behavior and expectations are trending increasingly in the direction of higher quality of service, more features and better accessibility from the service providers in order to enjoy the best experience ever while using network resources. However, this places pressure on mobile network resources and pushes these mobile networks to the limits of the unicast paradigm.

In this context, there is a critical question that needs to be asked: will the unicast delivery mechanism alone be sufficient to handle high congestion situations, or will additional broadcast/multicast delivery methods be required?

This paper provides an answer to this question and helps discover how to deliver high-quality, personalized live experiences to meet the growing demands of audiences.

Selecting The Right Technology

The next quantum progression for technology supporting mobile communications networks, 5G, promises to provide new and radically different technological and business opportunities. It not only enhances mobile broadband, but also brings new broadcast and multicast capabilities to the whole ecosystem, as it provides network operators and broadcasters significant opportunities in several new business areas while creating higher spectral efficiency and reducing costs.

For network operators or media content providers/owners in the mobile telco industry, this means a completely new range of business models for data delivery to very large numbers of consumers without affecting the cellular 5G mobile network.

This new technology enables consumers to access high-quality media over a range of smartphones and SIM-less devices with greater coverage and lower latency. 3GPP— since Release 14 and up to Release 16—specifies the Further Enhanced Multimedia broadcast multicast service (FeMBMS) as new broadcast/multicast enhancements for both dedicated and mixed modes. (FeMBMS is also known under the name of LTE-based 5G Terrestrial Broadcast, or is sometimes even shortened to 5G Broadcast.)

Using broadcast and/or multicast over 5G, mobile network operators can deliver premium content to mobile consumers still attached to cellular networks with consistently high quality of service (QoS) and higher quality of experience (QoE). This is accomplished either via an overlay network or with the supplemental downlink (SDL) concept.

5G Broadcast/Multicast Verticals

5G clearly holds the promise of original business opportunities. In fact, it's bringing new broadcast and multicast capabilities to the whole ecosystem by enabling new applications. Although live video distribution is very important, 5G Broadcast does not necessarily mean mobile TV.

5G is not only capable of delivering media and entertainment to smartphones but can also provide smart vehicles with over-the-air (OTA) updates, enhanced positioning and navigation, media and entertainment, as well as updating GPS maps. Live event multicasting makes more sense when using this feature. 5G Broadcast can transmit public safety multicasts such as urgent weather and community information, thus simplifying the relationship between community members and governing bodies.

Several other services could be optimized using multicast over 5G. These include OTA multicast for centralized configuration and control, live commerce, and rural eLearning where no Internet connection is available. In addition, 5G Broadcast enables venue casting that combines a live experience with the comforts of home.

The new technology is creating opportunities for broadcast network operators to make their infrastructure more dynamic and help them discover new distribution features. It also supports mobile network operators in offloading their heavy streaming and data loads to avoid infrastructure overprovisioning. As a result, they can serve consumers with higher quality of service while reducing both their capital expenditures and operating expenses.

The Main Advantages Of 5G Distribution

5G affords both wider coverage and spectrum efficiency. Broadcasting/multicasting information via overlay networks is much more efficient than sending it hundreds of thousands of times to mobile network cells. Thanks to greater cell coverage, this improved flexibility can substantially reduce deployment and operation costs. There's also a better quality of service and a higher quality of experience. Consumers expect higher quality with HD and UHD television, as well as a high dynamic range for better picture quality. With the lower latency and higher flexibility that 5G Broadcast offers, the consumer experience can be improved with more real-time apps.

Release 14 was a significant enhancement to the previous eMBMS, and is thus referred to as "Further evolved Multimedia Broadcast Multicast Service" (FeMBMS) or "enhanced TV" (EnTV). It's considered to be the first mobile broadband technology standard to incorporate a transmission mode designed to deliver terrestrial broadcast services from conventional High-Power High Tower (HPHT), Medium-Power Medium Tower (MPMT) and Low-Power Low Tower (LPLT) broadcast infrastructures, thus addressing the exact needs of broadcast network operators.

The enhancements introduced in this release include system architecture and interface simplifications, as well as extensions to the LTE Physical Layer. It establishes the foundation for 5G Broadcast as it fulfills the majority of ITU requirements for broadcast/multicast distribution in next-generation networks.

With respect to the Physical Layer, the main improvements in FeMBMS are support of larger inter-site distances for single frequency networks and the ability to allocate 100 percent of a carrier's resources to the broadcast payload, with self-contained signaling in the downlink.

From a system architecture perspective, a receive-only mode enables free-to-air (FTA) reception with no need for an uplink or SIM card, thus enabling the reception of content without registration of legacy user equipment with a network. Broadcast and Multicast options are planned for implementation with 5G New Radio (NR) under the name of NR Broadcast and Multicast. This is to be standardized in 3GPP from Rel.17, and is expected to be ready from Q3 2022 onwards.

An Enhanced Feature Set

In relation to the 3GPP Release-14 feature set presented by the first introduction of EnTV/5G Broadcast within the standard, enhancements made to the system architecture also include:

- an xMB interface through which broadcasters can establish the control and data information of audio-visual services while using different content types such as DASH, HLS and CMAF
- a new Application Programming Interface (API) for developers to simplify access to eMBMS procedures in the User Equipment (UE)
- The support of multiple media codecs and formats (SD, HD, UHD, HDR, etc.)
- a transparent delivery mode to support native content formats over IP without transcoding (e.g., reusing existing MPEG-2 Transport Streams over IP and compatible equipment)
- support of shared eMBMS broadcast by aggregating different eMBMS networks into a common distribution platform
- a Receive-Only Mode (ROM) that enables devices to receive broadcast content with no need for uplink capabilities, SIM cards or network subscriptions; i.e., free-to-air reception.

From the radio layer point of view the most significant enhancements include:

- the possibility of establishing dedicated FeMBMS carriers that allocate up to 100 percent of the radio resources to terrestrial broadcasting (i.e., with no frequency or time multiplexing with unicast resources in the same frame). There's self-contained signaling and system information in the downlink
- a new, reduced overhead subframe containing no unicast control region
- support for larger inter-site distances in single frequency networks, along with a higher spectral efficiency with a new OFDM transmission mode through 1.25 kHz subcarrier spacing (SCS) and a 200 μs cyclic prefix. These OFDM transmission mode changes are the most significant, as the longer OFDM symbol duration, occupying one subframe, made it necessary to design a new subframe structure, known as the Cell Acquisition Subframe (CAS), to allocate the synchronization and control channels, transmitted with much reduced periodicity (one in every forty subframes).

In addition, Release 16 brought new improvements to the Radio Access Network (RAN):

- SCS for fixed reception (Δf= 370Hz/ CP=300μs) / mobility < 120 Km/h
- SCS for fixed reception (Δf= 1.25KHz/ CP=200μs) / mobility ≈ 120 Km/h
- SCS for mobile reception (Δf= 2.5KHz/ CP=100μs) / mobility ≈ 250 Km/h
- SCS for mobile reception (Δf= 7.5KHz/ CP=33.33μs) / mobility > 250 Km/h
- Improved CAS content Physical Broadcast Channel (PBCH

Along with broadcast content, mobile broadband subscribers who have a SIM card can enjoy enriched service offerings when combined with independent unicast for interactivity, in a similar way to conventional HbbTV (hybrid broadcast broadband TV) sets. The introduction of a ROM and the new framing and OFDM transmission mode options may make FeMBMS suitable for use with conventional broadcast infrastructure (including high-, medium- and low-power sites).

The Technical Solution With Regard To The 3GPP Standard

As per 3GPP specifications starting from Rel.14, the main architectural approach has been defined via the deployment of 5G Broadcast/Multicast via an overlay network in the RAN using either HPHT or MPMT for a wide coverage. The Broadcast/Multicast core network is, of course, part of the End-to-End (E2E) solution where the new roles are defined as follows (see Figure 1):

- **The BM-SC (Broadcast Multicast Service Center)** provides membership, session and transmission, proxy and transport, service announcement, security, and content synchronization. It supports various MBMS specific user services such as provisioning and delivery. The BM-SC sets up the e-MBMS session, initiates delivery of the content by pulling it from the content server, applies an appropriate codec for the content, and collects the reception receipt from the UEs for certain kinds of content.

- **The MBMS-GW (eMBMS Gateway)** distributes MBMS user-plane data to eNBs using IP multicast and performs MBMS session control signaling towards the E-UTRAN via MME. It creates the MBMS bearer and receives the user-plane MBMS traffic from the BM-SC. Once received, it allocates a multicast transport address and performs the GTP-U encapsulation of the MBMS data.
- **The MCE (Multi-cell/multicast Coordination Entity)** manages MBMS content and resources.

If this above-mentioned architecture is not so easy to understand, we can still make things simpler for the network operators and thus provide a simplified architecture for Multimedia Services (as shown in Figure 2):

5G Broadcast/Multicast Interfaces

Within the overall infrastructure presented by 5G Broadcast, multiple important interfaces need to be considered:

- **Sm:** located between the MME and the MBMS-GW, receives MBMS service control messages and the IP Multicast address for MBMS data reception from the MBMS-GW. It also carries the EPS GTPv2-C messages:
- MBMS Session Start messages
- MBMS Session Update messages
- MBMS Session Stop messages
- **SGi – mb:** is the reference point between BM-SC and MBMS-GW function for MBMS data delivery
- **SGmb:** is the reference point for the control plane between BM-SC and MBMS-GW.
- **M1:** is the reference point between MBMS GW and E-UTRAN/UTRAN for MBMS data delivery. IP Multicast is used on this interface to forward data. The protocol used here is GTPv1-U.
- **M2:** M2 signaling bearer provides the following functions:
  - Provision of reliable transfer of M2-AP message over M2 interface
  - Provision of networking and routing function
  - Provision of redundancy in the signaling network
- **M3:** The M3 interface provides the reference point for the control plane between the MME and the MCE (E-UTRAN). The M3 Application Protocol (M3AP) supports the functions of the M3 interface by providing:
  - Support for both IPV4 and IPV6 addresses at MME endpoint.
  - Session Management - This overall functionality is responsible for starting, updating, and stopping MBMS sessions via the session control signaling on the SAE bearer level.
  - M3 Setup functionality for initial M3 interface setup for providing configuration information.
  - Reset functionality to ensure a well-defined re-initialization on the M3 interface.
  - Error Indication functionality to allow a proper error reporting.
  - MCE Configuration Update function to update the application-level configuration data needed for the MCE.
  - xMB: To simplify the access to eMBMS system functionalities content providers and broadcasters can now establish the TV service through the standardized xMB (broadcasting application programming) interface,

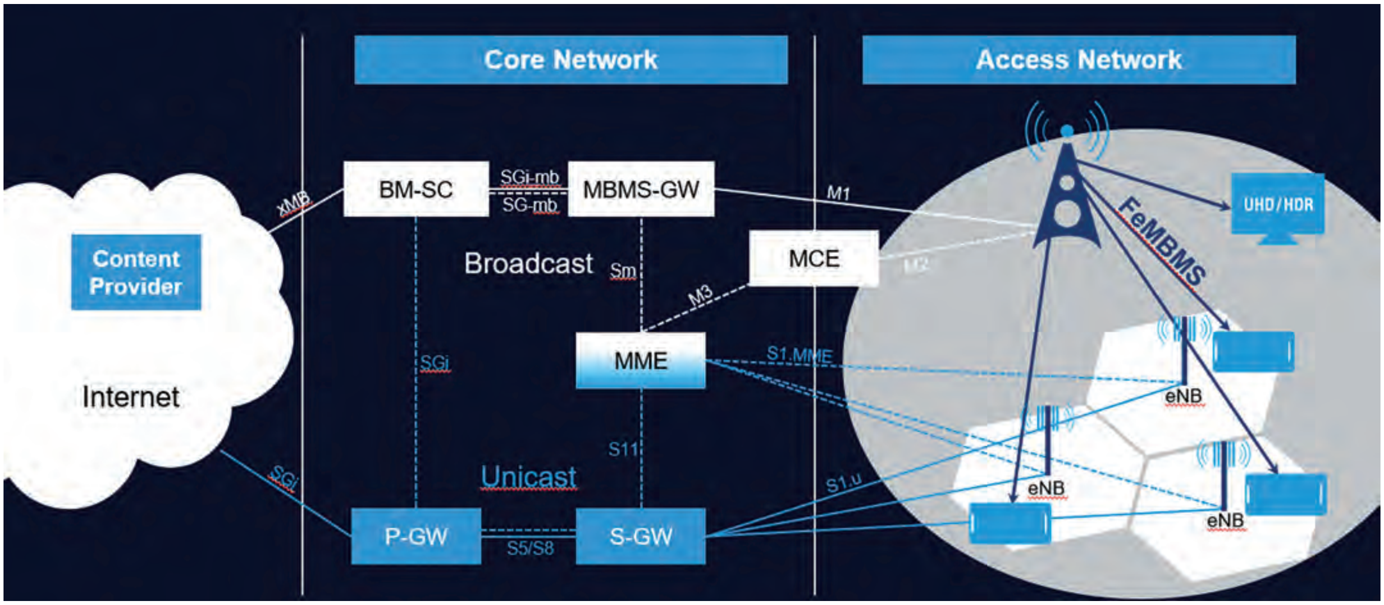

Figure 1. 5G Broadcast overall architecture.

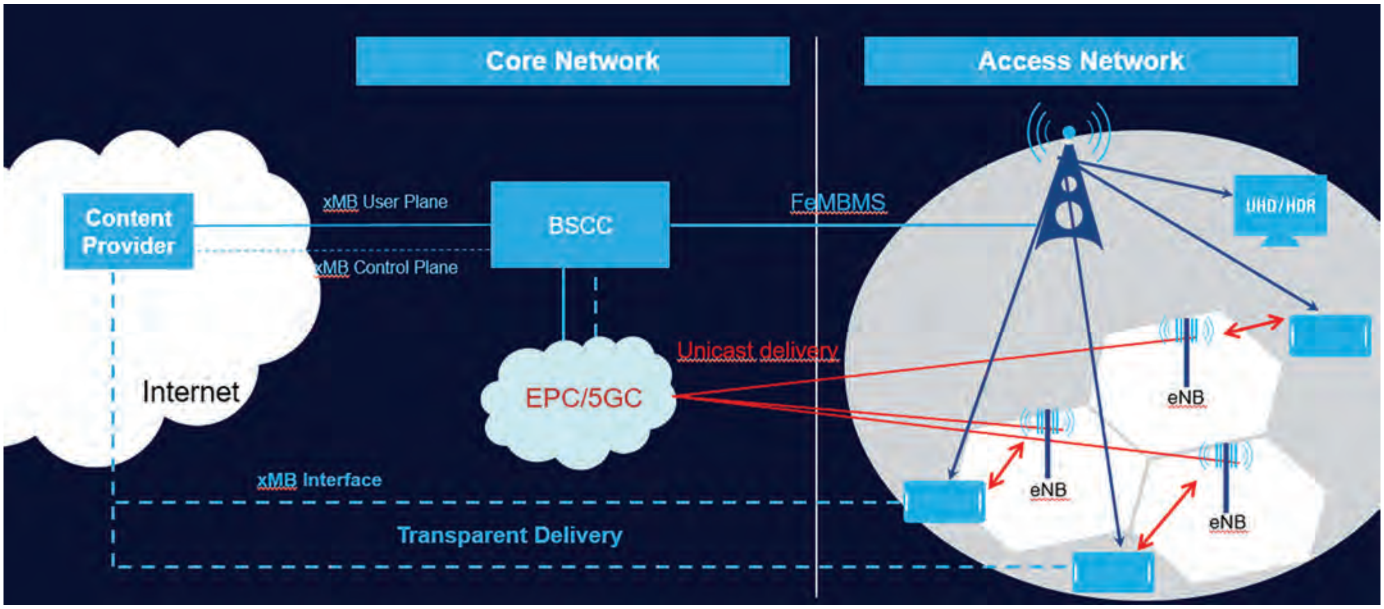

Figure 2. 5G Broadcast simplified architectural model.

which has two aspects: xMB-C for control, and xMB-U for delivery of media content to the BM-SC. 3GPP allows the inclusion of unicast distribution as a mobile system service, for example using eMBMS-operation-on-Demand (MooD) or unicast fallback.

Several solutions are proposed for delivering better quality services and providing a higher quality of experience with reduced costs:

- Solution 1 – overlay NSA (Non-Stand Alone) / SA (Stand-Alone) for use in rural and suburban areas (see Figure 3)
- Solution 2 – SDL (Supplemental Downlink) NSA/SA for use in dense urban areas (see Figure 4)
- Solution 3 – combined overlay and NSA/SA.

A more concrete way to enhance the existing cellular network could involve adopting Solution 1 for suburban areas and rural environments where line-of-sight is usually available. Here, an overlay network using HP/MP transmitters for greater coverage makes more sense in combination with either an existing non-standalone or standalone architecture.

However, in order to establish localized broadcast/multicast on a cellular level, Solution 2 would be more convenient in dense and/or urban areas, by deploying add-on low-power transmitters (LP Tx) within existing cellular sites with minimal costs. The low-power add-ons are purely software-based, and could potentially be easily integrated in the future into an existing cloud RAN (C-RAN) without additional hardware.

Furthermore, neither Solution 1 nor Solution 2 would prevent a network operator from choosing and deploying Solution 3. A combination of Solutions 1 and 2 in order to achieve nationwide deployment of broadcast and multicast applications can be easily imagined.

Market Tendencies

During the last decade, there have been several false dawns in connection with commercial high-quality mobile media broadcasts. What looks “fantastic” in an R&D lab or on a tradeshow stand has rarely lived up to expectations when it is applied to real world scrutiny.

5G Today was the very first project to test broadcast and multicast capabilities over 5G officially launched between July 2017 and February 2020 with project partners including the

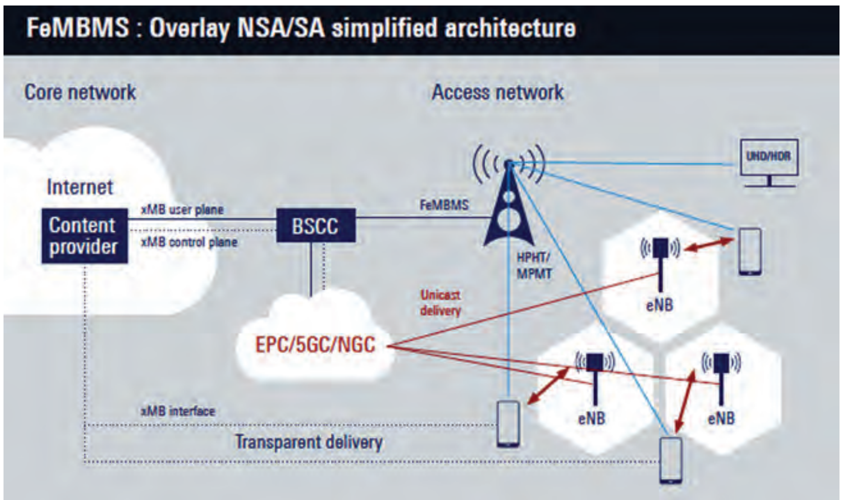

Figure 3. 5G Broadcast overlay NSA/SA simplified architecture.

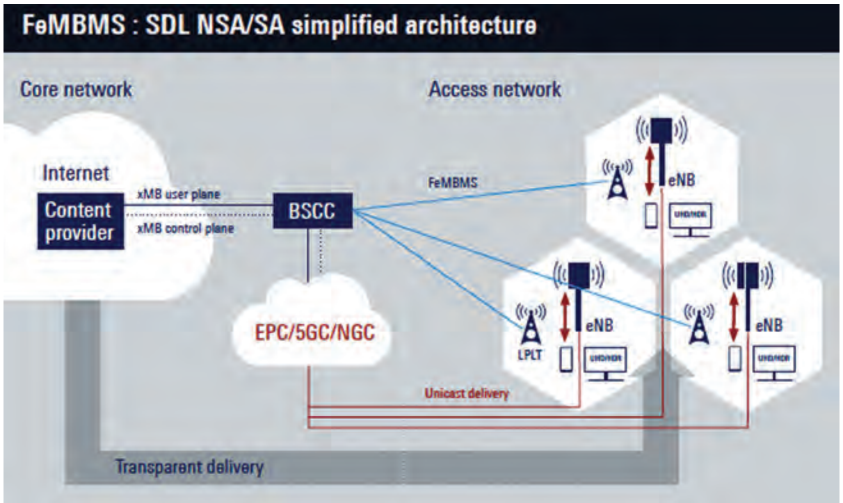

Figure 4. 5G Broadcast SDL NSA/SA simplified architecture.

Bavarian Broadcasting Corporation (Bayerischer Rundfunk, BR), the Broadcast Technology Institute IRT, Kathrein, Rohde & Schwarz, as well as Telefónica Germany, all jointly testing broadcasting options for future 5G technology.

Beijing was the second city to witness the start of another big 5G Broadcast project. The Academy of Broadcasting Science (ABS), as part of the governmental authority of the Chinese National Radio and Television Administration (NRTA), set up a proof-of-concept trial, which started in August 2019, and is still running as this paper is being written. This marked the first step of the long-term strategies pursued by both parties, which might comprise potential future 5G Broadcast commercial deployments.

Another metropolitan area trial was conducted in Rio de Janeiro, Brazil. Rio Globo, the largest Brazilian and Latin American TV network, recently conducted a 5G Broadcast field test, which began in October 2021 with the transmission of a rock music festival in 4K video via 5G Broadcast technology.

Other 5G Broadcast trials are taking place, or are scheduled, in Italy, France, Austria, Finland, Spain and the Philippines.

While 5G Broadcast is still an embryonic technology, it is demonstrating its capability to transform the mobile entertainment and information market. Today's trials will be tomorrow's commercial pioneers, with the big winners being the early adopters.

Technology Perspectives

From a specifications perspective, since March 2021, 3GPP has introduced fundamentally new enhancements to the LTE-based 5G terrestrial broadcast system in order to support new bandwidths of 6, 7 and 8 MHz. This recent improvement in 3GPP Rel-17 will provide broadcasters with the ability to roll out 5G Broadcast in the future using their UHF spectrum.

Also, a new ETSI specification (ETSI 103 720) has been recently introduced to the broadcast industry, enabling broadcasters to employ LTE-Based 5G Broadcast as a broadcast technology, enabling a mobile broadcast use case.

At a higher level, ITU WP6A is leading the discussion of officially including LTE-based 5G Broadcast as worldwide broadcast technology. At the upcoming World Radio Conference (WRC23), the future use of the remaining UHF bands (470 MHz to 900 MHz) will be determined in Europe, Middle East and Africa, i.e. ITU Region 1 on the basis of the review in accordance with Resolution 235 (WRC-15). Mobile operators are looking at the spectrum with greater appetites, while broadcasters will try to keep as much as possible of it.

The important question is "who will take the lead in the UHF band—mobile operators or broadcasters, or maybe both?" A "win-win "scenario might be the right choice over an "either/or" discussion.

Together with the 700 MHz, L-band, 2.6 GHz (SDL bands) and sub-1 GHz band deployment potential, 5G broadcast/multicast technology is awash in possibilities. It is therefore is no longer a question of "if," but rather a question of "when." The marketplace decision will soon be known.

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5G Broadcast/Multicast, R&S Booklet, Mohamed Aziz Taga, Version 01.00

5G Broadcast/Multicast, R&S Infographic

5G Broadcast/Multicast R&S All-In-One Core Network

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DAB Radio News And Views

By Bernie O'Neill, Project Director, WorldDAB

5G Versus DAB+ for Radio Distribution

A comparison of 5G broadcast versus DAB+ for radio distribution was one of the key sessions featured in the March 2022 Asia-Pacific Broadcasting Union's Digital Broadcasting Symposium.

Addressing delegates from around the world, the former head of the technical and infrastructure department at Deutschlandradio, Dr. Chris Weck, explained why he believes it is vital for broadcasters to proceed with their own DAB+ network for conventional broadcasting, supplemented by smart radio services. We would like to offer an edited transcript of Weck's presentation:

"Today, 5G is a very flexible standard for mobile networks, while DAB+ is the optimized standard for radio transmission to portable and mobile receivers.

"The main goal of 5G was to have a bidirectional unicast system, usually low-power, low-tower transmitters were used. For radio, it was broadcast in a unidirectional way with high-power and high-tower transmitters.

"Today, 5G has broadcast mode, which also has high-power, high-tower transmitters, so it is similar to the system parameters to DAB+, but because DAB+ has very robust transmission in a single-frequency network, it has very large coverage area. If you have 5G, you have a trade-off between the data rate and the coverage area.

"But what is the main difference between 5G and DAB+? It's that 5G addresses a smartphone, so that smartphone reception is the goal, while DAB+ addresses radio receivers, which usually have an antenna.

"Why do people want to have 5G for radio distribution? They think this is the latest modern system—but there is no substantial physical improvement. One goal is to make radio content available to smartphones—but today, radio is already available to smartphones via Wi-Fi or mobile networks using LTE or even 5G—so this is nothing new.

No Need To Lock Into A Single Standard

"The other argument is the use of one single standard for all on-air transmission systems. There is no inherent advantage in using only one standard—quite the contrary. One standard will meet a limited set of requirements and may therefore result in a compromise for other applications. Today, digital standards are implemented in software, and you can have multiple standards in one chip.

"The main issue is the transmission costs and the performance of the radio systems, and if you consider this, the big difference is antenna size—a radio antenna is a big antenna. The received power depends on the antenna aperture, and therefore on the physical size of the antenna.

"If you receive a signal with a radio, you receive about 15 to 20 dB more field strength compared to a smartphone. So, if you want to address smartphones for reception you need up to 20 dB more field-strength, which means up to 10 dB more transmission power.

"You can calculate from the ITU propagation curves that to compensate for 20 dB less field strength will mean nine times more transmitters for the same coverage. I think no broadcaster can afford this.

"What are the remaining benefits of 5G compared to DAB+? Radio content is already available to smartphones via mobile networks. Any 5G broadcast network owned by radio broadcasters will achieve the same benefits for users—there is nothing new for the users, except possibly saving some data fees. However, the network costs for broadcasters are much, much higher.

"The question remains: why give up a robust and efficient DAB+ network with affordable costs for broadcasters and full area coverage? Other technologies such as 5G will lead to much higher network costs or to limited coverage areas—or even generate dependencies on business models of third parties such as mobile operators, which are out of the control of broadcasters.

Dr. Chris Weck

The Advantages Of Hybrid Radio

"I have found that there is no real benefit of 5G broadcasts versus DAB+ for radio broadcasters or for radio listeners. However, 5G and DAB+ together already deploy today a very wide range of attractive radio services.

"So, because Hybrid Radio is available today, it allows for conventional full-area coverage and mobile reception via DAB+. It allows for free mass-media reception via DAB+, and it allows for smartphone reception and IP-based smart radio services via the mobile phone network or Wi-Fi.

"Hybrid Radio therefore represents the most economical solution for audio broadcasters, because they can realize the best coverage for listeners. And what is also important is that it is the most reliable in critical situations because these are two disjunctive transmission systems: DAB+ and IP. If one fails, the other can continue, and vice versa.

"Hybrid Radio based on 5G and DAB+ is already available today, so there is no need for broadcasters to go ahead with their own 5G network. It is better that they go ahead with their own DAB+ network for conventional broadcasting and supplement these radio services via Wi-Fi or 5G networks for smart radio services."

4G/5G Cellular Bonding For Live Video Broadcast

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Newsletter Deadlines

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Quarter 3	June 28, 2022
Quarter 4	Oct. 31, 2022
Quarter 1	Jan. 10, 2023
Quarter 2	Apr. 3, 2022

The Downward Path to Broadcast Engineering—No. 27

A suspected lightning strike station outage turns out to be much worse

By Jon Bennett

Jon Bennett

A broadcast engineer always fears the worst when the telephone rings at 2:00 a.m., as this is the time of day (or rather night) when such a call usually means something really bad has happened, just as a fireman does when the alarm bells start ringing late at night.

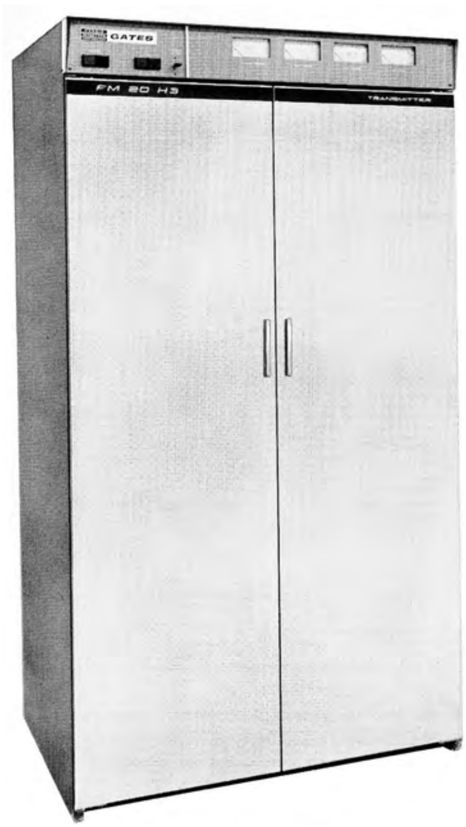
In my case, we were in the summer thunderstorm season and a storm was raging outside when I was awakened by the telephone's incessant ringing.

When I was finally able to clear away the sleep cobwebs and focus on what the voice at the other end was relating, I determined that it was the operator of one of the combo AM/FM radio stations to which I contracted engineering services, and he was reporting somewhat shakily that they were off the air. However, a little more conversation revealed that the urgency wasn't all that great, as the station's operator just asked me to arrive "first thing in the morning."

Waking Up To A Real Disaster!

I got a little more sleep, but did get up in time to arrive close to sunrise, well after the storm had moved out of the area. In looking things over there in the first light of day, I quickly realized that the outage was not simply due to an electrical storm taking the station off the air and perhaps damaging some of the equipment. That would have been too easy. This was at least a couple of orders of magnitude worse, as the overnight storm had spawned a tornado and toppled the station's tower.

The owner informed me that while he wanted to get both AM and FM operations back on the air as soon as possible, restoring the AM operation was a definite second in priority to getting an FM signal back on the air, as that side of things had a larger audience (and by inference, was more profitable).



The station's Harris 20 kW FM transmitter didn't seriously object to operating into a "cobbled-up" ground plane antenna.

Getting Started

In assessing things, I saw that the stations' common tower of several hundred feet was not completely toppled to the ground by the storm, as a "stub" of approximately 80 feet, along with the guy lines for this section, still remained vertical and seemed unlikely to fall.

However, what had once been the FM radiators were now on the ground, completely crumpled into scrap metal by the impact of their fall. It didn't take very long to determine that none of them could be salvaged and made workable, even for emergency purposes.

I gave the matter some thought over a cup of coffee and considered the numerous ground plane antennas I had created and experimented with as an amateur radio operator.

I doubted that even in an emergency situation such as this, most of the antenna manufacturers I knew about wouldn't have spare inventory, and even if they did, it would be several days before a replacement could be delivered and installed. Given the owner's urgency to get the FM back on the air, I figured that homebrewing a temporary ground plane antenna might be the best and fastest route to take.

I started the restoration initiative by climbing the remaining tower stub and cleanly cutting off the damaged 3-inch Heliax flexible coax feedline a few feet from above the top of the stub. Then a helper and I stripped the outer jacket and corrugated copper shield back so as to leave the center conductor protruding vertically. As this was air-core Heliax, we then filled the open end with sealant to keep water out of the remaining coax transmission line run.

I located some flat aluminum bar stock at the town's only open hardware store, and used this to create the necessary ground plane elements. After they were fabricated, I secured them to the Heliax shield with hose clamps and then headed back down to the transmitter room, which miraculously had been spared damaged either from the storm or the toppled tower. It was something of a miracle also that the station still had electrical power, given the intensity of the overnight storm and the damage to the surrounding area.

The author in the early 1970s doing STL path survey work in connection with the Houston One Shell Plaza master FM installation.

Will It Work?

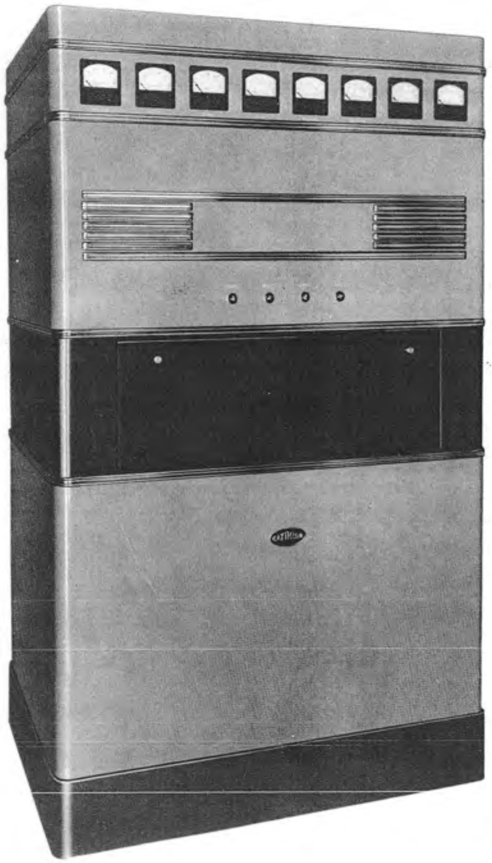
I rather cautiously fired up the FM transmitter and slowly increased power while watching the VSWR meter and tuning for the best match with the improvised antenna. I decided not to push things too far and leveled off at about 1 kW. The owner, who'd been standing in the sidelines throughout most of my endeavor, seemed very pleased to have at least one of his stations back on the air, even at reduced power, and let me know that I was "the hero and star of the show" that morning.

Returning The AM Signal To The Air

We left him to programming the station (and no doubt catching up on some of the missed commercial messages), and focused next on what might be done to get an AM signal back on the air now that the FM was up and running, albeit with a jury-rigged antenna and at a much lower than licensed ERP.

I decided the most expedient thing to do in that regard was to revert to an antenna design used in the early days of radio broadcasting, a "flat-top" or "tee" center-fed horizontal wire radiator.

We fabricated this with some scrounged insulators and wire that was on hand, using the remaining 80-foot tower (and former AM vertical radiator) section along with a convenient tall tree on the lot as supports for the ends of the "flat-top." When it was finally ready, I was a little concerned about how the late-1940s vintage Raytheon 1-kW transmitter might react to this drastically different load impedance, but the output stage designers back then must have been old school and there was enough range in the tuning circuity to provide a decent match and make the old fellow happy.



The vintage 1 kW Raytheon AM transmitter wasn't particular about antennas either. It seemed as happy feeding RF to an improvised "flattop" as it had to the station's well-engineered vertical radiator that was demolished by the storm.

The owner was overjoyed that he now had both stations up and running, even though it would be several months before the storm damage was cleared away and another tower and antenna fabricated and installed.

We shook hands and I departed, reminding myself to be sure and include the hardware store items in my next engineering services bill to the station—another day in the life of a contract broadcast engineer, and also a lesson learned.

Had I not had experience in fabricating and experimenting with ground plane antennas in my amateur radio work, I likely would not have considered, or even thought of, cobbling up one to get the station back on the air. I guess the old saying that "opportunity favors the prepared mind" is really true. At least the station owner thought so.

About The Author

__Jon Bennet__ is a retired broadcast engineer with some 35 years of experience at a number of AM and FM stations in Texas, and Virginia. While working in the Houston, Texas market, he served as engineering committee chairman for the One Shell Plaza FM master antenna group project, which involved the multiplexing of eight stations into a single antenna. He is a Life Member of the Society of Broadcast Engineers and a former member of the board of directors of that organization. Jon received his education at San Jacinto Junior College in Pasadena, Texas and at the University of Houston. He holds both FCC commercial and amateur radio broadcasting licenses, and is a past recipient of the 2008 Virginia Association of Broadcasters' "J. Jerry Freeman Excellence In Broadcast Engineering" award.

Mentorship and Women in Broadcast

Hosted By Samina Husain, BTS Secretary

I continue to follow the theme of mentorship and women in broadcast. This edition highlights two articles, the first from Carrie Wootten, managing director at Rise, an organization with a focus on women in broadcast. Understanding the importance and need of mentoring, Rise offers programs across many regions. Mentors and Mentees, are you interested? Check out https://risewib.com for more details.

The second article is by Fatemeh Fallahi of IRIB, the public broadcaster that provides radio and television services in Iran. Fatemeh describes her journey to becoming an R&D manager and where it has brought her and UHD Broadcasting in Iran.

As we move forward in 2022, BTS continues with significant activities, starting our first in-person participation at the NAB Show in Las Vegas. In addition, there are a number of upcoming BTS events: BMSB, our international Symposium; the virtual Pulse event which provides the latest technology news; our strong engagement with industry event the IBC Show, and our highly sought-after annual conference. I hope some of these events will bring us together again in-person, giving us the opportunity to meet friends and colleagues, and to share the latest developments from our industry.

Call To Action

Support the Women in Broadcast column and contribute to it with an article: tell us your stories, and please reach out and share your thoughts regarding women in engineering/broadcast, recognizing contributions and achievements by contacting us at bts@ieee.org.

The Rise Organization

By Carrie Wootten
Managing Director
Rise

Rise as an organization has changed significantly over the last 5 years—but its core remit and focus has remained the same— to have a gender-balanced workforce across the media technology sector.

Unfortunately, although the conversation around diversity and inclusion has changed dramatically in the last 5 to 10 years, and companies are much more receptive to striving towards these changes, there is still a long way to go. This is especially true when you look at the intersectionality of diverse characteristics, such as gender and ethnicity, for example.

In 2022, we launched three new chapters for our mentoring program. It will now be delivered across the United Kingdom, North America, Asia-Pacific countries, central Europe, northern Europe, and Australia/New Zealand. The reasons that women apply to this program are varied; some would like support in gaining a promotion, others want to address a gender pay gap, some want to understand the broader sector and make connections, while others want to understand how to navigate a working environment that is still dominated by men.

But with the support of a mentor, all of these issues can be addressed, and the value of the program is clearly demonstrated by the feedback we receive year-on-year from the women we support, such as in the following communication:

"I was inspired by the diversity and ambition of the women I met as a Mentee. Their drive, passion for their job and the aspirations they shared were truly motivating. Not only did Rise promote a feeling of camaraderie, the program was also extremely clear that my career growth is my responsibility and gave me the tools to chart my course and take my next steps. I'm grateful to have been included in the program and excited to apply what I've learned"

However, underlying most of the applications that we receive are a lack of confidence and/or "imposter syndrome." Our Female Leadership last year showed that a staggering 75 percent of the female leaders that we surveyed said that they had "imposter syndrome." As a result of this finding (along with our finding that 66 percent of the female leaders said that they classed themselves as risk takers), we will be rolling out a significant training program to support women in these areas throughout 2022. It is critical that we empower and support women to speak up and put themselves forwards for promotions, opportunities and of course, to speak at global industry events. Speaker training is something we will really focus on over the course of the next year.

One of the other key areas that Rise will be focusing on this coming year is our Rise Up Academy. We fundamentally believe that unless we inspire, educate and inform young people about the pathways and opportunities available to them in the media technology sector, we will not see the diversity of our workforce change.

We have been working across the United Kingdom during the last 6 months, delivering hands-on workshops to children aged nine on through to students up to 18 years of age. They build a four-camera studio and gallery from scratch, assisted by volunteers from across the industry. We know that the impact of these workshops can alter the way young people think about the industry and their potential career paths. Here's an example of the feedback received in connection with the program. This comes from Sumon Thakur, a Millfields Primary School Y5 teacher and computing lead.

"Frankly, I can't speak highly enough about our recent trip to a Rise Up workshop at Mulberry UTC in Bow. All the volunteers were incredibly welcoming and supportive; furthermore, the activities were very well structured, encouraging teamwork and demonstrating real life STEM applications in the world of broadcasting to the children very successfully. The quiz show at the end was such a great idea—a really fun way to end an amazing day that the children couldn't stop talking about on the bus home!"

Our ambition this year is #project2000, where we reach 2000 young people through our workshops. In addition to this, we are also looking to deliver a careers festival, a summer school, along with further virtual and face-to-face master classes. We are also aiming to launch the Academy in the Asia-Pacific region too.

As an organization, we really hope to provide tangible and concrete ways to achieve our ultimate ambition of a gender-balanced workforce. One other key element of this is our Rise Job Board, which was launched at the end of 2021. Companies are keen to reach women to ensure they receive more diverse applications, and the Job Board is a clear and direct way to do this. In addition, we know that work experience for young people has been impacted by the pandemic, so we're also looking to launch a new Work Experience site, where young people can look to apply for work experience, as trying to navigate this from outside the industry is extremely tough.

None of our work would be possible without our global sponsors, and collectively and collaboratively, we can change the diversity of workforce. It won't be achieved overnight, but will take time, investment, people and a commitment from everyone. However, if this is done, then the potential of what might be is incredibly exciting.

UHD Broadcasting in IRAN

By Fatemeh Fallahi
R&D manager
IRIB UHD

In 2010, IRIB, the national public service broadcaster of Iran (the Islamic Republic of Iran), has been busy with digital switchover and ASO planning. The TV industry is evolving and it has injected fresh blood into young engineers for researching and studying standards, and running tests and trials. Along with digital broadcasting, mobile TV and interactivity were some of the most important topics that were followed up. In this exciting atmosphere, I joined the mobile TV team at IRIB Research and Development department and started my work with trialing the DVB-H standard.

IRIB R&D develops innovative new products and technologies in the broadcast/broadband industry that lead the development of future technologies within the organization. It has made major advances in forward-looking basic research and innovation in media technology. After working with the DVB-H trials, I continued my journey in broadcast industry in the following areas: DVB head-end, transmitter, DVB-T/T2 standards.

Trialing DVB-H and MHP brought us valuable experience and showed the importance of using open standards. Our research led to using HbbTV for interactivity. After a successful trial of HbbTV in 2017, IRIB announced their official launch of HbbTV by adding HbbTV "red button" service to three TV channels in 2018, and it is now available on all of IRIB's HD TV channels. Along with the interactivity initiative, the organization also embarked on a program to provide higher picture and audio quality.

On July 2020, IRIB launched the IRIB UHD channel as an advanced TV channel with the objective of offering higher quality of content (video and audio) along with innovative services. I joined the team as R&D manager of IRIB UHD, using my experience on DVB and HbbTV for improving services on this new TV channel. The first year of the IRIB UHD broadcasting program involved a lot of hard work, as it included the setting up of a content production chain, a preparation and editing operation, contribution and distribution chains, adding interactivity, increasing coverage, connection with the viewers through an IRIBUHD website and a page on social media, as well as working with TV manufacturers in support of receivers for UHD-HDR based on BT.2020 and BT.2100 standards.

IRIB UHD is transmitted as part of the wider range of broadcasts of the new DVB-T2/HEVC digital terrestrial television (DTT) broadcasting system, with the network covering 70 percent of the Iranian population. IRIB UHD content is broadcast with a resolution of 3840 x 2160, with progressive scanning at 50 frames-per-second. High dynamic range is also offered using the HLG (hybrid log gamma) system, along with 5.1-channel surround sound. The IRIB UHD channel uses HEVC coding with a signal bitrate of 20 mbps.

Already there are two types of content shown on this channel—that acquired from other source and producers of live sport match broadcasts (for example UEFA European Football tournament 2020), along with the transmission of programs of other IRIB TV channels in UHD-HLG quality. The other category is short music videos, which involve a collection of natural landscapes and attractions of Iran that are filmed and edited by an IRIB UHD technical team. In preparing IRIB UHD's playlist, an attempt is made to take into account the interests of people in varying age groups, with content including kids' animation, movies, television series, and documentaries and live broadcasts of sport matches.

As the acquired UHD content arrives in various dynamic range formats—HDR (HLG or PQ) or SDR—the content has to be analyzed for standards compliance and subsequently delivered for color mastering or cross-conversion of PQ to HLG or SDR to HDR as required. The EBU Tech 3373 color bar signal is used to ensure that correct settings are applied in the conversion and also to highlight errors in the transmission chain.

As interactivity is important, the HbbTV "red button" service is also available on IRIB UHD. The service includes some general applications such as weather, the Quran, and games. There are also IRIB OTT services and applications that are related to the IRIB UHD channel such as a rich electronic program guide and channel-related news.

To encourage content producers for IRIB's national and regional TV channels to generate UHD/HDR content, movies and music videos, IRIB UHD held a UHD festival during the January 2022 18th Annual Iran Media Technology Exhibition and Conference (IMTEC). Although specifications for shooting and delivering UHD programs had already been published and announced by IRIB in 2018, this festival was a good opportunity for introducing IRIB UHD, along with its capabilities and technical standards for transmitting content to IRIB's national and regional TV channels, and also for discovering talent in regional centers.

The delivery of 4K HDR services over digital terrestrial television has become a reality, although UHD content production and broadcasting in Iran is still in its early stages. However, there is a lot of motivation and energy in our team to move this forward. The combination of DVB-T2 along with state-of-the-art audio/video codecs and HbbTV will ensure that terrestrial television can keep pace with other content delivery platforms.

ATSC Insider

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- Coordinate/harmonize with standards-setting bodies around the world

All ATSC Standards and Recommended Practices can be downloaded at no charge from the ATSC website, *https://www.atsc.org/documents*.

About The Authors

Madeleine Noland *is president of the, Advanced Television Systems Committee (mnoland@atsc.org). Widely respected for her consensus-building leadership style, she chaired the ATSC technology group that oversees the ATSC 3.0 broadcast standard before being named ATSC president in May 2019. Previously, as a representative of LG Electronics, she chaired various ATSC 3.0-related specialist groups, ad hoc groups and implementation teams since 2012. A 15-year industry veteran, Noland held key technology management and standards roles at Backchannelmedia Inc., Telvue Corp. and LG. She received* ***TV NewsCheck's*** *"2019 Futurist" Women in Technology Award and was named one of 2018's "Powerful Women in Consumer Technology" by* ***Dealerscope*** *magazine. In 2016, she received ATSC's highest technical honor, the Bernard J. Lechner Outstanding Contributor Award. She graduated cum laude from the University of Massachusetts.*

Jerry Whitaker*, Vice President for Standards Development, Advanced Television Systems Committee (jwhitaker@atsc.org). Whitaker supports the work of the various ATSC technology and specialist groups and assists in the development of ATSC Standards and related documents. He currently serves as secretary of the Technology Group on Next Generation Broadcast Television, and is closely involved in work relating to educational programs. He is a Fellow of the Society of Broadcast Engineers and a Life Fellow of the Society of Motion Picture and Television Engineers. He has served as a board member and vice president of the Society of Broadcast Engineers.*

AIBD Celebrates World Radio Day

By Amal Punchihewa

The Asia-Pacific Institute for Broadcasting Development (AIBD) hosted a Feb. 17, 2022 web-summit to mark the observance of World Radio Day. The event was themed "Celebrating a World of Sounds," and featured speakers from the region and beyond who shared their views on this form of mass communication in three sessions during the three-hour event which began at 2:00 p.m. Malaysian time.

In connection with the virtual event, the ITU issued the following statement:

"World Radio Day celebrates the contribution of radio to our society and the power of radio to touch lives. This year we mark the 10th anniversary of this international day. Observed annually on Feb. 13, World Radio Day is an opportunity to raise awareness of the importance of broadcast radio, support access to information, and improve networking and international cooperation in the field of radio communications."

As background, it should be noted that the Asia-Pacific region (APAC) has a long heritage and history of radio broadcasting dating back to 1925. Having observed the current global trends including digital transformation, hybrid and digital Radio, the AIBD's web event provided a forum for discussing the challenges and opportunities facing the APAC region. The web summit also aimed to identify the factors that hinder access to emerging radio to listeners or more broadly audiences. In addition, event speakers discussed what needs to be done to ensure that the "digital gap" is bridged, as it may be widening and disconnecting audiences as the Asia-Pacific region and other areas of the world embrace the digital transformation.

AIBD members are being confronted with the challenges of the rapid advancement of digital technologies created by digital transformation, so it is necessary to review key roles that radio plays, and to identify how we can sustain these. During the summit it was noted that the development of Internet-based listening habits and the exploration of the potential of "visual radio" are just two of the ways in which radio broadcasters are strengthening relationships with their listeners.

During the past two years, many radio broadcasters may have benefited from audiences that were more confined to homes than usual. During pandemic-driven lockdowns, they may also have been assisted by several new technologies. It was noted during the summit that increased listening took place via apps and smart devices. The concept of "visual radio"—with audio content enhanced with video for clipping on social media and other sites such as YouTube—is also gaining ground and being delivered with increasingly notable results. The addition of remotely-controlled pan/tilt/zoom (PTZ) cameras has been an enabler in developing the visual radio element.

Session 3 with its theme of "Narrowing the Technological Gap in the Regional Radio Industry" examined a wide range of aspects related to technology. Panelists represented industry regulators, public service and commercial broadcasting, and digital radio. They included Bala Murali Subramaney, chief technology officer at the Malaysian radio network, Astro Radio Sdn Bhd; Orasri Srirasa, director of NBTC, Thailand; and Les Sabel, S-Comm Technologies founder/managing director and chair of the WorldDAB Asia Pacific technical group. The session was moderated Amal Punchihewa.

ASTRO-Malaysia

Radio studio with advanced operator interface and "visual radio" capability.

Examining The 'Technology Gap'

In the discussion, panellist Subramaney expressed his views on the technology gap, mainly from the commercial broadcaster perspective with these comments:

"It is mainly driven by the organization itself," he said. "Most of the private broadcasters in the last five years [have unlocked] the technology gap. However, if the engineers or station related managers or unit does not [delve] deeper into the engineering aspects, they rely fully on the system integrator to build a system for them, and then move on. And at the same time, we also see some places where the radio engineers are very much involved in [and have a passion for] radio. While having a good emphasis on the technology, we pushed the managers to learn and keep on learning, and how to improve the content from the content planning to the content distributions."

The Radio Broadcasting Canvas In Thailand

Panellist Srirasa observed that in Thailand, from 2021 to 2022, the radio industry is changing "from a concession to a licensing" scheme.

"In the past, broadcasting via FM faced low audio quality caused by interference problems due to the congestion of FM radio stations," she said. "NBTC (the National Broadcasting and Telecommunications Commission) developed various technical notifications and implemented various measures to prevent such issues. Currently, the interference problems are resolved in most areas. Auction

Session Three participants (clockwise from top left) Amal Punchihewa (moderator), Les Sabel, Orasri Srirasa, and Bala Murali Subramaney.

for commercial FM services in Bangkok and the provincial area will be conducted in February 2022. The reserve price is in the order of 50 million Baht per station in the Bangkok area and above 100,000 Baht to 1 million Baht per station in provincial areas.

"The Digital Radio, DAB+ Trial in Bangkok and vicinity areas was started in 2018, covering 14 percent of the Thai population," said Srirasa. "[A]single multiplexer combines 13 major radio broadcasters who joined the trial. The future of radio [will] be hybrid. Users can receive content that they are interested in on a wide range of platforms (FM, digital radio-on-terrestrial, on-line platforms) depending on the place, time, and on receiver devices. A survey in Thailand revealed more than 30 percent of listeners receive via the terrestrial platform, 30 percent receive on-demand (online), and 30 percent received both online, and on-air. Digital radio is still in the trial phase and will expand to regional areas too soon.

"Based on Neilson Measurement in 2021 in Bangkok and the vicinity, about 37 percent of radio listeners still listen to the radio in the car, 48 percent at home, and 13 percent at the office. Having radio receivers in a car is important. In listeners' opinions, it is easier to access radio programs in a car and receive various content compared to the online platform. For example, the most [popular] FM [stations are] 'FM95' and 'FM93' [which program folk songs and easy listening music], and the most [popular] FM [station] for Public Service is 'JS100,' which provides news info, traffic report, emergency assistance and other public safety services to people. Even [though] 'JS100' has more than five million users on social media, most users listen to the radio when they are driving.

"In these few years, radio broadcasters—public and commercial—have tried to handle impact from technology disruption and changing user behaviour. They changed their business model. They reduce cost by making the organization lean, extending delivery via online platforms… so they can also get revenue from digital platforms. However, a major revenue stream is broadcasting on the FM platform.

"The current DAB+ Trial Project phase in Bangkok has the key aim [of improving] signals in the expansion phase in Bangkok to solve poor quality audio problems in some areas. During the expansion phase, trial[s] will be extended to regional areas having five sites in the north, northeast, south, and east regions. The plan is to be on-air by May 2022."

Australian Radio Broadcasting

In expressing his views about the digital broadcasting situation in Australia, panellist Sabel observed:

"I think Australia grasped the digital opportunity because there were a few incentives in this country [to help] get that gap narrowed. I think it is becoming very clear that digital radio is becoming essential in keeping radio alive due to a couple of reasons. In Australia, [there are] government-provided incentives to get the broadcast industry moving forward with digital. The regulator provided essentially three free bands of spectrum. They also basically [ensured] that there would be no competition from new entrants for six years. That is now expired. But the point [is that] the incumbent broadcasters were real winners in this. Broadcasters got free spectrum, the ability to expand the content and deliver [it] in a very competitive environment.

"When [Australia] went into the market in 2009, remember, we only have the second DAB+ in the world and we had receivers here, we got them down to about $100 at launch in 2009. Hundred Australian dollars is about 70 US$ now, I have seen radios in Aldi supermarkets for 15 Australian dollars, which is about $12 U.S. Therefore, receivers that were seen as a blockage [are not a factor] anymore."

"Now some people also think that smartphones are the way forward as well. Certainly reception through streaming is essential; streaming is a central part of the mix for radio delivery. I do not think there is any doubt about that. But I think if you have a close look at it, trying to rely on it for 100 percent of your delivery in the digital age has several issues."

About The Asia-Pacific Institute for Broadcasting Development

The Asia-Pacific Institute for Broadcasting Development (AIBD) was established in August 1977 under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It is a unique regional inter-governmental organization servicing countries of the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) in the field of electronic media development. Based on the AIBD, strategic plans and actions are derived to provide support to AIBD members, by analyzing the current trend of broadcasting policies and seeking harmonization and regulations to promote uniformity in the region with cultural and technological diversity.

About The Author

Dr. Amal Punchihewa *is a researcher, educator, advisor and consultant in ICT, Media, and Broadcasting with close to four decades of experience in the industry, academia, and research. Amal is a Chartered Professional Engineer and Fellow of IET(UK) and a senior member of IEEE(USA) He is also a distinguished lecturer of IEEE-Broadcast Technology Society. Amal facilitates and advocates technical guidelines and standards, and provides expertise related to the convergence of media, and evolving technology needs. He advocates, encourages, and manages member communities, and help them to understand the trends that shape the media, to empower media & ICT stakeholders to continue to take good strategic decisions. He is also the technical advisor of the AIBD and a member of the AIBD international advisory board.*

ITU Report

By David Guerra Pereda, BTS Member

'Turn About Is Fair Play'

In his 1961 inaugural address, the late U.S. president John F. Kennedy, made a very memorable remark:

"Ask not what your country can do for you, ask what you can do for your country!"

This seems to be "spot on" as far as ITU-R is concerned. Precisely, ITU-R seems a magical and endless well of technical documentation regarding radiocommunications but, naturally, there must be a wellspring to fuel Once in a while, we need to seriously consider moving from being a downloader to being a contributor in order to keep the water flowing.

The Contribution Process Explained

First, it is necessary to provide some background. The most technical section, so to speak, of ITU-R is organized in six Study Groups: SG6 being Broadcasting Service, which in turn is composed of several Working Parties (WPs). Within SG6 you have WP 6A for Terrestrial broadcasting delivery. There's the WP 6B Broadcast service assembly and access, and there's the WP 6C Program production and quality assessment Party. This structure will remain unchanged in this Study Period (for three or four years) until the next World Radio Conference is scheduled to be convened in 2023. Each Study Group holds meetings once or twice a year, with the meetings preceded by the meetings of its WPs. These WPs provide a gateway for the members to contribute to ITU-R.

Second, only ITU-R members can contribute to ITU-R. Four types of members from all around the world can be found in ITU. There are governments or public administrations, companies (also referred to as "sector members"), academic organizations, and international organizations (also referred to as "associate members"). The organization does assess an annual fee for the three last categories, which ranges from 3,975 Swiss Francs (about $4,250 U.S.) for members from academia to 31,800 Swiss Francs (about $$34,050 U.S.) or sector members. There is no need to pay for a membership, as groups may contribute payments on an occasional basis. In this case, there *is* something your country can do for you. You may contact the government organization that deals with ITU-R businesses in your country, and I'm sure they will be glad to hear about your proposal. After some discussion, the corresponding organization will hopefully be ready to act as a buffer and a facilitator through which the contribution may be submitted. Of course, the actual submission and presentation of your contribution to the ITU is on you, and you will have to go hand-in-hand with your country's delegates. In other words, you will be made an additional delegate by means of an ad-hoc accreditation, which is extended by the Focal Point for ITU in the organization for attending the meeting where your contribution will be discussed.

Third, but of utmost importance, is that you'll need to find a suitable ITU Question for your contribution. Or, put into the correct order, before considering the submission of a contribution you should have a look at the current ITU Questions in order to ensure that your potential contribution fits into the topics currently being discussed in the ITU. Along with a reference ITU-R Question, you'll have to decide which Working Party is the most appropriate to address your contribution. The actual guidelines for contributions submission are available on the ITU-R website. Some of them will require a so-called "TIES" account to be accessed. A TIES account is also necessary to access ITU ICT services commonly used in the meetings. The Focal Point of the ITU member that is sponsoring your contribution will provide you with one.

Fourth and last—how does a contribution end up being a part of ITU's well of technical documentation? The prospects for the outcome of a contribution can be merely informative or could lead to the development of a new ITU document or completion of an existing one. Apart from the Questions, there are three other common ITU-R technical documents: Recommendations, Reports and Handbooks. ITU-R Recommendations constitute a set of international non-mandatory technical standards, usually devoid of the background methodology that was followed in their creation. This methodology and other additional details can be found in ITU-R Reports. Handbooks could be described as a self-contained and self-explanatory compilation of contents related to Reports and Recommendations, in a text addressed to a radio engineer or radio system planner, in which particular attention is paid to the requirements of developing countries and no familiarity with other ITU-R texts or procedures is required. Handbooks are usually planned documents; that is, their development does not stem from a technical contribution, but rather they are the

Upcoming Events

of Interest to BTS Members

- **May 20–22, 2022** – Dayton Hamvention 2022; Xenia, Ohio - Greene County Fairgrounds and Expo Center
- **June 1–3, 2022** – BroadcastAsia 2022; Singapore - Singapore Expo
- **June 7–9, 2022** – ATSC Annual Member Meeting and NextGen Broadcast Conference; *(venue not yet announced; check event website for information as it becomes available)*
- **June 8–10, 2022** – AES International Automotive Audio Conference; Dearborn Michigan - The Dearborn Inn
- **June 15–17, 2022** – IEEE International Symposium on Broadband Multimedia Systems and Broadcasting; Bilbao, Spain - Bizkaia Aretoa Exhibition and Conference Building
- **Aug. 15–17, 2022** – Audio Engineering Society AVAR (Audio For Virtual & Augmented Reality) Conference; Redmond, Washington – DigiPen Institute of Technology
- **Sept. 9–12, 2022** – IBC Show 2022; Amsterdam, Netherlands – Amsterdam RAI
- **Oct. 24–27, 2022** – SMPTE Media Technology Show; Hollywood, California – Lowes Hollywood Hotel
- **Oct. 13–15, 2022** – Broadcast India Show; Mumbai, India - Jio World Convention Centre
- **Jan. 5–8, 2023** – CES Show and Exhibition; Las Vegas Convention Center, Las Vegas, Nevada
- **Apr. 16-19, 2023** – NAB Show; Las Vegas Convention Center, Las Vegas, Nevada
- **May 23–25, 2023** – NRB 2023 Christian Media Convention; Orlando World Center Marriott, Orlando, Florida

(IMPORTANT NOTE: Due to the on-going global pandemic; all of the event dates and locations listed above are subject to change with little notice, with many events being cancelled, rescheduled or postponed. When making plans to attend any of these trade shows, conferences, or meetings, always confirm details with event organizers first.)

If you have information on broadcast-related events that may be of interest to other Broadcast Technology Society members, please submit them at least three months in advance to the Broadcast Technology editor at BTSeditor@ieee.org.

result of discussion within ITU-R meetings. As for the rest, a contribution will be assigned to a sub-working work, along with other contributions dealing with a more or less similar topic, where it will actually be presented. If it is considered relevant, and once its prospect has been decided by the attendants, a drafting work will start in order to prepare a *preliminary draft version* of the intended new or revised Recommendation or Report. The final draft achieved in the meetings will be presented at the subworking work and there is agreement, it will be raised to a Plenary meeting of the WP. In principle, this drafting process may be extended for more than one WP meeting, in order to receive more contributions and allow addition time for consideration. Once the final version is presented and agreed upon, the "preliminary" qualifier will be removed and the *draft version* of the document will be carried to the SG meeting where, if approved, it will become an ITU-R document.

It's Really Not That Difficult

All of this process for contributing to the ITU-R may seem a bit cumbersome; however, everyone at the meetings is willing to provide help and guidance on the operational and administrative procedures, and newcomers are made to feel very welcome. To make matters even better, remote participation has become commonplace since 2020. Definitely, there is no excuse not to contribute to the oldest organization of the United Nations; an organization where nations seem really happily united.

What's New

Broadcast Technology presents new product releases from broadcast equipment manufacturers

Solid-State UHF DTV Transmitters

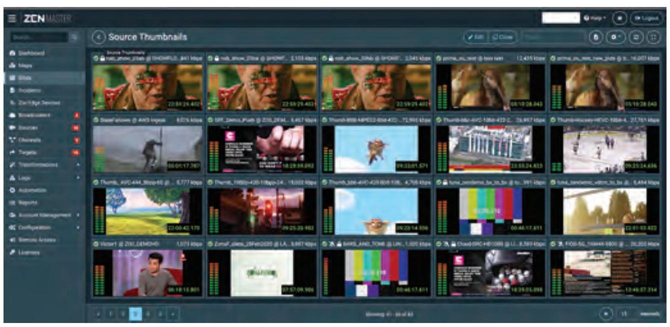
Comark has announced improvements to its SE E-Compact series of high-efficiency air-cooled solid-state transmitters for UHF digital television broadcasting service. The new third-generation BB3 models include dual commercial GE rectifier units in each power amplifier power supply, a new improved system controller with a simplified user interface, and optional front panel touchscreen controller display. As well as an optional outdoor cabinet for installations without the necessity of constructing a transmitter building or bringing in an equipment shelter.

These transmitters are available in power ratings between 1.1 kW to 13.2 kW.

For additional information, please visit Comark (Hitachi Kokusai Electric Comark LLC) at *https://comarktv.com*.

Live Event Streaming

Zixi's new Zen Master live video orchestration and telemetry control plane allows users to configure and monitor the company's live streaming platform, devices and appliances. It centralizes live stream acquisition and distribution, as well as ensuring the system's overall health through infrastructure views and alerts.



This latest edition of Zen Master now features live stream event scheduling and management of various production stages. It allows easy scaling of cloud infrastructures to accommodate demand, and provides consistent stream views among production teams, departments and partners, along with speedy configuration of new live channels without the need for additional engineering resources.

For additional information, please visit Zixi at *https://zixi.com*.

Broadcast Service/Control Center

The new Rohde & Schwarz BSCC1.0 software-defined broadcast service and control center provides delivery of multimedia content over LTE/5G networks in broadcast mode. It encapsulates content into specific FeMBMS bearers to be delivered from the evolved packet core (EPC) down to the receiver, and also generates accompanying service announcements.

The BSCC1.0 allows content providers to deliver high data rate content to mobile users, while at the same time providing a consistent quality of experience (QoS), resulting in a higher overall quality of experience (QoE), along with greater spectral efficiency and reduced operating costs.

For additional information, please visit Rohde & Schwarz at *https://www.rohde-schwarz.com*.

ATSC 3.0 Off-Air Receivers

Sencore's ARD 3000 series receivers provide off-air reception of NextGen TV broadcasts for station monitoring purposes. The ARD 3100 provides decoding of a single channel and the ARD 3400 decodes up to four channels. Both receivers require only a single RU. Decoded program streams are available as SDI signals.

In addition to off-air monitoring of broadcasts, the receivers are equally suited for re-encoding of ATSC 3.0 signals into other formats for distribution in existing systems. They provide support for ROUTE DASH and Dolby AC4 and accommodate RF signal inputs between 42 and 879 MHz.

For additional information, please visit Sencore at *www.sencore.com*.

Calling all Chapter Chairs

The IEEE Broadcast Technology is interested in your chapter activities, but have you ever wondered how to write a chapter report. Below are some directions that can help you get your chapter noticed.

Information for submitting Chapter Reports:

• Chapter Reports ideally should run approximately 200 to 500 words. (If a really newsworthy or unusual event is being described, we can accept slightly longer Reports, but nothing greater than 800 words.) We are looking for a summary of the event program or presentation. Please keep Reports straightforward and focused on the event. When someone is mentioned in a Report, it is very important that we receive the person's full name, title or position, organization they are affiliated with, and their connection with the story.

- Please identify all recognizable persons in your photos. We need their names, with title or position and affiliation. (Example: Mr. John Smith, vice president of consumer electronics production, Ajax Corporation.) If there is more than one person in a photo, please clearly identify everyone from left-to-right; please do not assume that we know persons depicted and will be able to fill in this blanks.

•This need for complete identification also applies to place and building names. Please make sure to provide the complete location of the event. (Don't just say the meeting took place in Smith Hall, as readers will likely not know that Smith Hall of part of the School of Engineering at Jones University.) Provide complete information about meeting venues.

• Very important—submit your Report as a straight Word file with no embedded logos, pictures, etc. Please do not send PDFs.

• Pictures are a very important part of every Report; however, they need to be good quality and tell a story; i.e., if a presentation is made at your meeting, your photograph should show the presenter standing at a podium, or at a chalkboard, etc. Group photographs are nice, but we really need at least one good photo of the lecturer making his/her presentation. Image size is very important too. An image that is acceptable on a Website is not necessarily large enough for publication in a printed magazine. Images must be at least 250 kb in size (one to two MB preferred). These must be sent as .jpg file attachments—no PDF— and PLEASE DO NOT EMBED IMAGES IN REPORTS.

• Please include answers to all of the following questions in your first paragraph: **Who** was involved? **What** happened? **Where** did it take place? **When** did it happen? **Why** (what was the reason?). Further, if the event you are describing was facilitated by an institution (university, company, etc.) that provided a meeting room, refreshments, etc.. Please include this information in every Report.

• Also, when submitting a Report, please provide complete identification about yourself, including your title or position and the name of the organization that you are affiliated with.

• Lastly, Reports must be timely. They need to be received by the **Broadcast Technology** staff no later than two to three weeks after the meeting or event took place.

If these items are not received in the required order, the Editorial Assistant will contact you for a revision. The **Broadcast Technology** editorial staff thanks you for your cooperation. We look forward to receiving and publishing your Reports. If you have any questions please send an email to btseditor@ieee.org

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Phone Number

We have a telephone number that's dedicated for IEEE BTS business: **732-562-6061**.

IEEE Broadcast Technology, Volume 1, Number 1 (ISSN 23794682) is published quarterly by the Broadcast Technology Society of the Institute of Electrical and Electronics Engineers, Inc. Headquarters address: 3 Park Avenue, 17th Floor New York, NY 10016-5997. It is sent at a cost of $1.00 per year to each member of the Broadcast Technology Society and printed in USA. Periodicals postage paid at New York, NY and at additional mailing offices. Postmaster: Send address changes to: IEEE Broadcast Technology, IEEE, 445 Hoes Lane, Piscataway, NJ 08854.

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