RCR Wireless News
INTELLIGENCE ON ALL THINGS WIRELESS

May 2024

Test and Measurement Forum

KEY FINDINGS REPORT

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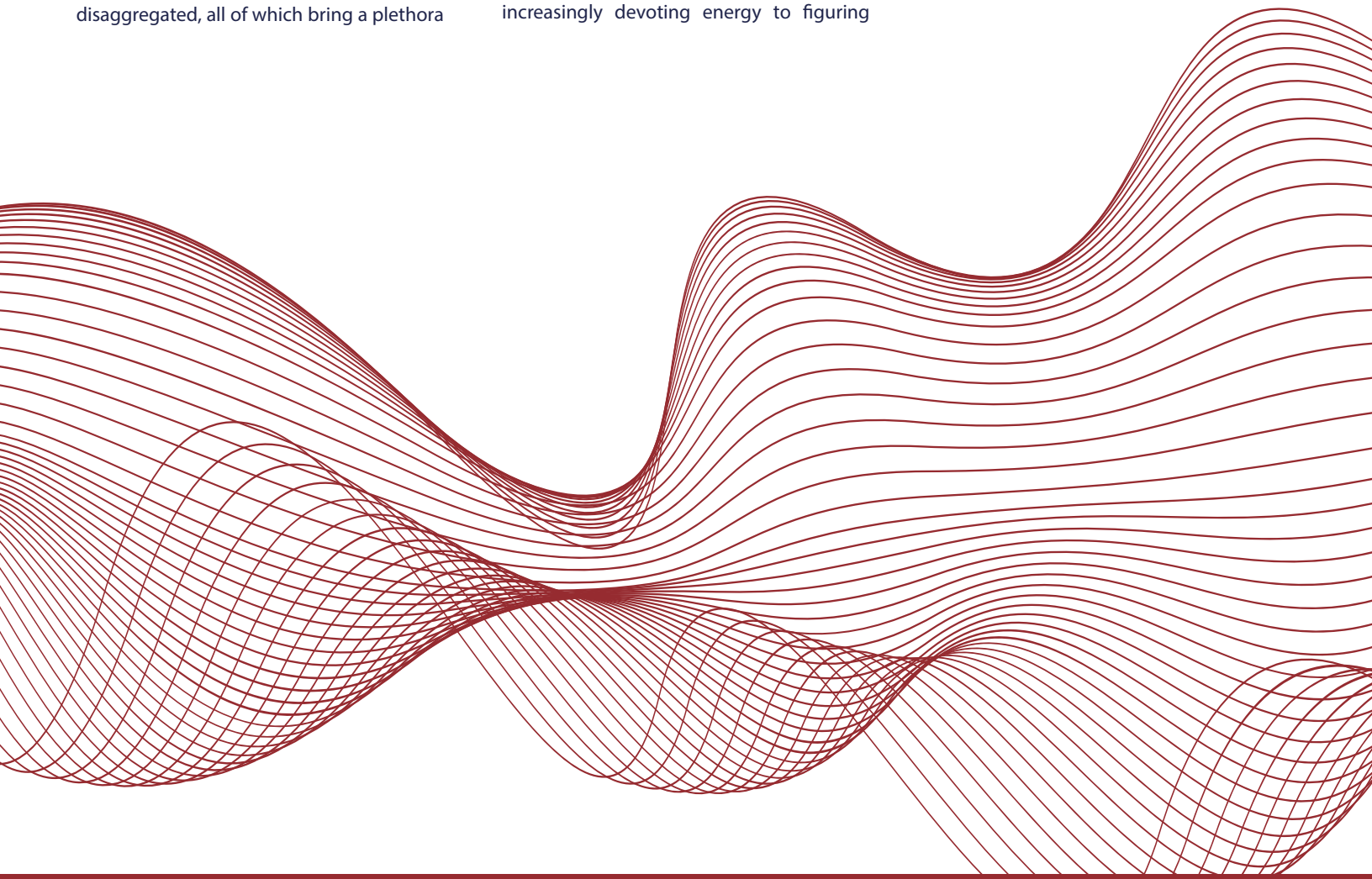
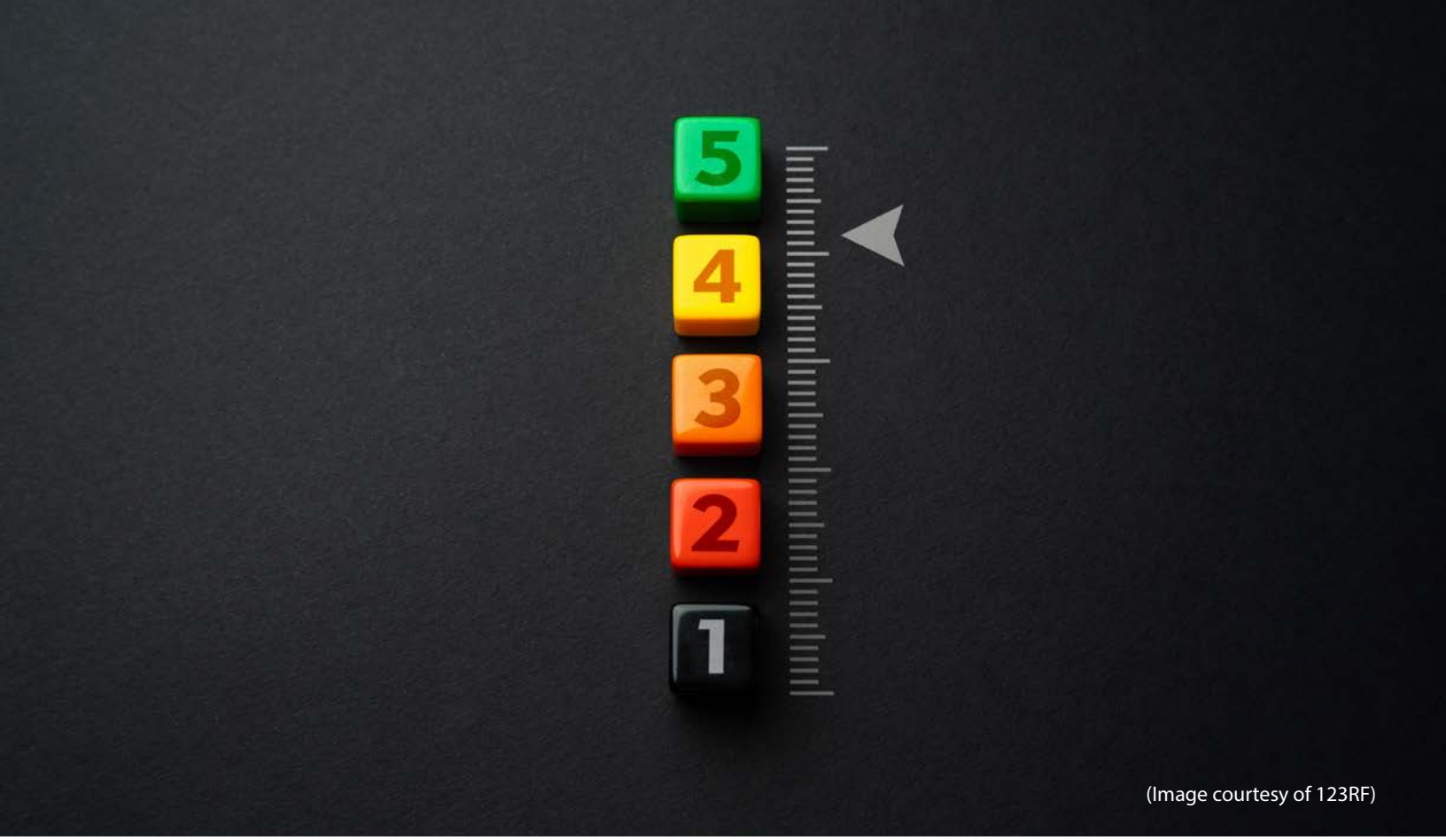
INTRODUCTION

The state of mobile networks is one of near-constant evolution, which has only accelerated in the current era of 5G, software-centric networks and Open RAN. This year's Test and Measurement Forum event reflected that evolution and the testing landscape, which is dealing with a mix of challenges that are well-known from LTE and previous cellular generations—like passive intermodulation, or PIM, and network timing and synchronization. But these have taken on different nuances in 5G networks and increased deployment in midband TDD spectrum. Additionally, there are new testing challenges to tackle as networks are becoming more software-based, more open and more disaggregated, all of which bring a plethora of complications to an already complicated testing proposition—thus necessitating more and more reliance on automation, machine learning and artificial intelligence to keep up with networks that both operating and changing at unprecedented speeds.

T&M Forum sessions tackled both 5G now and its next wave, as the telecom industry continues to work on assuring and monetizing 5G—which still mostly means Non-Standalone 5G—while also taking steps down the path to 5G Standalone. The pursuit of more intelligent networks and network tools is the demand of the day, with test companies and network operators increasingly devoting energy to figuring out how and where to integrate leverage AI and digital twins to more effectively validate and optimize networks, particularly through technology such as the RAN Intelligent Controller (RIC) in Open RAN. And because the test and measurement industry must always look forward to how future wireless features are being developed and implemented, the evolution of networks also has to encompass the latest developments around 5G-Advanced, Non-Terrestrial Networks and future 6G systems.

The following report recaps the topics, trends and debates of the 2024 Test and Measurement Forum.





(Image courtesy of 123RF)

WHAT TO WATCH IN TEST AND MEASUREMENT IN 2024

NTN and Open RAN are important industry focal points that bring about massive test and measurement complexities

To set the stage for the Test and Measurement Forum, Emil Olbrich, vice president of network technologies with Signals Research Group (SRG), laid out some of the market trends his firm is tracking, particularly the complexities presented by Non-Terrestrial Networks (NTN) and Open RAN.

But sitting above those particular technology categories, Olbrich said is "the biggest issue we see in the market [is] conformance versus performance testing…the real world versus the contrived. Being able to independently test and verify systems, I think, is very important."

Whether for direct-to-device communications supported by a satellite constellation or for a disaggregated radio access network (RAN), he stressed the need to focus less on whether a particular set of technologies adhere to what's laid out in the relevant standards and more on the end-user experience those technologies deliver.

Calling out the increasing adoption of artificial intelligence (AI) by network operators—a machination playing out faster than what's reflected in standardization work—means a further disconnect between conformance testing and performance testing. "I think it's tough to standardize innovation," Olbrich said. Specific to the use of AI in mobile networks, "Do we see a net improvement in overall system efficiency or do you see better performance as an end user? That remains to be seen."

Testing NTN

NTN is an area of growing interest with major operators engaging with satellite communications companies, specifically AT&T and AST SpaceMobile and T-Mobile US and SpaceX both working on satellite-enabled direct-to-device communications, and the U.S. Federal Communications Commission (FCC) taking up supplemental coverage from space (SCS) for extension of cellular coverage into rural areas. 3GPP standardization work on NTN began in 2017 with Release 15 and is ongoing.

Olbrich acknowledged this is a nascent area but also described a "back to the future" problem based on earlier satellite-based communications work done in the late 1990s and early 2000s by Globalstar and Iridium. Those challenges "don't necessarily go away," he said, going through link budget fading and signal-to-interference-plus-noise ratio (SINR), latency and timing synchronization, Doppler frequency synchronization, mobility and power management.

Another testing complication, he said, is around the variability in types of satellites and associated types of orbit--geostationary, geosynchronous or low-earth, as well as whether the goal is narrowband internet of things (NB-IoT), 4G or 5G communications. It's an "exciting era," Olbrich said. "As far as testing goes, there's no shortage of testing because there's a lot of different air interface technologies [and] implementations of it."

Open RAN interoperability test and measurement

Examining growing operator investment in multi-vendor Open RAN, Olbrich started off by making clear that disaggregated radio systems are working in the real world today. "We've personally shown, from our organization, performance metrics that are on par with some of the best networks, even exceeding some of the best networks, in the world." With the rise of Open RAN, he said, comes the need for testing interoperability between radio units, distributed units and centralized units from different suppliers.

Olbrich described "massive market demand" in this area but qualified that by calling back to his introductory commentary around conformance versus performance testing. "We don't like to test interoperability. We expect things to work when we get them in the field, and we want to test performance."

But given the realities of Open RAN interoperability testing, an increasingly automated process, he said, "This is going to be a continuing challenge." He noted a bright spot in the U.S. Department of Commerce (DoC) announcing in January it would provide a $50 million grant to greenfield Open RAN operator DISH Wireless to establish the Open RAN Center for Integration and Deployment (ORCID). The idea is to host various Open RAN vendors and test interoperability between radio, distributed and centralized units using DISH's commercial network.

EMIL OLBRICH
Vice President of Network Technologies,
Signals Research Group

Olbrich rightly noted that announced ORCID participants—Analog Devices, ARM, Cisco, Dell Technologies, Fujitsu, Intel, JMA Wireless Mavenir, NVIDIA, Qualcomm, Samsung and VMware by Broadcom—represent just a sampling of a much larger Open RAN vendor ecosystem. "I think the intention is good," he said. "We'll see what happens in reality." As to the collaborative testing piece, "I think the market is seeing [and] the U.S. government is actually seeing value in that."

Last test and measurement question for Olbrich: where should test and measurement vendors be focused? He gave the example of end-to-end testing for mobile gaming and extended reality (XR). "If you press a button on a game…how is that response…from when you touch a button until you get an action back on the server and get the response back. We can measure latency, but do we measure how fast the CPU and GPU on the phone are… all the way to the application server?…You have to take so much data from so many different nodes…Being able to do that end-to-end testing, but then delineate where the issues are, if we could see something like that that would help me do that, that would make my life much easier."

(Image courtesy of 123 RF.)

THE ROLE OF TEST AND MEASUREMENT IN DELIVERING 5G QOE?

5G enterprise services are completely changing the test and measurement dynamic

New enterprise services like private networks and network slicing have been at the center of conversations around how telcos can more effectively monetize 5G. However, offering these services introduces network complexities that, according to a panel of experts, are changing the network test and measurement dynamic completely.

Mark Watts, associate fellow of global network and technology at Verizon, said that there are three ways in which the carrier views emerging testing needs for 5G services. First, he said, network hardware and software needs to be validated. Then, the network readiness must be assessed. "Whether or not the network itself can provide the type of services that are expected in 2024 and beyond," he said. And finally, once new services are rolled out, each of those services must be validated from a user point of view to ensure quality of service and experience.

"Whether or not we would use a point-to-point type of test or node-to-node or router-to-router all depends on the type of service that we want to provide and how much flexibility and control we want to have over the network based on these newer services," Watts shared.

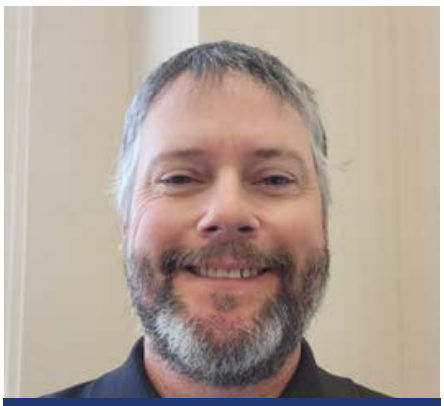
One such new offering is private networks, and because these offer a more bespoke network experience, especially when paired with network slicing, Jefferson Wang, senior managing director and cloud first chief strategy and growth officer at Accenture, explained that there will be instances in which a customer just wants the radio on premise, while another wants the radio and edge compute and still others that want full control and so they ask for local radio and compute infrastructure.

All of these scenarios, Wang continued, require different levels of testing, and depending on the scenario, there are changes to the integration to the RAN transport in the core, the integration to the backend of the enterprise itself and so on. "So, testing takes this new life," he said, adding that as a result, testing in 5G is moving from a more static process to CI/CD types of processes.

Spirent Communications' Senior Director of Assurance Strategy Ross Cassan agreed, adding that the company is seeing "a lot of stress" being placed on carriers as they look to implement these new features. And so, for its part, the company is focusing on reducing the amount of noise from the systems that the carriers are experiencing. One way the company does this is by leveraging AI and ML for fault validation, which ensures that once an alert is actually sent up the chain to a telco employee, there really is a validated and repeatable problem. "We are working towards closed loop," he said. "This is a key step in that journey."

Further, Cassan shared that it is becoming increasingly important to couple this end-to-end monitoring with active network segmentation. "As we move towards things like private networking, enterprise services, slicing all of these different domains in the network have to work together," he said. "By enabling active assurance across that entire set of domains, being able to run the same test from any interface end-to-end over-the-air, targeting specific nodes ... it allows us to very quickly pinpoint the issue and remediate ideally before customers are even impacted."

ROSS CASSAN
Senior Director of Assurance,
Spirent Communications



MARK WATTS
Associate Fellow, Global Network and Technology, **Verizon**

JEFFERSON WANG
Senior Managing Director,
Accenture

(Image courtesy of 123.RF)

HOW TO IDENTIFY AND TROUBLESHOOT PIM

EXFO and Verizon on how to effectively resolve PIM issues that impact network performance and drive up opex

Passive intermodulation (PIM) is a huge headache for mobile network operators. PIM can materially impact network performance while also costing operators time and money as they work to identify the source and work towards a fix. EXFO's Danny Sleiman, business development manager for global 5G strategy, said that today resolution of PIM issues takes 2.5 site visits with an average of 12 hours to resolve trouble tickets. Additionally, in two out of three cases, antennas are unnecessarily replaced.

PIM comes in two flavors. Internal PIM results from an operator's own system--things like bad cabling or damaged connectors, and is typically confined to single network branches. External PIM generally impacts multiple branches and comes from things like consumer signal boosters close to cell sites, oscillating repeaters, foreign wireless devices or even electronic signs.

From the operator perspective, Verizon Associate Fellow Dennis McColl laid it out: "There's a hyper focus on operational expense…The operational expense associated with RF systems is large, and as we add frequencies, as we add power, the problems associated with PIM go non-linear. If you're going to affect your opex numbers, you're certainly going to have to be on point when it comes to RF issues, and PIM is certainly one of those things, especially external PIM."

DANNY SLEIMAN
Business Development Manager, Global 5G Strategy,
EXFO

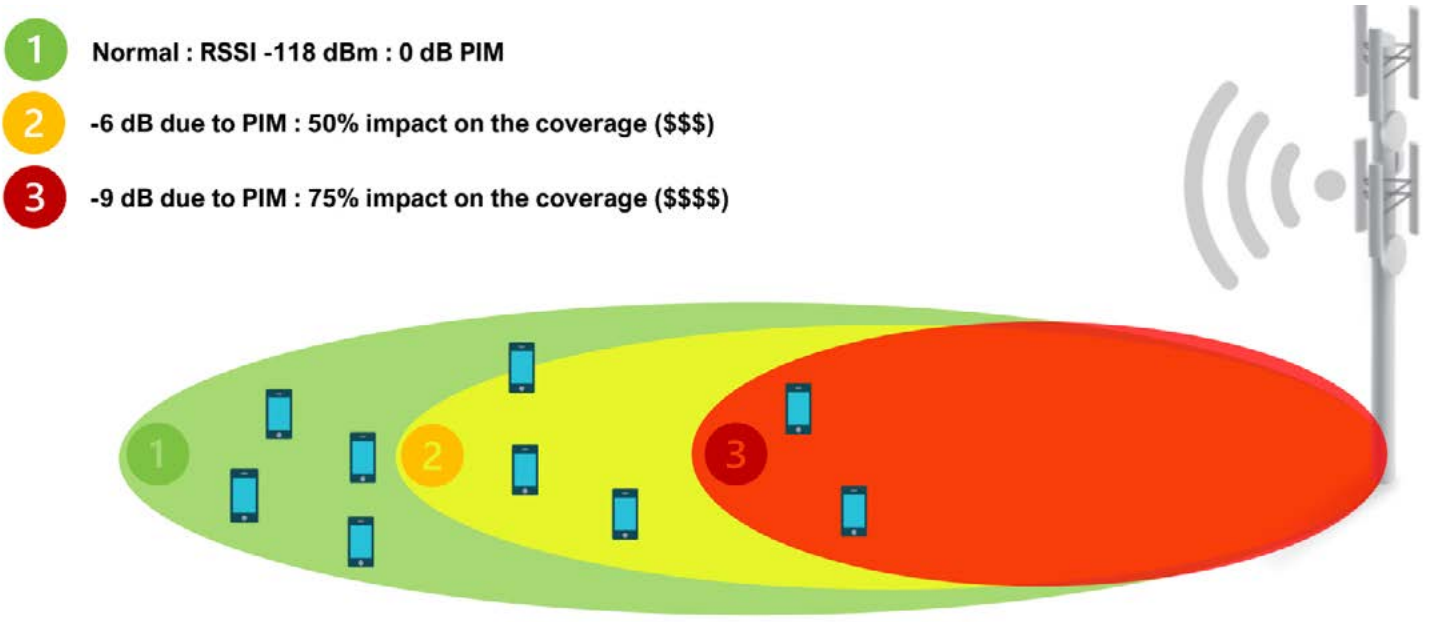
He called for a number of adjustments that would help operators more time- and cost-effectively address PIM and the problems it creates. First things first, operators need to be able to correctly identify PIM as opposed to some other type of external interference "otherwise you're going to start dispatching contractors for tower climbs or to do interference work. If you misidentify what's happening. That's waste; that's a large waste."

Another best practice, McColl said, is thinking about PIM when deploying new sites. In the real world that would mean putting antennas on the outside edges of buildings, not inside the parapet, and avoiding known PIM-causing parts in favor of PIM-free alternatives. "It seems very straightforward, but we're not in this practice. We should certainly be designing sites with PIM-free hardware." He described this as "PIM hygiene."

When it comes to external PIM, McColl said it's important to only engage with

DENNIS MCCOLL
Associate Fellow,
Verizon

certified contractors who have had the requisite training and hands-on experience. "We absolutely as an industry need to communicate the need for certification for external PIM specifically."



(Image courtesy of EXFO.)

Troubleshooting PIM with RF over CPRI analysis

Sleiman agreed with the idea that it all starts with PIM hygiene but, in terms of troubleshooting, he highlighted EXFO's approach of tapping into the CPRI connection between a base station and radio to analyze PIM's impact on RF and network performance. He also pointed out that increasing levels of PIM can have a huge (non-linear as McColl said) impact on per site coverage.

He laid out "a trusted method of troubleshooting PIM…The first thing that needs to be done is, 'Can you resolve this PIM issue without pulling any equipment?'" From there, techs should determine if it's internal or external, then follow the flow chart from there. "If you follow every step and you use the right tools, you're going to get to a point where you close your ticket and you're not going to have any unnecessary costs…and no radios being replaced."

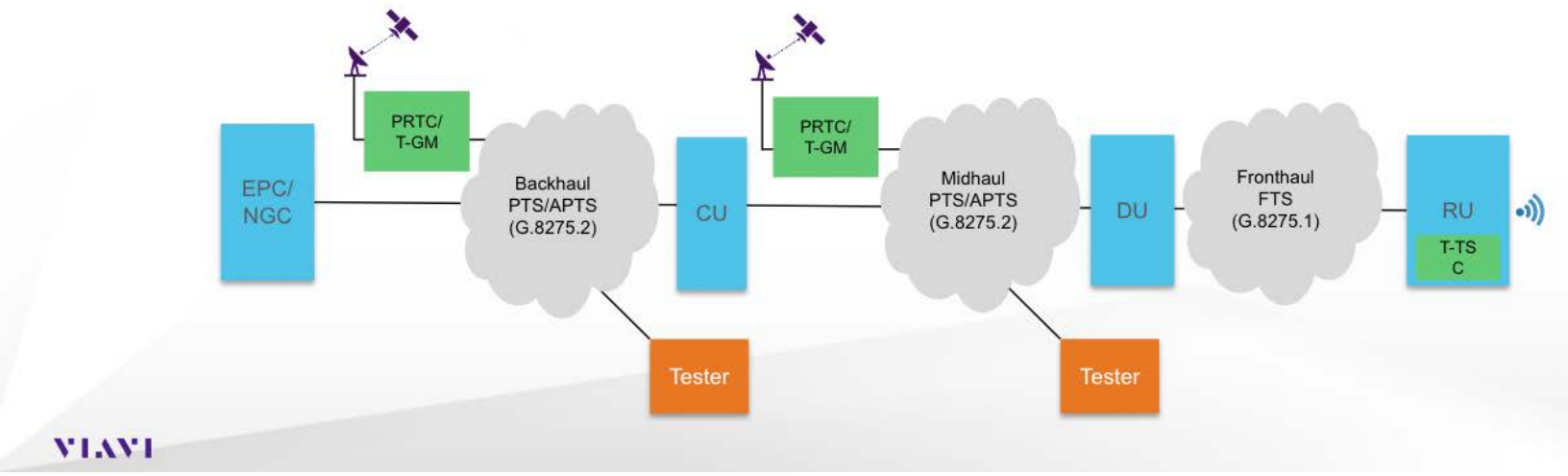
Discussing the RF over CPRI approach, Sleiman pointed out that the site remains operational during the test phase, and because there's no need to disconnect any RF connections, there's less opportunity to introduce new PIM. Because the site stays active, techs can see improvements or degradations as they're happening. "This can be done in under 20 minutes. You're able to know [if] you have an internal issue or an external issue…The improvements that are done on the site using your test equipment and the CPRI analyzer method will result in KPI improvements to your system."

Recall Sleiman's earlier figures around PIM. He said that with the CPRI analyzer method, the average of 2.5 site visits drops to 1.5 site visits, the time to resolution drops from 12 hours to six hours on average, and instead of unnecessarily replacing two out of three antennas, it's not necessarily to replace any antennas.

Does AI/ML have a role to play?

McColl said that using AI would require development of a model whereas many PIM-related problems boil down to simple math. On AI, "In many cases, you just don't need it because there's very simple ways to go after these things." He also pointed out that automation tooling mis-categorizing problems is currently an issue operators have to deal with. "I'd be worried about the use of AI to replace workers…Why are we wanting to go use AI? Is it to make things better or is it to improve the bottomline?"

Sleiman acknowledged that AI has some place in the PIM equation but, at the end of the day, "It's tough to pinpoint exactly where's the issue." AI can be used to simplify configuration and some aspects of troubleshooting but "to identify exactly that location or what it is, it's hard to do, or practically impossible" using AI versus experienced technicians equipped with the right tools.



(Image courtesy of VIAVI Solutions.)

HOW TO TEST AND MEASURE TIMING AND SYNCHRONIZATION IN AN OPEN RAN NETWORK'

The rise of Open RAN, where multi-vendor radio systems comprising centralized, distributed and radio units are made interoperable, is now decidedly mainstream. Following early commercial deployments from greenfield operators, Open RAN is scaling out in brownfield networks. In addition to the pre-deployment interoperability work, there's also a need for tight focus on test and measurement for timing and synchronization given the architectural shifts brought about by radio access network (RAN) disaggregation.

During the recent Test and Measurement Forum (available here on demand), VIAVI Solutions Senior Manager Reza Vaez-Ghaemi took a deep dive into test and measurement for timing and synchronization in increasingly dynamic, disaggregated wireless networks. Citing the relevant (and extensive) associated standards from 3GPP and ITU-T, Vaez-Ghaemi noted the importance of conformance to standards across networking domains.

Specific to Open RAN, Vaez-Ghaemi said, "O-RAN introduced four lower-layer split (LLS) synchronization configuration modes (LL1-C1 [through] LLS-C4), added requirements for time/phase and frequency budgets, node behavior guidelines and detailed error budget analysis aspects. It also brought in an Open Fronthaul Management plane that defines synchronization attributes that further help more smoothly interoperate solutions from different vendors."

In addition to conformance testing for open distributed units and open radio units, an end-to-end view comes into focus with interoperability testing for fronthaul and midhaul, as well as test requirements for transport networks in fronthaul, midhaul and backhaul.

In terms of relevant synchronization metrics, Time Alignment Error (TAE) includes relative and absolute figures; time error (TE) is defined as the time differences at a user network interface (UNI) compared to another UNI or based on a Primary Reference Time Clock (PRTC). To put that in context, MIMO diversity transmissions at each frequency need a relative TAE of 65 nanoseconds and 5G intra- and inter-band, non-contiguous carrier aggregation needs a relative TAE of 3 microseconds.

"The more we get into these advanced wireless services and capabilities, the synchronization requirements increase significantly," Vaez-Ghaemi said. "We see all these requirements becoming tighter and tighter."

In terms of the entire timing and synchronization chain, and how to test and measure across it, the workflow is as follows:

- GNSS/GPS installation verification, including antenna location, receiver functionality, cabling integrity, satellite availability and signal strength. Then ensure accurate antenna cable delay is measured and respective bias value is entered into the attached PTP primary.
- Fronthaul network synchronization testing, including verification of GPS, connection and configuration of sync parameters, and synchronization applications—emulate Precision Time Protocol (PTP) secondary and perform time error measurements, then emulate Synchronous Ethernet (SyncE) and validate frequency offset and Ethernet Synchronization Message Channel (ESMC).
- Midhaul/backhaul synchronization testing wherein operators may deploy (Assisted) Partial Timing Support (APTS), emulate Precision Time Protocol (PTP) secondary, and perform two-way packet selected time error and floor packet percentile measurements.
- SyncE testing, including functionality and configuration of Ethernet Equipment Clock (EEC) in the synchronization path, SyncE Wander Analysis to measure dynamic frequency error in the network, and use the Synchronization Status Message (SSM) to help establish whether the device under test is transmitting the proper quality level

REZA VAEZ-GHAEMI
Senior Manager,
VIAVI Solutions

- Finally, over the air (OTA) synchronization measurement to verify that the radio sync conforms to the appropriate synchronized mode and delivers the expected outcome in terms of frequency and time error versus GPS and time error versus GPS.

"At the end," Vaez-Ghaemi said, "this whole thing is about the air interface. That measurement measures basically time/phase and frequency against the GPS or another reference…[It] should be then within that limit 3GPP defined both for frequency and time error."

(Image courtesy of LitePoint)

SIMPLIFYING OPEN RAN MIMO TESTING FROM LAB TO LIVE

LitePoint focused on testing MIMO radio units as a whole rather than antenna-by-antenna

As operators look to maximize spectrum utilization and deliver strong quality of experience to users, multi-antenna MIMO radio units have become mainstays in global radio access networks (RANs). LitePoint has focused on a simplified testing approach wherein instead of radio unit (RU) testing that goes antenna-by-antenna, the MIMO system is tested as a whole. In addition to simplifying the process, this method gives better insight into real world performance.

LitePoint Senior Product Manager Middle Wen explained that testing all antennas at once in a 4x4 MIMO configuration can reduce test cycle time by almost half. He also noted that concurrent antenna testing can help expose RF performance issues. "The MIMO testing can help the engineers to verify the real performance," he said.

In an Open RAN system, RUs are typically tested in isolation, meaning it's not connected to the other components that would be present at an actual radio site. The primary focuses are on fronthaul and RF interfaces and the RU is connected to an emulated distributed unit (DU). "This testing setup is quite complex, expensive and difficult to set up," Wen said.

LitePoint's solution is its fully-integrated IQFR1-RU single box which supports RF parametric and fronthaul conformance testing thereby eliminating dependence on an emulated DU. The unit also supports MIMO signal generation and analysis and reduces time-to-market by leveraging automation software.

In the RU testing process, Wen called out the importance of uplink testing that involves not just the wanted signal but also a range of interference signals that could be present in a live network. LitePoint has also integrated this functionality into its single box to simplify the design of uplink testing scenarios, including reference sensitivity level, dynamic range, adjacent channel selectivity, in-band blocking, narrowband blocking, out-of-band blocking, receiver spurious emissions, receiver intermodulation and in-channel selectivity.

Speaking more broadly about Open RAN adoption, Wen pointed to a number of recent operator announcements, particularly AT&T's $14 billion, five-year deal with Ericsson, that suggest single-vendor Open RAN as a sort of "middle step" between single-vendor RAN and multi-vendor Open RAN. Regardless, "O-RAN I think is very clearly transforming the mobile industry," he said.

But, driving faster adoption in both greenfield and brownfield environments, he said, will come down to fast, accurate testing with an emphasis on the RU given that "it determines what the real radio performance of your entire system" will be. "RU testing is critical for the success of O-RAN."

MIDDLE WEN
Senior Product Manager
LitePoint

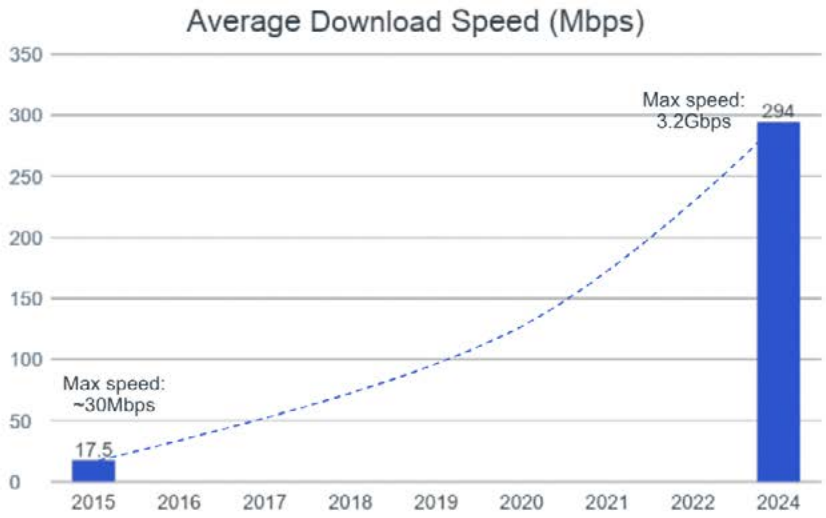
THREE NETWORK TRENDS IMPACTING SERVICE ASSURANCE

Cassan of Spirent Communications laid out key networking trends that are impacting service assurance and how the company is amending its strategy to address them.

Expansion and evolution of 5G

Massive investments in 5G and the recent roll out of mid-band spectrum in the U.S., said Cassan, are leading to notable increases in network performance, and while this is great news for network users, it presents a new challenge for those responsible for testing and validating the network.

Cassan shared a graph, which showed that in 2015, Spirent recorded an average speed of 17.5 mbps and a maximum speed of 30 mbps in a live network. Next he pointed to a test that the company ran in late April in Manhattan. "We're seeing an average of almost 300 Mbps across all three major carriers [and a] max speed of 3.1 Gbps," he said of the new test results, adding further that 89% of the testing done was on 5G.



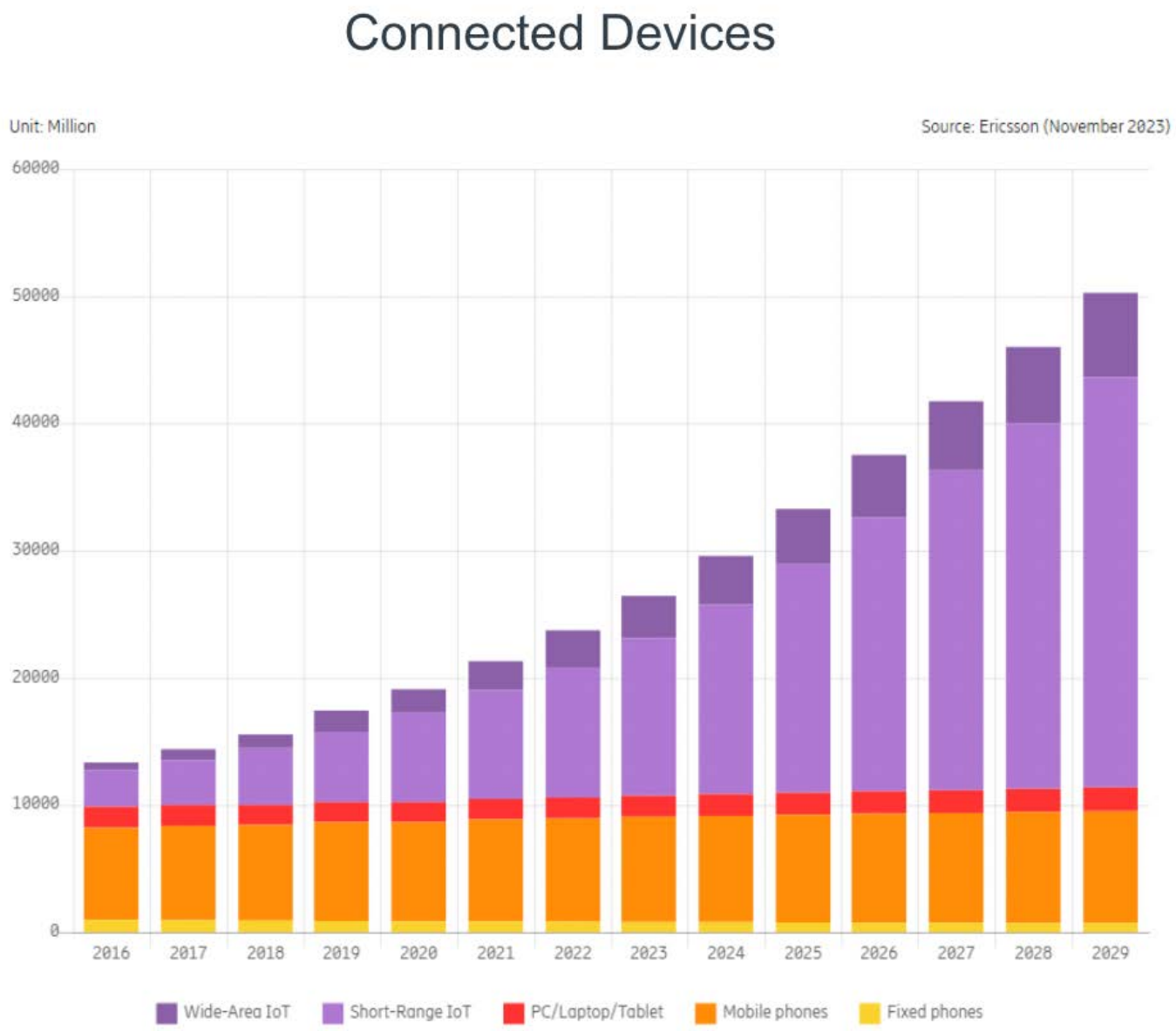
(Image courtesy of Spirent Communications.)

"The impact that this is going to have for assurance is just a lot more devices and a lot more traffic on the network and the strategy that we use for assurance is going to have to adapt to that," he continued. "The old strategy of capturing and tapping every bit isn't going to fly with these types of increases."

5G monetization driving new use cases

Cassan presented a growth chart detailing the prevalence of connected devices from 2016 to 2029. 5G, he said, isn't just about improving the consumer mobile experience; it's about introducing next-generation services and has a focus on enterprise use cases.

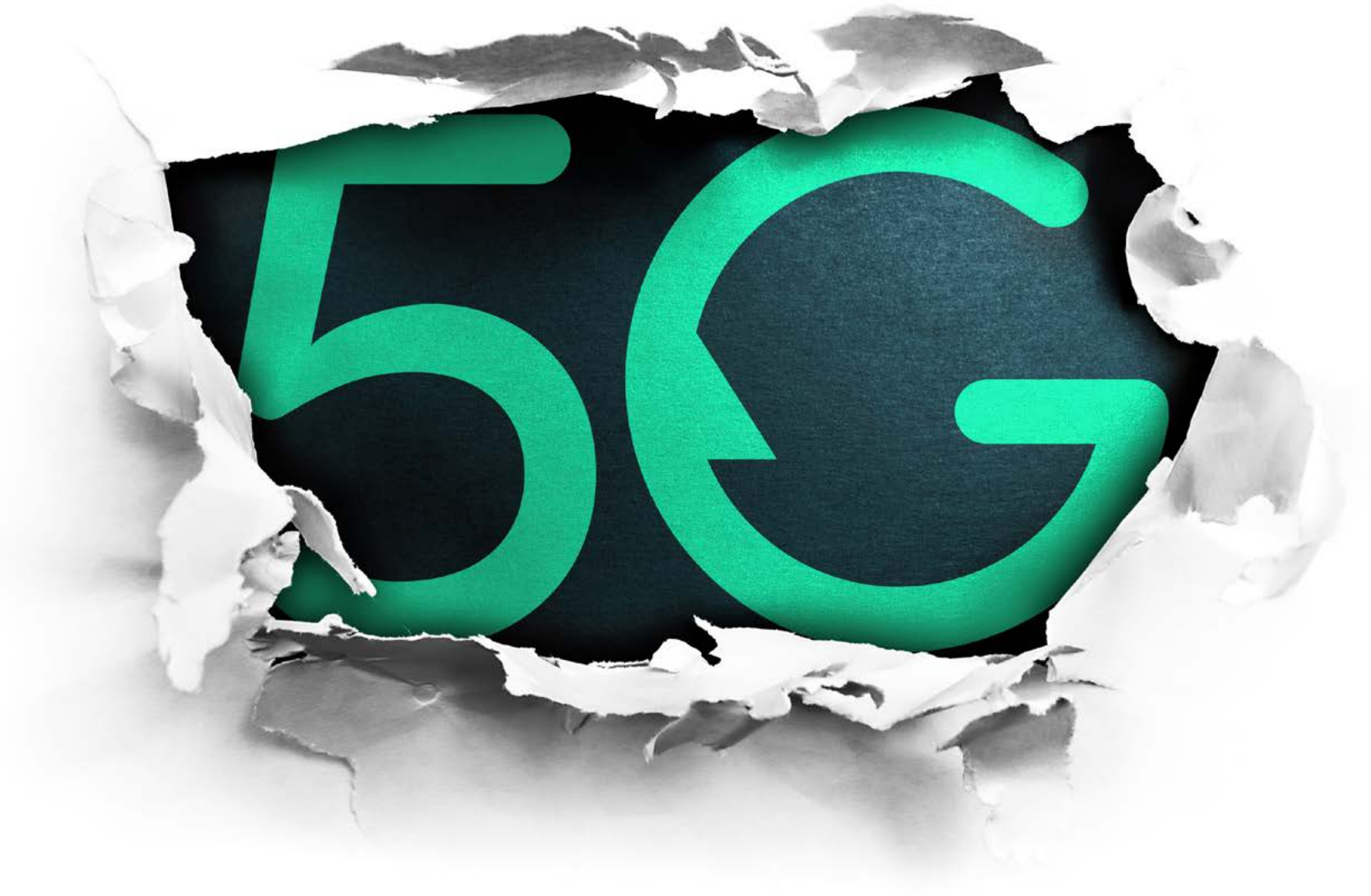
"The growth is not really in consumer services," he pointed out, reverencing the graph. He noted that smartphones, PC and laptop growth has remained "relatively stable," while enterprise devices like those designed for machine communication and IoT devices have experienced significant growth over the last few years.



(Image courtesy of Spirent Communications.)

"We see a lot of potential for new services and a lot of these types of services will depend on the network delivering on an SLA," he said. Therefore, companies like Spirent are tasked with assuring specific network requirements like latency loss or throughput for the first time.

Spirent



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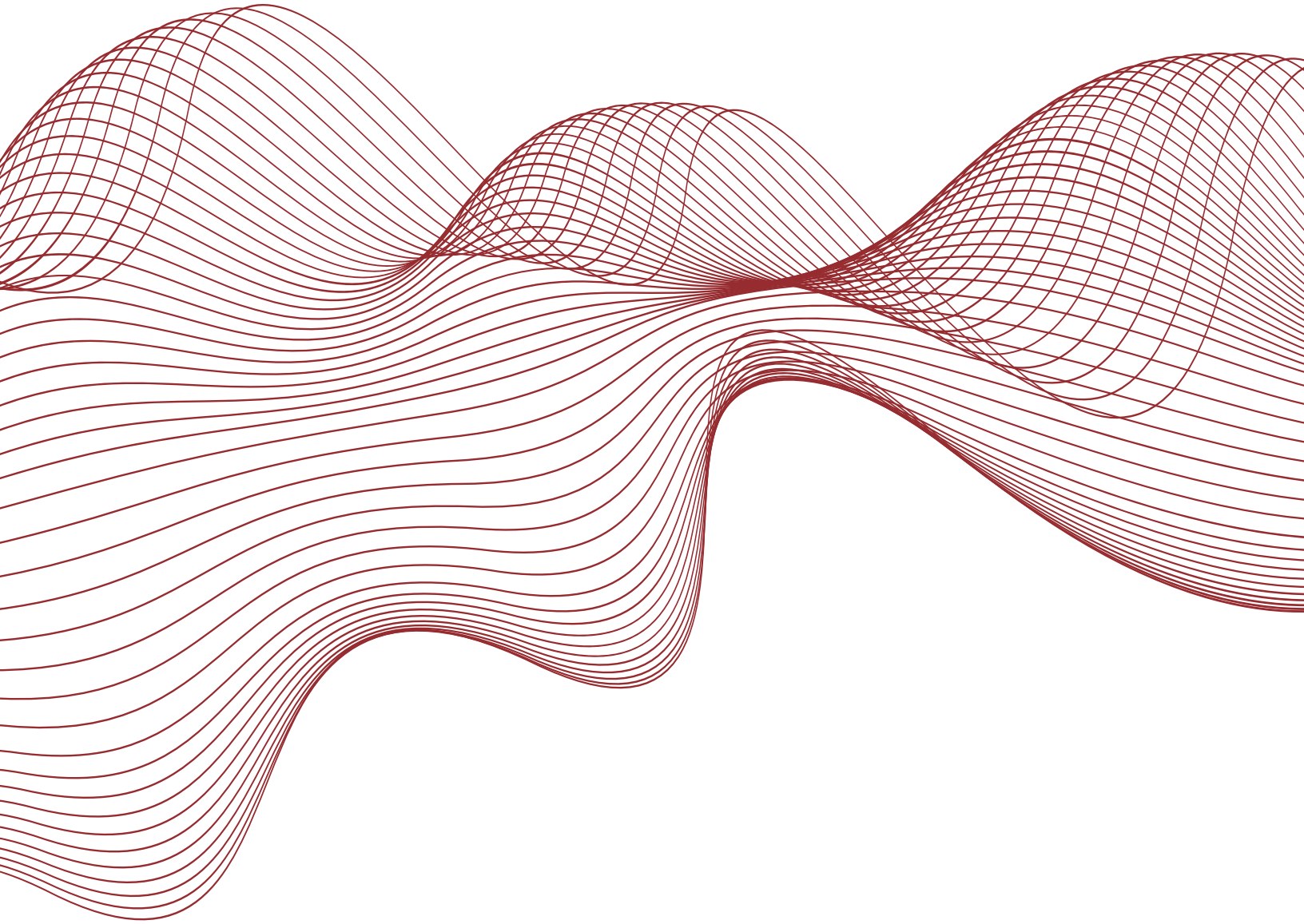
NETWORK AUTOMATION AND OPTIMIZATION

"As were moving to O-RAN, we are moving the mobile functions to private clouds and sometimes even public cloud but running on dedicated compute infrastructure," explained Cassan. As such, Spirent is looking to leverage service assurance in an increasing automated network environment.

While Spirent is "not quite ready to hand the keys to the network over to automation," the company is already taking steps to automate assurance in carrier networks, specifically around fault analysis, fault restoration reduction and change management.

"We're moving to a more proactive methodology, where we are looking at this as an end-to-end to seamless DeVops cycle," summarized Cassan. "We're automating the service activation, we're monitoring the network proactively, we're doing rapid and automated root cause analysis and finally, we are closing the loop with change management and validation."



(Image courtesy of 123.RF)

THREE OVER-THE-AIR (OTA) TESTING CHALLENGES

With OTA testing, more test points equals more test time

When it comes to over-the-air (OTA) testing, more test points equals more test time, and this has never been more true than in the case of mmWave. NI's Chief Systems R&D Engineer Gerardo Orozco shared the top three OTA testing challenges and how the company has successfully cut down test time through integrated motion control and dedicated hardware and software tools.

External switching

Orozco said that the first challenge identified by NI is that most testing instruments on the market have a signal generation box and a signal analyzer box. "Therefore, whenever they try to do a transmit and receive test, they need to have some sort of external switch to do this combination," he explained, adding that at frequencies in questions — roughly 24 GHz to 54 GHz — this leads to a lot of path loss. "You want to be as close as possible to your … antennas… The moment that you need to put external switches … the cable starts to be a little too long and there is extra complexity," he said.

To solve this, NI designed mmWave test heads located outside of the main portion of instrumentation. These can be placed a lot closer to the antenna and they are transmit and receive, which allows for testing "bi-directionality" without connecting and disconnecting.

GERARDO OROZCO
Chief RF Systems Engineer,
NI

Waveform switching

Another time-consuming challenge in OTA testing is that switching between CW (continuous waveform) and modulated waveform requires different equipment. "We want the same equipment to be able to do a CW type of test, which sometimes is do[ne] to get [a] very, very accurate way of the antenna pattern. But you also need to do modulated measuring … to see what the signal looks like when a wide band signal is going through," said Orozco.

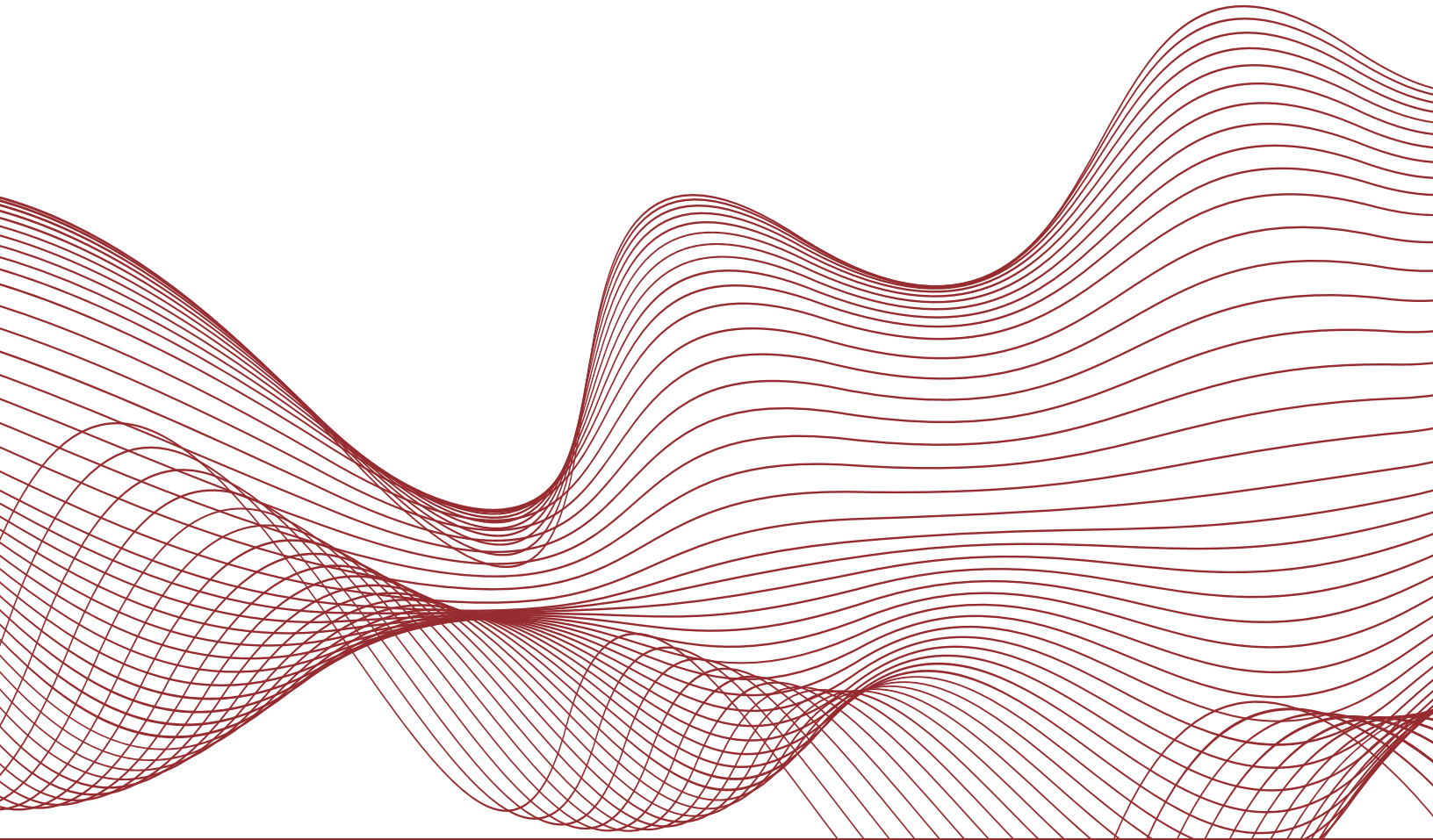
This is why NI designed equipment, said Orozco, that does both CW and modulated measuring. "That is what the instrumentation is expected to do," he said.

Movement

With over the air testing, the fewer points you test, the more systematic errors you get; however, more test points means more test time. "If you want a very small systemic error, you're talking about thousands of points and … that's minutes per test case," said Orozco. He explained that this challenge arises because as you're testing, there is movement; it takes time to accelerate and decelerate to get to the next point. "You stop, then you measure. That takes hundreds of milliseconds and when you multiply that by all of these points, you start getting into the minutes just to get one test case completed," he continued.

NI achieved five times improvement in test time using what it calls autonomous 3D sweeping, which Orozco said essentially means "do not stop."

"Instead of move, stop, move, stop. What we do is as we are moving, we have hardware triggers and we start capturing little buckets of RF signal, and then we start mapping them where they were in the location and the position is constantly moving," he said, noting that this "substantially" reduces test time with the same grid size.



(Image courtesy of 123.RF)

WHAT'S NEXT FOR TEST AND MEASUREMENT?—NTN, 5G-ADVANCED, 6G

With the continued evolution of 5G, close-in priorities for operators are understanding the why and how of 5G-Advanced, working with satellite providers on Non-terrestrial networks (NTN), and setting the stage for the commercialization of 6G in the 2030 timeframe. And before any of this can make much of an impact in the real world, it all has to go through rigorous (and ongoing) test and measurement processes. There are a number of key considerations in this dynamic technological landscape.

NTN for IoT, broadband and direct-to-cell communications

Starting with NTN, NI Fellow Marcus da Silva noted the variability in how NTN will be used, including for internet of things (IoT) use cases, satellite-based broadband to a dedicated terminal like SpaceX's Starlink service, and direct-to-cell communications like the AT&T/AST SpaceMobile and T-Mobile US/SpaceX tie ups. Da Silva called out the need "to deal with huge Doppler shifts…and then you also have to deal with much longer latencies."

VIAVI Director of RF and Wireless Architecture Ian Wong mentioned that using commercial devices for satellite-based communications brings up important questions around link budget and transmit power from the handset. "At the end of the day, there's a strong impetus to be able to support this with regular UEs," he said. "I think that's going to be the key challenge. And again, for all things, whether it's data access or IoT, I think it's a very similar challenge.

The test and measurement piece of NTN requires specialized equipment. Wong cited work with Rohde & Schwarz to pair that firm's NTN device tester with VIAVI's network tester. "We needed to emulate the UEs on the ground as they interact with the satellites in the air," Wong said. "And so we are actually modeling that accurately to enable…almost like as an NTN testbed. So there's a lot of interest out there, for people are just trying to understand…the issues that this network can encounter, and also what types of applications can actually be run with that network."

5G-Advanced for machine-type connectivity

Before we get to 6G, 5G-Advanced will hit the scene with a number of system-level enhancements and new features around indoor positioning and time-critical services among others. 5G-Advanced starts with 3GPP's Release 18 and will continue to be refined in subsequent releases.

Da Silva rightly pointed out that human cellular connections are approaching a point of saturation, meaning continued growth comes from connecting machines. In fact, he said, "We already have more machines being connected than we have people." And this speaks to some of the goals of 5G-Advanced. "Latencies are no longer necessarily people latencies," he said. "You may need robotic latencies, which may be much shorter than people latency…I think we're seeing that shift from people-to-people connection to machine-to-machine connection. And again, Release 18 goes part of the way there."

Wong called out that given the trajectory of 5G monetization, operators are "very cautious in terms of additional spending." So continued network capex needs to have a straight line to lower operational costs and, ideally, new service revenues. A lot of this could potentially come down to AI-enabled, more automated networks which is a focal point of Release 19. "I think there's a lot of pragmatism that's happening," he said…There's going to be new use cases. We want to support that to expand the serviceable market with verticals and private networks, etc…But I think there's definitely a lot of things that we can do to support our operator customers today to make the network more efficient and more cost-effective to operate."

MARCUS DA SILVA
Fellow,
NI

IAN WONG
Director of RF and Wireless Architecture, **VIAVI Solutions**

(Image courtesy of 123.RF)

New G, new spectrum, new features, new test and measurement methodologies

With 5G, key spectrum bands were divided into FR1 sub-6 GHz and FR2 from 24 GHz to 52 GHz. While 6G is still some ways out, research, development and testing are ramping up. On the spectrum side, the so-called upper-mid band, FR3 frequencies in the 7 GHz to 24 GHz range are emerging as the likely range for wide-area 6G coverage.

Wong said the current test and measurement focus is "how we can leverage that" FR3 spectrum. Other areas of study are artificial intelligence (AI) and machine learning (ML) "from the air interface all the way up to network management [and] optimization…And finally, let's call it new use cases, new ways to monetize, is always something that is top of operators' minds. And also energy efficiency."

This idea of 6G as AI-native suggests bringing AI into the physical layer, which in turn suggests new types of device and infrastructure testing. Given NI's expertise in device testing, da Silva said, "one of the issues that we are having to face and haven't completely answered yet, is the fact that if you have an AI/ML-enabled device, it is learning as it goes. Its behavior is not necessarily deterministic…So we're looking at the need to move from measuring parametrics on a device…to measuring a whole bunch of different parameters, different behaviors, and creating a map of what looks like a good device versus a bad device. And one of the things this brings to mind is we may need to have AI to test AI."

Final thoughts?

Whether it's test and measurement for Open RAN networks, end-to-end AI services, NTN, 5G-Advanced, 6G, some combination of those or something else all together, one of the big points of this particular panel, and of the forum in general, were that increasing complexities and more stringent requirements mean more testing, more measurement, more optimization, more everything really.

"I think the takeaways I would say I'd like to impart," Wang said, "is clearly we, as a vendor community, have to come together to really address these…pressing issues of the day. Our telecoms market, it's not in that upswing, as we all know. So we have to think about ways of trying to be more efficient. How do we address these issues that our operators are seeing? And I think we need the collective brainpower of the industry to really help achieve that."

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