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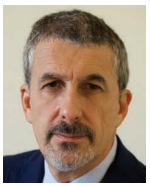

5G Consolidates Deployment by Targeting New Bands

Leafing through the usual flurry of news and announcements by standardization bodies, regulators, operators, and manufactures, it is hard to miss the increasing number of reports of trials involving promising new portions of spectrum, such as the much-coveted C-band. Sitting astride the so-called Wi-Fi bands at 2.4 and 5 GHz, the C-band has special appeal for urban coverage given its expected range of 1–2 km, not too dissimilar from 4G deployments. In this sense, the C-band is not an unknown quantity, thus enabling operators to replicate their coverage strategies on a spectrum largely unused by cellular communication. Now that regulating authorities around the world have started auctioning off more and more chunks of this portion of spectrum, interest is growing in trials targeting the C-band, with an eye toward coexistence issues with legacy technologies operating in it.

End-to-End Virtualization and Massive Multiple-Input/Multiple-Output on the C-band

As reported on 27 July 2021, Verizon and Samsung Electronics completed an end-to-end, fully virtualized 5G data session using C-band spectrum on a live network. The milestone was reached in preparation for an upcoming 5G ultrawideband expansion using Verizon's newly acquired C-band spectrum. The trials, conducted on Verizon's network (using C-band special temporary authority granted by the U.S. Federal Communications Commission) in Texas, Connecticut, and Massachusetts, used Samsung's virtualized radio access network (vRAN), which is built on its own software stack, and C-band 64T64R massive multiple-input/multiple-output (MIMO) radio in coordination with Verizon's virtualized core. The trials achieved speeds commensurate with traditional hardware-based equipment.

Virtualization is critical to delivering the services promised by advanced 5G networks. Key 5G use cases, such as massive-scale Internet of Things (IoT) applications, more robust consumer devices and services, augmented reality/virtual reality, remote health care, autonomous robotics in manufacturing, and ubiquitous smart city solutions, will heavily rely on the programmability of virtualized networks. Cloud-native virtualized architectures lead to greater flexibility, faster delivery, greater scalability, and improved cost efficiency, paving the way for wide-scale mobile edge computing and network slicing. Massive MIMO is an evolution of antenna arrays that uses a high number of transmitters, which enables more possible signal paths between a device and a cell tower. It also reduces interference through beamforming, which directs a beam from a cell site directly to where a customer is, resulting in higher, more consistent speeds for people using apps and uploading and downloading files. This trial used Samsung C-band 64T64R massive MIMO radios that support digital/dynamic beamforming, single-user MIMO, multiple-user MIMO, and dual connectivity and carrier aggregation.

Coexistence in the C-Band

5G Americas, the wireless industry trade association and voice of 5G and LTE for North and South America, announced on 14 July 2021 the publication of a white paper, "Mid-Band Spectrum and the Co-Existence With Radio Altimeters" [1], detailing the status of commercial availability of spectrum for 5G use around the world and highlighting 5G wireless communications coexistence as it relates to commercial aviation.

Since 5G has grown to 172 networks around the world, providing service to 298 million subscribers, there is a growing need to support additional demands for the technology by expanding the commercial availability of low-, mid-, and high-band radio spectrum. The United States and many other countries are deploying midband spectrum in the 3,300–4,200-MHz range. Yet the aviation industry in the United States is raising concerns about the effect of 5G deployed in the 3,700–3,980-MHz

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range on radio altimeters in planes and helicopters in the nearby 4,200–4,400-MHz range, which is 220 MHz away in frequency.

Chris Pearson, president of 5G Americas, said, "Low-, mid-, and high-band spectrum is all very important for 5G to fulfill its full potential. Globally, the number of 5G network deployments is rapidly increasing in midband spectrum. Many nations around the world that are using spectrum in the 3,300–4,200-MHz-range have been successfully operating 5G networks and have done so without reports of interference to radio altimeters."

In the United States, military and federal systems have operated near the altimeter band for decades without incident. The U.S. government identified, approved, allocated, and auctioned the 3,700–3,980-MHz "C-band" without any constraints, yet the country later sought additional comments about possible interference, at the insistence of the aviation community. The 5G Americas white paper discusses studies submitted by the aviation industry. These raise interference concerns, but as the paper explains, there are significant shortcomings in them. For instance, they are overly conservative in evaluating real-world conditions while ignoring the lack of interference events in Japan, South Korea, and Europe as well as federal systems in the United States.

The white paper was developed and written by a 5G Americas technical work group that included engineering experts and was helmed by project leaders from Nokia and Ericsson. It includes the following topics:

- an overview of the current spectrum landscape, with a focus on North America
- a review of midband spectrum for 5G
- a discussion of C-band 5G coexistence with radio altimeters.

According to Prakash Moorut, head of spectrum standardization at Nokia, "Today, there are approximately 105 network operators around the world that are using midband spectrum in either the 3,300–4,200-MHz range or 3,300–3,800-MHz range, with some additional interest in deploying the 4,400–5,000-MHz range. It is therefore important to continue the momentum of harmonized spectrum around the world to align with increased demand for 5G use."

5G New Radio Call on Citizen Broadband Radio Service

On 1 September 2021, Ericsson and Qualcomm Technologies said they completed the first over-the-air 5G New Radio (NR) call on Citizen Broadband Radio Service (CBRS) spectrum in a field trial. The combination of 5G NR over the CBRS enables new applications for enterprises, which, in turn, supports the proliferation of private networks, further propelling Industry 4.0 evolution.

The CBRS, shared spectrum from 3.55 to 3.7 GHz, has been the catalyst for innovation to expand cellular usage beyond enhanced mobile broadband (eMBB) in the United States. Combined with the commercial rollout of priority access licenses, LTE-based CBRS network deployments are rapidly gaining momentum and proliferating across thousands of sites in the country. These sites enable use cases such as fixed wireless access, mobile network densification, and private cellular networks.

As the rollout of 5G NR network equipment in the CBRS band occurs, private cellular network performance will have improved throughput, reduced latency, enhanced reliability, and greater connection density, enabling applications including mobile robotics, connected manufacturing and facilities, augmented reality industrial applications, and much more. In addition, the coordination of the CBRS and licensed spectrum, such as the C-band, through carrier aggregation further delivers increased capacity to enhance user experiences.

With the over-the-air 5G NR call, Ericsson and Qualcomm Technologies combined 5G NR with CBRS shared spectrum. The field trial took place at Ericsson's North America headquarters, in Plano, Texas, utilizing the Ericsson 5G Distributed Innovation Network and a smartphone form factor test device powered by the Snapdragon 888 5G mobile platform with the Snapdragon X60 5G modem–radio-frequency (RF) system. The stand-alone 5G network configuration with rooftop radios enabled various real-life evaluation scenarios, including intra- and interband mobility and carrier aggregation (3.55–3.7-GHz time-division duplexing and the C-band) as well as mobility between the n48 and 5G low band, or 4G. Ericsson 4408 and AIR 6449 radios were used. The over-the-air environment was made possible by Federal Communications Commission test licenses.

Advanced Plans for 5G Radio

The first internal 3rd Generation Partnership Project (3GPP) workshop on radio-specific content in Release 18 occurred from 28 June to 2 July 2021, reviewing more than 500 company and partner organization presentations, to identify topics for immediate and longer-term commercial needs for the following:

- eMBB
- non-eMBB evolution
- cross functionalities for eMBB and non-eMBB-driven evolution.

The workshop began a process scheduled for completion at the December plenaries, with cross-group Release 18 package approval. The time duration for the release in RANs is tentatively set at 18 months, with a final decision that was expected in September 2021, following Technical Specification Group (TSG) RAN#93-e. Wanshi Chen, TSG RAN chair, reported that "we have seen a set of balanced concepts for the evolution to 5G Advanced with Release 18 that will now go forward for email discussion. At this early stage, we have witnessed a generally balanced evolution in terms of mobile broadband evolution versus further vertical domain expansion, immediate versus longer-term market needs, and device evolution versus network evolution."

Mobile Networks in Africa

The International Telecommunications Union (ITU), regulators, industry experts, and academia met virtually between 5 and 16 July to discuss Africa's future RF spectrum requirements in the context of revisions made to radio regulations by the last World Radiocommunication Conference, held in Sharm-el-Sheikh, Egypt. The meeting followed recommendations from the African telecommunications industry to step up regional collaboration on radio spectrum management and make room for expected growth in terrestrial and space services, with the goal of ensuring that communities are connected across the continent.

Participants at the ITU Regional Radiocommunication Seminar for Africa, organized in collaboration with the African Telecommunications Union (ATU), reviewed updates to the radio regulations, the international rules governing radio spectrum management. They also discussed the regulatory framework for the management of international frequency and best practices for spectrum use by terrestrial and space services. The seminar drew more than 270 participants from 54 countries, including 42 countries in the ITU's Africa region, as well as from international organizations, the telecommunications industry, African network operators, industry associations, and universities.

In related news, on 15 September 2021, Nokia signed a memorandum of understanding (MoU) with the ATU to drive digital transformation and the knowledge economy for socioeconomic development across the continent. The two parties will leverage telecommunications, including 5G networks, to connect the unconnected and identify innovative use cases and business models. In addition, the MoU lays the groundwork for both organizations to better help governments shape telecom policy, develop talent, and promote inclusion and diversity. This includes women as well as the underprivileged in rural and urban areas.

The MoU was signed in Nairobi, Kenya, by John Omo, ATU secretary general, and Rajiv Aggarwal, Nokia representative and head of the company's Central, East and West Africa market unit. Announcing the partnership, Aggarwal said, "We remain keen on supporting Africa's digital transformation journey, and by collaborating with the ATU, we strengthen this commitment. We will leverage our global technology expertise and insights on policy matters to positively impact the universal socioeconomic development in the continent."

The MoU is based on the following six tenets:

- sharing best practices in telecom technology trends and developments
- identifying innovative industrial use cases toward the Fourth Industrial Revolution
- recommending the implementation of emerging technologies and business models
- promoting broadband to connect the unconnected
- developing talent for digital innovation
- promoting inclusion and diversity.

5G Millimeter Wave With Support for 200-MHz Carrier Bandwidth

On 25 July 2021, Qualcomm Technologies reported that it completed the world's first 5G millimeter-wave (mm-wave) data connection with support for 200-MHz carrier bandwidth. This accomplishment was powered by the Snapdragon X65 5G modem–RF system, which includes new mm-wave capabilities for global expansion with support for wider 200-MHz carrier bandwidth in the mm-wave spectrum and enabling stand-alone mode services over mm-wave. The Snapdragon X65 is Qualcomm Technologies' fourth-generation 5G mm-wave modem–RF architecture for phones, mobile broadband, computing, extended reality, the industrial IoT, 5G private networks, and fixed wireless access. The July development was achieved using a smartphone form factor test device and Keysight Technologies' 5G network emulation.

The achievement follows a demonstration of the modem–RF system breaking cellular speed records, at more than 10 Gb/s, at Mobile World Congress Barcelona in 2021. Thanks to the software-upgradable architecture of the Snapdragon X65, enhancements and expandability are possible across 5G segments to enable new features, capabilities, and the rapid rollout of 3GPP Release 16. The enhancements are especially key as 5G expands globally, including the anticipated rollout of ultrafast 5G mm-wave in China and other regions and extending to areas such as computing, the industrial IoT, and fixed wireless access. Overall, more than 40 global mobile industry leaders announced their commitment to support 5G mm-wave in June, including China Unicom and major Chinese original equipment manufacturers.

Machine Learning to Detect Network Anomalies

On 20 July 2021, Nokia and Vodafone launched a joint machine learning product, running on Google Cloud, to detect and remediate network anomalies before they impact customers. Based on Nokia Bell Labs technology and developed after a Nokia–Vodafone agreement signed in 2020, the anomaly detection product is being rolled out across Vodafone's pan-European network. The system spots and troubleshoots irregularities, such as mobile site congestion and interference and unexpected latency, that can impact customer service. Following an initial deployment in Italy on more than 60,000 4G cells, Vodafone will extend the service to all its European markets by early 2022. Anomaly detection is offered "as a service," an important dimension to Nokia's Cloud and Network Services business group strategy, and there are plans to eventually apply it to Vodafone's 5G and core networks.

Vodafone expects that around 80% of its anomalous mobile network

issues and capacity demands will be automatically detected and addressed via the service. The deployment enables Vodafone engineers to make fast and informed decisions, such as boosting capacity where customers need it, based on information managed through Google Cloud's data and analytics services. On Google Cloud, the anomaly detection service facilitates the streaming of network data to Vodafone's analytics platform, enabling simultaneous analysis across multivendor environments.

Network Energy Consumption Halved in New Trial

On 2 September 2021, Ericsson and Vodafone announced that, as part of a collaboration to improve network energy performance, they completed the first deployment of a new energy-efficient 5G radio in London. Situated on the roof of the Speechmark, Vodafone UK's central London office, the controlled operation of Ericsson's antenna-integrated radio (AIR 3227) saw Vodafone's daily network energy consumption decrease by an average of 43% in direct comparison to previous generations of radio technology and as much as 55% at off-peak times.

Designed for future-proof and sustainable networks, Ericsson's new radio is 51% lighter, and its compact design and improved energy management features will help to optimize site footprints, making 5G rollouts and 4G upgrades faster and easier. By April 2022, 1,500 of the radios will be deployed across Vodafone's network, helping to reduce the company's energy consumption forecast for its future 5G network and support a sustainable and responsible 5G rollout.

Andrea Dona, chief network officer, Vodafone UK, says, "Our strategy is simple: turn off anything we don't need, replace legacy equipment with up-to-date alternatives, and use the most energy-efficient options available. The success of this trial allows us to explore new ways we can more effectively manage the energy consumption of our network with our partner Ericsson. There is no silver bullet to manage our network energy consumption—it is about putting sustainability at the heart of every decision and adding up all the small gains to make a material difference."

5G Stand-Alone Core on Amazon Web Services

On 21 June 2021, Nokia announced that it will deploy its 5G stand-alone core for DISH, a satellite TV company, on Amazon Web Services (AWS). While DISH previously announced agreements with both companies, this news marks the world's first deployment of 5G in the public cloud, supporting DISH's cloud-native, open RAN-based 5G network with high-level scale, performance, and security. The company was expected to launch its 5G open RAN in Las Vegas, Nevada, in fall 2021, and a 5G stand-alone core is a critical component for such a deployment.

Nokia's choice of a 5G stand-alone core on AWS aims at enabling the automation required to meet evolving customer needs, helping DISH to support new enterprise and consumer 5G use cases quickly, securely, and across multiple cloud stacks at end premises. Nokia's 5G stand-alone core on AWS enables DISH to offer the responsiveness, flexibility, and efficiency needed to create innovative services while leveraging automation for ongoing operations and unlocking crucial capabilities, such as network slicing.

Nokia is providing voice core, cloud packet core, subscriber data management, device management, and NetGuard network security as well as professional end-to-end security services for DISH. These provide DISH the speed, flexibility, and intelligence to deliver 5G era services while cost effectively managing its network with near-zero-touch automation and adherence to service level agreements compliant with DISH's service-based architecture.

Gigabit 5G Airport in China

On 27 June 2021, China Mobile Chengdu reported the activation of Huawei's 5G distributed massive MIMO at Chengdu Tianfu International Airport to build the first Gigabit 5G airport in China. The field tests showed that the user-perceived rate across check-in areas exceeded 1 Gb/s, with the single-user rate increasing by 26%, on average, over common 5G networks, up to a peak of 1.25 Gb/s. Significant improvement was also displayed in the perceived rate and overall network capacity in multiuser scenarios. This high level of network performance will provide a solid foundation for common passenger services and 5G smart travel applications. The upgrade to wall-to-wall gigabit speeds will help carriers fulfill demand for premium mobile access and smart travel.

Chengdu Tianfu International Airport is the second international hub in southwest China's Sichuan Province. A 4F-grade airport on the Silk Road Economic Belt, it contains two terminals covering a total floor area of 719,600 m^2 and is able to support 40 million passenger trips, 700,000 tons of cargo and mail, and 320,000 aircraft movements annually. Travelers spend a considerable amount of time in airports watching videos, chatting with friends, and reading news on mobile devices, making wall-to-wall, high-speed mobile access a core requirement. Major airlines are also launching 5G-based smart travel services, such as VIP recognition, luggage tracking, and augmented reality map navigation, to improve travel.

The network provides high-speed experiences for its users no matter the service scenario by using Huawei's digital, indoor small cells combined with 5G distributed massive MIMO software functions. Distributed massive MIMO is vital to support wall-to-wall 5G gigabit speeds. By incorporating outdoor 5G massive MIMO, distributed massive MIMO provides indoor networks with joint beamforming and multiuser MIMO to enhance 5G network capacity

and user results. It improves signal quality by eliminating interference between channels working on the same frequency in multicell networks to provide high speeds and quality in target 5G coverage areas.

Multiaccess Edge Computing Security

On 3 June 2021, the European Telecommunications Standards Institute (ETSI) published a white paper [2], "MEC Security: Status of Standards Support and Future Evolutions," written by several authors participating in multiaccess edge computing (MEC) and related ETSI groups. The white paper, the first initiative in this domain, aims to identify aspects of security where the nature of edge computing leaves typical industry approaches to cloud security insufficient.

Edge computing environments are, by nature, characterized by a complex multivendor, multisupplier, multistakeholder ecosystem of equipment and software. Given this level of heterogeneity, security, trust, and privacy are key topics for edge environments. The advent of edge–cloud federations and the presence of (far) edge devices, e.g., in IoT environments, requires tackling MEC security through an end-to-end approach by leveraging relevant standards.

In this scenario, talking about end-to-end MEC security involves considering impacts on elements from all stakeholders. The white paper provides an overview of ETSI MEC standards and current support for security, complemented by a description of other relevant regulations in the domain and cybersecurity stipulations that are potentially applicable to edge computing. It concludes with a general perspective on future evolutions and standard directions in MEC security.

The white paper is addressed to all ecosystem stakeholders, as the adoption of edge computing means infrastructure owners and application/content providers must guarantee a level of security to meet customer demands. Clarifications in the paper constitute a step toward the alignment of the edge ecosystem and a means to encourage the adoption of MEC technologies.

MEC Deployment in a Multioperator Environment

On 20 July 2021, the ETSI MEC ISG released group report (GR), GR MEC 0035 [3], to enable inter-MEC system deployment and MEC–cloud coordination. The report was motivated by mobile network operators' interest in forming federated MEC environments and enabling information exchanges in a secure manner in the event that platforms and applications belong to different systems.

"A federated model of MEC systems enables shared usage of MEC services and applications," notes Dario Sabella, chair, ETSI MEC ISG. "However, to unlock the full potential of federated MEC environments, an effective and well-defined signaling framework among MEC system entities is needed, both at system level and host level. The GR MEC 0035 studies this framework for the first time," he adds.

GR MEC 0035 analyzes eight use cases that require intersystem coordination, including those in multimobile network operators' environments. Recommendations, evaluations, and possible technical solutions to solve key issues are included for each use case. Two use cases have recommendations to achieve vehicle-to-everything (V2X) service continuity, considering a typical MEC federation scenario of V2X services in an environment with multiple operators and equipment manufacturers. Another use case describes a location-based immersive augmented reality game, where an MEC federation can serve as a solution to limitations to providing an interactive application to users connected via different mobile operators. Additional use cases include the following:

- an application instance transfer between MEC and cloud systems
- intersystem communication involving an MEC system within a mobile operator's network
- connecting different services
- edge service availability on visited networks
- edge node sharing.

5G Innovation in Agribusiness

On 16 July 2021, Ericsson Brazil and John Deere established an agreement to research and develop technological innovation using 5G to boost agribusiness revenue. The agreement enables the companies to work together to develop solutions focused on 5G and the IoT to identify and solve issues in the sector through connectivity. Ericsson and John Deere R&D and innovation centers will apply IoT mobile ecosystem technologies, such as narrow-band IoT and Category M1 to drive solutions based on 3GPP standards.

Proofs of concept will initially be jointly developed at John Deere's Central Office for Latin America, in São Paulo, Brazil, and Center of Agriculture and Precision and Innovation, in Campinas, Brazil, where 5G equipment will be installed. The agreement includes equipping John Deere's factories with 5G devices to contribute to digital transformation and immersion in Agriculture 5.0. 5G will bring greater spectrum efficiency and lower energy consumption in comparison with 3G and 4G LTE. According to an Ericsson 5G business potential study, the agriculture sector has the potential to make US$9.6 billion by 2030, with US$1.9 billion in additional earnings enabled through 5G.

Transforming the IoT With 5 G

On 17 June 2021, Sierra Wireless announced that its EM9190 and EM9191 5G sub-6/LTE NR embedded modules completed interoperability testing with NTT Docomo on a 5G network in Japan. With the testing complete, EM9190 and EM9191 customers can deploy networking devices, computing equipment, and other connected products on NTT Docomo's high-speed 5G network

for live video streaming, video security, high-definition cloud-based video gaming, extended reality, robotics, and other next-generation IoT applications.

5G's higher data speeds, lower latency, and greater device capacity are set to transform the IoT market, enabling original equipment manufacturers and advanced electronics and other industrial companies to support eMBB, ultrareliable, low-latency communication, and massive machine-type communication use cases that were not possible before. The technology's ability to support these applications is why, in a recent report, McKinsey & Company stated, "As new use cases gain traction, it is expected that B2B 5G IoT unit sales will soar. … In the B2B sphere, we expect total revenue for 5G IoT modules to increase from about USD 180 million in 2022 to almost USD 10 billion by 2030."

Based on the standard M.2 form factor, the EM9190 and EM9191 modules are industrial-grade units that enable equipment makers, system integrators, and other companies to easily integrate secure 5G connectivity into their products. The EM9190 and EM9191 include an embedded subscriber identity module (eSIM) based on the Global System for Mobile Communications specification, the embedded universal integrated circuit card. This eSIM makes it easier for customers to switch networks anytime, using carrier-specific profiles for added IoT product deployment simplicity and flexibility.

Part of Sierra Wireless's EM Series of modules, the EM9190 and EM9191 have been designed to connect to 5G networks around the world and are currently being evaluated for certification by operators in Europe, North America, and other global regions. Equipment manufacturers and other IoT market leaders, including Allied Telesis, Dynabook, LiveU, NEC Personal Computers, and Panasonic, are among the companies that plan to use the EM9190, EM9191, and other EM Series modules to provide 5G connectivity for their products.

Intel and Airtel Collaborate to Accelerate 5G in India

As announced on 21 July 2021, Intel and Bharti Airtel, a communication service provider in India, will collaborate to drive network development of 4G and 5G vRAN and open RAN technology to transform Airtel's networks. The companies will work to evolve communications networks from fixed-function equipment to virtualized cloud-native deployments and enable edge-to-cloud communications. Airtel's network will be powered by a collection of Intel technology: the latest Xeon scalable processors, field-programmable gate arrays and enhanced application-specific integrated circuits, the Ethernet 800 Series, and a FlexRAN reference architecture. Transforming its network to meet the growing needs of its more than 345 million subscribers with flexible, software-defined infrastructure will enable Airtel to rapidly respond to varying customer requirements for bandwidth and latency. By providing the foundation for wide-scale eMBB, mobile edge computing, and network slicing, Airtel could offer new services for consumers while programming its network to yield long-term cost optimizations.

Led by affordable smartphones and the lowest data tariffs globally, India has the world's second-largest Internet population, at more than 620 million. The country's active Internet user base is expected to grow to 900 million by 2025. The advent of 5G will further deepen digital adoption through a range of industrial and customer use cases. Airtel is the first telecom operator in India to demonstrate 5G on a live network and is conducting trials in major cities.

Communication Across a Boundless Forest in New Zealand

On 15 July 2021, Motorola Solutions reported the deployment of a digital radio system to help New Zealand's City Forests work more safely and efficiently while complying with COVID-19 restrictions. Initially deployed to replace an outdated analog radio network, the system delivers additional benefits. Among them are contact-free communication and social distancing in the field, eliminating the need for drivers to exchange paper dockets.

The project incorporates MOTOTRBO SLR5500 digital two-way radio repeaters across four sites, with TRBOnet radio dispatch software providing data and safety features, helping to locate workers wherever they are in the forest. The system also provides a touch-free method for workers to exchange essential job details, including truck numbers, log quantities, and crew ID numbers. These functions are integrated and connected to a digital network radio core provided by the Orion Network.

City Forests manages more than 23,730 hectares of forest in the Otago region, growing more than 7 million trees while maintaining high standards and certifications for sustainability. Ensuring safety and security for workers and recreational users throughout such an expansive area requires instant, dependable, and secure communication. Forest Production Manager Guy Bonner said his organization has experienced many benefits by migrating to an advanced digital communication system: "Upgrading our network to digital not only enabled clearer voice communication but provided us with other useful features like text messaging and GPS capability."

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