SUCCESSFULLY MONETIZING 5G REQUIRES A RAN THAT EFFICIENTLY SCALES UP CAPACITY

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Introduction

Since initial rollouts, 5G coverage is scaling quickly, with mobile network operators commonly deploying 5G non-standalone (NSA) architectures to start. As a next step, mobile operators are evaluating how to optimally scale 5G networks given the further expected growth in 5G subscriptions and broader 5G adoption by enterprise verticals over the next decade.

From a use case perspective, 5G will unlock opportunities in both the consumer and enterprise domains spanning AR/VR, cloud gaming, and a wide range of enterprise and industrial IoT applications respectively. These services will drive exponential growth in mobile network traffic. As such, operators will require a mobile network capable of addressing a wide cross-section of high-capacity, low-latency, ultra-dense, and/or bandwidth-intensive applications. Indeed, while 5G revenue is at hand, ensuring the radio access network (RAN) can support a mix of both new and legacy use cases for the foreseeable future remains a strategic business priority.

From an infrastructure perspective, this implies the deployment of 5G on many more cells across a broader range of frequencies spanning low-, mid-, or high-band spectrum. At the same time, mobile operators are evaluating how the 5G RAN can be used not only as a service enabler, but as a way to embed efficiency into the network to deliver savings over the coming years. This could include adoption of new architectures such as virtualized RAN/cloud RAN and single RAN, and the transition to standalone (SA) 5G architectures and approaches such as O-RAN. With all these considerations in mind, and the likelihood that mobile operators will pursue multiple approaches, the challenge then becomes how to implement the 5G network evolution optimally and efficiently.

Further, in many regions, there is a clear choice to sunset legacy networks (in many cases close 3G) and focus on LTE and 5G, while in other regions, 3G and especially 2G will provide network coverage for some time. For many mobile operators, the ability to support a range of services from a common or single RAN platform (e.g., multi-RAT) will be a necessity; this will also apply in cases where there is interest to deploy a 5G-ready RAN for instant 5G service launch when ready.

In this paper, we discuss how radio and baseband innovations are at the fore of addressing today’s challenges. The 5G RAN (radio and baseband) needs to evolve to become a strategic tool to address both the technology- and service-related challenges from 5G rollouts, including:
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- Ability to reuse existing cell site infrastructure to reduce the impact on cell site footprint, and ability to modernize when needed
- Improvements in operational efficiency to reduce TCO during implementation and over the lifetime of the RAN
- Ability to construct a modular, scalable RAN, able to support 2G/3G/LTE and 5G today, alongside an evolving 5G over time
- Ability to scale to support capacity needs to ensure the RAN does not become a bottleneck when introducing 5G services

Overall, mobile operators are entering a new era whereby the ability to efficiently address a broad set of use cases delivered through a dedicated offering, or a mix of 2G/3G/LTE and 5G, will play a fundamental role in success over the coming years. As such, mobile operators will require requisite RAN (radio and baseband) innovation to efficiently address potential opportunities.

Mobile Operators Face Challenges on the Road to 5G Success

- Mobile operator revenue growth has slowed over the past couple of years, making investment decisions more challenging. In general, mobile operators have struggled to sustain ARPU over the past few years, even while network demands continue to rise. As such, investing in network upgrades becomes more challenging, as some mobile operators are focused on finding ways to improve profitability, while limiting spending more for network upgrades. However, to deliver immersive 5G services that enable mobile operators to drive ARPU gains, network investment is required. This makes the need for efficient RAN capacity scaling more relevant than ever.

- Cell site footprints are increasingly saturated. Many macro cells and small cell clusters are relatively saturated, limiting options when deciding how to deploy 5G radios and baseband solutions. For mobile operators to succeed, they will need to get creative with leasing negotiations, or be aided by the vendor community, which is designing radios and baseband with these considerations in mind.

- Uncertainty about 5G use cases remains. As of 2021, 5G remains largely in the consumer phase, whereby mobile operators are mainly focused on eMBB use cases. As such, enterprise use cases have yet to grow momentum, although progress is being made in areas such as automotive, mining, manufacturing, and transportation. However, until more 5G use cases emerge, mobile operators might be hesitant about upgrading their network infrastructure. These uncertainties underscore the need for modular scalability, enabling mobile operators to tailor network investments at the right time, without precluding the ability to upgrade capacity as needed.

How Mobile Operators Can Benefit from Innovation in Radio, Baseband Domains

When discussing the RAN within its requisite elements, including the radio and baseband functions, innovation will be required across both areas. Reducing risk, lowering TCO,
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accelerating rollout, and ensuring demonstrable ROI remain key markers for success. When considering the radio exclusively, it is best to evaluate the ability of the radio to address requirements across three key dimensions, including 1) completeness, 2) efficiency, and 3) operational performance.

1) **Completeness:** Adopting Innovative Radio Designs Will Position Mobile Operators to Address a Broader Set of Use Cases

The radio remains an integral part of the network value chain, ensuring mobile operators can meet the network demands of today, while ensuring support for tomorrow’s use cases. With 5G using a much wider range of spectrum bands for cellular services (e.g., mid- and high-band) as well as the continued use of sub-3GHz bands, the radio becomes even more important considering the broad cross-section of use cases it will need to support. As part of completeness, the radio should address all needs, including spectrum and deployment considerations.

- **Different locations will have unique needs and require distinct physical and practical solutions.** Mobile operators are deploying 5G across ultra-dense, urban, suburban, and rural areas to supplement or upgrade existing services. For example, some sites may be better served deploying massive MIMO (mMIMO) to support 5G use cases, while other sites will continue to run on more traditional radio products. Whatever the scenario, radio vendors should be capable of offering the full breadth of solutions to help support the differing needs from operators across their network footprints.

- **Various cell sites will leverage different spectrums, sometimes simultaneously.** While 2G-LTE services are generally offered on lower-band spectrum (e.g., sub-2.5GHz), 5G introduces the common use of mid-band (e.g., 2GHz–4GHz) and even high-band or mmWave (e.g., higher than 24GHz) bands with wide bandwidths to support new use cases and enhanced performance. As such, the radio portfolio needs to support multiple bands and concurrent radio technologies.

- **The ability to flexibly evolve the network as demand evolves over time.** While service evolution is expected over time, many 5G use cases remain in development. As such, it makes sense to deploy radios that provide what you need today and that can adapt to what is needed over time. For example, as a more diverse set of end devices go online, the radio will be a key enabler of new use cases requiring more throughput.

2) **Efficiency:** Leveraging Radio Innovation to Overcome Site Challenges, Lower Opex, and Improve TCO

While 5G use cases will require mobile operators to deliver heightened network performance, it has become clear that they also feel it is equally important for 5G radio to help improve TCO. As such, smaller form factors, lighter weights, and advanced modularity along with digital front-end and RF power amplifier technology will all play a role in delivering efficiency both during and after the deployment phase. Considering the expected challenge of deploying radios on existing sites, as well as new sites, these features will also play a role in easing deployment.
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- **Compact form factors can help address site considerations.** Smaller form factor radios can help mobile operators deploy networks that are less noticeable and present a lower wind load. Lighter radios can also improve ease of handling, lower the cost of installation, and mitigate the need for tower or pole strengthening and associated costs. Consequently, mobile operators can deploy networks faster, improving time to market and lowering installation costs.

- **Modularity can support both site constraints and scalability.** To overcome traditional upgrade challenges, solutions can include the use of hybrid antennas (e.g., interleaved passive active antenna), which enable mobile operators to better utilize the limited space on towers/poles and ease some of the typical deployment challenges. In practice, you integrate a multiband passive antenna supporting low-band with either an 8T8R remote radio head (RRH), 32TRX, or 64TRX mMIMO antenna for mid-band, within the same antenna unit. As such, leveraging a common platform and reduced form factor will make it easier to add capacity to already crowded sites at reduced cost compared to traditional methods.

3) **Operational Performance: Delivering Performance Gains for 5G**

While new radio design can help reduce both upfront and ongoing costs, 5G will also be about maximizing performance, particularly as mobile network traffic continues to rise.

- **Support for high-bandwidth use cases.** The use of both mid- and high-band spectrum, which drive mobile network traffic to new levels, supports the rollout of high-performance radios. For example, high-bandwidth scenarios could include radios that deliver 200MHz occupied bandwidth (OBW) within 400MHz of instantaneous bandwidth (IBW). Extended IBW enables coverage over fragmented/non-contiguous spectrum. Combined with extended OBW, a single massive MIMO antenna can serve what previously required multiple antennas.

- **Support for network sharing scenarios.** Another benefit is that extended IBW/OBW can support network sharing. Network sharing, whereby mobile operators share network resources, can reduce rollout costs and extend coverage in rural or underserved areas. In shared networks, IBW/OBW is also relevant in scenarios where non-contiguous spectrum allocations are pooled together. For example, IDC expects mobile operators in regions such as Europe and Asia/Pacific to pursue network sharing agreements at a higher volume than in the past.

- **Improved coverage.** While new spectrum opens the possibilities for new services, dependent on the frequency, coverage can be limited. For example, mid-band spectrum, and in particular mmWave spectrum radio-wave propagation, is not as good as the lower frequency bands. As such, radio innovation should reflect these concerns and strive to provide greater coverage. For example, mmWave coverage is boosted with high antenna gains and could be further assisted by combined mmWave and cm-Wave deployments.
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- **Lower site power consumption.** Leveraging software-upgradeable features, mobile operators can benefit by lowering overall site level power consumption, a key consideration to control costs associated with day-to-day operations.

*Baseband Innovation Can Also Drive Benefits*

In conjunction with the radio, baseband innovation will also play a key role in overall 5G success.

- **Common baseband platform capable of multi-RAT and 5G processing.** Cellular networks today comprise multiple radio access technologies (RATs) such as 5G-New Radio (5G-NR), LTE, 3G, and 2G. 5G networks achieve performance targets by combining the benefits from multiple spectrum bands (sub-6GHz, mmWave) with TDD and FDD schemes. A baseband platform compatible with multi-RAT, multimode, and multiband technologies is a future-proof investment to minimize the risk. Supporting multiple cell sites on a common baseband platform facilitates the addition of the processing capability required for 5G in existing carrier networks.

- **Advanced silicon to achieve high processing density with low power to reduce opex.** Wireless network data transmitted through 5G signals can be processed in computing silicon with different chip architectures, including SoC, FPGA, and general-purpose CPU. Each of these architectures has its own differentiators that empower it to play a role in the evolving RAN systems, which are designed for various implementation scenarios. Custom-designed network SoC can be tailored for wireless communication to achieve the optimal processing capacity to power consumption ratio with competitive die size. FPGA is adaptable to changes in industry standards at the cost of paying extra for its high programmability feature. Virtualized baseband processing in general-purpose cloud servers works well in aggregated cloud computing platforms, where effective integration density, power management and consumption need to be evaluated together for overall network deployment consideration. Each type of chip will need to be built on advanced semiconductor technologies to meet the performance requirements for 5G while maintaining or lowering the electricity consumption compared with the previous generation.

- **Scalable and expandable RAN system to grow with workload and subscribers.** 5G network proliferation will gather its momentum from various usage types such as consumer mobile communication, fixed wireless access (FWA), and private cellular network. A modular RAN system can be configured to serve FWA broadband customers or to upgrade mobile networks to 5G. When subscribers and data traffic grow, system capacity can be scaled up by adding plug-and-play hardware to handle extra L1/L2 and L3/transport network processing.

- **Wireless communication infrastructure architected to incubate technologies for the next-generation 6G network.** To propel 5G performance, AI-enabled hardware and techniques will soon accelerate functions such as RF spectrum monitoring and massive MIMO beam pattern optimization. Although the 6G network has not started standards definition, it is believed that precursor technologies employing AI/ML will come from 5G.
The United Nations' ITU-T has established a Focus Group on Technologies for Network 2030 (FG NET-2030) to answer specific questions on what enabling mechanisms and network architectures are suitable for the year 2030 and beyond. Networking improvement subjects like reducing transport backhaul protocol overhead, self-governing independent network systems, and new trust-building models will be valuable to shape up generations of technologies.

**Considering Nokia's AirScale Portfolio for 5G**

Nokia is a global leader in 5G network enablement, with hundreds of commercial 5G agreements around the world. Its flagship AirScale RAN portfolio, including its most recent portfolio additions, place it firmly in the discussion when considering both today's and tomorrow's 5G network needs.

**AirScale Radios**

- **Completeness of portfolio.** Nokia's AirScale radio portfolio includes numerous RRHs and mMIMO antenna solutions designed for low-, mid-, and high-band operations. In conjunction with its baseband, AirScale can also support legacy mobile generations, making it an ideal fit for mobile operators that want to sustain 2G/3G and LTE services as needed. Further, for mobile operators that want to upgrade existing RAN solutions (e.g., 2G-LTE) in conjunction with 5G, AirScale's ability to simultaneously support 2G-5G can deliver end-to-end RAN modernization while improving TCO.

- **Modularity at scale.** Leveraging a modular approach, AirScale radios and massive MIMO antennas can be deployed standalone or integrated into a hybrid interleaved passive active antenna, which features a multiband passive antenna to enable a wide-band multi-RAT configuration. As such, AirScale protects the initial investment, enabling in-field upgrades that will likely be needed in line with traffic growth.

- **ReefShark SoCs for performance and properties.** Nokia's newest RAN products are powered by the company's latest ReefShark SoC technology, providing a boost in both performance and physical characteristics. Further, the AirScale 32TRX mMIMO product weighs roughly 17kg, making it the lightest product in its category on the market. When considering rollouts, lighter radios can translate into faster rollouts, less impact on existing site civils, and less reliance on costly machinery to install.

- **AirScale performance aligns with 5G's unique needs.** AirScale mMIMO antennas support 200MHz OBW and 400MHz IBW, making them ideal products for use when deploying across fragmented spectrum or in instances where network sharing is under consideration. Finally, AirScale mid-band mMIMO antennas can support up to 320W RF output power, delivering enhanced coverage and cell-edge performance. AirScale RRHs deliver up to 480W RF power output, particularly if there is a need to enhance lower-band services.
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**AirScale Baseband**

- **Scalable with plug-in cards and software upgradable to full 5G (multi-RAT) functionality.** By installing additional plug-in cards, the base station can scale up throughput in pace with data traffic demand. Each AirScale baseband module can deliver up to 84Gbps with the latest ReefShark SoC to fulfill the growing 5G processing density in megacities. To cover all deployment scenarios, a native outdoor compact baseband unit is also available.

- **AirScale baseband module powered by the new ReefShark SoC custom designed to meet 5G processing requirements.** Nokia’s latest in-house ReefShark SoC meets the massive 5G compute requirements and reduces the power consumption cost of operators’ networks. It enables the modular plug-in card to have 8x more capacity with up to 75% lower power consumption compared to the previous generation. Nokia’s modular baseband design facilitates the latest plug-in unit technology to be added inside the already installed AirScale baseband. The new generation of common and capacity plug-in cards of different performance levels for the AirScale System Module can scale baseband L1/L2 and L3/transport individually according to deployment needs.

- **Single RAN and common backhaul to simplify the complex macro radio network.** A multipurpose hardware platform reduces network complexity by implementing multiple generations of RAN technologies in the software layer to determine hardware functionality. Nokia’s AirScale baseband can deploy 5G alongside existing LTE, 3G, and 2G layers, and supports general-purpose fronthaul interfaces through OBSAI, CPRI, and eCPRI to connect to radio units. To serve the 5G era from the beginning, its IP-based backhaul has high bandwidth to handle the transition from mixed generations in the early 2020s to majority 5G in the long term.

- **Prepared for future AI/ML-enabled network optimizations and edge cloud use cases.** Through the plug-in card based on ReefShark silicon with AI capabilities embedded, the AirScale baseband also enables integration of new features such as AI/ML optimization for real-time radio monitoring. Additionally, the AirFrame Open Edge server accompanies Nokia baseband solutions to fit any network deployment needs. The Open Edge server can run virtualized RAN (vRAN), edge cloud core network functions, generic edge compute workloads, the Nokia Service Enablement Platform (SEP) for Multi-Access Edge Compute (MEC), and O-RAN Radio Intelligent Controller (RIC) deployments. These connected network assets can be optimized together for high performance and to streamline operations.

**Conclusion**

For mobile operators to efficiently unlock 5G monetization, thoroughly planning network rollouts remains a key consideration. This paper has covered the reasons why 5G RAN solutions can and should be viewed as more than simply a network upgrade, but as a long-term strategic choice, particularly to enhance network performance and improve underlying capacity. Further, mobile
operators can potentially unlock new revenue while supporting existing services, limit capex, and deliver TCO gains over the lifetime of the RAN solution.

As noted, 5G RAN requirements include a host of new capabilities, all designed to ensure 5G RAN investments unlock the most value out of monetization, and operational efficiencies.

- **Single RAN (multi-RAT) leveraging SoCs is an optimal approach in the 5G era.** The multi-RAT demands on mobile networks will persist for several years. While some regions will sunset 2G/3G to free up spectrum and save costs, some regions will require legacy solutions for some time. Further, LTE will have a long-tail that lasts for the duration of the 2020s and will be deployed alongside 5G as a standard.

- Additionally, SoCs, which provide improved performance, have emerged as the de facto approach in enabling 5G RAN solutions.

- **Modular baseband is crucial to maximize ROI and minimize opex.** Baseband units can scale up throughput capacity in pace with data traffic demands by leveraging plug-in cards. As such, one baseband module can support hundreds of cell sites at once, if needed. Infrastructure capex is driven by demand gradually, and low opex is achieved by operating well-planned infrastructure.

- **Optimized radio units are a necessity.** Considering installation, radio units are typically the costliest units to install. To improve this, both form factor and weight can be limited, enabling ease of installation, faster time to market, and overall, less power consumption.

To be successful in the 5G era, RAN equipment selection and network planning remains a top initiative. This means considering a supplier with a proven portfolio that can deliver the innovation needed to bring a wide cross-section of 5G services to market more quickly. IDC believes that the RAN will remain a leading enabler in the 5G era and that Nokia's portfolio and vision position it to play a leading role as the market unfolds.
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