A STRATEGIC GUIDE TO 5G ROAMING:

MNO OUTLOOK 2022

A KALEIDO INTELLIGENCE WHITE PAPER

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Contents

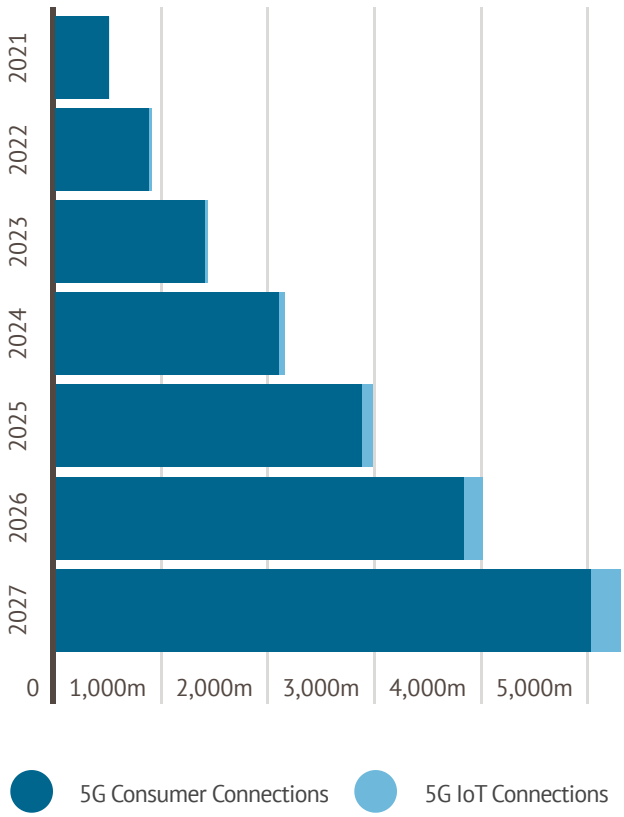
5G Roaming: Market Introduction

5G Global Market Status

The first 5G networks were introduced in early-2019, and nearly all smartphone vendors around the world are now offering mid-range and premium 5G devices. These services have been predominantly using NSA (non-standalone) architecture, with only a small number of operators having launched commercial 5G SA (standalone) mobile networks. Over the previous 24 months, mobile operators worldwide have accelerated their 5G strategies in terms of strategic planning, testing, and expanding rollouts.

By the end of Q3 2022, over 500 operators in 153 countries/territories will have invested in 5G networks in the form of tests, pilots, license acquisitions, and planned as well as executed deployments. Around 225 operators in 90 countries/territories have already launched commercial mobile 5G services, up from 61 commercial networks in 2019, and 140 commercial networks in 2020. Meanwhile, 120 operators are investing in public 5G SA networks; with more than 35 operators in 20+ country markets having launched domestic 5G SA networks (with an additional 20 operators preparing for further launches in Q4 2022-23).

5G Consumer & IoT Connections in Millions, 2022-2027



Source: Kaleido Intelligence, H1 2022 Connectivity Data Hub

Consumer adoption of 5G services will drive the total number of 5G connections to reach 5.3 billion in 2027. This is up from just over 500 million in 2021, an average annual growth of nearly 50% over the 6 year period. 5G consumer adoption is predicted to be significantly faster than for 4G and expected to represent 95% of the global 5G connections over the next 5 years.

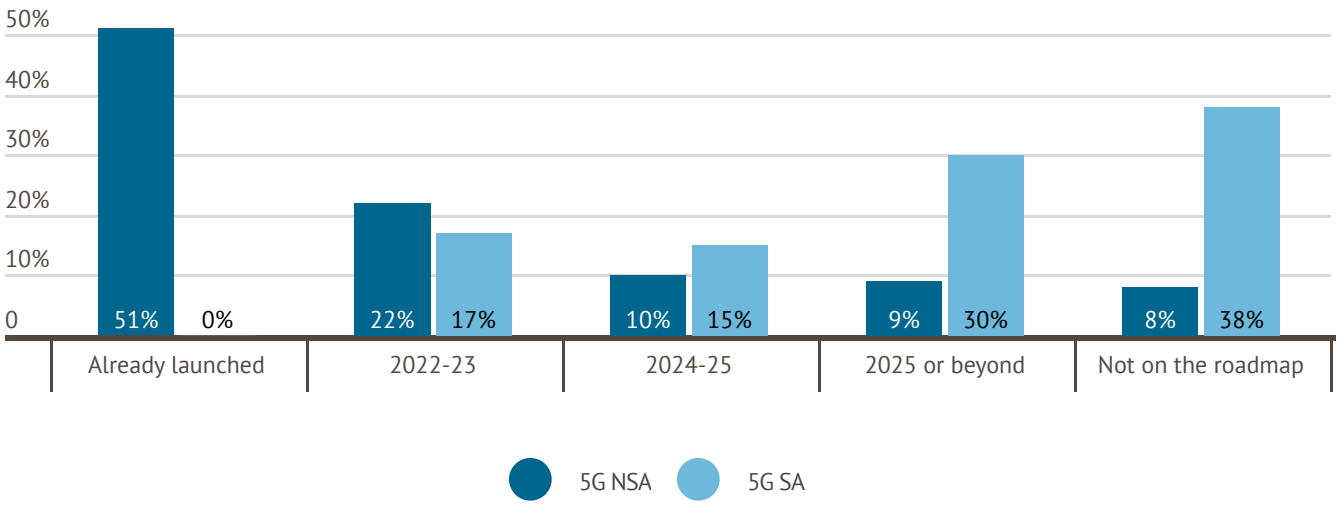
5G IoT is still at a nascent stage, due to a combination of lower hardware availability compared with other 3GPP technologies, the higher cost of hardware, and the continued lack of high-volume use cases that demand the bandwidth, connection density support or low-latency support that 5G connectivity offers.

5G Roaming Global Availability & MNO Readiness

5G roaming represents a significant opportunity for mobile operators and enables new use cases and enriched data services. However, international carriers will need to ensure that they are capable of providing sufficient bandwidth to address anticipated surges in roaming data usage from both consumers and IoT applications. There are additional challenges in the form of 5G SA roaming use cases involving ultra-reliable low- latency communication (uRLLC), such as autonomous driving and industrial IoT, and massive machine-type-communications (mMTC). While these use cases are supported by the 5G New Radio (NR) standard under 3GPP (3rd Generation Partnership Project) Release 15, developments to the standard are continuing.

5G roaming on NSA mode is available in over 50 country markets; however, from a SA perspective, operators are currently testing and trialling the same. According to Kaleido's 5G & VoLTE Roaming survey conducted in 2022, around 32% of mobile operators expect to launch 5G SA roaming by the end of 2024. In comparison, most operators will continue to deploy 5G NSA roaming: over 80% of mobile operators expect to have 5G NSA roaming services enabled by the end of 2025.

5G SA & NSA Roaming Launch Plans: When do you plan to launch 5G roaming?



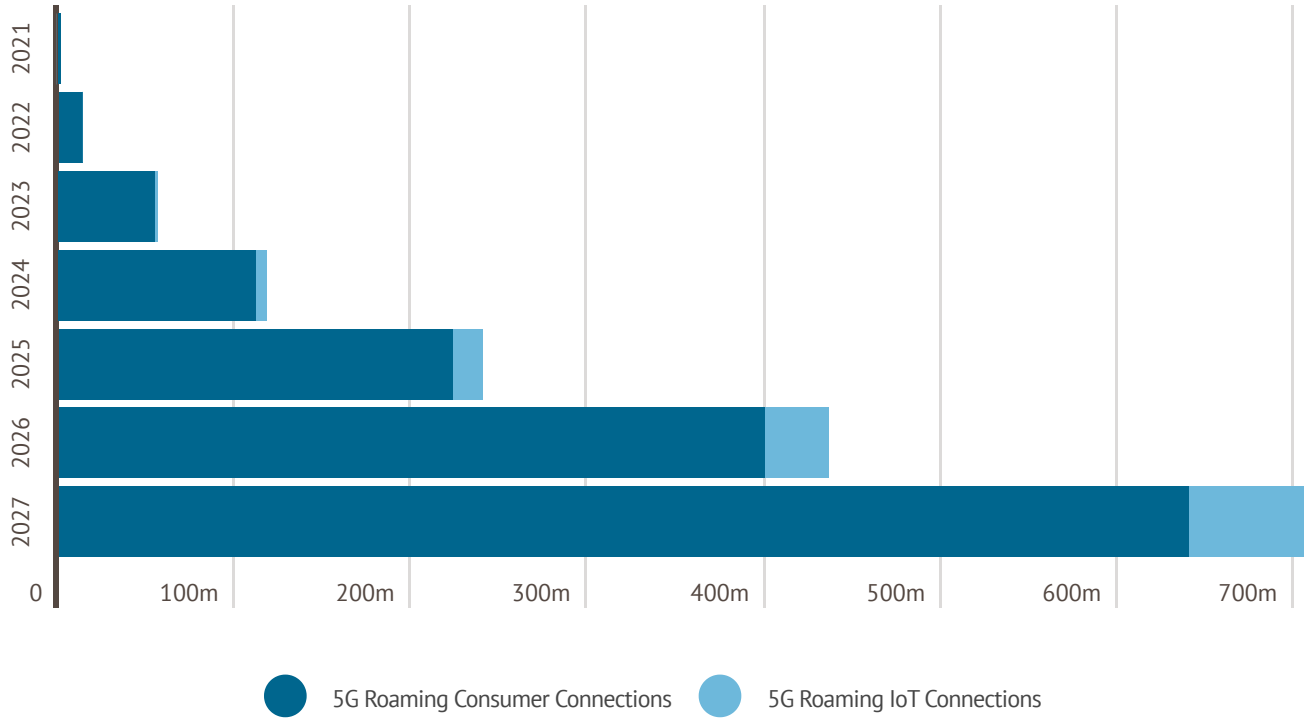
Source: Kaleido Intelligence, MNO Survey Q2 2022

There is a growing gap between operators of varying sizes, in terms of 5G investment and technology roadmap, as there is a greater focus amongst tier-1 operators on the domestic roll-out of 5G NSA and SA network deployment. Smaller operators continue to witness a shift in timescales on 5G NSA rollout in their roadmap, due to changing priorities following the impact of the pandemic. Despite launching or having 5G SA domestic rollout plans amongst numerous operators, 5G SA roaming continues to face standardisation and implementation challenges. Indeed, amongst these operators, 5G NSA is witnessing a greater uptake, with the primary focus being on providing roamers with a better user experience while roaming similar to domestic 5G services.

5G Roaming Outlook: Consumer & IoT Adoption

Kaleido forecasts that the number of 5G roamers will reach 640 million in 2027, representing an average annual growth rate of nearly 114% over the next 5 years. Given the increasing number of 5G NSA roaming agreements in place and adoption amongst active roamers as a percentage of global travel volume, Kaleido estimates 5G roaming adoption to reach nearly 15 million in 2022, representing just under 5% of total active roamers. By 2027, this will reach 61% of active roamers.

5G Roaming Connections Forecast, Consumer & IoT Services 2021-2027



Source: Kaleido Intelligence, H1 2022 Roaming Data Hub

In the short-term, it is highly likely that 5G IoT/M2M roaming will remain in a nascent stage of development. Operators are unlikely to invest into 5G core network upgrades until they either see a critical mass of devices demanding full 5G services, or they start competing nationally to make investments (and, in turn, compelling others to invest).

Kaleido estimates that some 65 million M2M connections will be roaming over 5G networks in 2027, representing nearly 25% of total 5G cellular IoT connections (excludes LTE-M and NB-IoT). The vast bulk of these connections will be within the automotive, security and industrial sectors, where high bandwidth applications benefit from 5G, and can safely be monetised by supporting operators.

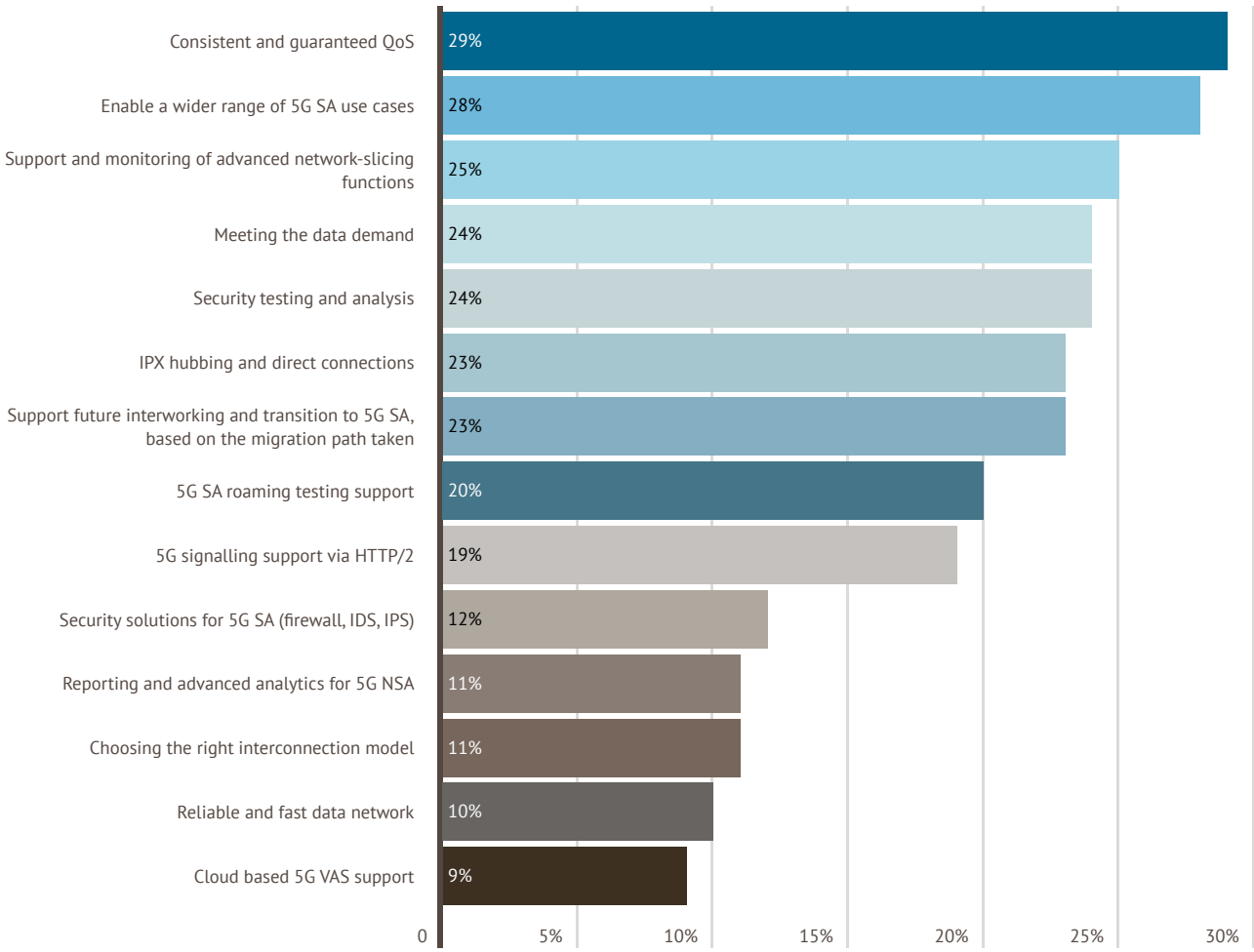
Preparing for a 5G Roaming Future

Addressing Key Requirements to Launch

With travel recovery beginning to peak and enterprises accelerating their IoT strategies, operators must now use 5G to address the surge in international network usage, as well as new roaming use cases. The immediate hurdles of the 5G migration are the investment in a 5G core, increasing IPX capacity, and enhancing the roaming experience and value-added services deployment scenario.

Consistent and guaranteed QoS for premium experiences was the number 1 expectation of 5G roaming for operators (Source: Kaleido Intelligence, MNO Survey, Q1 2022). Implementing and guaranteeing QoS is consistently observed to be a challenge by most operators, a complex criterion that's largely absent from roaming agreements or deployments. Meanwhile, enabling a wider range of 5G SA use cases while roaming, and the management of advanced network slicing functions, were also part of the top 3 expectations while deploying 5G NSA and SA roaming by operators.

What are your top expectations while launching 5G NSA & SA roaming?



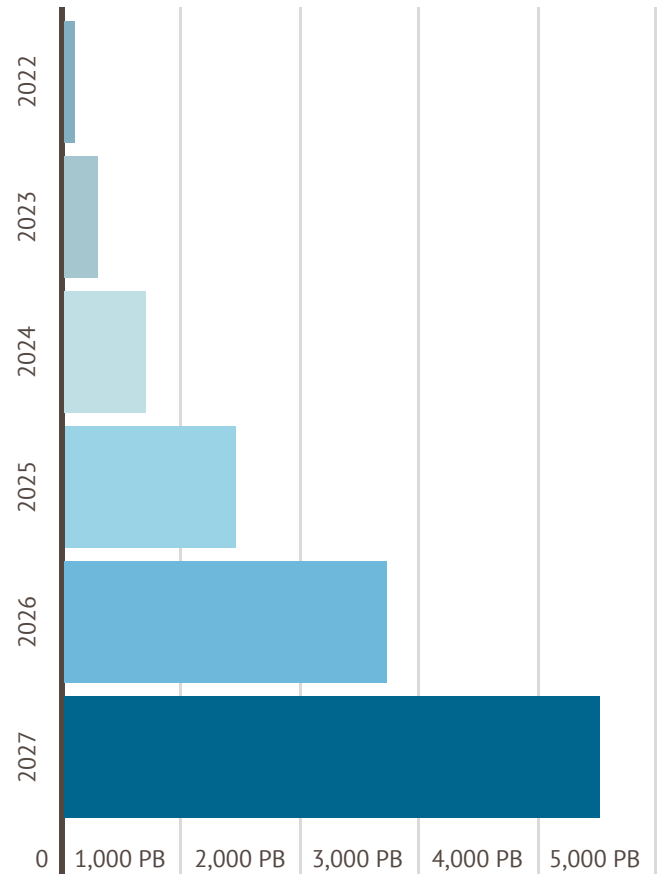
Source: Kaleido Intelligence, MNO Survey Q1 2022

5G will not only enable faster broadband while roaming, it will also facilitate an enormous volume of low-latency IoT connections and roaming use cases that require real-time connectivity, and enhanced reliability. Around 28% of participating operators found this to be amongst the top 3 MNO expectations from 5G roaming and understandably so: operators around the world are now realising IoT roaming is a viable opportunity, especially within the connectivity verticals of connected cars, transportation, industrial/manufacturing, and healthcare.

Network slicing, where a portion of the available network is sold and run as a separate entity from the rest of the network, further enabling new roaming business models, was also found to be a top expectation by 25% of the participating operators.

In addition, 5G networks represent several network improvements including a 100x increase in data rates and traffic capacity from 4G. The average consumer 5G mobile roaming usage and traffic generated are already exceeding 4G levels; and this will increase further with the deployment of 5G SA networks and roaming agreements. Kaleido forecasts that 5G roaming data traffic generated by consumers and IoT connections will exceed 4,500 Petabytes by 2027, representing around 72% of total roaming data
traffic by then..

Growth in 5G Data Roaming Traffic in Petabytes, 2022-2027



Source: Kaleido Intelligence, H1 2022 Roaming Data Hub

Operators expect IPX providers to meet this significant rise in bandwidth demand: around 24% of operators expect this level of capacity support and capabilities.

Signalling and interconnection in 5G will be based primarily on Service Communication Proxy (SCP), Binding Support Function (BSF) and Security Edge Protection Proxy (SEPP) functions.
Meanwhile, 5G SA also brings a new core network signalling protocol, HTTP/2. Operators will need to test and introduce this during the early stages of migration. These new protocols and functions will enhance the protection against any new or known inter-exchange/roaming vulnerabilities.

Nearly 20% of the participating respondents found this to be a top expectation while migrating to 5G SA.

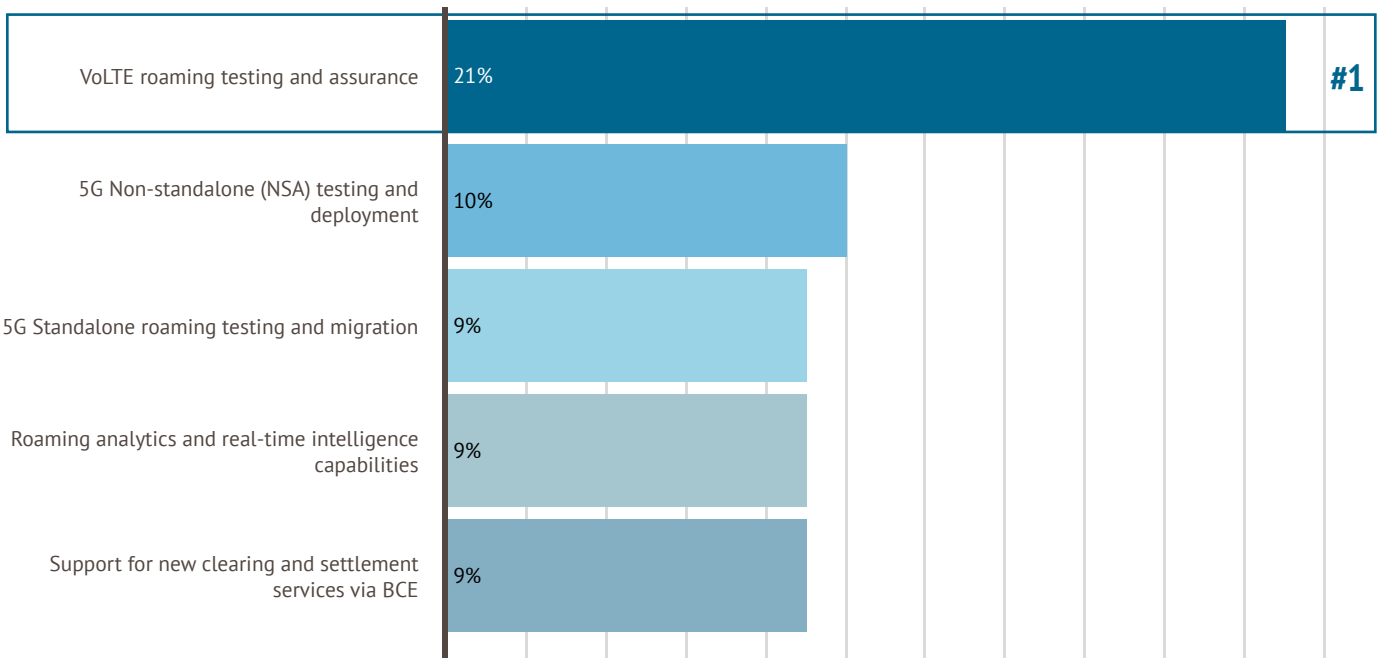
The Essentials: VoLTE Roaming Readiness

With more operators focusing on 5G rollout, and with 4G becoming mainstream, VoLTE roaming has become essential for operators worldwide. Operators will need to roll out VoLTE networks more urgently as, in a 5G standalone network scenario, only fallback to a VoLTE network is supported. According to Kaleido's 2022 annual wholesale roaming survey conducted in Q3, 21% of participating operators found VoLTE roaming testing and assurance to be the most important technical requirement from a roaming perspective for mobile operators in 2022.

The primary support that operators expect from their roaming vendor in implementing VoLTE roaming is quite understandably the testing and monitoring of IMS core and VoLTE services through virtual or real devices, to ensure that roaming service provides the same, or better experience as on legacy voice networks. Operators need to have a fully defined and functional testing strategy in place for not just VoLTE roaming, but also for fallback scenarios and interworking services. This automated testing of services must not be limited to handoffs, quality and dropped calls, but must include critical QoS factors including throughput and traffic load across multiple connections.

While VoLTE roaming struggled to be a top priority amongst mobile operators prior to 2022, this is rapidly changing with operators expected to accelerate their testing and deployment of VoLTE roaming over the next 12 months. 2022-2024 will be the years when VoLTE roaming finally takes off in almost all parts of the world: according to Kaleido's operator survey, around 79% of operators will have some form of VoLTE roaming agreements in place by the end of 2024.

What Are Your Key Roaming Requirements From A Technical Solution Perspective, Top 5?



Source: Kaleido Intelligence, MNO Survey Q3 2022

The Essentials: Implementing BCE

Traditional techniques for charging, reconciliation and settlement are simply not equipped to cope with a world where the growth in roaming traffic events is increasingly driven by devices, such as cars and industrial equipment, rather than smartphones. Those techniques, exemplified by TAP (Transferred Account Procedures) were designed to manage voice calls: unable to differentiate between devices and network technologies, meaning operators in turn are losing revenue by being unable to optimise the monetisation of IoT. Furthermore, those techniques are increasingly perceived as inefficient and labour-intensive: given the pressure on margins, there is a need to cut settlement costs, particularly resource-related, while also developing new revenue streams.

BCE (Billing and Charging Evolution) is a flexible optional settlement method, designed to address the weaknesses in TAP and specifically enable (via an automated process) the differentiation between different kinds of devices and traffic, thereby facilitating the introduction of far more tailored, nuanced billing. BCE introduces a range of automated and flexible wholesale charging and settlement models, enabling the successful expansion of operator 5G and IoT roaming footprints.

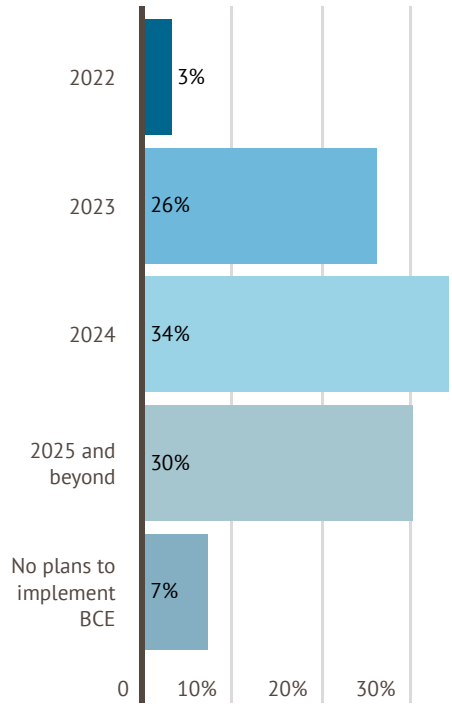
According to Kaleido's BCE MNO survey conducted in Q2 2022, monetisation of 5G roaming services was the number 1 reason for operators to migrate from TAP to BCE. BCE introduces a range of automated and flexible wholesale charging and settlement models, enabling successful expansion of operator 5G and IoT roaming footprints, rather than simply charging on a per MB and minute basis.

This approach is essential within a 5G environment: 5G's service-based architecture is designed to support converged charging and billing and to enable the definition of events and sessions which can be charged at highly granular levels.

5G offers dedicated network slices, each with its own range of characteristics tailored to the devices it serves, including quality of service, bandwidth, and latency - which in turn impact the way it can be monetised.

Billing parameters have therefore been developed to enable pricing to be determined by said characteristics. As a result, a greater charge can be billed if the quality of service and latency exceed the levels predetermined under the service level agreement (SLA).

When do you plan to launch BCE?



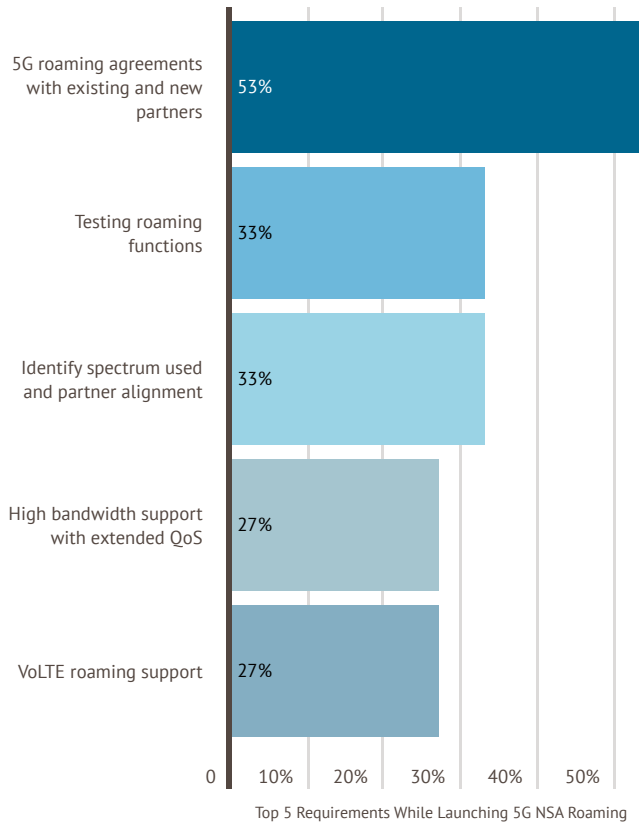
Source: Kaleido Intelligence, MNO Survey Q2 2022

The Essentials: 5G Roaming NSA & SA Requirements

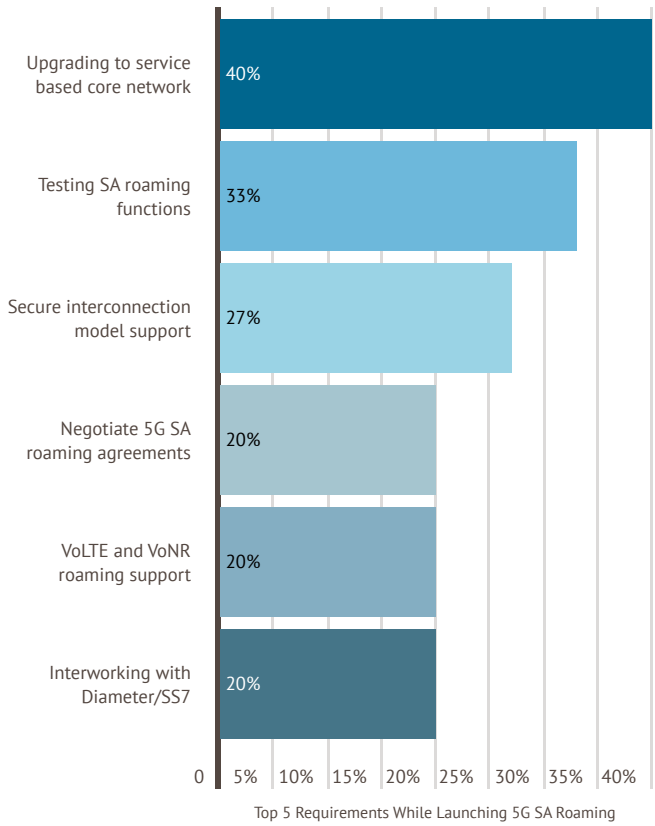
Mobile roaming data traffic is expected to rise by 525% between 2021 and 2027, driven by consumer mobile broadband users and new 5G services. This means that operators need their roaming vendors and IPX providers to give them better control over the data demand expected across a range of new consumer and IoT roaming applications. 5G roaming launched by mobile operators around the world is being introduced as 5G NSA roaming: this is an effective solution to support increasing data demands and latency requirements by leveraging existing 4G infrastructure and 5G NR. 5G NSA will continue to use the existing Diameter signalling protocol, and it is faster to deploy roaming services by mobile operators. According to the GSMA, operators can roll out 5G NSA roaming without any new roaming agreements but by signing a new LTE launch letter (BA50 v11.4 - Annex Y) and performing a new IREG test. In comparison, the launch of 5G in a SA architecture will require comprehensive testing, trials, and optimisation prior to the deployment phase in order to deliver reliable and secure interconnect services, while maintaining quality necessities.

In our 5G roaming operator survey, MNO respondents ranked launching 5G NSA roaming agreements with existing and new partners as the primary requirement, with testing roaming functions as the second most crucial requirement. Indeed, the gradual migration path towards 5G SA means that continuous testing, validation, and automation of 4G and 5G services will remain important.

What do you perceive to be the top 5 most immediate requirements while launching 5G roaming based on SA & NSA?



Source: Kaleido Intelligence, MNO Survey Q1 2022



Source: Kaleido Intelligence, MNO Survey Q1 2022

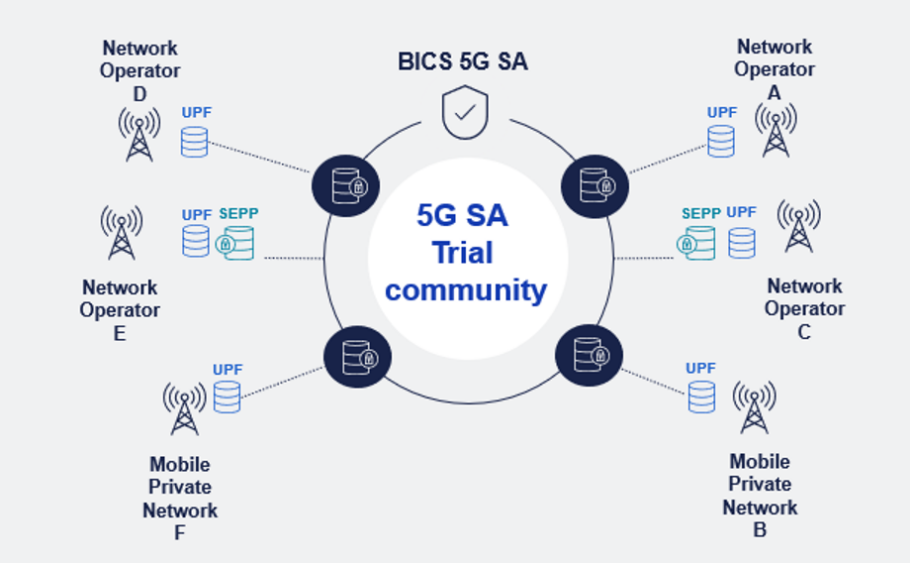
Operators will need to focus on progressing the migration from a 4G core to 5G and enable the transition from NSA to SA architecture. As operators migrate to 5G SA, they will need IPX providers to be capable of handling applications and services ranging from faster data roaming access and carrying VoLTE/Vo5G data to IoT and other M2M applications, requiring different levels of service levels, route diversity, billing models, and security.

In addition, operators will require full visibility and management of traffic on each network, with the ability to differentiate different traffic types such as IoT. Therefore, the need for reliable and superior level IPX experience, offering end-to-end service-level agreements, QoS, and improvements in key performance indicators, specifically for mMTC applications and uRLLC applications in healthcare, autonomous driving and other industrial and mission-critical applications requiring low latency has becomes extremely important.

Case Study: Enabling 5G SA Testing & The Advantages of Outsourcing

BICS is currently facilitating the first 5G Standalone (SA) roaming testing between 2 MNO customers, enabling its 5G SA roaming configuration and hosted SEPP solution to both parties. This will be an industry-first, live, and end-to-end 5G SA roaming testing -from both the signalling and the user-plane part. This showcases the value of technical outsourcing with a hosted SEPP solution, which is key to efficiently onboarding new 5G SA roaming agreements and reducing efforts on the customer side. The aim is to expand its trial community with more first movers, and share the experiences with all industry participants.

Finally, the primary objective is to bring value to the operator customers and enable them to stay ahead of the competition while addressing their customers' 5G SA roaming needs. Trials can be done between MNOs who have or do not have their own SEPP yet. Customers who do not have a roaming partner can test against BICS MVNO in Belgium.



The Essentials: 5G Network Slicing

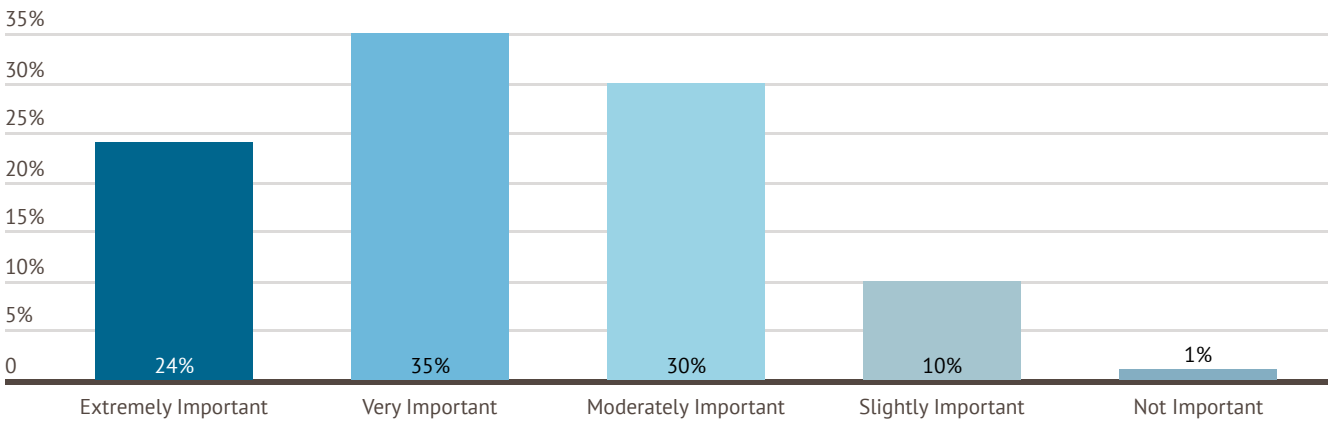
Network slicing makes use of network virtualisation in order to divide network connections into different virtual slices. Each of these individual slices then provides a different set of resources to the various types of traffic. There are different roaming scenarios by which slicing can be extended to several services and applications while roaming to ensure service continuity. These new business models based on network slicing will enable enhanced flexibility for mobile operators. According to Kaleido's survey, support and monitoring of advanced network-slicing functions is one of the top 3 most important requirements from their IPX vendors while launching 5G SA roaming services.

Meanwhile, 43% of mobile operators expect new wholesale connectivity services to drive and future-proof roaming revenues, by ensuring their roaming portfolio matches consumers' increasing bandwidth demand, as well as new 5G use cases enabled via network slicing. Significant growth can be expected after 2023 (especially from an IoT perspective) as operators offer new wholesale connectivity services tailored to meet the specific needs of applications, services, devices, customers or operators.

On the other hand, operators will need to work alongside their roaming partners and service providers on defining the various QoS parameters that will be needed to support network slicing roaming across public mobile networks. During testing, roaming service providers can act as a trusted intermediary between the network slice provider (operator) and customer (consumer and enterprises) in addressing any potential security issues, whilst managing the slice integrity and QoS commitments.

Considering the long term objectives, operators will need to be ready to focus on higher-value use cases, supporting consumer and MVNO- related consumer roaming applications to prioritise ROI on 5G network investments. The advantage of optimising slices, maintaining end-to-end integrity and management, and generating contextualised data will bring multiple possibilities for the operators to offer differentiated services across industry verticals.

Importance of Network Slicing in 5G Roaming



Source: Kaleido Intelligence, MNO Survey Q3 2022

Quantifying the 5G Roaming Opportunity

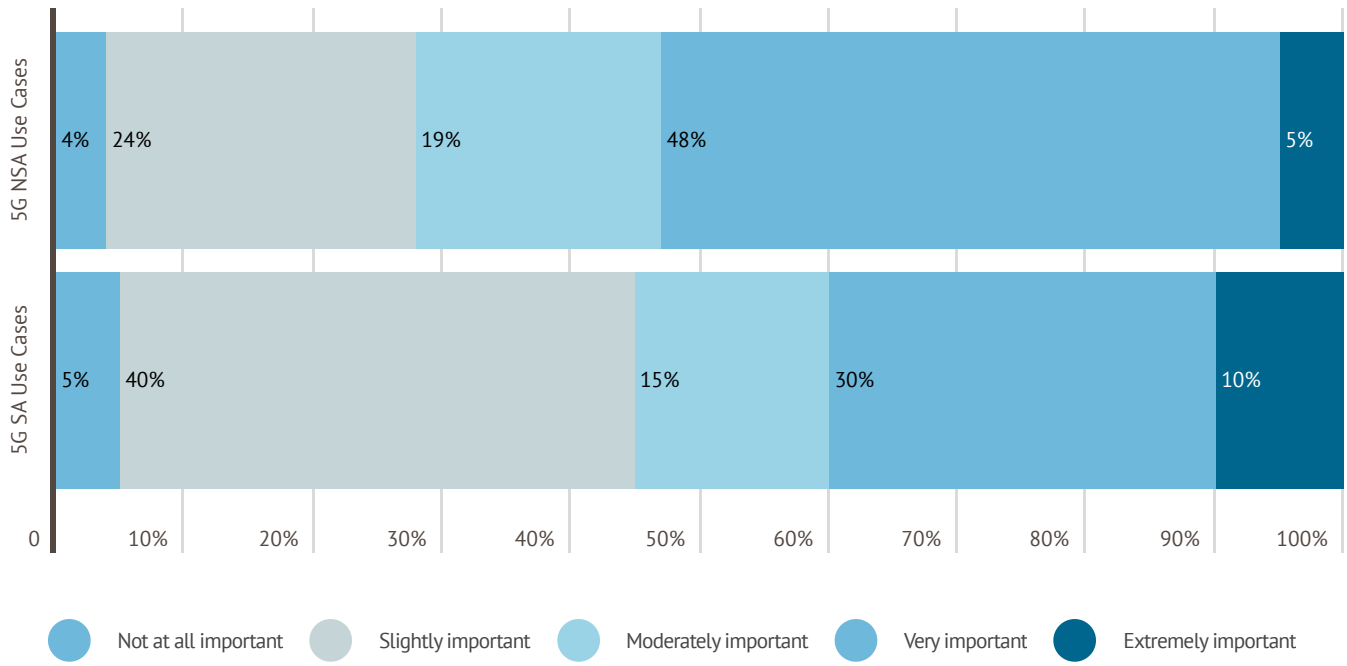
What will Drive 5G Roaming?

Roaming revenues in a post-pandemic world are expected to significantly improve, which is a good sign for the industry. Operators believe that IoT roaming and 5G roaming use cases are the two areas that will drive the most revenue over the next three years. Nearly 53% of MNO respondents participating in Kaleido's annual Wholesale Roaming survey, were of the opinion that 5G NSA roaming use cases would be a critical revenue driver over the next three years or so.

This highlights the strategic and more immediate focus for mobile operators around 5G, and the expectation to unlock new roaming revenue streams. Kaleido believes that 2022 and 2023 will see more 5G domestic and roaming rollouts - 5G NSA roaming is predicted to grow faster as operators worldwide launch lower tariffs to target the next level of the consumer base.

In comparison, around 40% of the respondents feel that 5G SA roaming use cases are an extremely or very important revenue driver for them. Surely, 5G roaming will initially aim to address faster eMBB (Enhanced Mobile Broadband) services for consumers, related to 4K-8K videos, AR/VR applications as well as HD communications. Operators will need to view regional or local breakout (RBO/LBO) for other low-latency applications and services where offloading data to the local network is recommended.

What Will Drive Roaming Revenue Over The Next 3 Years?



Source: Kaleido Intelligence, MNO Survey Q3 2022

However, additional roaming revenue generation via 5G services will depend on supporting more advanced services such as gaming, sports, VR/AR and other entertainment offerings for the consumers.

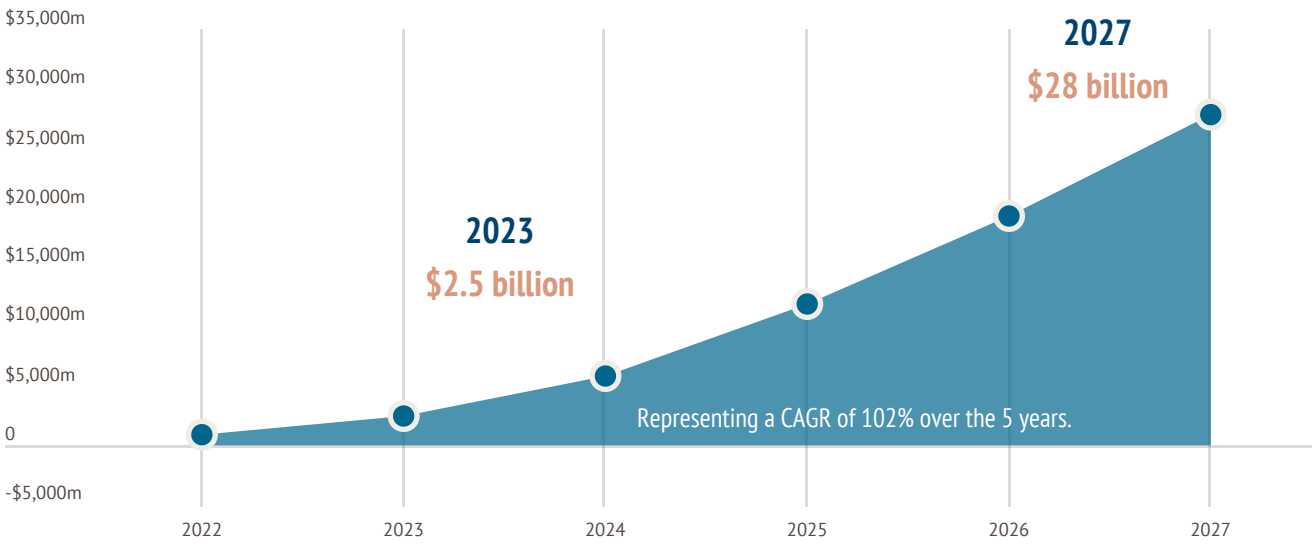
5G roaming is also about extending connections to IoT devices overseas and other mMTC and uRLLC roaming applications. As noted earlier, in terms of international uRLLC services, there is a demand for vehicle applications, industrial services and healthcare applications. Meanwhile, mobile consumer low latency services, such as VR/AR applications are still at a very early phase of adoption. In our latest 2022 5G roaming survey, there was an increase in demand amongst mobile operators for supporting VR/AR applications and services, potentially as a result of the increasing awareness and popularity of the Metaverse. Several operators are working on extending connectivity services by not just becoming the lead connectivity provider to the Metaverse, but also driving real-time computing and advanced management frameworks to unlock further growth.

5G Roaming Revenue Opportunities for 2027

Kaleido predicts that 5G roaming revenues generated by consumers and IoT connections will account for a significant proportion of the inbound and outbound roaming revenues in 2027, reaching 45% of total revenues and representing nearly $30 billion in value by then. This will represent an average annual growth of 102%, primarily driven by consumer connections and roaming traffic.

In comparison, 5G roamers will reach 61% of active roamers by 2027, accounting for 640 million in connections. While this proportion is currently low, representing less than 5% of active roamers in 2022, the volume of 5G roaming agreements in place and adoption amongst active roamers will rise over the coming years as domestic availability and consumer travel rises.

5G Inbound & Outbound Roaming Revenues from IoT & Consumer Connections in USD Millions

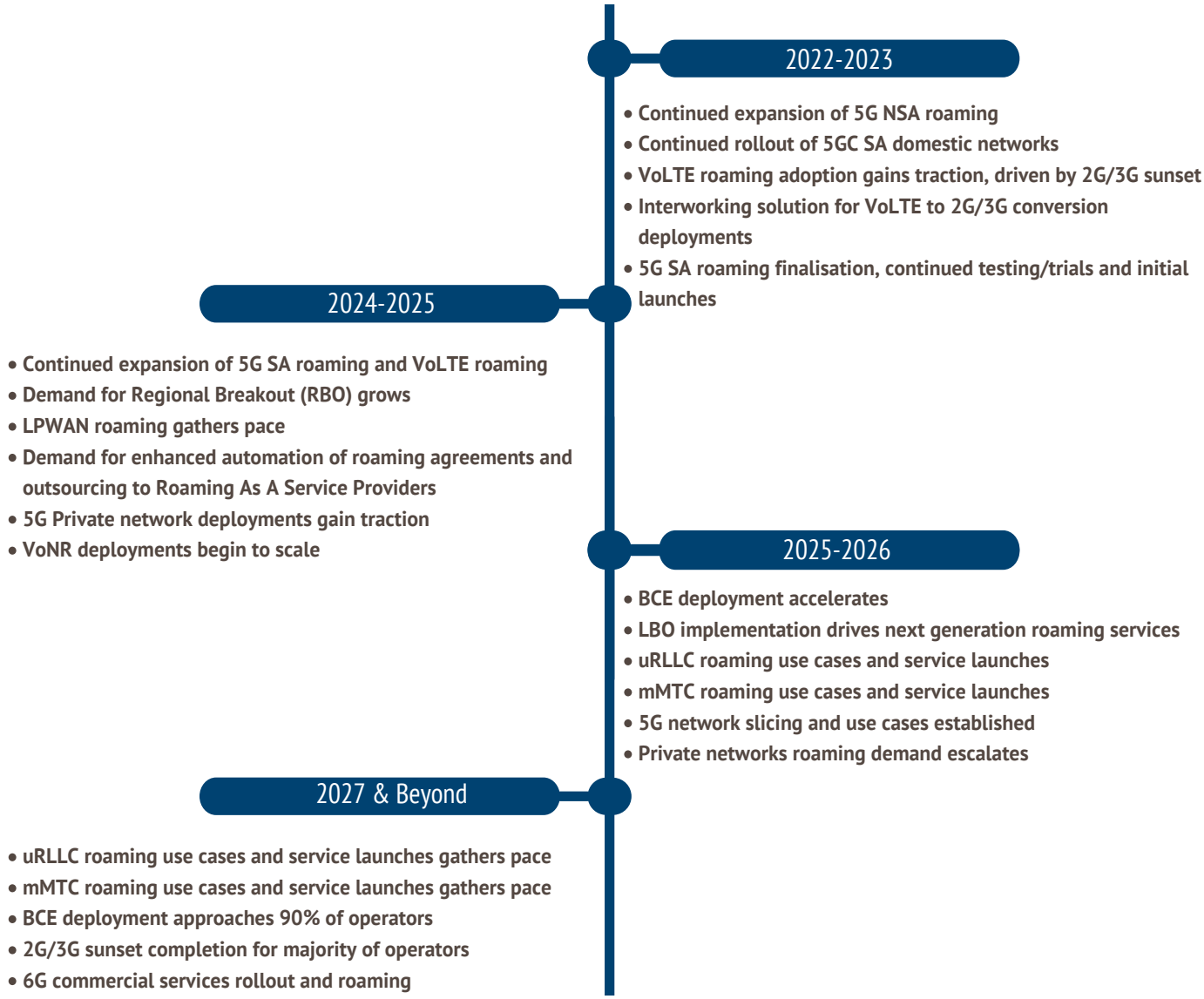


Source: Kaleido Intelligence, H1 2022 Roaming Data Hub

Conclusion: Mapping the 5G Roaming Timescales & Recommendations

It is evident that the global wholesale roaming space continues to evolve rapidly and the industry is well on track to complete a full recovery from the adverse effects of the COVID-19 pandemic. The below roadmap graphic illustrates the various milestones for 5G roaming deployment and outlines strategic recommendations for mobile operators to prioritise while planning 5G roaming implementation and migration. The rollout of 5G networks around the world will transform mobile roaming and generate additional revenue opportunities for stakeholders. Mobile network operators must continue to make significant investments in infrastructure and automation, to maximise their roaming revenues whilst preparing for future, next generation roaming services enabled by 6G and dedicated private networks.

5G Roaming & Operator Migration Strategies Roadmap



Source: Kaleido Intelligence

In 2023 and beyond, mobile operators will need to continue to focus on 5G roaming - both from an NSA and SA perspective, as domestic adoption of these technologies continues to rise alongside roamers' connectivity demands. For 5G NSA, there is minimal additional complexity for supporting roaming traffic and signalling; however, international carriers will need to ensure that they are capable of providing sufficient bandwidth to address anticipated surges in roaming data usage from both consumers and IoT applications. Secondly, ensuring adequate security levels will be very important while rolling out 5G SA roaming, with SEPP (Security Edge Protection Proxy) and SCP (Service Communication Proxy) implementation found to be the most important security implementation and priority execution requirements.

Additionally, operators must start preparing for the full transition towards 5G SA roaming and consequently, will expect IPX providers to offer both regional and local breakout to support their roaming needs. This will enable specific traffic profiles to be differentiated and optimise 5G roaming. With home routing, data traffic is tunnelled back to the home network and then to the internet. In comparison, LBO enables roamers to receive data services directly from the visited network instead of tunnelling back to the home network. However, these architectures have yet to be defined. LBO will be required for use cases such as 4K/8K video services, V2X (Vehicle-to- Everything) communications and other low latency applications and services where offloading data to the local network is recommended. Indeed, for mission-critical uRLLC applications, local processing via edge computing nodes will be required and operators will need to establish this in partnership with roaming providers and partners.

Meanwhile, network slicing is expected to form a crucial part of 5G network architecture and will require advanced automation capabilities within networks. The groundwork (5G SA commercialisation) for network slicing remains at an early stage of development and will need formal standardisation amongst operators to offer a guaranteed service and improved latency. Through serving specific device types, operators will have the opportunity to capitalise on this flexibility to generate new, robust revenue streams.

Finally, for future roaming settlement and monetisation, BCE is designed to support 5G and MIoT (NB-IoT, LTE-M), while also supporting data volumes up to Yottabytes. 5G's support for converged charging and billing enables charging on a per IMSI per day basis (where records are combined into a single monthly report), volume-based charging or threshold-based charging (where the charging, or the discount applied, changes when a threshold is met). However, it is recommended that operators must not be reluctant to begin migration to BCE until they implement 5G SA, which for many players in developing markets will not be until 2026/2027 at the earliest.

About BICS

BICS is a leading international communications enabler, one of the key global voice carriers and the leading provider of mobile data services worldwide. Its solutions are essential for supporting the modern lifestyle of today's device-hungry consumer – from global mobile connectivity, seamless roaming experiences, fraud prevention and authentication, to global messaging, and the Internet of Things.

For more information about BICS, please contact:
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About Kaleido Intelligence

Kaleido Intelligence is a specialist consulting and market research firm with a proven track record delivering telecom research at the highest level. Kaleido Intelligence is the only research company addressing mobile roaming in its entirety. Our Mobile Roaming & Connectivity research service covers industry leading market intelligence and publications on Wholesale & Retail Roaming, eSIMs, 5G Roaming, IPX, Private Networks, IoT MVNOs, IoT Roaming and Roaming Analytics & Fraud. Research is led by expert analysts, each with significant experience delivering roaming insights that matter.

Survey References:
Q3 2022 Wholesale Roaming MNO Survey
Q2 2022 VoLTE Roaming MNO Survey
Q2 2022 BCE MNO Survey
Q1 2022 5G Roaming MNO Survey

For more information on this market study and the surveys or if you have further requirements, please contact:
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