ericsson.com/
microwave-outlook

Ericsson Microwave Outlook

October 2021

Executive summary

5G is now well established across the world, making E-band, network slicing and backhaul spectrum reuse increasingly important.

Contents

Key contributors
Executive Editor: Git Sellin
Editor: Maria Edberg
Articles: Anders Henriksson, Andreas Olsson, Jonas Hansryd, Magnus Berggren, Maria Edberg, Mikael Coldrey, Mikael Öhberg

Customer-written article
Simon Baumeister, Telefónica
Axel Lauer, Telefónica

Looking at the spread of microwave backhaul over different regions, it is clear that microwave continues strong – a slight decrease in share is countered by more carriers per hop to support increased capacity. Going forward, a continued slow uptake of fiber share is expected, with a slightly higher transition rate in markets with lower fiber share, focusing on highly capable backhaul solutions. North America is going against current trends with a predicted increased share of microwave backhaul – the easy wins for fiber have already been taken.

E-band, an essential part of 5G wireless backhaul support, is now spreading from the large uptake in Eastern Europe and Central Asia, to Western Europe, the Middle East, Latin America and Africa. Telefónica Germany plans a massive deployment of E-band systems in the run-up to 2025 in order to address a year-on-year traffic growth of around 60 percent. Compared to traditional microwave systems, their E-band network share will increase dramatically from 1 percent today to 20 percent in 2025. Telefónica Germany has found that E-band, as standalone or in Multi-band solutions, is an excellent way to handle the demand for 5G, and to support the quick roll-out of 5G in both urban and suburban areas.

With the increased use of E-band, wind impact on E-band has become a topic of interest. Ericsson monitored the impact of wind on almost 500 E-band links for a year. Of these links, 32 percent were in fact impacted by wind, but 95.5 percent had no error seconds at all. The worst-impacted link still had over 99.99 percent availability. It was clear that the placement of the link was of great importance, however, the link availability wasn't impacted by wind as much as anticipated.

Some countries have limited spectrum availability, so the ever-growing demand for data traffic puts a strain on their networks. Using simulations of a real network deployment, we have concluded that an efficient way to handle higher traffic demand with limited spectrum in traditional bands is to enable more aggressive channel reuse. This, together with traffic-aware output power, reduces both interference and power consumption. In fact, the simulations showed that using a single 112MHz channel in the whole network, together with traffic-aware output power, reduced congestion by 20 times compared to a network with a pair of 56MHz channels.

Network slicing is gaining momentum as an enabler for new 5G services and market opportunities. Up to 30 percent of 5G use cases are expected to require network slicing in the future. The way to achieve a sliced network is to transform it into a set of logical networks on top of a shared infrastructure. Each network slice serves a defined business purpose.

Transport, being a fully integrated part of this infrastructure, must maintain the properties of the network slices it transports. Microwave technology and microwave nodes are well positioned to support network slicing using standard packet technologies and quality of service (QoS) schemes to ensure successful deployment in 5G networks.

Microwave backhaul in different regions

What is the microwave and fiber split in different regions, and what will it look like in the coming years?

While analyzing the microwave and fiber split in different regions (Figure 1), it's clear that there are large differences between regions, countries and even between service providers in the same country. Why is this?

There are many factors, like historical background and regulatory aspects where availability and spectrum cost varies largely country to country. In some countries, exceedingly high spectrum costs drive usage of unlicensed spectrum. Also, local right of way rules for fiber, and even allowance for fiber deployment, guide whether fiber or microwave is the dominant backhaul media. In Egypt, only government-owned companies can use fiber, leading to substantial microwave usage for backhaul. Elsewhere, governments incentivize fiber deployment, so it is more dominant. High population density can also drive fiber deployment. Where the importance of cost and deployment speed is substantial in other countries, this leads to more microwave installations.

So, what is the optimal split between fiber and microwave? A 50/50, 80/20 or 20/80 percent split can all be correct, depending on the service providers' situation.

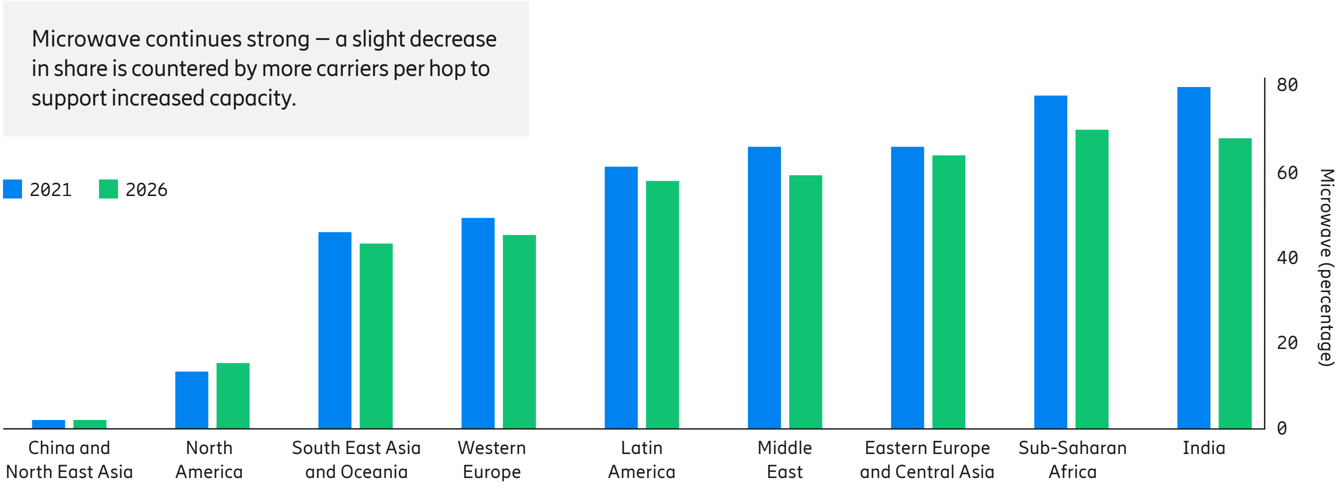
When comparing Figure 1 to the similar chart in Ericsson Microwave Outlook 2016, we see no dramatic differences to our 2021 prediction. There is a continuous, slow move to fiber, especially in dense urban areas. Availability and price decide the choice of media.

However, some regions have a larger or smaller portion of microwave today than predicted. This is partly to do with the fact that we have more data to use as a base for our prediction but, more importantly, some regions have focused on expansion in dense urban areas over suburban or rural areas, with a higher fiber penetration than predicted. The rapid uptake of E-band, and increased focus on the most cost-effective backhaul solutions, have increased microwave uptake in other regions more than predicted. In one country, close to 30 percent of microwave for mobile backhaul is based on E-band today. E-band, an important part of wireless 5G backhaul support, is spreading from the large uptake in Eastern Europe and Central Asia to Western Europe, the Middle East and Latin America.
In North East Asia, the possibility to use E-band microwave for wireless fronthaul in centralized RAN (C-RAN) deployments is emerging, but it is early days.

Figure 1 suggests the number of microwave radios will decrease during the coming years. However, the number of carriers per microwave connection is continuously increasing to support the required capacities. Previously, mainly 1+0 and 1+1 transceivers were used for a hop, but today many use a 2+0 configuration. In the future, a substantial number of hops will move to 4+0 using Multi-band, combining traditional bands and E-band, and other multicarrier solutions like carrier aggregation and MIMO.

Going forward, continuous slow fiber uptake is expected, with slightly higher transition rates in markets with lower fiber share, focusing on highly capable backhaul solutions. Conversely, in North America microwave usage is expected to increase. The easy wins for fiber have already been taken. Legacy backhaul media (copper) is expected to be replaced by fiber and microwave. E-band is critical to support the capacity needs for 5G in urban and suburban areas, together with traditional frequencies in Multi-band solutions.

Figure 1: Regional differences in deployed microwave backhaul 2021 and 2026 (percent)



Microwave continues strong – a slight decrease in share is countered by more carriers per hop to support increased capacity.

E-band: the global choice for 5G capacities

E-band is rapidly becoming the preferred choice for 5G wireless backhaul.

E-band progress around the world

Since this publication first mentioned E-band in 2014, a lot has changed. From starting life as an oddity catering for a few use cases, E-band has become a mainstream product, deployed on every continent and enabling the roll-out of 5G networks.

As can be seen in the updated map, E-band is now deployable in the vast majority of countries around the world. One significant change since our 2015 map is that in Africa, where only a few countries had approved the use of E-band at that time, more than one-third of all countries have now given the green light for deployment. In Asia, both India and China are now considering deployment and Indonesia has already approved it, while in Central and Latin America, almost all countries are now open for deployment.

The main driver for the ever-expanding use of E-band is its speed, flexibility and the fact that there is a lot of spectrum available, allowing for multi-gigabit connections where fiber is not an option. This, of course, goes hand-in-hand with preparation for, or actual roll-out of, 5G networks.

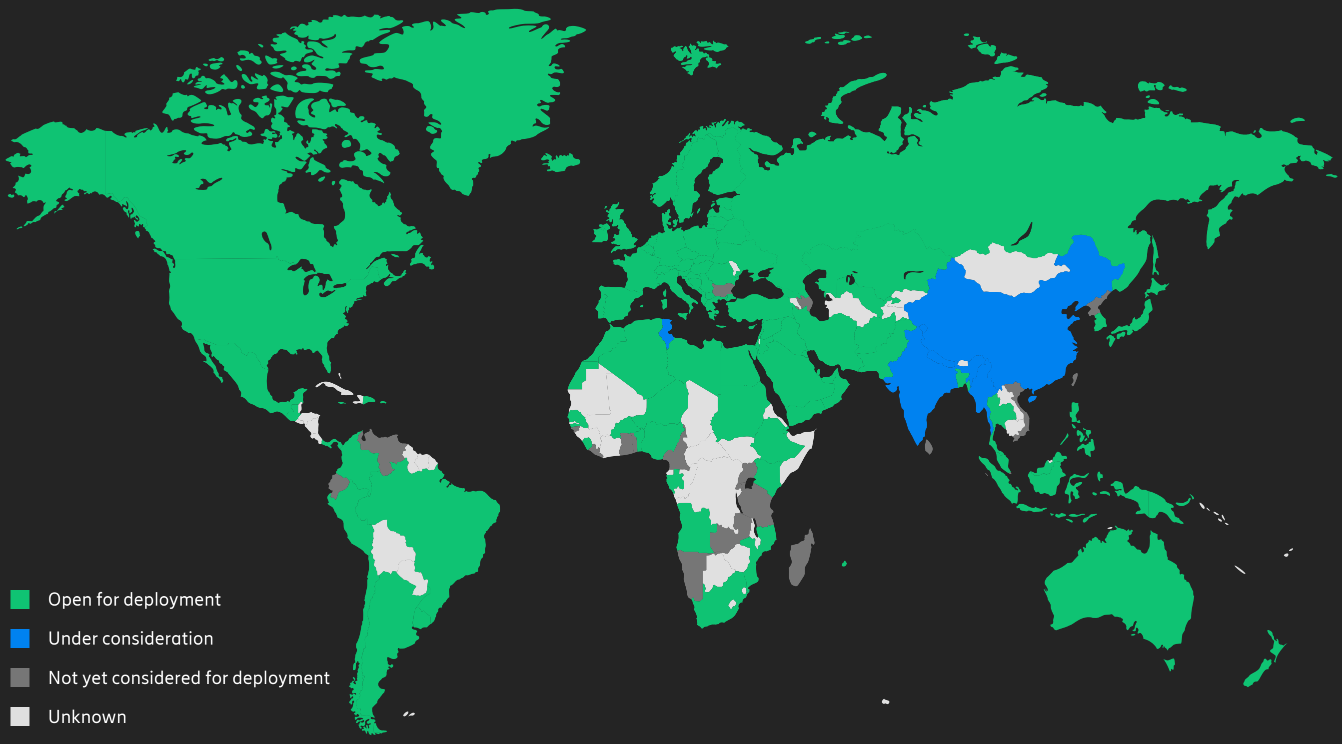
Besides providing high capacity, in some countries E-band also allows for a less expensive microwave connection, as the license fee per hop is substantially lower than for the lower frequencies.

Not only do we see a growing footprint of E-band as standalone installations in urban environments, but there is also a fast-growing number of deployments together with lower frequency bands – that is, Multi-band sites. Thus, E-band is moving out of the cities into suburban areas, with the longer hop lengths following these types of site configurations.

Looking ahead, one could also see use cases for E-band in fronthaul applications, once again in sites where fiber deployments are not an option. This typically occurs in countries where C-RAN deployments are predominant. Using E-band for fronthaul applications will naturally put further emphasis on higher capacities and push for longer hop lengths.

Given the benefits of high capacities, sometimes-lower fees and the possibility to stretch the hop length with a Multi-band system, it would not be a surprise if in a few years we can show you an all-green map.

Figure 2: Global E-band deployment status

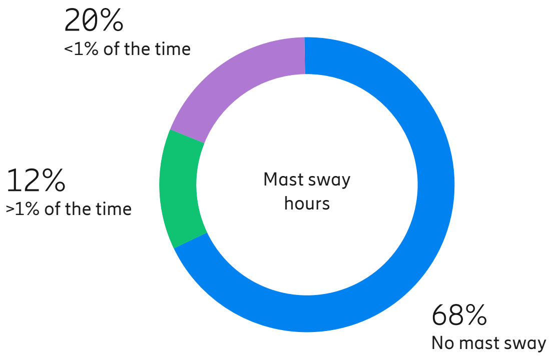


Wind impact on E-band

E-band radios operating at 70–80GHz offer benefits such as high capacities and high antenna gains with a small footprint. Antennas with 0.3m diameter could have up to 47dBi antenna gain, while a 0.6m diameter could have up to 51dBi resulting in beam widths of less than 1 degree, but it is a misunderstanding that E-band is unique in having narrow beams. There are antennas on any commercial microwave band, all the way down to 7GHz, that have similar antenna gains and beamwidths, but they relate to large sizes and weights, for example, a diameter of 3.7m at 7GHz or 1.8m at 23GHz. The uniqueness of the E-band is that it can offer high-gain antennas with a lightweight and compact form factor. However, narrow antenna beams require stable installations to remain focused at their targets. Early E-band installations were often installed with similar-sized radios at lower bands, and due to the narrower beamwidths, they were often, a bit unfairly, perceived as being more sensitive to mast sway and unstable installations.

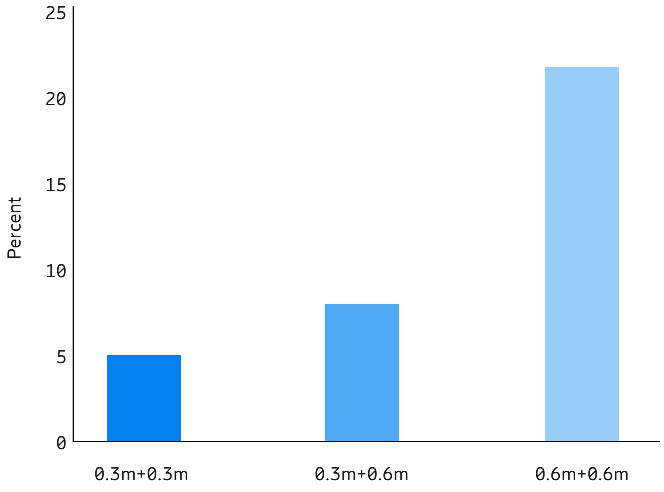
Together with a major European service provider, which has a large installed base of microwave links, we studied how E-band radios behave in a real network, with real site infrastructure and seasonal weather variations. How sensitive are the links to wind, and what is the impact from mast sway on the link availability?

Figure 3: E-band links monitored for 1.8 million hours



In total, 484 E-band links were monitored for 1.8 million hours. The worst impacted link had over 99.99 percent availability.

Figure 4: Antenna configurations for links impacted by mast sway more than 1 percent of the time



The service provider owns an E-band network consisting of more than 500 links and is currently expanding the network. In the study, we monitored 484 links over a full calendar year, tracking the mast sway in the network. The most common antenna configuration, accounting for 46 percent of the links, used 0.3m antennas on both ends, while 37 percent were equipped with 0.6m antennas and 17 percent used a 0.6m paired with a 0.3m antenna.

When deploying the radios, the service provider followed simple guidelines such as mounting on the lower half of monopoles. Data from more than 1.8 million operational hours was collected and the amount of mast sway was calculated by analyzing how the received signal varied over time. The detailed analysis was handled by AI algorithms, which automatically detected and distinguished mast sway events from other fade events such as rain, snow, multipath and line-of-sight blockage.

The results are summarized in Figures 3 and 4. Out of the 1.8 million hours, 0.4 percent (7,828 hours) showed any type of mast movement.

Two-thirds of the links (68 percent) did not show any mast sway, and may be assumed to be deployed on sites with stable infrastructure and therefore are also candidates for upgrade to larger antennas if needed. However, one-third were deployed on sites where instabilities were detected, and 12 percent were deployed on sites that caused mast movements for more than 1 percent of the time. These unstable links could be candidates for a site overview at a later stage. Studying the distribution between antenna configurations impacted by mast sway (Figure 4) confirms that there is a higher probability for mast sway with large, 0.6m antennas (22 percent) compared to small 0.3m antennas (5 percent).

To estimate the impact on the link performance, we measured the error seconds caused by mast sway in the link. Figure 5 shows mast sway and link availability, i.e. percentage of time without errors compared to time with errors for all links. The color shows the antenna configuration. The lower plot shows the worst 100 links. Only 7 links had an availability that was less than 99.999 percent.

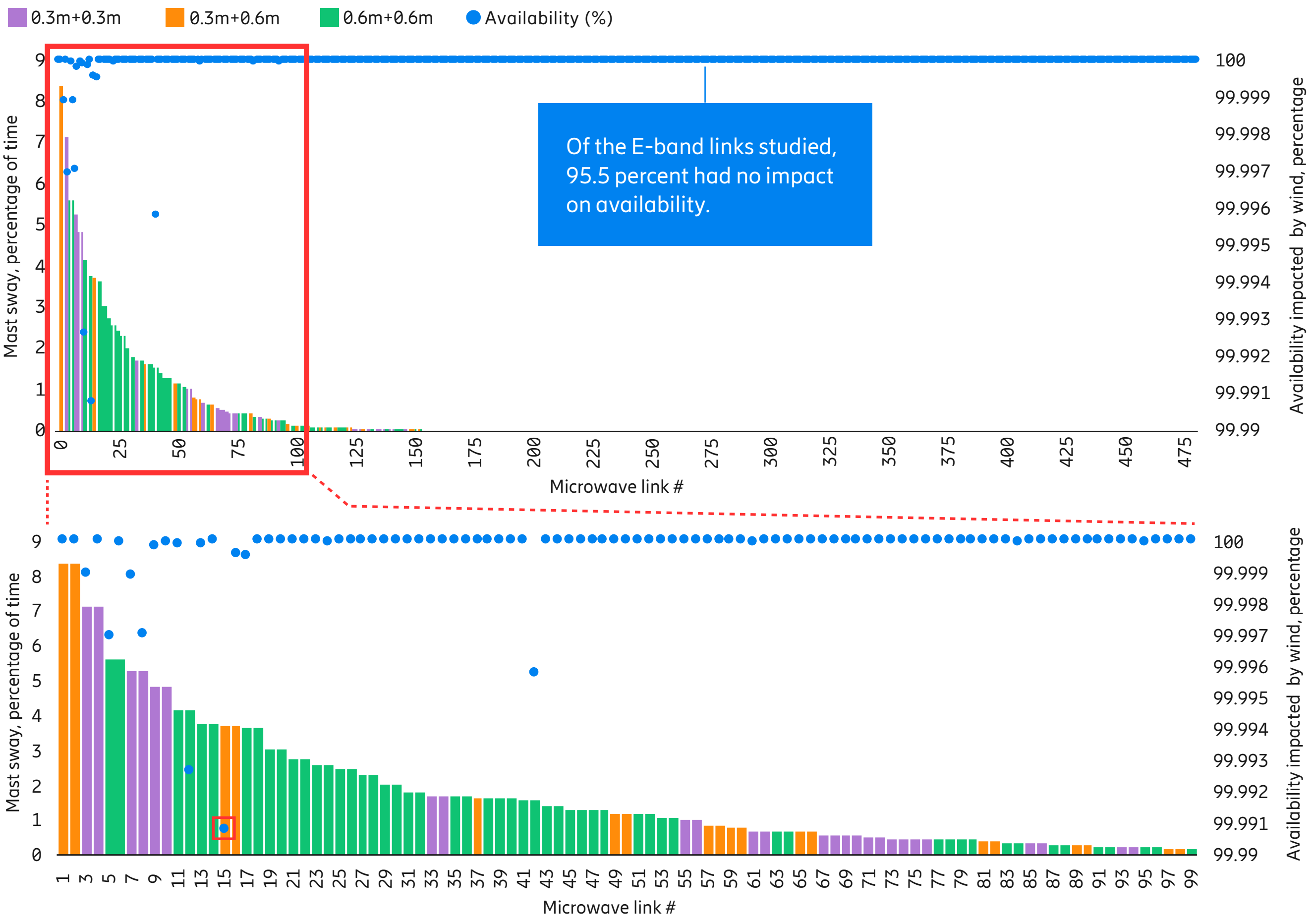
Wind had no impact on availability for 93 percent of the links equipped with 0.6m antennas.

93%

The worst availability (99.991 percent) was observed for link #15.

Figure 6 shows the site for link #15. The plot shows how fast and deep the received signal could fade for this link during a windy day in June 2020. The mounted E-band radio is indicated in the red square. It was mounted above the 50 percent height of the monopole, which was not according to the deployment guidelines from the service provider. However, there are often acceptable reasons for deviating from guidelines – in this case, it was difficult to find a clear line-of-sight below tree height.

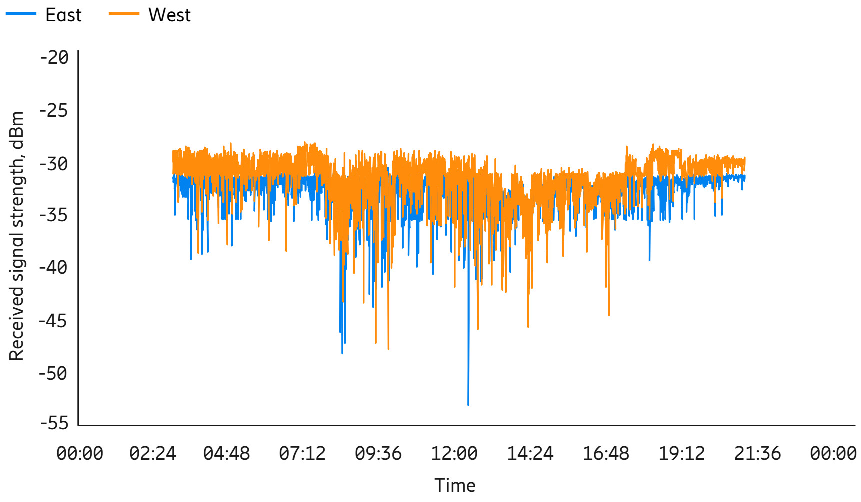
Figure 5: Availability and mast sway of the monitored links



Of the E-band links studied, 95.5 percent had no impact on availability.

In conclusion, the one-year study shows that mast sway in E-band backhaul networks is an effect that should be considered, but with tools for careful planning and monitoring it is often possible to control and mitigate the effect. More than two-thirds of the sites in the study showed no mast sway, and only a few showed any impact on link performance with the worst impacted site still having over 99.99 percent availability. More than half of the sites equipped with 0.6m antennas detected no mast sway at all and 93 percent of the sites with 0.6m antennas were error free with respect to mast sway.

Figure 6: Mast sway impacted by placement of link



Received signal strength of the worst impacted link, during a windy day

On the most impacted link in the study, the antenna was placed higher than recommended.

Telefónica Germany's perspective on using E-band for 5G

5G drives both the need for increased backhaul capacities and for new sites for 5G coverage.

As a prioritized activity, the service provider Telefónica Germany is currently looking for backhaul capacities of up to 10Gbps to connect both 4G and 5G sites to their backbone network. Telefónica Germany has a long tradition of using microwave as the backhaul media to complement fiber and sees value in the continued use of microwave for 5G, especially the use of E-band. The high availability of E-band spectrum compared to legacy frequencies, as well as the high capacity, makes E-band a good option for such connections.

Telefónica Germany started to introduce E-band systems in 2014, and the first of these were able to support 3.5Gbps over one carrier. E-band has since accounted for the majority of all new microwave installations, as can be seen in Figure 7, to support the ongoing 5G roll-out, with a large growth in the last year of almost 50 percent.

The preferred deployment strategy for urban and suburban areas is to use 1+0 systems with 5Gbps in a single radio, with a dual-polarized antenna from the start. This enables the option to upgrade the system by adding another 5Gbps radio on the second polarization when needed. Additionally, inter-frequency aggregation (IFA) systems, also called Multi-band systems, are being introduced for longer hops in rural areas; the very first links have already been installed.

The majority of Telefónica Germany's E-band installations, 75 percent, are located in urban and suburban areas. Most systems are placed on flat roofs, where the hop lengths and capacity needs are perfect for E-band. There are also some E-band systems, 12 percent, that are installed on masts or chimneys. The most common installations use 0.3m+0.3m antennas, and the lengths of the installed links are generally up to 3km. The IFA (or Multi-band) systems, that are combinations of E-band with legacy microwave systems, use 0.6m+0.6m antennas and have a hop length of up to 8.5km, have also been realized, as can be seen in Figure 8.

O₂ Telefónica

Telefónica is one of the largest telecommunications service providers in the world. The company offers fixed and mobile connectivity, as well as a wide range of digital services for residential and business customers.

Telefónica operates in Europe and Latin America, with 367 million customers worldwide. Telefónica Germany is one of the leading integrated telecommunications providers in Germany with 45 million customers and is building a high-performance, energy-efficient 5G network that will reach 30 percent of the population by the end of 2021.

Figure 7: Installed microwave at Telefónica Germany

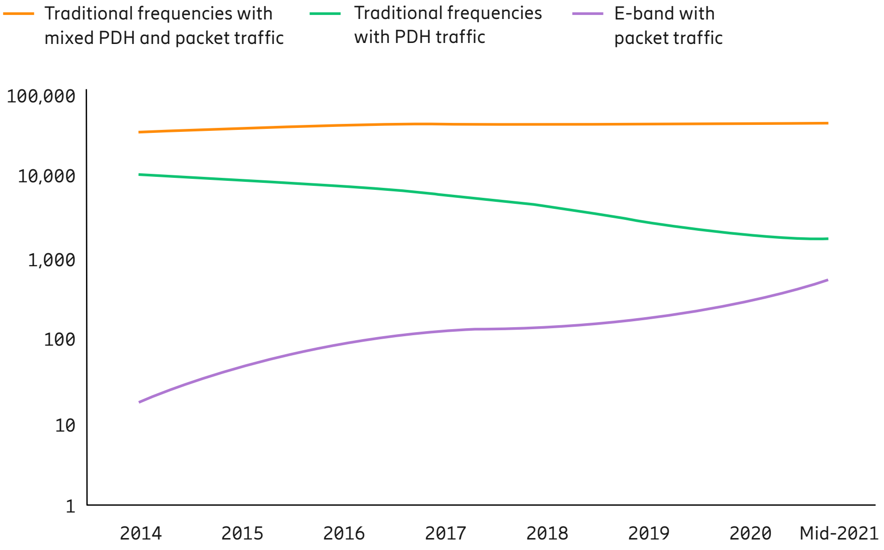


Figure 8: Distribution of Telefónica Germany's E-band antennas and system configurations

Antenna configuration	0.3m+0.3m		0.3m+0.6m		0.6m+0.6m	
System configuration	Number (%)	Max. distance (km)	Number (%)	Max. distance (km)	Number (%)	Max. distance (km)
1+0	60	2.48	12	3.08	10	3.05
2+0	12		3		2	
IFA 3+0					1	8.43

Telefónica Germany has learned a lot about E-band during the roll-out in recent years:

a. E-band fulfills the requirements of 5G.
b. Using the 0.6m antenna on a pole requires a more stable pole than the standard used by Telefónica. This must be considered during the planning.
c. Alignment of 0.6m E-band antennas requires more attention than for lower frequencies.

Other learnings from preparing for the roll-out of E-band include:

a. As all outdoor installations are always integrated with the antenna, the accessibility of the active components for maintenance has to be ensured by retrofitting ladders or platforms, or alternatively by installing a 2+0 system.
b. Dependency on legacy technologies, such as time-division multiplexing (TDM), needs to be removed. E-band is set to become a key building block on the way towards modernized and competitive 5G-ready RAN design.

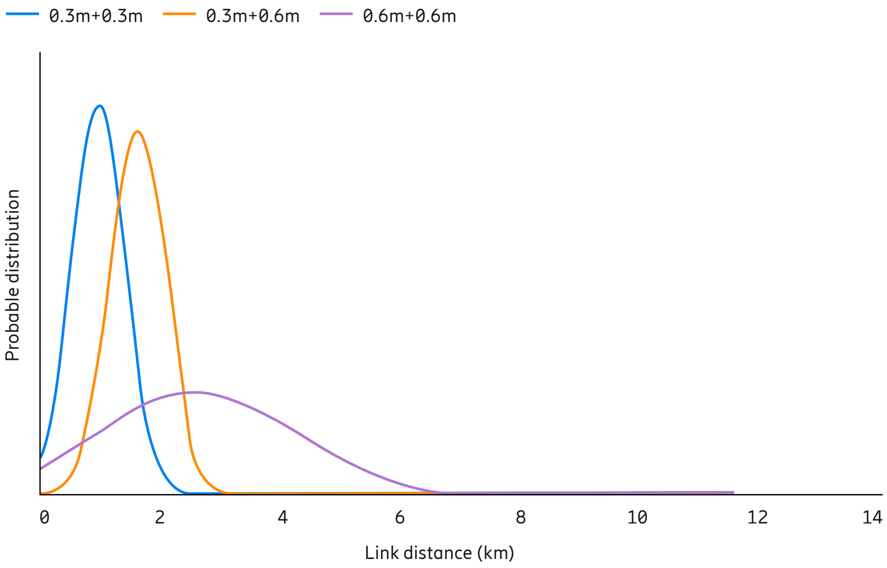
E-band has proven itself to be an excellent way to handle the required 5G capacities.

Going forward

Telefónica Germany plans a massive deployment of E-band systems in the run-up to 2025, to address the roughly 60 percent year-on-year traffic growth. The overall E-band network share, compared to traditional microwave systems, will increase from 1 percent as of today to 20 percent by 2025. Longer link lengths, from 3–10km, will be deployed as Multi-band systems. Telefónica Germany plans to move all microwave systems to a capacity larger than 2Gbps by 2025. This will be achieved by using a mix of 112MHz, 224MHz, E-band and D-band.

It is apparent that E-band, as standalone or in Multi-band solutions, is an excellent way to handle the required 5G capacities, and to support the quick roll-out of 5G in both urban and suburban areas in the German market.

Figure 9: Planned distribution and distance of Telefónica Germany's E-band configurations



Supporting network slicing in microwave networks

Network slicing is gaining momentum as an enabler for new 5G services and market opportunities. It is expected that up to 30 percent of 5G use cases will require network slicing.[1]

Network slicing helps build a customized network that individually serves specific use cases. A network slice is defined as a logical network with a particular set of characteristics, that serves defined business purposes, and consists of all the required network resources configured together – core, RAN and transport.

Figure 10 shows the architecture needed to create the logical networks that will support end-to-end network slicing. Transport is a fully integrated part of the architecture, and must have principles for creating transport services supporting the requirements for a network slice or group of network slices.

The transport domain must maintain the properties of the network slices it transports.

To achieve this, the transport domain will support sharing, partitioning, monitoring and alignment of transport resources, as well as co-management with core and RAN. We recommend that the support for network slicing in the transport domain is implemented using standard packet technologies, avoiding TDM-like solutions, for efficient use of resources and to avoid the need for large network fork-lifts.

A central concept is to identify which network slice, or group of network slices, a packet arriving at the edge/provider-edge (PE) nodes in the transport network belongs to, allowing for the creation of transport services with the correct service-level characteristics. Figure 11 shows the principles for identification.

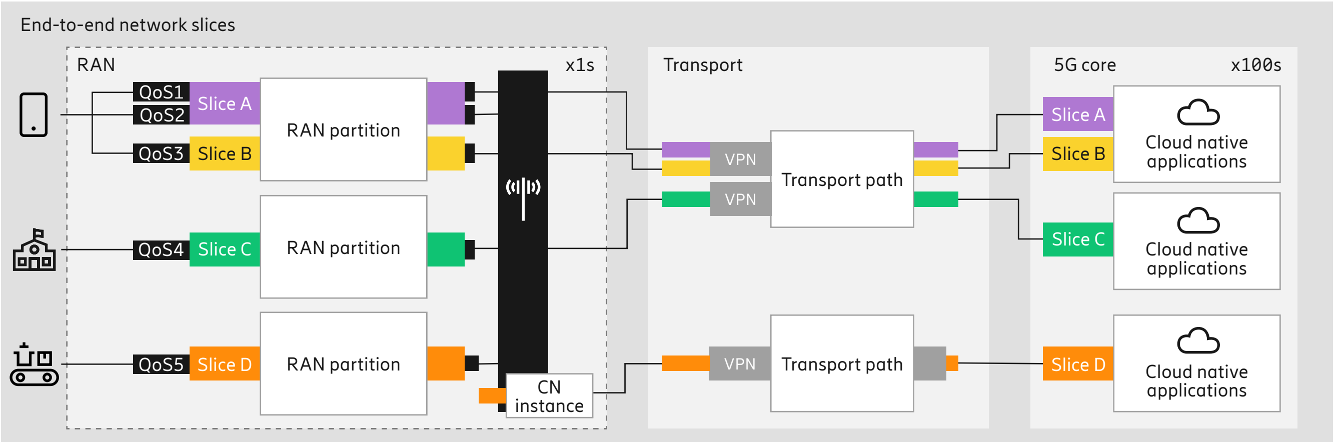
It is important that the identifier is located in the packet headers available to the transport nodes – that is, outside of any IPSec (or other) tunnel not terminated in the transport network. This limits the identifier to reside in the ethernet header or the IP header. The identifier can be explicit, meaning that RAN and core adds it specifically for network slice identification; or implicit, where an existing field in the header is also used for slice identification by creating the correct association with core and RAN.

A network slice, or group of network slices, can contain traffic of more than one traffic class, making it necessary to use a hierarchical identification principle. The first identifier points to the network slice and the second to the traffic class, which allows for better hierarchical quality of service (QoS) handling of network slices with multiple traffic classes.

Work is ongoing in standardization bodies to find the most suitable identifier. Possible candidates for the network slice are DSCP only, IP-address, IPv6 flow label or C-VLAN. IP-address and IPv6 flow label can then have DSCP for the traffic classes and C-VLAN PCP.

As the packets are identified, they are divided into transport resource partitions. This is a construct containing packets from one or more network slices that should be kept together in the network, due to their similar characteristics. The transport resource partitions are then instantiated as layer two or layer three transport services in the edge/PE-nodes, depending on the service provider's transport network type. Typical transport services would be S-VLANs in layer two networks, the most common network type in microwave networks today, or L3VPNs in layer three networks. If the network slices have very specific requirements, for example for latency, traffic engineering can be required to ensure that the wanted path in the network is followed. Figure 12 shows the transport service instantiation principles.

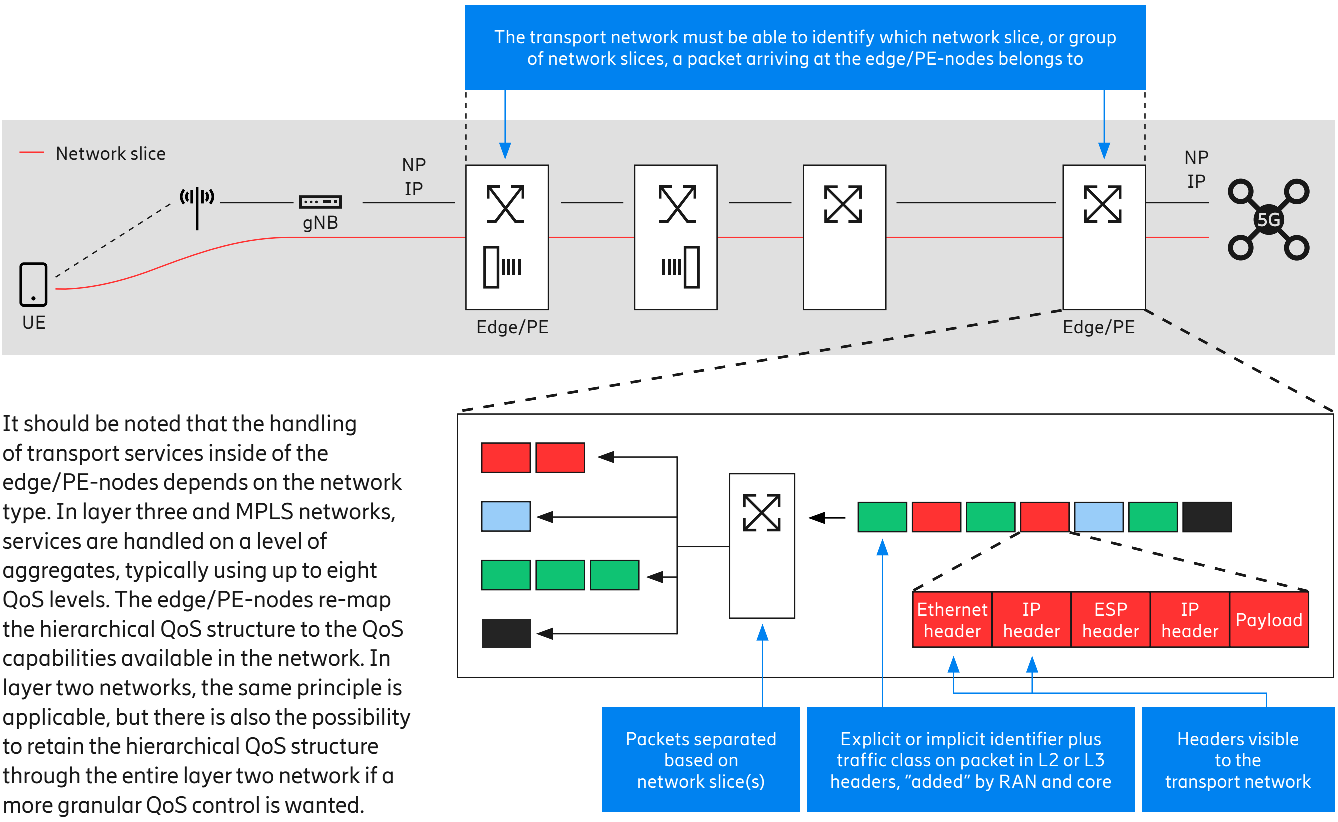
Figure 10: End-to-end network slicing architecture



---

[1] Network slicing: A go-to-market guide to capture the high revenue potential. https://foryou.ericsson.com/eso-network-slicing-value-potential-report.html

Figure 11: Packet identification and identifiers



It should be noted that the handling of transport services inside of the edge/PE-nodes depends on the network type. In layer three and MPLS networks, services are handled on a level of aggregates, typically using up to eight QoS levels. The edge/PE-nodes re-map the hierarchical QoS structure to the QoS capabilities available in the network. In layer two networks, the same principle is applicable, but there is also the possibility to retain the hierarchical QoS structure through the entire layer two network if a more granular QoS control is wanted.

To support network slicing, the edge and internal nodes in the transport network need to have the capabilities described, regardless of what transport media technology is used. Globally, many radio base stations currently use microwave technology for their last-mile connectivity, and will continue to do so for 5G.

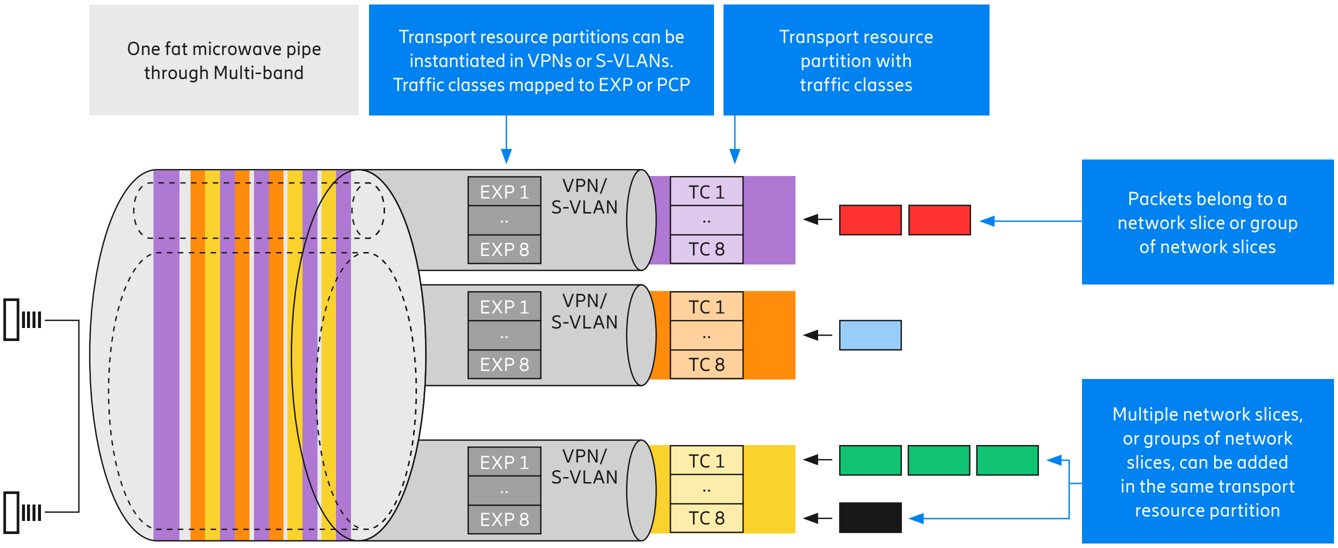
Multi-band technology and E-band are ways of supporting 5G capacities and concepts such as slicing. The microwave technology itself is agnostic to the network slices – instead, it is the node's capabilities as a switch or router, combined with its QoS mechanism both in packet and radio link domains, that are important to consider.

Microwave nodes today typically have all the packet features and packet QoS needed to implement support for network slicing in the transport domain, but it is essential to ensure proper interwork between the internal packet and radio link systems to achieve the wanted combination of bandwidth and QoS. Support for hierarchical QoS will ensure that the node can correctly handle more advanced network slicing applications when being used as edge/PE-nodes.

Figure 12 shows an example where the VPN or S-VLAN services, carrying network slices, are transported over a microwave hop using a Multi-band feature. The Multi-band feature forms a high-capacity fat pipe, where the highest priority traffic will be transmitted over the link with the highest availability. This, together with the nodes hierarchical packet QoS, effectively supports the QoS schemes needed for network slicing.

Microwave technology and microwave nodes are well positioned to support network slicing using standard packet technologies and QoS schemes to ensure successful deployment in 5G networks.

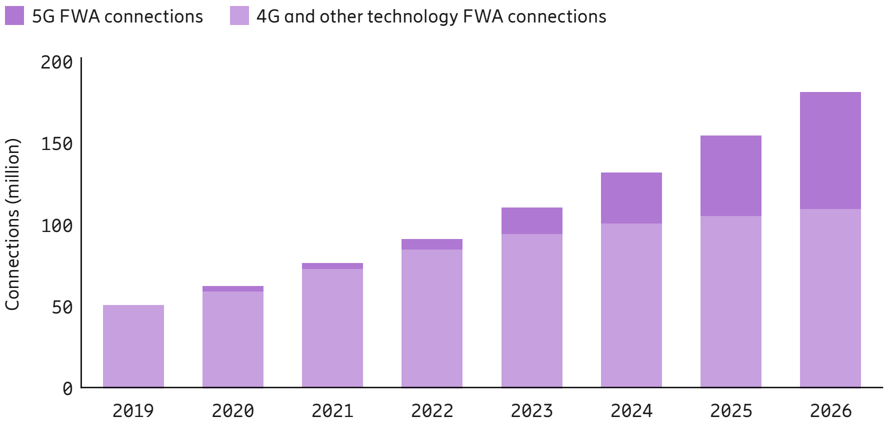
Figure 12: Transport resource partition and instantiation



Microwave: perfect for fixed wireless access backhaul

More than 70 percent of all service providers are now offering fixed wireless access (FWA), and microwave can contribute to the continued FWA growth.

Figure 13: The growing number of FWA connections



5G FWA connections are expected to reach 70 million by 2026, accounting for around 40 percent of total FWA connections.

70M

COVID-19 is accelerating digitalization and demand for fast, reliable home broadband connectivity. FWA is the quickest alternative for service providers to meet this demand. By the end of 2026, FWA connections are forecasted to exceed 180 million – around 25 percent of the global total mobile network data traffic. 5G FWA connections are expected to grow to over 70 million by 2026, representing about 40 percent of total FWA connections.[2]

Service providers already have most of the network components needed to offer an FWA service. Adding FWA capability merely involves increasing coverage in a well-defined, geographically selective way and adding access and backhaul capacity, as well as customer premises equipment (CPE), all while observing the FWA traffic model and its differences from mobile broadband when dimensioning the network. Once connections and usage have increased, there might be a need to scale, add network capabilities and densify network grids.

How can microwave assist with a successful FWA deployment?

FWA networks will need to support different types of services with defined QoS KPIs. Fast time to market (TTM) and low total cost of ownership (TCO) are also important. This implies that the transport network also needs to support these requirements (see Figure 14). Microwave technology has several ways to cater to capacity needs, and with advanced QoS mechanisms, can even support network slicing. Online gaming is an FWA service that requires a lower latency. Microwave is just that – a low-latency solution. To have low TCO, it is important to reuse existing network assets, including transport, whether it is fiber or microwave backhaul.

When expanding FWA to a new site where dark fiber is unavailable, or fiber is too costly or slow to deploy, microwave backhaul with E-band or Multi-band offers fast and cost-effective roll-outs with high capacity. Microwave can also be used as a temporary solution while waiting for fiber. The main factors determining the capacity of the last-mile transport for FWA are the maximum cell peak rate and average cell throughput rate during busy hours. Compared with mobile broadband deployments, the calculation of those rates must be adjusted to accommodate the targeted number of FWA connections, and the data rate offered to subscribers under the given radio conditions. In general, the average cell throughput for FWA deployments will be much higher than with mobile broadband-only deployments, and more predictable since the location and number of households is fixed.

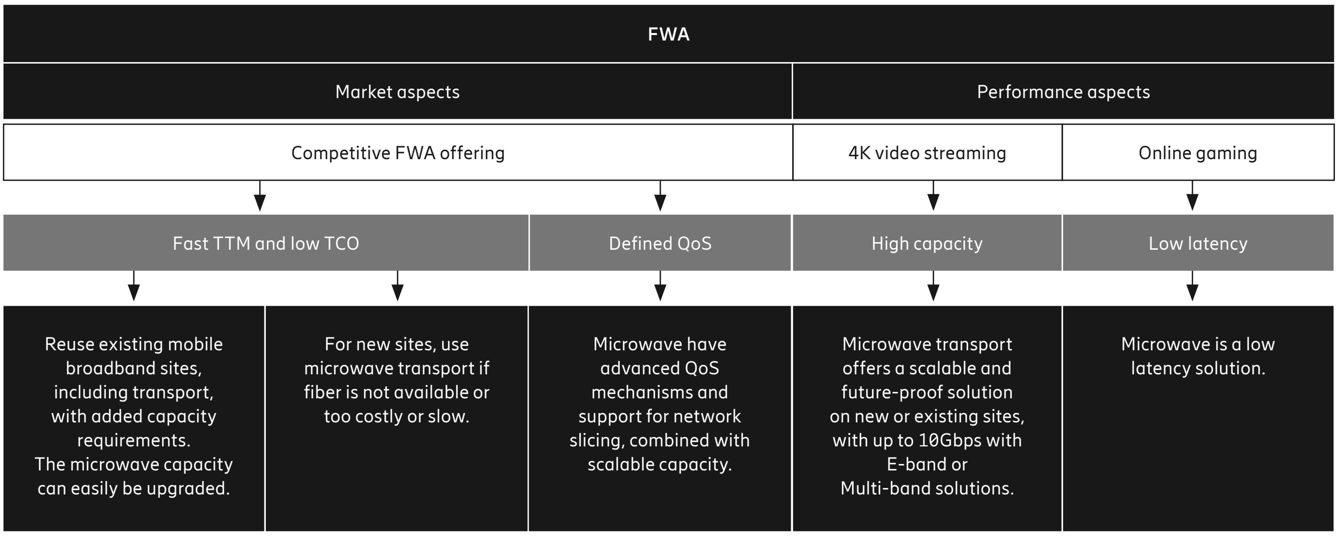
The evening is the FWA busy hour; there could be several 4K video streams per connection, each requiring high capacity. Microwave transport offers a scalable and future-proof solution on new or existing sites, with up to 10Gbps with E-band or Multi-band solutions.

Microwave is a key enabler for a profitable FWA service.

---

[2] Ericsson Mobility Report (June 2021)

Figure 14: Microwave supports FWA requirements



For existing sites with microwave backhaul, the capacity can easily be increased via software, increasing the modulation, using adaptive modulation, wider channels, carrier aggregation (if the hardware supports it) and header compression. It is also possible to add additional hardware to increase capacity, like using dual polarization with XPIC, carrier aggregation, MIMO, or connecting an E-band radio to the existing traditional microwave radio in a Multi-band setup. These are easy, cost-effective ways to add the capacity needed for FWA.

FWA connections are forecast to represent 25 percent of the global mobile data traffic by 2026.

Case study: European suburb

This example suburb has relatively mature LTE/New Radio (NR) mobile broadband, decent fixed broadband offerings (mostly ADSL), but no general fiber infrastructure deployed in the targeted areas.

We assume a population density of 2,500 people per km2, with an average of 2.5 people per household, and that there is an LTE/NR site present that can be expanded to support FWA.

The service provider uses the following as a basis for dimensioning the system with defined QoS offerings:

- The network should be able to connect at least 30 percent of households, with a first-year target of 15 percent.
- The households' TV needs are assumed to be served by FWA, via an IPTV bundle.
- For video streaming, households should experience a minimum data rate of 30Mbps during busy hours. This corresponds to two 4K HDTV video streams, or multiple SDTV and HDTV streams. This is the guaranteed QoS for the 5 percent worst-served households in busy hours. The downlink data rate for a specific household depends on location – 95 percent will have higher or much higher data rates, up to 430Mbps in this scenario.

For these FWA connections to the LTE/NR site, there are capacity requirements for both RAN and transport. For RAN, there will likely be additional radio units and basebands. For more information on ways to handle both the RAN and transport requirements, there are several examples in Ericsson's Fixed Wireless Access Handbook,[3] including this European suburb example. We will primarily focus on the transport aspect in this article.

Dimensioning the last-mile transport system is based on the maximum of the cell peak rate and average cell throughput rate during busy hours. Our example, with a minimum data rate of 30Mbps for the 5 percent worst-served households, results in a busy hour throughput rate of 330Mbps per site, with 15 percent of households connected. The cell peak rate of this same example is 430Mbps, resulting in transport capacity requirements of 430Mbps.

The existing mobile broadband capacity also needs to be considered, but the capacity required in the example is easily within the capacity range of microwave. When increasing FWA coverage to 30 percent of the households over 5 years, while the busy hour consumption increases by 2.1 times, the last-mile transport capacity increases to 1.4Gbps. This is still easily handled by a single traditional microwave link.

To summarize, FWA connections are forecast to represent 25 percent of the global mobile data traffic by 2026. Service providers have a great opportunity to utilize their existing mobile broadband network and start offering FWA in select areas. By reusing as much equipment as possible, a competitive FWA service can be offered with short TTM and low TCO. Transport is crucial to the successful FWA service, and microwave backhaul offers a scalable, future-proof solution for new or existing sites, with up to 10Gbps with E-band or Multi-band solutions.

---

[3] For more information, see Ericsson's Fixed Wireless Access Handbook. www.ericsson.com/en/fixed-wireless-access

Frequency reuse and wide channels – a perfect match

How can those service providers with limited access to microwave backhaul spectrum handle the increased data traffic demands?

Data traffic is growing year-on-year in our networks, and RAN is evolving with more spectrum and more spectrally-efficient features – for example, MU-MIMO – alongside densification, to cope with traffic growth. The demand on microwave backhaul capacity is increasing correspondingly. However, many service providers have limited access to microwave backhaul spectrum, especially in traditional bands. It is therefore important to utilize the available spectrum resources in the best possible way.

Microwave backhaul networks are traditionally designed so that links do not interfere with each other by assigning neighboring links different frequency channels. From a frequency allocation perspective, the consequence of such an interference-free design is that each link only has access to a smaller subset of available frequency channels.

Let's consider a simple network design scheme where links in a network are assigned one out of two separated frequency channels that do not interfere with each other (traditional network design). An alternative network design is to give all links access to both channels to increase their overall bandwidth, but in such a design there's an increased risk that the links will interfere with each other, which could increase their respective interference-to-noise ratio (I/N).

The question then arises: can the possible increase in I/N be compensated for by the increased channel bandwidth? The reasoning is that microwave backhaul links typically operate at very high signal-to-interference-and-noise ratio (SINR), and so are bandwidth-limited. Therefore, they would benefit a lot more in terms of capacity from using wider channel bandwidth instead of a very high SINR. In the bandwidth-limited regime, the capacity is approximately linear in bandwidth but only logarithmic in SINR (power). This implies that a wider channel requires less transmit power to support the same capacity as a narrow-band channel with high SINR. In general, lower transmit powers would also generate less interference to neighboring links. Additionally, links experience varying traffic demand over time. It may be so that at certain time instances, some links experience a higher traffic demand while other links experience a lower traffic demand. Consequently, in the case when links adaptively adjust their output powers to meet their respective capacity demands (see Figure 15), the eventual interference between the links will also vary with time and interference is reduced significantly compared to a system that uses fixed output power. In extreme scenarios, it may be that some links are carrying almost no traffic at all. In that case, why not let other links use the available spectrum resource? It would otherwise be a waste of spectrum.

Simulations based on typical network deployment

To quantify the gains of more aggressive channel reuse and traffic-aware output power, we evaluated different network designs by simulating a sub-network of a typical network deployment in India. The deployment and selected sub-network are illustrated in Figure 16. The overall deployment consists of thousands of links while the selected sub-network consists of 122 horizontally polarized 15GHz links with different antenna sizes and hop lengths. This sub-network was chosen because it contains several network hubs where multiple links are co-located. Links on a hub are more prone to interference from neighboring links located at the same hub and are therefore more challenging from a channel reuse perspective.

Two different network designs, namely reuse two and reuse one, are compared. In a reuse two design, each link is allocated one out of a total of two 56MHz channels, where close-by links are allocated separate channels. However, in a reuse one design, all links, including close-by links, are allocated the same 112MHz channel. Thus, for both designs the total spectrum consumed by the network is the same.

Different power allocation methods were also simulated: fixed output power and traffic-aware output power. When conditions allowed, fixed output power was chosen so that 99.995 percent availability for the maximum modulation of 4096QAM was achieved for both channel bandwidths. This means that the 112MHz channel has twice the peak rate of the 56MHz channel, but the same availability of their respective peak rate. However, the maximum output power was 18dBm for practical reasons.

Figure 15: Traffic-aware output power

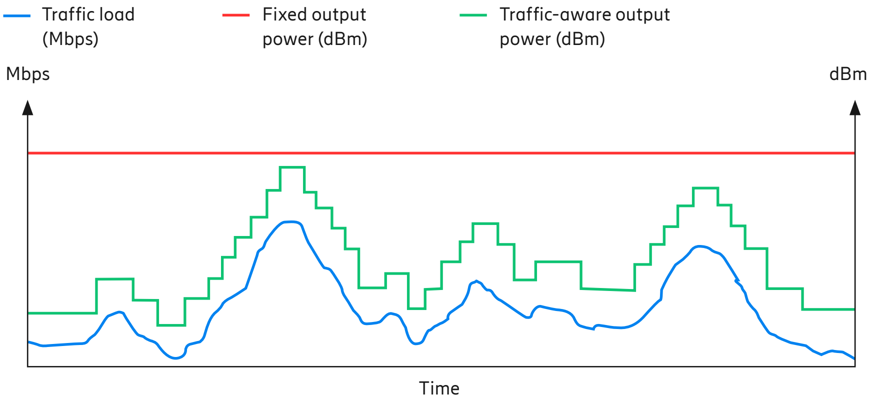
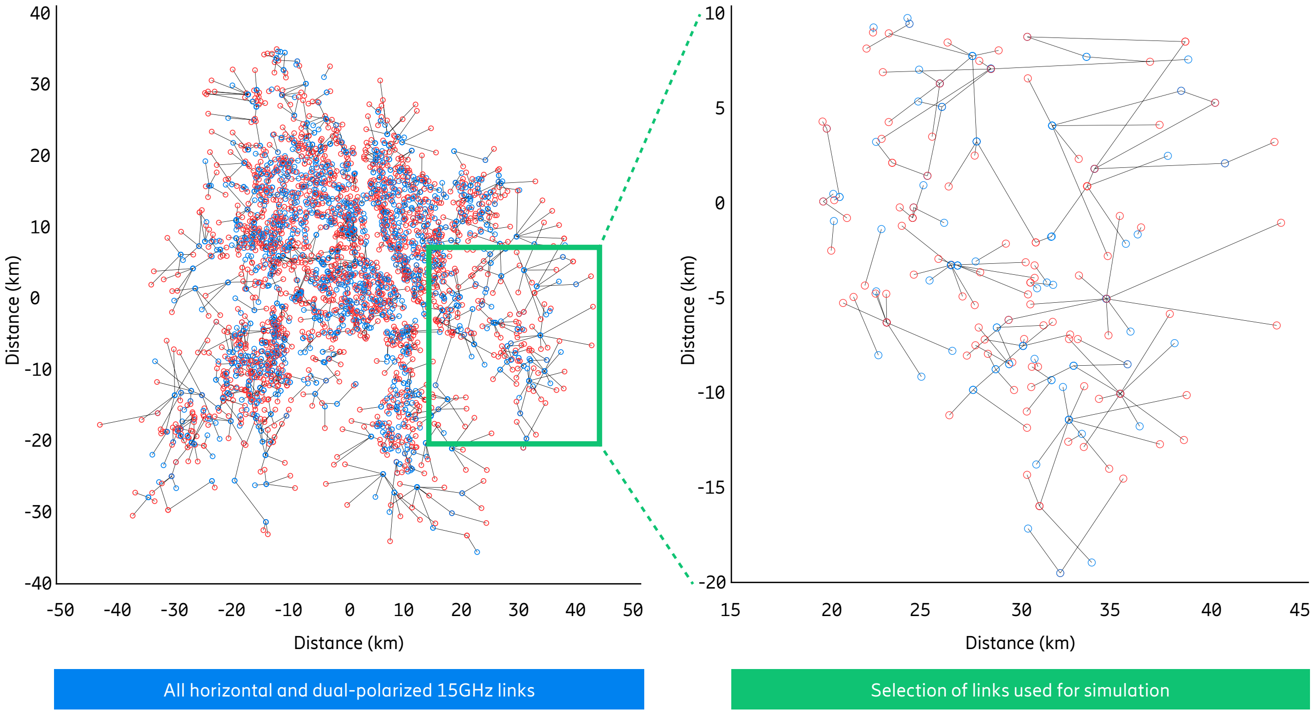


Figure 16: Typical dense network topology in an Indian city, used in simulation



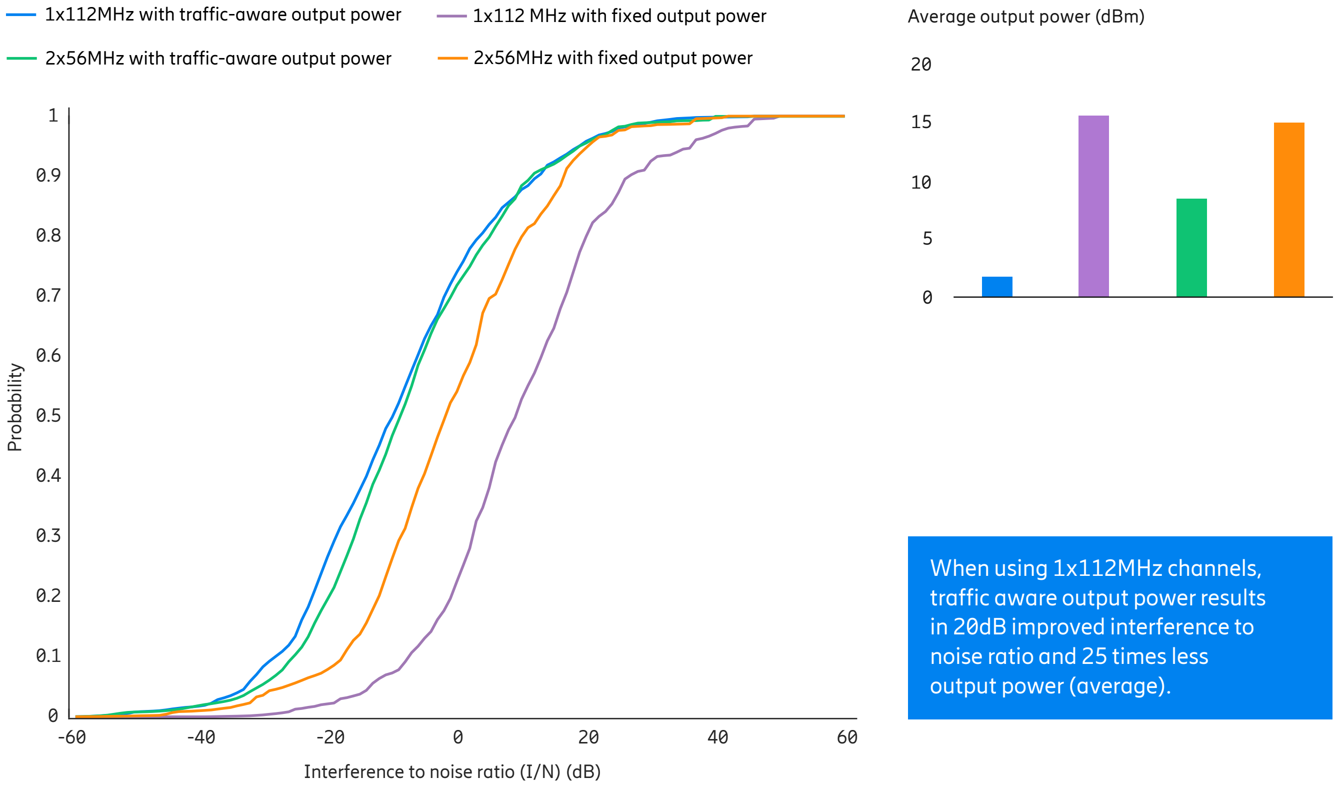
All horizontal and dual-polarized 15GHz links

Selection of links used for simulation

The traffic-aware output power was chosen so that the lowest modulation which fulfills the traffic demand is sought after, that is, it tries to match the output power and modulation to the instantaneous traffic demand as illustrated in Figure 15.

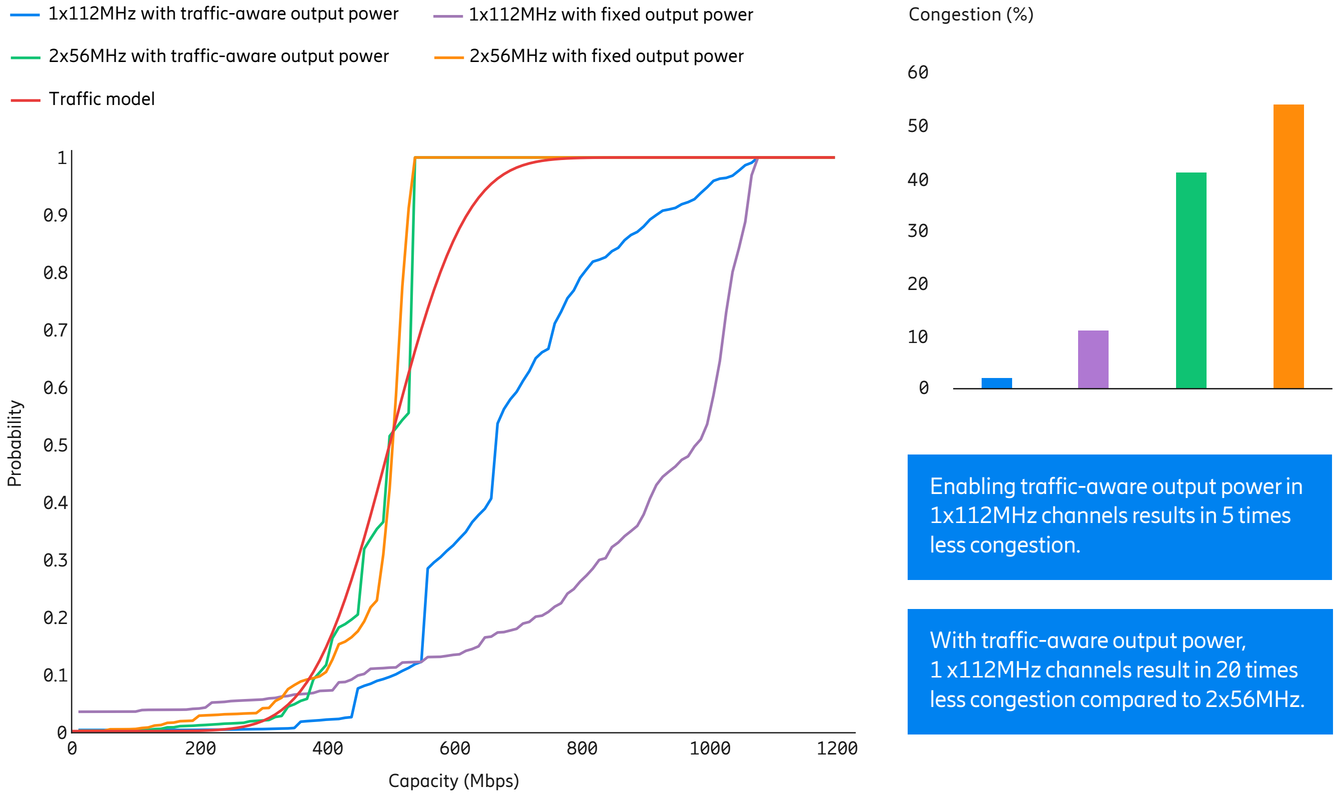
A high traffic demand was assumed and modelled by a normal distributed rate with a mean of 500Mbps and a standard deviation of 95Mbps. Its cumulative distribution function (CDF) is shown in Figure 18. In the simulations, rain cells were placed randomly over the network with a maximum rain intensity of 45mm/hour and the maximum rain attenuation observed in the network was about 35dB. To generate statistics, rain and traffic were generated randomly according to their respective models and in total 50,000 random realizations were generated over the whole network.

Figure 17: Interference with and without traffic-aware output power



When using 1x112MHz channels, traffic aware output power results in 20dB improved interference to noise ratio and 25 times less output power (average).

Figure 18: Comparing 1x112MHz with 2x56MHz channels in a high traffic load simulation



Enabling traffic-aware output power in 1x112MHz channels results in 5 times less congestion.

With traffic-aware output power, 1 x112MHz channels result in 20 times less congestion compared to 2x56MHz.

Simulation results

Figure 17 shows the I/N distribution for the two designs with and without traffic-aware output power. Interestingly, the simulation found that the reuse one (1x112MHz) system with traffic-aware output power has the best I/N performance, even better than the corresponding reuse two (2x56MHz) system. This is because a 112MHz channel needs less output power to support the same capacity as a 56MHz channel and therefore generates less interference. However, using proper planning with two separate 56MHz channels also reduces interference, but the simulations show that a single 112MHz channel is slightly better at reducing interference.

The benefit of using traffic-aware output power compared to fixed output power becomes obvious in Figure 17 where up to 20dB improvement in I/N is observed for 1x112MHz with traffic-aware output power compared to fixed output power. On average, traffic-aware output power results in 14dB of power savings compared to fixed output power for 1x112MHz. A positive effect from traffic-aware output power is also observed in the 2x56MHz case. Therefore, it is recommended to enable traffic-aware output power regardless of channel allocation scheme.

Figure 18 shows the corresponding capacity distribution for the different cases and also the traffic model. Thus, if a capacity curve is to the right of the traffic model, then congestion is less likely to occur. Link congestion is defined as the event when traffic demand exceeds the capacity of the microwave link. We calculated the percentage of congestion out of 50,000 simulations. It is observed that the 2x56MHz system has problems fulfilling the traffic demand and, in fact, it experiences 41 percent and 54 percent congestion with and without traffic-aware output power, respectively. However, the 1x112MHz system performs much better and experiences 2 percent and 11 percent congestion with and without traffic-aware output power, respectively. The simulations also found that the fixed output power case typically generates much higher capacity compared to its traffic-aware counterpart. This is simply a consequence of capacity overprovisioning since the fixed output power is independent of the varying traffic demand. Overprovisioning comes at a price of more output power consumption and interference. The negative effect of more interference is reflected by the higher congestion experienced by the systems with fixed output power. Nonetheless, fixed output power shows the capacity potential of reuse one, and traffic-aware power control will take care of any overprovisioning and provide interference reduction.

On closer analysis of the links that experience congestion, 6 out of the 122 links were found to have clear problems when using the same 112MHz channel, since they are simply too close and therefore suffer from interference. For example, we identified a short link that suffered from strong interference caused by two nearby and much longer links, which typically use much more output power to fulfill their traffic demands. But on the positive side, there were 116 links out of 122 for which reuse one fulfilled the traffic demand with high probability, whereas a reuse two design with a 56MHz channel would have resulted in congestion for those 6 troublesome links.

Conclusions

In conclusion, we need transport solutions that meet the traffic growth in our networks. Such solutions also need to be properly dimensioned, spectrally efficient and sustainable. Furthermore, an efficient way to handle a higher traffic demand with limited spectrum in traditional bands is to enable a more aggressive channel reuse, as was shown in our simulations based on a typical network deployment. In fact, it was shown that using a single 112MHz channel in the whole network, in combination with traffic-aware output power, reduced congestion by 20 times compared to a network with a pair of 56MHz channels. Reuse one can therefore be used to handle higher data traffic demands in our networks with a limitation in spectrum.

Ericsson enables communications service providers to capture the full value of connectivity. The company's portfolio spans Networks, Digital Services, Managed Services, and Emerging Business and is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

www.ericsson.com

Contact your local Sales team
Scan the QR code, or visit
https://www.ericsson.com/en/contact/sales-inquiry

Ericsson
SE-164 80 Stockholm, Sweden
Telephone +46 10 719 0000
www.ericsson.com

EAB-21:00814 Uen