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TEN GOOD REASONS

why mobile operators in Africa do not need 100 MHz of contiguous C-band spectrum each

1. 100 MHz of C-band will not deliver 5G coverage
2. 5G in C-band will not bridge the rural digital divide
3. URLLC does not require 100 MHz of contiguous spectrum
4. C-Band is not the correct solution for achieving URLLC
5. 100 MHz of contiguous spectrum is not the only way to deliver on user expectations
6. C-band will not be the only thriving ecosystem for 5G equipment
7. C-band is not the only suitable band for 5G
8. 100 MHz of C-band is not the cheapest way to roll-out 5G
9. 5G in C-band will not achieve climate change goals
10. 5G in C-band will not provide rapid deployment of Fixed Wireless Access

Global Challenges | Satellite Answers

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Table of Contents

Introduction

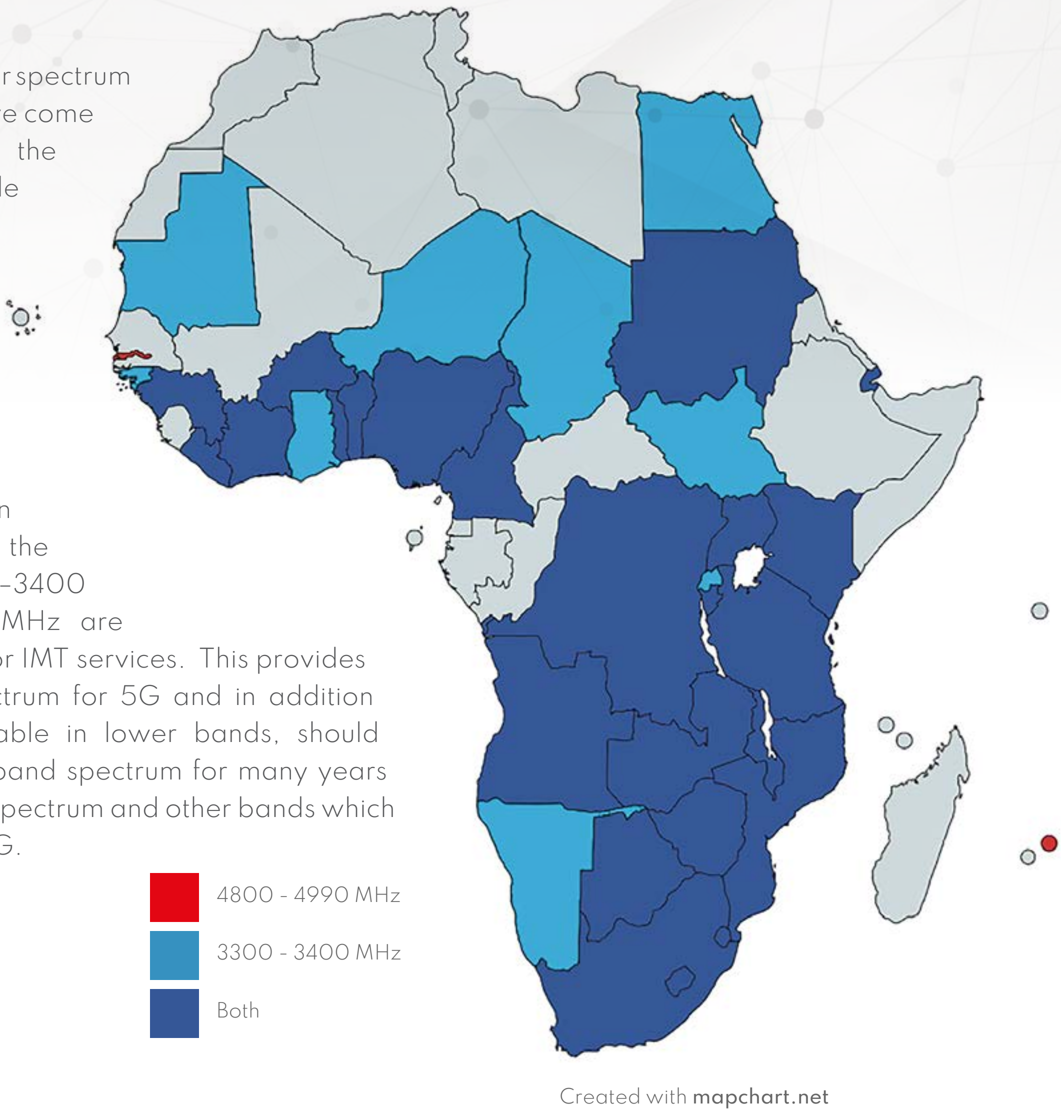
Background

The mobile industry is pushing for at least 80 to 100 MHz of contiguous C-band spectrum per MNO for 5G services across Africa. In Africa, unlike other parts of the world such as Europe, the C-Band is heavily used for broadcasting, backhaul, government, and mission-critical communications, the need for which results from Africa's unique, size, weather, topography, and population distribution.

As a fact, C-band is not unused. It is a busy and vital satellite communications band as evidenced by the more than 50 satellites that have C-band payloads over Africa. A recent report by the GSA and Huawei[1] showed that a number of these satellites are over 80% utilised even without taking into account transponders which have been booked but were not in use at the time. These satellites provide an important service, delivering connectivity in areas with heavy rainfall, and essential communications for users such as governments and airports.

ESOA supports the drive for spectrum efficiency however we have come to realise that some of the arguments being made for contiguous 80-100 MHz blocks of C-band spectrum do not add up, when compared to the importance of the services which already occupy the band.

It is worth noting that in many African nations, the frequency ranges 3300-3400 MHz and 4800-4990 MHz are already being identified for IMT services. This provides nearly 300 MHz of spectrum for 5G and in addition to other spectrum available in lower bands, should satiate demand for mid-band spectrum for many years in addition to existing 4G spectrum and other bands which can be re-purposed for 5G.



MNOs, however, are pushing for access to the whole of C-Band, which is already in use for satellite services, fixed links and in some countries fixed wireless access, despite the already allocated 3300-3400 MHz and 4800-4990 MHz mobile bands **not** being utilised in most countries. The need for additional C-band spectrum therefore needs to be balanced against the impact it would have on the incumbent services, especially considering the argument put across by MNOs that they will not use the C band for rural areas but rather for metro cities only.

Even without additional C-band spectrum, there is no reason for African countries to miss out on the opportunities offered by a decent 5G infrastructure. Arguably, the 5G infrastructure in Africa should eventually be better than elsewhere, because the region is less encumbered by legacy infrastructure than other continents, and in many cases, there is less investment in older technologies that MNOs need to monetise before replacing it.

This lack of legacy infrastructure means that Africa does not need to follow the lead of other continents without considering its unique position. Decisions made in other continents are often driven by compromise. In Europe, for instance, the 5G network will be built on a mature and expanding fibre infrastructure, and in places where there is already good 3G and 4G coverage. 5G is therefore a capacity top-up service in many countries and not intended as a wide-area, stand-alone network.

The first thing to do is split the two demands apart. One is not contingent on the other: 100 MHz channels may be desirable for 5G, but this does not imply that it has to be in C-band. More spectrum might be required, but it can come from elsewhere as there are other bands available (e.g. 2.3, 2.6, 3.3-3.4 GHz and 4.8-4.99 GHz which could be used by terrestrial component of IMT).

The African Telecommunications Union in their paper "Draft Recommendations for the Implementation of 5G (IMT2020) in Africa"[(2)] record that although mobile network operators are asking for 80-100 MHz they would be prepared to accept less. This is because 100 MHz assignments are uncommon and they recognise that spectrum limitations are generally unassailable even before considering the cost of mobile spectrum auctions.

So, why is the mobile industry demanding 100 MHz of contiguous spectrum in the C-band? Here are some of the reasons which have been given:

100 MHz is the MNO's ideal situation (and one never argues for a compromise as an opening gambit).

'Real' 5G requires 100 MHz channels, and without them the networks will not be able to supply the headline speeds that manufacturers have been touting and they believe users are expecting.

100 MHz is essential to deliver Ultra-reliable Low Latency Communications (URLLC) and without this much contiguous spectrum, 5G will not be able to provide the full breadth of services that specialist users are seeking.

Mobile operators wish to avoid local or regional assignments in a 5G band, and certainly wish to avoid sharing spectrum with each other, as this means having to synchronise their TDD networks, either nationally or across borders, which could be difficult to manage as well as introducing additional technical restrictions. Without synchronisation, an inter-operator guard-band is necessary, reducing spectrum efficiency.

C-band is the only 5G band with an active ecosystem of equipment, and as such, it is important that this specific band is made available for new services.

C-band is green-field spectrum in which operators can deploy their networks without needing to re-farm spectrum in other bands allowing more rapid deployment and lower roll-out costs.

5G is important for the economic development of the region, and C-band is critical in delivering these objectives.

As a result of this, operators and manufacturers are putting pressure on regional regulators to open up large amounts of C-band for new 5G services. Bearing in mind that in many African countries the frequency ranges 3300-3400 MHz and 4800-4990 MHz have been identified for IMT, and that most African nations have no more than 4 mobile operators, there is sufficient bandwidth in this spectrum in addition to the 2.3 and 2.6 GHz bands to provide 100 MHz to each operator. Even when there are more than 4 operators, there is still sufficient in this range to provide around 75 MHz each, and all without the need for additional C-band spectrum. In this report, we consider the arguments made for the need for 100 MHz of contiguous C-band spectrum per operator in Africa and examine whether or not they are backed up by facts.

Purpose of this document

This document is intended to provoke debate regarding the reasons which MNOs have given for requiring large amounts of C-band spectrum across Africa.

Key Questions:

Are the reasons MNOs have given real justifications for the need for the spectrum?

Can the needs be met using alternative spectrum, technology or infrastructure?

Most importantly, can Africa go one step further and identify solutions for 5G which are optimal for the region and do not just follow the lead of other continents?

Ten Good Reasons

Reason 1: 100 MHz of C-band will not deliver 5G coverage

The issue

In many African nations, the critical issue for today is not necessarily one of capacity and high speed connectivity, but one of bridging the digital divide and bringing coverage to everyone. 5G will certainly provide good broadband speeds, and therefore MNOs argue that they must have access to C-band to deliver this much needed connectivity.

The facts

New spectrum does not guarantee extended 5G coverage. Over recent years, many countries have licensed UHF frequency bands such as the 800 MHz band to their mobile operators. These lower frequencies are ideal for providing wide-area coverage due to their improved propagation characteristics compared to higher frequencies.

This has not, however, resulted in enormous increases in mobile network coverage.
This could be for a number of reasons:

- Providing 5G coverage requires suitable power and infrastructure to be available, which in large areas of Africa is not the case. New spectrum does not come with metal towers, concrete or electricity supplies.
- Rolling-out service in a new frequency band requires new infrastructure including antennas, base stations and backhaul. Many operators do not have the capital required to do this.
- New technologies and new frequency bands are often not immediately available in handsets, especially more basic devices. Thus, in addition to the cost of rolling-out services, operators may not see a widespread return on their investment for many years.
- Newer technologies tend to deliver higher bandwidth connectivity, and this requires higher bandwidth backhaul. Existing backhaul may be insufficient for newer technologies, either rendering them incapable of providing the necessary connectivity, or requiring additional investment to replace backhaul connections.
- The 5G coverage improvements offered by C-band compared with existing bands is negligible. If operators have not been able to provide sufficient 2G coverage in the long-established 900 MHz band, they will not achieve anything more significant in C-band.

Most European and Asian countries, which have already invested heavily in 4G, are only using 5G C-band for capacity infill in cities, leveraging 5G NR Phase 1 capability. Phase 1 (non-standalone mode) uses existing LTE coverage to carry out control functions, with data capacity provided by a 5G carrier only if additional, overlapping coverage is available. As such, in the first phase of 5G roll-out, a 4G network is required to handle the command and control functions, meaning that 5G coverage can not extend beyond any existing 4G coverage. In the second phase of stand-alone 5G, it is expected that lower frequency (i.e. 700 MHz) coverage will be needed as a command-and-control and coverage layer to support capacity hotspots in higher frequency bands (i.e. C-band or mmWave).

Conclusions

- **New spectrum requires new infrastructure and new investment before it can provide any coverage;**
- **If operators have not achieved widespread coverage with lower frequency bands, they will certainly not do so with C-band spectrum;**
- **There are many other factors affecting coverage which have a much greater impact than the availability of spectrum;**
- **5G service coverage will be dictated by, and limited by, supporting coverage in lower frequency bands. C-band alone will not provide enhanced coverage.**

Reason 2: 5G in C-band will not bridge the rural digital divide

The issue

In many countries in Africa (and indeed around the world), the provision of broadband connectivity in rural areas falls far behind that available in urban areas. Much effort has been expended in trying to bridge this digital divide and operators are indicating that if they are given large contiguous blocks of C-band spectrum for 5G services, it will enable them to provide coverage in otherwise underserved rural areas.

The facts

Not all radio bands are equal. In fact, they are all very different. It is certainly true that the lower the frequency the better it propagates, so millimetre wave bands such as 26 GHz are only suitable for supplying coverage over very short distances (e.g. in demand hotspots) and are therefore more likely to be used in limited areas to offer an improved WiFi-like experience, or for local Internet distribution, or perhaps along major roads for high-reliability transport applications such as driverless vehicles.

Radio waves propagate better at C-Band than in the mmWave bands however C-band is not suitable for wide area coverage. Free space path loss in this band is approximately 2.8 dB higher than at 2600 MHz, for instance and 14 dB higher than at 700 MHz. European MNOs used to complain about the relative cost of supplying national coverage at 1800 MHz when other operators had access to 900 MHz spectrum.

In Europe, which has a higher population density than much of Africa, C-Band is only being used for additional capacity in urban areas. It should also be noted that a major limiting factor to rolling out 5G will be the backhaul requirements. Even on 4G, a site must have fibre backhaul or it cannot achieve the expected data speeds or latency. The limiting factor on network rollout is always the supporting infrastructure and not the number of sites. For instance, the installation cost of a 5G base station is significantly higher if there is no pre-existing infrastructure, such as an existing 4G tower and backhaul. Backhaul is an emerging and variable unknown when costing 5G networks and can be very expensive[3].

Mobile operators have already recognised that C-band is not intended for rural coverage. The GSMA Intelligence report entitled "Economic benefits of using the 3.5 GHz range (3.3-4.2 GHz) for 5G" states, concerning C-band that:

> "...the model only considers benefits to the urban population. Due to its technical characteristics, it is expected that this is going to be the primary use of the band"

Figure 1: T-Mobile radio engineering SVP Mark McDiarmid illustrating with a cake how 5G bands are used
Image Credit: Jeremy Horwitz / VentureBeat[4]

In the VentureBeat article, Jeremy Horowitz says:

"As shown in the photo above, T-Mobile has depicted the three types of signals as a layer cake. The red low band tier covers a lot of space, slowly, while the yellow mid band covers less space at faster speeds, and the red high band covers the least space at super-fast speeds."

He continues:

"In quick summary, the bands work as follows in the real world. One low band (600-700MHz) tower can cover hundreds of square miles with 5G service that ranges in speed from 30 to 250 megabits per second (Mbps). A mid band (2.5/3.5GHz) tower covers a several-mile radius with 5G that currently ranges from 100 to 900Mbps. Lastly, a high band (millimeter wave/24-39GHz) tower covers a one-mile or lower radius while delivering roughly 1-3Gbps speeds. Each of these tiers will improve in performance over time."[5]

Conclusions

- C-band spectrum is not suited to wide area, including rural, coverage;
- Lower frequency bands (such as 700 MHz) are far superior for rural applications;
- Backhaul limitations may stymie the deployment of high bandwidth technologies in rural areas.

Reason 3: URLLC does not require 100 MHz of contiguous spectrum

The issue

Ultra-Reliable Low Latency Communication (URLLC) is one of the new features of 5G which sets it apart from previous mobile technologies, and is considered critical for some industrial applications, for example mission-critical communications and self-driving vehicles. Many operators have argued that unless they have access to a contiguous block of 100 MHz of spectrum, they will be unable to provide URLLC to their subscribers.

5G is best described as a toolkit of features and functions, many of which are mutually exclusive of each other. URLLC is one of these mutually exclusive features of 5G and requires high transmission speeds to enable larger resource blocks which can support these specialist applications.

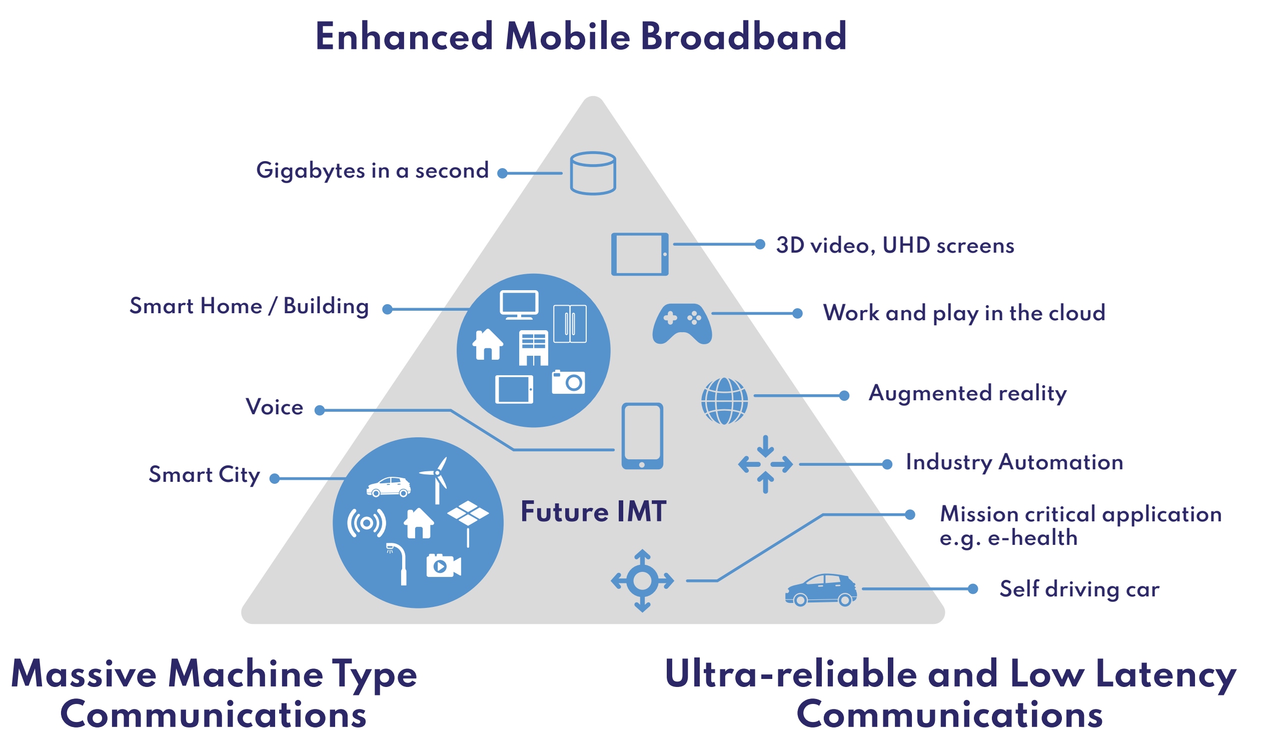


Figure 2: The ITU's 5G triangle

The facts

URLLC is a specialist application more suited to specific instances and not for general (public) use and as such is unlikely to generate the revenues needed to fund widespread 5G roll-out. ITU-R Report M.2410-2017 "Minimum requirements related to technical performance for IMT-2020 radio interface(s)" recommends 100 MHz as the minimum bandwidth required for URLLC (and eMBB). However, it also says that the required 100 MHz can be achieved through multiple carriers: there is no requirement to achieve the 100 MHz through a single carrier using a single contiguous block. URLLC is also not considered a high bandwidth or data-hungry service.

The 5G standard allows for the resource block sizes needed for URLLC in a 50MHz bandwidth which has additional advantages regarding the required signal strength and therefore the service range of the site.[(6)]

URLLC[(7)] is a technique for scheduling packet delivery rather than creating a continuous low-latency path, which means it is actually of little use for some ultra-low latency applications such as those used for electricity power line protection. It is possible using higher orders of modulation, and mmWave frequencies where wider transmission bandwidths are possible to sub-divide a standard timeslot to create smaller 'Mini Slots', which means that these mini slots can be timed to arrive exactly when required and improve latency further. These extremely low latency slots are not achievable in C-band.

Conclusions

- **The technical standard for 5G only requires 50 MHz carriers to achieve URLLC;**
- **URLLC is better delivered in mmWave bands where wider bandwidth carriers are far more readily available;**
- **URLLC is not likely to be a commercial driver of the roll-out of 5G services in Africa, being a specialist service.**

Reason 4: C-Band is not the correct solution for achieving URLLC

The issue

In many parts of the world, C-band is considered the only green-field spectrum band where 5G can be given relatively large contiguous blocks of spectrum which operators claim is necessary for URLLC. As such, the mobile industry claims the need for C-band spectrum for URLLC is being tied with the need for contiguous blocks of sufficiently wide bandwidth.

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The facts

URLLC is actually not frequency dependent. What it requires is bandwidth enough to be able to apply the technique. The time taken for transmission is measured as the transmission time interval (TTI). In 4G (LTE) networks, this is around 1 millisecond, however in 5G networks this can be as low as 140 microseconds.

To achieve these low TTIs requires that the mobile carrier is specifically established to achieve this function. Such a carrier has a different frame structure to other 5G carriers and to legacy mobile technologies, and thus it must operate in unencumbered spectrum, which is to say spectrum which is not geographically or spectrographically bordered by other mobile carriers. As was stated in Reason 3 above, 50 MHz carriers are all that is required for URLLC. Given the need to allow carriers delivering URLLC space around them (due to their different technical characteristics compared to normal 5G carriers), they would therefore require just over 50 MHz in which to operate.

The most straightforward way to deliver URLLC is to roll-out a network in clean spectrum, however, the implication[(7)] is that URLLC is actually intended for use in the mmWave bands (i.e. 26 GHz or higher), where over-the-air transmission distances are very short and backhaul is entirely fibre, with managed packet priority.

In addition, there is little value in achieving 140 microsecond TTI if the backhaul network from the 5G site to the point where the low latency is required introduces additional delays. A radio signal (or light in a fibre) can travel 42 kilometers in 140 microseconds. If, therefore, the distance that the backhaul travels is in the order of 10s of kilometres, this will begin to add additional latency in the order of that achieved by the 5G network itself. URLLC is therefore largely suited in campus or specialist applications where the backhaul infrastructure is short, such as would be installed in an industrial complex, for real-time SCADA applications and not for general coverage network elements.

Conclusions

- **URLLC needs clean, unencumbered free from neighbouring operators, which is more readily found in the mmWave bands;**
- **The main application of URLLC is likely to be in campus and industrial settings, and not on a general network;**
- **mmWave spectrum is far better suited to URLLC applications than C-band.**

Reason 5: 100 MHz of contiguous spectrum is not the only way to deliver on user expectations

The issue

Mobile equipment manufacturers and some MNOs argue that they require 100 MHz of C-band spectrum in order to deliver the kind of data throughputs that 5G is expected to provide. Without access to 100 MHz blocks, they claim that 'real' 5G cannot be delivered, and that users will be disappointed with the service, slowing down the time it would take for any investment in 5G to be recouped.

The facts

A technology called 'Carrier Aggregation' permits operators to bring together capacity from different carriers in the same (or different) frequency bands in order to deliver the required headline connection speeds. Indeed, many 4G operators already use carrier aggregation in their networks and speeds of up to 1 Gbit/s have been achieved with LTE-Advanced using multiple frequency bands.

Carrier aggregation may even have benefits in providing coverage, without any loss of achievable data throughput:

- **According to Ofcom in the UK, the required signal strength for good coverage is -104 dBm.**
- **With a 100MHz C-band carrier, a 30 dBW (1 kW) e.i.r.p. transmitter, and the Okumura-Hata path loss model, gives a range of 2.7 km.**
- **With a 50MHz carrier, the available transmitter power is focussed in half the bandwidth, meaning that the signal produced is 3dB larger, extending the range by 20% (or area covered by 44%). For the same transmitter power, you can therefore cover more area with a 50MHz carrier than you can with a 100MHz carrier.**
- **Using two aggregated 50 MHz carriers may provide better coverage, but with the same data throughput of a single 100 MHz carrier.**

Using multiple frequency bands may also have significant advantages. Different frequencies propagate in different ways and providing a service across a number of bands may provide more connectivity options than a single block of spectrum in a single frequency band, overcoming the obstacles which typically cause coverage problems for mobile networks. In order to serve rural and urban or dense urban areas, a 'portfolio' of spectrum including low, mid and high band frequencies is the best solution specifically because of the better overall balance of coverage and capacity it offers.

Carrier aggregation, however, requires additional processing of signals in user equipment. Studies have shown that this has a power impact of approximately 13% on newer user equipment compared to downloading the same amount of data using a single carrier solution. However, the impact must be taken along with considerations such as whether the use of carrier aggregation means the download is completed faster, with fewer acknowledgement transmissions by the user equipment[8]. If it is faster to download data using frequencies in multiple bands (which may also be less congested), then the small power impact is quickly nullified.

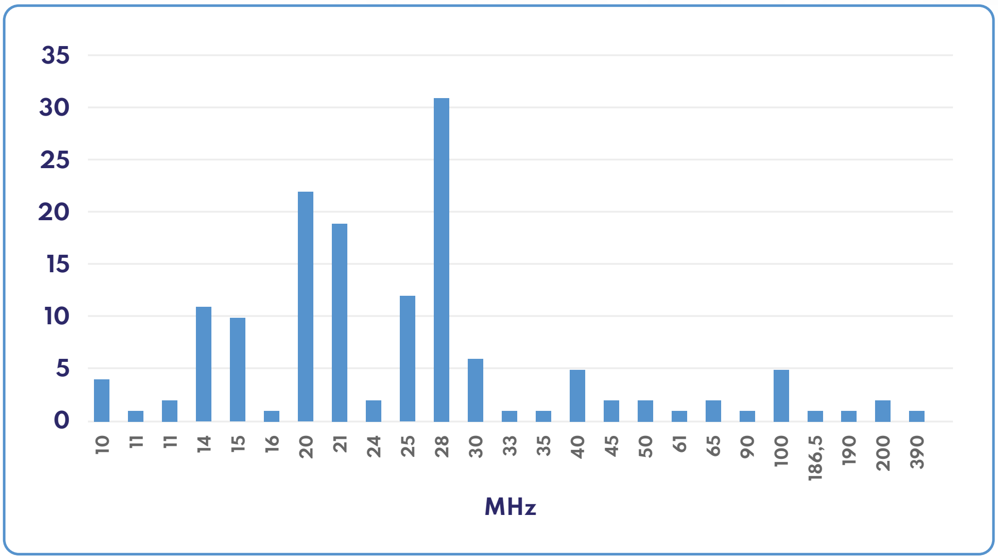
Note that it is the user equipment's transmitter (required only for uplink traffic) that always has the highest impact on battery consumption. If that is the case, then given that mobile traffic is download heavy, carrier aggregation has little appreciable impact on battery life. Indeed as described above, there may even be a power consumption advantage.

ECC Report 287 calculates that the reduction in efficiency of using carrier aggregation compared to having a single contiguous block comprises:

- **A 2.5% reduction in channel utilisation (from 98.3% to 95.8%);**
- **An increase in signalling from 6.3% to 12%;**
- **An increase in carrier activation delay from 2 ms to 10 ms.**

The report did not, however, consider that the solution using carrier aggregation (especially if in different frequency bands) may yield a more reliable connection, reducing the time required to transfer data, and thus from the user perspective, the carrier aggregated solution may be better and the inefficiencies identified may be cancelled out.

It is also worth noting that the report details the actual amounts of spectrum assigned to operators in the C-band. It is notable that the majority do not have access to 100 MHz contiguous blocks.



Based on a questionnaire sent to CEPT countries, the chart to the left shows the amount of spectrum which each operator has been assigned in the C-band. The vertical axis shows the number of operators and the horizontal axis shows how much spectrum they have in C-band as a contiguous block.

Figure 3: Amount of contiguous C-band spectrum assigned to mobile operators. Source: ECC Report 287

MNOs would, naturally, wish to avoid having to run two carriers in the same band at the same location to supply the necessary bandwidth, as this can be more costly from a network equipment perspective. However, this is not the same as 'requiring' 100 MHz of contiguous spectrum.

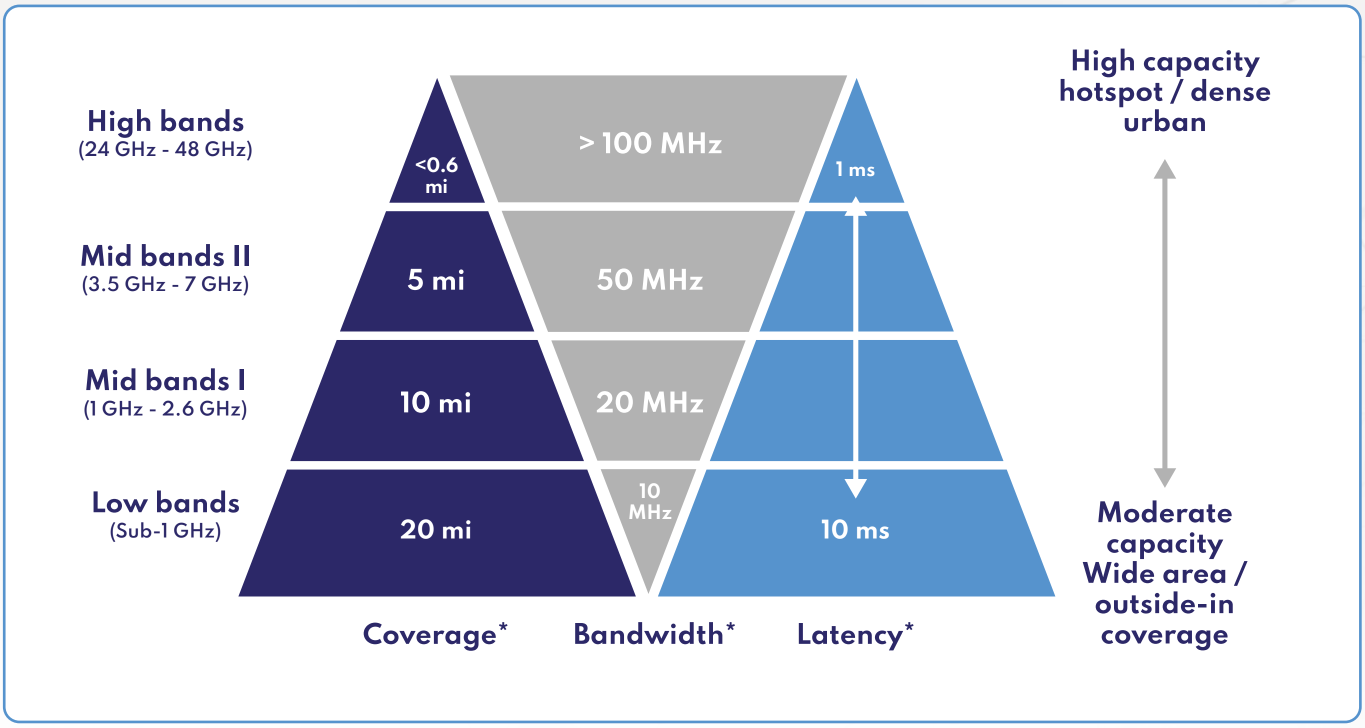


Figure 4: Coverage, bandwidth and latency. Source: Ericsson

Ericsson indicate that their expectation for the 'upper mid bands' is that operators will have around 50 MHz of spectrum.

Conclusions

- Carrier aggregation can deliver the same throughput using different pieces of spectrum, thus there is no need for a contiguous block;
- Smaller bandwidth carriers can improve coverage compared with using a single block;
- Although a like-for-like comparison of the use of a contiguous block compared with 2 aggregated carriers may have shown a small impact on the battery consumption of user devices, many other factors offset this and are likely to counterbalance any increase in battery consumption.

Reason 6: C-band will not be the only thriving ecosystem for 5G equipment

The issue

The mobile industry argues that they must gain spectrum in C-band to provide 5G services as this is the only band for which a thriving ecosystem of 5G products is available. They evidence this by the large number of 5G networks which are being rolled-out in C-band around the world.

The facts

Whilst manufacturers are now beginning to support the mmWave bands, 5G user equipment is mostly available for the sub-6GHz bands. The n78 band (3.5 GHz) is the most popular frequency band in terms of devices announced, which is unsurprising considering the number of networks using this frequency band.

C-band has been, until recently, the main focus for 5G manufacturers and MNOs. This is because it is the lowest green-field 5G NR band available in most countries around the world and offers better coverage when compared to the mmWave bands along with promising capacity not available in the lower bands. Conversely, it is also true that C-Band is a compromise: it is not the best band for coverage and it is not the best band for bandwidth. According to a pro-6GHz article on the GSMA web site, equipment is being made in that band in quantities that result in end-user devices and infrastructure becoming increasingly more affordable in this band[9]. The GSMA itself[10] also believes that there is a shift of emphasis towards 3GPP Band n96 at 6 GHz developing.

According to the latest statistics from the Global Mobile Suppliers Association (GSA), Band n78 is the most popular amongst user devices with over 600 being available. However, this is closely followed by Band n41 (2.6 GHz) which is catered for in around 550 devices and Band n1 (2.1 GHz) which is catered for in almost 500 devices. In comparison, the mmWave bands (n257, n258,

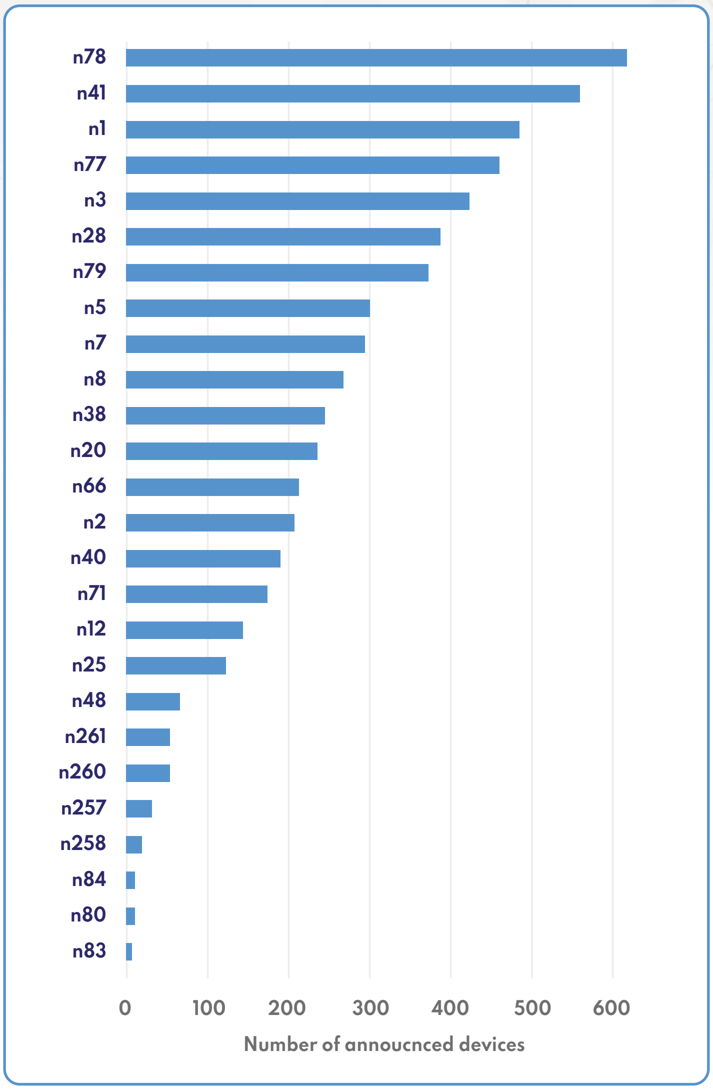


Figure 5: Number of user devices in each 5G band. Source: GSA, 5G Market Snapshot, August 2021

n260 and n261) are currently found in less than 50 user devices. It is notable that there are currently no devices which support 5G in the 6 GHz band (n96). Even Band n3 (1800 MHz) has greater support amongst 5G devices than the 700 MHz band (n28) which is seen in Europe as one of the 'pioneer' bands.

5G devices supporting previous 3G and 4G bands such as the 1800 MHz band (n3) and 2100 MHz band (n1) are appearing in larger numbers because operators, especially in the Americas, have started to deploy 5G in those bands. Over the last year, the number of devices supporting those frequency bands has grown substantially indicating a clear interest from operators in those frequencies as they prepare to convert their existing LTE holdings to complement the mid-frequency bands.

Sub-6 GHz carrier aggregation should further drive the support for those bands including in Europe. In France for instance, Free Mobile (Iliad) has relied on the 700 MHz band (n28) to provide wide 5G coverage at launch in addition to a much lower number of 3.5 GHz sites, whereas competitors have focused initially on 3.5 GHz frequency band experience. Of course, the use of low-frequency bands for 5G comes with inferior throughput due to the lower bandwidth available, but from a marketing standpoint, it enables operators to claim coverage dominance over the competition.

Much of the mmWave device ecosystem has been driven by the need to support US 5G networks. The growth dynamic for mmWave devices has come from the bands used by Verizon Wireless[11]. This has started to change as mmWave deployments have taken place in countries such as Korea and Japan, Russia, Singapore and Italy where usage for FWA has started. The ecosystem for mmWave devices should continue to build up as more countries, including in Europe will start to deploy mmWave networks.

Conclusions

- **Whilst it can be said that more 5G user equipment supports the 3.5 GHz band than any other, it cannot be said that only the 3.5 GHz band is supported by 5G user equipment;**
- **Band n41 (2.6 GHz) and n1 (2.1 GHz) are supported by nearly as many 5G devices as the 3.5 GHz band, surprisingly even more so than the so-called European 5G pioneer band at 700 MHz (n28);**
- **Operators are already beginning to repurpose their 3G and 4G spectrum holdings for new 5G services across a range of frequency bands.**

Reason 7: C-band is not the only band suitable for 5G

The issue

The need for 100 MHz of contiguous spectrum is being intrinsically linked with the use of C-band, whereas in reality the two are different requirements. The reason that the need for 100 MHz is being linked to C-band is that C-band is seen as the only 'green field' band in which 100 MHz blocks of spectrum could be made available.

The facts

C-band is not the only band which can be used for 5G. Indeed, the list of potential 5G bands includes a wide range of options, in particular the 2.3 GHz and 2.6 GHz bands (3GPP NR Bands n40 and n41 respectively) which offer clear opportunities for large contiguous blocks for operators should this be an important factor. Many African countries are yet to licence either or both of these bands, meaning that there is a unique opportunity to provide 5G in bands which are, in many ways, better suited than the C-band and would not impact the use of the band and its existing services.

Of 27 African nations surveyed:[(12)]

- **Only 12 (44%) have licensed any spectrum in the 2.6 GHz band;**
- **Only 5 (14%) have licensed any spectrum in the 2.3 GHz band.**
- **Less than 5 have licensed any spectrum in the 700 MHz band.**

The lower bands (i.e. 700 MHz) will be used for the basic wide-area coverage, with higher frequency bands used primarily to support additional capacity in areas that require it due to the higher site density achievable. It is therefore as important (if not more important) to licence the lower frequency bands which are required for stable coverage as it is to licence any of the higher bands whose use is for capacity only.

Many manufacturers and operators are now considering 6 GHz being promoted as an alternative to C-band as it offers more capacity, higher frequency reuse (5 dB higher path loss, which is good for radio capacity planning) and equipment is becoming available.[(10)]

The lower bands may already be in use supporting legacy systems, perhaps LTE, but also UMTS and GSM. These bands will be migrated to 5G eventually as is already happening in North America. In Africa, this may take some time as 3G and 4G continue to provide important services and returns on the assets supporting them need to be maximised. However, there is sufficient spectrum in other bands to make returns on 5G roll-out easier in many African nations than in other parts of the world.

Conclusions

- C-band is not the only band in which 5G can operate and many of the alternative bands have yet to be licensed in many African countries;
- The 6 GHz band is being seen as a strong alternative to urban C-band capacity infill;
- Lower frequency bands (such as 700 MHz) are vitally important for 5G networks and should be licensed first.

Reason 8: 100 MHz of C-band is not the cheapest way to roll-out 5G

The issue

Allied with the previous argument that C-band is needed as it is the only band where a suitable ecosystem of 5G products exists, is the notion that having 100 MHz of C-band spectrum is the cheapest way to provide 5G. It is cheaper as it is a green-field piece of spectrum and so no re-farming is necessary, and it is cheaper because it is a band in which there is such a wide range of equipment available.

The facts

If 5G is to be rolled out in C-band, studies have shown that there is a need for a guard-band between 5G services and satellite services, and that there is the need to fit a filter to satellite receivers in order to prevent 5G transmissions from overloading satellite receivers.

One question is then who will pay for the guard band between 5G and the satellite band? Ordinarily, there is a choice between one of the interested parties paying (in this case the mobile operators or those receiving satellite signals). This guarantees that the party that pays gets to use that spectrum safely. However, it is also possible for the regulator to retain that spectrum with a view to perhaps using it for applications less likely to interfere with the two adjacent users such as low-power services in industrial complexes away from C-band receivers.

A bigger question is who pays for the changes necessary to satellite earth stations (for example, the fitting of filters)?

- Mobile operators could pay (or the required funds could be taken from any proceeds raised at auction), however the exact number of stations affected may not be known making calculating the total costs difficult. For instance, wireless operators in the US are contributing to reimburse satellite operators (almost US$10 Billion) of the costs satellite operators have incurred in vacating the portions of C-Band that wireless operators have purchased for 5G services in the USA[13].

- Those who wish to continue to receive satellite services (i.e. consumers) could pay for the necessary changes, however they may argue that it is something they have not instigated which has led to the need for mitigations, and thus it is not their responsibility to pay. In addition, many of those receiving satellite signals (i.e. domestic reception) may not understand why their reception has been interfered with and thus recognise the need to fit a filter or make other changes.
- The regulator could pay for the mitigations. This has been done, for example, in the case of the introduction of the 800 MHz mobile band in which many domestic television receivers required filters to be fitted, however such a programme can be expensive to set-up and run.

The whole issue of guard-bands and mitigations (such as filters) does not apply to the use of other 5G frequency bands such as 2.1, 2.3 or 2.6 GHz. Thus, whilst equipment vendors may wish to push 5G equipment in C-band, given the need for mitigations, there may be a range of additional costs which would be incurred.

Conclusions

- The need for a guard-band of up to 100 MHz between 5G and satellite in C-band means some spectrum has to be left largely unused, which is not an efficient use of spectrum;
- The cost of mitigations to allow 5G and satellite services to co-exist in C-band are not trivial and may exceed any cost savings on network infrastructure (i.e. base stations).

Reason 9: 5G in C-band will not achieve climate change goals

The issue

There are a myriad of applications to which 5G is planned to be put. Amongst these is for tools which will assist with achieving climate change goals. Operators therefore argue that introducing 5G will be effective in combating global warming including the fact that 5G equipment will be less power hungry than previous mobile generations.

The facts

According to Zhengmao Li, EVP of China Mobile, a 5G mobile phone base station uses 3x the power of an equivalent LTE base station, mainly down to the 'massive MIMO' arrays used. 5G in C-band also requires 3x more base stations due to the higher frequencies involved. Some of this could be put down to China's well-publicised difficulties accessing 5G technology due to US sanctions, and perhaps also commercial posturing, but there is no smoke without fire[14].

A conventional LTE base station may have 4 transmitters and 4 receivers, but the equivalent 5G base station would have 64 transmitters and 64 receivers to cover the massive MIMO required, particularly given the poorer propagation achieved at 3.5 GHz compared to lower frequency bands. Even if the transmitters are individually more power efficient, that is a significant step up in power requirements.

A representative 4G/LTE site would use about 6kW of power, assuming a conventional 3-sector, 12 transmitter arrangement. The equivalent 5G site is likely to need a 10kW minimum provision[15]. Power savings can be made by reducing the number of transceivers in use from 64 to 32, or maybe even 16, but this comes at the expense of lower speed and capacity and with it a requisite reduction in the ability to deliver the headline 5G connectivity which users expect.

Approximately 80% of the power consumed by a mobile network is used by the base stations. To overcome these issues, 5G base stations can go into sleep mode when underutilised. This doesn't mean the site powers down until a user appears, but it can idle or turn off certain functions until required, including cutting down on control channel traffic. Using TDD instead of FDD means the base station is only transmitting part of the time, usually at a ratio of 70% downlink to 30% uplink. This promises an increased energy efficiency of 'up to' 30%[16]. The same source makes several assumptions regarding how 5G base stations can reduce power consumption, some less convincing than others. For example, for the same field strength, over the same area the use of higher frequencies (i.e. C-band compared with 700 MHz) will result in the need for more sites. Even if each of these sites is using lower power the total power consumption will likely increase. Efficiency improvements would only happen if the smaller sites were targeting coverage more accurately (implying that the big site was wasting coverage where it was not needed), and this ignores the costs associated with commissioning and backhauling multiple sites instead of one.

There is also little to suggest that any climate change improving applications which will run across a 5G network could not also run on existing 4G networks.

Some simple calculations:

- **In pure terms of area (Africa's land mass comprises 11,730,000 square miles) against coverage, that's an absolute minimum of around 30,000 sites to cover Africa on low band (i.e. 700 MHz) using a fixed, and theoretical raster of sites. Terrain restrictions would increase that figure.**
- **On C-Band, with a practical maximum coverage of no better than 10 square miles, 1.2 million base stations are required. That is, again, a basic fixed raster and does not take into account terrain or the need for overlapping coverage.**
- **Given power requirements of 10 kiloWatts per 5G site, that is a minimum continuous burn of 12 TeraWatts of power, simply to get continental coverage at C-Band.**
- **The sites only use 80% of the network's total power burn, so the absolute minimum total burn is going to be nearer 15 TeraWatts. That equates to 30,000 full-sized 500 MegaWatt coal-fired steam turbines running 24/7 solely to power a pan-African C-band 5G network.**

Conclusions

- 5G base stations will consume more electricity than an equivalent 4G base station;
- Many more 5G base stations will be needed in C-band than in lower bands, or compared with those required than 4G base stations;
- Together this means that 5G in C-band will be orders of magnitude more power hungry than a 4G network, offsetting any green credentials that operators may claim that applications on their network may provide.

Reason 10: 5G in C-band will not provide rapid deployment of Fixed Wireless Access

The issue

One of the services which currently occupies some of the C-band spectrum in many African nations are local area fixed wireless access (FWA) operators. These operators have had varying degrees of success, however they will have to be migrated out of the band to permit the mobile operators to roll-out 5G in the band. Mobile operators claim that they would be able to provide rapid deployment of their own FWA services (i.e. to supplant the existing services) if given sufficient C-band spectrum for their 5G networks.

The facts

In many countries in Africa, the lower part of the C-band (typically 3.4–3.6 GHz) has been assigned to fixed wireless access (FWA) operators. These operators typically provide broadband wireless connections to users and businesses in areas where the terrestrial (fibre and copper) infrastructure is poor or even non-existent. Many have invested heavily in equipment and infrastructure and provide a valuable service supporting commerce and development. Equipment for the band is relatively readily available meaning that if the services were forced to re-locate to a different frequency band, they may no longer be economically viable. Many also provide important competition to incumbent fixed and mobile operators, keeping prices reasonable and ensuring that operators do not take advantage of their oligopolistic positions.

Forcing them to close by re-assigning the band to mobile operators for 5G would have a number of negative effects:

- It would cut-off vital connectivity for their existing customers;
- It would allow incumbent operators to increase their prices for connectivity;

- It would effectively shut down the FWA companies by government decree in preference to a 5G service;
- The FWA operators may need to be compensated if they are required to move. This compensation should allow them to re-equip for a different band (for instance).

Of course it could be argued that these FWA operators could bid for spectrum in C-band were it to be made available through auction so that they could continue to operate their service, however their business model is very different to mobile operators and is predicated on a comparatively low number of subscribers and a relatively low cost base.

As has been previously stated, the availability of spectrum to mobile operators does not guarantee that they will roll-out services as they will need to ensure that they have the investment to do so. In addition, 5G FWA user equipment is far more expensive than that currently being deployed by most FWA operators which would push up the cost (and price) of provision.

Conclusions

- In many countries existing FWA services in C-band provide vital connectivity and competition;
- Providing mobile operators with C-band spectrum will require these existing services to come to an end;
- Alternative FWA services based on 5G are likely to:
  - take a long time to develop,
  - be more expensive than existing services, and
  - take away important competition to mobile operators' services.

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References

1. The Systems House. "African C Band Satellite Report" https://gsacom.com/paper/african-c-band-satellite-report-the-systems-house-2021/
2. Task Group on Emerging Technologies. Draft Recommendations for the Implementation of 5G (IMT2020) in Africa. s.l. : African Telecommunications Union (ATU), 2021.
3. The cost, coverage and rollout implications of 5G infrastructure in Britain. Edward J. Oughton, Zoraida Frias. Issue 8, 2018, Telecommunications Policy, Vol. Volume 42. 0308-5961.
4. Horwitz, Jeremy. The definitive guide to 5G low, mid and high band speeds. [Online] VentureBeat.com, December 2019. https://venturebeat.com/2019/12/10/the-definitive-guide-to-5g-low-mid-and-high-band-speeds/.
5. Ray Sharma. Vodafone Narrowband IoT service. [Online] The Fast Mode, 2019. https://www.thefastmode.com/investments-and-expansions/20443-vodafone-uk-doubles-nb-iot-sites-to-expand-coverage-to-98.
6. ShareTechNote.com. 5G Frame Structure. [Online] https://www.sharetechnote.com/html/5G/5G_FrameStructure.html.
7. metaswitch.com. What is 5G ultra reliable low latency communications (URLLC). [Online] https://www.metaswitch.com/knowledge-center/reference/what-is-5g-ultra-reliable-low-latency-communications-urllc.
8. LTE-A UE Power Consumption for Carrier Aggregation Scenario. Santos, Paulo T. M., et al. 2020, XXXVIII SIMPÓSIO BRASILEIRO DE TELECOMUNICAÇÕES E PROCESSAMENTO DE SINAIS – SBrT 2020, 22–25 DE NOVEMBRO DE 2020, FLORIANÓPOLIS, SC.
9. GSMA. 3.5 GHz TDD Synchronisation Q&A. London : GSMA, 2020.
10. GSMA. The importance of 6 GHz for 5G's future. [Online] GSMA, May 2021. https://www.gsma.com/spectrum/resources/6-ghz-for-5g/.
11. 5G Observatory. 5G Products (overview). [Online] March 2021. https://5gobservatory.eu/market-developments/5g-products/.
12. LS telcom. Analysis of the World-Wide Licensing and Usage of IMT Spectrum. ESOA. [Online] 5 April 2019. https://esoa.net/wp-content/uploads/2019-04-LSTelcom-Analysis-of-Licensing-Usage-of-IMT-Spectrum.pdf.
13. Mike Dando. C-band auction maps and charts: Who won what, where and how much. [Online] LightReading, 25 2 2021. https://www.lightreading.com/5g/c-band-auction-maps-and-charts-who-won-what-where-and-how-much/d/d-id/767682.
14. BROWN, Gabriel. Challenges of 5G deployment, according to Zhengmao Li. [Online] 2019. https://twitter.com/Gabeuk/status/1099709788676636672.
15. LightReading. 5G base stations are hungry, hungry hippos. [Online] LightReading.com, 2019. https://www.lightreading.com/mobile/5g/power-consumption-5g-basestations-are-hungry-hungry-hippos/d/d-id/749979.
16. KEITH, Robert. 5G Energy Efficiency Explained. [Online] A10 Networks. https://www.a10networks.com/blog/5g-energy-efficiency-explained/.