The WRC Series

3.5 GHz in the 5G Era

Preparing for New Services in 3.3-4.2 GHz

October 2021

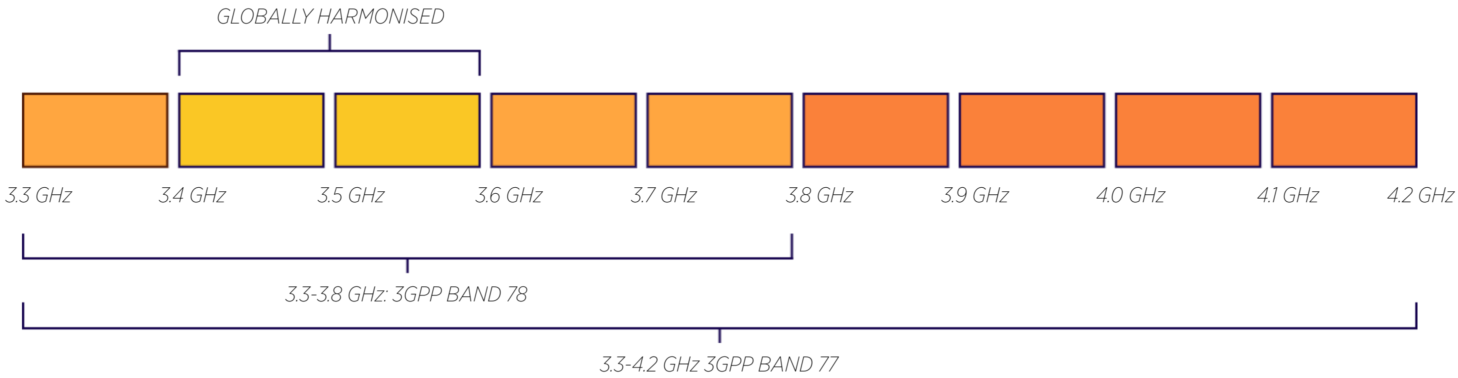
Introduction

Frequencies in the range 3.3-4.2 GHz are being used as the basis for the first implementations of 5G globally.

This spectrum is at a balancing point between coverage and capacity that provides the perfect environment for the earliest 5G connectivity. Planning of these frequencies has taken place over multiple WRC cycles and work on harmonisation continues today. However, in recent years, the 3.5 GHz range's status as the principal 5G launch band has become clear globally and with that comes a wider ecosystem, device diversity, and increased competition.

5G networks are also reaching into mmWave for the highest capacity and will use lower frequencies to provide greater coverage. However, all over the world the equilibrium provided by 3.3-4.2 GHz has seen these frequencies become the birthplace of 5G.

Early work and harmonisation



The use of band 3.3-4.2 GHz for mobile broadband has been the subject of harmonisation activity at various points in the past fifteen years, both at the ITU and within regional groups.

Work at the ITU has provided significant volumes of technical data regarding the performance of mobile networks and their interaction with other services. However, global harmonisation within the band 3.3-4.2 GHz is limited, with only a small portion of 200 MHz at 3.4-3.6 GHz having near-global harmonisation. Regional groups and individual countries have overtaken this.

Europe's process for making the band 3.4-3.8 GHz available started before WRC-07 and while practical implementation issues remain, the band has been successfully harmonised for 5G within Europe / CEPT. ASMG announced plans in December 2018 to move ahead of the ITU process with the harmonisation of the range 3.3-3.8 GHz for IMT and countries have already turned this decision into local spectrum plans, meaning that spectrum throughout the range is already used by 5G subscribers. There are not always regional decisions to support national use. In North America, both the US and Canada have implemented plans to use significant amounts of the spectrum beyond what will be ratified for use even by WRC-23. Latin America has seen Brazil, Peru, Uruguay and others announce at least 400 MHz while Asian countries such as Japan and Korea have led the world in assigning 500 MHz or more spectrum to mobile operators in the 3.5 GHz range. Outside of Asia, WRC-23 is an opportunity for the Radio Regulations to catch up in many of these cases.

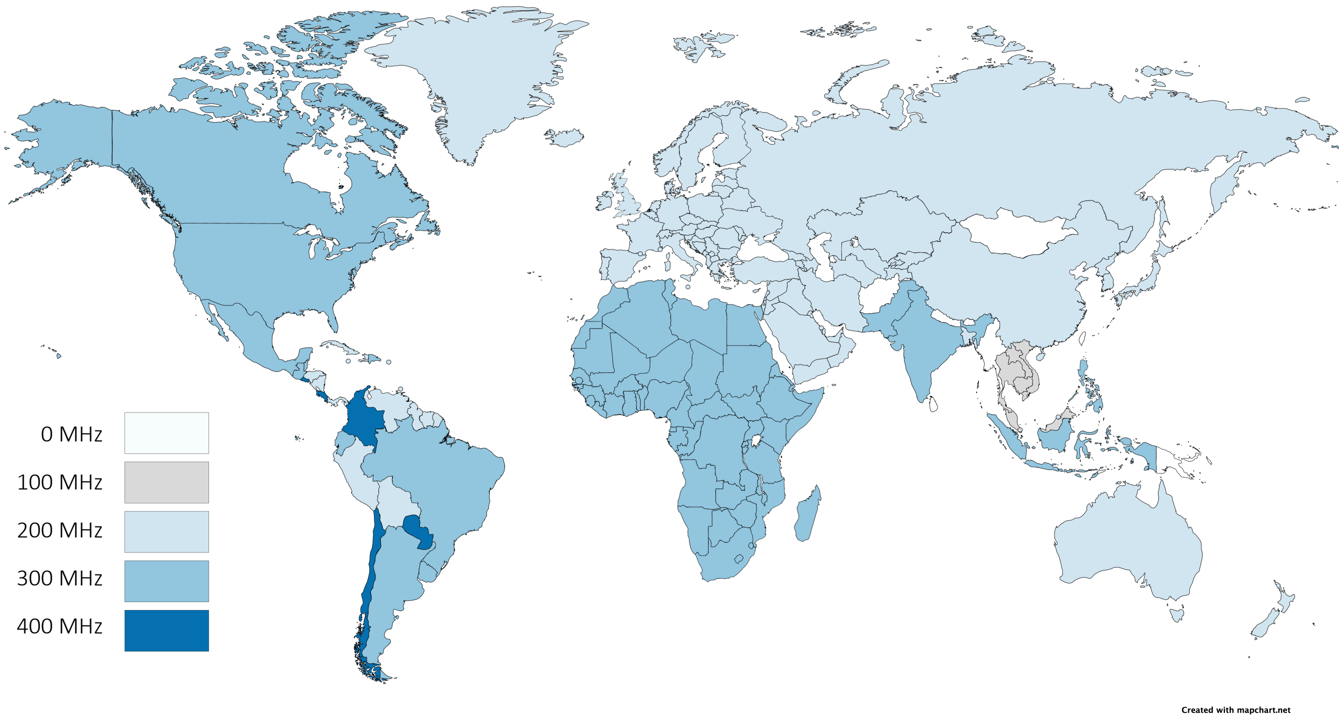
For the 3.3-4.2 GHz frequencies, channels of 80-100 MHz are required for each operator to maximise the efficiency and affordability in the first phase of roll out. More capacity will be required as demand increases. The earliest adopting markets from North America and Europe, through the Persian Gulf to East Asia, have made strong capacity plans in this range. Europe and Gulf countries are using 3.4-3.8 GHz for 5G launch. Japan is looking at 3.6-4.2 GHz, having already made 3.4-3.6 GHz available for LTE and 3.6-4.1 GHz for 5G. The US is making the bands 3.55-3.7 GHz and 3.7-3.98 GHz available for 5G while Canada will make 500 MHz of spectrum available.

The figures on the next page show the disparity between what has been agreed at the ITU and what is being used for 5G launches in the first markets. Historically, an IMT identification at the ITU was the first step of the development of a band for mobile broadband. While 3.5 GHz was first discussed from 2003 at the ITU, the real world has moved beyond the Radio Regulations. The first map on the next page shows the extent of the 3.5 GHz range that is identified for IMT in the ITU Radio Regulations. The second shows where countries have moved beyond the WRC decisions and assigned more spectrum on a regional or country level. These show a clear picture of the disparity between what is being used/planned on a national basis and the Radio Regulations.

The new Agenda Items for the 3.5 GHz range which are being considered at WRC-23 are an opportunity to correct some of this disparity and harmonise the band. Doing so will encourage investment, build competition and lower the costs of mobile broadband.

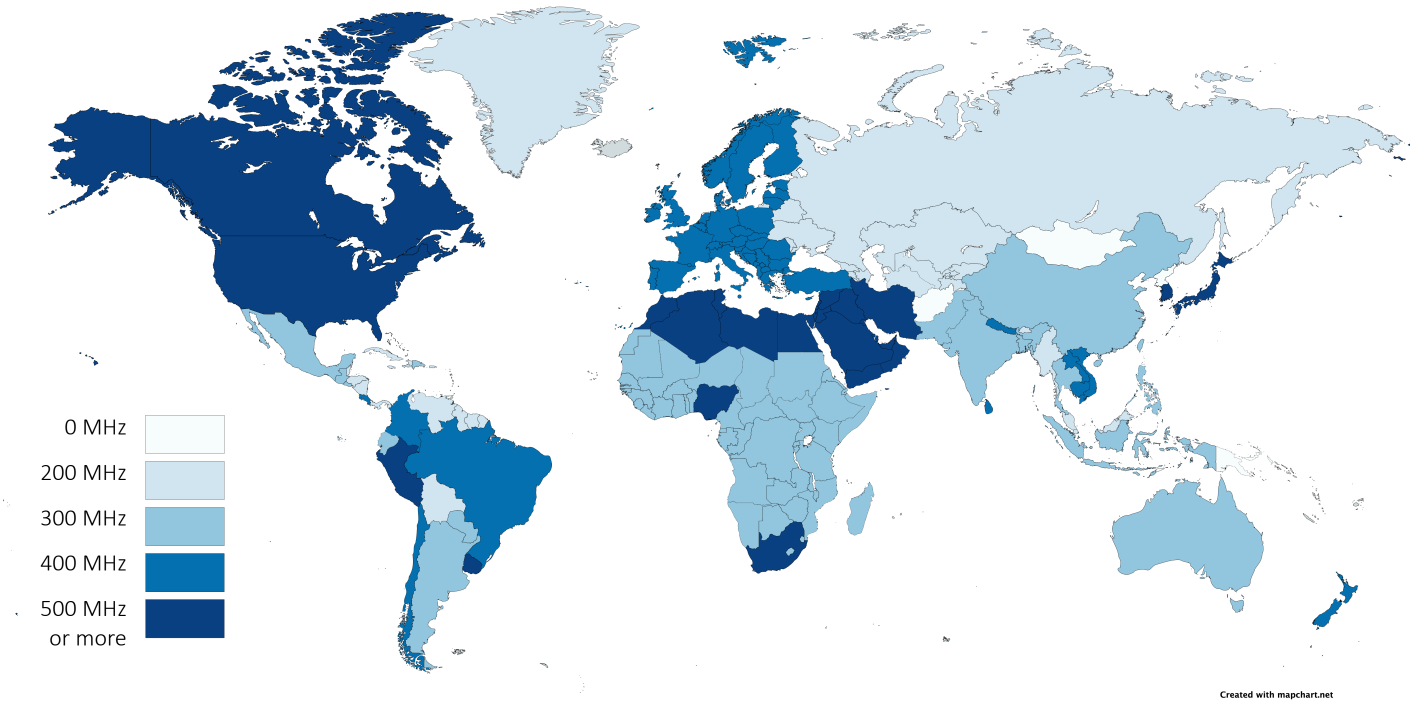
3.3-4.2 GHz IMT identifications

This figure shows how much spectrum in the 3.3-4.2 GHz band is identified in the Radio Regulations



Reality: countries have moved beyond the Radio Regulations

This figure shows how 5G markets have moved beyond the ITU in their 3.3-4.2 GHz assignments



3.3-4.2 GHz at the ITU

There has been a long-standing project to harmonise spectrum between 3.3-4.2 GHz within the ITU and the band has been subject to multiple WRC Agenda Items. This started in 2003 and with WRC-23 will continue up to 2023. This range was discussed in WRC-07 where some regional harmonisation was achieved. At WRC-15, the band was again discussed and while some near-global harmonisation was realised in the band 3.4-3.6 GHz, only this 200 MHz piece was widely identified for IMT. Attempts to widen the part of the band which was harmonised at the ITU were unsuccessful ahead of the launch of 5G and countries moved beyond the Radio Regulations.

However, some regional activity has spurred harmonisation outside of the WRC process. Arab countries have moved to make the band 3.3-3.8 GHz available for IMT immediately and seek further harmonisation at the ITU at a later stage. This echoes pan-European activity through CEPT which has worked to make sufficient spectrum available for the first phase of 5G at launch in the 3.4-3.8 GHz range.

3.4-3.6 GHz is harmonised in the Radio Regulations. On top of this, 5G services using other parts of the 3.5 GHz range are sometimes the subject of agreements at the ITU. Footnotes for 3.3-3.4 GHz and 3.6-3.7 GHz were also agreed at WRC-15. However, the identification to IMT is not harmonised globally beyond the first 200 MHz segment, 3.4-3.6 GHz, and some recent regional decisions to introduce IMT in parts of the 3.5 GHz range are not yet reflected in the Radio Regulations. There is a need to address this situation in order to ensure that what is agreed at the ITU keeps up with the reality: WRC-23 is an opportunity to do this.

ITU Timeline

WRC-07	WRC-12	WRC-15	WRC-19	WRC-23
80 countries sign into footnotes for 3.4-3.6 GHz	New Agenda Item agreed to discuss 3.4-4.2 GHz, inter alia	3.4-3.6 GHz harmonised; some additional identifications at 3.3-3.4 and 3.6-3.7 GHz	New Agenda Item agreed for WRC-23	Parts of 3.3-3.8 GHz being discussed for Regions 1 and 2

Outside ITU

2011	2017	2017	2018	2018	2018
Conditions of 3.4-3.8 GHz finalised in EU for 4G	First auctions of 3.4-3.8 GHz in Europe following agreement of use by 5G	CITEL approves 3.3-3.7 GHz bandplan for TDD	US announces flexible use of mid-band spectrum at 3.7-4.2 GHz	Arab countries announce use of 3.3-3.8 GHz	China assigns use of 3.4-3.6 GHz

2019	2019	2020	2020	2020	2021
Japan assigns spectrum between 3.6-4.2 GHz	Gulf Cooperation Council countries assign 3.4-3.8 GHz (Kuwait, Oman, Qatar, Saudi, UAE)	Canada considers flexible use in the band 3.650-4.0 GHz through public consultation	Brazil announces auction of 3.3-3.7 GHz in 2021	New Zealand assigns 3.590-3.750 GHz	US assignment of 3.7-3.98 GHz

WRC-23 opportunity

Agenda Item 1.2

"to consider identification of the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz, 7 025-7 125 MHz and 10.0-10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 245 (WRC-19)"

Agenda Item 1.3

"to consider primary allocation of the band 3 600-3 800 MHz to mobile service within Region 1 and take appropriate regulatory actions, in accordance with Resolution 246 (WRC-19)"

WRC-23 will consider expanding the amount of the 3.5 GHz range that is allocated to the mobile service and identified for IMT in the Radio Regulations. It is a chance to make sure that the band is widely harmonised and can allow countries to make use of the band for 5G at such a time as suits them.

The two Agenda Items will consider a primary allocation for mobile where it does not already exist. The primary allocation will mean that bilateral negotiations with other countries on cross-border coordination are done on a level playing field with mobile having equal rights. The mobile allocation will encourage network investment based on the certainty that the new mobile networks can be protected by successful coordination.

An IMT identification will help boost global harmonisation. It will drive network roll-out and encourage investment from equipment developers and network operators alike. The harmonisation creates a virtuous circle, expanding marketplaces for handsets which in turn creates a wider ecosystem, boosting diversity and competition while lowering costs.

WRC-23 Agenda Item 1.2 will consider an IMT identification in the band 3.3-3.4 GHz in Regions 1 and 2 while looking at 3.6-3.8 GHz in Region 2 only. Meanwhile, Agenda Item 1.3 considers a mobile allocation in 3.6-3.8 GHz in Region 1. Both of these will create a platform to give guidance to government and industry for the use of the band 3.3-3.8 GHz for mobile.

In the Americas, wider use of the band already exists. Spectrum beyond the Radio Regulations has been planned for use at the onset of 5G in countries throughout Latin America while the US 5G spectrum package includes use of the range up to 3.98 GHz and Canada has consulted on similar frequencies.. Agenda Item 1.2 is an opportunity to clear up the regulation surrounding 3.5 GHz and harmonise its use throughout the Americas. In Region 1, the mobile allocation being considered is a robust mechanism to enable 5G use of the band but is a softer approach. In some circumstances this might not have had the same positive impact on harmonisation. However, in Region 1, this spectrum is already harmonised for 5G in CEPT and ASMG so harmonisation is already agreed.

WRCs are a partnership between government and industry and 2023 will be an opportunity to overcome some of the challenges of 5G and connect more people. Spectrum is one of the drivers which can help achieve better digital equality and WRC-23 can help build a clear roadmap for the future. Harmonising 3.5 GHz to give sufficient channel sizes can have a huge impact on broadband cost and at the same time drive forward new 5G services.

The right decisions in Agenda Items 1.2 and 1.3 will not force any government's hand, but they will give them the opportunity to plan connectivity in their countries in the future. Ensuring WRC-23 gives national administrations that flexibility to move forward with their 5G plans will play a vital role in making sure 5G is for all.

Network density and cost savings

Sufficient channel bandwidth plays a vital role. Wider channels lower network density and this is an important factor in determining the cost of 5G services to consumers. However, it also has other advantages including less base stations sites and lower environmental impact. The number of sites is inversely proportional to channel bandwidth: narrower channels mean more sites. Decreasing channel size from 100 MHz to 60 MHz in the 3.5 GHz range will require increasing the number of cell sites by 64%.

CHANNEL SIZE IMPACT

100 MHz → 60 MHz =

64% INCREASE IN NUMBER OF CELL SITES

Ecosystem benefits from wider channels

MNO

Lower infrastructure costs leading to satisfying increased traffic ...and increased connectivity

MOBILE ECOSYSTEM

Expansion as a result of new subscribers and demand, leading to additional value-add for the economy

PRODUCTIVITY

Access to mobile broadband in urban areas enabling consumers to carry out more tasks, more efficiently

WIDER ECONOMY

Expansion of the mobile ecosystem will increase economic trade

GSMA Intelligence study on 3.5 GHz cost saving

GSMA Intelligence recently did a study which showed that assigning operators a wider tranche of spectrum in the 3.5 GHz band adds up to a huge regional cost saving. It considered a "base case" of 200 MHz of 3.5 GHz spectrum and calculated benefits for alternative cases with greater spectrum availability. It reported findings on the cost savings in each region that can be made if that 200 MHz of spectrum – in many cases this is the amount identified by WRC-15 – is increased to totals of 500 MHz and 900 MHz.

- The model was written to take conservative estimates considering only urban populations. These are expected to be the primary, although not the only, area that benefits from the 3.5 GHz range due to its technical characteristics.
- Data traffic in urban areas is forecast for the period 2020-2035, based on data consumption, number of subscribers and population forecasts.
- Future regional CAPEX/OPEX necessary to satisfy the growing demand is calculated considering aspects such as current spectrum availability, technological changes, % of 3.5 GHz allocation
- Infrastructure benefits are calculated based on cost savings from non having to build base stations. Revenues for handset, content and ecosystem are based on additional number of subscribers.

Global findings from GSMA Intelligence:

additional 300 MHz

$50 BILLION

additional 700 MHz

$80 BILLION

Regional breakdown

Region	Cost savings for 300 MHz increase above 200 MHz ITU baseline
Latin America & Carribean	US$ 3.5bn
North America	US$ 16bn
MENA	US$ 2bn
Sub-Saharan Africa	US$ 3bn
CIS	US$ 1.5bn
Europe and Central Asia	US$ 4bn
South Asia	US$ 4bn
South East Asia	US$ 3.5bn
East Asia & Pacific	US$ 14bn

Channel bandwidth and network performance

For the 3.3-4.2 GHz frequencies, channels of 80-100 MHz are required for each operator to maximise the efficiency and affordability in the first phase of roll out. More capacity will be required as demand increases. The earliest adopting markets from North America and Europe, through the Persian Gulf to East Asia, have made strong capacity plans in this range.

As explained on the previous pages, channel bandwidth has a critical impact on the cost of building networks and through this alone consumer broadband prices can be impacted. However, other issues exist of equal importance.

The availability of at least 80-100 MHz channel bandwidth per 5G network will boost peak, average and cell edge throughput with affordable complexity. Peak data rates are impacted by channel bandwidth and spectrum efficiency techniques such as MIMO should build on an environment where there is already sufficient channel bandwidth. Aggregating multiple carriers in the same handset is also a means of limiting the harm of piecemeal spectrum assets, but both these techniques have an impact on terminal complexity and thus device cost. Especially in emerging markets, handset cost is an important enabler of national broadband goals and relying on these spectrum efficiency technologies will raise device complexity and increase the entry price.

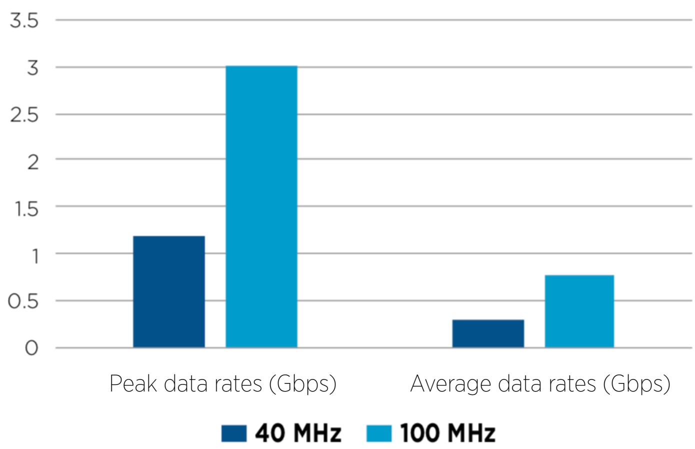
Wider channel bandwidths, which do not rely on these techniques, also allow for lower power usage. In the first instance this will lower the carbon footprint of mobile, but in cases where consumers have sporadic access to electricity it is vital to their continued access to connectivity.

Channel size is crucial: saving money and increasing network performance. It can make broadband more affordable and help connect the unconnected.

Data rates

Many 5G applications have significant data rate requirements. Video and virtual reality applications, enabled by enhanced mobile broadband (eMBB), will require the rate experienced to be above 100 Mbps.

The channel bandwidth available in 5G NR will affect data rates across the scale: peak, average and in the lower percentiles. Using IMT-2020 spectral efficiency targets we can get an assessment of the performance using different channel bandwidths. The graph opposite uses these targets to show achievable gross data rates with 40 MHz and 100 MHz contiguous blocks.



Theoretical peak data rates as given by ECC Report 287

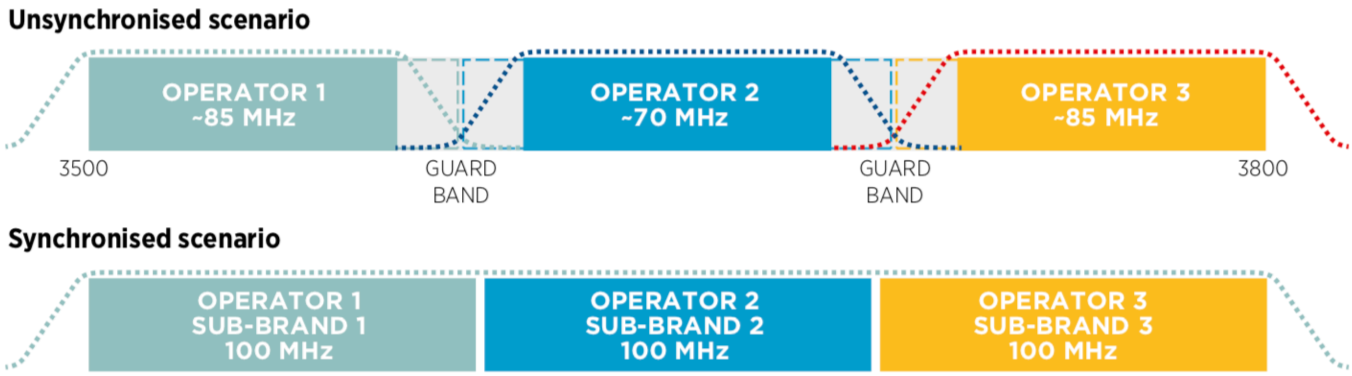
Synchronisation

> Member states should aim at ensuring a defragmentation of the 3 400-3 800 MHz frequency band so as to provide opportunities to access large portions of contiguous spectrum in line with the goal of gigabit connectivity.
>
> **Article 54 of the European Electronic Communications Code**

Synchronisation between mobile networks can help maximise the efficiency of the 3.5 GHz range and ensure optimal spectrum use.

Separation distances between non-synchronised networks are expected to be of approximately 60km for co-channel use (i.e. cross border) and approximately 14 to 16km for adjacent channel use. Synchronisation of TDD networks is the best way to avoid interference and efficient spectrum usage can be maximised through synchronisation procedures. Additional guard bands are not required and therefore network equipment cost can be reduced.

Synchronisation between operators in the same country and region will help avoid interference while cross-border interference is more likely if networks are not synchronised.



Co-existence

Coexistence between IMT and fixed satellite services (FSS) at 3.5 GHz was the subject of a 2019 Transfinite study for the GSMA. It considered adjacent band compatibility between IMT and FSS earth stations in the 3.4-3.8 GHz band. The study considered a number of different IMT deployments (macro and small cell), IMT emissions masks (based on 3GPP limits), FSS links (with different elevation angles) and FSS earth station receiver masks.

The results of the study indicate that, for IMT macro deployment and all combinations of spectrum masks and FSS links considered in the study, a guard band of 18 MHz would allow an I/N = -10 dB FSS protection criterion to be satisfied (some administrations stipulate a less conservative figure than this including in the US which uses -6 dB). For IMT small cell deployment, a guard band of 0 MHz would allow this. The study highlights that the performance of FSS earth station receivers will be very important in determining their resilience to interference from other services in adjacent bands. In event of interference to an FSS earth station, increasing the guard band will in many cases have little impact and will not be the best way of resolving interference cases, with other mitigation measures: site shielding or improved FSS receiver filtering being more effective. The report can be found here:

https://www.gsma.com/spectrum/wp-content/uploads/2021/04/Transfinite-3.4-3.8-GHz-Compatibility.pdf

GSMA HEAD OFFICE
Floor 2
The Walbrook Building
25 Walbrook
London EC4N 8AF
United Kingdom