
# 5G Spectrum

## GSMA Public Policy Position

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# Executive Summary

5G is expected to support significantly faster mobile broadband speeds and heavier data usage than previous generations while also enabling the full potential of the Internet of Things. From autonomous cars and smart cities to the industrial internet and fibre-over-the-air, 5G will be at the heart of the future of communications. 5G is also essential for preserving the future of today's most popular mobile applications – like on-demand video – by ensuring that growing uptake and usage can be sustained.

The success of the services will be heavily reliant on national governments and regulators. Most notably, the speed, reach and quality of 5G services will be dependent on governments and regulators supporting timely access to the right amount and type of spectrum, and under the right conditions. 5G spectrum awards have already begun and the variation in the amount of spectrum assigned, and the prices paid, means the potential of 5G services will vary between countries. This will impact the quality and capacity of 5G services and thus the competitiveness of national digital economies.

This paper outlines the GSMA's key 5G spectrum positions which focus on the areas where governments, regulators and the mobile industry must cooperate to make 5G a success.

1. **5G needs a significant amount of new harmonised mobile spectrum. Regulators should aim to make available 80-100 MHz of contiguous spectrum per operator in prime 5G mid-bands (e.g. 3.5 GHz) and around 1 GHz per operator in millimetre wave bands (i.e. above 24 GHz).**
2. **5G needs spectrum within three key frequency ranges to deliver widespread coverage and support all use cases. The three ranges are: Sub-1 GHz, 1-6 GHz and above 6 GHz.**
   - **Sub-1 GHz will support widespread coverage across urban, suburban and rural areas and help support Internet of Things (IoT) services**
   - **1-6 GHz offers a good mixture of coverage and capacity benefits. This includes spectrum within the 3.3-3.8 GHz range which is expected to form the basis of many initial 5G services**
   - **Above 6 GHz is needed to meet the ultra-high broadband speeds envisioned for 5G. Currently, the 26 GHz and/or 28 GHz bands have the most international support in this range. A key focus at the ITU World Radiocommunication Conference in 2019 (WRC-19) will be on establishing international agreement on 5G bands above 24 GHz.**
3. **WRC-19 will be vital to realise the ultra-high-speed vision for 5G, and government backing for the mobile industry is needed during the whole process. The GSMA recommends supporting the 26 GHz, 40 GHz and 66-71 GHz bands for mobile.**
4. **Exclusively licensed spectrum should remain the core 5G spectrum management approach. Spectrum sharing and unlicensed bands can play a complementary role.**
5. **Setting spectrum aside for verticals in priority 5G bands could jeopardise the success of public 5G services and may waste spectrum. Sharing approaches like leasing are better options where verticals require access to spectrum.**
6. **Governments and regulators should avoid inflating 5G spectrum prices (e.g. through excessive reserve prices or annual fees) as they risk limiting network investment and driving up the cost of services.**
7. **Regulators must consult 5G stakeholders to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans.**
8. **Governments and regulators need to adopt national spectrum policy measures to encourage long-term heavy investments in 5G networks (e.g. long-term licences, clear renewal process, spectrum roadmap etc).**

# Background

5G will be defined in a set of standardised specifications that will be agreed by international bodies – most notably the 3GPP and ultimately by the ITU in 2020. The ITU has outlined specific criteria for IMT-2020 – commonly regarded as 5G – which will support the following use cases:

1. **Enhanced mobile broadband:** Including peak download speeds of at least 20 Gbps, a reliable 100 Mbps user experience data rate in urban areas, and 4ms latency.[1]
2. **Ultra-reliable and low latency communications:** Including sub-1ms latency and very high availability, reliability and security to support services such as autonomous vehicles and mobile healthcare.
3. **Massive machine-type communications:** Including the ability to support at least one million IoT connections per square kilometre1 with very long battery life and wide coverage including inside buildings.
4. **Fixed wireless access:** Including the ability to offer fibre type speeds in both developed and developing markets using new wider frequency bands, massive MIMO and 3D beamforming technologies.[2]

The initial 3GPP 5G standard[3] will be submitted as a candidate for IMT-2020 and comprises several different technologies. This includes 5G New Radio (NR) which supports existing mobile bands as well as new, wider 5G bands. It support channel sizes ranging from 5 MHz to 100 MHz for bands below 6 GHz, and channel sizes from 50 MHz to 400 MHz in bands above 24 GHz. The full capabilities of 5G will be best realised through the wider channel sizes in new 5G bands. The ITU's minimum technical requirements to meet the IMT-2020 criteria – and thus the fastest speeds – specify at least 100 MHz channels per operator.[1] They also specify support for up to 1 GHz per operator in bands above 6 GHz.

Regulators around the world are actively developing their 5G spectrum plans and some have completed the first assignments. The key focus is on new mobile bands including spectrum in the 3.5 GHz range (i.e. 3.3-3.8 GHz) that has been assigned in numerous countries. Several countries plan to use spectrum in the 4.5-5 GHz range for 5G, including China and Japan, and a growing number of countries are considering the 3.8-4.2 GHz[4] range. However, the fastest 5G speeds will also need millimetre wave bands above 24 GHz. These will largely be agreed at WRC-19, under Agenda Item 1.13, which is assessing a range of bands from 24.25-86 GHz.[5]

The new 5G bands that regulators are making available will also affect how networks are deployed. Prime 5G mid-bands (e.g. 3.5 GHz) and millimetre wave bands (e.g. 26 GHz and 28 GHz) will suit dense 5G small cell networks in urban hotspots where additional capacity is vital. However, these frequency bands can also suit macrocells for wider area coverage – including fixed wireless access – using beamforming. These technological advancements mean that the 3.5 GHz band can provide the same coverage, and use the same cell sites, as the current 2.6 GHz and 1800 MHz mobile bands.

5G will also lead to the first major rollout of Time Division Duplex (TDD) cellular networks in most countries. Base stations and end-user devices on TDD networks transmit using the same channel at different times. This can create interference issues. For example, higher power transmissions from base stations on one network can interfere with the ability of base stations on other networks to receive signals from lower power end-user devices.

Interference mitigation measures include synchronising or coordinating all networks in the band, or implementing significant guard bands that waste valuable spectrum. In practice, close cooperation is needed between all operators within a band and it is likely that not all 5G use cases and deployment types will be able to be supported simultaneously. Regulators will need to consider these technical matters, and their implications, when deciding how to make spectrum available in these bands.

1. Source: ITU report 'Minimum requirements related to technical performance for IMT-2020 radio interface
2. Source: GSMA report: 'Fixed Wireless Access: Economic Potential and Best Practices' (2018)
3. 3GPP Release 15 is the body's first release of 5G specifications , was largely completed in June 2018 and will be submitted as a candidate for the ITU's IMT 2020 (5G) standards
4. For example, the US, UK, Canada and Japan are considering this range for 5G
5. Including 24.25-27.5 GHz, 31.8-33.4 GHz, 37-43.5 GHz, 45.5-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz. However, the United States, Japan, South Korea and Japan will also make use of the 28 GHz band that is outside the scope of WRC-19, but where a global primary mobile allocation already exists.

# Positions

1. **5G needs a significant amount of new harmonised mobile spectrum. Regulators should aim to make available 80-100 MHz of contiguous spectrum per operator in prime 5G mid-bands (e.g. 3.5 GHz) and around 1 GHz per operator in millimetre wave bands (i.e. above 24 GHz).**
   A central component in the evolution of all mobile technology generations has been the use of increasingly wide frequency bands to support higher speeds and larger amounts of traffic. 5G is no different. Regulators that get as close as possible to assigning 100 MHz per operator in 5G mid-bands and 1 GHz in millimetre wave bands will best support the very fastest 5G services. These targets are starting to be met with South Korea awarding 100 MHz to two operators (and 80 MHz to the third) in the 3.5 GHz band and 800 MHz per operator in the 28 GHz band in 2018.[6]

   In many countries, there are incumbent users in priority 5G bands so meeting these targets can be challenging. It is essential that regulators make every effort to make this spectrum available for 5G use. This can include:
   - Providing incentives for incumbents to migrate ahead of awarding the spectrum
   - Moving incumbents to alternative bands or within a single portion of the range
   - Allow incumbents to trade their licences with mobile operators

   If countries are assigning spectrum in one range in multiple phases in order to gradually migrate incumbents (e.g. assigning 3.4-3.6 GHz then 3.6-3.8 GHz), the process should involve re-planning the band afterwards to allow operators to create larger contiguous blocks. Long-term 5G roadmaps should be developed in consultation with stakeholders as soon as possible so operators understand how much spectrum will be made available by when, and what will happen to incumbents to help inform spectrum trading decisions.

2. **5G needs spectrum within three key frequency ranges to deliver widespread coverage and support all use cases. The three ranges are: Sub-1 GHz, 1-6 GHz and above 6 GHz.**
   Sub-1GHz spectrum is needed to extend high speed 5G mobile broadband coverage across urban, suburban and rural areas and to help support IoT services: 5G services will struggle to reach beyond urban centres and deep inside buildings without this spectrum. A portion of UHF television spectrum should be made available for this purpose through the second digital dividend.[7] The European Commission supports the use of the 700 MHz band for 5G services[8] and in the United States the 600 MHz band has been assigned and T-Mobile has announced plans to use it for 5G.[9]

   Spectrum from 1-6 GHz offers a good mixture of coverage and capacity for 5G services: It is vital that regulators assign as much contiguous spectrum as possible in the 3.3-3.8 GHz range and also consider the 4.5-5 GHz and 3.8-4.2 GHz[10] ranges for mobile use. Existing mobile licences should also be technology neutral to allow their evolution to 5G services.

   Spectrum above 6 GHz is needed for 5G services such as ultra-high-speed mobile broadband: 5G will not be able to deliver the fastest data speeds without these bands. It is vital that governments support mobile spectrum above 24 GHz at WRC-19 (e.g. 26 GHz) and additionally make the 28 GHz band available where possible. The 26 GHz and 28 GHz bands have especially strong momentum and as they are adjacent they support spectrum harmonisation and therefore lower handset complexity, economies of scale and early equipment availability.

6. Source: RCR Wireless, 'South Korea completes 5G spectrum auction'
7. The second digital dividend is the 700 MHz band in Europe, the Middle East and Africa and the 600 MHz band in the Americas and Asia-Pacific
8. 'European Commission stakes out 700 MHz band for 5G' – Telecom TV (2016)
9. Leading towards Next Generation "5G" Mobile Services' – FCC (2015)
10. For example, Canada, Japan, UK and the US are considering this range for 5G
11. See the GSMA's Mobile Industry view on Agenda Item 1.13 position paper for more information

3. **WRC-19 will be vital to realise the ultra-high-speed vision for 5G, and government backing for the mobile industry is needed during the whole process. The GSMA recommends supporting the 26 GHz, 40 GHz and 66-71 GHz for mobile.**[11] Governments and regulators hold the key to realising the full potential of 5G when they agree new mobile bands above 24 GHz at WRC-19. A sufficient amount of harmonised 5G spectrum in these bands is vital to enable the fastest 5G speeds, low cost devices, international roaming and to minimise cross border interference. It is therefore vital that governments participate in the regional preparatory meetings and at WRC-19 itself.

   The GSMA recommends IMT identifications in the 26 GHz (24.25-27.5 GHz), 40 GHz (37.5-43.5 GHz) and 66-71 GHz bands.[12] Additionally, due to the large amount of spectrum needed for 5G over time, the GSMA recommends that the 45.5-52.6 GHz range is studied in more detail. Technical studies show that coexistence between 5G and other services in bands is achievable. It is important that technical conditions to enable coexistence are appropriately tailored and are not overly restrictive, otherwise they risk harming the cost, coverage and performance of 5G services. Overly strict technical conditions risk rendering large portions of WRC-19 bands unusable in practice which will negatively affect 5G services.

   There is also an opportunity for countries which did not sign up to new mobile bands at WRC-15 to use WRC-19 to do so, subject to agreement with their neighbours. This would allow them to take advantage of spectrum that may be well suited to 5G, including 470-694/698 MHz, 4.8-4.99 GHz and bands in the 3.3-3.7 GHz range.

4. **Licensed spectrum should be the core 5G spectrum management approach. Spectrum sharing and unlicensed spectrum can play a complementary role.**
   Licensed spectrum is essential to guarantee the necessary long-term heavy network investment needed for 5G and to deliver high quality of service. The risks surrounding network investment are significantly increased without the assurances of long-term, reliable, predictable, spectrum access. Licensed spectrum, which enables wider coverage areas and better quality of service guarantees, has been central to the growth of widespread, affordable mobile broadband services.

   Unlicensed spectrum is also likely to play a complementary role by allowing operators to augment the 5G user experience by aggregating licensed and unlicensed bands. Combining licensed and unlicensed spectrum maximises the use of unlicensed spectrum while minimising the risk of delivering a poor user experience if the bands are congested.

   Spectrum sharing frameworks can also play a complementary role but must be carefully designed to avoid undermining the potential of 5G.[13] Where clearing a band is not feasible, sharing can help open up access to new spectrum for 5G in areas where it is needed but is under-used by current incumbent users. However, prospective bands for sharing must be harmonised and available in the right amounts, in the right areas and at the right times to support 5G. Mobile operators need assured access to significant amounts of spectrum for 5G so will require licensed access for a sufficient duration (e.g. 20 year licences) to justify widespread heavy network investment.

   Regulators should permit operators to voluntarily share spectrum with each other to help support super-fast 5G services, more efficient spectrum usage and to extend the benefits of network sharing arrangements. This should include permitting operators to enter into voluntary commercial agreements to lease their spectrum to other types of operators, such as enterprises, which want to build their own private networks.

   More complex, three-tier sharing regimes with set-aside spectrum for General Authorised Access[14] may limit, or eliminate, the potential for 5G services in the band. For example, the CBRS approach planned in the United States is unlikely to support high-speed 5G services, as there is only a limited amount of licensed spectrum available. Sharing models can also make it difficult to coordinate 5G networks to avoid interference as synchronising many different 5G networks that are used for different purposes can be challenging as their configurations may be incompatible.

5. **Setting spectrum aside for verticals in priority 5G bands could jeopardise the success of public 5G services and may waste spectrum. Sharing approaches like leasing are better options where verticals require access to spectrum.**
   Spectrum that is set-aside nationally for vertical industries in priority 5G bands (e.g. 3.5 GHz) poses several threats to the wider success of 5G. Set-asides can limit the assignment of sufficiently large contiguous blocks to allow mobile operators to deliver the fastest 5G services. Regulators should avoid set-asides where it will mean they cannot meet the aim of making available 80-100 MHz per operator in priority mid-bands (e.g. 3.5 GHz) and around 1 GHz in millimeter waves (e.g. 26 or 28 GHz).

12. The GSMA's detailed position on Agenda Item 1.13 including support for bands is available in a dedicated paper
13. See the GSMA's spectrum sharing position paper for more information
14. E.g. Licence-exempt spectrum but that may require registration on a spectrum access system database

More widely, set-asides for restricted use cases can lead to inefficient spectrum usage. Vertical industries are unlikely to use spectrum in priority 5G bands very widely across countries, so national set-asides are likely to go unused in many areas. Instead, mobile operators can provide customised 5G services for verticals who can then benefit from network slicing, small cells, wider geographical coverage, as well as the larger and more diverse spectrum assets, as well as deployment experience, at mobile operators' disposal. Voluntary spectrum sharing approaches are preferable to set asides as they can be used to support all potential 5G users, including verticals. For example, MNOs can be permitted to lease their spectrum assets so that verticals can build their own private 5G networks.

Mixing industrial and commercial networks in a band through set-asides will present technical deployment challenges which could result in harmful interference or limit the 5G services that can be supported. For example, all 5G networks in a band are likely to need to be synchronised which means very high speed public broadband networks could not co-exist with very low latency industrial networks in the same area. At the very least, the users of vertical set-asides will need to coordinate with 5G commercial networks to mitigate interference.

6. **Governments and regulators should avoid inflating 5G spectrum prices (e.g. through excessive reserve prices or annual fees) as they risk limiting network investment and driving up the cost of services.**
Governments and regulators should assign 5G spectrum to support their digital connectivity goals rather than as a means of maximising state revenues. Effective spectrum pricing policies are vital to support better quality and more affordable 5G services. High spectrum prices have been linked to more expensive, slower mobile broadband services with worse coverage.[15] The causes of very high prices are typically policy decisions that appear to prioritise maximising short-term state revenues over long-term socio-economic benefits. To avoid this, governments and regulators should:
    - Set modest reserve prices and annual fees, and rely on the market to determine spectrum prices
    - Avoid limiting the supply of 5G spectrum as scarcity can lead to excessive prices
    - Develop and publish a 5G spectrum roadmap with the input of stakeholders to help operators plan for future availability
    - Consult with stakeholders on licence terms and conditions and take them into account when setting prices

7. **Regulators must consult 5G stakeholders to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans**
The decisions regulators face around 5G spectrum are complex and will have a major impact on the quality of services and the use cases that can be supported. For example, if spectrum licence areas are very small then it may be impossible to support 5G deployments using macrocells, including fixed wireless access, as well as in-band backhaul. It is important that consultations are held to discuss planned deployments and how they may be impacted by very localised, regional or nationwide spectrum licensing. These should include technical deployment considerations including the required measures to minimise interference. It will be especially important to discuss how to manage synchronisation in order to best serve the interests of 5G operators.

8. **Governments need to adopt national spectrum policy measures to encourage long-term heavy investment in 5G networks (e.g. long-term licences, clear renewal process, spectrum roadmap etc).**
5G network deployments will require significant network investment. The speed of rollouts, quality of service and coverage levels will all be compromised without sufficient investment. Governments and regulators can encourage high levels of investment by adopting important spectrum policies including:
    - Supporting exclusive, long-term 5G mobile licences with a predictable renewal process
    - Producing a national broadband plan including 5G which details activities and timeframes
    - Publishing a 5G spectrum roadmap
    - Ensuring all mobile licences are technology neutral to speed up wide area 5G rollouts and encourage improved spectrum efficiency

15. GSMAi (2018) 'Spectrum pricing in Developing Countries' & NERA (2017) 'Effective Spectrum Pricing'

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