Introducing spectrum management

Spectrum primer series

GSMA™

Produced February 2017

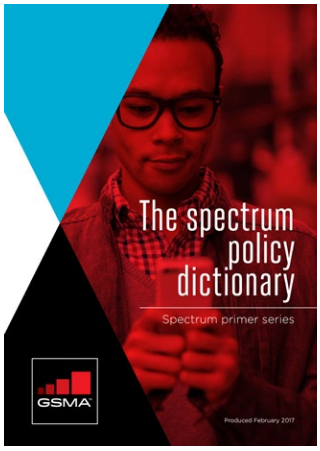
Introduction to the primer series

Spectrum management

These handbooks provide a general introduction to mobile spectrum, how it is managed and the challenge posed by rapidly growing data usage. They have been designed for readers who don’t have a technical background in the subject. While this is only a very brief introduction to the subject, these handbooks should hopefully provide a useful overview.

The titles in this series are:

- ► Introducing radio spectrum;
- ► Introducing spectrum management; and
- ► The spectrum policy dictionary.



Introducing spectrum management

This handbook introduces the issue of spectrum management, why it's necessary and the key principles and organisations involved.

1. What is spectrum management?
2. International spectrum management
3. National spectrum management
4. How to handle data growth
5. New technologies to add capacity
6. Densify networks to add capacity
7. Accessing more spectrum

1

What is spectrum management?

Radio spectrum is used to carry information wirelessly for a vast number of vital services ranging from television and radio broadcasts, mobile phones and Wi-Fi, to baby monitors, GPS and radar.

However, as the world becomes increasingly dependent on this evolving array of services, the demands being placed on the scarce supply of usable radio waves are rapidly growing. The public appetite for more information, faster communications and higher definition media means that the demand for radio spectrum easily exceeds supply.

At the same time, as radio spectrum becomes more intensively used, the risk of interference between different services grows. This challenge has an important international dimension because radio waves do not respect national borders, so services in one country can interfere with those in neighbouring territories.

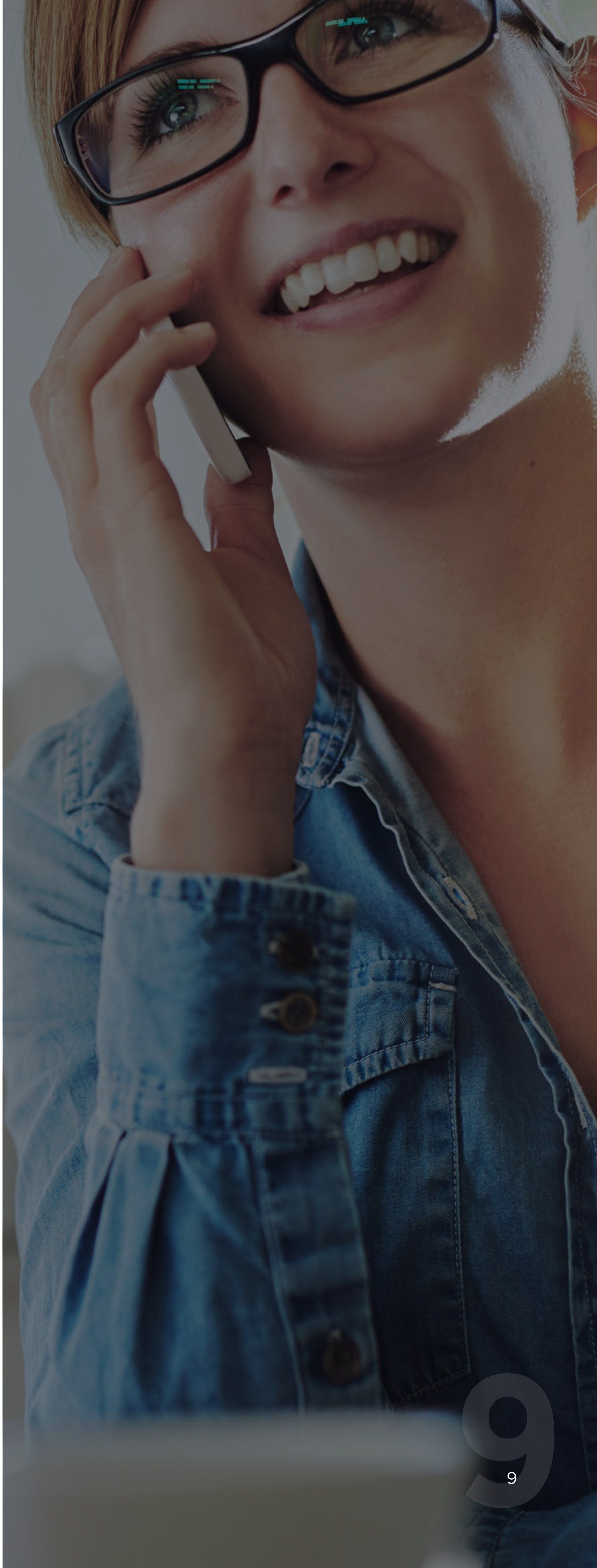
In response, governments employ spectrum management to:

- Ensure there is sufficient spectrum for the services which need it the most and provide the greatest socio-economic benefits;
- Encourage spectrum efficiency so the scarce resource can be maximised;
- Minimise interference nationally and internationally.

In this way national governments play a major role in the overall quality and reach of wireless services — from highspeed mobile broadband with widespread coverage, to high-definition TV and radio broadcasts, accurate navigation services (e.g. GPS & Galileo) and effective air traffic control, along with many others.

Spectrum management starts at an international level when governments come together to agree which frequency bands should be allocated to certain services. This minimises national and international interference, helps reduce the price of equipment and, in the mobile industry, enables consumers to roam onto foreign networks.

National regulators then use a variety of methods for licensing these frequency bands to specific service providers. When this is conducted in a fair and transparent way, it gives service providers the confidence to invest in spectrum, as well as the resulting radio networks, enabling the general public to benefit from the best possible services.



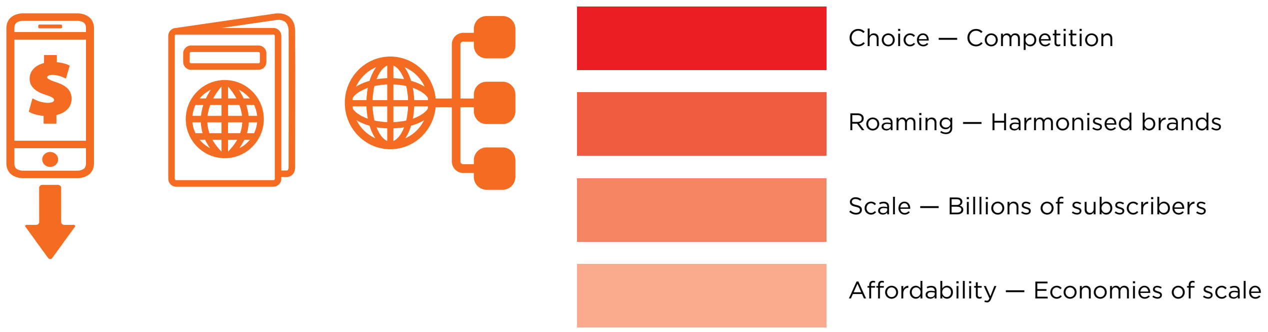
2 International spectrum management

Radio spectrum is a national resource so every country has sovereign control over how it is used. However, there are important benefits to adopting an agreed international approach. By using the same frequency bands and conditions for the same types of service across different countries — an approach called 'harmonisation' — governments can reduce international interference, lower mobile equipment costs and enable roaming.

Because radio waves and the services which use them do not stop at national borders, governments need to work together to avoid international interference. Regulators generally avoid interference by coordinating radio emission levels near borders. For example, under the Geneva 2006 agreement (GE06), national regulators across Europe agreed frequency plans to ensure new digital TV services being rolled out across the continent would not interfere with one another.

Harmonised spectrum results in lower cost equipment, such as mobile phones, and better economies of scale because the same products can be sold internationally. Given that mobile devices can only support a limited number of frequency bands, harmonisation makes it easier to build devices which consumers can use when they travel abroad.

Benefits of harmonisation



Regional and global bodies

International spectrum management is overseen by the radio division of the International Telecommunications Union (ITU), a specialist United Nations agency, responsible for information and communication technologies.

Every three to four years, telecom regulators from all corners of the globe convene at the ITU's World Radiocommunication Conference (WRC) to discuss and agree changes to the 'Radio Regulations', detailing which services are allocated to each frequency band.

This vital process allows governments to make additional harmonised spectrum available for services which are undergoing growing user demand. For example, one of the top agenda items at WRC 2015 was to allocate more spectrum to mobile broadband to meet the rocketing demand for mobile data.

> "The increasingly congested skies above our heads require careful management and monitoring, on a global basis, with intensive cooperation and discussion to avoid the risk of interference. That is one of the most important parts of ITU'S work, as the sole global agency charged with managing the world's shared radio spectrum and orbital resources."
>
> *Dr Hamadoun Touré, Former Secretary-General, ITU*

The ITU divides the world into three regions, which each has its own set of frequency allocations as part of the 'Radio Regulations'. This is done in order to manage spectrum and encourage harmonisation across large parts of the world. As such:

- Region 1: Europe, the Middle East, Africa, Russia and Mongolia;
- Region 2: The Americas including Greenland and some of the Eastern Pacific Islands; and
- Region 3: Asia-Pacific including most of Oceania.

Region 1

Region 2

Region 3

There are also a number of regional groups which aim to drive major long-term progress in telecommunications services. From a spectrum perspective, they provide a forum for national regulators to coordinate their spectrum policies and work together to ensure the appropriate changes take place at the next World Radiocommunication Conference.

These include:

Asia Pacific Telecommunity – which covers the Asia-Pacific region.

Arab Spectrum Management Group – which covers the Arab states in the Middle East and North Africa.

African Telecom Union – which covers all of the administrations on the African continent.

European Conference of Postal and Telecommunications Administrations (CEPT) – comprising 48 member administrations including all of the EU countries, Russia and Turkey.

Inter-American Telecommunications Commission (CITEL) – which covers the Americas and the Caribbean.

Regional Commonwealth in the Field of Communications (RCC) – which covers the Russian Commonwealth of Independent States, as well as the Baltic states which have observer status.

Spectrum speak: To 'allocate', 'identify', 'allot' or 'assign'
Different words are used to describe whether a frequency band is available for use by a type of service, a limited range of technologies or a specific company.

Allocation: A band is 'allocated' for potential use by a certain type of service (e.g. mobile, satellite or broadcasting) by a national regulator, which is contained in the National Frequency Allocation Table (NFAT), or on an international level through the ITU, as detailed in the 'Radio Regulations'.

Identification: A band may then also be 'identified' for a limited range of technologies (e.g. a band that is 'allocated' to the mobile service will often be 'identified' for International Mobile Telecommunications (IMT) which means it can be used by a specific set of compatible mobile technologies, including all 3G and 4G systems).

Allotment: A less-used term which refers to a decision made at a regional or national level to designate a frequency channel for use by a certain type of service in one or more countries under certain conditions.

Assignment: A specific frequency channel is then 'assigned' to a specific user by a national government or regulator (e.g. a band may be 'allocated' to the mobile service, 'identified' for IMT and then split into several sections which are each 'assigned' to different mobile operators).

3

National spectrum management

Based on this broad international framework, and specifically the ITU's Radio Regulations, national governments decide the services which will be allowed to operate in the various frequency bands. This is necessary because ITU's 'Radio Regulations' are not legally binding in member states and can also leave national governments with several options for the services which may operate in each band.

Governments detail their decision in a piece of spectrum management legislation called the National Frequency Allocation Table (NFAT). This lists the services which may operate in each band, associated conditions (e.g. emission limits) and future plans for bands (e.g. changing the types of service which could potentially operate in them).

Once the NFAT has been agreed, governments need to decide how to assign spectrum to specific providers (e.g. a mobile operator) in a fair, transparent and reasonable manner.

Spectrum assignment methods

There are a variety of approaches which regulators can use to exercise different levels of control over how spectrum is assigned to a particular provider and how it may subsequently be used.

The three broad approaches are:

1. **The administrative approach:** The traditional method where a regulator has total control, including choosing which companies are assigned spectrum and exactly how it is used. The most common assignment method is the beauty contest where several companies outline their proposed service and the regulator chooses the one with the greatest socio-economic benefits;

2. **Market-based approach:** This method uses market forces to determine the distribution of spectrum. Regulators treat spectrum like a private asset so licences are typically sold at auction and could, in principle, be re-sold or leased out by their owners afterwards to ensure market forces continue to guarantee that spectrum is used and distributed efficiently ; and

3. **The spectrum commons approach:** Also known as unlicensed spectrum or licence-exempt, this model allows anybody to use a certain band without prior permission as long as the transmission technologies adhere to certain rules — sometimes called 'politeness protocols' — which manage interference. Examples include Wi-Fi and Bluetooth.

The reality is that regulators typically adopt different approaches for different applications. For example, most retain overall control, allowing them to protect public interest services (e.g emergency services), but many regulators incorporate market forces (especially for mobile services), allow some licence holders to trade their spectrum, and allow short-range radio technologies, such as Wi-Fi or Bluetooth, to be completely unlicensed.

In general, the trend is towards greater use of the market-based approach as this incentivises licence holders to use their frequency bands efficiently because they have paid. This should ensure that spectrum is not wasted and is made available for the many services that need it.

> "The countries that get their spectrum policy right will achieve widespread access to affordable and innovative mobile broadband services. Strong communications infrastructure, in turn, brings significant wider economic benefits including boosting productivity and living standards."
>
> *Competition Economists Group, 2012*

Types of licence

Before issuing licences, national governments first need to decide what kind of licence to offer for each band. There are broadly three different types:

1

Individual licence:
The default licence type is the individual radio apparatus licence which permits a specific type of equipment to transmit in a certain area at a specific frequency using an antenna which meets specific parameters. Given that licence holders have exclusive access to the spectrum, it provides the best possible safeguards against interference and, therefore, good quality of service controls. These licences are typically used in bands that are in high demand such as those used by mobile operators, broadcasters and satellite providers among others.

2

Light licence:
A new approach that is generally designed for bands where there is a lower level of demand and, therefore, also a lower likelihood of interference. Light licences are issued to control the number of devices operating in a specific frequency in a certain area. Sometimes there are strict limitations on the number of licences that are issued in a specific frequency range, although this is not always the case as the prospect of interference may be a sufficient deterrent to a large number of licence applications. Nominal fees are charged for covering the cost of administering a database of transmitting devices.

3

Licence exempt/unlicensed:
As discussed previously, although no licence is required in these bands, conditions are generally imposed on the equipment which may be used to prevent interference.

Spectrum assignment goals

National regulators will typically strive to achieve several goals when assigning spectrum, which will vary according to circumstances in the market, and can be in conflict with each other. These include:

- **Maximise economic value:** Maximise the creation of long-term economic value by assigning spectrum to the services which will use it most effectively in order to create successful businesses;
- **Maximise societal value:** Ensure that the maximum long-term societal value can be generated from the spectrum;
- **Increase tax revenue:** Raise state revenues by charging service providers to acquire spectrum licences;
- **Encourage investment:** Incentivise bidders to invest heavily in their networks to improve the subsequent services, thereby achieving long-term socio-economic goals;
- **Impact market structure:** Establish a competitive market by ensuring several service providers have access to sufficient spectrum;
- **Maximise value of services:** Assign spectrum to ensure services can be offered most effectively. In the mobile industry this means that bands should be harmonised globally to ensure equipment is affordable and can be used abroad; and
- **Create fair assignments:** Create a fair outcome by ensuring the process is transparent so bidders understand the auction rules, the value of the spectrum and the conditions of use.

Spectrum auctions

The dominant method of assigning spectrum licences to mobile operators is the spectrum auction. Well-designed auctions are a means for governments to assign spectrum to the organisation which values it most highly, and creates financial incentives for them to use it efficiently.

However, there are other assignment approaches that may be more appropriate in specific market circumstances. For example, embarking on an expensive and time-consuming auction process may be unnecessary if the bidders are all known and there is sufficient spectrum to meet all their needs. In these situations administrative approaches, such as a beauty contest, may be more efficient.

Auctions are only a more appropriate approach when there is sufficient competition for the spectrum, that is when demand exceeds supply. In the mobile industry, regulators can get an insight into whether this is likely to be the case by looking at:

- The amount and type of spectrum to be auctioned (e.g. is there sufficient spectrum for mobile broadband services and is it harmonised internationally?);
- The expected demand for the spectrum from end-users;
- The level of competition expected for the available licences; and
- The likely value of the licences.

Auction best practice

If an auction is the appropriate approach then a regulator needs to choose an auction design. There are many alternatives, each with strengths and weaknesses. Although the multi-round designs are currently the most popular, the best option depends on the market circumstances and the regulator's objectives.

The most successful auctions involve close consultation between the regulator and prospective bidders to ensure the design and rules are appropriate, fair and transparent — and, therefore, won't be disputed afterwards.

Bidding for spectrum is a significant commercial risk for operators so they need vital information in order to value it effectively, including:

- Any restrictions surrounding how the spectrum may be used and other obligations (e.g. network coverage requirements etc);
- The duration of the licence and the ongoing charges; and
- The regulator's spectrum roadmap, which details its future spectrum plans, will help operators understand if the licence being offered is unique or if similar bands will be auctioned and in what timeframe.

Auction types

Sealed bid auction:
Bidders submit the price they are prepared to pay, in confidence, to the auctioneer.

English auction:
The auctioneer opens the bidding with a price for a single item which is raised as bidders indicate their willingness to pay, until only one remains.

Simultaneous (ascending) multi-round auction:
Groups of related spectrum licences are auctioned simultaneously with the bidding raised until only one bidder remains for each licence.

Combinatorial clock auction:
A multiple round auction with ascending bids where bidders are allowed to bid on a different combination of licences and complex algorithms determine winners and prices.

Reserve pricing

Regulators set a ‘reserve price’ in order to guarantee a minimum amount is paid for a licence at auction. The reserve price should reflect the socio-economic value of the spectrum, encourage it to be used efficiently and provide a reasonable financial return to the state.

Setting an appropriate reserve price is complex, but is extremely important for a successful auction outcome. When set too low, it may encourage frivolous bidding, an inadequate financial return to the state and assignments where the winner has little incentive to use it efficiently. When set too high, the price will discourage participation leading to limited spectrum uptake and even unsold spectrum, thereby wasting a valuable, in-demand resource. In recent years, several auctions have resulted in spectrum being unsold for this reason — including sub-1 GHz spectrum which operators value most highly because these low frequency bands provide excellent coverage.

When operators are forced to pay excessively high reserve prices, this limits the amount they can invest in the resulting networks which can result in lower quality and more expensive services for consumers.

An important reason auctions are popular assignment mechanisms is that the market determines the value of the spectrum, thus creating a fairer outcome. Reserve prices should, therefore, be set as low as possible to support this ‘value discovery’ process, while still guaranteeing a reasonable return to the state.

Benchmarking:
Uses the results of similar auctions in other markets to estimate the expected value of the spectrum. However, it is only valid when comparisons are made with very similar markets that have auctioned the same kind of spectrum. Unfortunately these like-for-like comparisons are often difficult to find, making the use of benchmarking problematic.

Modelling:
Calculates the value based on the predicted revenues of the services minus costs, although it can be difficult to calculate this accurately.

Opportunity cost:
Assumes that the cost of purchasing a specific spectrum band should be less than the alternative method of delivering the same capabilities. For example, a new licence will give a mobile operator a specific amount of additional network coverage and capacity which could also be achieved by other means. For example, by deploying a certain number of additional base stations, the costs can be accurately calculated.

Licence terms

Regulators usually specify terms and conditions as part of a spectrum licence which typically include the:

- Type of service that can be provided in a frequency band (e.g. only mobile services);
- Technologies that may be used to transmit in the band (e.g. 2G, 3G, 4G or technology neutral);
- In the case of coverage bands (i.e. sub-1 GHz) there may be possible coverage obligations (e.g. 90 per cent population coverage); and
- The duration of the licence (e.g. 20 years).

These terms and conditions can help ensure that services are protected and meet certain quality standards. For example, if licence holders could suddenly change the type of service operating in the band (e.g. from a mobile service to broadcasting) then unacceptable levels of national and international interference could be created and the vital spectrum harmonisation process would be disrupted.

The conditions which have an especially strong impact on mobile are:
► **Technology neutrality;**
► **Licence length and renewal procedures.**

Technology neutrality
It is possible for technical conditions to be too prescriptive and limit the opportunity for licence holders to innovate and, as a result, limit the benefits for consumers. For example, many of the original mobile licences were issued for a specific technology, such as 2G technologies like GSM or CDMA, which operators are not permitted to change.

This means that the 2G technology that operates in some bands cannot be upgraded to faster 3G or 4G technologies which add vital extra data capacity to mobile networks, giving subscribers faster mobile broadband services. This process of changing the technology used, known as refarming, is especially important given that 2G bands are often at the sort of low frequencies that would provide mobile broadband coverage very widely, including rural areas and deep inside homes and offices.

In response, many regulators are making licences 'technology neutral' which allows the licence holder to use any non-interfering technology. In practice, this means regulators specify that licences must be used for particular services (broadcasting, mobile, satellite) but do not mandate the precise underlying technology.

For mobile services, they will normally specify that an IMT system is used which encompasses the main technologies that are standardised for technical coexistence, including all 3G and 4G systems. This approach allows markets, and therefore consumers, to determine which technologies succeed while also promoting increased innovation and competition.

Licence length and renewal
A spectrum licence is normally valid for a specific duration. When this has elapsed the regulator chooses whether to retain the existing conditions or modify them and can then award it to either the existing licence holder or to a third party. The length of the licence and renewal terms can have a major impact on the quality, as well as the reach of mobile networks.

Regulators can encourage significant network investment, and therefore higher quality services, by granting licences that last for a minimum of 15 to 20 years. This gives operators adequate time to realise a reasonable financial return on their investments. If they adopt short licences, operators are less likely to invest appropriately in their networks as their access to spectrum in the future is not guaranteed.

Once the term of the licence has elapsed, regulators can make various changes including whether the licence remains available for mobile use or a different wireless service, the size of frequency band it applies to, the conditions surrounding its use, the length the licence, and the annual fee, etc.

As many of the original 2G spectrum licences are currently due for renewal, this is currently creating uncertainty for operators. This makes network investment risky and could ultimately disrupt services. In order to avoid this outcome, regulators are advised to employ a transparent and predictable approach to renewal. The process should begin three to four years before the licence expiry, providing ample time for services to be resumed in other bands where necessary.

How to handle data growth

There are several important ways that mobile broadband networks can support more data and achieve faster speeds, including using:

- **More 'spectrum efficient' technologies:** Operators are continually employing new technologies which allow more data to be squeezed into a given amount of spectrum;

- **Densified mobile networks:** Operators re-use existing spectrum by building more base stations and ensuring these simultaneously support 3G, 4G-LTE and, increasingly, Wi-Fi; and

- **More mobile spectrum:** The most cost-effective way of increasing capacity is by using more spectrum, but this must first be licensed to them by the national government or regulator.

5 New technologies to add capacity

Few industries embrace technological change as quickly as the mobile industry. Mobile networks have undergone major transformations in order to evolve from simple voice and text to supporting a level of data usage that few could have predicted.

At the heart of this change has been the adoption of new radio technologies that increase spectrum efficiency — allowing ever greater amounts of data to be carried in a fixed amount of spectrum. Over the past 15 years, mobile operators have deployed several 'generations' of mobile technology — from 2G to 3G and, most recently, 4G-LTE. The first 4G-LTE network was launched at the end of 2009 with the ability to deliver peak download speeds of up to 300Mbps. Five years later, 335 LTE networks were launched across 118 countries, making it the fastest-growing mobile technology in history (see fig 3).

However, it is important to recognise that each new technology generation uses wider channel bandwidths, as well as improved spectrum efficiency to drive faster connection speeds. This means they use increasing amounts of spectrum, making the need for new mobile frequency bands essential.

For example, a 2G channel[2] is 0.2 MHz wide, a 3G channel[3] is 5 MHz wide and a 4G-LTE channel can range from 1.4 MHz to 20 MHz wide — the fastest 4G-LTE services are only possible with the wider channel sizes. The most recent types of 3G and 4G-LTE networks are capable of providing users with especially fast speeds by combining several channels together, making them even more reliant on large amounts of spectrum.

Increasing access to LTE networks globallly

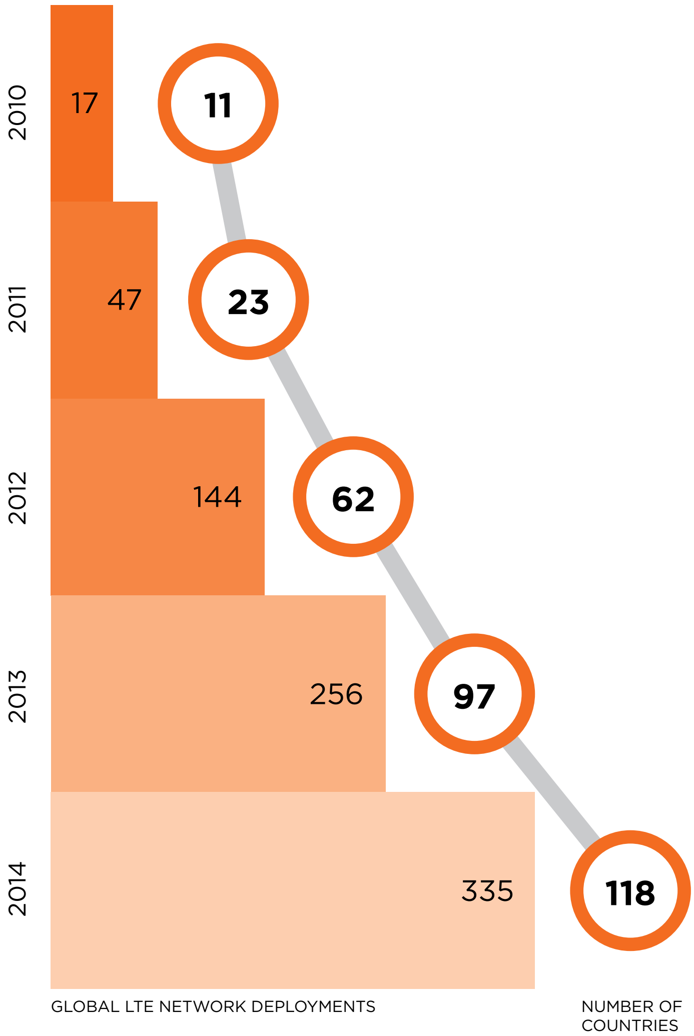


Fig 3. GSMA Intelligence: Rising LTE network deployments

2 ie. GSM – the most popular 2G technology
3 ie. WCDMA – the most popular 3G technology

While operators could support more data traffic by using 4G-LTE in all their frequency bands, it is important that they can continue to support users with older 2G and 3G devices rather than simply stopping their service. As such, there is likely to be a gentle migration as users adopt new devices and higher speed services.

Regulators can ease this transition, while also helping operators to adopt more spectrum-efficient technologies, by making spectrum licences technology neutral. This allows operators to use any non-interfering technology in a band, rather than restricting it to one type, which will allow the market, and therefore ultimately consumers, to decide when less spectrum-efficient technologies stop being supported.

6

Densify networks

to add capacity

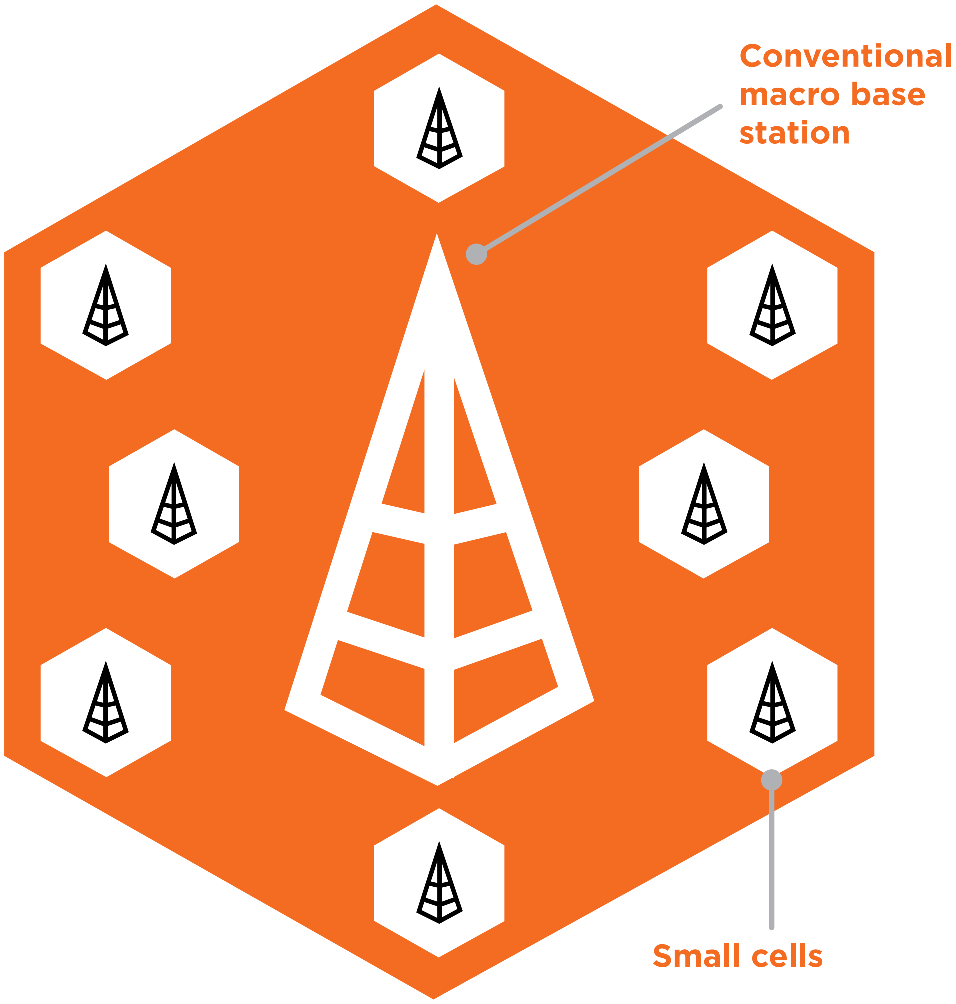
The growth in mobile data usage has outpaced the evolution of mobile technology to such an extent that operators have been forced to radically change the design of their networks.

While operators once used a small number of radio and base station types, they are now starting to use a significantly larger number of base stations, of varying sizes that simultaneously support several radio technologies (e.g. 2G, 3G, 4G-LTE and increasingly also Wi-Fi). This use of a wider variety of base stations means they have been dubbed 'heterogeneous networks' (or 'hetnets').

Most notably, this involves using large numbers of small cells, which are very low power base stations and bring the full data capacity of a conventional base station to a much smaller area.

While a base station would traditionally spread its radio capacity over a kilometre or more, a small cell could serve a single home or business, containing only a few people, resulting in faster and more responsive mobile services.

In the same way that 4G-LTE networks are more spectrum efficient than their predecessors — by squeezing more data into a single frequency band — small cells allow a single frequency band to be re-used more often, allowing it to carry more data.



TYPES OF BASE STATION

Macrocell:
Traditional approach that covers a wide area;

Microcell:
Small cell type that covers a small urban or rural area. Urban small cells (aka metrocells) are becoming increasingly popular for delivering additional capacity in busy hotspots, e.g. railways stations;

Picocell:
Small cell type that covers a business-size premise; and

Femtocell:
Small cell type that covers a home or small business.

7 Accessing more mobile spectrum

The easiest and most cost effective way of increasing mobile network capacity is by using more spectrum. This allows operators to create more frequency channels — so they can support more users — as well as create wider channels, which means users receive a faster service that can support bandwidth-hungry services like video.

Alternative capacity-building methods such as heterogeneous networks, including small cells, are typically more expensive as they involve new equipment and cell sites, as well as additional power, backhaul and planning costs. In this way, additional spectrum is a central component in order to deliver better value, high speed and more ubiquitous mobile broadband services.

There are two key factors involved in securing vital additional spectrum for mobile services:

1. **Make more mobile spectrum available internationally:** To avoid cross border interference and to establish a wide variety of low cost mobile devices that can roam abroad, new mobile spectrum is normally agreed internationally before being licensed by national governments. This is referred to as 'harmonised mobile spectrum'.

2. **License more spectrum to mobile services nationally:** Governments then license this 'harmonised mobile spectrum' to operators — most governments have not licensed as much mobile spectrum as possible.

How to make more mobile spectrum available internationally

The International Telecommunications Union (ITU) specifies the services that can operate in each frequency band within its 'Radio Regulations'. These are reviewed every four years at its World Radiocommunication Conference.

GSMA research indicates that the rapid growth in mobile data usage means an additional 600-800 MHz of spectrum will need to be allocated for mobile use by 2020. To put this in perspective, an average of around 1,000 MHz is currently allocated for potential use by mobile services. The 600-800 MHz shortfall takes into account the capacity improvements from the move to more spectrum-efficient technologies and densified networks. This task is especially challenging because it typically takes around ten years to secure new mobile allocations, clear the bands and launch services. This means that governments and regulators need to act now in order to meet predicted mobile data demand in the mid-2020s.

“We must unleash spectrum and the opportunity of mibile broadband. Spectrum is our invisible infrastructure; it’s the oxygen that sustains our mobile communications.”

Former FCC Chairman Julius Genachowski

Securing appropriate new spectrum to deliver the capacity and coverage needed to bring high-speed mobile services to both urban and rural consumers will be challenging. Spectrum is a finite natural resource, so new spectrum cannot be created. For mobile services to get access to additional spectrum, governments will need to examine how incumbent users, such as broadcasters and the military, can use their existing allocations more efficiently, or even be moved to different bands.

Against this background, it is important to understand that although mobile services play an essential socio-economic role, they actually use a comparatively small amount of spectrum.

Relative economic value of spectrum-using sectors in Europe

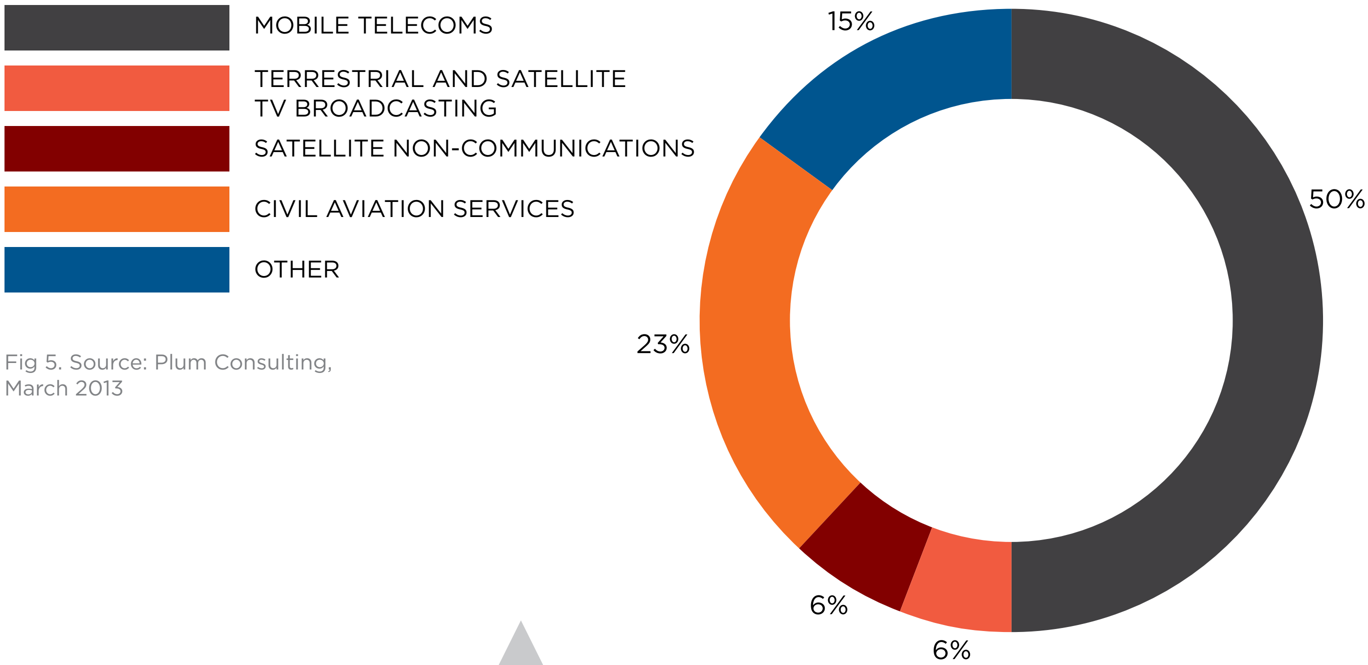


Fig 5. Source: Plum Consulting, March 2013

Governments will need to work with the international community to ensure that new mobile broadband spectrum is 'harmonised'. This means the same frequency bands must be allocated to mobile services across entire regions, not just individual countries.

This is essential because it creates large, unified markets which helps to reduce the cost of mobile devices and network infrastructure, while also minimising interference and enabling international roaming.

To succeed in this vital task, governments, regulators, members of the mobile ecosystem and existing spectrum users need to identify appropriate new mobile bands and demonstrate how the existing users can be viably accommodated in different bands, or in a reduced amount of spectrum.

New mobile bands should comprise a mixture of coverage (i.e. low frequency) and capacity (i.e. high frequency) bands. This will ensure that mobile operators are able to deliver mobile broadband networks that support heavy data use, in both urban centres and rural areas.

License more spectrum to mobile services nationally

The main way regulators can quickly increase mobile network capacity is by assigning spectrum licences to mobile operators in accordance with ITU's radio regulations.

A number of frequency bands have been permitted for mobile use by ITU but have yet to be assigned to mobile operators by some regulators. These include the so-called 'digital dividend' bands — 700 MHz and 800 MHz — and the 2.1 GHz and 2.6 GHz bands.

The digital dividend represents the most important new spectrum that has been allocated for mobile use in recent years. It refers to the frequency bands made available when terrestrial TV broadcasters moved from analogue to digital transmissions, which are more spectrum efficient.

In Europe, Africa and the Middle East, broadcasters are vacating the 800 MHz band while in Asia Pacific and the Americas, they are vacating the 700 MHz band. A second phase of the digital dividend should begin in 2015, when ITU agrees the terms for the 700 MHz band to be made available for mobile broadband in Europe, Africa and the Middle East.

Digital dividend spectrum is crucial because low frequencies travel further than higher frequencies and therefore provide improved mobile broadband coverage to remote areas and deep inside buildings.

The economic value of new spectrum bands

Region	New Spectrum Type	Additional GDP (by 2020)	Additional Jobs (by 2020)
Europe	Digital Dividend (800 MHz)	€119bn	156,000
Asia-Pacific	Digital Dividend (700 MHz)	$1tn	2,100,000
Latin America	Digital Dividend (700 MHz)	$370bn	112,000
Sub-Saharan Africa	Digital Dividend (800 MHz)	$49bn	506,000
Arab Middle East	Digital Dividend (700 MHz & 800 MHz), 2.6 GHz & 1.8 GHz	$57.5bn*	1,900,000*
North Africa	Digital Dividend (700 MHz & 800 MHz), 2.6 GHz & 1.8 GHz	$50.5bn*	4,000,000*

*By 2025.
Fig 5. Sources: GSMA Mobile Economy Reports 2013 *& GSMA Arab States Mobile Observatory 2013

Spectrum trading and sharing

Once regulators have allocated as much as possible, there are several other techniques they can use to encourage underused spectrum to be made available to meet increasing mobile data demand. Spectrum could be traded by licence holders directly or shared where it is underused. These methods may encourage licence holders to use their radio assets more efficiently because they can profit from what they don’t need, as well as facilitate access to additional spectrum where required.

Given that mobile services need additional spectrum to support rising data, operators typically do not have spectrum to trade, or share with others, especially in the busy urban areas where mobile broadband usage is highest. However, spectrum trading and sharing can open up sources of spectrum for mobile broadband in bands that are currently used for other services or applications.

It is important to remember that spectrum is generally only of use to mobile operators if it is located in bands that have been identified for mobile broadband, and where there is a good choice of low-cost devices for consumers. As such, spectrum trading and sharing does not circumvent the urgent need for new mobile broadband identifications by ITU at the World Radiocommunication Conference.

Furthermore, the rate of mobile data growth, coupled with the lack of guarantees surrounding access to shared or traded spectrum, means that the need to make additional exclusive licensed spectrum available for mobile services, remains the main priority for regulators.

Spectrum trading

Spectrum trading can allow licence holders to transfer their usage rights on a voluntary commercial basis. In effect, this means that licence holders with a surplus of spectrum can financially benefit by transferring the exclusive rights of its use to those who don't have enough.

Trades need not require significant regulatory involvement as long as the terms of the licence are not breached and market competition is not negatively impacted. In practice, governments simply need to implement an appropriate procedure for handling notification requests.

Trading creates a more flexible system of spectrum assignment that continuously adapts to changes in demand for spectrum and, above all, can ensure that spectrum does not lie fallow. However, it provides no guarantees that mobile operators can access the additional spectrum they need, so regulators must still license additional mobile spectrum where necessary.

Spectrum sharing

Spectrum sharing allows several users to use the same frequency band — these users could potentially range from service providers to businesses to individuals.

Sharing can ensure that the scarce supply of spectrum is easily accessible and not underused. However, spectrum sharing is not always workable in practice and can suffer from quality of service issues so needs to be carefully considered.

There are a variety of forms of spectrum sharing including:

Licensed Shared Access: A proposed sharing scheme that allows the licence holder to voluntarily sell access to spectrum which is being underused in certain areas or at certain times. The main benefit is that access can be guaranteed thus providing assured quality of service. As operators typically don't have unused spectrum in busy areas where data traffic is growing fastest, the source of the shared spectrum would typically be from another industry (e.g. the military). However, to be successful, the spectrum must be available at the right time and place, for the right price, and for a duration that warrants network investment;

Licence-exempt spectrum: Frequency bands that can be used by multiple users as long at the technology meets predefined 'politeness protocols' to minimise interference. One example is Wi-Fi which is increasingly being used by mobile operators in busy urban hotspots where data traffic is growing fastest. However, the resulting services are 'best effort' because there is no limit on the number of Wi-Fi networks, or users in any one area, which can result in unpredictable congestion and, therefore, poor-quality services. This means mobile operators generally only use licence-exempt spectrum to complement their exclusive licensed spectrum;

TV white space: Terrestrial broadcast TV spectrum in the UHF band that is unused in certain areas and at certain times, so could be repurposed for licence-exempt wireless broadband. However, such services face several challenges due to limited spectrum availability, small coverage areas, no guaranteed quality of service, potential interference and limited device support. Furthermore, broadcasters could use their spectrum more efficiently to eliminate white space, and free up spectrum that could be used for nation-wide mobile broadband services, with excellent rural and in-building coverage; and

Shared licensed spectrum: A method by which two or more mobile operators can share their radio spectrum. This sharing may be agreed on a commercial basis between the operators, to combine their coverage and capacity, or as a condition of the licensing process. However, this approach can negatively impact competition as services may not be suitably differentiated and may discourage network investment.

The importance of cooperation

Over the past decade there has been a genuine mobile broadband revolution. The way many consumers and businesses use mobile services today is profoundly different to a decade ago. From a world of voice and text, we now have a dizzying array of mobile apps, including high bandwidth video.

The benefits of this revolution are undeniable. For many people, life without their mobile device is unthinkable. Vital services like banking, education and healthcare are becoming increasingly reliant on mobile communications. The mobile economy is one of the leading drivers of financial growth and job creation. All of these benefits are dependent on mobile networks and their ability to support the astonishing, and seemingly endless, growth in data traffic.

In response, the mobile industry will need to densify networks and employ increasingly spectrum efficient technologies. But this alone will not suffice. The mobile broadband revolution isn't just attributable to engineers, but also to national governments which manage spectrum.

An enduring solution to the capacity challenge is only possible through close cooperation between governments and the mobile industry. Only by working together to identify and agree new mobile bands can the future of mobile services be secured.

Notes

Notes

Floor 2, The Walbrook Building,
25 Walbrook, London EC4N 8AF
020 7356 0600

Website: www.gsma.com/spectrum
Contact: spectrum@gsma.com

Produced February 2017