Spectrum

Best practice in mobile spectrum licensing

September 2016

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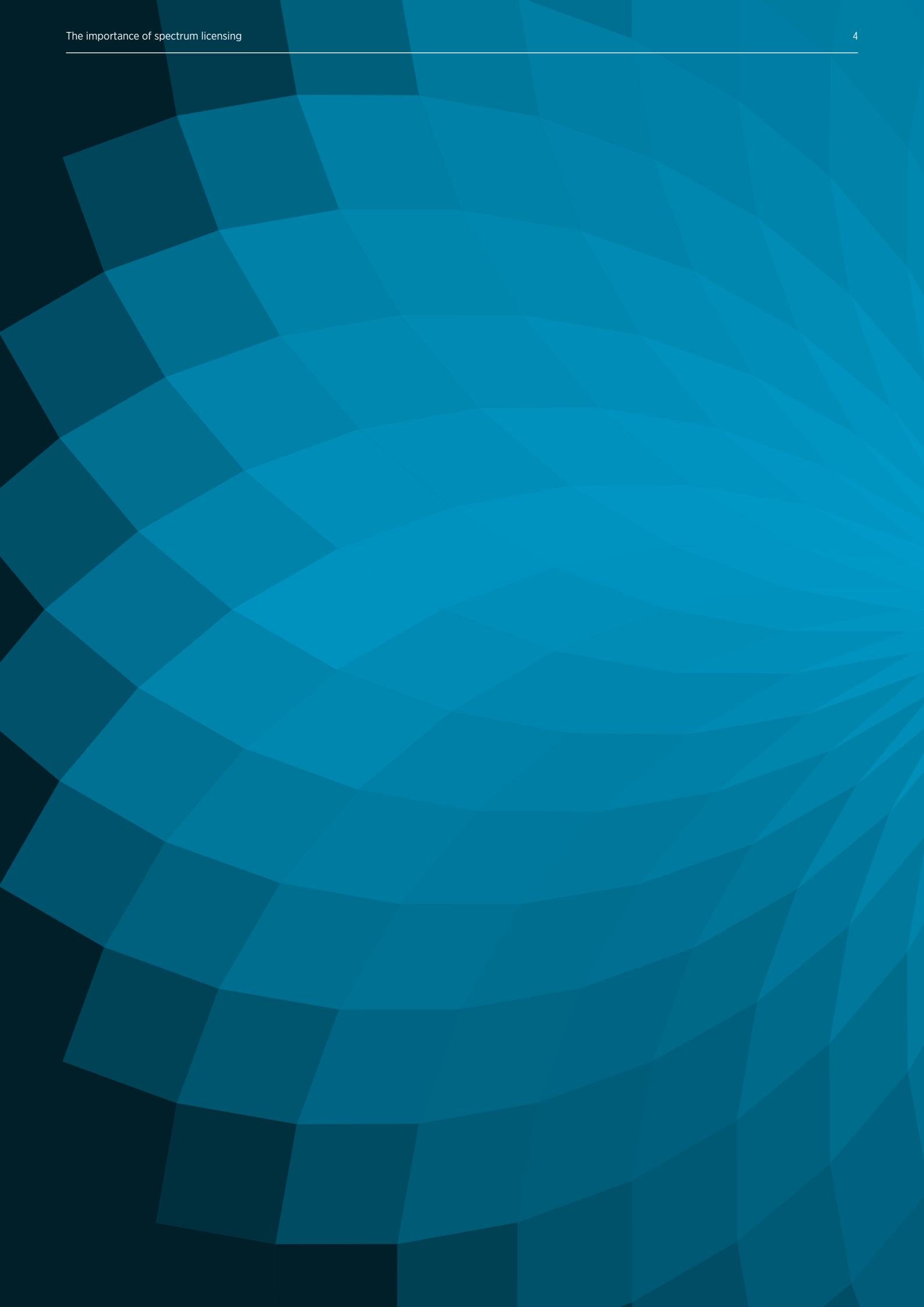


Summary

Mobile services are the main means of communications for the majority of the world's population, supporting economic growth and connecting communities. Effective spectrum licensing is critical to support the investment required to further expand mobile access, meet the rapid increase in demand particularly for data services and enhance the quality and range of services offered.

Realising the consumer and business benefits of mobile services will require licensing frameworks which:

- **ensure operators have access to sufficient spectrum;**
- **provide predictability to support the new network investment needed; and**
- **avoid costly restrictions on the use of spectrum beyond those needed to manage interference.**

The World Bank has noted that around 2 GHz of total spectrum will be needed in major markets for mobile services by 2020, whereas most developing countries have only around 500 MHz allocated to mobile services today and some have less than 300 MHz.[1]

Spectrum licensing is also gaining increased urgency as a result of the wave of licences that are approaching the end of their initial term over the next 5 years. Uncertainty over the future rights to use this spectrum deters operators from making substantial new investments to further develop their networks and services.

This report updates earlier work for the GSMA to assess how authorities can make the required spectrum available in a way that will deliver widespread and affordable access to mobile broadband. In particular, the report considers major policy issues arising from spectrum management and the advantages and disadvantages of the different approaches available to address these issues.

Our key finding is that there is no single best approach to assigning spectrum, but a need to develop approaches taking into account the specific market circumstances. The best approach will depend on the licensing authority's policy objectives as well as market conditions such as how spectrum is currently used, the competitiveness of the market and the risks to investment and service quality over the forthcoming period. The following key principles can help guide licensing authorities:

1. **Auctions can deliver strong social benefits as long as they are properly designed.** There is no one-size fits all approach to spectrum awards. Auctions are a proven means of awarding spectrum to those who are most likely to put it to the best use. However, poor auction design can lead to spectrum being assigned inefficiently or in a way that undermines competition. Administrative assignment can offer advantages over auctions in some circumstances, such as where authorities wish to assign licences with regard to a range of criteria. Whether an auction or administrative assignment is adopted, the implementation of the approach is important.
2. **A presumption of licence renewal encourages long-term network investment.** This helps avoid investment being delayed because of uncertainty over future rights. A decision not to automatically renew a licence should only be made where there is a reasonable prospect that the benefits from reassigning spectrum would exceed the costs. Given the large number of licences approaching the end of their current term, timely renewal decisions (ideally 5 years in advance of licence expiry) can facilitate ongoing network investment and enable planning so as to provide for service continuity to end-users.

1 World Bank, Digital Dividends, 2016, p. 214.

3. **High spectrum prices jeopardise the effective delivery of wireless services.** Seeking to maximise state revenues from spectrum can have negative socioeconomic costs. Competition in communications markets can be undermined and there is a risk of higher retail prices and lower network investment. Licensing authorities should set reserve prices conservatively to allow the market to determine a fair price and to reduce the risk of leaving spectrum unassigned. Where spectrum is auctioned, ongoing charges should be limited to recovering the cost of spectrum management. Any subsequent fees associated with licence renewal should not prevent reasonable returns being earned on risky investments as this discourages technological innovation.
4. **Predictable and timely spectrum licensing encourages long-term network investment.** Predictability can be supported when governments publish (i) national broadband plans setting out how targets for widespread broadband will be achieved and (ii) a spectrum roadmap providing a schedule for forthcoming spectrum releases to meet the government's broadband plan as well as other demands on spectrum.
5. **Spectrum licences should be technology and service neutral.** This enables spectrum to be used efficiently by mobile operators rather than being tied to declining technologies and services. High charges for change of use risk delaying the benefits of new technologies.
6. **Licence conditions should be used with caution.** Generally, conditions that are unrelated to avoiding interference should be kept to a minimum or removed entirely. Other important objectives, such coverage requirements, can generally be effectively addressed through direct policy measures. This can also be achieved by improving the conditions for widespread and affordable commercial services (such as removing sector-specific taxes).
7. **Licence duration should be at least 20 years to incentivise network investment.** The use of indefinite licence terms beyond the minimum period, and the presumption of renewal, can further enhance predictability.
8. **Competition can be supported by licensing as much spectrum as possible and limiting charges and other barriers to services.** Making available additional spectrum in capacity and coverage bands is key to supporting better quality, widespread, affordable mobile broadband services. Specific measures to increase competition, such as spectrum caps or set-asides, should be introduced only after assessing the benefits and costs of alternative options. In many cases, additional spectrum can bring the greatest benefit to society when it is made available to existing operators as their needs are greatest due to the rapid growth of data traffic on their networks.
9. **Voluntary spectrum trading should be encouraged to promote efficient spectrum use.** This supports improved mobile services by efficiently enabling unused, or lightly-used, spectrum to be transfered to operators who will make better use of it.

The importance of spectrum licensing

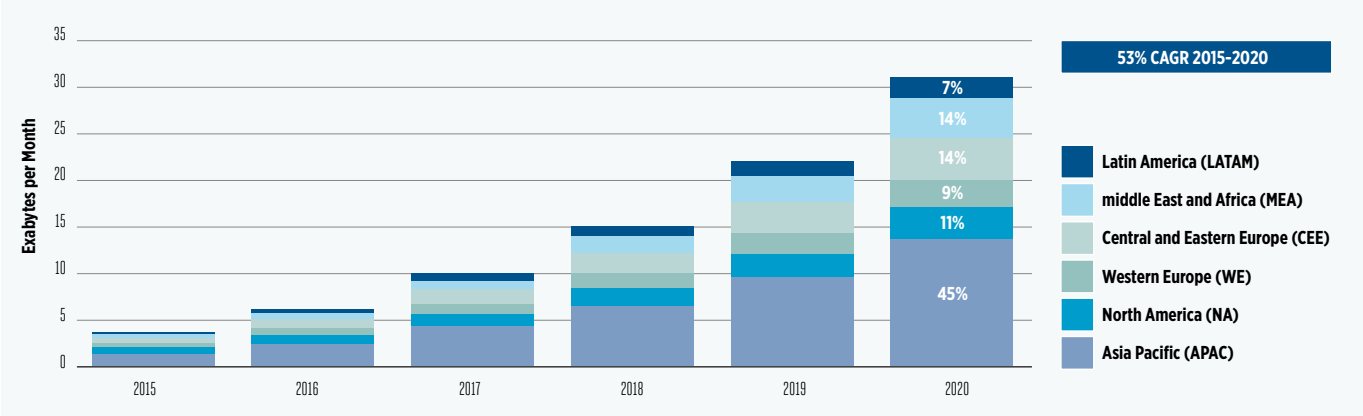
Growing demand for mobile broadband services is increasing the importance of countries' limited spectrum resources being used efficiently. The amount of spectrum made available and the terms and conditions governing its use are key determinants of whether the industry will have sufficient capacity to meet this demand while maintaining the quality and affordability of services.

Problems in spectrum allocation risk holding back not only the mobile industry but the wider economic and social benefits that are achievable through widespread access to mobile broadband, including increased employment, education and health benefits and the development of industries from agriculture to financial services. A 10 per cent increase in broadband penetration has been found to drive a 1.35 per cent increase in GDP for low-to-middle-income countries[2] and an even larger impact of a 3.19 per cent increase in GDP was found in a study focused on Latin America and the Caribbean.[3]

A key way in which mobile services drive economic and social opportunity is by expanding access to communications including high-speed Internet access. The ITU estimates that there are over 7 billion mobile subscriptions worldwide, up from 738 million in 2000 and that almost half of the world's population had access to mobile broadband in 2015.[4] Nonetheless, the ITU estimates that 4 billion people in the developing world are yet to gain Internet access.

Growth in use of smartphones and tablets enable a greater range of services to be accessed across mobile networks. Subscribers are using their devices for more data intensive services, with mobile video use growing rapidly and users increasingly using cloud-based services. Overall mobile data traffic is continuing to grow rapidly with Cisco expecting mobile data traffic to increase substantially in the years to 2020, with a compound annual growth rate 53%.

RAPIDLY GROWING MOBILE DATA TRAFFIC VOLUMES



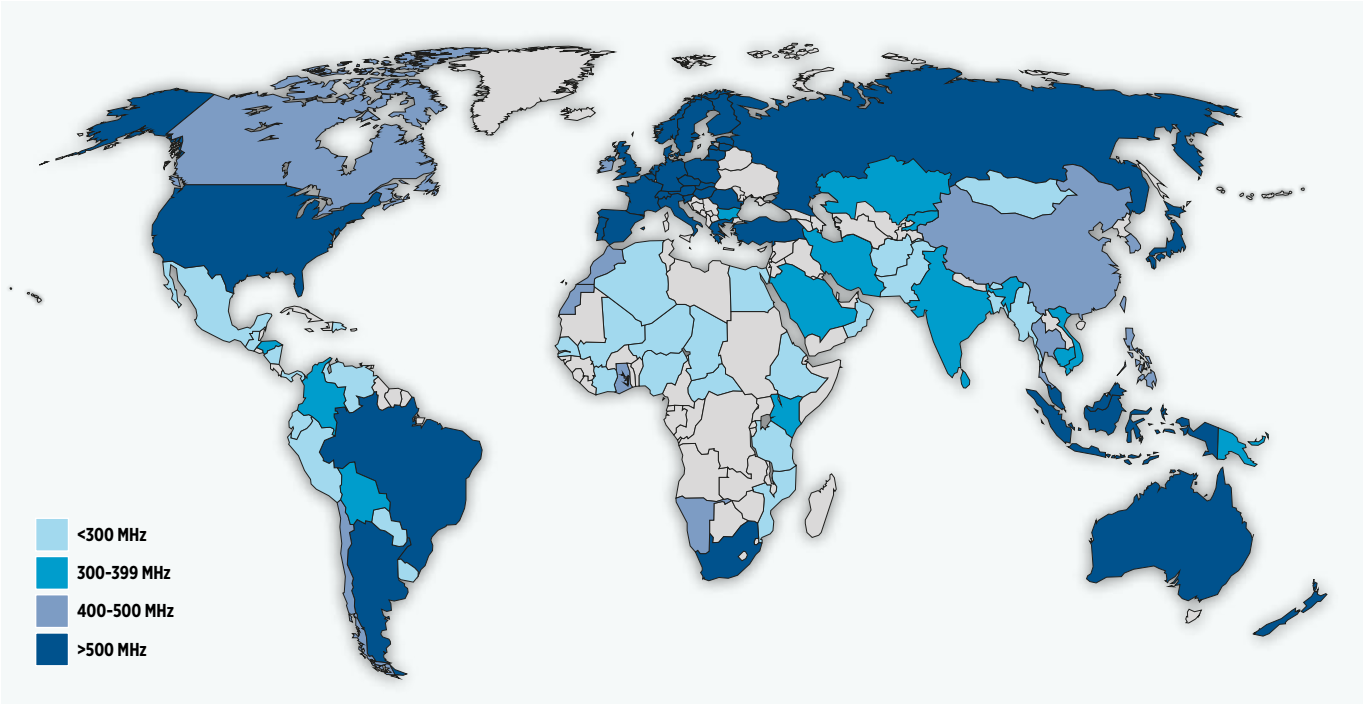
Source: Cisco VNI Mobile, 2016

2 Scott, Does Broadband Internet Access Actually Spur Economic Growth, 2012.

3 Inter-American Development Bank, Socioeconomic Impact of Broadband in Latin American and Caribbean Countries, 2012

4 ITU Statistics.

TOTAL SPECTRUM ASSIGNED FOR MOBILE SERVICES



Source: GSMAi, ITU and regulators websites (total spectrum calculated including both uplink and downlink FDD and TDD spectrum)

Technology improvements alone cannot deliver the required capacity. For example, even taking into account increased investment by operators in technology and networks, it is estimated in 2015 that the supply of licensed broadband spectrum in the US would need to increase by 50 per cent by 2020 to meet expected demand.[5] In many developing countries where growth in demand for services is also growing strongly, the supply of spectrum for mobile services is much more limited. Few countries in Africa, Latin America and parts of the Asia Pacific region have more than 400 MHz of spectrum assigned to mobile services.

To achieve the needed capacity, licensing authorities should prioritise:

- **making as much spectrum as possible available for mobile broadband including by re-allocating spectrum from less valuable existing uses; and**
- **ensuring that new, more efficient technology is deployed including 4G LTE, and in future 5G, so as to boost the capacity from the use of existing spectrum bands.**

The World Bank has noted that, in relation to making the Internet available, accessible and affordable: *"The most critical portion of the invisible mile involves spectrum management, which requires increasing the amount of spectrum available, ensuring competitive access, encouraging sharing of essential facilities, such as radio masts, and liberalizing the market for spectrum resale."* [6]

5 CTIA, Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections, 2015

6 World Bank, Digital Dividends, 2016, p.25.

Increasing the amount of available spectrum will increase the volume and quality of mobile services that can be provided while simultaneously reducing service costs. A key opportunity to allocate further spectrum to meet mobile demand is provided by the spectrum becoming available as a result of the transition from analogue to more spectrally-efficient digital television. This relatively low frequency spectrum reduces the cost of deploying mobile broadband coverage as fewer base stations are required to cover the same geographic area. The GSMA has estimated that common adoption of the 700 MHz band could generate US$1 trillion in GDP growth in the Asia Pacific region alone between 2014 and 2020 including the potential to create 2.7 million new jobs, support 1.4 million new businesses and increase government revenues by US$171 billion.[7]

Authorities should continue to examine opportunities to free more spectrum for mobile services, including by undertaking cost benefit analysis of different uses where spectrum is likely to be under-utilised currently.

Operators also need certainty in relation to spectrum access to support the high level of investment required

At a time when substantial network investment is required, the mobile industry is also faced with the uncertainty created by many operators' existing spectrum licences approaching the end of their initial term. Mobile network investments have long payback periods and operators will not undertake the investment required if they are unsure whether they will lose the right to use current spectrum.

Uncertainty over future rights to use spectrum risks:

- **deterring investment in extending and upgrading networks and deploying services;**
- **reducing incentives to compete aggressively;**
- **the loss of service continuity for customers; and**
- **spectrum being left under-utilised.**

The timely renewal of existing licences within an established, predictable licensing framework will be critical to enabling the investment required to meet the demand for mobile broadband. Countries that get their licensing approach right can better realise the potential of mobile broadband, bringing substantial benefits to consumers and businesses in terms of innovative, high quality services and lower costs of provision. In the remainder of this report, we assess the approaches that authorities can take to ensure that the industry has access to the required spectrum to maximise benefits for end-users.

7 GSMA, GSMA Announces Asia Pacific Could Generate US$1 Trillion in GDP Though Spectrum Harmonisation for Mobile Broadband, 2012.

Approaches to assigning spectrum

Realising the potential of mobile broadband will require governments to release as much spectrum as possible as quickly as possible while providing sufficient certainty over future rights of use to facilitate network investments.

Spectrum can be used both in licensed and unlicensed formats, with spectrum either assigned to a specific operator or reserved for a technology and open to all users. Unlicensed spectrum is able to support the delivery of certain services using low-power technologies over short distances, notably the use of the 2.4 GHz and 5 GHz bands for Wi-Fi. However, if all spectrum were unlicensed many existing services would not be able to be offered because of the resulting interference between spectrum users.

Licensed spectrum is required for mobile services to ensure sufficient quality of service and customer value which, in turn, will facilitate the large investments needed to deploy high performance mobile networks with wide coverage. Licensing particular spectrum bands for mobile services can also support international harmonisation which delivers lower cost devices and equipment through scale economies. Dynamic spectrum access techniques are also being developed which will enable specific spectrum bands to be shared between multiple uses or users by avoiding signals being transmitted at the same time, although the technology is still at a relatively early stage.

A range of objectives may be considered by authorities when assigning spectrum licences:

- **promoting the efficient use of spectrum particularly by ensuring that the spectrum will be put to its highest value use;**
- **supporting competition in communications markets;**
- **ensuring service continuity for end-users;**
- **having a well-run, timely and legally robust process;**
- **potentially other policy goals such as achieving wide coverage; and**
- **in some cases, generating revenue to government.**

The extent to which different objectives are affected will depend on the particular market context. In some cases, an authority may be forced to balance competing objectives. Generally, overall benefits to society will be maximised where importance is attached to promoting efficient spectrum use and ensuring competitive communications markets. Using spectrum management to pursue other policy goals, including government revenue generation, can carry significant overall costs to society relative to alternative means of achieving those goals. For example, while limiting the amount of spectrum made available would raise spectrum prices, this would also increase the cost of mobile services and constrain the growth of the other sectors of the economy that rely on mobile communications. Governments will have greater revenue generating capacity in the long-term by supporting economy-wide growth including through enabling low cost deployment of mobile infrastructure.

Competition in communications markets can generally be achieved through making sufficient spectrum available to support several rival networks at efficient scale. Nonetheless, as discussed further in this report, spectrum assignment may sometimes raise challenging competition issues particularly in mature mobile markets.

General approaches for assigning spectrum

There are two main approaches used for assigning the rights to use a particular spectrum band:

- **Auctions in which the licence is assigned to the highest bidder (with that bidder either paying the amount they bid or, in some cases, the amount of the second highest bid);**
- **Administrative approaches (often called 'beauty contests') in which the licensing authority assigns the spectrum to the candidate that is considered to best meet a number of criteria such as financial resources, industry experience, technology and rollout plans and, in some cases, price offers.**

Hybrid approaches may also be used, these combine elements of the two main approaches such as where the licensing authority initially selects a short-list of bidders based on administrative criteria and then holds an auction to assign the licence between the shortlisted candidates.

	Advantages	Disadvantages
Auctions	■ Well-designed auctions result in spectrum being assigned to the operators who value it most and will generally therefore put it to use in the way that generates the greatest benefits to society ■ Seeks to discover the market value of spectrum and obtain a fair return on a vital national asset ■ Specific non-price objectives can be targeted through licence conditions but these should only be imposed following careful consideration and where other measures have been ruled out ■ Outcome is typically transparent and generally legally robust	■ Poor auction design can lead to spectrum being assigned inefficiently or in way that harms competition in communications markets (including as a result of high reserve prices limiting participation) ■ Inflated prices risk restricting the licensee's ability to invest in high quality networks with widespread coverage
Administrative assignment	■ Enables a range of criteria to be taken into account and for authorities to balance the trade-off between objectives ■ Authorities can select the level of the licence fee which may improve operators' ongoing financial viability and assist in raising capital for network investment ■ Ability to set network investment or coverage requirements to focus on delivering high quality services rather than raising state revenues ■ Can be quick and cheap to organise and is appropriate where spectrum demand does not exceed supply	■ Licences may be assigned to the candidate that presents an attractive proposal rather than the candidate that can make best use of the spectrum. Where operators fail to meet commitments after the auction, authorities may face difficult choices as to whether to cancel the licence or otherwise penalise the operator ■ Administrative assignment is vulnerable to bias or corruption and even the perception of such can lead to protracted legal disputes that delay spectrum being put to good use

There is no single best assignment approach but rather a need to assess the merits of each on a case-by-case basis. Auctions are most suitable when there is excess demand for the spectrum and hence the benefit of auctions in awarding spectrum to the operators which are most likely to put it to the best use helps maximise benefits to society. Administrative assignment may be suitable in cases where there is less demand, an authority wishes to consider multiple objectives, or where an authority wishes to avoid high licence costs which could impact network investment.

As important as the choice of general approach, is to ensure that the approach is implemented in a rigorous way. This includes identifying key issues through public consultation, weighing up the trade-offs in specific design choices (noting the importance of efficient spectrum use and ensuring competition in communication markets) and providing sufficient time and transparency so that potential candidates can make informed planning decisions.

Auction design

In using auctions to award spectrum, major design issues that need to be addressed include:

- **Avoiding coordinated or collusive outcomes in the auction: participants have the incentive to limit competition in the auction and achieve lower prices. In some cases, the auction rules may enable explicit collusion, such as the Swiss 3G auction in 2000 which allowed for bidders to form joint ventures with the result that the number of final bidders reduced from nine to four, the same number as licences available. In other cases, bidders may be able to tacitly collude including through using their bids to signal how the bidders would like to divide up the available lots.**
- **Supporting price discovery and truthful bidding: where the auction design enables bidders to discover information about market value based on bids by other operators, the auction can help promote efficient spectrum assignment. Effective rules can encourage truthful bidding and avoid gamesmanship. However, the basic price discovery function of an auction can be undermined by setting unreasonably high reserve prices (with risks of unsold spectrum and/or less funds available for investment).**
- **Ensuring the appropriate incentives for entry: some auction designs may discourage smaller operators and entrants from bidding if they perceive they will have little chance to outbid rivals or would only win if they have overestimated value. If not prevented by auction rules, operators may also engage in predatory and entry deterring behavior. This is particularly likely in auctions with bidder asymmetries and high costs of entry.**

Regulators have used a variety of auction formats including simultaneous multiple-round auctions, sealed bid auctions and combinatorial clock auctions. The choice of auction format can influence auction outcomes as well as the resulting competition in communications markets. Simultaneous multiple-round ascending auctions, which were initially the most common format for spectrum auctions, enable bidders to discover information about the value other bidders place on licences. This may help achieve efficient assignment where there is substantial uncertainty over valuation, but can be somewhat complicated for regulators to run or for bidders to participate in, especially if the bidder needs to aggregate licences. Sealed bid auctions are simple to run and can attract entrants but carry risks of inefficient assignment because of the lack of information available to bidders about the value others place on the licences. Combinatorial auctions are particularly suited to the assignment of multiple bands where there is complementarity between spectrum lots and where bidders have strong and divergent preferences for packages of spectrum. No format is likely to provide a perfect solution – even if one format is ‘better’ at meeting competition objectives, it may have other drawbacks, such as complexity or the risk of inefficient outcomes.

MAIN AUCTION FORMATS ADOPTED FOR SPECTRUM ASSIGNMENT

	Benefits	Risks
Simultaneous Multiple-Round Ascending Auction (SMRA) Lots are auctioned individually but simultaneously in discreet bidding rounds with ascending prices for each spectrum lot and the auction continues until no more bids are submitted	■ Efficient spectrum assignment is supported by the information revealed during the auction and by bidders with the highest spectrum valuations being able to outbid rivals ■ Relatively simple format ■ Works best for spectrum licences that are substitutes which therefore do not give rise to aggregation risks ■ Prices paid for similar licences are non-discriminatory as it is costly for dominant bidders to deter entry and makes it more likely that smaller bidders will not have to pay higher average prices	■ Bidder strategy can be complex when trying to aggregate multiple lots ■ May introduce gaming opportunities ■ Lots are assigned independently, giving rise to the risk of winning unwanted lots because of failure to win complementary lots ■ Aggregation risk distorts incentives and with strong synergies between lots, a SMRA cannot be expected to generate efficient outcomes (this can be mitigated by allowing withdrawals or allowing standing high bidders to 'switch' demand)
Sealed bids Each bidder submits a single offer and the licence goes to the highest bidder The bidder pays either their bid or, under a second price rule, the highest losing bid	■ Less vulnerable to collusion and can attract entry ■ Relatively easy and quick to run ■ Can raise more revenue than a multiple round auction where competition for the licence turns out to be weak	■ Limited information available to bidders as they have no insight into rivals' values ■ Use of the first price rule can lead operators suffering the winner's curse, in which they have overestimated the true value of the licence ■ May lead to spectrum being assigned inefficiently
Combinatorial Clock Auction (CCA) Multiple round auction allowing bids for packages of lots, rather than for individual licences. An initial ascending clock phase continues for each package of generic spectrum blocks until excess demand for each group is eliminated, followed by a final round of sealed bids to determine specific assignments	■ Supports flexible lot structures which help avoid aggregation risks (i.e. bidders ending up with unwanted combination of lots) and thereby support efficient assignment ■ Second price rule whereby prices paid by winners are set at the lowest hypothetical bid amount at which they could have still won encourages straightforward bidding based on own valuations ■ A flexible format that allows for use of spectrum floors and other constraints	■ Less price revelation than in an SMRA ■ Complex to administer and participate in as it requires bidders to develop valuations for many packages before the auction ■ CCA only works well if bidders can evaluate all the bidding options that are open to them ■ Can give rise to strategic gaming possibilities, allowing participants to raise rivals' costs, resulting in bidders potentially paying vastly different prices for spectrum

In addition to the choice of auction format, there are also various tools available to regulators in designing auctions to promote competition or increase the likelihood of efficient outcomes, although there are often trade-offs involved in their use.

REGULATORY TOOLS FOR USE IN AUCTIONS

	Benefits	Risks
Lot size	■ Smaller lots which can be aggregated can lead to more efficient spectrum assignment and provide for multiple operators having access to important spectrum	■ Lots that are too small increases the need for bidders to aggregate multiple lots and may lead to operators acquiring spectrum which they are unable to use
Spectrum caps and set asides	■ Helps smaller players/entrants to win licences by preventing individual bidders from acquiring an 'unduly large' share of the spectrum or specifically sets aside certain spectrum for such operators	■ May lead to spectrum being poorly used and can weaken incentives to grow customer base. Can penalise big operators whose large customer base gives them a need for more spectrum, and prevent operators from offering the fastest broadband speeds by limiting their ability to use techniques like carrier aggregation
Information available on bids	■ Limiting what information is made available during the auction can block signaling behavior and promote rivalry	■ Limiting information weakens price discovery which may impede efficient outcomes
Reserve prices	■ Reserve prices reduce gains from collusive behaviour and help governments achieve some minimum revenue for the spectrum even when demand is low	■ If set too high can discourage marginal bidders from participating and can lead to spectrum remaining unsold, thus risking restricting network investment leading to slower rollouts, slower speeds and reduced coverage

Problems of poor auction design

While auctions have attractive properties including the potential to promote efficient outcomes, their advantages can be undone by problems in the auction design and rules. Particular design choices raise the risk that spectrum may not end up with the operators that can best use the spectrum such as where authorities seek to impose an unsustainable market structure or set high reserve prices which may result in spectrum remaining unsold or limiting network investment. If bidders successfully coordinate, not only may spectrum be assigned inefficiently but the government would not receive the market value for the spectrum.

In the 2013 Czech 4G auction, bids reached triple the reserve price before the auction was cancelled because of concerns the prices would have led to high prices for 4G services and delayed operators' ability to launch the new services. After a new auction design was chosen, the spectrum sold for less than half the level of the earlier bids.[8] FICORA in Finland, also had to call a halt to their 4G auction after 9 months with no indication of ending. The original auction rules allowed bidders to shift their bids among the different blocks of spectrum being auctioned off, effectively reducing their bids between rounds. However, the updated rules required bidders to increase their offers in every round of bidding, with this new obligation the auction was completed within a month. The 2015-16 Thai auctions of the 900 MHz and 1800 MHz spectrum also encountered problems with high prices and with one of winners defaulting on its licence payment.

8 CTU, Press Release frequencies for LTE auctioned, 2013

900 MHz and 1800 MHz auctions in Thailand

900 MHz and 1800 MHz licenses were originally assigned in Thailand to the state-owned enterprises DTAC and TOT who allowed private firms to build and operate their networks. At the licence expiry date, the licences provided for the spectrum to be returned to the National Broadcasting and Telecommunications Commission (NBTC) for re-auction.

The SMRA auctions for the 900 MHz spectrum and 1800 MHz spectrum ran sequentially in November and December 2015. Four participants competed for this spectrum comprising the existing operators AIS, Digital DTAC and True as well as a new entrant Jas Mobile. The auction process required participants to remain at NBTC's premises until the end of the auction. The auctions ran for 33 hours and 66 hours each, with the 900 MHz auction allowing bidders a three-hour sleep break for each auction day while the earlier 1800 MHz auction had no such allowances. The high levels of competition, heightened by existing spectrum scarcity and uncertainty over future spectrum release, as well as the pressure imposed by the bidding schedule, drove the auction prices up such that the 900MHz spectrum was sold to True and Jas Mobile for THB151.9 (USD4.3 billion) and the 1800MHz was eventually bought at THB80.8 billion (USD2.3 billion) by True and AIS. Concerns about the level of these prices paid resulted in shares in the bidders falling to a three-year low.

The prices were much higher than prices internationally on a price per MHz per pop basis.[9] This has caused subsequent problems, with Jas Mobile defaulting on its licence fee payment and NBTC needing to re-auction the second 900 MHz lot in May 2016.

Conclusion on auction design

There is no single 'best' auction format. For regulators, a key challenge in auction design is managing the objectives of achieving efficient spectrum assignment while supporting competition in communications markets. Seeking to maximise auction revenues risks much greater costs to society, especially the digital economy, if competition in communications markets is undermined and network investment is limited as a result.

Low participation can be a concern especially in mature mobile markets. There are a wide variety of tools available to regulators to address these issues including the choice of auction format, determination of spectrum lots, spectrum caps and set asides, bid information disclosure and reserve prices. However, these tools are often conflicting and their effectiveness will depend on local market conditions.

9 DotEcon, Thai break? Lessons from the 900MHz and 1800MHz auctions, 2016

Administrative assignments

Administrative assignment involves the regulator choosing which applicants' proposal best meets their objectives which may include coverage, quality of service and potentially a variety of wider social and economic goals. However, for an administrative assignment to work well, the selection criteria and process should be clear and the weight given to each objective should reflect its importance to society (with consideration of alternative, more targeted tools which could be used to meet more specific goals at lower cost). The use of vague and subjective criteria and a lack of transparency increases the risk of favoritism and corruption and the potential for the outcome to be challenged in the courts. Some of the tools to promote downstream competition in auctions can also be used in administrative assignments. Where authorities sets the licence fee, there may be a need to trade-off objectives and even where the objective is clear estimating the appropriate price can be challenging.

A particular problem of administrative assignment is the risk that successful applicants turn out to be unable to fulfil their offers particularly if market or technologies forecasts prove incorrect. Licensing authorities should set out in advance what penalties will be imposed should promises not be achieved. These penalties should be proportional to the significance of the breach of conditions.

Administrative assignments in Chile

Chile's regulator, Sub-Secretaria de Telecomunicaciones (SUBTEL), has used beauty contests for licensing spectrum, including for the award of the 850 MHz band for 2G services and in recent 700 MHz and 2.6 GHz awards. Licences are assigned after submissions of technical proposals, and only if there is a stalemate between the operators' proposals is there then auction between those operators. SUBTEL has used the licensing approach to award spectrum to new entrants, impose MVNO hosting obligations, as well as targeting particular network coverage, capacity and speed levels. Chile leads the region in mobile market development, with a network readiness score of 4.6 points, first in Latin America and 38th globally.[10]

While Chile has achieved high levels of network development, there are concerns that the licence obligations required are too onerous for new entrants, as well as if the tenders themselves disregard caps on total spectrum holdings. In the case of the 700 MHz auction, a case was brought before the competition watchdog, Tribunal de Defensa de la Libre Competencia (TDLC), on whether the bidding process for the 700 MHz band allowed for free and open competition. Awarding spectrum by beauty contests which result in a range of licence conditions can also make it more difficult for the spectrum to be traded later. This is an issue in Chile where AWS spectrum awarded in 2009 to new entrants was under-used despite the main operators' demand for the valuable spectrum.

10 World Economic Forum, Global Information Technology Report 2015, 2015

Choice of approach in the context of licence renewal

Where spectrum is already licensed to an operator, determining how that spectrum should be assigned when the existing licence approaches the end of its term raises a number of specific considerations. There are various renewal approaches available to regulators. A presumption of renewal allows current spectrum holders to renew their licences except under certain defined circumstances which are expected to arise relatively rarely. Where the rights to use spectrum are not renewed automatically, they may be put up for potential re-assignment either using an auction or administrative assignment. Hybrid approaches are also possible under which part of the spectrum is renewed and part made available for potential re-assignment.

APPROACHES FOR SPECTRUM LICENSING RENEWAL

	Advantages	Disadvantages
Presumption of renewal	■ High predictability which supports future investment in the sector ■ Minimises customer service disruption from operators losing spectrum and needing to reconfigure networks or exit the market ■ In conjunction with trading, supports efficient spectrum use over time	■ In some instances, spectrum may be better re-assigned (eg spectrum replanning, serious breach of conditions, spectrum left idle) ■ If not set out in original licence terms, may be considered unfair to unsuccessful bidders
Re-auctioning	■ Auction uses market to identify the true "opportunity cost" ■ Promotes efficient outcomes / efficient use of spectrum (i.e., those that value it most are allocated the spectrum) ■ Outcome is transparent and legally robust	■ Discourages long-term network investment and may be disruptive to existing businesses as incumbent operators risk losing critical spectrum ■ May be subject to 'gaming', therefore auction design is critical ■ Auction prices carry a greater risk of the licence cost undermining operators' financial viability
Administrative assignment	■ Quick and cheap to implement ■ Promotes continuity of existing services ■ Works best if benchmarks are available from local precedent or other countries	■ Government may get prices wrong ■ Price setting may not be transparent and could be vulnerable to legal challenge ■ May fail if low competition
Hybrid solution	■ Attempts to balance achieving some predictability and some flexibility	■ Risk to investment and service continuity/QoS ■ Potential costs associated with reconfiguring networks ■ Trading off predictability for flexibility would only be beneficial in some circumstances

Uncertainty over future rights to use the spectrum may lead to operators ceasing investment in the development of their networks and competing less strongly to grow their customer base until the uncertainty is resolved. A failure to renew an operator's existing rights to use spectrum also may harm service continuity or quality of service to customers. Operators may also be forced to pay excessive fees to try to retain their existing spectrum rights (as was the case in India) particularly if the auction design does not adequately protect ongoing competition.

Issues with re-auctioning expiring 900 MHz licences in India

900 MHz licences were initially assigned in India in 1994 and 1995 on the basis of regional areas or 'circles'. With several of these original 900 MHz licences due to expire, India's Department of Telecommunications (DoT) re-auctioned the licences in February 2014 and March 2015. Existing operators faced a serious risk of losing spectrum critical for them to meet service demand with reasonable quality of service. With a significant overall shortage of spectrum being made available, operators were forced to bid aggressively against each other to seek to protect the viability of their existing operations. Final prices were much higher than reserve prices. Prices for the 900 MHz spectrum ended up being on average 1.7 times those of the 800 MHz spectrum sold in the same auction – indicating a high risk of distortion. The auctions also resulted in a redistribution of spectrum between the operators, with Reliance Communications (Rcom) only retaining licences in two of the seven circles where it licences were being re-auctioned.

The CEO of Bharti Airtel, Gopal Vittal, was quoted after the auction as saying *"auction design and the scarcity of spectrum have resulted in exorbitant bids to secure the spectrum, particularly in renewal circles, where huge investments have already been made on the assurance of a continuity of business enshrined in the licenses issued by the DoT."*[11] A later review[12] found that the auction "resulted in unreasonable prices, high debt levels for companies, and expensive charges for consumers. Many firms complained that they were forced into costly decisions that harmed their competitiveness and made it impossible to innovate in ways that consumers need in the 21st century." Rcom has subsequently lost subscribers to the two largest operators[13] suggesting that the re-auctioning of licences may also be adversely impacting competition.

11 Bharti Airtel media release.

12 Shamika Ravi and Darrell M. West, Centre for Technology Innovation and Brookings (2015), 'Spectrum policy in India'

13 Telegeography.

Authorities should attach weight to minimising uncertainty particularly by creating a presumption of renewal. For example, spectrum licences in Canada have a high expectation of renewal, unless a breach of licence condition has occurred, a fundamental reallocation of spectrum to a new service is required or an overriding policy need arises. A presumption of renewal can be considered equivalent to the use of indefinite licence terms, such as in the UK for spectrum used for mobile purposes, where the licences can only be revoked after a minimum period on spectrum management grounds and subject to a specified minimum notice period.

Where a regulator expects clear benefits from re-assigning some spectrum that would outweigh the significant costs involved, hybrid approaches can balance the expected benefits with the importance of protecting ongoing investment and service delivery.

Hybrid spectrum re-assignment approached in Hong Kong and New Zealand

Both the Office of the Communications Authority (OFCA) in Hong Kong and Radio Spectrum Management (RSM) in New Zealand have adopted hybrid approaches to address the expiry of existing spectrum licenses.

In Hong Kong, with the 2.1 GHz licenses due to expire, a decision was made to renew using a combination of administrative reassignment and auctions. The four incumbent licensees were offered first rights of refusal on two thirds of their existing spectrum holdings and the remaining third of the band was to be put up for auction. In April 2014, CSL was acquired by HKT, with the condition that the combined entity divest a further share of their combined 2.1 GHz holdings which was also included in the auction. While the combined CSL/HKT was barred from participation in the auction, the other two incumbents, SmarTone and Hutch were awarded spectrum, along with a new entrant China Mobile HK who won 2×19.6 MHz, thus returning the market to four operators.[14]

When the spectrum in the 800 MHz and 900 MHz bands were due to expire in New Zealand, RSM guaranteed the renewal of some of the spectrum to the incumbents, Telecom and Vodafone. However, RSM gave them two options for how much spectrum was renewed:

- **Telecom and Vodafone could each sell 2×5 MHz to a third party, and have the remainder of their rights renewed, or**
- **2x7.5 MHz of each company's management rights would not be renewed and the Crown would allocate them to a third party.**

The incumbents both selected to sell spectrum to new entrant, 2Degrees, and the three operator market structure has proved sustainable with 2Degrees gaining a market share of just under 24%.[15]

14 OFCA, Auction of Radio Spectrum in the 1.9 – 2.2 GHz band for the Provision of Public Telecommunication Services, Successful Bidder Notice, 2015

15 Commerce Commission, Annual Telecommunications Monitoring Report, 2015

Recommendations on general licensing and renewal approaches

Where spectrum is to be assigned for the first time, there is no single 'best' licensing approach and authorities should make their decision on the approach and design taking into account the specific market context. In choosing the assignment approach, licensing authorities should prioritise the objectives of promoting efficient use of spectrum and network investment while also ensuring effective competition in communications markets.

Whether an auction or administrative assignment is adopted, the details of the implementation of the approach are important. A decision not to automatically renew a spectrum licence should only be made where there are expected to be potential benefits from reassigning spectrum (such as more efficient spectrum use or greater competition) that are likely to exceed the costs (e.g. disruption to services and customers, the risk of deterring investment, customer service degradation and any required network reconfigurations).

Ensuring a predictable, timely and open licensing process

A predictable and timely licensing and regulatory framework enables operators to build the business case for the long-term network investment required to support the digital economy. Regulatory stability and transparency also helps improve the quality of licensing decisions and minimises the risk of protracted legal proceedings.

A long term spectrum management plan

Governments can maximise the social gains from its spectrum resource by developing a spectrum management framework which supports investment, the efficient use of spectrum and competition. The spectrum management framework should:

- **ensure that sufficient spectrum will be available for the services that will deliver the greatest benefits to society and that mechanisms are in place to identify and re-allocate spectrum where it is currently idle or under-utilised;**
- **setting out a timetable for future spectrum releases and licence renewal decisions;**
- **establish clear rights governing the use of particular bands to avoid intolerable interference and a robust compliance regime;**
- **base licensing decisions on a detailed assessment of the costs and benefits of a range of licensing options with particular regard to longer term impacts on investment incentives and sustainable competition (including recognising licensees' legitimate expectations);**
- **avoid unnecessary restrictions and conditions on the use of spectrum which can carry large costs and delay the introduction of new technologies and services;**
- **facilitate international harmonisation of the use of spectrum bands so as to support international roaming and realise scale economies in equipment manufacturing; and**
- **assign the responsibility for licensing decisions to an independent regulator required to follow specific, transparent criteria in making its decision and with an independent appeals process with the power to enforce its decisions.**

Many countries have recognised the importance of reforming their spectrum management as part of the development of National Broadband Plans. These plans set out targets to achieve widespread access to broadband as well as the way in which those targets will be achieved. Making further spectrum available and liberalising the use of spectrum can play a critical role in improving broadband access including in extending coverage and in ensuring affordable services. 134 National Broadband Plans were in force by the mid-2013 and the adoption of these has been associated with a significant increase (7.4%) in mobile broadband penetration.[16] The strength of such plans in promoting investment and confidence in the sector is promoted by their political support, comprehensibility, enforceability and the buy-in from stakeholders. Due to the quick moving nature of developments in the digital economy, these plans need to be reviewed and updated on a regular basis.

16 Broadband Commission, Why National Broadband Plans Matter, 2013

Three key elements of a spectrum management framework that can promote stability and transparency, which we discuss in further detail, are ensuring that there is:

- **a clear roadmap on both new spectrum releases and licence renewals;**
- **sufficient notice is given for decisions relating to licence expiry; and**
- **consultation on key decisions.**

Spectrum roadmap on releases and renewals

A spectrum roadmap is a plan for both government and stakeholders setting out the steps and timing in making available unused spectrum and in better utilising existing spectrum allocations. In particular, a spectrum roadmap should cover:

- **an audit setting out current use of spectrum and identifying any spectrum that could be re-allocated to higher value use;**
- **the schedule for future spectrum releases;**
- **how spectrum will be assigned including a framework for determining spectrum prices and other terms and conditions;**
- **the timing and process for spectrum renewal decisions;**
- **a plan for the introduction of technology neutral licensing and trading if not already in place.**

A spectrum roadmap is an important means of ensuring sufficient spectrum will be available to meet the requirements driven by changing technology and demand. Information on future spectrum release is critical in order for businesses to prepare investment plans, secure financing and develop arrangements for deploying particular technologies.

While it will not be possible or desirable to detail every approach in advance of analysing the expected demands for particular spectrum, where a menu of approaches will be considered investment risks can nonetheless be reduced by the authority setting out what factors or criteria they will use to choose between the specific approaches.

The Australian Communications and Media Authority (ACMA) publishes an annual update of their 5-year spectrum outlook. The current edition, published in September 2015, sets out their plans for an auction of residual 1800 MHz spectrum, reallocating 2 GHz licenses due to expire in 2017, reviewing planning arrangements in the 800 MHz and 900 MHz bands, review L-band (1.5 GHz) spectrum for applicability for mobile and opening up access to unsold 700 MHz lots. On the other hand, uncertainty over the dates for the use of the Digital Dividend in some countries in South America increases the risk to network investment and can lead to other spectrum being held for precautionary reasons even when it would deliver more value in other uses.

Digital Switchover planning and the 700 MHz band in Latin America

700 MHz is a key band for the provision of widespread, affordable mobile broadband services due to the band's propagation benefits. However, while a number of Latin American countries have made steps towards enabling the band's use for mobile broadband, there have been delays in clearing the band from its existing assignment for broadcasting.

As of May 2016, mobile operators in eight Latin American countries have been awarded 700 MHz spectrum for the purpose of 4G network deployment.[17] However, Colombia is the only country to have completed the digital switchover by migrating analogue TV services in the 700 MHz band to digital. A further four Latin American countries have ongoing switchover processes, while the remainder, including Argentina, Chile, Nicaragua and Panama where awards to mobile have occurred, have made no official announcements regarding switchover completion dates.

Uncertainty in the availability of this band carries a range of negative risks including the delay of 4G services and that operators that have already acquired the spectrum would have less incentive and ability to fund network launches in alternative bands.

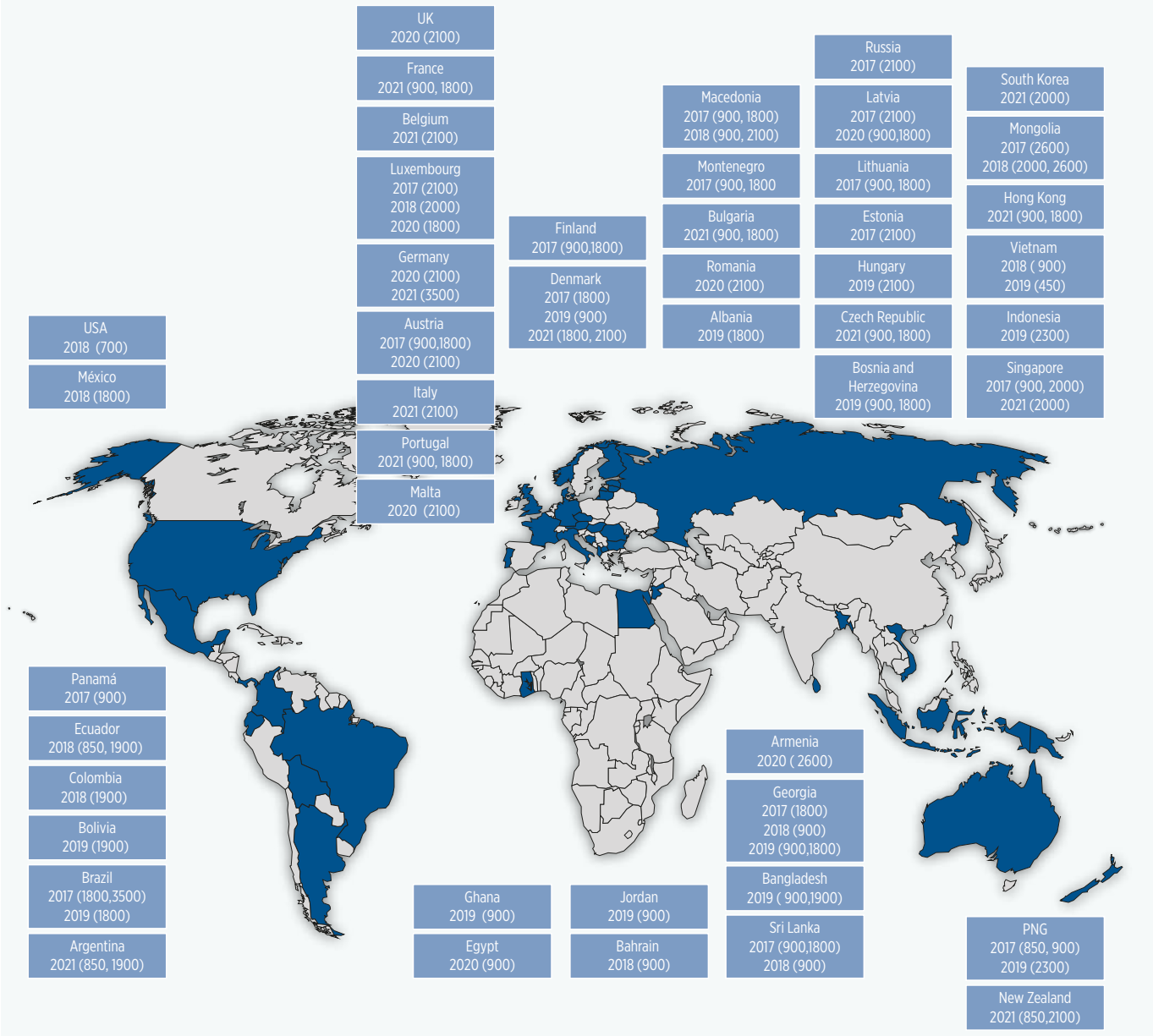
Timely licence renewal

Giving the complexity and cost of decisions to acquire spectrum, authorities should provide market participants with as much notice as possible of forthcoming assignment processes and decisions. Timing is particularly important for spectrum renewal decisions as the earlier renewal takes place before the date of licence expiry, the lower the risk of investment being reduced or postponed because of uncertainty over the period over which the operator will be able to recover the costs of the investment. This is a key issue in many markets currently as many existing spectrum licences are approaching the end of their term.

Early notice of renewal decisions also enables operators to better plan for investment and service continuity. For example, if some spectrum is not renewed, operators may be able to acquire other spectrum or make network investments that reduce the risk of service disruption to consumers. A minimum period for a licence renewal decision should be 5 years, as applied by some jurisdictions (e.g. the UK and New Zealand), to support ongoing investments in developing mobile networks.

17 5G Americas, LTE Deployment Status, 2016

EXAMPLES OF LICENCES APPROACHING THE END OF THEIR TERM



Consultation

Consultation supports efficient spectrum licensing by providing a forum for the perspectives and information of different industry stakeholders to be taken into account, including in relation to the likely effects of different options. Input from different stakeholders is essential to evaluating benefits and costs and determining the best approach prior to a licensing decision being made. For example, consultation can inform the choice of licensing and renewal approach, reasonable reserve prices or, for administrative approaches, the licence fees and the costs and benefits of imposing particular conditions. Setting out the reasons for decisions and providing a right of appeal can also improve the quality of decisions by protecting the rights of affected parties and ensuring decisions are reasonably based.

Recommendations on licensing process

Licensing authorities should ensure that the overall licensing framework offers stability and transparency to reduce regulatory risk and promote investment. National broadband plans and spectrum roadmaps are important ways in which the government can identify how to achieve widespread broadband access and incentivise high levels of private network investment. Given the large number of licences approaching the end of their current term, timely renewal decisions (ideally five years in advance of licence expiry) can facilitate ongoing network investment and enable planning so as to provide for service continuity to end-users.

Spectrum pricing

Where spectrum is auctioned, the spectrum licence price is determined by the auction itself. However, where spectrum is not auctioned, authorities will need to consider whether to levy charges for the use of the spectrum. In both cases, seeking to maximise state revenues risks much greater costs to society, especially the digital economy, if competition in communications markets is undermined and network investment is limited as a result.

Authorities set spectrum licence fees for three main purposes:

- **to recover the administrative cost of licensing process and spectrum management (e.g. a 'user pays' model);**
- **to encourage efficient spectrum use; and**
- **to raise revenue for the government.**

Efficiency in markets is promoted where users take into account the opportunity cost of a resource. The opportunity cost of spectrum is the value the spectrum would have if used in the next best alternative. Where there is no excess demand for the spectrum band, then the opportunity cost of the spectrum will be zero. However, where there is excess demand for spectrum, setting prices to reflect the opportunity cost of spectrum may promote efficient spectrum use in markets where spectrum is not able to be traded. Nonetheless, it is important that spectrum charges are set conservatively to avoid the risk that valuable spectrum goes unsold, and therefore is not put to a positive socioeconomic use. Where spectrum is tradeable, operators can be expected to take into account the value of the spectrum in other uses (i.e. the potential sale price for the spectrum) and hence spectrum charges will not generally be needed to achieve efficient spectrum use.[18]

Governments may seek to raise higher revenues by setting licence fees that exceed the opportunity cost of the spectrum. The higher the level of licence fees, the greater the risk that no operators will acquire the spectrum and the benefits to society from the use of the spectrum will be lost. High licence fees may also reduce the number of viable competitors both through the cost of the fees themselves and by making operators more vulnerable to changes in market conditions.

High spectrum fees also carry risks to network investment. High charges may reduce the funds available for investment or lead to higher debt levels which increase the cost of raising additional capital. The impact of high spectrum prices on consumers could be significant. A recent study[19] compared the price paid in Europe for 800 MHz licences to the number of 4G connections, the level of 4G penetration and the level of 4G coverage. The findings showed that countries where the cost of 800 MHz licences were lower had higher 4G market penetration and network coverage two years after having launched LTE services in the band.

18 The UK regulator has argued that operators may not fully take into account the opportunity cost of spectrum. Given the spectrum is generally a valuable asset, it is unlikely that operators do not manage their spectrum resources efficiently. However, even if this were the case, setting annual charges would then raise the ongoing costs of service provision and this can be expected to flow through into higher end-user prices and/or reduced network investment thus impacting the quality and reach of services.

19 Arthur D Little and the GSMA, The socio-economic benefits of greater spectrum policy harmonisation in the EU, 2015

High fees may also reduce expected future returns to investment. In the context of licence renewal, authorities should be particularly careful not to set fees that effectively seize returns on earlier risky investments. Doing so, will deter operators from making future investments where there are significant market or technology risks, despite the potential for such investments to benefit society.

Authorities should also ensure that they do not inadvertently deter investment and competition through the way in which spectrum charges are imposed. For example, fees set based on some measure of the size of operators can discourage operators from competing to grow their customer base while fees based on the size of the network may deter network investment.

Spectrum pricing in Kenya

The Communications Commission of Kenya charges licensees both an exclusive spectrum bandwidth assignment fee and a spectrum usage fee.[20] The Assignment fee is charged on based on the assigned bandwidth, while the spectrum usage fee varies based on the number of transceivers (TRXs) in the network using the following formula:

Spectrum usage fee =
100,000 × TRX in network × weighting factor

This pricing structure discourages network rollout, as deploying more TRXs increases the spectrum fees payable by the operator, thus negatively impacting mobile coverage and quality of service.

20 Communications Commission of Kenya, Frequency Spectrum Fees Schedule

Comparative assessment of pricing approaches

There are a range of spectrum pricing approaches with differences in terms of:

- **their ability to meet particular objectives (e.g. recovery of regulatory costs, promoting efficiency or government revenue objectives);**
- **whether charges are levied as an upfront lump sum or annually or a combination of upfront and annual charges); and**
- **whether the authority select the absolute level of the charge or whether it varies with revenues or some other measure.**

Prices that reflect the market value of spectrum will help promote efficient spectrum use. Auctions and spectrum trading can directly determine market value. Where these market mechanisms are not used, authorities may seek to estimate the market value of spectrum (e.g. administrative incentive prices). One way in which to estimate market value is to consider the costs operators would avoid by gaining an additional increment of spectrum. In particular, operators with more spectrum, need fewer cell sites to supply the same traffic volumes. The incremental value of spectrum can be estimated on the basis of this trade-off taking into account the network being modelled as well as traffic forecasts. An alternative approach is to estimate market value using benchmarks of recent auctions. Both approaches require the use of assumptions and may have strengths and weaknesses in particular contexts. For example, the accuracy of benchmarking depends on market prices being available for comparable spectrum offered in comparable markets and subject to similar terms and conditions. Ofcom's use of benchmarking to set annual licence fees in the UK for 900 MHz and 1800 MHz spectrum shows how complex benchmarking can become with significant scope for error.[21] For important spectrum bands where the cost of errors can be high, the use of both avoided cost modelling and benchmarking can improve accuracy.

Setting an upfront licence fee is often seen by economists as preferable to annual charges because once the fee is levied it is a sunk cost which will not affect service prices. However, upfront fees carry greater risks to operators particularly smaller operators and when future technological and market development is uncertain. Where authorities impose annual charges or new charges for licence renewal, regulatory risks to investment can be reduced by authorities following a transparent pricing framework with clear criteria. As noted with regard to the example of Kenya above, setting prices by reference to an operator's customer base or its network size risks deterring competition and investment. Such pricing may also undermine efficient spectrum use as operators with few customers would face minimal spectrum charges.

21 Ofcom, Annual license fees for 900 MHz and 1800 MHz spectrum, 2015

PRICING APPROACHES FOR SPECTRUM

Pricing Approach	Advantages	Disadvantages
Prices set to recover administrative costs of spectrum management	■ Appropriate where there is no excess demand for spectrum	■ May not lead to efficient spectrum use where there is excess demand for the spectrum and where spectrum assignment is not market based
Auction	■ Can provide a transparent and objective way to set prices that support efficient spectrum use	■ Flaws in auction design (e.g. high reserve pricing, limited spectrum availability or insufficient information on forthcoming awards) can result in inefficiently inflated prices or spectrum remaining unsold. This may restrict competition and risk higher mobile retail prices and/or limiting network investment, thus delaying improvements in quality and the reach of services. Changes in market conditions may mean that auction prices turn out to have been too high with the risk that existing operators prove unviable and exit
Share of revenue	■ Shares risk between government and operator and can promote new entry	■ Requires modelling based on assumptions
Avoided cost modelling of spectrum value	■ Provides a direct estimate of the value of an increment of spectrum	■ Risk to investment and service continuity/QoS ■ Potential costs associated with reconfiguring networks ■ Trading off predictability for flexibility would only be beneficial in some circumstances
Benchmarking	■ Simple and transparent where close benchmarks exist	■ Will be inaccurate if the analysis does not fully account for differences in factors impacting on market value

Reserve prices

Reserve prices are used in auctions to help discourage non-serious bidders and ensure a floor price for spectrum in case competition for the licences is weak. However, reserve prices should be set conservatively so as not to undermine the price-discovery function of the auction which is central to the market-based approach to spectrum management. If reserves are set too high then valuable spectrum may go unsold, or sold at such a high price that consumers may suffer due to limited competition and high prices and/or through underinvestment in mobile networks resulting in poorer quality of service.

Recent evidence shows that high reserve prices are a growing concern. A study[22] found that in most recent auctions (51%) over the past 10 years, the gap between the final price paid and the reserve price is negligible, suggesting the government rather than the market determined the outcome. Such non-market based prices mean operators may be paying more for spectrum than its competitive market value which risks lower network investment and higher consumer prices.

22 Plum Consulting, Reserve prices in spectrum auctions: why size matters, 2016

The same study also found that a significant number of recent auctions ended up with unsold licences. For example, in the Digital Dividend auction in Australia in 2013 the level of reserve prices set by the Government led to one of the three Australian mobile operators withdrawing before the auction and 30 MHz of spectrum in the 700 MHz band being left unsold. The consequence of this is that this spectrum is not being used to supply services to consumers (potentially leading to higher priced and less competitively offered 4G services) and the government failed to obtain revenues from the spectrum that might have been earned had it sold.

High reserve prices and auction inefficiencies in Africa

While beauty contests to assign spectrum have been more common in Africa in the past, auctions are now being used more frequently. There have sometimes been issues in auction design with, for example, a number of recent 4G auction failing to assign available spectrum particularly where reserve prices have been set at high levels compared with reserve prices set elsewhere.

TABLE 1 - SUMMARY OF THE IMPACT OF HIGH RESERVE PRICES ON RECENT AFRICAN SPECTRUM AUCTIONS

Pricing Approach	Year	Band	Spectrum available	Spectrum unsold	Reserve Price ($million per lot)
Mozambique	2013	800 MHz	2×25 MHz	2×25 MHz	30 per 2×5 MHz
Ghana	2015-16	800 MHz	2×20 MHz	2×10 MHz	67.5 per ×10 MHz
Nigeria	2015-16	2.6 GHz	2×70 MHz	2×40 MHz	16 per 2×5 MHz
Senegal[23]	2015-16	700 MHz, 800 MHz, 1800 MHz	2×30 MHz 700 MHz band 2×20 MHz 800 MHz band 2×30 MHz 1800 MHz band	2×30 MHz 700 MHz band 2×20 MHz 800 MHz band 2×30 MHz 1800 MHz band	55.24 per concession (each concession of 2×10 MHz 700; 2×5 MHz 800; 2×10 MHz 1800)

Unsold spectrum can lead to reduced coverage and slower services, or some services not even being offered or offered at a higher price to recover the costs of operators needing to deploy greater network equipment. High reserve prices can also be counter-productive if government revenues end up lower because of the failure to sell all spectrum.

23 In June 2016, after the January 2016 failure of the 4G spectrum auction, the state-owned operator, Sonatel, renewed their operating licence and gained extended rights to use additional spectrum for 4G, paying $55 million for 2×10 MHz 800 MHz and 2×10 MHz 1800 MHz for 4G use.

Where competition is expected to be strong, reserve prices can be set as minimum safety net as competition in the auction will ensure a fair price for the spectrum.

Recommendations on spectrum pricing options

Spectrum prices should promote, and not undermine, the optimal use of spectrum for the benefit of society. A danger of governments setting higher charges to raise revenue is that fewer competing operators will be viable or end-user prices will be higher limiting the benefits that would have been achievable through affordable mobile services. High spectrum fees also reduce the funds available for investment thus negatively affecting the quality, speed and reach of mobile broadband services. High fees can also lead to higher debt levels which raise the cost of raising additional capital. High annual fees may also reduce expected future returns to investment. In the context of licence renewal, authorities should be particularly careful not to set fees that effectively remove returns on earlier risky investments. Doing so, will deter operators from making future investments where there are significant market or technology risks, despite the potential for such investments to benefit society. Licensing authorities should set reserve prices conservatively to allow the market to determine a fair price and to reduce the risk of leaving spectrum unassigned.

Setting non-price terms and conditions

Spectrum licences have traditionally contained a range of non-price terms and conditions which go beyond those necessary to manage interference between users. Providing for flexible spectrum use by limiting licence conditions enables spectrum be redeployed at a time of rapid technology and market changes and brings down the cost of service provision.

Technology and service neutrality

Restricting the use of spectrum to particular technologies and services exacerbates scarcity of spectrum and prevents customers from gaining access to new services. Removing restrictions that limit the use of spectrum to particular services or technologies (beyond those needed to manage interference) enables a country to maximise the benefits from its spectrum resources on an ongoing basis. Operators' ability to introduce new, more spectrally efficient, mobile technologies (including LTE, LTE advanced and in future 5G) will be critical to meeting exponential growth in demand for mobile data services.

A number of countries only allow for licences to be made technology neutral after payment of fees. High charges for changing licences to be technology neutral risks delaying the benefits of new technology to end-users.

Technological neutrality in Guatemala

Guatemala was an early adopter of technology neutral licences. Since 1996, licensees have been allowed to decide which service and technology to implement within the licensed spectrum. Guatemala's Superintendencia de Telecomunicaciones (SIT), awards licences with conditions set only on permitted interference, frequency band and duration of the licence.

The flexibility provided to the operators in Guatemala allowed them to develop efficient networks, with penetration and subscriber traffic increasing relative to neighbouring countries while prices were kept relatively low.[24] Operators were also able to move to new technologies, such as 3G and 4G, without needing for new spectrum to be licensed or existing conditions changes. Technology neutral licences have since been adopted more widely across Latin America.

24 ITU, Spectrum Management for a Converging World: Case Study on Guatemala, 2004

Licence obligations

Licensing authorities often impose additional obligations on licensees aimed at achieving particular policy objectives. These can include obligations relating to universal access, such as coverage and service commitments, as well as obligations relating to the promotion of competition. Where a licence is assigned using a beauty contest, rather than an auction, commitments to meet non-price criteria can come to dominate the assignment process.

When mobile spectrum was licensed to only a single incumbent operator, imposing a series of obligations as part of that operator's licence represented a relatively straightforward way to achieve particular objectives. However, the development of competition in communications markets raises the need to regularly review which policy objectives remain relevant and which operators should be subject to any obligations. As a result, licence obligations can often result in greater costs than benefits.

Overarching licence obligations

Bangladesh is an example where the licensing authority sought to use licence renewal to meet other objectives that had nothing to do with the efficient use of spectrum. For example, the regulator included obligations on employment regulation (limiting employment of foreign nationals), a social obligation fund and corporate social responsibility. There is a strong case for such regulatory issues to be addressed within a separate regulatory framework – with their own consultation process – and should be removed from the licence renewal framework. Bangladesh's licensing authority also required an IPO of 30% of the equity within 2 years, although local financial/capital markets were unlikely to be established enough to support the required financing.

Coverage and service obligations

Many licensing authorities have imposed obligations on licensees to provide a particular level of service coverage within a specified timeframe or included requirements to offer certain services, or quality of service as well as measures relating to universal access and consumer protection goals.
In deciding whether to impose such obligations, licensing authorities should consider:

- **the benefits and costs of such obligations; and**
- **whether there are less costly means to achieve the objectives.**

Whether a particular regulatory obligation is required to support universal access goals will depend on the specific market circumstances. Competition often drives the widespread availability of affordable mobile services given that coverage and price are key means by which operators seek to gain a competitive advantage over their rivals.

Stringent coverage or service requirements carry risks. Obligations may force operators to deploy networks and services faster than economically or commercially sensible to do so. For instance, this could arise where technology is still at an early stage with a number of technical flaws remaining or where equipment prices are relatively high before more widespread international take-up. Obligations may also force operators to incur losses (e.g. by deploying networks in advance of sufficient demand for the services) which can create financial difficulties particularly for entrants without established cash flows.

Costly licence obligations in Argentina and Peru

The 2014 auction in Argentina of 4G 700 MHz and AWS (1700 MHz/2100 MHz) spectrum included a set of stringent coverage obligations. Licensees were required to roll out 4G services to all localities with over 500 inhabitants, approximately 98% of the population. This target would place the Argentinian 4G network coverage well ahead of the global coverage level forecast by the GSMA for 4G (~62%) and even 3G (~85%) by 2020.[25] These obligations are unlikely to be practical or would be ruinously expensive for the mobile operators, especially given the low population density in rural areas.

The licence renewal process faced by Telefónica Móviles in Peru for their 850 MHz and 1900 MHz spectrum holdings took close to 2 years, commencing in November 2010 with negotiations continuing until January 2013. In order to secure the licence renewal and not have spectrum returned to the regulator, Telefónica agreed to comply with certain requirements including the provision of free internet in government institutions and coverage extensions. Telefónica estimated the cost of meeting these commitments to be $1.2 billion.

25 GSMA, Mobile Broadband reach expanding globally, 2014

Extensive coverage obligations imposed on all licences may lead to costly duplication of network infrastructure. A number of regulators have sought alternative ways to ensure access in rural areas while avoiding inefficient network duplication:

- **the German regulator imposed a 'shared' obligation on all operators who acquired 800 MHz to coordinate to ensure coverage in rural areas before rolling out to urban areas; and**
- **one of the 800 MHz licences in Sweden included an obligation to provide mobile broadband to locations currently lacking access to other forms of broadband.**

Where obligations are imposed they should be made clear prior to the auction or assignment process so that operators can develop a viable business case. Costly obligations would be likely to be reflected in lower auction prices. Governments should therefore assess whether the impact on auction revenue is an appropriate trade off to extend mobile coverage or whether the adoption of an alternative approach, such as providing targeted government funding for the extension of one network in underserved areas, would be more efficient. A competitive tender could also be held to identify the lowest level of government subsidy required for an operator to extend coverage to the target area.

Where operators fail to meet their licence conditions (as was the case with 3G licence conditions in European countries including France, Spain and Sweden), regulators are confronted with the dilemma of whether to take the drastic step to revoke the licence with potential harm to competition or postpone or abandon the licence condition. Relaxation of licence conditions can lead to legal challenges by other operators who have met conditions or by potential new entrants who may have bid for the licence if they had known the obligations would not be enforced.

An alternative to imposing rigid coverage and service obligations is to support the commercial provision of services in rural areas including releasing spectrum in lower frequency bands, allowing for network sharing and removing or minimising mobile-specific taxes and charges. Measures that improve the commercial viability of extending coverage are more likely to be achieved, and at lower cost, than seeking to enforce licence obligations.

Minimum 20-year terms for new licences

The longer the duration of a licence, the greater the certainty provided for operators to undertake long-term investments in rolling out networks and in deploying new services. Investors would be reluctant to undertake investments if the licence runs for a shorter period than the expected payback period and if there is uncertainty over whether the licence will be renewed again in the future.

On the basis of the expected payback period for substantial new network investment, many countries including Canada, New Zealand, the UK and more recently Australia have decided to provide for a minimum term of 20 years for new mobile licences. Such a term will help support investment in 4G and in the near future 5G. Perpetual spectrum licences, with a minimum notice period for revocation, or a presumption of renewal can avoid unnecessarily introducing uncertainty over renewal as a result of a fixed term.

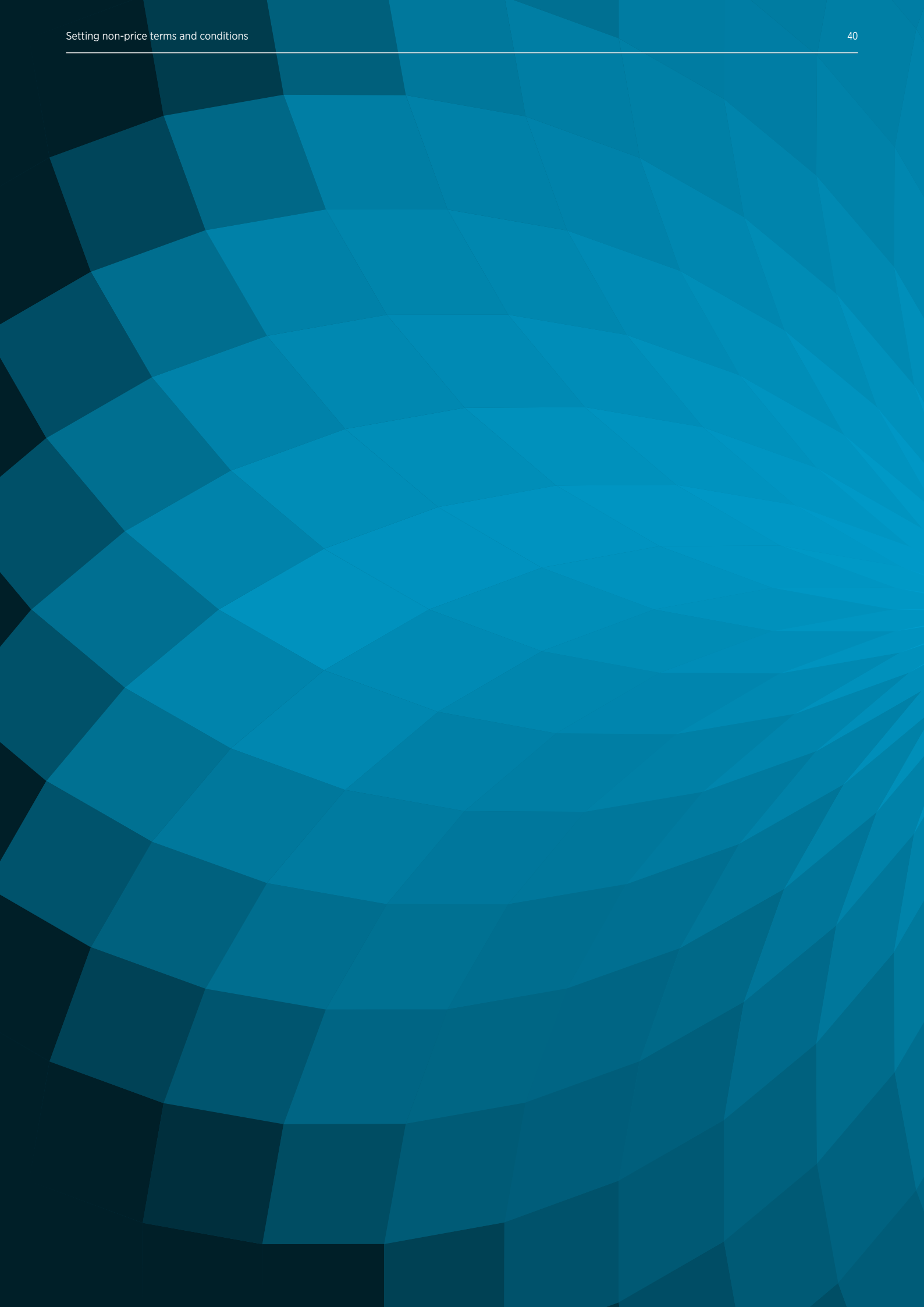
Longer licence terms both support and are supported by a move towards a more market-based approach to spectrum management. Longer licence terms provide the certainty for operators to take advantage of increased flexibility to introduce new technologies and be more willing to trade spectrum. The risk of long licence terms locking spectrum into outdated, inefficient use is also greatly reduced when licensees are allowed to change the use of spectrum or sell to another party that can make better use of it.

Providing greater certainty for licensees in Australia

In 2015, the Australian Communications and Media Authority (ACMA) and the Department of Communications published their Spectrum Review Report, setting out plans to reform Australia's spectrum policy and management framework. The review highlighted the benefits of extending licence duration and recommended increasing the maximum duration from 15 to 20 years. The ACMA and the Department consider that this extension balanced the benefits of "providing users of spectrum with greater certainty to innovate and invest whilst supporting the development of secondary markets" with the risks of "reducing government flexibility as circumstances change".

Recommendations on non-price terms and conditions

Authorities should limit conditions on the use of spectrum to those necessary to safeguard against harmful interference. New spectrum licences should be technology and service neutral. Where governments have particular coverage or other policy objectives, they should consider the range of alternatives available to meet those objectives including supporting commercial provision of widespread and affordable access. Mobile licences should have a minimum 20-year term to provide for sufficient certainty to support mobile network investment which have long pay-back periods



Promoting competition through licensing

As access to spectrum is essential for the supply of mobile services, the way that spectrum is assigned and how it is managed on an ongoing basis can impact on the level of competition in mobile markets.

In general, governments can best promote competition by making as much spectrum available as possible and by limiting charges and other conditions on the industry so that multiple operators will be viable. Specific additional measures to increase competition only make sense where competition is not already effective, additional players would be sustainable and where the competitive gains outweigh any loss arising from spectrum being used less intensively.

In assessing whether to impose particular measures to promote competition, licensing authorities should:

- **Assess what would be the level of competition in the absence of the measures. Where competition is already expected to be effective then imposing additional obligations may bring little additional benefit while carrying costs such as in terms of spectrum not being assigned to its most valuable use or the market becoming excessively fragmented resulting in higher costs and prices.**
- **Identify whether there are ways to achieve effective competition that do not constrain the ability of any operator to support growing data usage by existing customers or attract new customers. For example, reducing mobile-specific taxes and licence fees and freeing additional spectrum can improve the viability of all players in the market.**

Whether particular measures are to be introduced or retained to protect or promote competition, it is important to evaluate the costs and benefits of each measure to ensure that benefits do exceed costs and that the particular measure is chosen that is expected to achieve the policy aim at the least cost. Authorities should aim to avoid penalising successful operators by having their spectrum rights re-assigned to players that have failed to attract as many customers.

Where an authority is assessing whether to renew some existing spectrum rights so as to promote competition, the authority should evaluate the effects of reassigning different amounts of the spectrum. The more spectrum that an existing operator is required to release, the more likely it is the operator will need to turn to more expensive solutions to try to retain sufficient capacity to serve existing customers and the greater the risk that service quality will suffer. On the other hand, an entrant with a relatively small customer base would not be expected to need the same capacity as a larger player. Spectrum caps and the amount of any spectrum set aside for new entrants should be carefully determined so that all operators can deploy networks in a technically and economically efficient manner. Further, before such caps and set-asides are applied, authorities should undertake a rigorous market analysis to ensure that there are in fact players or potential new entrants who can make efficient use of any released spectrum.

Licensing approaches to promote competition

A range of specific measures have been used in practice with the aim of promoting competition particularly in the early stages of market development.

Spectrum caps and set-asides

Spectrum caps limit the quantity of spectrum that can be held by an operator. Spectrum set-asides reserve a particular block of spectrum for a particular bidder or type of bidder such as a new entrant.

Spectrum caps and set-asides can be effective in attracting entrants to participate in licensing assignment processes and they can also limit later market consolidation leading to a loss in competition. However, these measures may lead to less efficient spectrum use as operators with larger customer bases may have greater need for additional spectrum. Fragmented spectrum holdings can also raise the overall industry cost of service deployment and risk preventing some services from being able to be offered. For example, tight restrictions on LTE spectrum can impede both the speed and the services offered, noting that LTE can use contiguous spectrum for carrier sizes up to 2 x 20 MHz.[26]

Spectrum caps previously imposed in many countries have been modified or removed entirely as additional spectrum in new frequency bands has been made available. However, in Latin America, tight spectrum caps are still in place in a number of countries (often ranging from 40 MHz to 80 MHz) with many operators already at this ceiling which risks costly network solutions and impairs quality of service and competition.

Spectrum caps and facilitating market entry in the New Zealand 700 MHz auction

In 2013-14 New Zealand's Radio Spectrum Management conducted an auction for the 700 MHz spectrum (i.e. the 'digital dividend' spectrum). The auction took place over three rounds, with the first two assigning quantities of spectrum and the final round focussing on preferred placement in the band.

The auction rules set spectrum caps of 2×15 MHz for the first round and, in the event that not all lots were sold, a relaxed limit of 2×20 MHz in the second round. These caps were set after considering both theoretical arguments and benchmarking international spectrum caps used in digital dividend auctions. The 2×15 MHz cap was selected to enable all existing operators to provide effective services in the band while the relaxed 2×20 MHz cap would optimise the use of the technology for better services.

In the first round of the auction, the three incumbents acquired, at the reserve price, eight of the nine available 2×5 MHz lots. In the second round, the final lot was acquired for close to four times the reserve price. The flexible spectrum caps enabled the smallest operator to acquire 2×10 MHz of spectrum at reserve price, with the two larger operators then competing aggressively for the final lot.

26 Future LTE-A systems will support the aggregation of non-contiguous spectrum and the ability to create effective bandwidths in excess of 2 x 20 MHz.

Open access requirements

Open access licensing approaches involve spectrum being licensed to a particular provider that will then be required to provide wholesale access to competing retail providers. Such models are put forward as ways to support greater coverage or the introduction of new technology such as LTE through pooling demand while protecting competition at the retail level. Various proposals have included a significant role for government such as under a Public-Private Partnership (PPP) approach in which government contributions are made for shared network investment, land assets and/or preferential land access rights. In assessing the case for open access models, governments should first consider whether competing providers would be viable as mobile competition has generally been effective in achieving widespread access and the introduction of new technologies and services at affordable prices. It might be that competition is only not viable in some areas of the country. The ownership of the wholesale network would also be important. If owned by an operator also active at the retail level, there could be opportunities for anticompetitive discrimination. If owned by all operators, there may be difficulties in reaching agreements on investment and financing for network extensions or upgrades. If governments retain an equity stake, there could be a risk of the operator coming under pressure to favour particular groups or businesses or to protect the operator against competition should alternative networks in the area prove viable. The access price of the wholesale network is also likely to require ongoing regulation.

Allowing operators commercially to share networks in parts of the country where multiple infrastructure would be uneconomic is likely to be a more practical and cost effective way to achieve coverage objectives. The government could also offer a subsidy for network coverage to be provided to an area with operators bidding on the basis of which operator would be willing to provide coverage to the area for the least subsidy.

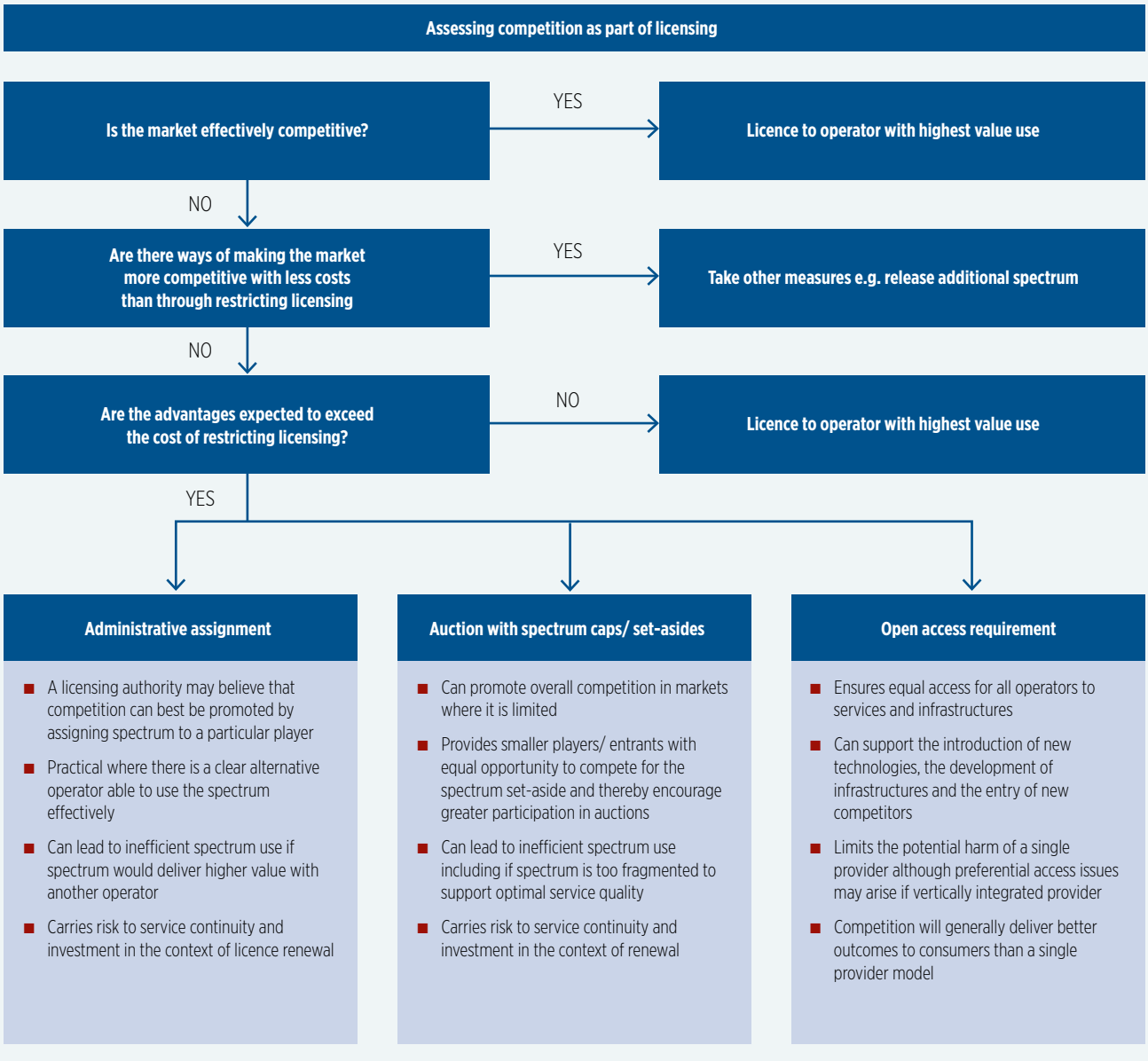
Wholesale licensing in Rwanda

The Government of Rwanda and Korea Telecom (KT) entered into a Public Private Partnership (PPP) to deploy a wholesale LTE network in the country using 800 MHz and 1800 MHz spectrum. This launched in November 2014 as Olleh Rwanda Networks (oRn), and network operators rapidly announced their plans to launch LTE services.

There have been a number of problems; prices were originally considered prohibitively high and in February 2015 oRn was obliged to reduce its LTE tariffs by 70%, from RWF4,100 to RWF1,300 per GB and further reductions in tariffs have been required in 2016. Additionally, take-up of LTE services in Rwanda has been low, in part due to the high prices for LTE packages, but also due to the unaffordability of LTE devices. This has left a tranche of 800 MHz and 1800 MHz spectrum underutilised.

27 oRn, Company Profile, 2016

ARE SPECIFIC MEASURES NEEDED TO PROMOTE COMPETITION?



Spectrum re-assignment in mobile mergers

Spectrum licensing has been a key issue in the assessment of a number of recent proposed mobile mergers by regulators. For example, requirements to divest spectrum holdings were important in the clearance of the mergers: H3G Austria/Orange (2012), H3G Ireland/O2 (2014), and Telefonica O2/E-Plus (2014).

Whether or not a spectrum divestment is in the overall interests of society requires a comprehensive analysis of the likely effects on the divestment on competition and the efficient use of spectrum. For example, a merger that enables the parties to use a larger block of spectrum may enable LTE to be delivered at the best possible speeds. Requiring the divestment of significant spectrum to a new entrant might lead to that spectrum being poorly utilised relative to a situation in which it was available to meet the needs of operators with larger customer bases. This could lead to higher end-user prices and lower quality of service. Requiring large spectrum divestments may also deter parties from proposing mergers in the first place, even when they would bring overall social benefits.

Recommendations on promoting competition through licensing

Governments can best promote competition by making available as much spectrum as possible and by limiting taxes, licence fees and other conditions that risk limiting the number of viable competing operators.

In competitive markets licensing spectrum to the bidder who values it the most can be expected to lead to the optimal use of a country's spectrum. However, where competition is not effective, then governments may wish to assess the likely benefits and costs of specific restrictions on licensing aimed at promoting competition. Generally, there will be a need to weigh any potential competitive gains with potential effects on the efficiency of spectrum use and the resulting quality and cost of services to end-users.

* Neul assumed 15000 end points in a cell at 0.4 bps taking into account overheads, modulation efficiency and spectrum efficiency. The resulting basic spectrum requirement was 50 kHz (ie 3.3Hz per device) which increased to 400 kHz (i.e. 26.7Hz/device) when assuming a frequency reuse factor of 8.

Spectrum trading

Allowing spectrum rights in new and renewed licences to be traded between operators is an important way to ensure that spectrum continues to be used efficiently over time. In particular, trading encourages efficiency by allowing for spectrum rights to be transferred to those who will make better use of them.

Benefits of voluntary spectrum trading

In helping to reduce spectrum shortages faced by some operators while ensuring valuable spectrum does not lie fallow, trading can allow for a country's spectrum resources to be used more intensively thereby supporting higher volumes of services, increased service quality and lower costs of service provision. In being voluntary, spectrum trading enables the parties that have the best information on the value of spectrum in specific uses to determine whether a trade would be value enhancing (i.e. a buyer will only acquire the rights if they are prepared to pay a price at least equal to the seller's valuation of the spectrum). Voluntary trading also reduces risks for operators including market entrants as they are able to sell rights that they end up not needing while also having the opportunity to acquire new rights as they grow. The ability to trade licences can ensure that spectrum is used efficiently without any need for further charges to be imposed by government.

There is growing experience with spectrum trading globally including in Australia, Canada, most of the European Union, Guatemala, New Zealand and the USA as well as trading being introduced more recently in countries such as India. This experience highlights that certain measures can help facilitate trading in the interests of consumers.

- **Trading is more likely to take place where there is substantial available spectrum and where there is high degree of predictability including in relation to future spectrum availability, the regulatory framework and where licences have sufficiently long terms for the buyer of the rights to undertake investments to make use of the spectrum. Spectrum trading is made difficult where decisions about whether licences are to be renewed and the conditions that will be attached to the new licences are made close to the expiry date of the existing licences.**
- **Authorities should be notified of the trades taking place so that it is clear who holds spectrum usage rights. Notification also enables authorities to assess whether a proposed trade would create any risks to competition. Spectrum trading could be subject to competition law or to specific ex ante competition assessments.**
- **While some authorities have been concerned that spectrum trading may lead to windfall gains, it is the potential for gains that motivates efficiency-enhancing spectrum trades to the benefit of society. While some operators may make gains, there are many operators that have incurred significant losses in acquiring spectrum. A gain may simply represent a return on the risks of acquiring spectrum. There is no reason to tax gains from spectrum sales any more than gains from the sales of other business assets.**

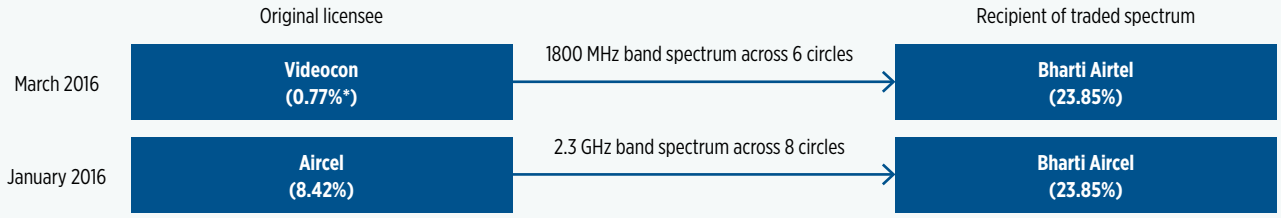
A regulatory framework that supports voluntary spectrum trading offers the potential for substantial benefits to society from ensuring the ongoing efficient use of spectrum.

* These Inter-site distances of 500m and 1732m, have corresponding site coverage areas on an idealised tri-sector hexagonal grid of 0.216km2 and 2.6km2 respectively. For comparison, the same areas with a circular coverage pattern would have cell ranges of 0.26km and 0.91km (i.e. approximately half of the inter-site distances).

Introduction of spectrum trading in India

In October 2015, India's Department of Telecommunications published Guidelines for Trading of Access Spectrum by Access Service Providers allowing mobile operators to trade any frequencies that they have held for over 2 years. Operators can acquire spectrum holdings up to a maximum of 25% of the entire spectrum allocation in any given licensing region, or 50% of the spectrum in a given band. The regulation has enabled trades to take place even within a few months of its introduction. For example, Bharti Airtel has acquired spectrum from smaller operators with less need for the spectrum and potential trades between other operators are being discussed.

FIGURE 1 – BHARTI AIRTEL SPECTRUM TRADES IN INDIA SINCE REGULATION INTRODUCED



* Share of wireless subscribers, November 2015, TELECOM REGULATORY AUTHORITY OF INDIA

For India, with its highly fragmented mobile market in which there were 12 mobile operators in November 2015, trading is proving to be a timely and practical way to rationalise spectrum holdings. The trades will improve spectrum utilisation levels thus helping to reduce network congestion and support higher quality data services.

Issues in implementation

Markets work best when there are well-specified, enforceable, property rights, low transactions costs, and competition is effective. Authorities can support efficient spectrum trading by ensuring that these conditions are present to support the development of spectrum markets.

Markets are based on a private property rights system and trading bandwidth requires a clear and commercially sensible and defensible definition of initial property rights or entitlements. A spectrum licence may specify the right to exclusive usage in terms of frequency and geography (and potentially in relation to a time dimension) as well as reasonable interference levels both in terms of allowable levels of interference caused by the licensee to other spectrum users and the maximum levels of interference which the licensee must accept experience from others. As experience of spectrum trading in developed countries grows, developing countries will be well-positioned to learn from their experience enabling trading to be introduced in the longer term at lower risk.

IMPLEMENTATION ISSUES FOR SPECTRUM TRADING

	Key issues
Well specified spectrum rights	Defining 'well defined, technology neutral, property rights' in the context of spectrum has proved to be complex, and there is no universally agreed right adopted by the ITU. In general, the more flexible the property right used, the more problematic interference control. In the absence of an internationally agreed definition, regulators should conduct a cost benefit analysis regarding the appropriate level of flexibility for their market. It is likely that for spectrum currently allocated to mobile services most of the economic benefits will flow from trading between operators.
Licence renewal	Uncertainty over future rights to use the spectrum can act as a major barrier to spectrum trading. There may be few buyers of spectrum rights if there is only a short tenure left and significant uncertainty over whether a right will be renewed.
Transaction costs	Transactions costs will also affect market efficiency. These will in part be a function of the frequency and ease of trading. In the absence of a secondary market, the only way to trade spectrum may be by acquiring a firm which holds a licence subjecting them to costs of acquisition and subsequent costs of disposing of other assets owned by the acquired company. Additionally, a licence acquired this way will likely be for a large amount of bandwidth while secondary markets should allow parties to divide or aggregate spectrum. Transaction costs can also be reduced by ensuring that detailed information on current spectrum holdings is made available, as well as plans for future spectrum releases. Allowing the development of specialist spectrum trading brokers can also help reduce transaction costs.
Competition issues	Whether trading would lead to a loss in competition would depend on: ■ the amount of spectrum available to competitors; ■ the degree of competition in communications markets. Accordingly, whether a particular transaction should be prohibited on competition grounds is likely to require a case-by-case review which could potentially be under general competition law (as occurs in New Zealand). Safe harbours could be determined and acquisitions permitted if the operator has a market share below a certain level and if the spectrum acquired represents only a small share of spectrum suitable for supplying that service.
Taxation of gains	Trading may result in existing licensees earning financial gains over the price originally paid for the licences, which it may be argued should belong to the government. However, the gains provide the incentive for efficiency-enhancing trades and the larger the tax imposed on these gains, the less likely they are to take place. Governments will need to determine how best to meet revenue requirements, taking into account principles of efficiency, equity and simplicity. A large tax on gains from spectrum sales would be likely to come at a substantial cost to efficiency.

Recommendations on trading

Licensing authorities should allow voluntary spectrum trades between operators and facilitate trading through clearly defined spectrum rights, long licence terms and limited administrative costs. In advance of a formal spectrum trading framework being established, authorities should be prepared to assess proposals for particular trades subject to consultation and consideration of any risks to competition or of heightened interference.

Transparent and well-timed licence renewal processes and information on spectrum availability, pricing and conditions would also facilitate trading.

Spectrum trades should be subject to competition law and/or ex ante competition assessments. Competition issues should be assessed taking into account the specific circumstances of each trade, although certain safe harbors could be established such as where the operator acquiring the spectrum has a market share below a certain threshold and/or the spectrum represents a relatively small share of the overall spectrum available for those services.

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