



Auction Best Practice

GSMA Public Policy Position

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Executive Summary

Auctions have become the dominant mobile spectrum assignment mechanism over the past three decades. They were designed to provide a transparent, impartial and legally robust means of assigning spectrum to those who will use it most efficiently to support competitive, high quality mobile services. Alternative approaches like administrative awards and lotteries have generally proved less able to assign spectrum in an efficient, impartial and legally robust way.

However, the benefits of auctions can be lost when they are not properly planned. Some have failed to assign spectrum despite it being in demand, while others have been contested for artificially inflating prices, which risk harm to consumers. Some have led to claims they are biased in favour of some operators, or for not preventing strategic behaviour, leading to inefficient spectrum distribution. A key concern in recent awards surrounds a lack of spectrum being auctioned as this leads to slower mobile broadband services and can inflate spectrum prices.

As a result, effective auction design has never been more vital to delivering the best possible mobile services. This paper provides a backgrounder on why auctions are used, some different types and the wider process of running an auction. It also outlines the GSMA's global key spectrum auction positions which are:

- 1. The top priority for spectrum auctions should be to support affordable, high quality mobile services**
- 2. Auctions are a tried and tested award mechanism but can and do fail when poorly designed**
- 3. Auctions should not be the only award process as they are not always suitable**
- 4. Auctions designed to maximise state revenues risk serious harm to consumers**
- 5. Assign a sufficiently large amount of spectrum and publish roadmaps to support high quality mobile services**

- 6. Spectrum caps and set-asides distort the level playing field**
- 7. Licence obligations and conditions should be designed to minimise the cost of covering non-profitable areas, and avoid distorting the award of spectrum**
- 8. The chosen auction design should not create additional risk and uncertainty for bidders**
- 9. Poorly chosen lot sizes or inflexible packages of spectrum lots risk inefficient outcomes**
- 10. Policymakers should work in partnership with stakeholders to enable timely, fair and effective awards**

Background

Why auction mobile spectrum?

The emergence of competitive telecom markets created the need for public policymakers to design a mechanism for assigning mobile spectrum licences. This is necessary when the demand for spectrum – both in terms of the number of applicants and how much spectrum they each want – exceeds the amount of spectrum on offer. Given spectrum is a critical, and scarce, natural resource, and the amount allocated for mobile use is relatively small, the challenge is how to choose the applicant who would use it most efficiently to deliver the greatest socioeconomic benefits.

There are broadly two common approaches to assigning mobile spectrum licences: administrative approaches (e.g. beauty contests) and market-based approaches (e.g. auctions)¹. Beauty contests were adopted first and involve governments or regulators choosing the winner(s) based on proposals submitted by applicants. They are still used – especially in developing markets where running auctions may be regarded as complex and expensive – and can be successful, especially where public policy objectives such as improving coverage are the dominant concern. However, beauty contests are inherently subjective and vulnerable to bias so spectrum may not be awarded to the best candidate and the outcome is more likely to be legally contested. Key concerns are that the winner may be the applicant who can produce the best proposal – not the best mobile service – and the process lacks transparency which can make the result open to dispute.

Auctions were proposed as a spectrum licence assignment mechanism in the 1950s but were not embraced until the 1990s. The central advantage is that licences are awarded to those who value them most and are thus more capable of recouping their investment by competing vigorously to build high quality networks with good coverage in order to win over consumers. Beyond awarding licences to those most likely to put the spectrum to good use, auctions also have several other benefits. They are an objective assignment mechanism so are less likely to be legally contested when carefully planned. They can also generate significant revenues for the state as fair return for access to a natural resource (spectrum), and the amount raised is – among other factors – determined by market competition.

As a result, auctions have emerged as the dominant mobile spectrum assignment mechanism. However, the benefits of auctions can be lost when they are not properly designed. Some have failed to assign spectrum despite it being in high demand, while others have been contested for artificially inflating prices, which risk harm to consumers², or for leading to unfair distributions of spectrum. This means effective auction design has become vital to delivering the best possible mobile services.

A key concern in recent awards surrounds the amount of spectrum being assigned. A lack of spectrum leads to slower mobile broadband services and risks inflated prices at auction as operators bid aggressively to secure as much as possible. There is already a significant variation in the amount of 5G spectrum that is assigned around the world, and the prices paid at auctions, which means the potential of 5G services will vary notably between countries.

Auction types

The field of spectrum auction design has grown almost as rapidly as the mobile marketplace. Initial designs have been refined since their advent in the early 1990s, and while there is continual innovation in the field, there is a relatively small set of reliable auction formats which have been adapted to minimise perceived weaknesses. Spectrum auction designs fall into two major categories, single round auctions and multiple round auctions.

Single round auctions

This auction type gives bidders just one chance to submit an offer for the licence(s) they are interested in, bids are then evaluated and a winner is chosen. The most common form is the single round pay-as-bid auction – also known as a single round, first price, sealed bid auction. Bidders are not given the benefit of information on the bids of other bidders, so are essentially bidding blind. This can lead to unintended, and undesirable, consequences. Because of the lack of information, bidders can end up paying significantly more than they would need to in order to beat the bids of others. This creates an incentive for a bidding approach where the bidder shadows/shades³ the bids down, thereby running the risk of not being awarded the frequencies despite actually valuing them more. This can result in a “winner’s curse” in which the spectrum is awarded to the bidder that is most optimistic in a context of uncertainty, but not necessarily to the one that can create more value.

1. Technically there is a third approach which assigns spectrum randomly (e.g. using a lottery). This was famously used to assign some analogue mobile licences in the US in the 1980s but has not been widely repeated.
 2. Expensive spectrum has been linked to lower quality mobile services with worse coverage and higher prices (see studies by NERA in 2017 and GSMAI in 2018 and Policy Tracker in 2017)
 3. Given the lack of information about other bids, bid shading is a strategy where a bidder chooses to exercise caution and bid lower than they might otherwise to avoid overpaying

Multiple round auctions

This auction type helps solve that problem by allowing bidders to respond to the bids of other bidders over a series of discrete bidding rounds. Generally, bids are submitted for all of the lots on auction and some information about those bids is revealed to all bidders. Another bidding round is opened to allow counter bids, and the process continues until a closing rule is met (generally that there are one or more rounds with no counter bids). These multi-round auctions generally employ some manner of bidding activity requirement to force bidders to be active in each round of bidding thus preventing ‘sniping’ which happens when bidders wait until the end of the auction to begin bidding. Sniping limits the information discovery of the other bidders, as the bidder doesn’t participate during the initial rounds thus defeating the aim of providing better information about market prices.

There are a number of different types of multiple round spectrum auctions, with the standard format being the Simultaneous Multiple Round Ascending (SMRA) auction. In most spectrum auctions there are multiple licences on offer. These can be divided into spectrum blocks and/or geographic regions⁴. In an SMRA auction, all of the licences are put up for bid at the same time. This approach allows bidders to place bids on the licences they need to complete their business plan. They aggregate complementary licences, and if the prices rise too high for them, consider substitutes or simply stop bidding.

In the case of an auction with a large number of licences, bidders may have to evaluate a significant amount of information after each round of bidding and determine the best strategy for the next round. Generally, the bidding continues round after round until there is no bidding activity for one or more rounds. Thus, a bid on one licence is enough to keep the entire auction open for all licences. This simultaneous stopping rule is designed to recognise the fact that there are synergies among the licences, and a bid on one could cause another bidder to switch to a substitute, so closing bidding on licences individually would foreclose that option. The standard SMRA auction is a “first price” auction – the highest bid wins and the bidder pays the price they bid.

There are more complex multiple round mechanisms that involve submitting bids for combinations of licences (e.g. Combinatorial Clock Auctions). These allow bidders to express the value for groups of licences and even create all-or-nothing combinations to limit the exposure of winning some but not all of the licences they want or need. These auctions are complicated for authorities to administer and for participants so their use has been limited to date and there has been varying degrees of success.

The auction process

The bidding event itself is just one part of the larger auction process. Typically, the process begins with a consultation about the spectrum that is being auctioned and comment is sought on the amount of spectrum, how it will be licensed in terms of block size and geography, and any licence terms and conditions. Then the process involves a similar consultation on the auction design itself: how to qualify to bid, the auction format and the auction rules. Once final procedures, terms and conditions are established, bidders apply to participate. Typically, this involves a financial and legal commitment. This is followed by a pre-auction seminar for qualified bidders and often mock auctions so bidders can become comfortable with the format and the electronic system. Then the bidding event happens, followed by post-auction processes, including final payment and submission of any necessary information before licences are issued.

The auction length generally depends on the number of licences on offer and the level of competition in the auction, and can range from a day to months. An example auction timeline from the US regulator, the FCC, is below:

Consultation:	4-6 months prior to auction
Final rules:	3-5 months prior to auction
Information seminar:	60-75 days prior to auction
Applications due:	45-60 days prior to auction
Upfront fees due:	3-4 weeks prior to auction
Qualified bidders announced:	10-14 days prior to auction
Mock auction:	2-5 days prior to auction
Auction begins	

4. Most countries use national licences but several larger countries have licences for different regions (e.g. Australia, Brazil, Russia and the United States). There can be several hundred different licence areas.

Positions

1. The top priority for spectrum auctions should be to support affordable, high quality mobile services

High quality mobile services are vital for consumers and businesses and deliver major- and ever expanding - socioeconomic benefits.⁵ They rely on increasing amounts of spectrum to support faster broadband speeds and rapidly growing data demand. Given there is a limited supply of mobile spectrum, it is vital that governments and regulators primary goal is to ensure it is awarded to operators who will use it most efficiently to support affordable, high quality mobile services.

Spectrum auctions have emerged as the primary means of assigning spectrum to meet this goal. By awarding licences to those who value them the most, they are most likely to proactively use the spectrum as widely and efficiently as possible. However, governments and regulators may also try to use auctions to meet other goals such as raising revenues for the state, or altering the structure of the mobile market by facilitating the entrant of a new operator. While these can be legitimate goals in some cases, they should not undermine the primary goal of supporting affordable high quality mobile services through sustainable, long-term heavy network investment.

2. Auctions are a tried and tested award mechanism but can and do fail when poorly designed

Auctions have become the dominant mobile spectrum assignment mechanism over the past three decades. They can provide a transparent, impartial and legally robust means of assigning spectrum to those who will use it most efficiently to support attractive, high quality mobile services. Alternative approaches like administrative awards and lotteries have generally proved less able to assign spectrum in an efficient, impartial and legally robust way.

However, there are numerous examples of spectrum auctions that have failed to assign all or part of attractive mobile spectrum. Some auctions have assigned spectrum at prices that are regarded as being excessively high and could subsequently harm users of mobile services. Such failures are frequently due to the design of the auction or wider regulatory issues. These include high reserve prices, artificial spectrum scarcity and auction rules which prevent price discovery or flexible bidding amongst others.

3. Auctions should not be the only award process as they are not always suitable

Auctions have proved effective at determining fair and efficient spectrum assignments in a timely manner when the demand for spectrum from qualified applicants exceeds the available supply. However, auctions can be complicated to design and operate and can therefore be avoided when there is evidence of lack of excess demand, or when all qualified operators and the government or regulator are able to find a mutually agreeable split of the spectrum on offer at a fair price.

Notably, auctions may not be suitable in situations where demand is lower such as local licences where there are fewer people/businesses or where there are unavoidable limitations on how the spectrum can be used (e.g. low power/indoor only). Alternatives can also be attractive given auctions can be time consuming, especially if a framework of rules and procedures doesn't exist, and expensive for the regulator to run and bidders to participate in. However, where there is not enough spectrum to satisfy operators' spectrum requirements, or where the requirements are incompatible, auctions are the fairest means of determining the assignment.

While auctions can work well for initial spectrum assignments, they are almost always inappropriate in the case of renewing mobile spectrum licences that are expiring. The key focus for renewals should be to provide the predictability licence holders need to invest heavily in their networks throughout the term of the licence. If expired licences may be re-auctioned - and thus operators may lose access - then it becomes rational to limit investment in the network in the years preceding expiry. This can in turn negatively impact mobile coverage and broadband speeds and if the operator ultimately loses the spectrum can lead to sudden drops in network quality.

Auctions are suitable for expired licences if the licensee does not want to renew the spectrum or if they have breached the terms of the licence. In cases where spectrum assignments are deemed to be unbalanced or inefficient then the market should be allowed to correct itself by facilitating spectrum trading. Laws which prevent expiring licences from being automatically renewed should be revised to better protect network investment and quality of service.

5. The mobile industry contributed \$3.6tn to the global economy in 2017 (i.e. 4.5% of GDP) according to GSMAi

4. Auctions that are designed to maximise state revenues risk serious harm to consumers

Spectrum is a scarce resource that underpins wireless services which deliver profound socioeconomic benefits. Governments should aim to base mobile spectrum prices at a level that ensures that no alternative user would be willing to acquire the rights at that price (i.e. opportunity cost pricing⁶). But many go beyond this by actively trying to extract rents from operators (i.e. value based pricing⁷) and raise state revenues through spectrum awards. Recovery of fair value of this public good is an acceptable aim, as long as revenue raising is not so excessive that consumers of mobile services, and the wider digital economy, suffer. The primary goal in all spectrum awards should be to encourage efficient spectrum use while recognising the significant investment necessary to provide high quality mobile services.

Policy measures that inflate the price of spectrum can result in spectrum going unsold, or sold at such a high price that the affordability and quality of services are adversely affected, thus impacting the broader digital economy. High spectrum prices are associated with more expensive, lower quality mobile broadband services with worse coverage - as well as irrecoverable losses in consumer welfare worth billions of dollars worldwide⁸. A common policy mistake when aiming at extracting rents is setting excessively high reserve prices or annual fees rather than letting the market determine a fair price. Others include creating uncertainty by failing to publish a spectrum roadmap or artificially limiting the supply of spectrum, and auction design mistakes which increase risks such as first price rules, overly large lot sizes and not allowing for reasonable price discovery.⁹

5. Assign a sufficiently large amount of spectrum and publish future spectrum roadmaps to support high quality mobile services

Public policy makers in advanced digital economies respond swiftly to new mobile spectrum demand and distribute as much spectrum as possible as soon as operators have a business case to use it. A sufficient amount of spectrum, in the right frequency bands, is essential to deliver the affordable, high quality mobile broadband services that consumers want, and businesses need to be competitive on the global stage. High quality 5G services are dependent on wide frequency bands which means that where little spectrum is made available at auctions then spectrum prices can be artificially inflated which in turn harms consumers (see position 4).

Mobile operators need assurances that a sufficient amount of spectrum in the right mixture of bands will be made available over a long period to give them the certainty needed to make long-term heavy investment in national mobile networks.¹⁰ There is already a significant variation in the amount of spectrum 5G assigned in different countries which means the potential of 5G services will vary considerably. The GSMA recommends awards of at least 80-100 MHz of contiguous spectrum per operator in initial 5G mid-bands (e.g. 3.5 GHz) and 800 MHz per operator in initial millimetre wave (mmWave) bands (e.g. 26/28 GHz). Regulators should also plan timely significant further awards in both ranges to help 5G scale as needed. This should include more spectrum in the 3.5 GHz range (3.3-4.2 GHz), as well as 6 GHz and 40 GHz.

Regulators should publish, and regularly update, a spectrum roadmap for at least the following five years detailing how much is planned to be made available in what bands and when. Auctions, and other awards, should aim to make available as much spectrum as possible in a band in order to enable operators to offer high-speed cutting-edge services - especially for 4G and 5G which benefit from very wide frequency bands.¹¹

Holding back spectrum when there is demand for it and failing to release future plans for spectrum availability creates a challenge in many countries - especially developing markets. This artificial spectrum scarcity also inflates spectrum prices as operators struggle to secure the spectrum they need and has been strongly linked to slower mobile broadband speeds, slower network rollouts and worse coverage.

6. Spectrum caps and set-asides distort the level playing field

In the era of competitive mobile markets, auctions have become the primary means of assigning mobile spectrum licences. They allow the market to determine spectrum assignments - rather than a government or regulator. In this way they support the competition which has delivered better outcomes for consumers than the previous state-owned monopolies - and helped drive the mobile revolution. However, governments and regulators can, knowingly or unintentionally, make decisions about spectrum auctions that distort fair market competition.

Auctions should be open on fair and equal terms to all qualified applicants that are committed to rolling out a network and provide services. However, sometimes regulators help to “pick winners” by setting aside spectrum for certain applicants such as new entrants or industry verticals. This type of market manipulation is only appropriate after a formal market review finds evidence of market dominance, and then demonstrates that setting aside spectrum is an appropriate, proportionate action that will lead to long-lasting and sustainable market benefits. Setting aside spectrum is dangerous as it restricts the amount operators can access which can negatively impact mobile broadband speed and coverage and inflate spectrum prices.

Set-asides are not the only means of manipulating the market. Regulators and governments can also set spectrum caps which restrict how much spectrum an operator can access. Caps risk jeopardising an operator’s ability to support growing consumer usage, deliver faster speeds and provide improved coverage. Regulators should define and set caps with care to balance giving operators sufficient freedom to pursue their particular business strategies and target spectrum portfolio while also preventing spectrum hoarding and the damage this can do to competition.

7. Licence obligations and conditions should be designed to minimise the cost of covering non-profitable areas, and avoid distorting the award of spectrum

Regulators sometimes include obligations and conditions in spectrum licences to achieve certain objectives which in turn have an impact on the market and the value of the licences. These can include obligations to provide a certain level of mobile coverage or to provide wholesale access to other service providers. They can also include conditions which may limit what technologies (e.g. 2G-only) or services (e.g. fixed wireless access) that can be provided using the spectrum. Obligations and conditions typically pose a financial burden on the winning bidder and thus should be considered when setting reserve prices and annual fees.

Once policy makers have decided which objectives they wish to prioritise, they should consult with stakeholders on how best to achieve them and, where necessary, how they should be reflected in the cost of the spectrum. Failure to do so risks leaving spectrum unassigned or reduces the incentive or capacity to invest in competitive cutting-edge mobile networks. Two obligations that must be carefully considered are coverage obligations and wholesale access obligations.

Coverage obligations should not foster inefficient duplication of networks in non-profitable areas or distort efficient assignments by discouraging bids from well qualified applicants. They should be applied holistically, rather than to a specific band, so licensees can meet them using the most efficient combination of bands - especially as new mobile technologies leverage multiple bands to provide optimal services. Coverage obligations are not suitable for most 5G bands (e.g. mmW and mid-bands) as they are designed for delivering high capacity rather than coverage. There are a variety of other, more innovative regulatory approaches to improving coverage that regulators are encouraged to adopt¹². Similarly, rollout obligations should be used with caution as they can distort the most efficient and effective 5G rollout strategy.

It will take time for licensees to achieve their full 5G rollout plans. Regulators may therefore want to adopt obligations to prevent under-use or spectrum hoarding. For example, if a local licensee - such as a mobile operator or an enterprise vertical - does not use its spectrum in a reasonable period of time then the unused spectrum should be made available to others who do have immediate plans (e.g. “use it or lose it” obligations). Similarly, if a national licensee is not using its spectrum in a particular area in a reasonable period of time then it could be sub-leased to others (e.g. “use it or lease it” obligations). However, such obligations should not undermine realistic planned future usage which can take time to achieve. They should also enable the licensee to be compensated appropriately for reasonable costs they may have incurred (e.g. spectrum costs).

Wholesale access obligations should not be included unless there is clear market evidence for their need. Parties requiring wholesale access should seek this through commercial negotiation with competing providers and on appropriate commercial terms. To provide certainty, it should not be possible to amend any obligations during the term of a licence. Uncertainty in licence terms and conditions will jeopardise investment. All obligations should be factored into the price of spectrum licences as they have a significant impact on their value and the costs associated with acquiring them.

6. To ensure the winners of the licence pay at least the cost of denying the next-best alternative use case (e.g. broadcasting)

7. This is where governments or regulators set a reserve price or final price above the opportunity cost in order to try to secure some of the additional value the spectrum is expected to confer to an operator

8. Insert link to NERA & GSMAI work

9. Please see the GSMA spectrum pricing policy position for more information

10. For example, mobile operators are expected to invest US\$0.5 trillion globally in networks (exc. spectrum) between 2018 and 2020 (GSMAI)

11. For example, the ITU's minimum technical requirements to meet the IMT-2020 criteria (aka 5G) specify at least 100 MHz channels per operator

12. See GSMA position paper on improving mobile coverage (available here: <https://cp.gsma.com/expanding-mobile-coverage/>)

8. The chosen auction design should not create additional risk and uncertainty for bidders

If an auction has been determined to be the most appropriate award mechanism, policy makers should be aware that there is no single auction design that suits all types of spectrum award. Factors like individual market dynamics, the type and amount of spectrum being auctioned – including the number of bands – need to be factored into the choice. This includes deciding whether to auction a single band or several bands simultaneously in cases where there is synergy as complements and/or substitutes.¹³ However, there are core principles that should be followed. The aim should be to transparently and fairly assign spectrum to the operator at the market value while minimising risk and uncertainty which can lead to excessively high bids that may ultimately harm consumers and businesses.

In most cases, effective awards can be achieved using widely supported and well-proven ascending price award formats with multiple rounds. Multi-round auctions have the benefit of allowing price discovery and allowing bidders to express preferences for complements and/or substitutes. These multiround approaches must be carefully designed with activity rules that lead to a fair outcome and avoid bid sniping. Bids should be binding but there should be scope for some limited withdrawal to address exposure problems.¹⁴ Too much flexibility can lead to excessively long auctions and allow room for anti-competitive or frivolous bidding, so the rules must be carefully considered. Award procedures with high risk such as first price¹⁵ sealed bid auctions should be avoided as they can lead to excessively high prices and produce an inefficient assignment if bidders rationally choose to bid lower than they might otherwise to avoid the winner's curse (e.g. bid shading).

A well designed auction determines the fair market value of mobile spectrum by facilitating price discovery. If setting a minimum value for a licence, a reserve price, regulatory best practice is to set it well below a conservative estimate of the market value and allow the auction mechanism to determine the current fair market price. In order for the auction to work properly, the auctioneer should provide bidders with updated information on demand for the lots. If the reserve is set too high, or there is no information on demand - so bidders are essentially bidding blind - then price discovery is undermined and the auction risks inefficient and unpredictable outcomes - including unsold lots or excessively high prices.

9. Poorly chosen lot sizes or inflexible packages of spectrum lots risk inefficient outcomes

Auctions should be designed to allow operators to secure the optimum spectrum to meet their needs (e.g. amount, type, location etc) and thus ensure it is used as efficiently as possible. Policy makers can support this by ensuring enough spectrum is made available in the award; it is offered in small generic block sizes to support varying demand from all bidders; and activity rules allow bidders to aggregate complementary licences and/or move to substitutes during the auction.

When bidders are competing over a small total amount of spectrum that is offered in large blocks, with rules that forbid moving to substitute licences, then it is likely the outcome will be inefficient which will harm the market. It is essential that the total amount of spectrum on offer can support market demand and cutting-edge mobile technologies. Traditionally, individual block sizes of around 5-10 MHz are sensible so that bidders can aggregate blocks to meet their needs. In 5G mid-bands, equal lot sizes of around 10 MHz each are sensible so bidders can aggregate them to meet their needs, while in the millimeter wave bands block sizes of around 100-200 MHz are suitable. Mismatched lot sizes can create artificial scarcity which risks inflating spectrum prices and operators failing to secure their desired amount of spectrum.

A careful and considered approach to block sizes also avoids artificially creating scarcity through a small number of larger blocks which increases the likelihood that some bidders will completely lose out and thus harm market competition. Activity rules should permit operators some degree of freedom to move among combinations of licences and react to changing demand during the auction (e.g. if demand is high for one lot then bidders can consider pursuing substitutes instead).

Auctioning frequency-specific lots can lead to distortions and price inflation on blocks on the boundaries between bidders' target frequency ranges and increase the length of the bidding process. If stakeholders agree that certain spectrum blocks are similar and variations in value across lots are not expected, it is more efficient for bidders to bid on generic lots. Once that is concluded a secondary bidding stage (or mutual negotiation) can decide which specific block(s) each winning bidder receives. Blocks with specific characteristics and value (such as at the end of a band, and requiring special coordination with adjacent users) should be offered concurrently but separately.

10. Policy makers should work in partnership with stakeholders to enable timely, fair and effective awards

The mobile market has benefitted from rapid growth and transformation. In order to make sure regulation enables, rather than hinders, this momentum, regulators should work in close partnership with stakeholders. For example, it is essential that policy makers plan to make spectrum available as soon as operators are ready. Making sufficient spectrum available in good time helps countries advance their digital development by helping to support cutting-edge mobile services. Policy makers should also develop a national spectrum roadmap in consultation with operators. The aim is to ensure the spectrum will be made available in time to meet market demand and when sufficient compatible equipment is or will be available.

The award planning process should begin well in advance of the award date and involve industry consultation to determine which assignment format is most suitable (e.g. auction, beauty contest, negotiated administrative award). Once the format has been chosen, regulators should consider the technical conditions, obligations and reserve price (or final price in the case of administrative awards) for the band(s) to ensure they are fair, realistic and would not distort the market. A comprehensive consultation with all stakeholders should follow which provides sufficient time to allow for all issues to be adequately discussed and where necessary revised.

At all stages of this process it is vital to ensure the central goal should be on enabling the most efficient use through high quality and affordable mobile services. This is undermined when governments prioritise maximising revenues from spectrum above improving the affordability and quality of mobile services. Mobile users and the wider digital economy are best served when all spectrum management decisions, including pricing, are assigned to an independent regulator that is tasked with protecting their interests. The success of auctions are jeopardised when pricing decisions are made by the treasury whose interests can be different to those of an independent regulator.

13. Lots are complementary when a bidder may ideally want several. They are substitutes when a bidder may consider a different lot if they can't get their preferred lot (e.g. due to higher than expected demand)

14. This is where bidders can end up with insufficient spectrum to meet their minimum requirement

15. Under first price auctions the winning bidder pays the winning amount they bid but this has a greater risk of being excessively high leading to the 'winner's curse'. Second price auctions are recommended where the highest bidder pays the value of the second highest bid



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