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RADIO SPECTRUM POLICY GROUP

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RSPG Report on Efficient Awards and Efficient Use of Spectrum

RSPG Report on Efficient Awards and Efficient Use of Spectrum

1. Executive Summary

This report has been prepared by the Radio Spectrum Policy Group (RSPG) to examine the issue of efficient awards and efficient use of spectrum bands harmonised for Electronic Communications Services¹, as set out in the RSPG Work Programme.²

Our objective is to share views and best practices on spectrum award approaches and related conditions of use with a view to promoting efficient use of spectrum. This report analyses the spectrum requirements of future Wireless Broadband Systems (WBB), taking into account different geographical characteristics, market situations, and different usage scenarios, with the aim of ensuring that spectrum is well utilized and that future speed, capacity and coverage requirements are met.

The work has sought input from Member States, BEREC, consultants, academics and stakeholders to examine the experience of awards across Europe from the last twenty years in order to share best practice as a means of providing examples for Member States in preparing for and conducting awards.

Our initial conclusions are that despite variations in approaches across Member States, auctions remain an important tool in the regulatory toolkit for ensuring efficient use of spectrum. However, they are not the only option and they sit alongside other processes for awarding spectrum such as beauty contests or hybrid approaches. Nonetheless, given that auctions have become the most commonly used, this report has focused primarily on auctions, examined auction examples and listed the benefits and challenges they have brought.

From our studies, it is clear that one size does not fit all and there isn't one single method of awarding spectrum that could be extrapolated across all Member States or all bands without the risk of significantly diminishing overall consumer benefit and economic value. However, there are some key lessons that can be learnt from across the EU and globally in the approach to designing and conducting awards.

Common to all of these, and of particular importance to stakeholders is clarity, simplicity and regulatory certainty. Both Member States and stakeholders see merit in auctions and other award methods retaining their evolutionary character, with flexibility at the national level in order to take into account specific local circumstances and market conditions. That said, there are likely to be aspects of good practice that will be common across all awards.

The RSPG thinks that consistency in terms of approach across Member States, without being overly prescriptive and coupled with national prerogative to determine methodology given policy objectives and priorities at Member State level, is the optimum way forward. This will provide national regulatory certainty and some consistency across the EU without stifling innovation or dis-incentivising investment with overly bureaucratic approaches.

¹ RSPG14-556final

² RSPG14-553rev1

Further details of the lessons learnt can be found in the body of this report and are summarised in an analytical checklist in Annex 1.

2. Introduction

Article 2 of the amended Commission Decision³ establishing a Radio Spectrum Policy Group (RSPG) states that *“the RSPG shall assist and advise the Commission on radio spectrum policy issues, on coordination of policy approaches, on the preparation of multiannual radio spectrum policy programmes and, where appropriate, on harmonised conditions with regard to the availability and efficient use of radio spectrum necessary for the establishment and functioning of the internal market”*.

Under its' Work Programme, The RSPG was tasked with examining current practice on awards across the EU with the objective of sharing best practices which Member States may use in designing and implementing awards processes.

This is to promote application of the best practice approaches to secure the optimal use of the scarce resource that spectrum represents and contribute to the development of the internal market for electronic communications, thus encouraging competition, growth and innovation in all aspects of the communications value chain for the benefits of consumers.

2.1 Structure of the Report

This report focuses on ECS bands as identified in the Article 6 of the RSPG or future possible harmonised bands (i.e. subject to current European Commission mandates to CEPT: 700MHz, 1452-1492MHz, 2.3-2.4GHz). Other WBB solutions (Wi-Fi and satellite as described by RSPG opinion WBB) are not addressed in this report.

The remainder of this report is structured as follows:

- Section 3 deals with the suitability of current and near future harmonised spectrum bands to meet needs for mobile broadband;
- Section 4 deals with awards in general, covering the main types of awards currently used;
- Section 5 focuses specifically on auctions and discusses current trends and best practice;
- Sections 6 and 7 examine the promotion of efficient use of spectrum, including competition and coverage as policy objectives, including the effect of spectrum sharing;
- Finally, Section 8 draws together some key messages from the Working Group with regards to best practice, and these are further explored in Annex 1.

Where the RSPG has previously prepared materials of relevance, the RSPG has drawn on these and where relevant referred to them. These include:

- RSPG/BEREC Report on Competition: Transitional Issues in the Mobile Sector in Europe⁴;

³ 2009/978/EU: Commission Decision of 16 December 2009 amending Decision 2002/622/EC establishing a Radio Spectrum Policy Group

⁴ BoR (11) 07 / RSPG10-351 Final. February 2011

- RSPG Report on Improving Wireless Broadband coverage⁵;
- BEREC/RSPG Report on Infrastructure and spectrum sharing in mobile / wireless networks⁶;
- BEREC/RSPG Report on exploring the economic and social value of radio spectrum for certain electronic communications services with respect to the frequency assignment procedures⁷;
- RSPG Report on Furthering Interference Management through exchange of regulatory best practices concerning regulation and / or standardisation⁸; and
- RSPG opinion on Spectrum for Wireless Broadband and Broadcasting in the Frequency Range 400MHz to 6GHz.⁹

⁵ RSP11 393 FINAL - 16 November 2011

⁶ RSPG11-374 final - 16 June 2011

⁷ BoR (12) 15 RSPG12-410 rev2

⁸ RSPG13-527rev1 final 28 June 2013

⁹ RSPG13-522

3. Suitability of current and near future harmonised spectrum bands to meet needs for mobile broadband

A key challenge for spectrum management in the future will be to ensure that Member States respond appropriately to the growth in demand for spectrum from a wide range of existing and new applications. This report focuses on mobile services which are expected to be one of the key drivers of the increasing demand for spectrum but it is also important to recognise that a wide range of other services will also be looking for access to more spectrum.¹⁰

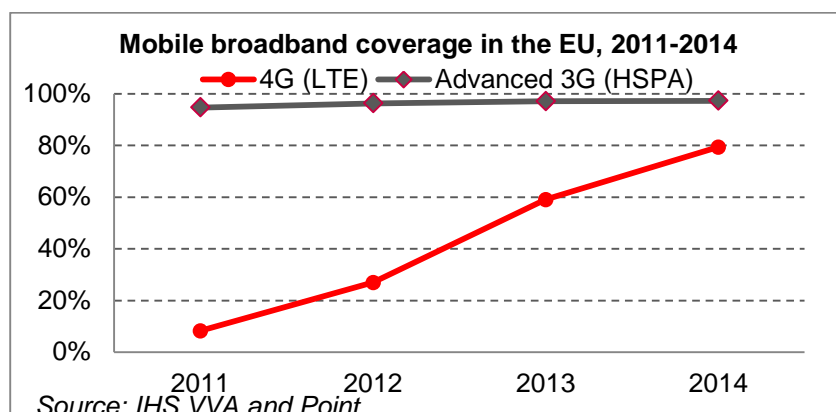
The current harmonised bands and those likely to be harmonised in the near future are described in this report in terms of responding to the current growth of the mobile market (towards 4G: LTE). An important aspect of this is the availability of harmonised spectrum at EU level including bands for 3G (UMTS) (i.e. 1920-1980MHz/2110-2170MHz) which was supported by EU legislation requiring Member States to grant UMTS authorisations before 2002.¹¹ Effective growth started later than some expected due to slower than anticipated take up of 3G services, which didn't materialise until the widespread availability and take up of smart phones. By contrast the relatively rapid take up of 4G services has been supported by readily available equipment and consumer demand.

Today, this harmonised spectrum is largely used in Europe by 3G and advanced 3G (see hereafter). The current European harmonised framework has been subject to updates during the last few years : 900MHz and 1800MHz and 2GHz bands in particular to offer the possibility to use various mobile systems in the relevant bands (for example UMTS, LTE in 900/1800MHz, LTE in 2GHz). Today we are close to reaching near 100% mobile broadband coverage across the EU with advanced 3G and the deployment of 4G services is growing rapidly.

Compared to some other regions of the world where the mobile broadband migration largely skipped 3G technology to move directly to 4G technology, 3G and advanced 3G have been considered in Europe as a response to the demand for mobile broadband data and have been supported by policy initiatives.

¹⁰ See also the RSPG Opinion on RSPP which addresses the issue of national specific spectrum requirements

¹¹ Decision 128/1999 on the coordinated introduction of a third-generation mobile and wireless communications system (UMTS) in the Community

Table 1 - Mobile broadband coverage in the EU, 2011-2014¹²

The RSPG has been tasked with assessing the suitability of current, and potential, harmonised mobile bands (for instance 2.3 - 2.4 GHz and 700 MHz), to meet future capacity, speed and coverage requirements, taking into account Member States' different market conditions, usage and geographic characteristics.

Regardless of variations in forecasts, it seems clear that there is, and will continue to be, significant growth in demand for mobile data. This will be common across all EU Member States, although the extent of the demand will depend on many factors including for example population density, consumer demand and usage patterns.

To respond adequately to this demand, a multi-faceted solution needs to be found. Mobile networks will need to increase capacity mainly in radio access and, as a consequence, in backhaul and other network components, often in synergy with an evolution of fixed access networks. Supported by relevant investment, the mobile network capacity can be increased by various methods described below, ranging from improvements to the current networks to additional spectrum resources.

- **Improvement of mobile networks architecture (access)**

Capacity may be improved by updating the main network architecture to include smaller cells (or "small cells") or offloading data traffic onto "Wi-Fi" or "femto-cell" access points to address local capacity needs. Mobile Operators are also looking for locations for new emission sites and base stations with higher capacity and updated backhaul facilities (either fibre or radio).

- **Usage of more efficient technologies**

Alongside increasing the amount of spectrum available and the improvement of the network architecture, developing and utilising the most efficient technologies also plays a key role in ensuring spectrum is used optimally. Technology lifecycles vary from sector to sector but incentivising the uptake of efficient technologies is paramount. The increasing deployment of technologies in mobile networks such as software defined networks and network function virtualisation should make it easier and more cost effective to deploy new and more efficient technologies, almost continuously.

¹² European Commission Digital Scoreboard, 2015. Graph indicates households passed. In 2014, deployments of 4G (LTE) continued: home coverage increased from 59% to 79%. 4G coverage is still below that of 3G (HSPA) and LTE deployments have been mainly in urban, areas, with only 27% of rural homes are covered. However, in ten Member States, LTE is already available also in the majority of rural homes, with very high rates in Denmark, Sweden and the Netherlands.

- **Carrier aggregation**¹³

Carrier aggregation (CA), offering the possibility to aggregate two carriers from two different frequency bands (or two carriers within a band) could increase the data rate provided by mobile networks who could then use different frequency bands to respond to a single demand, capitalizing on various spectrum assets they hold could facilitate a seamless transition towards higher speed broadband.

- **Additional spectrum resources**

A mobile operator could reuse the same emission site and same technology to deploy additional spectrum. Additionally they may be able to implement additional carrier aggregation mechanisms when standardised and available. The capacity of the wireless base station, both in terms of access speed and traffic flow capacity, is then improved.

Additional spectrum resources in two frequency bands will be harmonised in the near future: 2.3 - 2.4GHz / 700MHz responding to the current demands. These bands will benefit from international harmonisation and the early availability of equipment. Additionally, the recent harmonisation Decision on 1452-1492MHz is likely to introduce a technology innovation, Supplemental Downlink (SDL), within the European market. Europe is taking a leading role in driving this initiative forward.¹⁴

3.1 Current and future harmonised frequency bands

In response to calls in the Radio Spectrum Policy Programme (RSPP) to find 1200MHz of spectrum for mobile broadband by 2015, the RSPG's Opinion on WBB (2014) identified in 2014 suitable frequency bands to respond to future needs in its Opinion on WBB. It undertook a robust assessment of spectrum between 400MHz and 6GHz in order to ascertain which bands would be suitable, in the short, medium or long term, for mobile broadband services. It provided a clear and coherent roadmap for the Commission, highlighting bands which could be made available relatively quickly and with relative ease and those that, although slightly more challenging, would reap considerable benefits. It triggered harmonisation initiatives in 1452-1492MHz and 2.3 - 2.4GHz (including through Licensed Shared Access (LSA) as required - see below) and will be helpful in meeting the needs of mobile services over the next few years.

In addition, the RSPG has undertaken extensive work on the future use of the 700MHz Band and, in its Opinion on the Long Term Strategy for the UHF band, recommended that the 700MHz is made available for Electronic Communication Services (ECS) by the end of 2020 with the possibility of delaying this by up to 2 years without the need for derogation.

The EU collectively agreed that 1200MHz was an appropriate target, based on a realistic expectation of what the majority of Member States will require in the near term, therefore we can assume 1200MHz represents 'average' maximum demand. When we reach, collectively, the 1200MHz target in the RSPP, we may have reached the maximum required by the 'average' Member State. By that we mean a Member State with 'average' size, 'average' population and 'average' demand. This is the point at which harmonisation reaps the most benefits: for example by enabling manufacturers to benefit from economies of scale and subsequent consumer benefits.

Moving on from here, there may, for a multitude of reasons, be some Member States (or parts of Member States like metropolitan areas) with much larger demand or capacity

¹³ <http://www.3gpp.org/technologies/keywords-acronyms/101-carrier-aggregation-explained>

¹⁴ Official Journal L119/58 - 12 May 2015

requirements and also those that with lower demands require less. It is at this stage where the risk of sterilisation of spectrum is at its greatest and where there must be flexibility to meet areas of high demand without sub optimally affecting areas of low demand.

The implementation of the harmonisation measures (designation and making the band available) should take into account these variations in market demand, on a case by case basis, at the time of entry into force of the harmonisation measure. Some Member States may need this spectrum at a later stage (or not at all) compared to other Member States where the demand is more urgent.

Consequently, if new harmonised technical conditions are considered for additional frequency bands at the European level, flexibility may be required in some Member States when it does not impede the use of the band under the harmonised conditions by neighbouring Member States. In cases where the national market demand does not require access to those bands or demand is not emerging, the deadline for reallocation of the bands to electronic communications should be considered. This assessment should be done on a case by case basis, taking into utmost account the Opinion of RSPG (when the date is not mentioned by an existing legislative measure at European level such as RSPG). The RSPG addressed, in particular the 700 MHz, 1452-1492MHz and 2.3-2.4GHz frequency bands in its last Opinion on RSPG.

Where the demand is lower because of national circumstances, variations in implementation will be required at the national level. One approach could be to allow Member States to use the spectrum for services that fulfil national needs as long as they do not constrain the use of services in those Member States who have harmonised their spectrum for the given (usually mobile) services. This should not jeopardize the long term harmonised availability to electronic communication services and the resulting economies of scale for equipment operating in the newly identified frequency bands.¹⁵

3.2 Licensed Shared Access (LSA)

In order to ensure a more efficient usage of spectrum at national level, RSPG has developed a regulatory approach in its Opinion on Licensed Shared Access (LSA) which describes in particular the role of various stakeholders.¹⁶

This approach gives access to new spectrum resources for electronic communications while maintaining usage for the incumbents (for instance government users).

LSA is a regulatory approach which can be implemented at national level where the conditions of sharing are set out as part of the national regulatory framework. This regulatory and innovative approach is compatible with the current European Framework.

LSA offers the possibility for those Member States who need to use this approach as part of their authorisation regime, to facilitate multiple users in the same band so as to increase spectrum efficiency and optimisation. Incumbent usage could continue to operate in the band, and usage could evolve over time as needed according to conditions defined under the national LSA sharing framework.

¹⁵ See RSPG Improving Wireless Broadband coverage – see “Where there is a low level of demand in a Member State for wireless services” p 25

¹⁶ See RSPG13-53 – RSPG Opinion on Licensed Shared Access

New entrants in the frequency band (such as mobile operators) could benefit from access to new harmonised spectrum resources.

LSA does not prejudge what modalities for the authorisation process are deployed and the Member State or National Regulatory Authority (NRA) should take into account the national circumstances, market demand and type of incumbent users which may vary from country to country.

The LSA approach is being considered in relation to the use of the 2.3 – 2.4GHz spectrum and trials of LSA are currently on-going in some Member States.

3.3 Spectrum for 5G

5G is currently much debated, but not yet defined. The Commission and several Member States have separately held workshops and sought input from stakeholders regarding what 5G might actually look like.

Whilst nothing conclusive has yet been defined, it is expected that 5G will provide much faster mobile broadband speeds than current 4G technologies and that in order to deliver these speeds it will need large blocks of contiguous spectrum. A consensus is beginning to emerge that additional spectrum is not the only answer, but that a mix of current and new spectrum will be necessary. Aggregation of bands/carriers in the current and near harmonised spectrum, along with much more efficient technology, represents a strategic opportunity for Europe to pave the way towards 5G.

5G will need several aspects to be commercially viable, including a global standard, which should emerge from the standardisation process. and access to harmonised spectrum in Europe and other regions. The ITU has begun looking at this and it is expected that a future agenda item (for WRC-19) will be agreed at WRC-15 looking at spectrum for IMT above 6GHz. Additionally, Member States and the Commission are starting to think about availability of suitable spectrum.

5G is likely to utilise a broad portfolio of spectrum, including lower frequency bands and large contiguous blocks above 6GHz. As a result, we expect 5G to make use of existing mobile bands and require new ones. It may involve heterogeneous networks using both licenced and unlicensed spectrum operating in innovative ways with spectrum sharing becoming an increasingly integral part of spectrum use. By the end of 2017, the RSPG will develop an opinion, including those bands understood at this stage as having the best potential for harmonisation and addressing relevant spectrum issues raised by 5G. This will be addressed further in upcoming work by RSPG in 2016.

4. Awards

A useful starting point in considering awards is to look at European legislation, in particular the Authorisation Directive 2002 (as amended in 2009),¹⁷ and the Radio Spectrum Policy Programme Decision (2012).¹⁸ Taken together, along with other relevant European legislation, they compel Member States to apply “the *most appropriate and least onerous authorisation system possible in such a way as to maximise flexibility and efficiency in spectrum use. Such an authorisation system shall be based on objective, transparent, non-discriminatory and proportionate criteria*”.¹⁹

The Authorisation Directive states that when competitive or comparative selection procedures are used to grant radio frequencies rights, Member States shall grant such rights on the basis of selection criteria which, inter alia, must give due weight to the achievement of the objectives of Article 8 of the Framework Directive - *Policy Objectives and Regulatory Principles* - and to the requirements of Article 9 - *Management of radio frequencies for electronic communications services*.

Where it is reasonable to conclude that demand for spectrum is likely to outstrip supply, the most efficient mechanism for an award, absent other countervailing public policy issues or objectives, will be through a competitive process. A competitive process is likely to produce an outcome where the licence holder will seek to make their investment profitable while fulfilling the licences obligations set by Member States such as broadband coverage targets.

4.1 Award mechanisms

There are various types of award mechanism that may be used for bands allocated for ECS, with the most common being an auction. This is because it is the process deemed most likely to allocate spectrum to the users who have the highest valuation and therefore can be expected to make best use of it.²⁰

- **Auctions**

Auctions have been widely used to allocate spectrum rights in Europe since 2000. Auctions have several advantages for both Member States and bidders compared to other award mechanisms. A well-designed auction captures policy objectives and incentivises bidders to bid according to their true valuation of the spectrum, ensuring that the bidder with the highest valuation secures the spectrum and resulting in the spectrum being sold to the bidder who is

¹⁷ Directive 2002/02 of the European Parliament and the Council on the authorisation of electronic communications networks and services

“*Least onerous authorisation system possible should be used to allow the provision of electronic communications networks and services in order to stimulate the development of new electronic communications services and pan-European communications networks and services and to allow service providers and consumers to benefit from the economies of scale of the single market*”

¹⁸ Official Journal L81 / 55, 21 March 2012

¹⁹ Ibid – see Article 2(a)

²⁰ Various award mechanisms are described in further detail in the Joint BEREC – RSPG Working Group on Report on Competition Issues; Report on exploring the economic and social value of radio spectrum for certain electronic communications services with respect to the frequency assignment procedures. RSPG12-410 (rev2).

likely to use it most effectively and efficiently. It may, however, be more difficult to give weight to other policy objectives as selection criteria.

Auctions and capturing policy objectives within auctions are explored further in Section 5 of this report.

- **Beauty contests**

Beauty contests are a good option to promote several policy objectives, such as coverage or quality of service. The licensees are selected using criteria set by the awarding body and that are well known before the process. Licences are awarded to the applicant who best meets the identified criteria and can make optimum use of the radio spectrum. The applicants may compete to achieve the best overall rating on a combination of criteria. Some of these criteria will involve applicants making undertakings, e.g. on roll-out and coverage or quality of service. These undertakings will generally be translated into authorisation requirements.

This mechanism has the advantages of flexibility and being able to include factors beyond the pure economic value of spectrum, thereby reflecting national objectives in awarding spectrum. These could include, for example, financial viability of an applicant, technical experience, innovation, expansion plans and planned degree of coverage, market penetration and price. The success of this procedure is, to an extent, dependent on transparent criteria and a sufficiently clear evaluation process.

There are some potential disadvantages to beauty contests; most notably they include more subjective criteria than auctions, leading to a potential risk of disputes on criteria or possible legal challenge. As a result, this type of award procedure should be designed in order to establish robust and transparent provisions.

Depending on the set-up of the proceedings, the administrative costs should be carefully assessed in advance. Nevertheless, there is the risk that the revenue obtained for the spectrum rights do not sufficiently reflect their economic value due to uncertainties in assessing the economic benefits that those rights to use radio frequencies can deliver to the service provider.

- **Hybrid approaches**

A hybrid approach generally merges certain elements of beauty contests with those of an auction combining commitments to meet national obligations with a financial bidding process. One example of such a hybrid is the award for 2.6 GHz and 800 MHz in France. This is described in more detail in Annex 2.

Potential advantages to this format include the acceptance of voluntary commitments made by successful bidders, for example, regarding ambitious coverage obligations and competition (MVNO and roaming - see Annex 2 for more details), which may be a good way to balance national objectives.

However a potential disadvantage may be that although it allows for the weighting of various commitments, the nature of the weighting may be susceptible to subjectivity (as are all models where weighting is part of the process) again leading to disputes and legal challenge.

- **First come first served**

The award of spectrum rights on a first-come first-served basis is made according to the order in which applications are received. Successful parties are those who submit their application the quickest once a license class is made available.

This process is suitable in particular for those frequency bands in which scarcity of spectrum is not expected in the foreseeable future. In a public consultation process the awarding body should ensure that there is no scarcity of spectrum as well as ensuring that all interested parties are fully aware of the process.

While these proceedings may not be suitable for spectrum in high demand, this method has the advantage of being relatively quick and light on resource requirements for both Member States and spectrum users. Additionally, it could be argued that assigning spectrum rights in this manner at least makes it available for use, as opposed to it remaining unassigned. However, there are some disadvantages including the possibility that at some point in the future, significant demand might emerge for those frequencies; or that there is an increased chance of dispute if lack of demand has not been conclusively proven.

4.2 Objectives of awards

Identifying and articulating public policy objectives national circumstances is a strategic part of a well-designed award. It is important to be clear about what the Member State wants to achieve and this will then help to inform the award design and other related decisions. This must be done within a robust national legal framework.

There is no one-size-fits-all in terms of spectrum awards. As a starting point, when defining the objectives of an award, consideration should be made of the:

- Market / Competitive structure: This encompasses, amongst other things, competition issues, asymmetries (such as information or financial), number and market share of wholesale operators; number and market share of retail operators; quantity and quality of spectrum held by each wholesale operator; overall population and relevant density, existing licenses which determine obligations (such as coverage obligations), renewal dates, etc; and
- Market and technological developments including the cost of raising capital; Smartphone penetration; consumer demand; existing coverage; what technologies could reasonably be expected to make use of the spectrum in the foreseeable future.

In terms of objectives, the following are some of the most common:

- Efficient use of spectrum (potentially including ensuring that all the spectrum be assigned);
- Enhancing and/or safeguarding competition (including promoting new entrants/facilitating market entry, ensuring a minimum number of competitors);
- Increasing broadband penetration and promoting roll-out of broadband networks and services;
- Enhancing coverage in rural areas (regional development);
- Promoting innovation; and
- Promoting business opportunities and employment (economic development).

There are some other objectives which have also been applied by Member States, such as raising or maximising revenues, or securing a reasonable return for the spectrum. However others are explicitly prevented from considering revenue related issues in undertaking a spectrum award.

Award objectives may sometimes conflict, resulting in the need to make open and transparent decisions about their relative priority. During this prioritisation process it is important to provide clarity and to involve stakeholders in the decision making process through a consultation process.

In order to achieve the stated objectives, Member States should consider, among others, the following:

- The award process should be transparent and easily understood by potential bidders;
- The award process should encourage participation in the process, and avoid outcomes where spectrum goes unsold despite demand existing for that spectrum;
- The award process should minimise uncertainties (such as common value uncertainty which may exist among bidders who may want to use spectrum to deploy different or new technologies)²¹;
- In the case of multi-band awards (where several spectrum bands are awarded at the same time) the award process should allow sufficient flexibility to express preferences related to complementarities or substitutability;
- The award process format and rules should minimise the risk of inefficient outcomes for bidders; and
- The award process should promote incentives for bidders to engage in a manner expected of normal competition, and not to engage in strategic or collusive behaviour.

Each award design will need to be tailored to the particular circumstances in the market at that time and Member States will need to ensure that as far as possible, that the design and rules chosen reflect the objectives of the award and create a fair environment for all bidders. Some case studies are included in Annex 2.

²¹ See Section 5.4.1.e below

5. Perspectives on spectrum auctions

This section explores issues which need to be taken into consideration when designing an auction. It intends to be a high-level discussion on what these issues are, and not a comprehensive formulation.

5.1 The benefits of auctions

There are several advantages for Member States that chose to auction spectrum rights:

- According to economic theory, auctions are most likely to put the spectrum into the hands of those who value it most and are incentivised to make the best use of it;
- Auctions allow the market to decide the price of the spectrum. A well designed auction is generally the most efficient pricing method since the market holds the most complete information about consumer needs and technological and market development. Auctions should allow for price discovery which is important to achieve an efficient result under common value uncertainty. If the bidders have limited information about the value of the spectrum, knowing how other bidders value the spectrum can help the bidder form their valuation;
- When designing auctions the Member State has a lot of flexibility to account for both economic and socioeconomic objectives. For instance it is possible to integrate public policy objectives other than allocative efficiency, such as coverage obligations or competition in the auction design; and
- Auction results should be less vulnerable to post award disputes since the allocation terms in a well-designed auction are quantifiable. In an auction the winner is the bidder with the highest bid. By participation in the auction each bidder implicitly accepts these terms and it is not possible to negotiate the outcome during or after the award. Furthermore it is transparent to the bidders who has won and why.

5.2 Different types of auction formats

Several formats have been widely used in spectrum auctions around the world and are now relatively well understood by Member States, NRAs, auctioneers, bidders and academics. The most commonly used have been the CCA (Combinatorial Clock Auction), the SMRA (Simultaneous Multiple-Round Ascending Auction) and Sealed Bid Auctions (with first and second price rules). They all have advantages and disadvantages which should be considered by the auctioneer in the preparation of the award in conjunction with the overall policy objectives and priorities.

In many recent auctions the award process was separated into two stages. In the first stage, the so-called principal stage, the amount of spectrum each bidder wins is determined. The second stage, called the secondary stage, determines the exact location of the lots won within the band. The formats described below are primarily used in the principal stage of the auction.

Some formats, however, have a single stage, where bidders bid for frequency-specific lots.

Short description of different pricing rules

An important aspect in designing an auction is the pricing rule because of the incentives it provides to bidders. In general two types of pricing rules can be distinguished: first price and second price.²²

In a first price auction each winning bidder pays the full amount of its own winning bid. A first price auction exposes bidders to some form of strategic complexity as they will need to try to evaluate how much other bidders are likely to bid, to avoid paying more than necessary. In a combinatorial auction a first price rule may have another disadvantage; what is known as the “threshold risk”, explained later in this section.

In a second price auction the winning bidder pays the second highest bid – the highest losing bid. If only a single object is auctioned, the second price rule incentivises truthful bidding. However, a second price rule may create a disadvantage to budget constrained bidders as they might not be able to bid their valuation, also explained later.

In a second price auction the winning bidder pays the second highest bid – the highest losing bid. The second price rule incentivises truthful bidding because bidders have no incentive cannot try to minimize the amount they pay by bidding strategically. The price a winning bidder pays will always be determined by other bidders, therefore there is a good incentive to bid according to one’s own valuation.

An opportunity cost based pricing rule is a generalisation of the second price rule often applied in combinatorial multi object auctions.²³ As with the second price auctions the winning bidders don’t pay their own bids. The winning bidders only pay the values that prevent any other bidder and subgroup of bidders from winning. This value is the opportunity cost of awarding the spectrum to the winning bidder. By making a winning bidder pay the opportunity cost of winning the rule aims at incentivising truthful bidding. Furthermore, the opportunity cost based pricing rule could help overcome the threshold risk in combinatorial auctions.

5.3 Auction formats

There are multiple auction formats which may be utilised depending on the Member State objectives and the flexibility of choice of auction format provides Member States with the opportunity to optimum means of securing multiple policy objectives depending on the mix of frequency bands / lots to be auctioned, the technology to be deployed and the services to be provided. These auction formats are described in summary form below and explained in more detail in Annex 3.

- **Single item versus multiple items auction**

In a single item auction there is only one single item for sale. There are basically four formats that are used in single item auctions:

- Sealed-bid first-price auction;

²² The possibility to choose one of these pricing rules depends on the auction format. Whereas sealed-bid auctions can be designed as first-price or second-price auctions ascending multiple round auctions are usually pay-what-you-bid (i.e. first price rule) auctions..

²³ In the academic literature the pricing rule is known as “Vickrey-nearest core pricing rule” or “minimum revenue core pricing rule”.

- Sealed-bid second-price auction;
- Ascending multiple round auction; and
- Descending multiple round auction

In a sealed-bid auction, bidding takes place in one single bidding round. The highest bid wins. The price the winning bidder has to pay depends on the pricing rule. In a first-price auction the winner pays what he bid. In a second price auction the winner pays the second highest bid.

In an ascending multiple round auction bidding takes place over several bidding rounds. The auction starts with a minimum opening bid and the price increases in the course of the auction until only one bidder is willing to pay the price. The descending multiple round auction starts with a high price and the price decreases from round to round until the first bidder accepts the price. In both formats winners pay what they bid.

- **Multiple items**

These can be auctioned either sequentially in a series of single item auctions or simultaneously. The following formats are mainly used if items are auctioned simultaneously:

1. Combinatorial auction formats:
 - a. Combinatorial Clock Auction (CCA); and
 - b. Sealed Bid Combinatorial Auction (SBCA)
2. Non Combinatorial auction formats:
 - a. Simultaneous Multiple-Round Ascending (SMRA); and
 - b. Clock auctions

5.3.1 Combinatorial auction formats

The feature common to all combinatorial auction formats is that a bid submitted by a bidder is for a package of lots. Bidders must be awarded one of the packages of lots that they have bid for during the auction or nothing at all; a bidder cannot be awarded any combination of lots for which it did not explicitly submit a bid.

This feature is important in auctions where there are aggregation risks, as will be explained later. The most common examples of combinatorial auction formats are the CCA and the SBCA.

- **Combinatorial Clock Auction (CCA)**

The Combinatorial Clock Auction (CCA) is a multi-unit two-phased bidding process.

The first phase of the CCA is a multiple-round clock phase. Prices in each round for each lot category are set by the auctioneer and bidders respond to these by bidding on a number of categories; in lot categories where demand exceeds supply, the price is increased until there is no excess demand for any lot category. A points-based activity rule is usually adopted, whereby bidders may only decrease or maintain demand, measured by eligibility points, from one clock round to the other. Bids made throughout the clock phase of the CCA are binding, as they will be considered like all other bids when evaluating which combination of bids has the highest value and becomes the winning outcome.

The second phase is the Supplementary Bids Round. This is a single-round sealed-bid process where bidders may place bids for the packages they bid on during the clock rounds and place bids for other packages. Supplementary bids are subject to constraints aimed at

ensuring that bidding is consistent with the preferences revealed during the clock rounds. In order to be feasible, bids made in the second phase of bidding must adhere to auction rules, such as spectrum caps and floors on bid amounts, but they are also subject to caps on bid amounts generated based on bids in the first round of bidding. These caps on bid amounts are imposed to ensure that bidders can only express preferences for some packages over others, in the second phase, that are consistent with their bidding behaviour in the clock phase. Examples of these sorts of caps are the “absolute cap rule”, the “relative cap rule”, and the “final price cap”.

At the end of the Supplementary Bids Round, all bids placed by bidders in the clock phase and in the Supplementary Bids Round are brought together. The combination of bids (maximum one bid per bidder) that maximises total value is selected and the bids included in that combination are winning bids. A base price for each winning bid is calculated usually according to a second price, or opportunity cost rule. Such a pricing rule requires bidders to pay an amount that is just sufficient to ensure that no losing bidder or no coalition of losing bidders would be prepared to pay more for the spectrum.

- **Sealed-bid single-round combinatorial auctions (SBCA)**

In sealed bid single-round formats bidders are invited to submit mutually-exclusive bids for different combinations of spectrum. These are usually package bid auctions, like the CCA.

As with the CCA, all bids placed by bidders are brought together and the combination of bids (maximum one bid per bidder) that maximises total value is selected as the winning combination. A first or a second price rule may also apply. Under a first price rule, winning bidders pay as bid. Under a second price rule, as in the CCA, winning bidders are required to pay an amount that is just sufficient to ensure that no losing bidder or no coalition of losing bidders would be prepared to pay more for the spectrum.

5.3.2 Non combinatorial auction formats

The most common formats where bids are not for packages (i.e., they are not combinatorial) are the SMRA and the simple clock auction.

- **Simultaneous Multiple-Round Ascending (SMRA)**

The SMRA is an ascending, multiple-round, multi-unit format. The highest bid for each lot in each round is nominated Standing High Bidder, or provisionally winning bidder. The rounds proceed with increasing prices, until there are no new bids. When the rounds end, the Standing High Bidders become winning bidders and pay their bids.

Similar to the clock phase in the CCA, a points-based activity rule is often used. This means that bidders may only decrease or maintain their level of demand from one round to the other, measured by the number of eligibility points.²⁴

This means that each lot carries a specific range of frequencies. The SMRA has also been used with frequency-generic lots. This means that lots do not have a specific frequency range, but only a pre-determined amount of bandwidth. As noted above, with generic lots,

²⁴ In some SMRAs, a phased activity rule is used in the first rounds of the auction. With a phased activity rule, bidder only needs to bid a fraction of their eligibility to be able to maintain eligibility in the following round.

bidders are awarded a number of lots at the end of the principal stage of the auction and then proceed to an assignment stage to determine the exact location of their frequencies, although other means of assigning an exact location have also been used.

- **Simple Clock Auctions (CA)**

A simple clock auction may be combinatorial or non-combinatorial. By combinatorial, it means the bidder places package bids which are either accepted or rejected in their entirety. In a non-combinatorial clock auction, bidders place bids for individual lots and they are not allowed to contract demand if by doing that they would generate excess supply. This means that bidders do not have the guarantee that they will either win the number of lots they bid on, or nothing at all, as they may win part of their demand only.

Clock auctions are less common in Europe than SMRAs, but share many similarities with the latter. As noted, usually bids in a simple clock auction are non-combinatorial, like the SMRA. Also, prices are linear, a point based eligibility rule is usually used and there are restrictions to contracting demand if that generates excess supply. However, there are a few important differences.

In the SMRAs usually bidders may reduce demand even if that causes excess supply by withdrawing bids. Also, SMRAs tend to be slower because standing high bidders are not forced to immediately raise their bids, whilst bidders in the clock auctions always need to respond to new prices. Some clock auctions allow for intra-round bidding, whereby bidders may specify the price point at which they wish to contract demand and/or move the demand across lot categories. This mitigates price overshooting, whereby the risk that the auctioneer sets a price that exceeds the market-clearing level results in inefficiently unsold spectrum.²⁵

5.4 Challenges

In the previous section we noted that auctions have substantial advantages over other award mechanisms. There are, however a number of challenges involved when designing an auction. The auction designer needs to understand the impact of these challenges and address them, in view of the objectives which have been set out and the market context within which the auction will take place (market structure and development, and technological developments).

The challenges have been grouped into three themes: Difficulty in bidding, Gaming and Other issues.

5.4.1 Difficulty in bidding for the preferred spectrum

In some circumstances, described below, bidders may face difficulties when bidding for their preferred spectrum during the auction. This may have an impact on the efficiency of the outcome, if bidders adjust their bidding strategies in different ways and this causes the auctioneer to fail to sell the spectrum to those who value it the most. It may also impact competition, as weaker bidders may be particularly disadvantaged. If these bidders are also the most innovative, then innovation in the market may also be impacted.

a) Aggregation risks

²⁵ It must be mentioned that price overshooting is not necessarily caused by prices set too but might also be caused by complementarities. In that case a simple clock auction could fail to produce an efficient outcome.

Aggregation risk refers to the risk faced by bidders who have a value for a combination of lots which exceeds the sum of the value placed on the individual lots included in that combination. The risk is that such bidders bid in accordance with the value for the combination of lots, but fail to win the whole combination. For example, a bidder may want to acquire a minimum amount of spectrum, say, four lots, and have little value for being awarded less than four. If the expression of this type of valuation is not easily facilitated and relatively riskless within the bidding process, bidders may deviate from straightforward bidding behaviour to insure themselves against the risk of ending up with only some of what they want at a price at which their winnings have negative value to them. A way to solve the aggregation risk is to hold combinatorial auctions – whereby as explained previously bids are for packages of lots, which are either accepted or rejected in their entirety.

b) Substitution risks

The risk that a bidder may not be able to move their demand across different lots of spectrum as a response to changes in relative prices; Substitution risks can arise when one or more bidders view at least some alternative packages of lots as substitutes but cannot reflect this willingness to switch its bidding from one package to another based on prices because of some sort of impediment to switching. One way to address this is to allow bidders to express all their preferences across all possible combinations of spectrum. This is what the CCA and the sealed-bid combinatorial auctions do.

In order to further decrease the risk of non-contiguous assignment, the auction rules could state that all the lots a bidder wins will be assigned on a contiguous basis.

c) Fragmentation risks

The risk that a bidder ends up with a non-contiguous assignment of spectrum; this is a concern in auctions where bidders bid for frequency-specific lots, instead of generic lots. Therefore, a way to address this concern is by allowing bidders to bid for generic lots in the principal stage of the auction, and then bid for the exact location of their frequencies in the assignment stage.

d) Threshold risk

This is the risk that a group of small bidders may fail to collectively outbid a larger bidder, when it would be efficient for them to do so. This may be because bidders may have an incentive to reduce their contribution to the burden of outbidding the larger bidder or an unintended consequence of anti-collusion rules. Auctions with a second-price rule reduce the incentives for bidders to do this, as they do not pay what they bid, but the price which is strictly necessary to outbid the largest bidder.

e) Common value uncertainty

This may occur if there are elements of the value of spectrum that are common and unknown to bidders. Individual bidders have to formulate their own expectations which, on average, will tend to be right but optimistic bidders tend to overestimate the common value. If bidders do not take this risk into account it may lead to the so called winner's curse problem.

One way to address this is to allow bidders to extract information about the likely valuation from other bidders during the auction (known as price discovery) and adapt their expectations accordingly. This is usually done by holding multiple-round auctions, like the SMRA and the CCA.

f) Bid shading

This may occur when bidders do not reveal their true value for the spectrum, thinking that will allow them to pay less for it. This is a concern in first price auctions. This is because in these auctions the price bid impacts the probability of winning, but also the price paid. Rational bidders will try to strike a balance between these two opposing effects. Usually, they will formulate expectations as to how much the second-highest bidder is likely to bid, and bid slightly above that. This may risk efficiency in the auction, if these estimates are wrong and the highest value bidder fails to win the spectrum. A way to mitigate this concern is by adopting a second-price, or opportunity cost pricing rule, as described earlier in this section or to run an ascending multiple round auction.

g) Risks faced by budget-constrained bidders.

Budget-constrained bidders may not want or be able to bid up to their full valuations for the spectrum. This is particularly a concern in second-price auctions, like the CCA. Bidders in these auctions may choose to bid up to their budget limit for a large package of lots, and reduce the amount bid for a smaller package, in order not to reduce the probability of winning the large package. However, this may result in the bidder acquiring neither the large nor the small package. Instead, the bidder may bid their budget limit for a large package of lots, and their full valuation for the smaller package. This however reduces the probability of winning the large package. The strategic complexity caused by these concerns may have an impact on the auction efficiency and, insofar as smaller bidders are the ones who are budget constrained, it may impact competition in the market after the auction.

A way to mitigate this concern is to hold a multiple-round stage, like the CCA does. A bidder can then attempt to predict whether it does have a chance of acquiring a large package or not.

h) Auction complexity

One can distinguish between two different types of auction complexity:

- complexity of the rules and the inherent auction mechanism; and
- complexity of decisions faced by bidders (bid complexity).

Bid complexity refers to the strategic complexity bidders may face when they need to deal with the challenges presented above. This might require them to formulate assumptions about the nature of the demand from other bidders in order to work out the best strategy.

Bid complexity may be mitigated by construing relatively complex rules, which allow for a more complete expression of preferences but at the cost of increasing the complexity in the rules.

The CCA is usually perceived to be complex in this sense and is often considered to have a relatively complicated structure (in the main due to the use of algorithms for winner determination and pricing). Design of an effective bid strategy does require an understanding of key concepts such as:

- the concept of opportunity cost underpinning the pricing rule; and
- the supplementary bids round and the caps on bids that result from primary bids.

Once the model itself is understood and bidders have generated their valuations for different packages of lots, the process of bidding to reflect these valuations (and importantly, relative preferences between different packages) bidding can be relatively straightforward.

However, while having bidders working out their business cases ahead of the auction has many important advantages; some bidders may face difficulties devising their bidding

strategy within their organization ahead of the auction, particularly in the presence of significant uncertainty regarding the business model and the value of the spectrum.

Overall, complexity in the rules may be problematic if:

- the costs to bidders in time and money of preparing for an auction become a material proportion of the value of the spectrum for award, as this risks deterring potential bidders; or
- There is the possibility that small bidders or potential new entrants may lack auction experience and the resources to invest in substantial auction preparation and development of bid strategy.

Auctioneers may mitigate this concern by providing adequate training, for example holding mock auctions, running seminars and making software available to bidders or potential bidders sufficiently in advance of running the auction.

5.4.2 Gaming

A second category of challenges relate to gaming in the auction. Experienced or more knowledgeable bidders may be able to distort the outcome of the auction to their benefit. If these bidders win spectrum not as a result of having a higher valuation, but of knowing how to unduly exploit the auction rules to their benefit, the outcome may be inefficient. Again, weaker bidders may be particularly disadvantaged. As a result, competition may suffer.

i) Tacit collusion

A potential issue with open auctions is that it may allow bidders to engage in tacit collusion, whereby a number of bidders jointly reduce their demand in order to reduce the prices they have to pay in the auction. The open rounds in an auction may facilitate such outcomes by providing bidders with an opportunity to signal their intentions, observe the behaviour of their competitors and (progressively) adjust their own bids. This may be a concern on efficiency grounds if individual bidders end up winning less (or more) spectrum than they would otherwise, based on their relative valuations.

In contrast, such bidder interaction is not possible when using a sealed bid auction format or a format that includes a sealed bid round such as a CCA and may mitigate these concerns, as bidders would not be able to signal or test demand reduction. Limited information in multiple-round auctions, like the SMRA and the CCA, also mitigate this concern by increasing the risk of unilaterally reducing demand in the auction, without knowing whether other bidders are doing the same. All other things being equal, higher reserve prices reduce the gains from engaging in tacit collusion, as the scope to lower prices in the auction is more limited.

j) Price-driving

Price-driving bids are bids that do not reflect a bidder's intrinsic valuations for the underlying lots of spectrum but bids are placed with the aim of increasing the price paid by other bidders. Such behaviour need not necessarily be a concern on efficiency grounds, unless if there is a genuine probability of those bidders (bidding strategically in excess of valuations) ultimately winning those the spectrum lots at a price above their valuation, or if they impact the way other bidders bid in the auction.

It may also be a problem if the auction format or rules are seen to favour or disadvantage particular bidders through the impact of price-driving strategies (e.g. if 'weaker' bidders appear to be less able to engage in such strategies due to budget constraints or due to inexperience). Finally, price-driving behaviour during open rounds of an auction can erode price discovery.

In general, the likelihood of such behaviour depends on the extent to which bidders can judge the probability of any particular bid becoming a winning bid. This may depend on the degree of transparency but also on other detailed auction features, e.g. any provisions that can make bids non-committing. For example, in a CCA, in some cases bidders may be able to calculate supplementary bids that have zero probability (or a low probability) of winning, while having the effect of raising prices paid by others. In an SMRA, price-driving may be encouraged by design features such as withdrawals or allowing bidders to specify a minimum spectrum requirement.

Broadly speaking, the incentive for price-driving should be weaker when lot categories are highly substitutable for many bidders:

- In such a scenario, bidders will respond to price-driving behaviour in one category by switching to other categories and therefore applying upward pressure on prices in those other categories; and
- Therefore, if a bidder attempts to drive prices up in a category that it is not interested in, it will risk causing a knock-on effect that subsequently also drives up prices in those categories containing lots that it is actually interested in winning.

k) Strategic demand reduction

Strategic demand reduction is a phenomenon that can arise in auctions where bidders are choosing the quantity of lots they are bidding for. In some auction formats, the quantity of lots sought by a bidder can be anticipated to affect the price it needs to pay. Such a bidder may identify that the price for its winning package may be lower on a per lot basis if it seeks to win fewer lots from early in the process (instead of competing for many lots and then dropping back to fewer lots if its larger package gets too expensive). Faced with this situation, a bidder may choose to bid for fewer lots than it would have bid for had it not anticipated having any effect on price. This can lead to inefficiency (as bidders are not seeking lots they have value for) and reduce competition.

l) Eligibility parking

Some auction formats, like the CCA and the SMRA, require bidders to maintain certain levels of activity in order to maintain their ability to bid in the auction. Usually this is done by what we described above as a point-based eligibility rule. If this rule is not well designed, bidders might be able to adopt a strategy whereby they bid for spectrum they do not want to win in order to maintain eligibility to bid for their most preferred spectrum at a later stage of the auction. This distorts price discovery in the auction and may subject bidders to common value uncertainty.

5.4.3 Other issues

Finally there are a couple of further issues which do not fall under the previous categories;

m) Strategic investments

Bidders may incorporate the value of foreclosing or weakening their competitors in their bids, instead of purely reflecting their intrinsic values. This may risk efficiency and more clearly competition in the market. Adequate limits to how much spectrum each bidder may acquire (spectrum cap), or setting aside spectrum to a new entrant/smaller player, are ways to mitigate this concern.

n) Software issues: accessibility for bidders, security risks, implementation issues

Many of the recent spectrum auctions have taken place over the internet. This requires the auctioneer to develop software. It is imperative that the software works according to the auction rules and that the security and integrity is guaranteed. Otherwise the software could lead to outcomes that aren't in accordance with the auction rules, or there might be security breaches that compromise bidders or the auctioneer. To mitigate these risks it is important that auctioneers subject the auction software to rigorous testing.

To make sure that the auction software performs the way it is intended and that the software does not hinder bidders in their participation it is also important to provide clear instructions to the bidders with regards to the ICT requirements of the software. This allows bidders to prepare their own ICT accordingly. Nonetheless, for any troubles which arise during the auction, the auctioneer should be able to provide ICT support.

5.5 Assessment of formats

The most commonly used formats in Europe in the last eight years have been the SMRA, the CCA and the sealed bid auction, as the tables below show:

Table 2: Multi band awards

Country	Year	Format	Bands				
			800 MHz	900 MHz	1800 MHz	2.1 GHz	2.6 GHz
Germany	2010	SMRA	✓	✓	✓		✓
Italy	2011	SMRA	✓		✓	✓	✓
Spain	2011	SMRA	✓	✓			✓
Spain	2011	SMRA		✓			✓
Portugal	2011	SMRA	✓	✓	✓	✓	✓
Greece	2011	SMRA		✓	✓		
Romania	2012	Clock	✓	✓	✓		✓
Netherlands	2012	CCA	✓	✓	✓	✓	✓
Ireland	2012	CCA	✓	✓	✓		
Czech Republic	2013	SMRA	✓		✓		✓
Austria	2013	CCA	✓	✓	✓		
Slovakia	2013	CCA	✓		✓		✓
United Kingdom	2013	CCA	✓				✓
Norway	2013	1PSB ²⁶	✓	✓	✓		
Slovenia	2014	CCA	✓	✓	✓	✓	✓

²⁶ first price sealed bid

Table 3: Single band awards

Country	Year	Format	Bands				
			800 MHz	900 MHz	1800 MHz	2.1 GHz	2.6 GHz
Sweden	2008	SMRA					✓
Finland	2009	SMRA					✓
Austria	2010	CCA					✓
Denmark	2010	CCA					✓
Netherlands	2010	CCA					✓
France ²⁷	2011	Sealed Bid single round / sequential	✓				✓
Sweden	2011	SMRA	✓				
Sweden	2011	Clock			✓		
Denmark	2012	CCA	✓				
Norway	2012	Clock				✓	
Finland	2013	SMRA	✓				

Each auction format has different advantages and disadvantages. We noted that some formats and some particular policies are likely to address particular challenges better. Therefore, the choice of the format and of policies should depend on how likely the risks are to materialize, and how important those risks are, taking into account the particular objectives set out for the award.

In the end the auction design will have to strike a balance between all these different advantages, disadvantages, challenges, opportunities, and risks. We will briefly summarize the main advantages and disadvantages of each auction format.

SMRA

The SMRA is perceived to be transparent and easy to understand. It gives some degree of certainty and control to bidders. When a sufficient amount of competition is expected in the auction, the format may perform well even if it is multi-band. Like the CCA, its multiple-round nature allows for price discovery. However, it does not deal, or deals imperfectly, with aggregation and substitution risks. As a consequence, the best bidding strategy may not be to bid straightforwardly, but to form expectations about how other bidders are likely to bid. Finally, the SMRA may provide incentives for signaling, collusion and strategic demand reduction.

Sealed-bid auction

The sealed-round nature of the auction reduces the incentives for tacit collusion. It also deals well with strategic demand reduction. If the auction is combinatorial, it deals well with aggregation and substitution risks. However, these formats do not allow for price discovery and therefore may expose bidders to common value uncertainty and possibly to the winner's curse. A sealed-bid single-round auction with a first price rule exposes bidders to some form of strategic complexity, as they will need to try to estimate how other bidders are likely to bid. It could also lead to the threshold problem.

²⁷ NB the 2.6 GHz auction was held first and the 800MHz held second a few months later.

CCA

The CCA deals well with aggregation and substitution risks. The sealed-bid nature of the Supplementary Bid Round and the second price rule reduce the incentives for tacit collusion and for strategic demand reduction and in principle provide good incentives for truthful bidding. Finally, the multiple-round clock stage allows for price discovery. However, the rules and the inherent mechanics are sometimes perceived to be complex. In addition, the Supplementary Bid Round, together with the second price rule, may pose problems to budget-constrained bidders. In some circumstances, bidders may be able to exploit the Supplementary Bid Round and place bids with little or no probability of winning, only to increase the price paid by their competitors. The CCA provides incentives for truthful bidding, but it also requires bidders to work out their value for the spectrum in advance of the auction which may be problematic to some bidders.

Simple clock auction

The simple clock auction shares many similarities with the SMRA. As noted above, an important distinction is that in the SMRAs usually bidders may contract demand even if that causes excess supply by withdrawing bids. That is not the case in some simple clock auctions. In the clock auctions, where bidders may contract demand even if it generates excess supply, bids are not binding until the last round. This may facilitate strategic bidding, which may result in unsold lots.

Finally, clock auctions tend to be quicker than SMRAs because bidders in the clock auction format always need to respond to new prices. Instead, in the SMRA, standing high bidders do not need to respond to the new round prices unless they are outbid.

5.5 Developments in auction formats**SMRA**

There has been an attempt to address substitution and aggregation risks in the SMRA. This has mostly been done via:

- Allowing bidders to withdraw Standing High Bids. This may however create room for strategic bidding, as bidders may be less committed to their bids. For this reason, it may be appropriate to introduce some kind of penalty in case withdrawals result in unsold spectrum and/or a limit to the number of times a bidder may withdraw;
- Allowing bidders to specify a minimum requirement of spectrum. If bidders end up as Standing High Bids on less than their minimum requirement, they do not win anything; and
- Introducing further combinatorial elements. For instance, only assigning standing high bids to a bidder when all its bids can become standing high bids for instance hierarchical package bidding.

There has also been an attempt to mitigate the likelihood of bidders engaging in strategic demand reduction, tacit collusion and/or signaling in the SMRA by:

- Introducing generic lot categories. With generic lot categories, bidders do not bid, and prices are not calculated, for each single lot, but for the lot category as a whole. This may make signaling more complicated;

- Pre-specify bidding increments. When bidders can specify prices in their own bids, they may use this to communicate to other bidders. This might in turn facilitate tacit collusion;
- Setting appropriate reserve prices. All else constant, the higher the reserve prices, the lower the gains from tacit collusion and/or strategic demand reduction; and
- Restricting the level of information disclosed to bidders during the auction. More restrictive information policies will increase the risks of engaging in tacit collusion / strategic demand reduction.

CCA

The CCA has continuously been changed in the last decade to reflect new insights. Recently approaches to making the clock stage more informative to bidders and more indicative of the final outcome have been tried by:

- Applying a relaxed activity rule: this allows bidders to submit a richer set of bids in the clock stage that would otherwise be deferred to the Supplementary Bid Round; and
- Implementing a final price cap: this is a further constraint on the Supplementary Bid Round that should make the outcome of the final clock round more indicative of the final outcome of the auction and could help bidders that are budget constrained.

Simple clock auction

A number of additional rules have been imposed to improve on those simple clock auctions where bids are not committing until the last round.

For example, the 3G and BWA auctions in India in 2010 consisted of a simple clock auction format augmented with a system of standing high bids. This meant that as long as a lot was bid on at the reserve price in the first round, it was always associated with a bidder, and the bidder with the standing high bid at the end of the auction for the lot became its winner. Another way of mitigating this concern is to prevent bidders from being allowed to contract demand if that generates excess supply.

If bidders are allowed to contract demand even if that generates excess supply, then there might be unsold lots even though there was demand for them at the reserve price. There is the possibility within the simple clock auction to look to earlier bids from bidders with winning packages and see if additional lots might be awarded to these bidders at lower prices. Leaving to one side the effect on bidding behaviour that such a modification may have, the remaining issue is that alternative outcomes are not fully considered. The magnitude of the effect this may have depends on, among other things, the scope for unsold lots. The larger the minimum requirement of lots by bidders, and the existence of increasing returns to additional lots, the greater the potential for unsold lots and the larger the number of unsold lots that might result in a simple clock auction. If the number of lots unsold at the final clock price is large, the range of options for awarding these lots might be rather limited if we only consider outcomes where existing winners are awarded more lots.²⁸

²⁸ Note that the 're-activation' of previous bids has its own drawbacks; it exacerbates incentives for strategic demand reduction and it has a number of follow-on consequences for bidding because of the effect of such re-activation on budget-constrained bidders.

One possibility to address this issue is to allow for bidders to express their value for a range of different packages and to award lots based on the highest value option for doing so (given certain rules), having evaluated all different combinations of these bids and the collective value they generate. This process of accepting a range of different bids from each bidder and evaluating all options for awarding the lots available based on these bids is used in both the CCA and the SBCA formats; it is known as winner determination.

5.6 Other considerations for Member States when designing auctions

- **Spectrum packaging**

The choice of how to make the spectrum available and which spectrum to make available in the auction is of crucial importance.

As noted above, most recent spectrum auctions were divided in two stages: a principal stage with generic lots followed by a secondary stage. Using generic lots makes bidding in the main stage simpler and speedier. A principal stage with generic lots also reduces the opportunity for strategic bidding aimed at splitting a competitor's spectrum holdings and allows the auctioneer to only present contiguous spectrum blocks in the secondary stage.

However, in some circumstances it may make sense to make spectrum available in frequency-specific lots, particularly if the value of each specific frequency varies greatly within the band and bidders need to be protected against the risk of being awarded spectrum they value less.

- **Lot categories**

Another way of protecting bidders when there are significant differences in value between different frequencies is by having generic lots, but splitting those lots into different lot categories. This way bidders who only bid in a given lot category know they will not be awarded spectrum from another category.

When there are differences in value, but they are not clear, there are two opposing effects. In some auction formats, like the SMRA, a high number of lot categories may create difficulties when bidders want to express their preferences by moving their demand across different categories as relative prices change. With a low number of categories bidders have to wait until the assignment stage to know whether they have won lots in their preferred part of the spectrum.

- **Lot sizes**

Making the spectrum available in small lot sizes provides greater flexibility and allows the auction, instead of the auctioneer, to determine the optimal allocation of spectrum. It could create competition, even if only existing operators participate in the auction.

However, small lot sizes may create unnecessary fragmentation and introduce aggregation risks, depending on the format. A format like the CCA addresses these concerns by allowing package bidding.

During the preparation phase of the spectrum awards, Member States will assess the market demand and technological developments to determine the optimal lot size. Given current technologies and foreseeable future developments lot sizes will tend towards blocks of 5MHz, 10MHz, 20MHz, or in the future maybe even larger blocks.

During the preparation phase of the spectrum awards, Member States will assess the market demand on various spectrum bands which could be made available from amongst the

available harmonized spectrum described earlier in this report. The trend in the mobile industry, among other issues, will be assessed. In particular, the availability of mobile equipment over the years following the awards and availability of mobile equipment to use certain type of blocks: 5MHz, 10MHz, 20MHz, etc. in accordance with harmonized spectrum conditions.

- **Multiple bands**

In addition to deciding whether to split the spectrum in a given frequency band into lot categories, the Member State also needs to decide whether to cover multiple frequency bands in the same auction. The available harmonised spectrum at the time of the auction (new harmonised spectrum, harmonised spectrum on which current authorisations will expire – see ECO report 03)²⁹ and the relevant market demands for various bands should be carefully assessed.

Including multiple bands in the same auction allows bidders to express a relative preference for the spectrum in the different bands, facilitating more efficient network investment. Bidders may in particular wish to win spectrum in one band only if they can also acquire spectrum in another band. By awarding the bands at different points in time, bidders who have this type of preference may be at risk of acquiring spectrum in one band, but not the other. In addition, bidders may be indifferent as to whether they win spectrum in one band or the other, in which case they would prefer to acquire spectrum in the cheapest band. If the two bands are not made available simultaneously, the bidder will not know whether spectrum in the first band to be made available will be the cheaper or more expensive than spectrum in the subsequent band.

However covering multiple bands may cause a delay in the availability of one or more frequency bands. Alternatively, it may result in making a frequency band available too early, before bidders understand its true value, or making the award more complex for bidders. Larger quantities of spectrum in the same auction may also pose competition challenges, which may be mitigated by spectrum caps. Finally, it may cause problems to budget-constrained bidders.

If many or all important bands are included in the same auction, there is a risk that the auction becomes not just about that spectrum but an auction about market access. It is also important to ensure a steady flow of spectrum to the market in order to respond to market developments or technological changes to ensure that innovation is not hindered.

- **Reserve prices**

Optimising reserve prices also plays an important role in the auction. Where they are set too low they may invite frivolous bidding which may cause an inefficient outcome, the participation of speculative bidders and undermine the overall policy objectives of the award. In addition, reserve prices set too low may increase incentives for collusion, whereby bidders artificially lower their bids in order to get spectrum cheaper. Some Member States have found that setting a realistic reserve price ensures timeliness of the auction process.

Reserve prices that are set too high will reduce the scope for price discovery in the auction. If prices are set at a level above true opportunity cost, they may result in unsold spectrum lots.

²⁹ ECO Report 03 - THE LICENSING OF 'MOBILE BANDS' IN CEPT – May 2011

- **Deposits / guarantees**

The use of deposits or bank guarantees is normal practice, but the examples and implementation are dependent on the legal framework in the Member State and what the circumstances are in the Member State and in the award design.

The primary purpose of deposits and guarantees is to avoid uncommitted bidding. If auction participants can bid without the risk of having to pay the amount bid, a rational strategy would be to bid whatever it takes to win and only afterwards decide whether to pay or not depending on price. Auctions may have difficulties ending and if the winning bidder can walk away from the auction with no penalty and the auction must be re-run. The credibility and efficiency of spectrum auctions could quickly fall if auctions are systematically sabotaged in this way.

The auctioneer should use deposits or bank guarantees which are triggered under the auction rules to pay for winning bids or parts of bids in the case of default by successful bidders, to deter from this strategy. Amounts should be as low as reasonable to encourage auction participation and minimise bidders' costs but high enough to deter 'false' bidding. There are views that bank guarantees might be more suited for large amounts (millions of EUR and upwards) to avoid actual transfer of large amounts between bidders and auctioneer (which means costs, risk of theft, need for careful administration and control). Deposits are easier and more straightforward for smaller amounts and smaller bidders who may find it difficult and expensive to get bank guarantees. Unused deposits are refunded after the auction and guarantees returned, when winning bids are paid in full.

Deposits or bank guarantees may very well be linked to bidding eligibility at the start of an auction, e.g. 1 MEUR secures eligibility for 1 lot, 10 MEUR secures eligibility for 10 lots.

- **Anti-collusion rules**

Preventing explicit or tacit collusion is important to ensure that all bidders have equal opportunities and to guarantee a competitive auction that leads to an efficient outcome which does justice to the value of the underlying spectrum. Preventing collusion during the auction is largely managed through rules pertaining to the information provided to bidders during the auction and possibly specific rules that sanction collusion. Collusion however, can also happen before the start of the auction. Whilst general competition law provides instruments to act in this case, specific rules to further prevent this from happening can also be used. For example, parties that have applied to participate in an auction could be prohibited from publicly stating their participation seeing as that kind of information might influence the decision of other parties to participate in the auction.

When considering specific anti-collusion rules, account should be taken of the possible unintended consequences that these rules can have. Rules that are very strict or too vague could lead bidders to be overly cautious, for instance, impacting regular operational meetings and procedures between mobile operators.

One can also legitimately ask whether applying anti-collusion rules has an added value over general competition law which already precludes companies from actions that prevent, restrict, or distort competition.

Whilst specific anti-collusion might be deemed necessary it is important to consider their possible unintended consequences, to formulate them as specifically as possible, and to ensure that the sanctions for violating these rules are in proportion to the offence.

5.7 Conclusions on auction formats

Based on the work of RSPG to date on evaluating auctions that have taken place over the last twenty years, there is “no one size fits all” when it comes to auction formats. All formats have advantages and disadvantages and need to be tailored to the specific circumstances of each market, each band or bands being auctioned and each award.

There have been developments and enhancements in the traditional forms of the spectrum auction formats listed above, introduced by some regulators. On one hand, these follow from the lessons learned and the experience gained while running auctions. On the other hand, there is a field of academic research that is providing further insights into how these formats work and the type and nature of the incentives they are likely to generate.

6. Promoting efficient use of spectrum, competition and coverage

This section focuses on the mechanisms that can be deployed in order to promote the efficient use of spectrum, competition and coverage. Typically such issues should be considered when designing any spectrum award as such mechanisms will often form an integral part of the award process (for example spectrum caps which could restrict the amount of spectrum for which an operator is able to bid). In other examples they may take the form of obligations which are imposed through a licence condition (for example a coverage obligation). In all cases it is essential that there is transparency about the mechanisms that will be used and the obligations that will be imposed as part of the award process. This ensures that operators are clear about the rules of the award and the commitments that they will be expected to meet if they are successful bidders in the award.

In most countries, spectrum is regarded as a public asset which the state should manage efficiently and effectively. The mechanisms which can be used, considered in this section as a toolbox to promote competition, coverage and the efficient use of spectrum are:

- Licence duration;
- Licence renewal;
- Spectrum fees;
- Mechanisms to enable spectrum re-farming;
- Revenues from awards;
- Technology and service neutrality;
- Spectrum caps and set asides;
- Coverage obligations;
- Wholesale access obligations;
- Standardisation;
- Spectrum trading and leasing; and
- Management of under-utilised spectrum.

6.1 Licence duration

Licence duration is important in that it provides licensees with the certainty that they require in order to have confidence to invest in the development and deployment of their network, and needs to be carefully assessed when defining the licence duration. In most Member States licences are awarded for a specific duration, usually around 15-20 years. While in some Member States this is a policy decision, in others, there are statutory requirements that limit the duration of usage.

In a few cases, the licence duration is not specified and a revocation notice may be issued after a set period of time.³⁰ For example, in the UK, Ofcom generally grants indefinite licences with a minimum period of notice for revocation (such as five years) for spectrum management reasons. In order to give the licensee certainty following the award that they will have at least a minimum period to recover their investment, Ofcom will offer assurances during the award that no such revocation notice will be issued for a certain period (e.g. not in the first 15 years).³¹

³⁰ For further details, please refer to ECO Report 03. <http://www.efis.dk/views2/report03.jsp>

³¹ In this example the licensee will then have a minimum duration of 20 years (15+5 years), with a 5 year notice period thereafter.

The nature of investment in mobile networks has evolved and changed over time as a result of the different characteristics of 2G, 3G and 4G networks. The RSPG considers it essential that licences are of sufficient duration, taking into account national circumstances, to provide legal certainty and the promotion of investment. Equally, however, care must be taken to ensure that spectrum is not sterilised; for example if the use for which the band has been harmonised does not materialise as expected, or changes over time or as a result of technical innovation or changes in consumer demand (such as 1900-1920MHz where rights have been granted 15 years ago).

6.2 Licence renewal

Expiry of licences is an issue in a number of European countries and different approaches have been used. This includes re-awarding the spectrum through a new award process such as auctions, thereby requiring the incumbent operators to bid to secure future access to the spectrum; or renewing existing licences in the hands of the incumbents.

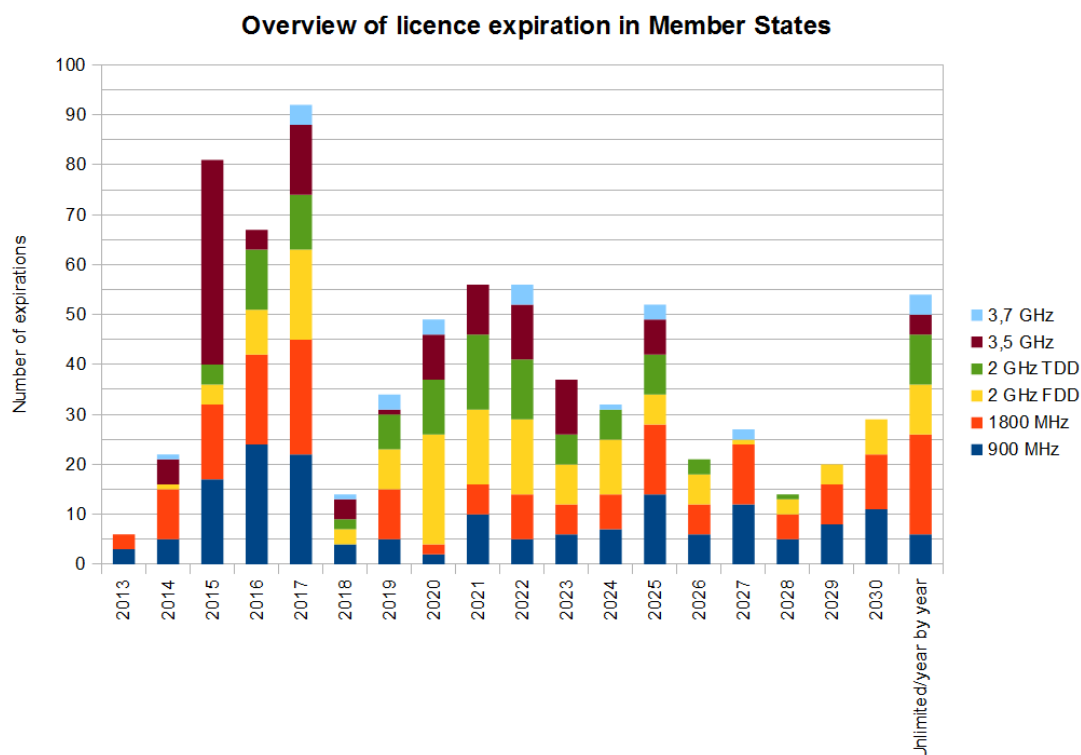
In many European countries, the spectrum currently harmonised for wireless broadband is based around the bands that were initially harmonised to support the introduction of 2G and 3G technologies, namely:

- 900/1800MHz (2G GSM) with initial authorisations granted in the 1990s with license durations typically of 15 or 20 years. Additionally, in some Member States, the 900MHz band has been subject to new authorisations in recent years
- the 2GHz FDD – paired bands (3G UMTS) with authorisations granted between 2000 and 2004 in a significant number of European countries (typically with license duration of 20 years).

It is worth noting that the bands have tended to be made available in a harmonised manner within a similar timescale. Moreover, many Member States have similar license durations. This is reported in ECO report 03 and RSPG noted that;

- for the 900/1800MHz bands there are two broad periods within which expiry falls in a number of Member States: 2015-2017 and 2025-2027;
- for the 2GHz bands a number of expiries fall within 2016-2017 or 2020-2022.

The same approach could apply for the 3.5 GHz bands where a number of authorisations were granted in two waves, 2000-2002 and 2005-2009. A more detailed analysis showing when particular licenses expire in Member States is set out in the table below (taken from ECO report 03).

Table 4 Expiry of current spectrum rights of use ³²

One could imagine a similar pattern emerging for further frequency bands which are harmonised in future given that availability will be guided to a large extent in many instances by the deadline for implementing the relevant EC Decision.

Based on lessons learned from recent years, RSPG noted that the timing of awards could be triggered, among others, by:

- a new EU harmonized frequency supply: EC Decision on harmonized technical conditions under Spectrum Decision; and/or the expiry of the current authorizations(see table above), where applicable.

A key question concerns the point prior to expiry at which the renewal process or new awards should take place. Typically in Europe such processes take place around a year or two prior to the expiry of licenses but there are many ways to handle timing for such an award or renewal depending on national circumstances. One observation identified by the RSPG is that the interests of different operators may vary according to when an award takes place. As a generalization, the RSPG has noted that incumbent operators may be more amenable to awards taking place well in advance of expiry of the incumbent licenses (more than two years in advance) whereas new entrants are more likely to prefer a shorter period between award and expiry.

Renewal of authorisations can also be used as a tool by the Member State to introduce competition (see French market case – renewal of 900MHz authorisations while making spectrum available for a new entrant – see section 6.6).

³² ECO Report 03. <http://www.efis.dk/views2/report03.jsp>

6.3 Revenues from awards as a policy objective

In some countries it is explicitly stated that an objective of a spectrum award is to ensure a reasonable return for the spectrum asset. In some cases this means that an objective of the award is to raise a certain level of revenues in return for the award of spectrum licences. In other countries, however, raising revenues is deliberately excluded as an objective of an award. The RSPG notes that both approaches are used in Europe and emphasises the importance of being transparent about award objectives and ensuring that the objectives of the award are appropriately balanced.

In some countries it is allowed for the auction fee to be paid in instalments rather than require that it to be paid up front in full. Alternatively the auction fee may be split so that part is paid up front while the remainder is paid in annual instalments. In Denmark, in 2012 and 2010 for example, 20% of the auction fee was paid up front with the remainder in instalments over the next eight years.

It seems reasonable to assume that in such a case, the government will add a market based interest rate to the annual instalments. Otherwise it might risk being accused of state-support as paying in instalments might be considered as borrowing from the state at relatively low interest rates (on government bonds). In this way the real present value of the auction fee will remain the same over time. Furthermore, it might be assumed that the government will seek a guarantee for the future payment of the remaining auction fee (e.g. in the form of a bank guarantee), to protect itself against cases where the bidder will cease business or go bankrupt. Also when licenses are traded directly or indirectly (through mergers and acquisitions) the obligation to pay the remaining instalments is transferred together with the aforementioned guarantees.

An effect to take into account is that the value of future payments is normally felt to be less of a burden than a similar payment that has to be paid immediately. The effect might be that the bid that an operator is willing to make with installed payments might tend to be higher than in the case of an upfront payment. Another effect that has been argued is that it could enable new entrants without relatively deep pockets to take part in auctions more easily.

6.4 Spectrum fees

Fees are one of the main tools that may be used by Member States to incentivise the efficient use of spectrum. However, in a number of countries, incentive based spectrum fees might be considered less relevant in relation to the harmonised bands, at least for the initial period for which licences are awarded following an auction. This is because the successful bidders will pay the amount that they have bid in the auction and, unless stipulated in the auction rules, will not expect to pay further fees for the initial duration of the licence. In this case, the amount paid in the auction acts as an incentive to deliver value from the spectrum acquired as the licensee will want to make a return on their investment.

However, while all Member States are keen to promote efficient use of spectrum following an award, there are some differences in the various approaches used.

A common approach within Europe for auction fees is a combination of up front and staged payments.³³ However there are other methods, for example in the UK, auctioned licences are indefinite in duration but come with a minimum period (typically 20 years). Auction fees are required to be paid upfront and no further fees are paid for the duration of the minimum licence period. At the end of the minimum period, annual licence fees based on opportunity cost may be imposed to incentivise continued efficient use of the spectrum and reflect the extended or rolling nature of the licence.

One of the concerns raised with incentive pricing is that it can be difficult to calculate the spectrum fee that should be imposed at the end of the minimum period. Some of these issues were considered in a previous RSPG/BEREC Report on the economic and social value of spectrum.³⁴

A further model used in some countries is to require the full auction fee to be paid up-front but additionally include an annual fee for the duration of the licence. The intention is that the annual licence fee will provide an ongoing incentive to use the spectrum efficiently and the bidders can be expected to factor in the annual licence fee when they value the spectrum in the auction process.

The RSPG notes that all these methods can work well. In all cases, however there are common principles that should be respected, including:

- Transparency over the level of any fees that will be charged over the licence period: bidders need to know what proportion of fees will be required to be paid up front and the extent of any annual fees;
- Certainty that fees will be paid (and a clear understanding of what will happen if they are not): this is particularly important where all or part of the auction fees, are proportioned over the duration of the licence; and
- Appropriate mechanisms in place to incentivise efficient use of the spectrum whilst avoiding undue burdens: this can be achieved through auction fees paid up front, annual licence fees or a combination of both.

Up-front versus ongoing fees

The RSPG notes that on-going fees will depress the upfront value of a licence, as bidders will take such payments into account when determining how much they will want to pay upfront for the licence. In addition, loosely specified, variable on-going fees may cause or accentuate uncertainty about the overall value of lots, which could further depress the amount that bidders are willing to pay for spectrum usage rights. There may also be a concern that bidders could seek to change the terms of future commitments made at the time of the award. Furthermore, this could have the unintended consequence of distorting the auction process itself.

However, on-going fees could also boost demand by reducing the need for an upfront payment, especially if they are well specified in advance of the auction. For example:

³³ See Report RSPG BEREC Report on Economic and Social Value of Spectrum, February 2012 <http://rspg-spectrum.eu/rspg-opinions-main-deliverables/>

³⁴ See Report RSPG BEREC Report on Economic and Social Value of Spectrum, February 2012 <http://rspg-spectrum.eu/rspg-opinions-main-deliverables/>

- being able to defer part of the payment for licences may be valuable to bidders with a limited upfront budget, as reducing upfront payment needs may strengthen their position relative to competitors with a higher upfront budget (but who could possibly place a lower overall value on some of the lots offered); and
- In addition, on-going fees may lower the financial exposure for bidders who are uncertain about the value of lots; as such bidders could avoid the burden of any remaining on-going payments by returning the spectrum they acquired at a later date if it fails to achieve the value they expected.

6.5 Various mechanisms to re-farm spectrum for ECS

The mechanisms for re-farming differ from country to country: re-farming fund, etc. and also from the context or the band to be addressed and the incumbent. These re-farming issues encompass various aspects such as: legal, financial, policy, social and economic including the efficient use of spectrum. They should be addressed at national level on a case-by-case basis taking into account the various national contexts and legal mechanisms in force to clear spectrum where and when appropriate.

Re-farming mechanisms may be valuable when combined with change of use, thereby enabling licensees that may not be using existing spectrum in an optimal way to obtain greater value by making the spectrum available to another user for an alternative (better) use.

The RSPG has previously addressed re-farming in the context of liberalisation of spectrum use in the RSPG report on value of spectrum.³⁵

³⁵ See Report RSPG BEREC Report on Economic and Social Value of Spectrum, February 2012 <http://rspg-spectrum.eu/rspg-opinions-main-deliverables/> - See Section 5

In the RSPG Opinion on UHF spectrum the RSPG notes that the scope and mechanism of any possible compensation in relation to the UHF band is a national issue and recommends that the Commission should provide early guidance to Member States on any compatibility issues with state aid rules.³⁶

RSPG has noted the planned incentive auction of 600 MHz spectrum in the US. This will be a two sided auction where, on the one side, broadcasters will signal how much money they would want to vacate spectrum and, on the other side, mobile operators will bid to determine how much they would be prepared to pay for access to the spectrum. Where the two meet there is potential for a deal, (win-win situation for either side) although in reality the whole process will be complex and any release of spectrum will likely require repeatedly restacking of broadcast channels across the country during different stages in the auction.

The RSPG is watching developments on this incentive auction process in the US. The process was launched at the end of 2012 and is still ongoing. In addition, the RSPG notes that there are some considerable differences between spectrum management approaches in the US as compared within the EU, not least in relation to broadcast planning, authorisation, market structures and the national broadcasting sector. At the moment, the RSPG does not consider that the incentive auction approach being developed in the US with respect to the 600 MHz band could be directly applied within Europe, although RSPG will continue to monitor these developments.

6.6 Implementing technology and service neutrality

Technology and service neutrality (T&SN) aims to give spectrum users greatest flexibility over how they use the spectrum that they hold including over the technology they deploy. This is important as the users of spectrum need to respond rapidly to consumer demands, for example because they want to innovate and are willing to take risks. Technology and service neutrality can therefore help to deliver benefits to European citizens and consumers.

The implementation of T&SN in the mobile bands has enabled the mobile operators to choose the best technologies and services to meet the needs of consumers. In practice, Mobile operators will make some trade-off between legacy systems (i.e. GSM in 900MHz and 1800MHz, UMTS in 2GHz) and new systems (LTE) having better performance according to number of criteria (OPEX, CAPEX, revenue from legacy, potential revenue from new systems, competitive advantage, etc.)³⁷. The European landscape of the harmonized spectrum bands (800MHz, 900MHz, 1800MHz, 2.1GHz, 2.6GHz) offers opportunities for economies of scale leaving mobile operators to choose the best mobile technology according to their own strategic objectives.

In Europe, technology and service neutrality is defined in Articles 9(3) and 9(4) of the Framework Directive and has been set out in the RSPG Opinion on WAPECS (RSPG 05-102) which identified initial frequency bands where the principle applied. More recently the principle has been extended to further bands through the relevant RSPG Opinion on Wireless Broadband.

Technological and service neutrality as defined in the Framework Directive

³⁶ RSPG Draft Opinion on the long term strategy on the future use of the UHF Band - RSPG14-585(rev1) – Nov 2014

³⁷ see ECO report O3 on various systems implemented in various frequency bands

In practice, harmonised technical conditions developed under the European Spectrum Decision framework are consistent with the principles of technology and service neutrality as defined in the Framework Directive. The European Commission grants mandates to CEPT to define “least restrictive” technical conditions which form the technical basis for mandatory EC Decisions. A key component of this harmonised technical condition is the harmonised band plan.

The relevant provisions in the Framework Directive aim at ensuring that the Member State/NRA neither imposes nor discriminates in favour of the use of a particular type of technology or service. It takes into consideration the possibility to impose restrictions on the type of technology used in ECS networks in order to avoid interference or ensure technical quality of service. It also takes into consideration the possibility to impose restrictions on the type of service that may be deployed, in order to avoid the inefficient use of radio frequencies.

The application of technology and service neutrality is in practice limited by technical and usage restrictions that are required in order to prevent harmful interference. Moreover, giving greater flexibility to spectrum users over how they use spectrum can make the interference environment more complex and less predictable with regard to adjacent band compatibility. It may be necessary to keep technical conditions under review to respond to technical evolution. Nonetheless the RSPG considers that restrictions should be kept to the minimum necessary, so that the spectrum user has maximum flexibility to decide the services that they wish to provide.

National implementation of technological and service neutrality

The RSPG has sent a questionnaire to the Member States in order to gather information on the implementation of technology and service neutrality. This found that all Member States have implemented, in their national legislative and regulatory framework, the principle of neutrality in terms of technology and services for mobile broadband licenses in the harmonised bands.

2G licenses at 900MHz and 1800MHz

Some countries (Austria, Denmark, Finland, Hungary, Ireland, Luxembourg and Malta) had 2G licenses (900MHz and 1800MHz) expiring during the period 2011-2019. They have or are taking advantage of the expiry of these licenses to re-farm the corresponding frequency bands (creation of contiguous blocks) and allow the "neutral" use in these bands (actually limited by European standard technical conditions to GSM, UMTS, LTE and WiMAX). This re-farming was in some cases driven by the introduction of a new player in the mobile market.

Some countries, such as Ireland and Austria, have used the expiry of the existing 2G licenses to organize a combined auction process grouping the bands 900MHz and 1800MHz, which have been re-farmed, with the 800MHz band that was not yet assigned. In Austria the 900MHz and 180 MHz spectrum was re-farmed for “neutral” use for the remaining period (2015 – 2019) right after the auction.

Slovenia conducted a simultaneous license award on all harmonized frequency bands, except for the band 3.4 to 3.8GHz.

In France, the 900MHz band was opened in 2008 for the 3G operation on the request of the three MNOs. As set out in their licences they had to free some frequency for a fourth MNO. As of today, no request has been received to apply T&SN in this band. The 1800MHz band has been partially neutralized in 2013 following a request by an MNO. The NRA has defined a methodology for the implementation of T&SN in this band which will be followed by a spectrum release from all historical 1800MHz licensees after a T&SN request. On this basis, the NRA had neutralized mid-2015 the other 1800MHz band licensees and attributed the released spectrum to a fourth MNO which will be effective by the 25th May 2016 deadline. They still have the possibility to ask at any time for early lifting of technological restrictions in the 1800MHz band, if they want to use 4G in this band prior to the that date.

Mobile broadband

Some Member States (Bulgaria, Cyprus, Latvia, Slovakia, and Romania), which have not yet assigned the 800MHz and 2.6GHz bands have upgraded existing MNO licenses to respect the principles of T&SN. Malta, after a public consultation on the introduction of neutrality in the 2.1GHz band, has not identified competition issues and has amended existing licenses accordingly.

Finland has amended its regulations from January 1, 2015 so that the all ECS frequency bands are technologically neutral. A number of other countries (Hungary, Lithuania, and Spain) have not yet studied the question of neutrality for existing licenses in the 2.1GHz band. Some are waiting for a corresponding market demand. In Austria the 2.1GHz band has been liberalised.

For the 3G band, the NRA in France (ARCEP) has launched a consultation at the end of 2014 which will be aiming to define the methodology to pursue.

6.7 Promoting competition: spectrum caps and set asides

In order to promote competition, spectrum managers will often consider spectrum caps as one of the rules of a spectrum award. This was one of the issues considered in the RSPG BEREC Report 10-351 on Competition Issues in the Mobile Sector.³⁸ Spectrum caps limit the amount of spectrum that an individual operator is able to acquire in an award, therefore ensuring that competition is not distorted by the spectrum holdings of a single operator. Spectrum caps, or set asides, can also help to promote new entrants by limiting the spectrum available to incumbents.

Spectrum caps are often set to limit the total amount of spectrum that an individual operator may hold, but they may additionally be used to limit the amount of spectrum that an operator may hold within a particular range (such as below 1 GHz).

The RSPG notes the importance of ensuring that any spectrum caps are set at the right level; too stringent and an operator may be prevented from offering services that will benefit consumers, not stringent enough and competition may be distorted.

Another competition measure that may be implemented is spectrum reservation, whereby the Member State makes some part of the spectrum available only to particular bidders (usually new entrants or smaller players). One way of implementing spectrum reservation is

³⁸ See http://rspg-spectrum.eu/wp-content/uploads/2013/05/rspg10_351_transitional_issues.pdf

to set a particular type and amount of spectrum aside and only allow particular categories of bidders to bid for it.

When setting aside spectrum, it is important to ensure that the type and amount of spectrum reserved is optimum. For instance, it may be that there was another type of spectrum that if reserved would still allow the Member State to meet its objective – say, to promote entry in the market – but result in a lower opportunity cost for the other players. In the UK's 800MHz / 2.6GHz award, an innovative way of implementing spectrum reservation was used, whereby market information generated by the auction itself was used to decide the specific spectrum to be reserved.³⁹

Spectrum caps, floors, and set-asides influence the incentives for bidders, in terms of their bidding strategies. When designing an auction the effects of these measures should be taken into account.

The RSPG notes that spectrum caps and reservations should reflect the identified objectives of an award based on a market assessment in order to be consistent with competition law.

6.8 Coverage obligations

Another feature common to a number of recent awards was the inclusion of coverage (population or geographic) or roll-out obligations to fit with national policy objectives. These national policy objectives address specific issues which differ between Member States: infrastructure competition, rural coverage, density of population, etc. Such obligations are used by Member States to ensure that licensees are required to build out their network to meet certain pre-defined criteria. This can be particularly important to ensure that networks are rolled out to rural and less populated areas where there are likely to be fewer economic incentives than in more populated urban areas. Broadband coverage was the topic of a previous Report published by RSPG in November 2011.⁴⁰

The RSPG considers that coverage or roll-out obligations at national level can be an important tool to promote broadband access, especially in rural and less economically attractive parts of the country. The RSPG notes that where such obligations are imposed they should be appropriate to achieve the identified policy objective. The RSPG considers that coverage obligations are best developed at national level where they can be aligned with national policy and priorities.

An important aspect relating to coverage obligations relates to their inclusion in licenses and conditions relating to monitoring and enforcement. In particular, Member States must ensure that they have appropriate mechanisms to accurately measure coverage and clear enforcement processes in place which can be applied if coverage obligations are not met.

6.9 Wholesale access obligation and national roaming requirements

Requiring a network operator to provide wholesale access can be a way of promoting retail competition. However, in order to impose such an obligation a thorough competition analysis should be conducted. It is extremely important that the objectives of any wholesale access obligation are made clear, including to promote new entrants.

³⁹ <http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/800mhz-2.6ghz/>

⁴⁰ See http://rspg-spectrum.eu/wp-content/uploads/2013/05/rspg11_393_report_imp_broad_cov.pdf

A specific variant of wholesale access obligations is to require network operators to provide access to their networks or spectrum in rural areas. Rather than having the aim to promote competition (which is the traditional aim of wholesale access obligations), the aim of such measures in rural areas is to promote coverage. This could be, for example, through:

- national roaming which is a requirement in a Member State under which a network operator may be required to offer access to other network operators that have not built out in a particular area in order to extend their coverage. In France, an operator without sufficient lower frequencies has obtained, after the 800MHz /2.6GHz awards, a roaming access to the 800MHz network in the “priority rollout zone”⁴¹; and
- at a local level, the operators could benefit from mutual and reciprocal roaming access to a network deployed by a unique MNO in an area identified by a national policy where it is necessary to have cost efficient investment (programme zone blanche in France for example).

Such obligations can be contentious. While there are clear potential benefits of extending coverage for those networks that have not built out to some areas, other factors also need to be taken into account, not least impact on competition and investment. In particular, if a network operator knows that it is likely to be required to open up access to its network in a sparsely populated area, it may be less likely to build out in that area in the first place. Furthermore, an effective access obligation might require regulating many detailed parameters such as prices and technical conditions and could result in heavy regulation.

6.10 Standardisation

Interaction between Regulation and Standardisation

Spectrum harmonisation developed by administrations in close cooperation with industry (see EC Decision developed on the basis on CEPT reports in response to EC mandates under the Spectrum Decision) and standardisation (ETSI, CENELEC) provides legal certainties for investment in Europe.

An RSPG Report on Interference Management, following a corresponding RSPG Opinion on Streamlining the Regulatory Environment, describes the relationship between the harmonisation and standardisation process.⁴² Member States are involved in the drafting of Harmonised Standards through ETSI in response to requests made by the Commission for the application of harmonised legislation in the European Union. The regime in force in Europe to put radio equipment on the market is based on a declaration of conformity and does not include either type approval or registration of equipment. This unique framework at world-wide level supports innovation and reduces barriers for industry to access to the European market. Spectrum harmonization at European level could also trigger standardisation.

Moreover, it may also be beneficial for the wider market if the planning of spectrum awards bears in mind the global context of electronic communications services and the value chain

⁴¹ Operators were placed under specific obligations to roll out in pre-defined areas by specific deadlines

⁴² See RSPG 13-527 rev 1 at <http://rspg-spectrum.eu/rspg-opinions-main-deliverables/> and http://rspg-spectrum.eu/wp-content/uploads/2013/05/rspg08246_finalopinion_streamlining.pdf

supporting it as Europe competes globally for the investment that supports innovation in the communications industry.

Improving the usage of spectrum and addressing receiver parameters

It is important to ensure that spectrum users are incentivised /required to update to new technologies which may be more spectrally efficient than previous technologies, thereby promoting efficient use of spectrum.

One area where this is particular important is in relation to receivers. There have been cases over recent years where poor quality receivers have hindered the re-farming and better use of spectrum, either in band or in an adjacent band.

The RSPG welcomes the Radio Equipment Directive which explicitly covers receivers. The RSPG notes that receiver parameters should be included in harmonised and product standards for all equipment. Administrations should encourage the development of good performance receiver specifications and inclusion of appropriate essential requirements and test specifications into harmonised standards.⁴³

The introduction of wideband mobile systems (LTE) reveals coexistence issues with systems in adjacent bands due to low level of receiver performance (see LTE/SRD at 863MHz for example).

With better selectivity features and improved strong signal handling, radio receiver equipment is better protected from emissions of services in adjacent bands. In fact, the immediate impact could be the reduction of guard bands between services. It should be noted, however, that requiring better receiver performance can imply additional cost.

RSPG therefore supports the promotion of adequate receiver performance and recognizes that relevant radio receiver parameters become increasingly necessary to facilitate the introduction of new systems, to extend sharing opportunities and to ensure efficient use of spectrum.

6.11 Trading and leasing of spectrum rights

Under Article 6(8) of the RSPG, Member States are required to allow transfer or leasing of rights of spectrum in the harmonised bands.

In practise, the majority of cases of trading of spectrum rights of use in the harmonised bands in Europe are identified when regional/local regional authorisations are in force (for example 3.5GHz regional licence in France) or in the case of a merger between mobile operators. This is likely to be subject to the analysis of the NRA and competition authorities.

Spectrum trading and spectrum leasing of usage rights should help to facilitate efficient use of spectrum in the harmonised bands by enabling rights to move into the hands of the user that will make best use of it. In practice, however, take-up of trading of spectrum usage rights across Europe has been mixed, with many countries only experiencing limited trades although a few, such as Sweden, have seen a significant number of trades in the harmonised bands. Examples of trades which have been undertaken in Europe include:

⁴³ Directive 2014/53 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5

- In the UK Everything Everywhere traded 2 × 15MHz of 1800MHz to H3G in the UK as a consequence of the merger between T-Mobile and Orange and the competition assessment; and more recently chipmaker Qualcomm announced that has traded the 1452 – 1492MHz band for use as Supplemental Downlink (SDL) to Vodafone and H3G.
- In France, trades have occurred in the 3.5GHz band (see RSPG Position Paper Wireless Broadband 2009) where regional rights of use were traded in this band. One stakeholder achieved a national spectrum “footprint” through this approach.
- In Sweden all spectrum licenses can in principle be traded or leased, subject to approval of the regulator (analysing e.g. effects on competition). In harmonised ECS-bands there have been trades of e.g.:
 - 50MHz of 2.6GHz TDD-block from Intel Capital to H3G.
 - 2 × 25MHz of 1800MHz-spectrum, 2 × 40MHz of 2.6GHz FDD-spectrum, 2 × 6MHz of 900MHz-spectrum from Tele2 and Telenor to their jointly owned company Net4Mobility. This is also an example of spectrum pooling and network sharing.
 - Application for trade of 2 × 15MHz of 2.1GHz spectrum from Orange to TeliaSonera. Application denied by regulator since TeliaSonera already owned 50% share of SUNAB, another 3G-licensee in the band acquired from Tele2.
- In Austria, several regional spectrum usage rights were sold in the 3.5GHz band between 2007 and 2013. In the 450MHz band 2 × 2.5MHz was transferred between two operators in 2014. Also in 2014 TMA sold 2 × 1MHz of 900MHz to H3G. Furthermore, several trades occurred in connection with a merger. For example H3A traded 900MHz, 2.1GHz and 2.6GHz spectrum to A1 in the course of the merger between H3G and Orange in 2012; While T-Mobile sold 2.1GHz to H3G and One in course of the merger between T-Mobile and Tele.ring.
- In Norway spectrum trades have occurred in the 2.6GHz band (paired spectrum) and the 2GHz band (unpaired spectrum) in 2008, 2009, 2011 and 2015. Furthermore, there was a trade of a 900MHz licence in 2008.

The RSPG notes that spectrum trading and leasing of spectrum usage rights can, in theory, help to mitigate any inefficiencies arising from a spectrum award, for example if an auction or beauty contest does not result, for whatever reason, in the optimal distribution of spectrum between the bidders. It can also enable redistribution of spectrum usage rights over time, for example to respond to changes in demand or changing consumer needs. Allowing the market to work in this way can have advantages over direct regulatory intervention as the latter can raise legal concerns and be very slow and highly contentious if the Member State seeks to intervene to vary the distribution of spectrum between licensees. Nonetheless, the RSPG notes that take-up of spectrum trading varies between countries and that in most countries overall volumes of trades in the mobile bands remains low.

There are a number of potential reasons for limited take up of trading and leasing in the harmonised bands including:

- Narrow market structure (few MNOs): few operators in few bands may result in mobile operators being reluctant to trade usage rights to one of their competitors

given the impact it may have on the competitive landscape (possibly to their own detriment);

- Size of market;
- Spectrum is a valuable asset: operators may not be incentivised to transfer spectrum because it represents a strategic asset for them. At its worst this may lead to hoarding strategies and consequent rises in transaction costs; and
- In some cases and some countries the supply of spectrum is starting to outstrip demand and therefore the need for trading is limited.

The RSPG considers that further work may be undertaken to understand reasons for the differing levels of trading of spectrum rights of use of ECS across Member States. Even though secondary market does not represent an objective by itself, it can be a tool that contributes to a better spectrum management. In the meantime, it is clear that spectrum managers will also have to look at other mechanisms to promote efficient use of spectrum in the harmonised bands. As more service and technologically neutral spectrum becomes available and as the market responds to more users with different interests and business models we may start to see increased likelihood of trading of spectrum rights of use of ECS.

6.12 Management of under-utilised harmonised spectrum

Spectrum harmonisation brings many potential benefits including; economies of scale in equipment manufacturing leading to competitive services and prices being available for consumers; greater technical efficiency; and international mobility. However, these benefits should be measured against the loss of flexibility that harmonisation can introduce and the constraints placed on the way in which that spectrum may be used, therefore potentially foreclosing activities that could yield greater economic benefit and possibly leading to under-utilisation of spectrum if the envisaged demand does not materialise.

The issue of under-utilisation of harmonised spectrum has been previously addressed by the RSPG, in the Report on Improving Broadband Coverage (2011) and in the Opinion on Wireless Broadband (2012).⁴⁴ The 2011 Report concluded there were several possible reasons why spectrum might not be fully exploited. The two predominant reasons that are often cited are lack of demand (for various reasons) and regulatory conditions. The RSPG is also considering the issue in its work on a future review of the Radio Spectrum Policy Programme (RSPP).

There are already examples where, in some Member States, spectrum harmonised for ECS is already underused due to lack of demand. This could be because the needs of the national market do not support the requirement for the whole bandwidth or potentially because similar services are already provided over another platform (e.g. wired) where coverage is near universal and the need for further spectrum for this service is unnecessary.

Addressing under-utilised spectrum

An important element in ensuring spectrum is not under-utilised is the role of the National Regulatory Authority. Many of the mechanisms identified earlier in this Section can be expected to help in this regard. In addition to these, two further mechanisms that could be

⁴⁴ See RSPG11-393 Final - 16 November 2011 and RSPG13-522 – 30th May 2013

considered are sunset clauses and 'use it or lose it obligations' (UIOLI). These are considered below.

Review mechanisms; sunset clauses/limited duration clauses

Clauses such as a sunset or a limited duration clause are measures within a regulation or law that provides that the law shall cease to have effect after a specific date or be subject to review on its continued effectiveness. It could be argued that such clauses may provide the means by which to ensure that harmonised technical conditions, in what is a fast developing market, do not inadvertently stifle technological or regulatory advances.

In the context of Electronic Communication Networks (ECNs) and Electronic Communication Services (ECSs), EC Decisions developed under the Radio Spectrum Decision do not generally have such clauses. Nevertheless EC Decisions may contain a form of review mechanisms, although these do generally contain a date specifying the review point.

There are generally two forms of clause: one where there is an automatic expiration of a regulation after a certain period; and another where there is an assessment of the suitability of a regulation at a certain point in time. There are advantages and disadvantages to the application of such clauses.

Advantages:

- Provide the possibility of addressing inadequate regulation, or overly restrictive regulation (this may be useful when a regulation has not adhered to the principles of technology or service neutrality);
- Compels the Commission and/or NRAs to regularly undertake a review of the effectiveness of Decisions at particular points in time;
- Ensures that regulatory instruments are proportionate and appropriate for the policy problem they are there to address and that the industry is not confronted with multiple pieces of legislation, some of which may be out of date; and
- Apply pressure to rights holders to use the spectrum, in the knowledge that if the spectrum remains unused at the point of review, there may be calls to consider the validity of the regulatory measure.

Disadvantages:

- An outright sunset clause may give rise to the concern for some users that there is less security of tenure for their spectrum use. Unless it goes hand-in-hand with adequate license durations and clear information regarding what happens at point of renewal, sunset clauses could create uncertainty for the rights holder. For example, if an EC Decision automatically expired after a period of time, there may be a risk that the Commission/Member States deem that spectrum suitable/required for another use.

In this context, a date specified review of an EC Decision addressing harmonised technical conditions seems a useful tool in order to assess the need to maintain, amend or withdraw those technical conditions.

Role of UIOLI obligations on assigned spectrum

Pursuant to Article 9 (7) of the Framework Directive, Member States may lay down rules in order to prevent spectrum hoarding, including measures to withdraw rights of use. Moreover, they shall also ensure that competition is not distorted by any accumulation of rights (see Article 5 (6) of the Authorisation Directive).

The EU framework is built upon the principles of technology and service neutrality⁴⁵ and market mechanisms which contribute to more efficient usage. A central tenant of this framework is that there is a commercial interest in, and value for, spectrum and that the market is best placed to secure the optimal use of the spectrum, bearing in mind that the spectrum rights of use could be granted, in particular, in accordance with national policy objectives.

RSPG would expect that where spectrum has value, it will generally be used or the spectrum right of use could be traded, under national conditions and that spectrum will not be left idle or be under-utilised for long periods of time if it is commercially inefficient to do so. However, RSPG recognises that there are legitimate circumstances in which it can be appropriate for spectrum to be left idle or be under-utilised, such as the following examples:

- The capacity or the economic interests of the license holder can sometimes be impeded by external factors, which were difficult to anticipate either by the licensee or by the administration at the time of the initial spectrum award. It can be the case when the take-up for the use of a given band, at regional/global levels, is slower than expected (an example could be found in the MSS or WiMAX experience) or non-existent (such as in the case of expected solutions for of Mobile TV); and
- Furthermore, not all amassing of spectrum rights will be anticompetitive in its intent or effect. There may be perfectly legitimate reasons for holding but not using spectrum at a given point in time. The acquisition of spectrum rights of use well in advance of network deployment, may form a logical and integral part of a commercial strategy, for example to meet future projected growth in demand, particularly given that spectrum awards or auctions do not happen that frequently. A potential spectrum user may wish to secure the resources for the future growth of a business while not knowing when the next opportunity to acquire spectrum may be. If that potential user knows (or thinks) it may have a use for that spectrum, albeit not immediately, it may take the decisions to try to acquire the spectrum via auction and then leave it unused until the demand or technology develops. This is a legitimate business decision based on securing the resources for the future growth of a business. This makes the identification of anti-competitive hoarding difficult. Nonetheless where anti-competitive hoarding is thought to be present, ex-ante competition measures can be used to remedy it.

'Use it or lose it' (UIOLI) obligations are aimed at addressing the specific risk of spectrum rights holders anti-competitively and speculatively hoarding or otherwise inefficiently using

⁴⁵ See the EU Framework Directive and the RSPP

spectrum. UIOLI, as a solution, could be an appropriate tool to redistribute spectrum in a flexible and swift way, depending on the circumstances, to support the most efficient use of spectrum by all users. Such clauses, may, in certain circumstances represent a “safety net” to tackle the potential cases of detrimental under-utilization of spectrum when Member States have utilised other, more commonly used regulatory interventions that normally, when used effectively lead to the optimisation of spectrum use (such as incentive pricing, ex-ante competition measures for anti-competitive hoardings).

A pre-requisite of this regulatory approach is an effective means of defining and detecting inefficient use.

It should be noted that any UIOLI provisions should be implemented and monitored by the NRA in a proportionate way, in order to prevent some risks that should be carefully assessed, such as:

- rather than correct, they may foster inefficient use by encouraging the spectrum rights holder to put the spectrum to just any use;
 - rather than be obliged to hand it back;
 - trading the spectrum right of use on the secondary market (which may constitute a barrier to efficient trading); and
- Requiring use of spectrum through UIOLI clauses may impact the interest of stakeholders in the award process if they undermine any longer term use or value the spectrum holder may anticipate.

7. What role for sharing / pooling between MNOs in awards?

7.1 Sharing

The finite nature of spectrum supply means that the likelihood of opportunities for large scale clearance programmes bringing new spectrum to the market may be decreasing at the same time as demand for spectrum for new and innovative applications and services is increasing.

This challenge of meeting the potential gap between supply and demand will have to be met, at least to some extent, by sharing, with new developments in co-existence and sharing increasingly becoming the norm. The challenge in a constrained environment will be how to marry up the desire for certainty of tenure by uses and users, the need for new modalities in sharing which may include increasingly less exclusive tenure and the need for consistent technical approaches to harmonisation in order to ensure economies of scale for both industry and consumers.

Additional drivers for sharing will include seeking to increase coverage either by population or geographic area, delivering faster and deeper coverage for consumers and the reduction of costs associated with setting up a network by sharing facilities between one or more operators.

RSPG has previously characterised spectrum sharing as the simultaneous usage of a specific radio frequency band in a specific geographical area by a number of independent entities, leveraged through mechanisms other than traditional multiple and random-access techniques.

Benefits of sharing between MNOs

Potential benefits of spectrum or network sharing can include:

- Spectrum sharing between MNOs and enhanced frequency re-use might allow the spectrum users to deliver larger channels, and thus better bitrates to mobile users;
- Network sharing may materially reduce network costs for operators which may encourage faster rollout, increased coverage, particularly in previously underserved areas (by geographic or population metric) and lower prices for consumers;
- Deliver faster and deeper coverage for consumers;
- Promotion of more efficient investment. In areas where sharing spectrum can deliver the required quality and speed, costs previously devoted to coverage issue can be refocused as investment in network densification where it is required;
- Ensuring supply / liquidity / consistency of supply and conditions of supply and use which is needed to meet the needs of provision of low cost, local and wide area internet access; and
- Dependent on the type of sharing model, the competitive situation on the market and the regulatory framework sharing might lower market entry barriers for new players as it lowers the costs that are sunk.

7.2 Taking sharing between MNOs into account in award design – competition assessment

From a regulatory perspective, the sharing of aspects of a mobile network, whether infrastructure or spectrum, is largely a competition issue and as such there are a set of identifiable parameters against which an assessment of potential competition effects can be consistently made and against which appropriate remedies can be addressed, either as part of the award process or subsequently.

The current primary measure for such assessments is the European Commission Guidelines on horizontal cooperation agreements.⁴⁶ In considering issues of spectrum sharing or pooling in relation to an award, Member States will need to undertake some form of competition assessment of how that sharing will have an impact on the value chain.

Decisions about whether and how to include spectrum sharing modalities in the award programme should be considered at the outset of the award design. In particular, at the point at which the award objectives are being considered and established, so as to identify and address those policy objectives which, absent appropriate regulatory intervention during the design of the award, may not be delivered. These are likely to remain specific to the frequency to be used and the service to be offered, and combined with policy objectives, including efficient use of spectrum that the Member State is seeking to achieve.

In the context of sharing, the most obvious policy considerations would include coverage (population or geographic), rollout, particularly capacity and quality, efficient spectrum utilisation and technical feasibility.

7.3 Recent examples

In Sweden, a licence condition in the Swedish 3G-licences was that a certain percentage of mobile sites could be shared between licensees. The incumbent TeliaSonera did not win a license but acquired a 50% share of the Tele2-owned licensee SUNAB. The licensees Telenor and HI3G formed the jointly owned (50/50%) company 3GIS to roll-out rural 3G coverage. The Swedish regulators experience 15 years later is that these joint ventures have not had negative effects on competition (still at the lower end of consumer prices in Europe) but definite positive effects on rural coverage and access.

Also in Sweden Tele2 and Telenor formed the jointly owned (50/50%) company Net4Mobility to roll-out a combined GSM/LTE-network. Net4Mobility bought some of their spectrum directly in auctions of 800 MHz (2 × 10MHz) and 1800MHz (2 × 10MHz). In several applications for trading Tele2 and Telenor have sold spectrum in 1800MHz (2 × 25MHz), 2.6GHz (2 × 40MHz) and 900MHz bands (2 × 6MHz) which have been approved by Swedish regulator. Net4Mobility will have a strong position in spectrum holdings (approx. 46 % of available harmonised ECS-spectrum under 3GHz). Tele2 and Telenor have stated the intention to continue competing in the end-consumer market, which could mitigate negative effects on competition.

The Swedish regulator did a competition assessment similar to that which the competition authorities would have had to do if Tele2 and Telenor had decided to merge. Since Tele2 and Telenor are the second and third largest MNOs in the Swedish market after TeliaSonera, the joint venture had the advantage of strengthening the competition between the largest and second largest competitors in the market. There is also reason to believe there can be an increased focus on rural coverage as a competitive advantage, when the second and third operators increase their economies of scale. Earlier TeliaSonera had been a clear market leader in rural coverage. The assessment is of course specific for the competitive situation at a certain moment in time, but if competitive problems or distortions should arise there are tools to address this: e.g. spectrum caps/exclusion in future awards, competitive analysis of future trading, SMP-analysis of mobile origination.

⁴⁶ Guidelines on the applicability of Article 101 to horizontal cooperation agreements (2011/C1/01). Official Journal C11/1 14/1/2011

As an example of frequency re-use, in Finland the mandatory co-ordination distance for frequency re-use between geographically adjacent service areas has been minimised and in some cases completely removed in the 3.5GHz frequency band, through voluntary agreements between license holders. The holders of the same frequency block have agreed on co-existence in the coordination area. These agreements have maximised the cumulative service area and contributed to an improved broadband coverage. However, this is not legally possible in some member states.

7.4 Competition issues

Possible effects on competition should be evaluated on whether any form of sharing has an impact on competition in the relevant wholesale and retail access markets.⁴⁷

Most of the potential negative effects from spectrum sharing arrangements can be categorised as competition issues and should be subject to the same rigorous competition assessment applied to the rest of the auction process.⁴⁸ Some of the potential considerations that Member State could take into account as part of their assessment on possible distortion or restriction of competition by sharing could include;

1. whether sharing will be unilateral (one operator providing access to another), bilateral (two operators providing mutual access) or multilateral (several operators providing access to each other), and how this is being taken account of in terms of lots in the auction and valuations put on these lots;
2. the geographic scope of the sharing agreement (one site, several or all sites in a certain region or the territory of a Member States, international);
3. Likely impact on the competitive situation in the concerned markets before and after the sharing (will having sharing affect important competition parameters such as coverage, prices and network quality?);
4. whether the operators would be able to retain their independent control over the radio planning and the freedom to add sites;
5. whether operators would still be able to conclude similar agreements with other parties; and
6. whether the operators would retain the ability to differentiate themselves in terms of prices and quality and variety of services, especially in areas where spectrum was being shared; NB each of these could be competition issues in and of themselves, they are cited here in relation to their role in differentiation only.
 - Although network or spectrum sharing arrangements usually lead to beneficial effects such as more efficient utilisation of capacity, it is feasible that by lowering capacity to each party there could be a consumer detriment because

⁴⁷ Helpful legal and economic criteria for analysing the compatibility of individual co-operation agreements with Competition Law can be found in Communication (2011/C 11/01) on Guidelines on the applicability of Article 101 to horizontal co-operation agreements. See Ch2 on general principles on the competitive assessment of information exchange and Ch4 on production agreements. Those criteria do not, however, constitute a 'checklist' which can be applied mechanically. Each case must be assessed on the basis of its own facts

⁴⁸ http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/224-berec-rspg-report-on-infrastructure-and-spectrum-sharing-in-mobilewireless-networks

operators have reduced incentives to price services competitively at the retail level than if they had spare capacity. This may be ameliorated to some extent by the emergency of more efficient hardware and software that increases capacity;

- Dependent on the model sharing might lead to a shift of fixed costs towards marginal costs. As marginal cost influences pricing decision of operators sharing could have an effect on retail prices;
- It could also lead to a reduction in the incentives for each party to supply capacity to MVNOs. If MVNOs are less able to compete in the retail market, this could lessen competition to the detriment of consumers;
- New entrants wishing to obtain access to the network (at any level, passive or active, or as opposed to buying wholesale services) may face the presence of a duopoly in a particular region, potentially reducing their ability to enter the market. The extent of the concern also depends on whether such an entrant is expected to generate incremental benefits to consumer and could be addressed by ex post competition were it to emerge;
- Increased risk of tacit collusion focusing on lower quality, reduced innovation or denial of access to new entrants. There is increased co-ordination between operators which gradually reduces expenditure on network quality and innovation which is damaging in its own right and may lead to foreclosure of MVNOs or new market entrants; and
- Information sharing aids co-ordination in the wholesale or retail markets. There are four areas of potential concern in relation to information sharing: Sharing of traffic data; sharing of new capacity, coverage and capability forecasts; Monitoring of unilateral demand sites; Exchange of information for fault handling purposes. Much of this data may reveal commercially sensitive information and so aid co-ordination in downstream markets and thus potentially reduce competition and should be assessed prior to the award.⁴⁹

7.5 Final remarks on sharing

RSPG believes that mobile network sharing could be considered as an integral part of the award process, depending on the specific policy objectives of the award. In particular where coverage promotion and investment optimisation are being considered, these are likely to be achieved by their inclusion as part of the process (for example ensuring maximum coverage of networks to provide optimum coverage both by geography and population). Possible effects on competition should then be evaluated during the award design process. Moreover, any network sharing/spectrum pooling initiatives from authorised operators shall be subject

49 The European Commission decision in O2/T-Mobile proposed network sharing arrangement in 2003 is of particular assistance in determining how to approach such issues as information sharing: *“Notwithstanding the confidential nature of the information being exchanged, the cooperation must be analysed in the context of the overall agreement. The exchange of information is necessary to allow the parties to site share and to provide seamless roaming to their customers. The information being exchanged is primarily of a technical nature, and does not allow one Party to understand the overall competitive strategy of the other Party. In particular, a Party cannot determine with any accuracy the nature of the end user applications.”*

to competition assessment from the Member State which could clarify some sharing rules as appropriate.

8. Key Messages

Spectrum plays a vital role in the communications value chain and its continued scarcity means that efficient use of spectrum and efficient processes for awards for spectrum usage rights for electronic communications are a policy priority for all administrations.

Europe benefits from harmonised spectrum and is ready to address 5G

Europe benefits from the availability of existing and future harmonised spectrum to respond to the current growth of mobile market towards (4G: LTE). The RSPG notes that additional harmonised spectrum: 1452 –1492MHz, 2.3 – 2.4GHz, 700MHz will help Europe to meet the target of 1200MHz identified in the RSPP. However, the RSPG also notes that the identification and allocation of new spectrum is only one of the solutions available to respond to the growth of mobile data traffic. Other solutions include network densification, evolution of network architecture, usage of more efficient technologies and standards innovation.

It is important to recognise that due to geographic differences in the nature of demand and noting the reliance on harmonised spectrum, variations are likely to emerge in future. Where the demand is lower because of national circumstances, variations in implementation will be required at the national level. One approach could be to allow Member States to use the spectrum for services that fulfil national needs as long as they do not constrain the use of services in those Member States who have harmonised their spectrum for mobile services.

The RSPG has addressed these and related issues in:

- its Opinion on the RSPP covering recently harmonised spectrum (1452-1492MHz) or where harmonisation decisions are under consideration (700MHz, 2.3-2.4 GHz); and
- its opinion on Licensed Shared Access (LSA) which describes in particular the role of various stakeholders under the LSA approach. This is being considered in some Member States who require it to facilitate multiple licensed access in a band, including in the 2.3 – 2.4GHz band where trials are on-going in some Member States

The RSPG also considers that 5G systems will make use of existing mobile bands and require new ones. They may involve heterogeneous networks using both licenced and unlicensed spectrum operating in innovative ways with spectrum sharing becoming an increasingly integral part of spectrum use. The RSPG will develop, before the end of 2017, an opinion, focusing on those bands having the best potential for harmonization and addressing relevant spectrum issues raised by 5G. This will be addressed further in upcoming work by RSPG in 2016.

Awards: “there is no one size fits all”

In this report, we have highlighted how recent experience across Member States has shown that auctions have become the most common competitive award process due to their effectiveness at enabling sellers to realise the economic value of the spectrum and exposing

buyers' willingness to pay in a transparent way. Auctions are an effective means of award, enabling regulatory transparency and consistency amongst sellers and bidders. This report provides some best practices in order to share knowledge on spectrum awards, focusing on the main auction methods which take various forms. Other award mechanisms may also be used in certain national contexts in order to meet specific requirements.

Some key messages have emerged during the preparation of this report:

- Identifying and articulating objectives up front is key – be clear about what the award is meant to achieve and this will then help to inform auction design and other related decisions. This must be done within a robust legal framework;
- It is important to be transparent and to involve stakeholders in the decision making process starting with the national consultation process. Careful and effective planning of spectrum awards is key to their success;
- There are various auction formats, each has its merits and should be tailored to suit the national market and policy objectives. Indeed even within a single country there will be different formats which will be most suitable to deal with different circumstances at different times;
- Policy objectives can easily be incorporated in the auction design;
- Challenges with auctions can be mitigated by adjusting elements of the auction design; and
- There is no 'one size fits all'; i.e. there is no single model that can simply be replicated across each and every Member State. Auctions are increasingly common for the award of scarce spectrum and generally achieve Member State objectives if well designed. There is continuous development of auction formats and it is important that Member States keep abreast of these advances.

In terms of objectives, the most commonly identified during the drafting of this report were:

- Efficient use of spectrum (potentially including ensuring that all the spectrum be assigned);
- Enhancing and/or safeguarding competition (including promoting new entrants/facilitating market entry, ensuring a minimum number of competitors);
- Increasing broadband penetration and promoting roll-out of broadband services;
- Enhancing coverage in rural areas (regional development);
- Promoting innovation; and
- Promoting business opportunities and employment (economic development).

Although objectives may be largely common, there are national variations. For example, approaches to promoting competition (including encouraging new entrants) differ including

set asides and incentivising MVNO access. Other approaches include using spectrum caps to address asymmetry in spectrum holdings. Member States need to be aware of unintended consequences arising from caps or set asides.

The timing of awards is usually addressed through national consultation and needs to balance on the one hand making spectrum available as early as possible, and on the other, awarding spectrum too early (well before it is actually available and standardised equipment has become available) which may make it difficult for the operators participating in the award to accurately assess their future spectrum needs and therefore the value they place on the spectrum.

RSPG identified that availability of harmonised spectrum under a spectrum decision is a first driver for an indicative timing of awards but not necessarily the only one. The expiry of the current authorisations also triggers the timing of awards. For example, RSPG noted that in the next few years, a number of authorisations in 900MHz and 1800MHz will expire and that the bands have tended to be made available in a harmonised manner within a similar timescale. RSPG is addressing in more detailed the 700MHz, 1452-1492MHz and 2.3-2.4GHz timing issues in its Opinion on RSP and will continue to examine this in relation to future Opinions on proposals to amend the Telecoms Framework.

The RSPG noted a recent trend towards multi-band awards. While these can offer advantages, they may pose challenges to operators, and can put mobile operators in a difficult position, especially where they include spectrum being re-awarded at the end of a licence period. Effectively the operator may be put in the situation where it faces significant costs if it does not bid for (and win) certain bands.

There are also some countries that have a specific objective to raise revenues or secure a reasonable return for the spectrum. However, while some countries include such an objective, others do not. Indeed, some administrations are explicitly prevented from considering revenues in undertaking a spectrum award.

Efficient use of spectrum: various mechanisms as a “tool box”

RSPG considered various mechanisms to promote efficient use of spectrum, competition and coverage are:

- Licence duration

The RSPG considers it essential that a licence term is of sufficient duration, taking into account the national circumstances, the provision of legal certainty and promotion of investment. Most Member States issue licences that have been awarded for a specific duration, usually around 15-20 years. In a few cases, licences have indefinite duration but a possible revocation notice may apply after certain period (e.g. 20 years with a defined notice period of five years).

- Licence renewal

Different approaches to dealing with licences on expiry (as well as different dates for licence expiry). Renewal of authorisations can be used as a tool by the Member States/NRA to introduce competition. RSPG noted that

- for the 900/1800MHz bands there are two broad periods within which expiry falls in a number of Member States: 2015-2017 and 2025-2027; and
- for the 2GHz bands a number of expiries fall within 2016-2017 or 2020-2022

- Spectrum fees

The RSPG identified various methods. All these methods can work well. In all cases however there are common principles that should be respected, including:

- Transparency over the level of any fees that will be charged over the licence period: bidders need to know what proportion of fees will be required to be paid up front and the extent of any annual fees;
- Certainty that fees will be paid (and a clear understanding of what will happen if they are not): this is particularly important where all or part of the auction fees are proportioned over the duration of the licence; and
- Appropriate mechanisms in place to incentivise efficient use of the spectrum whilst avoiding undue burdens: this can be achieved through auction fees paid up front, annual licence fees or a combination of both.

- **Mechanisms to enable spectrum refarming**

Mechanisms to refarm spectrum may include various aspects such as legal, financial, policy, social and economic considerations, including the efficient use of spectrum. These should be addressed at the national level on a case by case basis taking into account various contexts and legal mechanism in force to clear spectrum where and when appropriate.

The RSPG does not consider that the incentive auction approach being developed in the US with respect to the 600MHz band could be directly applied within Europe at this time, although RSPG will continue to monitor these developments.

- **Technology and service neutrality**

The application of technology and service neutrality is in practice limited by technical and usage restrictions that are required in order to prevent harmful interference. Moreover, giving greater flexibility to spectrum users over how they use spectrum can make the interference environment more complex and less predictable with regard to adjacent band compatibility. It may be necessary to keep technical conditions under review to respond to technical evolution. Nonetheless the RSPG considers that restrictions should be kept to the minimum necessary, so that the spectrum user has maximum flexibility to decide the services that they wish to provide.

- **Spectrum caps and set asides**

Spectrum caps, floors, and set-asides may influence the incentives for bidders, in terms of their bidding strategies. When designing an auction the effects of these measures should be taken into account. The RSPG notes that spectrum caps and reservations should reflect the identified objectives of an award based on a market assessment in order to be consistent with competition law.

- **Coverage obligations**

The RSPG considers that coverage or roll-out obligations can be an important tool to promote broadband access, especially in rural and less economically attractive parts of the country. The RSPG notes that where such obligations are imposed they should be appropriate to achieve the identified policy objective. The RSPG considers that coverage obligations are best developed at national level where they can be aligned with national policy and priorities.

- **Wholesale access obligations**

Requiring a network operator to provide wholesale access can be a way of promoting retail competition. However, in order to impose such an obligation a thorough competition analysis

should be conducted. It is extremely important that the objectives of any wholesale access obligation are made clear, including to promote new entrants.

- Standardisation

The European framework for mobile broadband is technology neutral which supports innovation and fosters the deployment of new and more efficient technologies through infrastructure and service competition. This is important to ensure that spectrum users are incentivised / required to update to new technologies which may be more spectrally efficient than previous technologies, thereby promoting efficient use of spectrum. Member States are involved in CEPT and ETSI in order to develop coherent regulation and standards.

In addition, RSPG supports the promotion of adequate receiver performance and recognises that ensuring relevant radio receiver parameters is becoming increasingly necessary to facilitate the introduction of new systems, to extend sharing opportunities and to ensure efficient use of spectrum.

- Spectrum trading and leasing

The RSPG considers that further work may be undertaken to understand reasons for the differing levels of trading of spectrum rights of use of ECS across Member States. Even though a secondary market may not represent an objective by itself, it can be a tool that contributes to better spectrum management, by potentially mitigating any inefficiencies in the award outcome should the occur. In the meantime, it is clear that spectrum managers also have to look at other mechanisms to promote efficient use of spectrum in the harmonised bands. As more service and technologically neutral spectrum becomes available and as the market responds to more users with different interests and business models we may start to see increased likelihood of trading of spectrum rights of use of ECS.

- Management of under-utilised spectrum

The issue of under-utilisation of harmonised spectrum has been previously addressed by the RSPG, in the Report on Improving Broadband Coverage (2011) and in the Opinion on Wireless Broadband (2012).

RSPG considers that a regular review of a Decision seems a useful tool in order to assess the need to revise or amend or withdraw of a particular framework.

'Use it or lose it' (UIOLI) obligations can in certain circumstances represent a "safety net" to tackle the potential cases of detrimental under-utilisation of spectrum. A pre requisite of this approach is to define and detect the inefficient use. Such regulatory provision should be implemented and monitored by the NRA in a proportionate way and risks assessed carefully. However there are drawbacks to the approach such as the difficulty of defining and detecting inefficient use.

- Sharing / pooling between MNOs

RSPG believes that sharing could be considered as part of the award design process, depending on the specific policy objectives of the award. In particular where coverage promotion and investment optimisation are being considered, these are likely to be achieved by their inclusion as part of the process (for example ensuring maximum coverage of networks to provide optimum coverage both by geography and population). Possible effects on competition should then be evaluated during the award design process. Moreover, any of network sharing/spectrum pooling initiatives from authorised operators shall be subject to competition assessment from the Member State which could clarify some sharing rules as appropriate.

ANNEX 1 - Spectrum Awards – Analytical Framework

This Annex provides a framework for approaching spectrum awards design based on experience from Member States of awards conducted to date.

It aims to identify the most commonly considered issues that Member States assess at the different stages of award planning. It reflects much of the information included in the main body of this report and cites concepts and considerations that RSPG believes may be considered 'Best Practice'.

This is not meant to be a prescriptive list for Member States, but an aide-memoire or a generic analytical framework, as an example, for approaching the award preparation. Not all considerations will be relevant for all awards in all Member States at all times. A Member State's ability to prioritise and give appropriate weight to certain criteria is essential to ensure that awards and auctions in particular are an evolutionary approach to assigning spectrum rights, and ensuring that Member States meet their overarching public policy objectives from the award.

The theory and practice of awards, particularly auctions, should and will continue to evolve in response to considerations such as the specifics of the frequencies to be awarded, the policy objectives, technological innovations and developments, market demand and consumer behaviour.

Stages	Considerations and Challenges
Member States (MS) and EU spectrum policy objectives	MS should ensure that there is an available sufficient supply of technically harmonised spectrum for Electronic Communication Services (ECS) (EC decision) and market demand for such harmonised frequency supply. This implies the need to conduct a public consultation.
National considerations / Award objectives	<p><u>Objective setting</u></p> <p>Identifying and articulating public policy objectives with national circumstances is a strategic part of a well-designed award. It is important to be clear about what the Member State wants to achieve and this will then help to inform award design and other related decisions. This must be done within a robust national legal and analytical framework.</p> <p>There is no one-size-fits-all in terms of spectrum awards. As a starting point, when defining the objectives of an award, you should first look at:</p> <ul style="list-style-type: none"> • Market / Competitive structure: This encompasses, amongst others, competition issues, asymmetries (such as information or financial), number and market share of

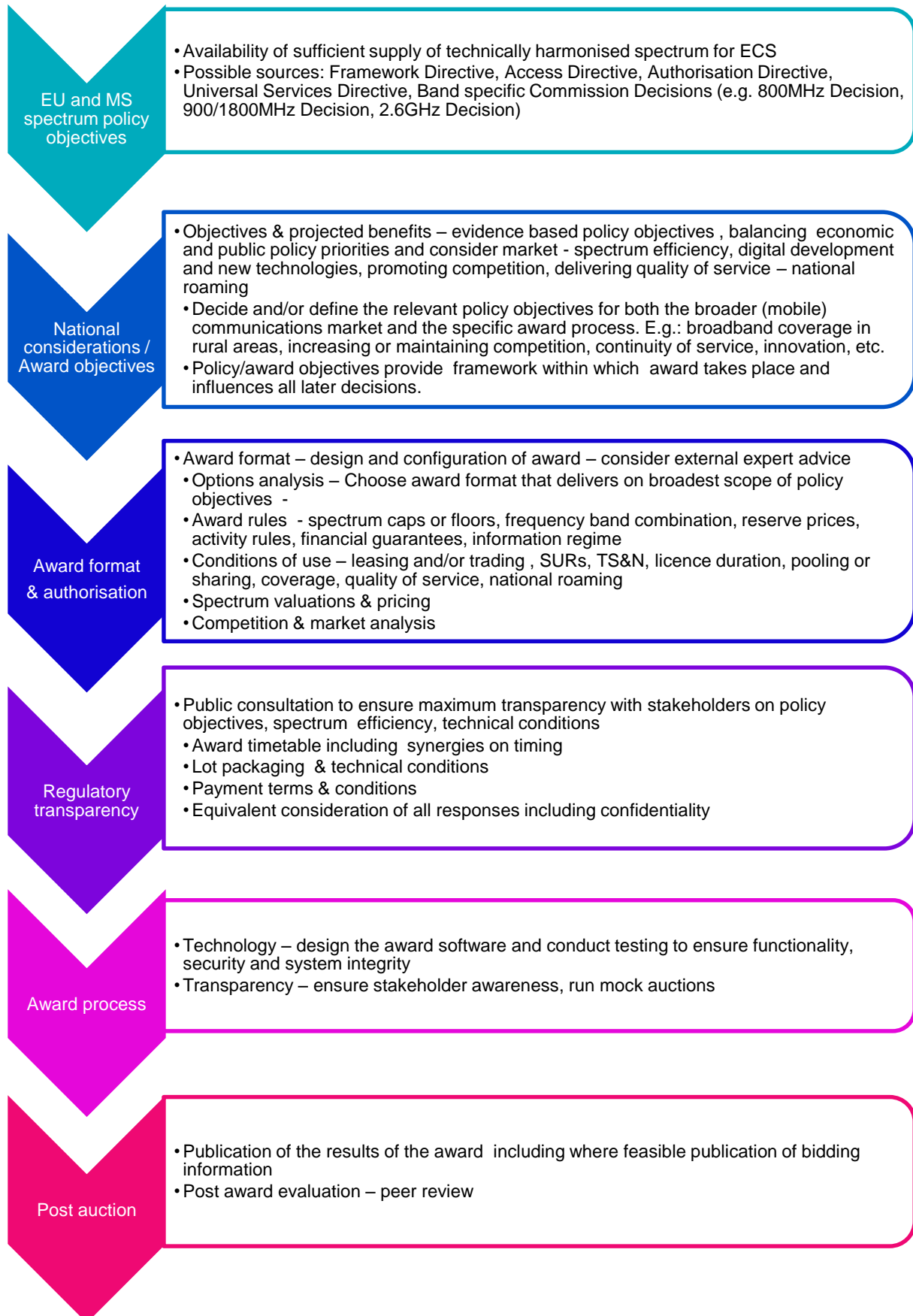
	<p>wholesale operators; number and market share of retail operators; quantity and quality of spectrum held by each wholesale operator; overall population and relevant density, existing licenses which determine obligations (such as coverage obligations), renewal dates, etc.</p> <ul style="list-style-type: none"> • Market and technological developments including the cost of raising capital; Smartphone penetration; consumer demand; existing coverage; what technologies could reasonably be expected to make use of the spectrum in the foreseeable future. <p>In terms of objectives, the following are some of the most common:</p> <ul style="list-style-type: none"> • Efficient use of spectrum (potentially including ensuring that all the spectrum be assigned) • Enhancing and/or safeguarding competition (including promoting new entrants/facilitating market entry, ensuring a minimum number of competitors) • Increasing broadband penetration and promoting roll-out of broadband networks and services • Enhancing coverage in rural areas (regional development) • Promoting innovation • Promoting business opportunities and employment (economic development) <p>Objectives may sometimes conflict resulting in the need to make open and transparent decisions about their relative priority. During this prioritisation process it is important to provide clarity and to involve stakeholders in the decision making process starting with the consultation process.</p> <p>In order to achieve the stated objectives, Member States should consider, among other things, the following;</p> <ul style="list-style-type: none"> • The award process should be transparent and easily understood by potential bidders • The award process should encourage participation in the process, and avoid outcomes where spectrum goes unsold despite demand existing for that spectrum; • The award process should minimise uncertainties (such as common value uncertainty which may exist among bidders who may want to use spectrum to deploy different or new technologies); • In the case of multi-band awards (where several spectrum bands are awarded at the same time) the award process should allow sufficient flexibility to express preferences related to complementarities or substitutability; • The award process format and rules should minimise the
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	<p>risk of inefficient outcomes for bidders; and</p> <ul style="list-style-type: none"> • The award process should promote incentives for bidders to engage in a manner expected of normal competition, and not to engage in strategic or collusive behaviour. <p>Award design will be tailored to the particular circumstances and Member States will seek to ensure so far as possible that particular design and rules chosen reflect the objectives of the award and create a fair environment for all bidders. Some case studies are included in Annex 2.</p>
<p>Award format & Authorisation conditions</p>	<p>The consideration and final choice of award format may go a long way to meeting the objectives of the award</p> <p>1. Options analysis</p> <ul style="list-style-type: none"> • Select the most appropriate award process; auctions, hybrids, beauty parade or first-come, first-served basis? • Key considerations are most likely to be whether the frequencies are in excess demand and conducting an analysis of the options available and select the method that will best achieve the prioritised award objectives. • If frequency supply exceeds demand, then a low cost assignment procedure such as first come first served can get the spectrum into use quickly. If the licences subsequently increase in value, then a parallel system of secondary trading will enable them to be re-channelled into their most efficient hands and (if flexibility of use is allowed) more efficient uses. <p>Where scarcity is foreseeable, the main choice is likely to be between a comparative competitive review and an auction.</p> <p>Assuming the MS proceeds with an auction:</p> <ul style="list-style-type: none"> • Ensure that the auction design is proportionate to objectives and avoids complexities that may confuse or deter bidders. • Don't just go for the one that was used last time. As both the theory and practice of auction design continue to evolve, examine and use new auction design developments and adopt them as appropriate. Consider auction design in the round, including those designs or approaches that haven't been successful. Consider and identify what the consequences might be of a poor design choice or poor implementation? For instance: spectrum remains unsold so economic value is not extracted; spectrum is bought but not brought into use

	<p>either because it is acquired by inefficient users or as a defensive strategy?</p> <p>Other factors to consider, for example:</p> <ul style="list-style-type: none"> • Avoiding collusion between bidders either implicitly through signals or explicitly but failing to maximise bids. • Participation - encouraging bidders and particularly new entrants to participate encourages better prices and better efficiency in the conduct of the auction. • Deterring predatory behaviour which can result in weak bidders being excluded and strong bidders potentially colluding; aggressive bidding behaviour can be communicated in advance, essentially disrupting the bid process. <p>2. Award rules to consider</p> <ul style="list-style-type: none"> • spectrum caps or set asides • frequency band combination • reserve prices • activity rules • financial guarantees • information regime • packaging of lots - spectrum pooling or sharing <p>3. Conditions of use /authorisation</p> <ul style="list-style-type: none"> • Conditions of right of use – the rights shall be tradable / leasable, SURs conditions, TS&N, licence duration, pooling or sharing, coverage, quality of service, national roaming. • Sharing and Pooling - What role is there for sharing or pooling either as facilitated or mandated options? • Licence duration (and Licence renewals?) Pros and Cons of the options for licence duration taken into account the national context. • Any other authorisation considerations? <p>4. Spectrum valuations and pricing</p> <ul style="list-style-type: none"> • Very high reserve prices may not lead to optimum outcomes. They may inadvertently exclude potential bidders thus affecting the auction outcome, potentially leaving spectrum unsold and reducing overall economic value attained. <p>Is benchmarking based on auction outcomes the optimum method? Where might it be and where might it not be? For instance the amount paid in one country reflects the value of the spectrum under a particular set of circumstances</p>
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	<p>which may not be wholly comparable to the award under preparation. Consider combining benchmarking with other methods.</p> <p>5. Competition & market analysis</p> <ul style="list-style-type: none"> • Ensuring that social and economic benefits are maximized from the spectrum awarded means it is important that licensees continue to operate in a competitive marketplace post-award. • Explicit support of competition objectives such as minimum number of market players or ensuring a new entrant. • Member States can impose conditions as part of the auction process which may help to promote and sustain competition in the market long after the auction. <p>Are there are a set of substitutable/interchangeable frequencies in the provision of services to defined end users?</p> <ul style="list-style-type: none"> • Examine what frequencies can be deployed and whether they can provide effective competition to one another in providing services; • Conduct a thorough analysis of the market and how it may develop. Analyse the market before the auction and potential for competition concerns after the auction is conducted depending on the outcome; identify objectives associated with the market – i.e. the need to maintain competition amongst a minimum number of national wholesalers.
Regulatory transparency	<ul style="list-style-type: none"> • Conduct a public consultation to ensure maximum transparency with stakeholders on policy objectives, spectrum efficiency, technical conditions. • Auction timetable including synergies on timing. <ul style="list-style-type: none"> - Consider the balance between the timing of a sale (for example, the availability of finance to potential bidders) and the wider economic benefits from holding a sale sooner rather than later. - Consider the timing of the award with those of EU neighbours to assess whether there is benefit for the market and consumers and appetite amongst industry for contemporaneous awards - Are there any drawbacks of timing? Lot packaging & technical conditions • Payment terms & conditions <ul style="list-style-type: none"> - Offering the option of upfront versus staged payments? May be of benefit to more highly leveraged bidders but may lead to concerns of

	<p>default or favouring risky bidders.</p> <ul style="list-style-type: none"> - Allowing staged payment may enable bidders to invest in deployment immediately mobile network operators to invest immediately in deploying their spectrum. <ul style="list-style-type: none"> • Equivalent consideration of all responses including confidentiality.
Award process	<p>Technology</p> <p>Increasingly online award mechanisms are being used to conduct spectrum auctions and there are some important success factors around their use:</p> <ul style="list-style-type: none"> • Design the award software and conduct testing to ensure functionality, security and system integrity. • Site Design, Content and Support – the design should be clear, intuitive and easy to use. It should include appropriately detailed levels of information on the process of award, particularly the organization of auction listings, lots etc. • Security - an effective encryption mechanism must be in place for online an online auction process in order to prevent security problems. • User Services and Support - Interactive customer services and support: feedback systems, email communications and support calls are basic and critical interactive customer services. <p>Transparency and accessibility</p> <ul style="list-style-type: none"> • Ensure stakeholder awareness. • Run mock auctions for scenario planning; how is the process conducted? Increasingly online mechanisms are being used to conduct spectrum auctions and there some important success factors around their use.
Post award	<ul style="list-style-type: none"> • Publication of the results of the award including where feasible publication of bidding information. • Post award evaluation – peer review to ascertain whether the award was conducted according to the plan and against Best Practice. • Monitor and evaluate whether the expected long-term and wider benefits flowing from the sale are achieved. i.e. monitor usage of the spectrum released in this auction and should also assess whether the expected consumer benefits are being achieved.



Annex 2 – Member State Case Studies

1. Case Study: The Irish Multi-Band Spectrum Award 2012

Background

This document details the approach taken by the Commission for Communications Regulation (ComReg) in Ireland for the release of spectrum rights of use in 800 MHz, 900 MHz and 1800 MHz frequency bands.

On 16 March 2012, ComReg, in its capacity as manager of Ireland's radio spectrum, published its response to consultation and decision⁵⁰ to hold an auction to award a number of individual rights of use in the 800 MHz⁵¹, 900 MHz⁵² and 1800 MHz⁵³ radio spectrum bands.

The auction offered spectrum rights of use across these three critical bands for the period 2013 to 2030. In total, 280 MHz of sub-2 GHz spectrum (i.e. 2 × 140 MHz of paired spectrum) was made available, more than doubling the licensed assignments in these particular bands at the time.

The Auction

The core decision arrived at by ComReg was to hold an open auction process for all spectrum rights in the 800 MHz, 900 MHz and 1800 MHz bands.

ComReg concluded during its consultation process that this approach was preferable to an award process involving limited or no competition for spectrum-use rights, in which incumbent mobile operators would be awarded spectrum-use rights simply by virtue of their incumbency.

Given the many complexities of a single award process across three spectrum bands and the need to cater for a wide range of legislative and regulatory policy requirements, much work was required to devise the optimal award format and conditions. The key features of the award process that ComReg adopted were as follows:

- a) it would involve a number of stages, including an application stage, a qualification stage, a main stage and an assignment stage, with the outcome of the qualification stage determining whether the procedure moved directly to the assignment stage, or whether the main stage would be necessary due to demand exceeding supply;
- b) the main stage, if it occurred, would consist of a combinatorial clock auction⁵⁴;
- c) the winners of spectrum would be those who made the highest bids;

⁵⁰ ComReg Document 12/25 – Response to Consultation and Decision on the release of the 800 MHz, 900 MHz and 1800 MHz Radio Spectrum Bands - published 16 March 2012.

⁵¹ This comprises the frequency ranges 791 - 821 and 832 - 862 MHz.

⁵² This comprises the frequency ranges 880 - 915 and 925 - 960 MHz.

⁵³ This comprises the frequency ranges 1710 - 1785 and 1805 - 1880 MHz.

⁵⁴ The combinatorial clock auction is a price clock-based auction method used to sell multiple items in a single process. It provides bidders with the flexibility to bid on different combinations of spectrum across the three bands. The CCA format also creates incentives for bidders to bid their full value for the spectrum.

- d) the main stage of the auction, if it occurred, would determine who wins what amount of spectrum; the assignment stage would determine at which location (within each spectrum band);
- e) to accommodate the pattern of then current licence assignments⁵⁵, spectrum usage rights would be assigned across two time periods (or 'time slices'), applicable to each of the three spectrum bands in respect of which rights of use were being allocated as follows:
 - Time Slice 1: 1 February 2013 - 12 July 2015; and
 - Time Slice 2: 13 July 2015 - 12 July 2030,
 with all rights of use coming to an end on 12 July 2030, absolutely; and
- f) to safeguard competition, a competition caps was placed on the spectrum that bidders, either as a single entity or in combination with other bidders, could acquire:
 - 2 x 20 MHz of sub-1 GHz spectrum (i.e. 800 MHz and 900 MHz spectrum);
 - 2 x 50 MHz of total spectrum in these bands; and
 - 2 x 10 MHz of 900 MHz (Time Slice 1 only).

To safeguard competition and promote spectrum efficiency, a minimum price was applied, based on a conservative lower bound estimate of the market value of liberalised spectrum derived from an international benchmarking analysis, which was calculated as being €20M per 5 MHz band of paired sub-1 GHz spectrum (13 lots), and €10M per 5 MHz band of paired 1800 MHz spectrum (15 lots).

It was decided that the minimum price would comprise two equal parts, being the upfront reserve element, and a Spectrum Usage Fee (SUF) to apply over the duration of the licence, appropriately adjusted for the time value of money i.e. The SUF would be linked to the consumer price index (CPI).

Interesting Additional Features of the Award

An 'Early Liberalisation' option was included that facilitated the 'liberalisation' of existing GSM 900 MHz and 1800 MHz rights by way of open competition. Incumbents who bid in the award process could choose if they wished to convert existing technology-restricted licences into technology-neutral licences as well as bidding on the price they were prepared to pay to do so.

'Preparatory Licences' were issued immediately after the award process to facilitate successful parties in preparing networks in advance of the spectrum being permitted for use.

Rules were put in place in advance of the award to address 'Transitional Arrangements' - addressing the activities required for operators to move across and within bands to their assignments as determined in the award process.

⁵⁵ The GSM 900 MHz and GSM 1800 MHz licences of Meteor Mobile Communications Ltd were due to expire on 12 July 2015. The GSM 1800 MHz licences of Telefónica O2 Communications (Ireland) Ltd and Vodafone Ireland Limited both expired on 31 December 2014.

Licence Conditions

The following are some of the main Liberalised Use licence conditions that apply to all licences won in the award process:

- a) all licence holders must attain and maintain a minimum coverage of 70% of the population. Existing GSM and 3G licence holders are to attain this coverage obligation within 3 years, whilst new entrants (being those persons who do not currently hold an existing GSM and/or 3G licence) are to attain this coverage obligation within 7 years, together with an interim coverage milestone of 35% of the population within 3 years;
- b) licence holders may use spectrum rights in multiple bands to achieve the coverage targets, but at least 50% of the coverage requirement (i.e. 35% of the population) must be met using spectrum rights in the 800 MHz, 900 MHz and/or 1800 MHz bands;
- c) minimum quality of service conditions shall require that network unavailability will be less than 35 minutes per 6 month period and the minimum voice call quality standard will comply with the levels currently set out in existing GSM licences;
- d) technical requirements to facilitate the co-existence of services in the 800 MHz, 900 MHz or 1800 MHz bands with services in the same spectrum band or in adjacent spectrum bands; and
- e) all licence holders are required to comply with International Memoranda of Understanding ('MoUs') on cross-border frequency coordination relevant to the spectrum band.

2. Case study: Coverage obligations in the Danish 800 MHz auction

Background

This document details the approach taken by the Danish Business Authority (DBA) for the release of spectrum rights of use in the 800 MHz frequency band.

On 25 August 2010, the former Minister for Science, Technology and Innovation made a decision to award by auction available frequencies in the 800 MHz band. DBA was to hold the auction. At the same time, it was decided that the 800 MHz band should be used for electronic communications services, including mobile broadband. In total 2x30 MHz of paired spectrum was made available.

The release of the spectrum served two objectives:

- Facilitate effective competition in the telecommunications market to ensure the provision of advanced and improved services in new and existing markets across Denmark.
- Everyone should have access to a broadband connection of at least 100 Mbit/s by 2020.

To meet the objectives coverage obligations were defined in the 800 MHz licences and aimed at improving the availability of broadband services in areas where the current availability of high-speed broadband services was the lowest.

The Auction

In order to meet the main objectives, DBA decided on a five stage auction process. The five stages included an application stage, a qualification stage, a principal stage (the bidding stage), an assignment stage, and a grant stage. The outcome of the application and the qualification stage determined whether the principal stage would be necessary.

The spectrum available was divided into five lots – one lot of 2x10 MHz and four lots of 2x5 MHz. The bottom 2x10 MHz of the 800 MHz band was subject to usage restrictions that required the user of these blocks to protect DTT viewers against interference. Hence this spectrum formed a unique lot category termed "Category A". The remaining 2x5 MHz lots were offered as frequency-generic Category B lots.

The specific frequencies assigned to each winner of any Category B lots were determined in a process that ensured that licensees were awarded contiguous frequency blocks.

As a default, all licences were subject to a coverage obligation. The coverage obligation applied to the postcodes in three coverage areas specified in the licence. However, the licensees were not required to fulfil the coverage obligation with the 800 MHz frequencies included in their licence. Hence, the coverage obligation could be fulfilled by using any frequencies that the licensees had at their disposal.

It was sufficient for the coverage obligation to be met by a single licensee in each coverage area and therefore it was not necessary that all licences were subject to the obligation in all coverage areas. Hence, bidders were able to bid for exemptions from serving the coverage obligation in coverage areas during the auction alongside frequency lots.

The coverage obligations were defined separately for three non-overlapping coverage areas. The coverage obligation for Category A and Category B lots varied. The Category A lot had a coverage obligation in coverage area 1 only. Category B lots had a coverage obligation in all three coverage areas.

Table 1: Availability and reserve price of exemption lots in the auction:

Category	Number of lots available (endogenously determined)	Reserve price per exemption
E1	Number of bidders who are awarded B lots minus 1	DKK 10 million
E2	Number of bidders who are awarded B lots minus 1	DKK 10 million
E3	Number of bidders who are awarded B lots minus 1	DKK 10 million

Given the many complexities of assigning different spectrum categories and exemptions from the coverage obligations and to incentivise truthful bidding, a combinatorial clock auction was chosen for the principal stage. The winners would be those who made the highest bids.

To meet the objective of effective competition in the telecommunications market a spectrum cap of 2x20 MHz was placed on the amount of spectrum a bidder could acquire during the auction. The cap ensured that no single bidder could acquire the total amount of spectrum auctioned.

Activity rules were used in the auction in order to promote price discovery and truthful bidding. They were applied on both frequency lots and exemption lots.

Coverage obligation

The licensees should ensure supply of a mobile broadband service offering users the experience of connecting at a download bit rate of at least 10 Mbit/s.

In each coverage area specified in the license, the licensee should ensure 98% geographical outdoor coverage of the land area with the exception of forests and 99.8% outdoor coverage of households, enterprises and holiday houses. The licensee should also ensure that the minimum coverage rate in each postcode area is 75% of households, enterprises and holiday houses.

The coverage obligation has to be fulfilled by the end of 2015 at the latest. The licensee is obliged to provide documentation that the coverage obligation is fulfilled by the end of March 2016 at the latest. There are no specific requirements for the documentation and the licensee can use the method that it finds most suitable, taking into account the technology used and the network implementation.

3. Case Study France 2.6 GHz and 800 MHz bands

An award process is based on several criteria such as a financial criterion predominant for an “auction procedure” which could be completed with additional criteria added to reach specific political objectives.

In France, the award process for the 800 MHz and 2.6 GHz bands, were successively conducted in 2011 and consisted in a hybrid approach: each band was assigned according to a combinatorial sealed-bid single-round auction that included additional criteria.

In practice, for both award procedures, the candidates were to make an offer for each frequency block (and combination of these blocks) they were interested in. At the end of each procedure, they were ranked by the NRA according to a final mark corresponding to the multiplication of the bidding price with the selection criteria multipliers.

In addition to the MVNO commitment, the award procedures were also designed to promote competition in the French mobile market through the following rules: a spectrum cap in each frequency bands (2x15 MHz for the 800 MHz and 30 MHz duplex for the 2.6 GHz), a guaranteed minimum amount of spectrum in the 2.6 GHz band if four players or less are qualified and a mechanism to introduce roaming access to the 800 MHz network in the “priority rollout zone” for an unsuccessful candidate of the 800 MHz band which has been granted spectrum at 2.6 GHz.

First, the 2.6 GHz band candidates based their offer on their bidding price (higher than the reserved price) and a commitment to provide favourable conditions for MVNO to access their broadband mobile network as “full MVNO”.

- 4 MNOs were selected; 2 were granted 2x15 MHz and 2 were granted 2x20 MHz in the 2.6 GHz band; 3 of the 4 selected MNO choose the MVNO commitment, the bidding were 1.3 fold higher than the reserved price.

Then, the 800 MHz band candidates based their offer on their bidding price (higher than the reserved price), a commitment regarding the local coverage and a commitment to host MVNO material.

- 3 MNOs were selected; each were granted 2x10 MHz; 2 of the 3 selected MNO choose to the MVNO commitment; all choose to the regional development commitment, the bidding were 1.46 fold higher than the reserved price. A fourth MNO which was not selected could also to roaming rights from one of the 800 MHz successful candidate, to be able to cover the priority rollout area.

The award design succeeded in reaching the two main national objectives and in the same time offering an optimized income for the French State. This award will contribute to the digital development of the metropolitan territory with an accelerated rollout of 4G networks in the “priority areas” and have promoted competition in the French mobile market

More detailed information

The candidates were to make an offer for each frequency block (and combination of these blocks).

The 800 MHz band candidates based their offer on the following parameters:

- a proposed price M,
- a commitment to host MVNO material, associated with a fixed multiplier C_{MVNO} for the score ($C_{MVNO}=1 + 1/n$ ⁵⁶ with commitment, else $C_{MVNO}=1$),
- a commitment regarding the local coverage (95% of the population of each *departement* after 15 years), associated with a fixed multiplier C_{AdT} for the score ($C_{AdT}=1 + 1/n$ with commitment, else $C_{AdT}=1$).

The 2.6 GHz band candidates based their offer on the following parameters:

- a proposed price M,
- a commitment to host MVNO material, associated with a fixed multiplier C_{MVNO} for the score ($C_{MVNO}=1 + 2/n$ with commitment, else $C_{MVNO}=1$).

A score was assigned to each offer, taking into account all the criteria, and corresponded to the multiplication of the price proposed with the corresponding multipliers where applicable:

- For the 800 MHz band procedure: Score = $M \times C_{MVNO} \times C_{AdT}$,
- For the 2.6 GHz band procedure: Score = $M \times C_{MVNO}$.

Each possible combination of offers was assigned a final score equal to the sum of the scores of each offer. The frequency blocks were assigned to the operators according to the combination reaching the highest final score.

The award design succeeded in reaching the following two main national objectives and in the same time offering an optimized income for the French State.

1. The digital development of the metropolitan territory: rollout of innovative networks for all

This was the primary objective for the 800 MHz, resulting from the digital dividend, as stated in the Pintat law of December 17, 2009. 800 MHz License holders must achieve the following coverage obligations (in terms of population), using technologies allowing high-speed data rates⁵⁷.

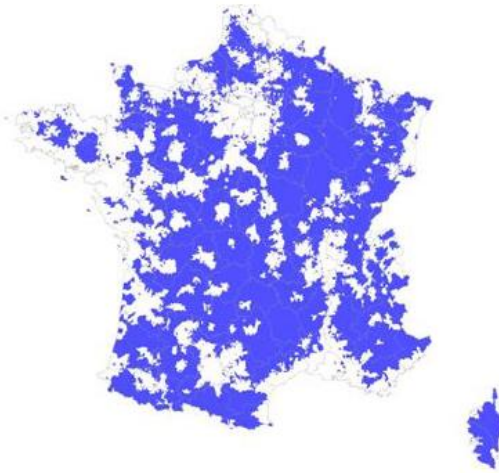
	T + 12 years	T + 15 years
Overall metropolitan coverage	98%	99,6%
Departmental coverage	90%	95% (*)

(*) This coverage ratio reflects a commitment taken by all candidates for enhanced coverage

A "priority rollout zone" has also been defined (see maps below) corresponding to the sparsely populated areas of metropolitan France which cover 18% of the population and 63% of the territory. A specific schedule associated to the network rollout has to be followed by 800 MHz license holders in this priority rollout zone (40% of the population by 5 years and 90% of the population by 10 years). To facilitate 4G network rollout, network and frequency sharing is encouraged in this area (see point 2 below)

⁵⁶ n represents the number of 2x5 MHz blocks on which the bidder made an offer.

⁵⁷ theoretical maximum throughput higher than 60 Mbps when using 10 MHz of spectrum



2. Promote competition

Specific rules have been implemented in the 800 MHz and 2.6 GHz bands award in order to stimulate competition in the mobile market.

Regarding the equitable access to spectrum by mobile operators, the award:

- limited the maximum amounts of frequencies that can be granted (15 MHz duplex inside the 800 MHz band, 30 MHz duplex inside the 2.6 GHz band),
- guaranteed a minimum amount of spectrum in the 2.6 GHz band if four players or less are qualified,
- anticipated a roaming access to the 800 MHz network in the “priority rollout zone” (see point 1 above) for an unsuccessful candidate of the 800 MHz band which has been granted spectrum at 2.6 GHz

Regarding the MVNO access, the award introduced an incentive via a selection criterion. Operators could take the commitment to provide favorable conditions for MVNO to access their broadband mobile network as “full MVNO”.

Result of the 800 MHz and 2.6 GHz awards

On the basis of the offers submitted by the candidates, the results of the awards are as follows:

791 MHz 832 MHz	801 MHz 842 MHz	811 MHz 852MHz	821 MHz 862 MHz
Bouygues Telecom	SFR	Orange France	
Block A	Blocks B + C		Block D

2500 MHz 2620 MHz	2515 MHz 2635 MHz	2535 MHz 2655 MHz	2550 MHz 2670 MHz	2570 MHz 2690 MHz
SFR	Orange France	Bouygues Telecom	Free Mobile	

The following table provides details on the offers made by each of the successful bidders:

License recipient	Spectrum awarded	Financial bid	Commitment to host MVNO's
SFR	15 MHz duplex	150 000 000 €	No

Orange France	20 MHz duplex	287 118 501 €	Yes
Bouygues Telecom	15 MHz duplex	228 011 012 €	Yes
Free Mobile	20 MHz duplex	271 000 000 €	Yes
Total	70 MHz duplex	936 129 513 €	
<i>Reserved price</i>		<i>700 000 000 €</i>	

License recipient	Spectrum awarded	Financial bid	Commitment to host MVNO's	Regional development commitment
Bouygues Telecom	Block A (10 MHz duplex)	683 087 000 €	Yes	Yes
SFR	BlockB+C (10 MHz duplex)	1 065 000 000 €	Yes	Yes
Orange France	Block D (10 MHz duplex)	891 000 005 €	Yes	Yes
Total	30 MHz duplex	2 639 087 005 €		
<i>Reserved price</i>		<i>1 800 000 000 €</i>		

The 800 MHz band and 2.6 GHz award brought a total income for the State budget of close to €3.6 billion, compared to the reserve price of €2.5 billion.

It could also be noted that Free Mobile whose application for 800 MHz band spectrum was eligible and qualified, and which has been awarded spectrum in the 2.6 GHz band, has satisfied the criteria set in the call for applications allowing it to apply to roaming rights from SFR in the 800 MHz band⁵⁸, to be able to cover the priority rollout area.

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⁵⁸ Free Mobile will therefore be able to apply for roaming rights from SFR whose license includes two blocks of spectrum in the 800 MHz band. As a result, Free Mobile will legally be able to make use of these rights once its own 2.6 GHz-band network covers 25% of the population.

Annex 3 - Auction format mechanics

Simple Clock Auctions

There are many forms of clock auctions. In general a simple clock auction progresses over a number of rounds, where similar lots are combined into the same lot category:

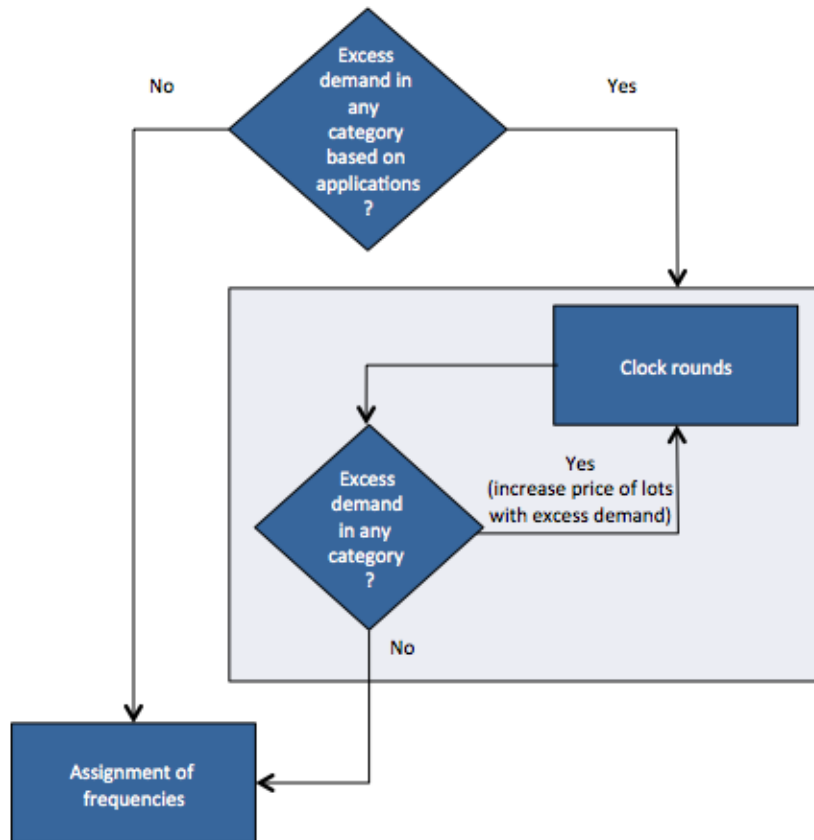
- In advance of the first round, the auctioneer declares prices that will apply during the first round,⁵⁹ and price increments that will apply on a category-by-category basis if there is excess demand in one or more lot categories;
- During the first round, bidders state their demand for lots in all categories based on the pre-set prices for each category;
- After the round, the auctioneer will assess demand:
 - If there is no excess demand, the auction will close and each bidder will be assigned the package of lots they bid on in the first round at the sum of round 1 prices for lots in their winning package; and
 - If there is excess demand for at least one lot or lot category, then another round will be announced and the auctioneer will declare prices that will apply during the next round. Prices will be unchanged relative to the previous round for categories of lots not in excess demand, and prices will increase by one increment for categories of lots in excess demand.
- Where further rounds are required in multi-round auctions, activity rules govern the bidding behaviour that is feasible. Activity rules are aimed at ensuring that bidders do not withhold their true demand until near the end of the open phase, so that the information disclosed during the open phase is meaningful. In essence, activity rules intend to prevent bidders from expanding their demand when prices increase. The simplest activity rule that might be imposed is that package size cannot increase from round to round as prices increase – they can only be reduced or maintained.
- The auctioneer will continue the process of declaring prices, accepting bids at these prices during rounds and assessing demand until there is a round in which there is no excess demand.
- Following the close of a round during which there was no excess demand:
 - Bidders in that round will be declared winners;
 - The packages they bid for in that round will be declared winning packages; and
 - Their winning prices will be the sum of the prices in that round for all of the lots in their respective winning packages.⁶⁰
- If lots have been auctioned in lot categories and based on the auction outcome there is more than one alternative possible assignment of frequencies in one or

⁵⁹ This will either be (i) the reserve price or (ii) the reserve price plus one price increment in the event that bidder applications are treated as bids.

⁶⁰ While this is a 'pay as bid' auction format, bidders are only required to bid up to the amount that is necessary to force competitors to contract their demand. Therefore, the price achieved to is marginally above the opportunity cost, reflecting the value that competitors are willing to pay. Note that this assessment of what represents opportunity cost only holds if values are linear (e.g. the value of two lots is twice the value of one lot), all lots are the same and there are no unsold lots. Without these assumptions, the opportunity cost becomes more complex to compute.

more category, the assignment of specific frequencies to winners in such categories will be conducted in a follow-up process.

This process is illustrated below:



Sealed bid combinatorial auction

During the single round of the sealed bid combinatorial auction, bidders are permitted to express multiple bids for different packages of lots. These bids are subject to 'floors' on the value of their bids, which amount to the sum of the reserve prices for the lots included in a package. They may also be subject to caps on the number of lots that they contain (spectrum caps, which would be set out prior to the bidding round). Following the end of the round, all combinations of bids submitted in the round are generated, and all feasible combinations of bids are evaluated. A combination of bids is feasible to become the winning outcome if:

- It contains exactly one bid from each bidder, where this might be a default zero bid (a bid for zero lots for a bid amount of zero representing that bidder winning nothing) for one or more bidders;
- The number of lots in each category awarded in the combination of bids is no greater than the number of lots available in the auction in any category; and
- The bid amounts associated with all bids in the given combination of bids adhere to applicable floors.

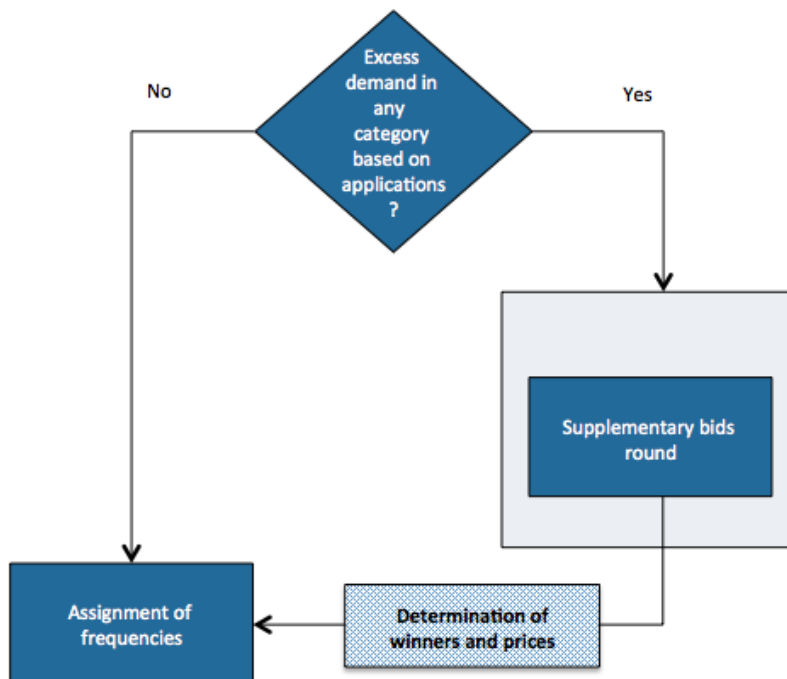
The highest value combination of feasible bids is declared the winning outcome.

Prices to be paid for winning packages are determined through the use of opportunity cost pricing, with:

- each winning bidder paying enough for its package to still win this package, given the value of feasible bids of other bidders; and
- winning bidders (respectively each group of winning bidders) collectively paying enough for the combination of winning packages to still win, given the value of all other combinations of feasible bids.

If lots have been auctioned in lot categories and based on the auction outcome there is more than one alternative possible assignment of frequencies in one or more categories, the assignment of specific frequencies to winners in such categories will be conducted in a follow-up process.

This process is illustrated below:



Combinatorial Clock Auction

Mechanics of the auction

As with the simple clock auction, the first phase of bidding progresses over a number of rounds, where similar lots are combined into the same lot category:

- In advance of the first round, the auctioneer declares prices that will apply during the first round, and price increments that will apply on a category-by-category basis if there is excess demand;
- During the first round, bidders state their demand for lots in all categories based on the pre-set prices for each category;
- After the round, the auctioneer will assess demand. If there is excess demand in any category, then another round will be announced and the auctioneer will declare prices that will apply during the next round. Package size (as defined by eligibility points associated with each lot) can only be reduced or maintained as prices increase.

- The auctioneer will continue the process of declaring prices, accepting bids at these prices during rounds and assessing demand until there is a round in which there is no excess demand.

Following the close of a round during which there was no excess demand, the auction moves from the first to the second phase of bidding, the supplementary bids round.

During the supplementary bids round, bidders are permitted to express multiple bids for different packages of lots:

- They may increase or leave unchanged bids for packages bid for during the first phase; and
- They may place bids for packages not yet bid on.

During the first phase, rules are imposed on bidding activity in order to limit the scope for bidders to bid strategically, with activity rules ensuring that bidders could not withhold their true demand until near the end of the open phase. In the supplementary bids round, analogous rules are imposed on bidders through caps on supplementary bids, ensuring that preferences for packages of different sizes are consistent with those preferences expressed through bids submitted during the first phase.

Following the end of the supplementary bids round, all combinations of bids submitted in the auction to that point are considered and all feasible combinations of bids are evaluated. A combination of bids is feasible to become the winning outcome if:

- It contains exactly one bid from each bidder, where this might be a default zero bid (a bid for zero lots for a bid amount of zero representing that bidder winning nothing at all) for one or more bidders;
- The number of lots in each category awarded in the combination of bids is no greater than the number of lots available in the auction in any category; and
- The bid amounts associated with all bids in the given combination of bids adhere to applicable caps and floors (generally, the sum of the reserve prices of lots included in each package).

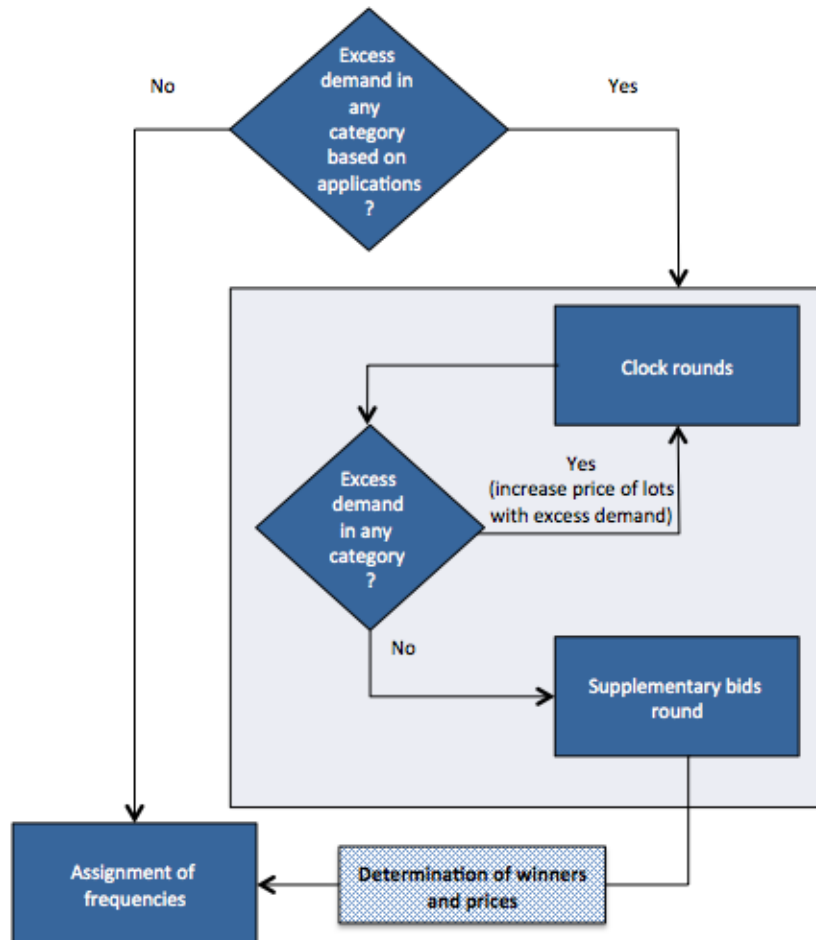
The highest value combination of feasible bids is declared the winning outcome.

As in the SBCA, prices to be paid for winning packages are determined through the use of opportunity cost pricing, with:

- each winning bidder (respectively each group of winning bidders) paying enough for its package to still win this package, given the value of feasible bids of other bidders; and
- winning bidders collectively paying enough for the combination of winning packages to still win, given the value of all other combinations of feasible bids.

If lots have been auctioned in lot categories and based on the auction outcome there is more than one alternative possible assignment of frequencies in one or more categories, the assignment of specific frequencies to winners in such categories will be conducted in a follow-up process.

This process is illustrated below:



SMRA

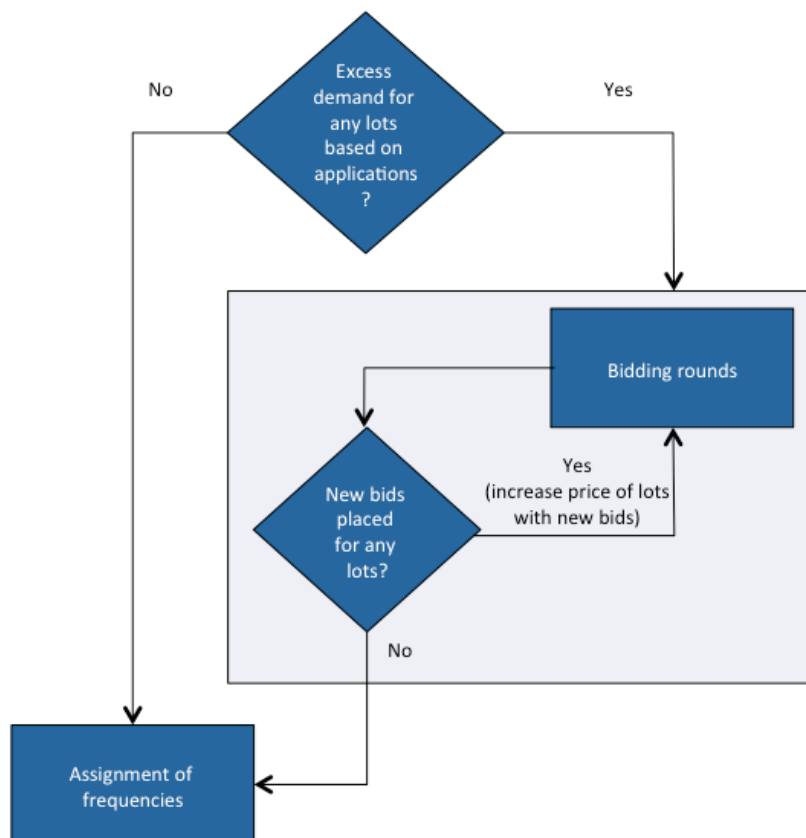
Mechanics of the auction

With this format, an auction for all lots available proceeds simultaneously as follows:

- In advance of the first round, the auctioneer declares prices that will apply during the first round.
- During the first round, each bidder may place a bid for one or more of the lots available, subject to any spectrum caps or other restrictions.
- After the round, the auctioneer assesses demand. For each lot, the highest bid received on the lot becomes the standing high bid on that lot, and the associated bidder is notified that it is the standing high bidder on that lot. If there are multiple bids for a specific lot at the round price, a tie-breaking rule is used to select a standing high bidder.
- In all following rounds:

- A new, higher price is set for those lots that received at least one bid at the previous round price.⁶¹ Price remains the same for all lots that have not received any bids at the most recently set price.
- During the round, bidders are able to place bids at the prevailing prices. A bidder's activity in a round is set by (i) the lots on which it has the standing high bid, as determined in some previous round, *plus* (ii) the lots on which it places a new bid in the current round. A bidder's activity can only be maintained or decreased in subsequent rounds; it can never increase.
- The auctioneer continues this process of declaring prices and selecting standing high bids until there is a round in which no new bids are made. At this point, the auction closes and standing high bids become winning bids, with those bid prices becoming final prices.

The process is illustrated below:



Note that while this auction format is a 'pay as bid' auction, winners are still only required to pay the opportunity cost of their winnings, as the price of each lot is set at the level at which competition for the lot ceases, the approximate value of the lot to the competition.⁶²

⁶¹ This is non-discretionary bidding, where the auctioneer sets the level of new bids. However, there are a number of variants of this, where bidders set their own, higher prices within certain constraints.

⁶² The actual value of a lot to a 'loser' will be somewhere in between the last price at which it bid for the lot and the next round price, at which it did not place a bid. The concept of opportunity cost becomes more complex with non-linear prices, multiple types of lot and/or unsold lots in the final round.

Building upon the 'traditional' SMRA format, some implementations have included more sophisticated features, for example:

- Frequency-generic lots may be used instead of frequency-specific lots, where lots of a similar nature (often, lots of the same size and in the same band) are aggregated into a single generic lot category. In this instance, bidders would be able to bid for a number of lots in a category, rather than explicitly for specific frequency blocks. In such cases, an additional assignment stage is necessary in order for winning bidders to bid for their desired frequency assignments. This removes the risk of winning non-contiguous frequency assignments within a lot category.
- Allowing a bidder to withdraw its standing high bid on one or more lots under certain conditions. This may help bidders seeking multiple lots to be able to switch between alternative combinations of lots in a single action.
- A staged activity requirement to allow bidders some flexibility during the early rounds, so that they may get a sense of relative prices before expanding their demand to all of the lots they wish to win. In the situation where bidders are interested in a number of alternative packages across different categories, this facility would allow them to hold back from committing themselves to certain categories until after some price information has been revealed. Nevertheless, the auction may not close until the activity requirement has been raised to 100% – that is, until bidders are required to express their full demand.

The precise context of a particular award is important in determining whether or not any additional SMRA features can be expected to have a beneficial net effect. These additional features may also bring the complexity of the SMRA to a level comparable to that of the CCA format.

Annex 4 – Feedback from joint BEREC/RSPG Workshop and from meeting with stakeholders.

In order to ensure RSPG had gathered as much input as possible to our work, the RSPG provided an opportunity to seek input from our BEREC colleagues and from industry stakeholders by holding a joint RSPG / BEREC Workshop in Brussels in November 2014 and focused on the experience of Member States, over the past 20 years, of holding spectrum awards. Additionally a meeting with the GMSA and Mobile Network Operators was held in December 2014 to discuss mobile operators' experience of participating in spectrum awards.

The workshop and meeting covered many issues relevant to the topic of spectrum awards. Some of the key points and themes that were raised are set out below.

Joint RSPG/BEREC Workshop (Nov 2015)

The Workshop was attended by members of RSPG and BEREC. Two external speakers were invited– Don Muldoon from DotEcon and David Salant from Toulouse School of Economics. In addition to the two external speakers, the workshop also provided an opportunity for a number of Member State representatives to present on their experience of spectrum awards.

Some messages and themes that emerged from the workshop include:

- Auctions are not the only way of awarding spectrum but they are increasingly popular and generally work well: they will continue to be the predominant method of award going forward.
- There is however no single right auction model and one size does not fit all. All formats (including SMRA, CCA and others) have merits depending upon circumstances.
- Identifying and articulating objectives up front is key – be clear about what you want to achieve and this will then help to inform auction design and other related decisions. This must be done within a robust legal framework.
- It is important to be transparent and to involve stakeholders in the decision making process. Careful and effective planning of spectrum awards is key to their success.

In terms of objectives, the following were identified

- Efficient use of spectrum (potentially including ensuring that all the spectrum be assigned)
- Enhancing Competition (including promoting new entrants/facilitating market entry)
- Increasing broadband penetration and promoting roll-out of broadband services
- Enhancing coverage in rural areas (regional development)

- Promoting innovation
- Promoting business opportunities and employment (economic development)

There are also some countries that have a specific objective to raise revenues or secure a reasonable return for the spectrum. However, while some countries include such an objective, others do not. Indeed, some administrations are explicitly prevented from considering revenues in undertaking a spectrum award.

The workshop also identified and considered some of the differences across Member States, including:

- License duration (which ranges from 15 years to indefinite)
- Different approaches to dealing with licences on expiry (as well as different dates for licence expiry)
- Many countries apply spectrum caps, some use set asides – David Salant however warned on the need to be aware of unintended consequences arising from caps or set asides – it was suggested by some that caps could be time limited.
- Approaches to promoting competition (e.g. over whether to mandate or incentivise MVNO access)
- Auction format: CCA, SMRA and single-round sealed-bid formats are most common but other options are also used (e.g. hybrid beauty contest/auction model in France).

Other topics discussed at the workshop included the effectiveness of spectrum trading, for example to resolve any inefficiencies in the award outcome. It was also noted that, while bands had different expiry dates across Europe, the expiry dates did tend to fall within certain clusters across countries.

Those that participated in the Workshop agreed that it had been a useful event and that there were benefits in sharing experience of spectrum awards across Member States. For example, it was noted that the risk of unintended consequences could be minimised by sharing best practice. Some Member States provided examples of where the auction experience in practice had not worked exactly as anticipated.

One point of unanimous agreement was that there is no ‘one-size fits all’, ie there is no single model that can simply be replicated across each and every Member State. Indeed even within a single country there will be different formats which will be most suitable to deal with different circumstances.

Meeting with MNOs (Dec 2014)

One point that the MNOs were keen to emphasise was their view that spectrum awards should seek to promote investment. The operators noted that they are global companies and, as a result, Europe was competing with other regions in terms of where and how much they invest. They also emphasised that 4G is not like 2G where operators initially invested heavily to roll out a network but were then able to sit back and take returns. Instead,

for 4G, operators need to invest constantly in order to keep up with increasing demand. They need to recover last year's investment as well as that of 10 years ago.

There was discussion of the need to distinguish between regulatory and political decisions. In particular, concern was expressed by some MNOs about situations where spectrum is awarded and then, at a subsequent point, political decisions are taken which impact the terms of the award. Coverage is one example of where this has occurred, imposition of wholesale access obligations is another.

The operators were generally supportive of auctions as a mechanism to award spectrum and also agreed that all auction formats have their advantages, depending upon individual circumstances. As with the RSPG/BEREC Workshop there was a clear view from the operators that there is no one-size that fits all.

One MNO was concerned by (what they described as) seemingly ever increasing starting prices. There was a particular note of caution against benchmarking as operators felt there was a tendency to benchmark against high final auction prices that had been achieved elsewhere which was leading to an escalation of starting prices. On the contrary it was pointed out that low reserve prices allow opportunity for price discovery which can be an important aspect of an award process. This will also mitigate the risk of spectrum remaining unsold. The operators were keen to emphasise the benefits to the economy of releasing spectrum in a timely manner which they noted would greatly outweigh any immediate gain from revenues raised.

There was some discussion of the recent trend towards multi-band awards. While this can offer advantages, at least one operator had a concern that it can put operators in a difficult position, especially where it includes spectrum being re-awarded at the end of a licence period. Effectively the operator was concerned that it is being put in a situation where it has no choice but to bid for (and win) certain bands.

An emerging theme from some of the operators was that European mobile markets were generally highly competitive and, as a result, it was no longer necessary for European Regulators to seek to promote competition. As indicated above, the operators felt this could be a particular problem when they had to bid for bands for which licences were expiring. The problem, they argued, can be made worse by spectrum caps and set asides. One operator argued that auction rules (especially reservation policies) need to be looked at more closely in the context of European competition policy.

On a related point, some operators felt that some administrations were too focused on attracting new entrants. At least one argued that, if administrations took such an approach to new entrants, they needed to take an equally flexible approach to companies wishing to exit the market. In short they wanted more lenient policies on consolidation. They noted that of the 20 new entrants that emerged between 2000 and 2003, only 6 remained.

There was discussion as to whether some Member States had a tendency to overcomplicate awards. Innovation is clearly important but there was concern that 'unnecessary' innovation and experimentation could have detrimental impact (through unintended consequences). One point on which all agreed was the need for clarity and certainty and the importance of giving bidders the tools well in advance so that they can be properly understood (one

example was given where a bidder had not acquired spectrum because they did not understand the rules, even though they wanted the spectrum and were willing to pay).

Some other points that emerged from the discussions included:

- A desire from the operators to see longer-term licence durations – they suggested this would address some of the problems they face with re-auctioned spectrum (by giving sufficient time to recover investment).
- Debate over when is the right time to award spectrum: on the one hand there was a view that making spectrum available as early as possible had to be a good thing, but on the other it was noted that awarding spectrum too early (well before it is actually available) can create uncertainty.
- A desire for greater consistency between spectrum policy and competition policy: one example given was decisions to introduce wholesale access obligations in markets which had been found to be competitive.
- Differing views on spectrum trading: it was noted that this has been quite effective in the US but has been less successful in Europe. There was some suggestion that trading might become more prevalent in Europe as markets mature and, potentially become more aligned. Others however were sceptical noting that spectrum is an MNO's most strategic asset and as such was the last thing they would be prepared to sell. It was noted that sufficiently long licence durations might facilitate greater take-up of trading.
- Lots of interest in the US plans for an incentive auction in the 600 MHz band but quite a lot of scepticism as to whether such an approach, even if successful in the US, could be replicated in Europe.
- The issue of how to defragment bands, especially with an eye on 5G: it was noted that trading and re-auctioning might help to defragment.
- Concern expressed by the operators about overly prescriptive coverage obligations. The Operators emphasised the need for flexibility to determine how coverage obligations should be met and certainty over how coverage will be measured (eg choice of handset). It was noted that local planning issues can often be one of the determining factors in terms of coverage.

Finally, all operators noted the importance of clarity and certainty as well as consistency with existing laws and regulations. All operators were in favour of spectrum managers sharing experience of spectrum awards and seeking to increase their knowledge base.