5G and mmWave spectrum

Regulatory approaches to the assignment of mmWave spectrum

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Introduction

The abundance of mmWave spectrum is presenting regulators with challenges as to how best to assign the spectrum

Regulators in many markets are grappling with the challenges of assigning mmWave spectrum. The abundance of spectrum means that demand may not exceed supply and so auctions may not necessarily be the appropriate approach. In this paper, Coleago examines some of the challenges facing regulators and looks at the approaches that have been used and are planned to be used to award mmWave spectrum. Our conclusion is that regulators need to be more flexible over their choice of award mechanism and potentially less prescriptive and demanding in terms of licence conditions. In addition, ensuring that spectrum trading can be facilitated will also be important for ensuring that the spectrum is being used as efficiently as possible.

Uncertainty in relation to 5G mmWave networks and the business case

Considerable uncertainty exists around who will use mmWave spectrum and what they will use it for

Usually, when a regulator plans a spectrum auction, they can be fairly certain that the "usual suspects," in the shape of the existing mobile operators, are likely to participate. They may be joined by an MVNO seeking to become "less virtual," and possibly a cable or fixed line business seeking to add mobility to its portfolio in an increasingly converged telecommunications market. This is not necessarily the case with the award of mmWave spectrum.

mmWave spectrum is expected to play a crucial role in realising the expected performance gains of 5G - low latency, high data speeds and large numbers of connected devices. However, there is considerable uncertainty about who will operate 5G mmWave networks and what customers will do with them once they are operational.

mmWave spectrum has poor propagation characteristics which are measured in the low hundreds of metres at best. This means that the existing mobile operators, with their networks of large, widely dispersed macro sites, are not necessarily best placed to deploy mmWave spectrum which requires a network of small cells. The inherent advantage that mobile operators' existing networks provide in deploying low and mid-frequency spectrum, is significantly reduced in the case of mmWave spectrum. This opens up the possibility of a much wider number of potential 5G mmWave network operators. Whilst traditional, large-scale mobile operators will be seeking mmWave spectrum to add a new "capacity layer" to their existing RAN, other potential players may include:

- new niche operators seeking to start new services including rural FWA, campus based super-fast broadband, host-neutral capacity expansion in public or private areas and WiFi replacement services in commercial / hospitality locations, business / science park areas, large-scale housing complexes, large-scale shopping areas etc;
- existing virtual operators who want to deploy highly targeted, on-net areas to reduce air-time costs for their existing customers;
- high security operators such as military bases, hospitals and emergency service locations;
- sports venues, stadiums and parks where large numbers of people gather and where venue and park owners may choose to establish their own networks; and
- common RAN operators, who currently provide shared towers and may move towards providing a net-neutral, very high capacity RAN in areas where service area competition has been reduced.

High levels of uncertainty need to be taken into account when designing the award process

If uncertainty about who will operate 5G mmWave spectrum networks is high, uncertainty over the mmWave 5G spectrum business case is even higher. South Korea is currently one of the most developed 5G markets in the world and yet the Korean operators are not entirely sure what to do with their mmWave spectrum, according to a recent Report.

In June 2018, South Korea awarded 800 MHz of spectrum to each South Korean operator in the 28 MHz band. According to the report, the spectrum will be used to provide business-to-business services but their plans for the business-to-consumer segment are yet to be agreed and any investment is not expected immediately, possibly not commencing until 2022.

Not knowing who the potential participants in the award process will be and uncertainty over their business plans means that regulators will potentially need to adopt a more flexible approach to the award process. Furthermore, that flexibility will need to be maintained even after the award process as business models are likely to evolve and the most economically efficient users of the spectrum may change.

Regulatory challenges in assigning mmWave spectrum

The conventional wisdom is that auctions are often the best practice approach to assigning spectrum

The economic orthodoxy in relation to spectrum assignment is that the use of spectrum auctions is best practice for the assignment of a valuable, scarce, natural resource. A well-designed and competitive auction should result in the spectrum being assigned to those that generate the greatest socio-economic benefit from its use – a typical regulatory objective in relation to spectrum management. The key requirement for an auction to deliver economic efficiency is that it is competitive. A competitive auction, however, depends crucially on the presence of scarcity where the demand for spectrum exceeds the supply of it.

In the case of mmWave spectrum, such as the 26 or 28 GHz bands, there is sufficient contiguous spectrum available that each operator can be assigned a block of between 500 MHz and 1,000 MHz and the regulator may still have some to spare. Furthermore, as we are increasingly seeing in a number of auctions, operators sometimes prefer to reduce their demand to end an auction early at lower prices rather than fighting for a disproportionate share of spectrum at high prices with potentially dubious benefits in terms of competitive advantage.

It is not obvious that auctions are the optimal approach to awarding mmWave spectrum

Given the uncertainties associated with 5G, many regulators recognise that most bidders will prefer to obtain a fair share or close to fair share of spectrum at the lowest possible price rather than competing for a larger allocation. Consequently, auctions for mmWave spectrum and possibly also for frequencies around 3.5 GHz, are unlikely to exhibit the competitive tension required to realise the benefits of auctions in terms of allocative efficiency. It is therefore not surprising that that those regulators that have assigned mmWave spectrum have adopted a variety of different approaches and that there is no consistency amongst the plans of regulators yet to assign mmWave spectrum.

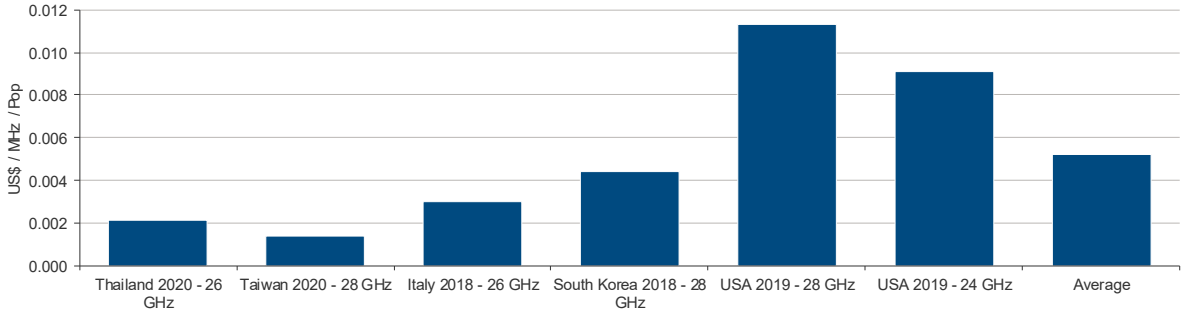
A number of regulators have already awarded mmWave spectrum

So far, relatively few operators have assigned mmWave spectrum

Relatively few markets have completed mmWave spectrum auctions in recent times. Auctions have been held in Australia (1999 and 2000), the United Kingdom (2000), Austria (2007) and Sweden (2009) but these awards focused on making mmWave spectrum available for Fixed Wireless Access services. The use of a different technology and the historic nature of these awards mean they would provide a poor guide to the value of 26 GHz spectrum allocated for 5G services today. Both Ireland and Greece have auctioned spectrum in the 26 GHz ranges in 2018 but these were for fixed links.

However, recent and relevant auction data is available from Italy (2018), South Korea (2018), the United States (2019), Thailand (2020) and Taiwan (2020). The results of these auctions are presented in the Exhibit below.

Exhibit 1: mmWave spectrum auction benchmarks



Source: Coleago spectrum auction database

USA 24 GHz and 28 GHz auctions

The United States held two mmWave spectrum auctions during 2019 in the 24 and 28 GHz ranges. Spectrum was awarded on the basis of regional licences and there were 55 winners across the auctions. The large, national operators AT&T, Verizon and T-Mobile secured the majority of the spectrum although Sprint did not acquire any spectrum across the two auctions. However, a number of smaller, local operators also secured spectrum: US Cellular; FTC Management Group (rural telecom company based in South Carolina); Nemont Communications (rural wireless operator based in Montana); LICT Wireless Broadband Company; LLC (a rural telecom with operations in parts of California, Iowa, Kansas and elsewhere); and Bluegrass Consortium (rural wireless network operator based in Kentucky) were amongst the smaller operators securing spectrum.

It is also interesting to note that spectrum was also secured by a start-up, Starry which paid $48 million to secure spectrum in the 24 GHz range to support its Fixed Wireless Access business targeting a small number of major cities. The acquisition represented a change in strategy for the company as it had previously been operating in unlicensed spectrum.

Italy 26 GHz auction

In Italy, 1,000 MHz of the 26 GHz spectrum was divided into five lots of 200 MHz and was auctioned in September 2018 via a Simultaneous Multi-Round Ascending auction format with a cap of two Lots or 400 MHz of spectrum. The five lots were all allocated, raising a total of 167.3 million Euros. Telecom Italia paid 33 million Euros for a single Lot, Illiad received another Lot for a little less at 32.9 million Euros, whilst Fastweb, Wind and Vodafone paid 32.6 million Euros each. The price represented a small premium (0.5%) to the Reserve Price highlighting a lack of competitive tension. Fastweb is an Internet Service Provider and is likely to use the frequencies to offer a fixed-wireless home broadband service rather than a true mobile offering which may be the approach adopted by the other bidders.

The licence duration was set at 18 years and winners are required to deploy the spectrum in all Italian provinces within four years. Italy adopted a “club model,” in relation to the band. Each licensee is allowed to use all the awarded spectrum (up to 1 GHz) in areas where frequencies are not used by other licensees although each license holder has pre-emptive usage rights on its assigned Lot. In addition, each licensee must provide wholesale access to other non-telco, vertical players for the development of 5G services. A further access provision also required that where an operator had agreed to deploy the spectrum in privately owned venues (e.g. ports,

airports, stadiums, arenas, national parks, etc.) then the operator must offer wholesale access to other operators to avoid foreclosure and the duplication of investment.

The licence terms were developed to provide operators and other potential users of the spectrum with a reasonable degree of flexibility to accommodate the uncertainty over where and how the spectrum will be used.

South Korea 28 GHz auction

In June 2018, South Korea completed an auction in which it awarded spectrum in both the 3.5 GHz and 28 GHz bands. The 28 GHz band comprised 2,400 MHz of spectrum packaged into 24 blocks of 100 MHz each and there was 10 block spectrum cap. Spectrum was awarded for a licence term of only five years. The three incumbents, SK Telecom, KT and LG Uplus all acquired equal allocations of 800 MHz at close to the Reserve Price.

Taiwan 28 GHz auction

Taiwan awarded spectrum in the 28 GHz band as part of a multi-band auction which included spectrum in the 1800 MHz, 3.5 GHz and 2.5 MHz ranges. 2,500 MHz of spectrum was available in the 28 GHz band, packaged into Lots of 100 MHz each with bidders subject to a cap of 800 MHz. The auction concluded in early January 2020.

The spectrum was won by the majority of the incumbents: Chunghwa secured 600MHz, while Taiwan Mobile, APT and FET obtained 200 MHz, 400 MHz and 400 MHz respectively and Taiwan Star did not win any spectrum in the band. The winner of each Lot will be required to install a minimum of 375 5G base stations, up to a maximum of 3,000. Winners paid a small premium of 3% over the Reserve Price.

Thailand 26 GHz auction

In 2020, the National Broadcasting and Telecommunications Commission (NBTC) offered 27 Lots in the 26 GHz range. All but one of the 27 Lots were awarded and they did so at the Reserve Price. The demand varied significantly between operators with AWN securing 12 licences whilst DTAC secured the fewest, with only two licences.

Summary of recent auctions

The majority of mmWave spectrum auctions have seen spectrum assigned at or close to the Reserve Price

With the exception of the US auction, all other mmWave spectrum auctions have resulted in spectrum being awarded at or very close to the Reserve Price. Furthermore, despite the potential for bidders from outside the industry to participate, the winners of the vast majority of spectrum remain the traditional mobile operators. The majority of the awards have, therefore, effectively been administered assignment at a regulatory determined price to incumbent operators. The Communications Authority of Hong Kong recognised the potentially low levels of demand for mmWave spectrum and elected to adopt an administered approach.

Hong Kong 26 / 28 GHz administered award

Hong Kong adopted an administered appproach

Across both the 26 and 28 GHz bands there is 4,100 MHz of spectrum available in Hong Kong. The Communications Authority (CA) concluded that, given the amount of available spectrum, it was unlikely that there would be competing demands for the spectrum and so decided to adopt an administered assignment approach.

The CA decided to award 3,700 MHz as non-shared spectrum for the provision of large scale public mobile services networks and 400 MHz on a shared basis for the provision of localised wireless services including fixed services. Spectrum was packaged into

Lots of 100 MHz with a cap of 800 MHz of spectrum per operator for non-shared spectrum and 400 MHz for shared spectrum.

The shared spectrum was assigned on a geographically restricted basis with applicants limited to deploying the spectrum within a 50 square kilometre basis for specific locations such as university campuses, industrial estates, airports, technology parks, etc. Holders of shared spectrum are not permitted to provide conventional mobile telephony services although Fixed Wireless Access was permissible. Holders are limited to providing innovative 5G services to specific user groups.

The applicants for non-shared spectrum were required to meet certain coverage obligations. An applicant acquiring the maximum spectrum permissible under the cap of 800 MHz, was required to install a minimum of 5,000 radio units within the first five years following spectrum assignment. The network and service rollout obligations would be reduced proportionately in accordance with the amount of spectrum assigned. During the five years: 20% of the radio units must be installed within the first one and a half years following spectrum assignment; an addition of 20% within the next one and a half years; an addition of 30% of radio units by the end of the fourth year; and an addition of the remaining 30% of radio units by the end of the fifth year.

To obtain spectrum, companies were required to meet pre-qualification and licensing criteria and the CA would determine, based on an assessment of overall demand, how much spectrum to assign to each applicant.

The pre-qualification process required applicants to state the types of service they would provide as well as demonstrating their technical, organisational and financial capabilities to fulfil the licence obligations as well as posting a deposit in the form of cash or a letter of credit issued by a qualifying bank.

The Hong Kong Spectrum Policy Framework requires that Spectrum Usage Fees (SUFs) should be applicable to all non-Government users of spectrum. Where spectrum is not released through auction or other market mechanisms, the SUF should be set to reflect the opportunity cost of the spectrum. If demand was sufficiently low, a level set at demand of 75% or less of available spectrum, then no SUF would be charged to reflect that there was effectively no opportunity cost.

If demand exceeded 75%, then the SUF would be calculated based on the Least Cost Alternative (LCA) approach for deriving the opportunity cost for the spectrum. The level of SUF for the non-shared spectrum was based on the existing charges for the use of fixed links or satellite uplinks. The shared spectrum charges were based on a much lower figure to reflect the geographically limited nature of the assignment.

The assignment process itself comprised two stages. In the first stage:

- for spectrum in the frequency band(s) with excess demand, each applicant will be provided with one frequency slot by turn for each round of distribution (i.e. x frequency slots will be distributed for x number of applicants in a single round);
- the above process will be repeated and the applicant whose demand is fully satisfied in a round of distribution will be excluded from the next round of distribution; and
- the distribution process will stop when the number of frequency slots available for distribution in the next round is less than the number of remaining applicants.

There will then be a second stage distribution where the remaining frequency slots in the frequency band(s) being considered will be distributed to the remaining applicants on a random basis.

Following the conclusion of the process, China Mobile Hong Kong Company Limited (CMHK), Hong Kong Telecommunications (HKT) and SmarTone Mobile Communications Limited were each awarded 400 MHz of spectrum.

As the total amount of spectrum assigned accounted for less than 75% of the total available spectrum in the 26 / 28 GHz bands, those awarded spectrum are not required to make any payments in relation to access to the spectrum.

Despite the spectrum being awarded free of charge, it was interesting to note that Hutchison Three declined to apply for spectrum. Local reports suggest that the operator deemed the coverage obligations to be too demanding given the limited availability of devices and uncertainty over the business model for mmWave spectrum. Recognising the low level of demand, Three's strategy may be to acquire the spectrum in the future when the market is more mature and devices more readily available and to delay the costs of meeting the coverage obligations.

Planned approaches vary significantly

A number of different approaches are planned to be used in Europe and elsewhere

Across Europe and beyond, regulators are at different stages of the award process. Some have not yet turned their attention to the award of mmWave spectrum, others are consulting with industry or have decided on their approach.

Countries currently consulting or having completed a consultation on the award of mmWave spectrum include Austria, Belgium, France, Germany, the United Kingdom, Portugal, Spain and Hungary.

Hungary

Hungary consulted on the award of 26 GHz spectrum during 2019, but due to the lack of interest and demand for the band, there are currently no plans to make the spectrum available.

Finland

Finland is currently in the process of auctioning three blocks of 800 MHz in the 25.1-27.5 GHz band for national, mainland use, with a starting price of EUR 7 million per block. The lower part of the 26 GHz spectrum, namely a block of 850 MHz from 24.25 GHz to 25.1 GHz, will be reserved for developing local networks, such as at ports and industrial complexes.

Sweden

In early 2020, the Swedish telecoms regulator, PTS, announced plans for the assignment of 26 GHz spectrum by 2021 at the latest. PTS said it will release 2400 MHz between 25.10 GHz and 27.50 GHz for block permits that are geographically limited to Sweden's largest built-up areas, and for local area coverage outside those areas. The spectrum will be available from 2025 and 2026 onwards following the cessation of the current fixed link operations.

Singapore

Singapore is also moving away from auctions for the award of mmWave spectrum

IMDA, the Singaporean regulator, has decided to make 5G spectrum (3.5 GHz and mmWave) available through a Call for Proposals (CFP). 5G operators will be selected based on the merits of proposals and their alignment with IMDA's policy objectives. The scoring and ranking of proposals will be based on:

- network design and resilience (40%);
- network rollout and performance (35%);
- price offered for one Lot of 3.5 GHz band (15%); and
- financial capability (10%).

The IMDA has determined that there is sufficient mmWave spectrum for all existing mobile network operators to acquire 800 MHz of spectrum each. In light of the likely limited levels of demand, the IMDA has not decided to impose any spectrum access fees other than annual spectrum fees.

Flexibility in assigning and managing mmWave spectrum

Given uncertainty, flexibility will be critical to ensure spectrum is assigned efficiently

Given the abundance of spectrum available in the mmWave bands and the relatively small number of mobile operators (three to four in most markets) who are likely to provide the majority of demand, regulators should consider alternative assignment procedures other than auctions.

The simplest option would be to administratively award a fair share of mmWave spectrum to each existing operator, subject to an annual spectrum usage fee based on the costs of spectrum management and possibly some minimum levels of investment. Such an approach will leave market forces to determine where and how the spectrum is most effectively used. This approach could be accompanied by a strategy of making additional, possibly shared, spectrum available to promote innovation and creativity outside of the traditional mobile market.

As a number of broader government policy goals may be supported by the deployment of 5G networks, it may be necessary to be more prescriptive in terms of licence conditions as these broader benefits may not be captured fully in the private valuations of mobile operators. If a regulator has a clear vision of the role 5G will play in its industrial strategy, then this can be reflected in more demanding licence obligations. However, given the uncertainties regarding the 5G business case, if the obligations are too demanding, this may result in some or all of the spectrum being left unassigned. If the existing mobile industry is expected to meet more demanding obligations then the regulator should be more circumspect about making additional spectrum available outside of the existing industry as this may result in obligations becoming non-commercially viable if those not subject to the obligations can capture value that would otherwise accrue to the mobile operators.

We may see a return to the use of some form of comparative assessment or "beauty parade" for the award of mmWave spectrum

A further alternative is to return to the approach of comparative assessments (sometimes referred to as "beauty parades"). If the regulator is uncertain as to how 5G might support the Government's broader industrial and social policy goals, potential users of the spectrum could be invited to prepare a "bid book" which would describe their investment and business plans designed to meet both Governmental and commercial goals. Spectrum would be awarded to those with the most compelling bid books. Such an approach faces the usual challenges of a comparative assessment which include a lack of objectivity in the award process, a possible lack of transparency and the need for the regulator to potentially pick winners. However, when spectrum is not scarce, the downsides of such an approach may be less of a concern.

Spectrum trading can provide an ongoing mechanism through which spectrum moves to its most profitable use

Whichever approach is adopted, regulators should ensure that it is accompanied by a spectrum management strategy that embraces and facilitates spectrum trading (subject to any competition concerns). The opportunity cost imposed by the possibility of a spectrum trade will provide the incentives for spectrum to move to its most efficient use over time.

Spectrum trading was first introduced in the late 1980s in the US and New Zealand and has since been introduced in many countries around the world. In Europe, regulation to support spectrum trading is widespread having been pioneered in Denmark in 1997. Many other European Union Member States subsequently introduced trading particularly after the European Commission actively encouraged spectrum trading in the Revised Framework Directive of 2009 (which covered the regulation of communications services more generally).

The potential downsides to trading should also be considered. Spectrum transfers could lead to a concentration of spectrum holdings resulting in a distortion of competition. Regulators in other jurisdictions have addressed this in a number of ways, e.g. a full competition assessment on a case by case basis, a two-stage process where trades are only reviewed if pre-published conditions are met, and spectrum caps.

Spectrum trading on its own may be insufficient to secure the optimal use of spectrum. The secondary market may not function as well as desired because:

- demand and competition for spectrum may be low;

- there may be significant transactions costs in trading spectrum which prevents trades that would be efficient from happening e.g. it may be costly for buyers to get all the necessary information on spectrum availability and quality to properly value spectrum if spectrum information is not published or available from the regulator; and
- a licensee holding spectrum that is idle or inefficiently used may prefer to continue to hoard it to maintain its market share, rather than allow a competitor to use the spectrum to compete successfully against the original licensee.

As a result, regulators may need other mechanisms to promote efficient spectrum use in the long term by having the option to re-assign the spectrum when substantive concerns about efficiency arise. Setting annual fees based on economic value for spectrum that has become scarce or congested but has been awarded by administered processes - i.e. administered incentive pricing or AIP - can also complement spectrum trading in promoting efficient spectrum use.

Conclusions

Regulators will need to re-think their approaches to assigning spectrum and be flexible in the case of mmWave spectrum

Uncertainty amongst regulators about how best to assign mmWave spectrum is almost as great as the industry's uncertainty over the business case for 5G. The absence of scarcity means that auctions are no longer the obvious choice for assigning spectrum. Regulators should be flexible about their approach to award mmWave spectrum and generally avoid being too prescriptive in order to allow the market to be as creative and innovative as possible. However, regulators should ensure that spectrum trading is possible to provide ongoing incentives for efficient use as well as being prepared to adopt additional measures to ensure the spectrum moves to its most valuable use.

About Coleago Consulting Ltd

Graham Friend, M.A., M.Phil., (Cantab), ACA, is an economist and the Managing Director and Founder of Coleago Consulting. Coleago is a specialist telecoms strategy consulting firm and advises regulators and operators on issues relating to spectrum, regulation and network strategy. Coleago has worked with a number of operators on 5G spectrum valuation and has confronted many of the challenges discussed in this paper. If you would like to discuss any of the issues raised in this paper, then please contact Graham Friend.

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