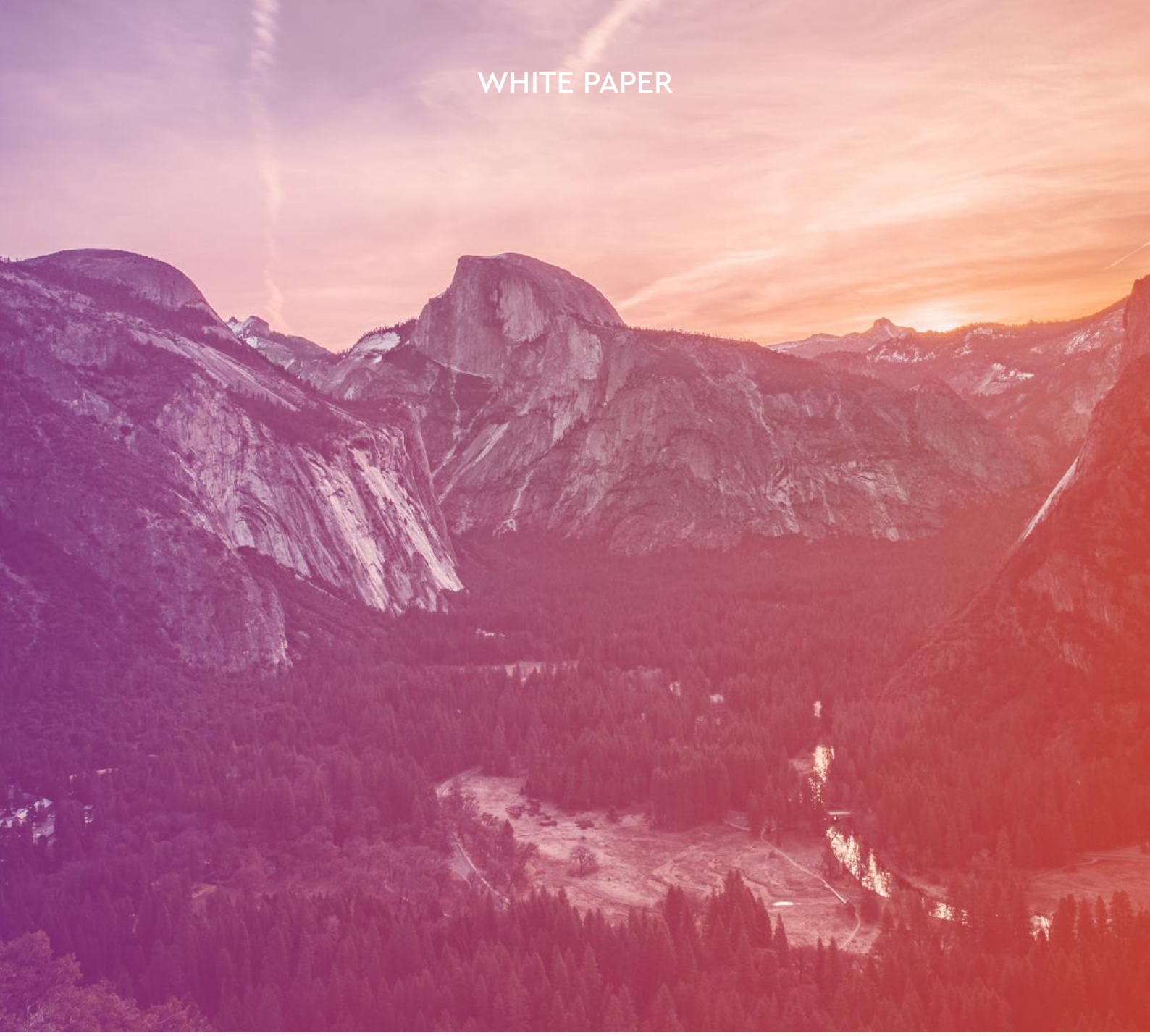
WHITE PAPER



5G-SPECTRUM SHARING

THE TIME AND TECHNOLOGY ARE RIGHT FOR INTRODUCING DYNAMIC SPECTRUM ACCESS NOW IN THE 5G PIONEER BAND AT 3.6 GHZ

NOMINET
SPECTRUM
MANAGEMENT

Contents

1. Introduction

Background

The Future Telecoms Infrastructure Review (FTIR) published by the Department for Digital, Culture, Media, and Sport (DCMS) in July 2018 places crucial importance on the development of 5G mobile technology, which will drive development and growth at a key turning point for the UK.

The direction set out by DCMS in the FTIR is timely and important. Nominet's whitepaper wholeheartedly supports the conclusion of the FTIR that a "market expansion model" is the best option for the future of 5G. A market expansion model is the way to unleash the potential of 5G in terms of investment, innovation, and availability; and to achieve exceptional mobile coverage and ultra-reliable, low-latency connectivity for billions of devices. These are crucial to making the UK a future world leader in 5G.

A market expansion model for 5G needs to build on the ecosystem's existing strengths while crucially making room for innovation. In this paper, we will set out a way to achieve this market expansion model and explore the possible alternatives.

What is the 5G problem that needs to be solved?

The current funding model for mobile investment is not sustainable. Mobile Network Operators (MNOs) have shouldered the weight of network development through the first four generations of mobile technology. However, in recent years the market has seen declining revenues and low growth. 5G will require an unprecedented scale of investment in order to position the UK as a world leader, and therefore a new model is required in order to bring about the overall increases in investment required for 5G, without hampering competition. It will be important to get the right combination of MNOs with the incentive to invest, and new businesses investing, innovating and contributing to the 5G ecosystem.

The current model is built around the cellular mobile industry, but 5G is about many other use cases. 5G mobile broadband will be required to provide the data backbone of the economy of the future. It will supply the Internet of Things (IoT): smart cities, autonomous vehicles and smart enterprises. At the same time, as DCMS's FTIR recognises, 5G is likely to develop in a different way to the "coverage-first" model which has characterised the previous generations of mobile networks. It will require a mix of technologies, be phased, and require the use of spectrum bands with different characteristics. If 5G is to be deployed quickly in line with the Government and Ofcom's goals, upgrades of existing networks, and deployment of small cells to provide for high-band 5G, are likely to require levels of investments far higher than those that MNOs are likely to be able to invest under the current model. This is not only a matter of network investment; it is a matter of innovation, which comes from the flourish of new players adopting new business models. Removing barriers will enable new players to enter the market and do something different to compliment what established players are currently doing. Small local players should be able to enter the playing field, compete, contribute to the overall infrastructure improvements, and provide new services which are currently not financially appealing for the large MNOs.

4G coverage is not widespread enough, 5G would be worse if we continue using the same model. Ofcom's latest Connected Nations report highlights that combined 2G, 3G and 4G coverage by all operators was at 77% of UK landmass in May 2018, while 6% is not covered by any operator[1]. If we look at 4G alone, the percentages are 64% and 11%, respectively. In other words, around 36% of the UK is still without 4G and the existing model risks moving the UK in reverse; many areas will still be catching up with 3G and 4G availability just as these services become ill-equipped to deal with the capacity requirements for the next generation of connected devices. The digital divide between better and less well-connected areas will be magnified.

A huge amount of spectrum is being wasted across the country. In the current model, spectrum won by one of the MNOs at an auction is held for their exclusive use. This means that in all areas of the country where the MNO is not deploying services, the spectrum that they own is sitting idle, when it could be used by others to provide much needed services to communities in the area. MNOs are being sold spectrum which is sitting idle, while other service providers are blocked from entering the market to provide much needed services. Change is urgent if the 5G future of the country is not to be irreparably damaged by continuing on this course.

[1]ofcom.org.uk/__data/assets/pdf_file/0019/122194/connected-nations-october-2018.pdf, p.10.

2. An alternative approach

The 5G spectrum market expansion model

The government has proposed in its Future Telecommunications Infrastructure Report (FTIR) that Ofcom should consider a market expansion model in the 3.6–3.8 GHz band to solve these problems and prepare the UK to be a world leader in 5G. It comprises two different but complementary competition models, side-by-side, to reflect the reality that the UK comprises broadly of two different sorts of demographics side-by-side.

- The first demographic zone comprises relatively compact geographic centres of population, "relatively" low cost to provide 5G coverage and where the policy priority can be to promote competition between the MNOs.
- The second demographic is a much larger zone, with a much lower density of population, where it is relatively expensive to provide 5G coverage and the policy challenge is to secure any infrastructure investment from anyone.

Having one national policy for both zones leads either to falling between two stools or worse, one policy objective not being met at all. That is a very real prospect for the coverage of 5G enhanced mobile broadband infrastructure to serve the over 9m consumers and citizens living in rural communities.

The market expansion model needs two different means of releasing 5G radio spectrum; the first for the MNO competitive zone. This is best delivered by a spectrum auction as a means of arbitrating between the demands of competing MNO's. The second is for the expansion zone. This needs a different approach that will deliver spectrum at a much lower price. But it has to be spectrum from the same 5G pioneer band, as that is where global volumes are now being generated that will drive down costs. This capability will end up in every new smartphone, at every price range, as well as in many other devices in the future. This market expansion model is illustrated in Figure 1.

As illustrated in Figure 1, it is important to note that MNOs do not lose out from creation of the expansion zone. In fact, they can benefit from it, both financially and from the increased innovation injected into the digital ecosystem which, in turn, creates further opportunities.

Figure 1: DCMS 5G market expansion competition model.

The spectrum model to enable this "market expansion model" outer zone itself comprises two components: opportunistic dynamic spectrum access and light licensing of an "anchor" of spectrum. The detail of the model proposed is at Figure 2.

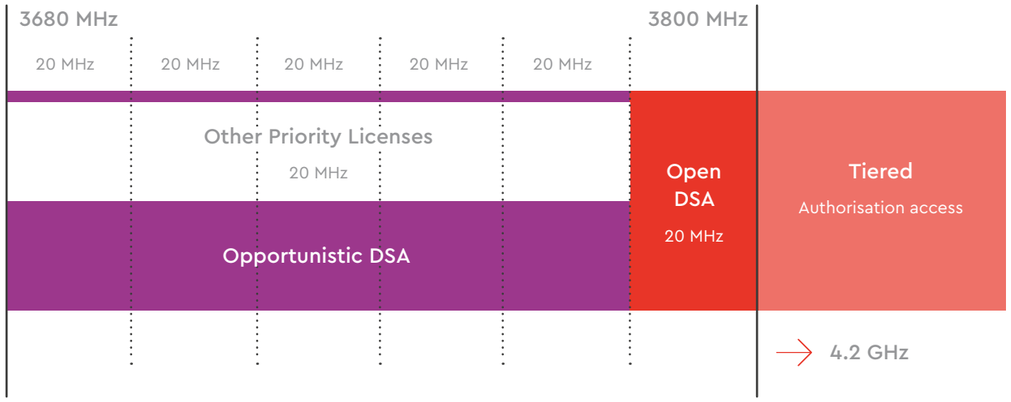


Figure 2: Proposed spectrum allocation approach for the market expansion model.

Opportunistic Dynamic Spectrum Access

Dynamic Spectrum Management (DSM) is an approach to improve the efficiency of wireless spectrum usage with a centrally co-ordinating database. Applying an opportunistic Dynamic Spectrum Access layer across all of the auctioned spectrum in the band would open up the potential for sharing the spectrum asset that would otherwise lie idle. Dynamic Spectrum Access can drive a leap in the ecosystem efficiency. It does this by:

- Allowing all of the scarce 5G pioneer band spectrum at 3.6 GHz to be brought into play at every location. This can deliver an increase in capacity and data speeds as the MNO coverage road maps diverge.
- Allowing new players to use the spectrum, on an opportunistic basis, in areas the mobile operators are not operating. This delivers a gain in geographic spectrum efficiency. Traditionally it has been assumed that rural coverage is challenging in business case terms due to the low population density available to fund cell site investment. However, this stems from a low mean population density. Closer inspection of population distributions (Reference 1) show that the vast majority of the rural population lives in clusters – small towns, villages and hamlets – where the local population density can be at suburban levels. To meet these needs cost-effectively, cells which can deliver coverage and capacity to small areas are needed at the lowest possible cost. This is a reason to use spectrum where the largest global volumes are being generated.

An additional benefit of a DSA database approach, is that it enables flexible protection of incumbent users of spectrum. For example, Ofcom has commenced the process to revoke fixed links licences by December 2022. It is also varying the grants for Recognised Spectrum Access (RSA) for satellite earth stations so that, from June 2020, Ofcom would no longer take into account registered satellite earth stations with a receive component in the band for frequency management purposes. DSA provides a great deal of flexibility for protecting these incumbent users of spectrum and then opening up their spectrum as and when this protection is no longer required.

Lightly licensing some 5G spectrum (e.g. 20 MHz)

To make best use of the market expansion zone, it is important to give thought to security of tenure for new entrants to the market. Over rural Britain the probability of any mobile operator providing coverage is low and the probability of all four mobile operators turning up is negligible. But the fact that it might happen will chill investment. The "market expansion model" solves the problem by making available to the market a small amount of anchor spectrum that will be open on a shared basis. It needs to be priced to match the very fragile business models in rural areas but at least cover the cost of running the supporting database access management service. The government does not specify an amount in the FTIR but 20 MHz (5% of the 5G pioneer band) would be a good working assumption and that is the reason for this number in Figure 2.

What this would mean in practice?

Figure 3 shows an area of Lincolnshire. We have used WaveDB, Nominet's global platform for dynamic spectrum management, applied to the 3.6–3.8 spectrum bands soon to be auctioned, to project potential coverage. We have assumed that all MNOs roll out the 5G spectrum immediately on all masts currently providing 4G signal as of 2012 – this is obviously highly unlikely, but is a very optimistic maximalist view of how the 5G spectrum could be used by the MNOs. It is important to note that we chose this area entirely at random – there are thousands of comparable areas throughout the UK where a similar picture would apply.

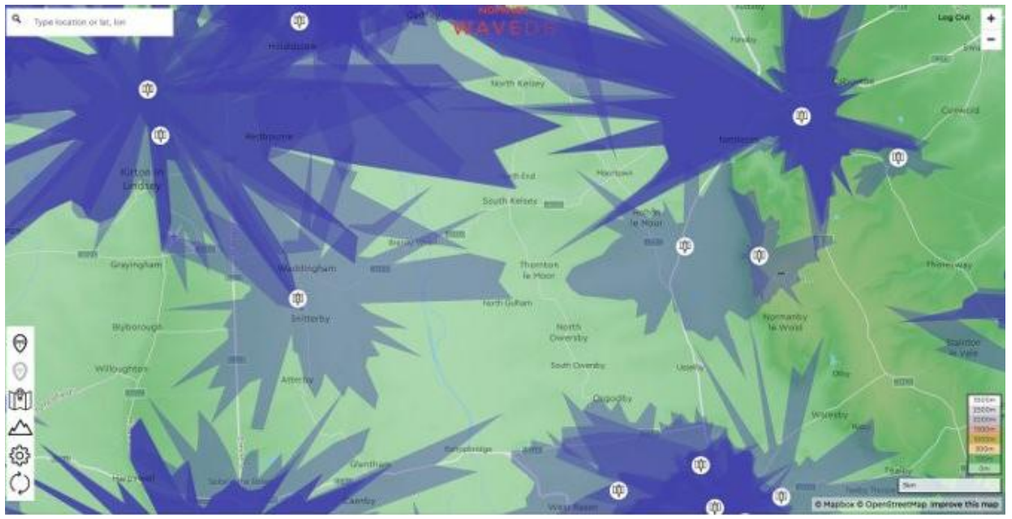


Figure 3

The example shows that North Owersby (among several other villages) is a gap in everyone's network coverage. A use-it-or-share-it approach allows the village to invite an ISP to set up its own microcell in an MNO's 20MHz of spectrum, fitting between the areas where the MNO is actually providing coverage. This is shown at Figure 4.

Figure 4

In addition, the ISP can use the 20MHz anchor spectrum to set up a larger, higher-powered cell, which serves two functions: it extends coverage to other communities in the area, and provides a backstop so that if the MNO decides to extend its use of spectrum in the future, the local network can continue to function (see Figure 5).

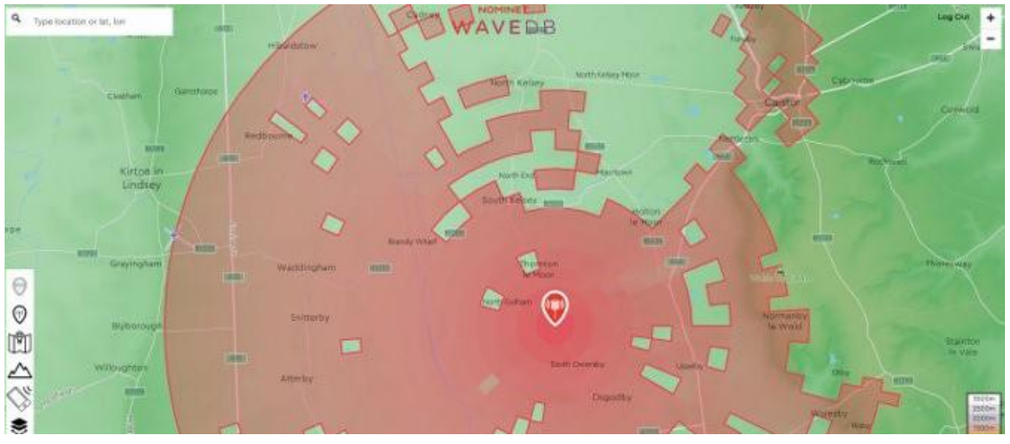


Figure 5

Finally, even in heavily urban environments, there are benefits from this market expansion model. The example in figure five shows how small gaps in coverage can be shared; here a South London high school can establish a private/indoor femtocell without disrupting the incumbent network's operation.

Figure 6

3. Alternatives to the proposed approach

Alternatives to a market expansion model set out above, which could help to achieve better coverage and geographic spectrum efficiency would be:

- Impose a coverage obligation. This won't work at 3.6 GHz as finding a meaningful value, for example 80% of the population, would lead to nobody bidding for the spectrum. A "Dutch" auction could find a market value for the coverage obligation, but it is likely to be so low as to offer little gain in geographic spectrum efficiency.
- Impose a use it or lease it option. Using this model, license holders would be able to lease their spectrum. However, there is no evidence of a liquid functioning spectrum trading market in 4G spectrum and no grounds for believing one will emerge for 5G spectrum. There have been proposals to force spectrum owners to lease spectrum where they are not using it (use it or lease it). A parallel would be a house owner forced to lease a spare bedroom to a social tenant. That reduces their future flexibility and impairs the capital value of the house. It may work but is very draconian. It also makes it extremely difficult for bidders at spectrum auctions to put a value on their bids.

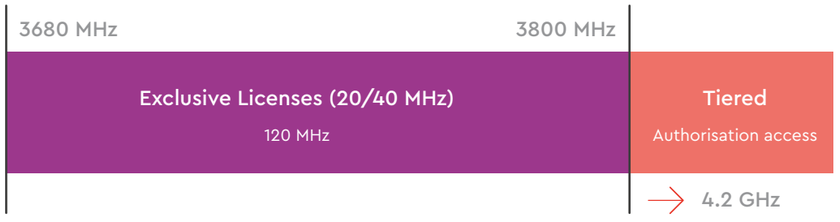


Figure 7: Status Quo

Some form of market expansion model therefore seems to be essential to success in 5G. However, the argument could be made that the market expansion model proposed above is too far to leap at once. Nominet has therefore set out further options below that would realise some of the benefits, while creating a pathway to further innovation in the future.

- DSA rights for licensed users only. This helps the MNO to access on an opportunistic basis a much larger amount of spectrum wherever other licence holders are not operating. Whilst this approach enables some of the benefits of the market expansion model, these are more limited due to the constraint of depending on MNO decisions to release spectrum. It does not provide any incentive for new players to serve areas not currently covered by any MNO.

- DSA rights but without any 20 MHz of anchor spectrum. The argument for this would be that there is a finite amount of spectrum and the MNOs will struggle to create channels of sufficient strength. Removing the anchor frees up more spectrum for auction.

  The problem with this approach is that it leaves uncertainty by removing a backstop, as described above, which risks chilling investment from alternative providers.

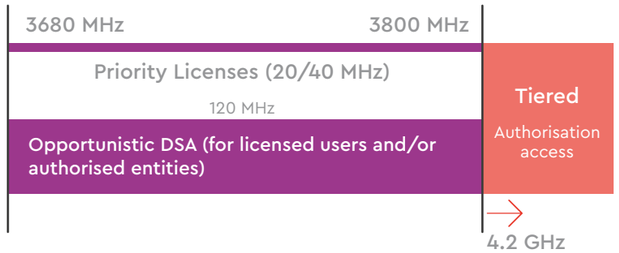


Figure 8: Spectrum allocation approach where winners of the auction or authorised entities can opportunistically make use of the spectrum, if not used by other licensees.

4. The underpinning database technology needed is tried and tested

With the exception of coverage obligations, all of the options explored above rely on Dynamic Spectrum Management (DSM). This is an approach that can improve the efficiency of wireless spectrum usage through databases. By understanding the current and intended usage, DSM enables spectrum to be maximised more effectively than with a single-user approach. Using a geo-location database containing details of assets and rules, DSM enables spectrum to be allocated in real-time, based on the location of the user and other considerations, such as radio parameters and type of usage. As a result, DSM improves efficiency of spectrum use, opens up new market opportunities and enables wireless advancements for businesses.

Importantly, DSM is a robust and proven technology. Ofcom has overseen the successful implementation of DSM databases for TV White Spaces (TVWS). Using DSM to manage usage of the spectrum, TVWS radios offer broadband speeds over several kilometres, and the signal can travel through permanent obstacles such as trees, as well as across challenging terrain. Today, DSM is being used in several countries to ensure that spectrum can be used more effectively, with no interference towards other licensed users.

The TVWS experience has ensured DSM is now a tried and tested method of enabling a tiered sharing framework. Crucially, Ofcom is familiar with it and sees it as meeting the objective[2] of "enabling new players to innovate and enable shared use of the spectrum." This means we have a proven effective solution at hand; one that would take little time to implement in other bands as a result of our extensive experience.

The work being undertaken in the US under the CBRS framework will also provide confidence in database management technologies to support spectrum sharing. The CBRS framework is based on three-tiered spectrum sharing, and is designed to ensure coexistence with incumbent users who cannot provide any information "a priori" to a central database, and other users, where some might require priority over others. Incumbents are generally military services using networks operated close to coastal areas. It's worth noting that the system in use in the CBRS was originally designed for usage in a specific frequency band, but the basic operational principles are "frequency-agnostic" and can be used in other bands.

[2] *ofcom.org.uk/__data/assets/pdf_file/0019/108604/Review-of-the-authorisation-regime-for-spectrum-access.pdf, p.4*

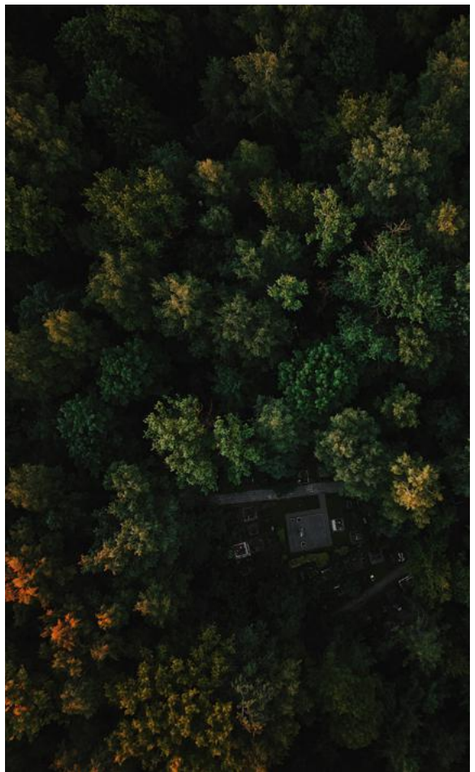
A further reason to be positive about DSA for 5G is that Ofcom has already set out the regulatory framework for spectrum sharing and indicated that it recognises the important role of spectrum sharing in facilitating innovation. Ofcom referred to tiered access in its Framework for Spectrum Sharing of 2016 as one of the authorisation tools to adopt in order to deliver optimal spectrum use; this is in line with Ofcom's Spectrum Management Strategy, which foresees a combination of market mechanisms and regulation as a means to achieve it. One of the incentives to share is the creation of 'tiers' of users, which are a hierarchy of different categories of users in a given frequency band.

Not only has Ofcom been one of the first regulators in Europe (and in the world) to authorise database-enabled use of TV White Spaces, in which Nominet has already been playing an important role as a trusted and reliable database provider; it has also approved a framework for spectrum sharing in 2016, which supports the regulator's assessment for sharing opportunities. We believe this framework is already able to support sharing for 5G purposes adequately; it would be possible to put it to use very quickly. Setting up a sharing framework would take up less time and effort than usually required to design and run an auction.

5. Conclusions: Making the UK a world leader in 5G will require a new approach

In this paper we have set out our support for the market expansion model and for the importance of a new approach to spectrum for 5G. This approach will unlock a wide range of benefits:

- **Speed:** The market expansion approach set out can unleash the benefits of 5G extremely quickly. In the traditional auctions model, roll out of 5G must wait until each MNO rolls out its coverage across the country. As experience with previous rounds shows, this happens with varying speed depending on the perceived financial incentives linked to coverage. The market expansion model would mean that ISPs could immediately be injected into the ecosystem, immediately providing coverage in areas that MNOs will not get to and adding new innovative use cases. Developing a database to support the mixed approach would take very little time given that it is a tried and tested method, as set out above.



- **The economy:** Sharing will lead to short-term and long-term economic gains. Successful roll out of 5G will boost the UK economy, particularly if we are a first mover. More rapid roll out `across the country therefore increases the economic dividend. Opening up use of otherwise fallow spectrum across the country also has the potential to boost the economy, by creating a whole new ecosystem of ISPs and new entrantservice providers using the data services created.

  The interim report of the Future Communications Challenge Group of January 2017[3] estimates that the economic impact of 5G in the UK could be around £112bn in 2020, rising to £164bn in 2030. If the UK was to lead technology development in 5G, such impact would go up to £198bn in 2030; about 5.7% of the UK's GDP. In other words, failure to ensure UK leadership in 5G would result in missing the opportunity to create £173bn of incremental GDP over the 10 years 2020 to 2030.

- **Nationwide connectivity and growth:** Spectrum is a critical asset for 5G. Its increasing scarcity makes it even more crucial – we cannot afford to use it inefficiently in the UK. The stark rural-urban divide in coverage means that if we keep the current approach to spectrum awards, we are likely to continue to have regions of the UK where spectrum is awarded but unused. This translates into missed opportunities, and in turn into missed growth across the country.

Nominet strongly endorses a market expansion model as the way to deliver a world leading 5G future for the UK.

[3]https://www.gov.uk/government/publications/interim-report-of-future-communications-challenge-group-uk-strategy-and-plan-for-5g-digitisation

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