Rural Britain needs a new spectrum model to drive modernisation of the rural economy

Co-authors:

Bob Stewart - University of Strathclyde
Dani Anderson - University of Strathclyde
Dave Happy - Telint Ltd
David Crawford - University of Strathclyde
Desmond O’Connor – Origami Networks
Dr Pasquale Cataldi – Nominet
Karina Maksimiuk - Agri-EPI Centre Ltd
Malcolm Brew - University of Strathclyde
Prof. Stephen Temple CBE - Visiting Professor to the 5G IC, University of Surrey
Tim Brown – University of Surrey

5G RuralFirst

Executive Summary

The importance of the 5G pioneer band 3.4-3.8 GHz to the rural community is examined in some detail. The case is made as to why a traditional approach to the release of 5G spectrum will leave rural Britain out in the cold in terms of the transformative benefits of 5G. Some alternative options are looked at and the conclusion is reached that the “market expansion model” set out in the Government’s Future Telecommunications Infrastructure Report is the best option. Some use cases are presented that show opportunistic dynamic spectrum access offers more than enough bandwidth to meet the rural use cases but a small amount of anchor spectrum, to be lightly licenses on a first come first served basis, is essential to create viable investment conditions for the market expansion model. The paper shows why an amount as little as 20 MHz is sufficient when coupled with opportunistic dynamic spectrum access rights. Such an amount is 5% of the 5G pioneer band at 3.6 GHz and would be a sound national investment likely to offer a good return from a more productive rural economy.

1. Introduction

The purpose of the DCMS & industry funded 5G Testbed projects is to be pathfinders for harnessing the benefits of 5G to modernise industries and improve the on-line lives of citizens and consumers. The challenge of achieving this in rural Britain is recognised in the Institution of Engineering and Technology (IET) report, 5G Networks for Policy Makers [4], which observes that “the greatest network infrastructure challenge of the 5G era will be coverage.” This project is looking at three rural testbeds, throughout the United Kingdom from the Orkney Islands to Somerset. The Orkney Islands testbed is looking at how spectrum can be shared at 700MHz and 3.5GHz and 26Ghz. (including at sea - within UK territorial waters), whilst in Somerset and Shropshire 5G agri-tech solutions are being developed that push the boundaries of connectivity coverage, speed and latency. This White Paper focusses specifically on the spectrum problem to be solved for high capacity rural 5G networks at 3.6 GHz.

This whitepaper represents the views of the individual authors on the spectrum lessons that have emerged from the 5G RuralFirst project, and are in line with the project findings, but does not commit the project collaborators or partners to those views.

2. Significance of the 5G Pioneer Band at 3.6 GHz

Radio spectrum is often referred to as a “scarce resource.” In fact, if one takes the entire electromagnetic spectrum and its potential for reuse, it is not actually that scarce. The scarcity comes from overlaying various constraints that turn spectrum into valuable mobile products and services within the financial reach of almost everybody on the planet. The most important of these constraints is global harmonisation of spectrum bands suitable for mobile services. Next comes global standards written to work within these bands. Finally, in today’s market, comes the choice made by a handful of the large system vendors, chip vendors and smart phone suppliers as to which specific bands to invest large amounts of development resources into. The result delivered into the huge global market creates massive scale economies and therefore low-priced cell transceivers and compatible consumer devices. Radio spectrum that falls within the constraints outlined above is scarce.

This explains why the 5G pioneer bands identified across the European Union (“EU”) are of considerable interest. The mere identification of these bands has changed the direction of 5G since 2015, with a particular focus emerging across the world on the band 3.4-3.8 GHz but also with 26/28 GHz and 700 MHz being essential spectrum band tools to deliver the full capabilities of 5G.

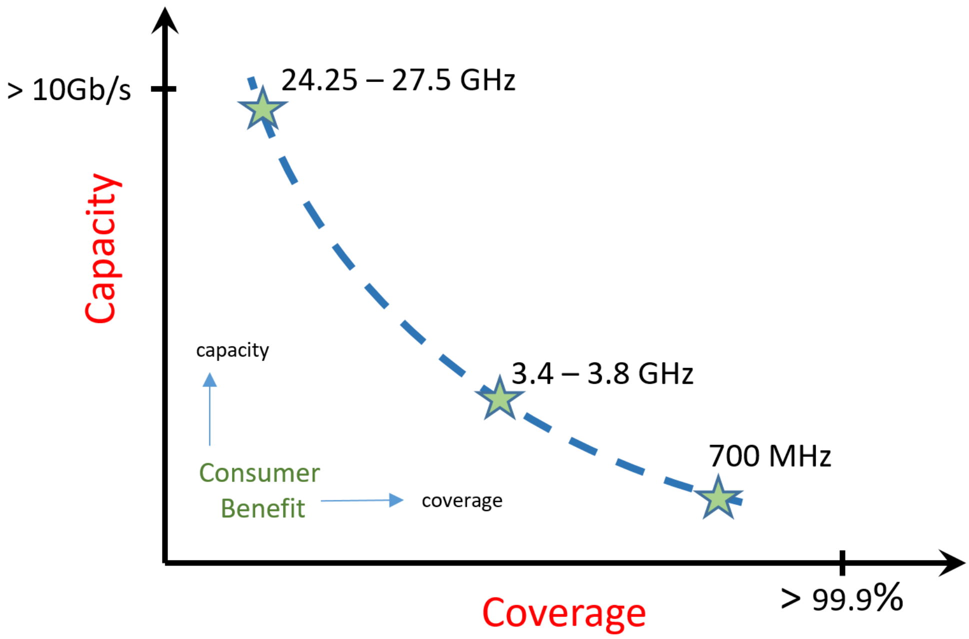

Figure 1 – Qualitative illustration of coverage and capacity versus frequency. Source Euro-5G [1]

The fact of there being three bands reflected the very first formal recognition that it was no longer possible to rely on a single spectrum band to solve every problem faced by public cellular mobile networks. When they were first rolled out in the UK, the band at 900 MHz was a universal solution to achieve both coverage and capacity.
When the band at 1800 MHz was introduced it was to allow more mobile operators into the market to provide identical services to the 900 MHz operators. The economic challenge of doing this at 1800 MHz was recognised by regulators and for a period higher termination rates were granted to the 1800 MHz operators to help subsidise the higher cost of wide area coverage. When the band at 2.1 GHz was introduced for 3G, few recognised that "universality" was going to start to break-down. A decade of consumer complaints about poor 3G coverage followed. This had nothing to do with the 3G technology but the choice of 2.1 GHz. Regulators had to tighten up the coverage obligation and this has proved a challenge.

The arrival of 4G saw, for the first time, a band lower than the prevailing cellular bands introduced (800 MHz) along with a band higher (2.6 GHz). A coverage obligation was imposed on one of the 800 MHz licenses with the expectation that competition would drive the other licensees to follow. But no thought was given, at the time, to imposing any sort of coverage obligation on 2.6 GHz. Exclusive national licenses were granted nevertheless.

This was a turning point for cellular mobile spectrum but it was never properly recognised. The first formal recognition that more than one band was now essential to deal with the divergent demands for coverage and capacity came out of a Horizon 2020 project Euro-5G [1] in which the University of Surrey participated. A very insightful illustration in Figure 1 emerging from this work that neatly illustrates the problem to be solved in the 5G era.

This is the reason for the choice of the 3.4-3.8 GHz as a 5G pioneer band – to try to find the optimal spectrum band point of maximising the conflicting characteristics of both "coverage" and "capacity". What is encouraging is that first in Europe and almost simultaneously in other parts of the world, the industrial momentum has built up behind the 3.6 GHz band. What remains an issue is what happens to 5G coverage "beyond the natural limits of commercially viable coverage within the traditional regulatory framework"?

3. Why traditional approaches to spectrum management policy aimed at a majority of the population will leave rural Britain out in the cold in the coming 5G era.

Ofcom has a duty to citizens and consumers, so it is perfectly reasonable for Ofcom to focus on ensuring coverage where the majority of people live. There is a long history of coverage obligation being attached to the release of spectrum to achieve this:

- In 1985 the GSM (2G) licences had a coverage obligation to cover 60% of the population which translates into around 10% of the UK' land area
- In 2000 the 3G licenses included coverage obligation requiring the mobile operators to cover 70% of the population or 15% of the UK's area.
- In 2010 the Government directed Ofcom to increase this obligation further, requiring operators to cover 90% of where the UK population lives or 45% of the UK's area.
- That proved a huge stretch for the industry and one mobile operator failed to meet the deadline. The policy flaw was also in specifying the obligation in terms of where people live whereas mobile connectivity is, at its most indispensable, when people travel to and from their homes and places of work.
- In 2013 one licence for 800MHz spectrum had an obligation for 98% of the population and 95% of the geographic area of the nations. This leap was only possible by going down in the spectrum below 900 MHz and the sacrifice was in the potential capacity.
- In 2013 the award of spectrum at 2.6 GHz was given out on a national basis but with no coverage obligation or expectation of national coverage. The roll out has been driven by locations of capacity peaks rather than contiguous coverage business objectives. This has naturally led to vast areas of the UK where the spectrum is unused.
- In 2018 The award of spectrum at 3.4 GHz was given out on a national basis but again with no coverage obligation or expectation that the market will deliver national coverage. In fact, the 5G pioneer band planners did not envisage coverage at 3.6 GHz extending much beyond urban areas. The national exclusive licences prevent anyone else contributing to coverage. It leaves a problem…how will rural 5G coverage ever be provided?

Ofcom are on the case to extend very basic connectivity at 700 MHz (2 Mb/s). That is to be welcomed. However, it only gets rural Britain to where they should have been 10 years ago and falls two orders of magnitude below where the rest of Britain will be 10 years from now. Ofcom have no policies in place to meet rural Britain's need for high capacity 5G

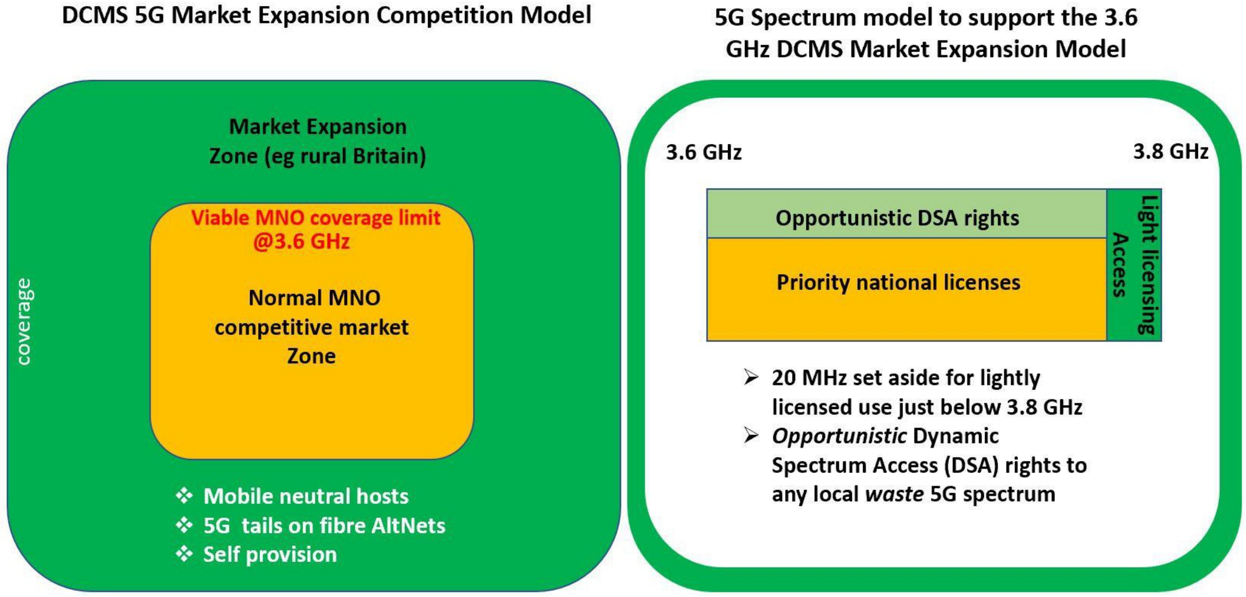

Figure 2 – *Simplified Illustration of Spectrum Allocation between licensed, DSA*

infrastructure on a comparable time-scale to that of urban Britain.

The Government recently published their Future Telecoms Infrastructure Review (FTIR) in which this question has been examined in depth. They have concluded that the best solution is what they term the "market expansion model" [para 221]:

This is a "big idea" as it offers a spectrum policy framework matching the circumstances of rural Britain in a way that is complementary and not in conflict with Ofcom's traditional approach. It proposes a spectrum supporting framework. The yellow competitive market zone gives priority to national licenses where spectrum is allocated for providing broadband service by MNOs within a viable coverage limit in urban and built up areas, while the green zone is providing market expansion in locations where there is unused (or wasted) spectrum, which could be accessed via opportunistic DSA, while for areas where such spectrum is occupied, some spectrum is proposed to be set aside and reserved for semiopen access (SOA) as an "anchor" band. This solution would provide the spectrum access for specialist use cases such an indoor factory requiring exclusive spectrum or a rural location with requirement to exclusively access remote controlled agricultural equipment.

4. Alternative Options to the FTIR market expansion model?

In reviewing options, the starting point should be to examine whether a continuation of the status quo of Ofcom auctioning the spectrum on the basis of national licenses is likely to solve the problem of rural 5G enhanced mobile broadband coverage?

Option 1	Option 2	Option 3
Exclusive national licensing only Rely on spectrum trading	"X" MHz lightly licensed for new entrants (eg X=20 MHz) + opportunistic DSA to 200MHz	Spectrum sharing as something for the future (Next chance in the 3.8-4.2 GHz)
Spectrum limited to MNO's own	**More complex to organise**	DSA opportunity could be wider
Could happen now	**Implement in 2019**	Likely to be 5 years away
Spectrum trading has poor record	**"X" MHz guarantees access**	No certainty of change
No mechanism of fair pricing	**Very low cost entry**	3.6GHz spectrum waste remains
Spectrum waste over 80% of UK*	**Puts spectrum waste to good use**	

Table 1 – *Proposed options for 3.6-3.8 GHz for access to capacity.*
Description given in black, advantages in green, disadvantages in red

This is shown as Option 1 in the table. The merit of the status quo is that 5G pioneer band spectrum exists today below 3.6 GHz. The theory put forward by economists when the market approach to spectrum first emerged was that a market in spectrum would emerge where unused spectrum would be freely traded. It would offer enterprises a fast means to readily acquire the spectrum they needed. A decade and a half later the theory has been comprehensively disproved. The Ofcom spectrum trading register shows a total absence of a liquid market in harmonised cellular mobile spectrum. This is unlikely to change in the future. The reason is that trading pieces of their spectrum at different geographic locations limits the future flexibility for an MNO and impairs the capital value of the spectrum. There is no sensible price point that makes sense and least of all in rural areas where the market has already decided that coverage is unprofitable. It is more trouble than it is worth and certainly not off-setting the loss to the trade-in value of clean national spectrum. Indeed, a self-help community group wanting to self-provide a 5G cell in a village and raising money at jumble sales to pay for a spectrum lease will hardly meet an MNO cost of raising an invoice.

Another option is to postpone the role out of 5G coverage in rural Britain by alternative providers and self-help groups until spectrum can be released just above 3.6 GHz. This is shown as Option 3 in table 1. The release of another 400 MHz of spectrum (3.8-4.2 GHz) would certainly go some way to bringing down the price of spectrum. From a dynamic spectrum access viewpoint access to 400 MHz would be more attractive than access to 200 MHz possible in the 3.6-3.8 GHz band. But the option has a number of drawbacks:

- There is no time-scale for when it might happen. It is not just a question of spectrum release by Ofcom (although that is complex enough with the incumbent services in the band) but when the global eco-system would main-stream it into a flow of inexpensive devices and beyond that, when devices will have diffused into the consumer base to drive traffic onto cells working in the band. It could be as much as 5-7 years away.
- There is also uncertainty whether the Treasury's need for a flow of revenues from

spectrum auctions will not lead to the same outcome we have seen in the 3.4-3.6 GHz band where new entrants are priced out of the auction.
- There remains doubt on the availability of a choice of 5G devices at all price points that come with the most widely deployed 5G band in the world.
- The final down-side of postponing a solution to access to 5G spectrum in rural areas is that it leaves unchallenged the huge geographic waste of spectrum. Waste of a valuable resource on this scale is not good for the economy and certainly at variance with Ofcom's duty to ensure efficient use is made of the radio spectrum.

This leaves the proposition set out in the Government's Future Telecoms Infrastructure Report in paragraph 221. This is shown as Option 2 in Table 1 and illustrated in Figure 2. The model appears to comply well with the following criteria:

- It could be implemented as early as next year
- A small amount of spectrum set aside for lightly licensed use provides security that entities will always be able to offer a level of minimum service (an anchor band)
- Dynamic spectrum access turns "Waste spectrum" into high performing cells
- The cost of access will be exceedingly low as it is "waste" spectrum that would otherwise perish
- The global momentum behind 3.6 GHz means equipment prices will also eventually be very low and widely available from competitive sources
- The probability is high in rural areas that some gains from DSA will always be possible as the probability of four of them all turning-up everywhere is very remote.

This option appears to be the best solution for small entities, self-help groups and individual enterprises, like farms, to have an opportunity to provide 5G coverage in rural areas, good for self-provision, contributes to the overall pool of 5G coverage and provides a competitive incentive to deploy early to secure the dynamic access rights.

The main down-side of what otherwise appears a perfect option to the rural coverage issue is that removing "X" MHz from the 120 MHz of the 5G pioneer band still to be released increases the contention in the coming 5G 3.6 GHz auction amongst the mobile operators trying to top-up their radio channel bandwidths to a full 100MHz. By how much the contention increases depends upon the value of "X" chosen. This conflict of interest is a matter for Ofcom and Department for Digital Culture, Media and Sport to resolve. The same conflict of interest does not exist with the opportunistic dynamic spectrum access to "waste spectrum" as all the MNO's will also be beneficiaries. MNO's would notice no practical difference whether DSA is being used or not. The impact on the capital value, if any, will be reflected in the auction price, which is why this reform has to be introduced before an auction and not afterwards. Whether there will be any material impact is open to conjecture as any downward effect will be off-set by there being 100 instead of 120 MHz to be sold.

5. What value of "X" is needed for lightly licensed use?

Figure 3 illustrates some examples of rural use cases and their associated bandwidth/ latency requirements.

Figure 3 – *Example rural use cases and associated bandwidth/latency requirements.*

To deep dive on just one use case in Figure 3, Hands Free Hectare, the current iteration of the test bed leverages drone & tractor mounted cameras delivering a real time uplink payload of up to 34.5Mbps and 82Mbps respectively with a 20ms round trip delay time (RTT) latency requirement on one 20Mbps traffic flow of the 82Mbps total. We expect further test bed iterations will reduce overall traffic flow requirements, but we can report that several of the agritech use cases that can provide significant cost benefits and productivity improvements in the agritech sector have strong uplink traffic requirements. There is no doubt that the opportunistic Dynamic Spectrum Access to the entire 3.6-3.8 GHz band would deliver more than enough bandwidth to meet the demands illustrated in the use cases, with capacity left over for technology evolution, domestic use and those visiting a farm.

The case for "X" MHz of anchor bandwidth comes down to whether anyone will invest in the first place against the risk of all four mobile operators coming along later, establishing cells, and the new entrant having no "waste spectrum" to use to sustain their 5G infrastructure. There is minimal consequence for the local businesses and consumers of all 4 MNO's turning-up later, as having a choice of MNO's offering 5G connectivity is an outcome beyond their wildest dreams. For the new entrant, it would be terminal.

The "X" MHz anchor spectrum is the ultimate backstop, but the real power of the model is the way it works in conjunction with the DSA first come first served rules Should one MNO turn up later the new entrant will have the anchor spectrum plus the spectrum of the three absent mobile operators. In the case of two MNO's turning up later, the new entrant will have the anchor spectrum plus the spectrum of the two absent mobile operators. If three MNO's turn up later the new entrant has the waste spectrum of the absent fourth MNO plus the 20 MHz. That can give them almost competitive parity with the other three late arriving MNO's. Only in the remote likelihood of all four turning up later will the new entrant be falling back to the anchor spectrum. Since the four MNO's will only have come to take away market share…the anchor spectrum is likely to be proportionate to their reduced market share.

We already know from the first auction that the minimum amount of 5G pioneer band spectrum any of the incumbent MNO's will be 40 MHz and the maximum is likely to be 100 MHz. Pitching "X" at 20 MHz creates a model where a new entrant will have a sustainable competitive position for 80% of permutations of late arriving MNO's drying up the pool of "waste" spectrum and in the worst case, enough spectrum to match their likely diminished market share. It is a robust model.

A value of 20 MHz is only 5% of the full 5G pioneer band and 16% of the spectrum still left to be auctioned. If the second auction sells the spectrum at the same unit price as the 3.4 GHz spectrum auction achieved, then the Treasury would receive only 7.5% less from the proceeds of both auctions…a very modest investment in terms of the future potential gains from a more productive rural economy.

6. Conclusion

The government's FTIR "market expansion model" works for Rural Britain and redresses the shortcomings of the current Ofcom traditional approach for the release of 5G spectrum. Around 20MHz of anchor spectrum lightly licensed combined with dynamic spectrum access to local waste spectrum provides a robust model. The spectrum has to come from the 3.6-3.8 GHz band as, at this point in time, it is the only band that will deliver low cost 5G cells and smartphones in the foreseeable future.

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