Insight Guide

How to connect rural Britain - time to think again?

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Executive summary

In October 2019, the UK Government announced it will help fund a £1billion shared rural network (SRN). Mentor applauds any move to extend rural connectivity, but we believe the current SRN model needs a radical rethink if it is to be cost effective and make the best possible use of valuable 700MHz spectrum.

Under the current SRN proposal, the four national MNOs, EE, O2, Three and Vodafone, will invest a total of £530 million over 20 years for sharing existing masts and infrastructure in partial not-spots, where currently not all four MNOs provide coverage.

The government meanwhile will commit up to £500 million of investment in networks for areas where there is currently no coverage provided by any operator. The aim is to spread 4G coverage by all MNOs to 92% of the UK's geography by 2025. The SRN also means additional mobile coverage to 280,000 premises and 16,000 kilometres of roads, according to the government.[1]

There are several reasons to welcome a new shared rural mobile network. Wireless solutions are the most sensible strategy for connecting remote rural areas and, with a budget of approximately £1billion, an SRN could extend coverage to many underserved UK communities.

But the major shortcoming in the current SRN plan is that it splits spectrum in rural areas between four mobile operators. Fragmenting spectrum makes more sense in competitive urban markets where it will probably provide a thin coverage layer, extended by much higher frequency capacity spectrum.

But the UK's rural not-spots and partial not-spots are areas of market failure. If they weren't, all four operators would have already built networks in the final 9% of the country. It is also important to put any public funding of rural networks in the broader context of a Connected Britain. Mobile networks in remote rural areas need to do more than just provide outdoor mobile voice and data. They must also support fixed wireless services, where good fixed broadband is unavailable. And for that they need capacity.

Pooling spectrum on rural sites increases the overall capacity that customers can tap into - opening up the prospect of fixed-wireless services, boosted by roof top antennae. Sharing spectrum and physical masts forces sharing of everything else i.e. antennas, radios, baseband electronics and backhaul, allowing MNOs to greatly reduce infrastructure and operational costs.

The Rural Connectivity Group (RCG) in New Zealand clearly shows what can be achieved when spectrum sharing, network coverage targets and government funding are in place. There, the national mobile operators are working together to build a shared rural network to bridge the digital divide.

Mentor does not believe technology or standards need be a barrier. A true SRN could inter-work with MNOs through national roaming, or by using 3GPP RAN sharing models of Multiple Operator Core Network or Gateway Core Network, with technical co-ordination controlling radio interference.

In this insight guide, we explore how an ambitious approach to building an SRN, based on spectrum-pooling in 9% of the UK's most rural areas, will maximise the service delivered by the valuable 700MHz, 800MHz and 900MHz spectrum - and minimise network costs to deliver greater bandwidth and service choice to the UK's unconnected communities.

[1] https://www.gov.uk/government/news/1-billion-deal-set-to-solve-poor-mobile-coverage

Turning spectrum licensing outside-in

The UK Government's initiatives to close the digital divide between rural and urban areas have failed, according to a September 2019 report by the UK Parliament's Environment, Food and Rural Affairs Committee.[2]

The report recognises there has been a "significant improvement in both broadband and mobile coverage since 2015," but states it has "only barely kept up with increasing demand." This is an issue because the UK Government sees broadband and mobile communications as a utility and has a "digital-by-default" strategy for delivering public services.

> *There is no expectation that the 95% 4G target will be hit in the next three years*

Motivating rural investment

The problem of how to increase rural coverage is not unique to the UK, nor is the UK alone in facing difficulty resolving it, even with investment. The conundrum for regulators and governments worldwide has been how to motivate profit-driven private MNOs to invest in building out and operating public utilities, in areas where there is little or no hope of recouping investment. It involves either holding out a funding carrot, wielding a regulatory stick, or deploying a combination of both.

The background to the development of the current SRN model is the UK's spectrum auctions in the 700MHz and 3.6-3.8GHz bands, due to take place in 2020.

Ofcom had proposed the time-honoured practice of attaching rural coverage obligations to the 2020 auctions. Instead, MNOs advocated an SRN, which they say is the easiest way to provide 92% of the UK landmass with a choice of 4G services from all operators between now and 2025 - and to reduce the percentage of the UK with no coverage to 3%. In return for operator investment, Ofcom will consult on the MNOs' call to remove coverage obligations from licences in next year's spectrum auction.

For sure, past rural roll-out obligations have fallen short of their targets. The UK Government, for example, wanted to see 95% of the UK's geography covered by 4G networks by 2022.[3] Today, only three-quarters of the UK's geography enjoys 4G coverage from all four operators[4] and there is no expectation that the 95% target will be hit in the next three years.

Deciding where spend goes

But it is unclear how the government and the taxpayer will gain from having rural roll out obligations removed, in return for government investment. Especially, as there is no visibility on how and where government money will be spent over the course of the two-decade SRN programme. For now, the government has announced it "will commit up to £500 million of investment." And initial public announcements about the SRN do not mention Ofcom's comprehensive list of the UK's not-spots or the proposed need for 500 new rural sites, published in January 2019.[5] The Department for Digital, Culture, Media and Sport (DCMS)'s Future Telecoms Infrastructure Review (FTIR),[6] also calculated that 500 new mobile base stations would go a long way to address the rural coverage problem.

It is also unclear how much impact the operators' joint £530 million investment will have on rural

[2] https://www.parliament.uk/business/committees/committees-a-z/commons-select/environment-food-and-rural-affairs-committee/news-parliament-2017/rural-broadband-report-published-17-19/
[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf
[4] https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/getting-rural-areas-connected
[5] https://www.ofcom.org.uk/consultations-and-statements/category-2/award-700-mhz-3.6-3.8-ghz-spectrum-revised-proposals
[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

service over the next 20 years, given that they look set to spend it on sharing each other's existing masts and infrastructure to close almost all partial not-spots. This suggests an upgrade of existing infrastructure to bring all operators to the same level of coverage, rather than an expansion of service into new areas. If the goal really is to extend high speed mobile network coverage into rural areas, then new mobile base stations are needed.

Maximising efficiency

Ofcom's own analysis,[7] in 2018, estimates that a 20m high base station in a rural area typically costs in the region of £250k to build and £20-40k per annum to operate. And the Regulator's own high-level modelling suggests it would cost no more than £300 million for an operator to increase geographic coverage to 89-90% by building 500-700 new base stations and operating them for 20 years. [Ofcom's 2018 report found no operator provided better than 77% good geographic data coverage in the UK, with the figure rising to 86% for good geographic voice coverage]. All of which raises questions about the efficiency of the current SRN plans, which the government is promoting as a £1 billion investment.

Shared Rural Network vs Shared Neutral Host

	MNO SRN Plan	Mentor Proposal
Spectrum	4x MNOs	Shared
Antennas	4x MNOs	Shared
Base Station Electronics	4x MNOs	Shared
Towers	Shared	Shared
Sites	Shared	Shared
Backhaul (Fibre/Microwave)	4x MNOs	Shared

But even if government money funds new base stations in rural not-spots, local residents, businesses and tourists would benefit much more from the resulting 4G and fixed wireless broadband services, if they ran on pooled spectrum.

The best spectrum for rural coverage is sub 1GHz because it covers vast areas and penetrates deep into buildings with fewer base stations than with spectrum in

[7] https://www.ofcom.org.uk/consultations-and-statements/category-2/award-700-mhz-3.6-3.8-ghz-spectrum-revised-proposals

higher bands. Mentor believes it makes sense in rural areas to pool all available and unused spectrum in the sub-1GHz bands to operate a single, high-capacity network that actively shares towers, antennas, radios, spectrum and backhaul transmission. This would mean combining, not only the 700MHz spectrum, but 800MHz and 900MHz bands as well, with the exception of the 900MHz spectrum needed by O2 and Vodafone to provide legacy 2G services.

Reducing waste

Today's alternative of separating sub-1GHz spectrum into four tranches would waste capacity in the following ways:

- Wide channels are much more efficient at carrying traffic. Creating narrow bands wastes 20% or so of potential capacity
- The distribution of customers will never perfectly match the distribution of spectrum, leaving one operators' spectrum on a given mast overloaded, and another's hardly used
- Prevents future 5G New Radio being able to utilise fallow guard bands between tranches, which would increase potential capacity by around 8%.

> *Pooling spectrum increases capacity*

Pooling efforts

Rather than agreeing to remove rollout obligations, Ofcom could auction spectrum for the 91% of the UK's geography with 4G coverage to the highest bidders, as usual. The sub-1GHz spectrum covering the remaining 9% of the UK's landmass (in effect the rollout obligations) could then be given to a shared network responsible for building and deploying the rural network, aided by strictly defined government funding.

The resulting shared mobile network capacity can deliver both better mobile service but also a credible broadband service to homes and businesses in the coverage area. While not a match for full fibre, it could be a lifeline in those sparsely populated areas where fibre networks are non-existent.

Events in other countries suggest MNOs are well placed to drive the creation of a single shared rural

network, made more efficient by shared spectrum. In New Zealand, national mobile operators, supported by government policy and funding, are collaborating to build a shared rural network with the specific purpose of bridging the digital divide through the Rural Connectivity Group (RCG). The RCG clearly shows what can be achieved once spectrum sharing, network coverage targets and robust government funding are in place.

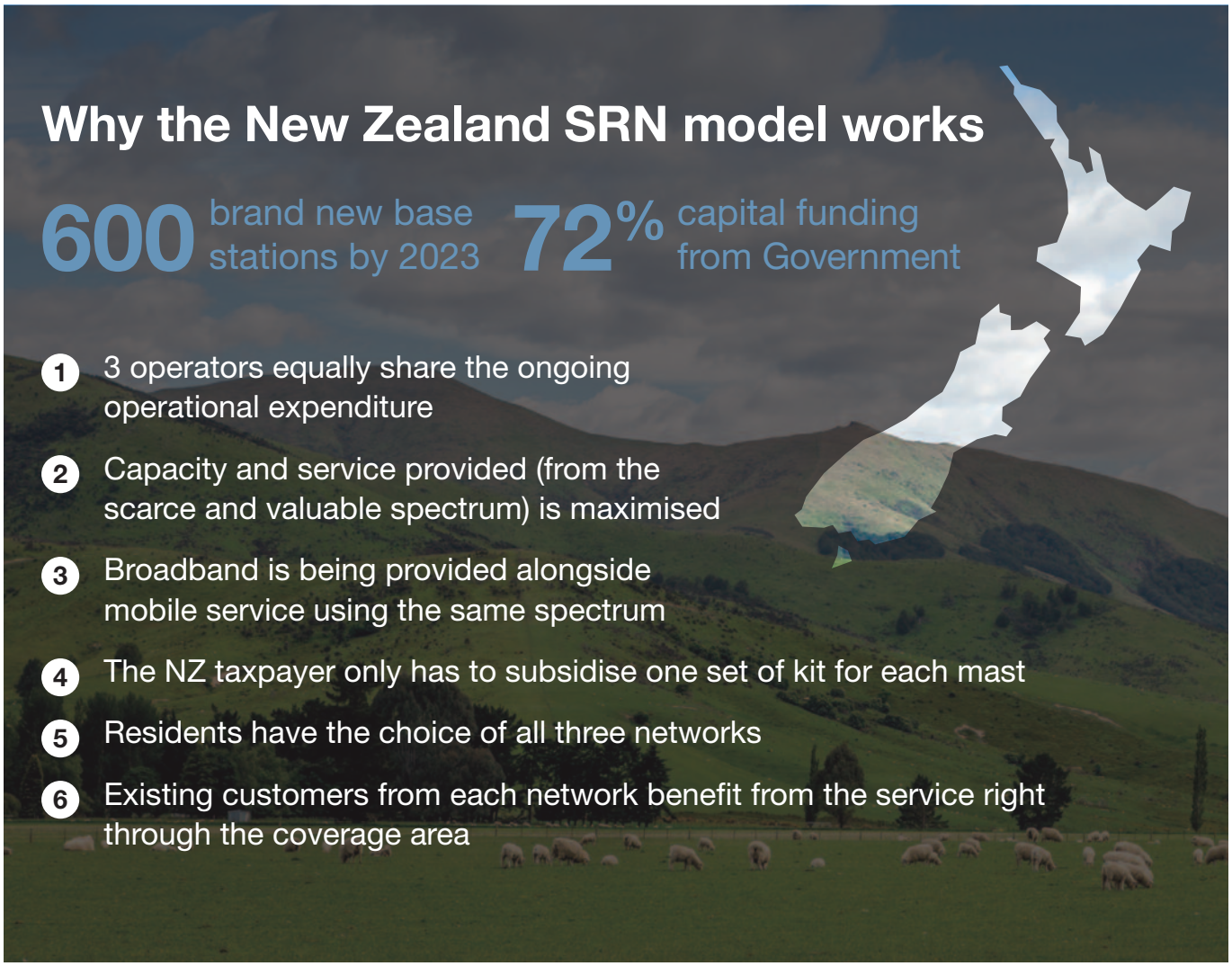
The New Zealand model

The RCG,[8] which is jointly owned by New Zealand's three national operators, Vodafone, SPARK and 2Degrees, is drawing on the MNOs' combined pool of spectrum, including in the 700MHz range, to create the network. The aim is to build 600 rural 4G sites by 2023, with the New Zealand government funding 72% of the capital costs and the three operators evenly splitting the remaining 28%. In addition, the three operators equally share the ongoing operational expenditure. A third-party, Crown Infrastructure Partners, ensures the network is built on time and to budget - and helps coordinate with government transport and conservation bodies.

In New Zealand, the three operators' engineers have worked together to integrate the RCG radio network into each operator's different equipment choices, standards and policies. The three operators will compete to sign up as many customers as possible to the shared network on-the-basis of pricing and services, just as they would anywhere else in the country.

Extending rural broadband

Crucially, the network addresses the New Zealand government's principal policy goal of providing good rural broadband coverage, with mobile operators offering a home or office mobile broadband solution boosted by roof top



[8] https://www.thercg.co.nz/

receivers, as well as mobile data service to handset users.

Not only does the RCG model maximise the use of scarce and valuable spectrum, the New Zealand taxpayer only has-to subsidise one set of shared active network equipment for each mast. In contrast under the SRN model, it currently looks as though each operator will deploy their own active network equipment on each mast, introducing unnecessary expenditure and power consumption, for zero additional service capability - money and energy that could be better allocated to additional sites.

Fixing wireless broadband access

Ofcom estimates there are approximately 40,000 UK premises without any mobile or broadband coverage - and many more suffer from poor service or a lack of choice. If the UK is serious about bridging the rural digital divide, then the UK's SRN should be as bold as New Zealand's RCG in using pooled spectrum.

Being able to draw on the largest possible pool of spectrum is essential if operators are to not only extend service, but also maximise broadband speeds in rural areas. If Ofcom allocates the 700MHz spectrum in tranches nationwide, as planned then, as the table illustrates, two operators, each using half of the 700 Band paired spectrum, will have access to a throughput per radio of 21Mbps, rising to 35Mbps when using a supplemental downlink [SDL]. Adding unused 800MHz and 900MHz spectrum to the 700MHz

Cellular network capacity for rural broadband

Wireless is a great way to reach communities of widely scattered users. And the latest 4G and pre-5G cellular technologies have greatly increased coverage and capacity.

But, the capacity of each base station radio is shared across all active users so, although "peak" data rates can be high, data rates per user are much lower in busy hours. This is made worse if some users are in poor radio conditions, when the radio network must allocate disproportionate radio resources to these users, which dramatically reduces the radio link throughput.

The following table illustrates downlink throughput capacity per radio for LTE cellular in different scenarios

			Spectrum	Spectral Efficiency	Throughput per Radio
Pure Mobile Services	2 Operators, each using half of 700 Band paired spectrum		15MHz	1.4 bps/Hz	21 Mbps
	2 Operators, each using half of 700 Band including SDL		25MHz		35 Mbps
	Single Neutral Host using 700 Band paired spectrum		30MHz		42 Mbps
	Single Neutral Host using 700 Band including SDL		50MHz		70 Mbps
	Single Neutral Host using 700 Band paired spectrum and 800+900 Bands		80MHz		112 Mbps
	Single Neutral Host using 700 Band including SDL and 800+900 Bands		100MHz		140 Mbps
Fixed Wireless & Mobile Services	Single Neutral Host using 700 Band	Fixed Wireless	40MHz	5 bps/Hz	200 Mbps
		Basic Mobile	10MHz	1.4 bps/Hz	14 Mbps
	Single Neutral Host using 700+800+900 Bands	Fixed Wireless	90MHz	5 bps/Hz	450 Mbps
		Basic Mobile	10MHz	1.4 bps/Hz	14 Mbps

Notes:

- The blue rows in the table include use of the Ofcom 700 Supplemental Downlink (20MHz). This is not part of a standard LTE Band plan, so few (if any) customer smartphones will be able to use this spectrum making its benefit in mobile questionable. Contrast the 2x 30MHz Ofcom paired 700 spectrum which aligns to the standard LTE Band 28. For Fixed Wireless, we anticipate a custom-engineered Home Gateway being able to use the Ofcom 700MHz Supplemental Downlink.
- Mobile device spectral efficiency of 1.4 bps/Hz assumes LTE-A and 2x2 MIMO. This is a conservative number averaging across entire radio cells and including in-building losses, poor gain and limited MIMO discrimination from internal mobile device antennas, and cell edge interference.
- The 5 bps/Hz for Fixed Wireless assumes LTE-A and an antenna with high gain, good 2x2 MIMO discrimination, and directionality reducing interference (between base stations but not between sectors on the same base station). External rooftop mounting is assumed providing better radio propagation and avoiding in-building losses.
- The Neutral Host's use of 2x 20MHz of 900 Band leaves 2x 14.8MHz of 900 Band for O2 and Vodafone to continue to operate any 2G/3G rural mobile services.
- The external antenna in Fixed Wireless will also benefit coverage. As will the benefit from uplink transmit power not being limited by mobile device battery life conservation.

spectrum would give a 112Mbps per sector downlink capacity, rising to 140Mb/s if SDL is used. The resulting fixed wireless throughput per radio, based on pooling, could be expected to reach 450Mbps and provide the sort of deep indoor coverage that rural properties need to access good quality broadband services.

Guiding good coverage

In addition to enabling spectrum pooling, the UK Government and Ofcom should offer clear guidance on where to build networks, in return for a government commitment to provide substantial funding. The UK's not-spots and partial not-spots are highly fragmented and covering them requires careful planning, based on identified needs and close collaboration with local authorities and other stakeholders. Even with the best will in the world, MNOs remain private companies and need guidance, information and financial support if they are to be expected to satisfy a government's digital policy.

We believe the UK government should seize the opportunity to transform rural broadband communications by injecting capital at levels similar to those in New Zealand and couple it with regulatory oversight to drive the build out of the 500 sites as suggested by the DCMS, using shared spectrum to enable fixed wireless broadband connectivity. After all, it is only when rural communities can access high speed broadband at a price in line with the most competitive areas of the UK that the government can truly claim to be effectively tackling the digital divide.

How countries outside the UK are tackling rural coverage

New Zealand is not alone in re-thinking rural coverage. A number of other countries have adopted spectrum and network sharing, discounting or highly targeted coverage obligations to increase rural connectivity. New Zealand's model is clearly more ambitious than the UK's SRN and, at first glance, the others are too.

Finland

Like New Zealand, Finland has embraced mobile network and spectrum sharing. In 2014, it established Finnish Shared Network Ltd., which uses pooled spectrum to enhance rural mobile and broadband services,[9] providing a shared 2G, 3G and 4G network for the Finnish MNOs, DNA and Telia Finland in Northern and Eastern Finland. It covers half of Finland's total geographical area but only approximately 15% of the population. Because it pools spectrum from DNA and Telia, it can double connection speeds on its shared network infrastructure in rural and remote areas.

Austria

In September 2019, the Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR) set out its plans for 700MHz, 1500MHz and 2.1GHz bands spectrum auctions in the first half of 2020. Winners of the 700MHz frequency auction will have an obligation to connect 900 rural communities with 5G with a minimum of a 30Mbps downlink and a 3Mbps uplink. The RTR has also proposed offering operators a discount on spectrum costs, if they extend coverage to 2,000 rural communities, as well as active and passive network-sharing.[10]

France

In January 2018, the French telecoms regulator, ARCEP announced its Mobile New Deal,[11] which sets operators precise targets to increase coverage and competition in rural areas. As part of their licences in the 900MHz, 1800MHz, 2.1GHz bands, the four national operators have to provide rural coverage in several thousands of specified sites, with 600 designated for build out in 2018, continuing with 700 in 2019; and 800 for 2020, 2021 and 2022. The four MNOs will be asked to install 2000 new shared masts and shared radio access networks in areas indicated by ARCEP's mobile coverage map. The remaining areas will be decided on an annual basis by local government representatives and the French government.

[9] http://yhteisverkko.fi/en/
[10] https://www.rtr.at/en/pr/PI23092019TK
[11] https://www.arcep.fr/cartes-et-donnees/new-deal-mobile.html

Conclusion

Spectrum auctions have worked well for 91% of the UK's geography, but completely failed the 9% of land mass where there are not enough customers or traffic to fill a network to economic levels.

The current SRN proposal keeps the traditional spectrum ownership model alive, while also serving as a justification for the backward step of eliminating roll out obligations for prime 700MHz spectrum bands.

Rather than repeat another version of what has demonstrably failed throughout the years, Mentor advocates using the proposed £1 billion to fund a new SRN company that is 100% owned by the four mobile operators.

The new company would have its own independent board and obligations to build a shared network, with a clearly agreed set of base station locations and timeframes for going live. It would also set-up a robust integration and operational approach, with a simple cost recovery mechanism for charging back to the operators.

And Ofcom could give the SRN spectrum in the 700MHz and other sub 1GHz bands, covering the 9% of uncovered rural areas, while auctioning spectrum in the 91% to the highest bidder, without roll-out obligations.

By creating a true SRN based on spectrum pooling, MNOs and the Government can optimise spectrum use and make sure public funding begins to decisively bridge the rural divide.

Mentor has three solid decades of experience in running difficult, business-critical programs in the UK and European Telecoms markets. Breaking new ground by helping to create some of the first wave of Alt.net deployments, Mentor worked behind the scenes with most of the UK's infrastructure players.

Today, Mentor is helping mobile operators, fibre providers and infrastructure players to figure out how to respond to the huge opportunities presented by 4G densification and the move to 5G.

Specifically for:

- Mobile operators – crafting new design and deployment schemes for fibre networks and optical solutions across their core and access networks
- Fibre providers - designing solutions that meet the unique architecture, operational and business case requirements of the mobile operators
- Infrastructure players, and their investors, as they look to earn new revenues from the opportunities presented by the move to 5G.

With our strong industry relationships and independence – combined with deep design, operational and commercial experience – we wil work with you and your team to provide the people, resources and expertise to get your business-critical program over the line – with certainty.

We call it The Mentor Way. Results. Nothing less.

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