Rural Broadband Services – Backhaul (BV 372U)

Technology Strategy Board
Digital Britain Feasibility Study
Final Report

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ÆGIS spectrum engineering

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1 INTRODUCTION

One of the aims of "Digital Britain" is to ensure universal access to 2 Mbps broadband by 2012. A range of different technologies including DSL, wireless, fibre to street cabinets and satellite infill is expected to be needed in order to deliver basic broadband. Mobile is one option for delivering broadband to users located in geographic areas where it is technically difficult and / or uneconomic to provide broadband services using wired solutions.

However mobile operators will require each prospective new site in rural areas to "cost in" based on the expected annual traffic and revenue. The backhaul links will be an important part of the cost equation – it has been suggested that backhaul transport can account for more than 30% of the technical operation costs as well as 30% of the capital investment. Therefore if the costs of backhauling can be reduced by using adaptive fixed links operating in part of the 1800 MHz band (1710 – 1785 MHz paired with 1805 – 1880 MHz) it may encourage further roll-out to rural areas.

To understand whether cellular spectrum can be used for fixed links we have examined a number of key issues in the following sections of this report:

- Amount of bandwidth that might be required to backhaul a base station
- Interference issues when the same spectrum is used for base station transceivers as well as backhaul
- Potential for cost savings
- Economies of scale – possibility of a similar approach being adopted in other countries
- Any regulatory constraints.

It has been noted that the potential to use the same spectrum for backhaul as well as base stations is being considered in respect of LTE (long term evolution) with the inclusion of self backhauling as a layer 3[1] solution. This would most likely apply to LTE-Advanced where spectrum allocated might have carriers larger than 20 MHz.

2 BANDWIDTH REQUIREMENTS

2.1 Fixed terrestrial links

Traditional fixed point to point radio links were designed to deliver a required system availability taking into account the impact of propagation outages due to fading caused by rainfall or anomalous propagation (e.g. ducting). So, for example, a link designed for 99.995% availability would be unavailable for about 26 minutes a year and for the rest of the year it would be possible to use a higher modulation mode and so increase the data throughput and capacity. The use of adaptive modulation in more recent equipment allows the modulation deployed to vary according to the

[1] Layer 3 – wireless router (layer 3 relay) forwards IP packets on the network layer.

propagation conditions over the radio path and so maximise the use of the available bandwidth without increasing the transmitter power and interference environment.

To calculate the required bandwidth, for different traffic split percentages, it is assumed that the total required capacity per site in the uplink or downlink is 13 Mbps (assumes a typical carrier bandwidth of 5 MHz and the use of LTE).

Traffic Split (%)			BW for (High) Priority (MHz)	BW for (High+Medium) Priority (MHz)	BW for (High+Medium +Low) Priority (MHz)	Required Bandwidth (MHz)
High	Medium	Low				
10	20	70	1.27	1.9	2.52	2.52
10	30	60	1.27	2.54	2.52	2.54
10	40	50	1.27	3.17	2.52	3.17
20	20	60	2.54	2.54	2.52	2.54
20	30	50	2.54	3.17	2.52	3.17
20	40	40	2.54	3.81	2.52	3.81
30	20	50	3.81	3.17	2.52	3.81
30	30	40	3.81	3.81	2.52	3.81
30	40	30	3.81	4.44	2.52	4.44

Table 1: Backhaul Link Required Bandwidths for Various Traffic Split Assumptions

It can be seen from the table above that the maximum bandwidth required per base site, for the above traffic splits, is theoretically between 2.52 MHz and 4.44 MHz. The actual required bandwidth will depend on the channel plan adopted – whether it is based on, for example, multiples of 0.5 or 1.75 MHz. It should be noted that if there is a need for a sectorised base station site then bandwidth requirements could increase by a multiple of 3 and this might impact on the feasibility of such a solution.

3 INTERFERENCE CONSIDERATIONS

There are two possible situations where the 1800 MHz band could be used for fixed links. The first is where a mobile operator is allowed to utilise his own spectrum for both mobile and fixed services and deploys fixed links in geographic areas where the 1800 MHz band is under-used. This means the interference environment will be under the control of the mobile operator and the main concern will be the potential for a fixed link in a rural area to interfere with the cell sites in a nearby sub-urban or urban area where the same frequencies are deployed. The second is where a small amount of spectrum is dedicated to the deployment of fixed links and the mobile service is supported by the remainder. However in our view the second option is less attractive as this will lead to less spectrum being available in urban areas where it is required to provide the necessary capacity over the mobile networks.

The two most likely interference scenarios, assuming the first option, are described below. We do not consider that there is likely to be a problem of interference between a mobile base station or a mobile device into a fixed link because of the geographic separation, transmitter powers and also the use of directional antennas for the fixed link. Nor do we consider there is likely to be a problem of interference from a fixed link into the mobile devices (cell phones) as they are more likely to be in the clutter and very few, if any, will experience interference.

3.1 Interference from a fixed link transmitter into a base station

The most likely interference scenario is between a fixed link transmitter and a mobile base station located on an elevated position pointing towards the fixed link. To examine a practical example we have assumed a base station at grid reference NS5369668195, 39m agl. In practice this is a prominent Orange macrocell on Strathclyde University which is assumed to be the victim site. Assuming a maximum field strength of 20dBuV/m (10% time) at the base station antenna then the map below shows the geographic areas where a fixed link transmitter could be deployed using propagation model ITU-R P.1812.

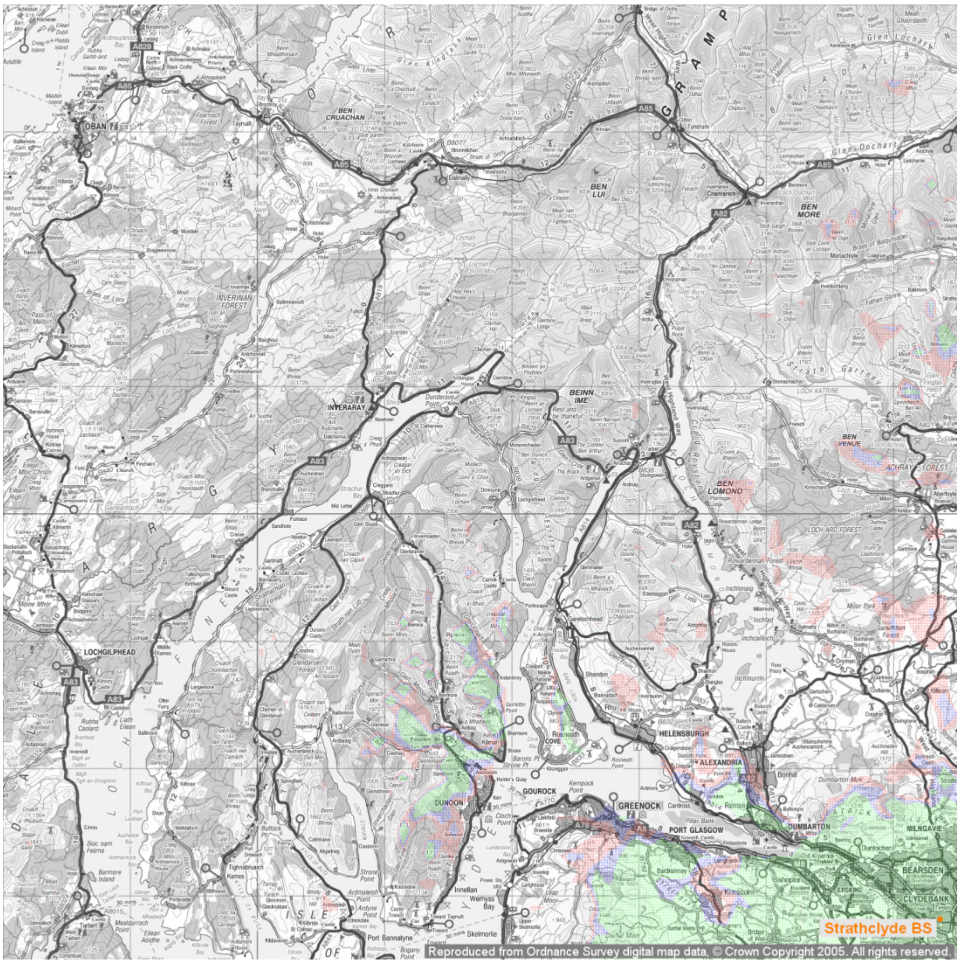

Figure 1: Geographic areas where a fixed link transmitter could be deployed

The contours assume a fixed service eirp of 400W directed towards the victim base station and beyond the red contour fixed service sites can be deployed. If the fixed link transmitter is pointing away from the base station the blue and green contours represent 10 dB and 20 dB advantage respectively. It can be seen that because of the terrain the diffraction loss available is high. The situation would be very different in flat areas such as East Anglia where the possibility of sharing the same frequencies, even with significant geographic separation, is unlikely to be tenable.

3.2 Interference between fixed links

The possibility for interference between fixed links will impact on the total amount of spectrum that may be required. If the interfering path is not obstructed or there is insufficient antenna discrimination then it will mean a frequency cannot be re-used and further spectrum is required.

We considered a possible scenario where there were 6 base sites deployed to provide coverage to rural locations connected back to a point of presence in the nearest larger village of Aberfeldy as shown in the map below:

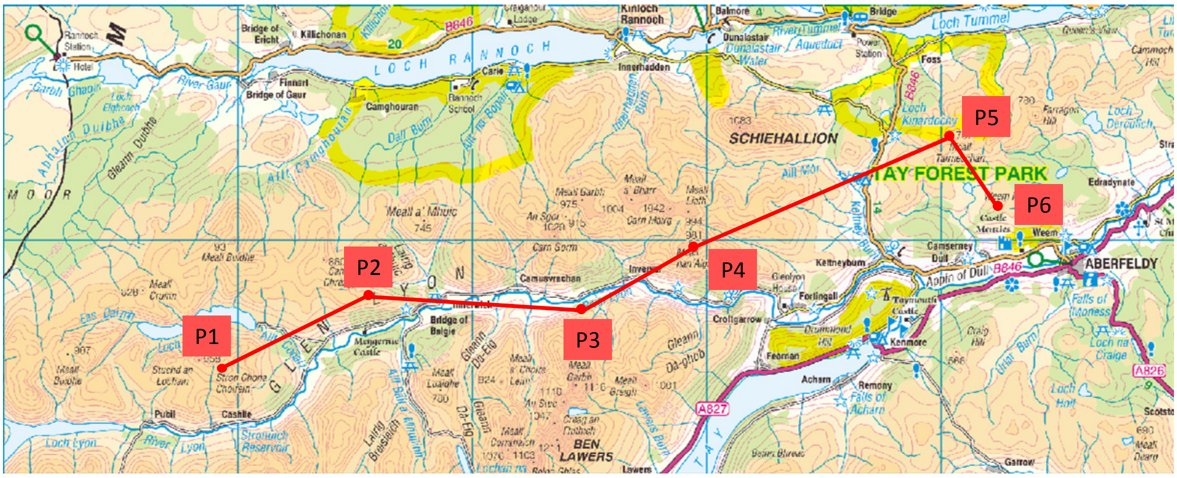

Figure 2: Map showing the potential fixed links needed to connect to point of presence in Aberfeldy

In this specific case it was found necessary to deploy a different frequency on the hop P3 to P4 to avoid the potential for interference from P1 and P2 into P4. In such a situation double the bandwidth would be required to support the backhaul links. It is also noted that in the case of a daisy chain of links each base site will add in traffic and therefore more capacity and bandwidth will be required for the links closer to the point of presence.

3.3 Cross border co-ordination

It should be feasible to build on existing cross border co-ordination agreements to cater for fixed links – existing agreements may already cover point to point links that have remained in the band. The potential to locate fixed link transmitters near borders, pointing into neighbouring countries, will depend on the terrain as the situation is the same as explained in Section 3.1 above.

4 COST SAVINGS

The advantage of using the 1800 MHz band is the achievable link lengths and to some extent the possibility of operating over partially obstructed paths. Our calculations have indicated that it is possible to operate over links up to 30 kms with a relatively low EIRP of 13 dBW and up to 17 kms with an EIRP of 6 dBW. Even with an additional obstruction loss of 20 dB a link length of over 5 kms is possible with a transmit EIRP of 6 dBW. This might avoid the need for additional repeaters and cost savings could easily be in excess of €90k.

Other benefits in comparison with deploying backhaul links in, for example, the usual 7.5 GHz, 13 or 15 GHz bands are:

- Cheaper antennas. At 1800 MHz it is possible to deploy grid-type dish or yagi antennas rather than solid dishes that are necessary in the higher frequency bands. Solid dishes are more expensive because of the material and manufacturing costs.
- Cheaper mounting structures (e.g. towers). The weight and wind-loading of grid and yagi antennas is considerably lower than those of an equivalent size solid dish (e.g. 5 kg compared with 69 kg). This difference reduces the cost of mounting structures. Also the main lobe beam width of a grid antenna is wider than that of a comparable 7 GHz solid dish (e.g. 9º compared with 2.4º) and this places less constraints on the rigidity (stiffness) as it is possible for the mounting structure to flex more without significantly losing antenna gain.
- Maintenance costs. It is possible to install the RF equipment at the base of the tower rather than behind the antenna and this can significantly reduce the cost of maintenance as it is easier and quicker (with less health and safety issues) to gain access to the equipment.
- Licence fees. There is the potential to reduce the cost of annual licence fees as it will not be necessary to use spectrum from other bands – in the UK we have estimated that over a 10 year period this might reduce costs for a single base station by between £44,670 and £25,960.

5 REGULATORY CONSIDERATIONS

Regulatory constraints on the use of the 1800 MHz band for fixed links will be due to:

- Whether the fixed service is identified as co-primary in the European Common Allocation Table[2] and National Allocation Tables
- Adoption by CEPT Members of ECC Decisions and Recommendations
- Licence conditions.

It may be necessary for the national regulations to be amended in some countries as in a number (e.g. Austria, Belgium, France, Hungary, Lithuania, Norway and Switzerland) the 1800 MHz band is only allocated to mobile services on a primary basis. The Decisions[3] may require revising to make it clear it is also possible to deploy backhaul links in the band. Individual licence conditions may need revision so they allow the use of the spectrum for backhaul links. Finally, as noted earlier, it may be necessary to review existing cross-border agreements.

6 POTENTIAL TO DEPLOY FIXED LINKS ON A EUROPEAN BASIS

Our understanding is that in those countries where operators have access to both 900 MHz and 1800 MHz spectrum it is likely that there will be very limited usage of the 1800 MHz band outside the urban areas. In rural areas the 900 MHz band is used to provide coverage and in most instances there is currently sufficient bandwidth to also meet the traffic capacity requirements. It is only in specific towns / large villages where it may prove necessary to deploy the 1800 MHz frequencies to provide additional capacity for the cellular network.

6.1 Economies of scale

It will require a number of countries to be interested in deploying fixed links in the 1800 MHz band to provide the necessary economies of scale for a manufacturer to invest in developing the equipment. Information provided previously to Aegis by a fixed link manufacturer / vendor indicated that it is not uncommon for manufacturers to either refuse to develop / manufacture equipment where the volumes are low or charge a premium for the RF units.

If the population density across Europe is considered, as shown in the map below, there are significant geographic areas where the population density is below 5 – 24 persons per km² and therefore the potential for a number of countries to be interested in such an approach to provide backhaul links.

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[2] See European Frequency Information System (EFIS) at Hwww.efis.dk/H

[3] For example it may be necessary to revise existing Decisions ERC/DEC/(95)03 and ECC/DEC/(06)13 to also include mention of fixed links or possibly develop a further Decision specifically mentioning the 1800 MHz band for the deployment of backhaul in rural geographic areas.

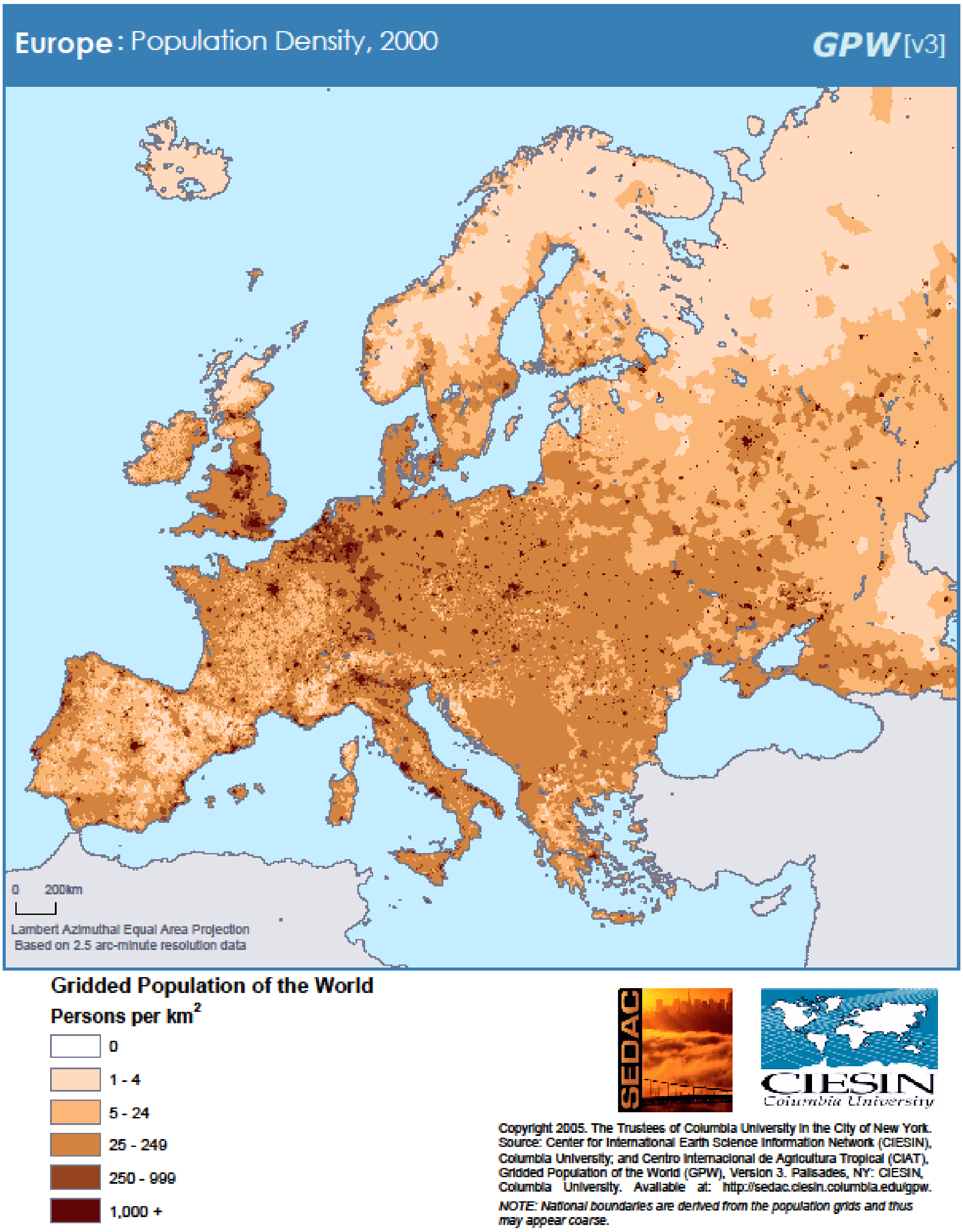

Figure 3: Population density in Europe

There are also a significant number of countries where there are frequencies that have not been licensed in the band or where operators have been awarded more than 2 x 20 MHz. There does appear, on the basis of the above, to be the potential for economies of scale.

7 CONCLUSIONS

The table below summarises briefly the outcome of the study and highlights some areas that are unresolved or where further investigation would be required for greater certainty.

	Positive	**Negative**	**Unresolved / Requires further investigation**
Would backhaul using LTE air interface be preferable to adaptive fixed links			√ (Not part of the study, but unlikely to be relevant to all base sites as may use other technologies such as HSPA)
Regulatory constraints	√		√ (May require changes to some countries' national legislation and licences)
Potential for cost savings	√		
Improved spectrum efficiency	√		
Viable channel plans	√		
Viable bandwidth requirements	√		
Achievable link lengths	√		
Interference considerations (ability to share spectrum on a geographic basis)	√ (Geographic areas with hilly terrain / high diffraction loss)	√ (Flat geographic areas / low diffraction loss)	
Cross-border considerations	√		√

	Positive	**Negative**	**Unresolved / Requires further investigation**
	(Appears that existing cross-border agreements may be sufficient)		
Potential for economies of scale	√		√ (No guarantee that other administrations would wish to adopt such an approach)

Table 2: Summary of the outcome of the study

Overall the outcome of this study is positive and in our opinion the next steps would be to discuss the concept with operators and equipment manufacturers (equipment and antennas). If the outcome is positive then manufacturers will need to develop prototypes in order to undertake measurements to prove feasibility. In parallel it will be necessary to address standards and regulatory issues within Europe to fully define when and how 1800 MHz spectrum can be used for rural backhaul. Also as mentioned earlier it is necessary to consider whether LTE is a more likely effective solution than adaptive fixed links.