Title: Tackling Partial Not-Spots in Mobile Phone Coverage **IA No:** **Lead department or agency:** DCMS **Other departments or agencies:**	**Impact Assessment (IA)** **Date:** 05/11/2014 **Stage:** Consultation **Source of intervention:** Domestic **Type of measure:** Secondary legislation **Contact for enquiries:** partialnotspots@culture.gsi.gov.uk

Summary: Intervention and Options

RPC Opinion: Awaiting Scrutiny

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present Value**	**Net cost to business per year** (EANCB on 2009 prices)	**In scope of One-In, One-Out?**	**Measure qualifies as**
£m	£m	£m	Yes/No	In/Out/zero net cost

What is the problem under consideration? Why is government intervention necessary?

Research by Ofcom indicates that the public now consider mobile voice and text to be an essential form of communication. Currently 21% of the UK's geographic area and 3% of premises have mobile phone coverage provided by only one or two mobile network operators (MNOs).Those living in such areas (known as partial not-spots) are limited in their choice of mobile phone operator. Those visiting these partial not-spots, either for short or long durations, are unable to get coverage if their own network is unavailable. The problem is particularly acute in rural areas, where over 35% of consumers report frequent lack of mobile signal.

What are the policy objectives and the intended effects?

This policy aims to eliminate partial not-spots for voice calls wherever possible and maximise the area in which consumers can make and receive calls within the current combined network coverage footprint of the four UK mobile network operators. The intended effects are to improve connectivity and overall consumer mobile experience to all. Doing so will provide incremental benefit to local businesses and economic activity, as well as less easily quantified social benefits (e.g. social inclusion and enhanced consumer choice).

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

5 policy options were considered as a long list. These options are:
- (1) Promotion of dual-SIM phones and (2) broadband based solutions
- (3) Multi-Operator Mobile Virtual Network Operators (MO-MVNOs)
- (4) Infrastructure sharing
- (5) Mobile roaming

These were assessed in terms of impact, technical feasibility, costs, risks and disruption to the market. Infrastructure sharing, MO-MVNOs and mobile roaming were taken forward to a shortlist and explored in more detail. For the purposes of this consultation and impact assessment the Government is not proposing a preferred option. Government would prefer voluntary approaches to each option on the part of MNOs, but may consider implementing specific options through regulation as indicated below.

Will the policy be reviewed? It will/will not be reviewed. **If applicable, set review date:** Month/Year

Does implementation go beyond minimum EU requirements?			N/A		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	**Micro** No	**< 20** No	**Small** No	**Medium** No	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)			**Traded:**	**Non-traded:**	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister: ..... Date: 05/11/2014

Summary: Analysis & Evidence

Policy Option 1

Description: Do Nothing

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
			Low: Optional	**High:** Optional	**Best Estimate:**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate				

Description and scale of key monetised costs by 'main affected groups'

There are no monetised costs in the Do-Nothing scenario

Other key non-monetised costs by 'main affected groups'

There are already some industry level consolidations and solutions that are being undertaken to address this problem. This includes the passive infrastructure sharing between Vodafone and O2 under Project Beacon, as well as initiatives to provide mobile voice services via broadband. Implementing these require some capital costs for MNOs but these would happen under any policy intervention so form a counterfactual against which other options are compared.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate				

Description and scale of key monetised benefits by 'main affected groups'

Other key non-monetised benefits by 'main affected groups'

There are some benefits of additional connectivity in partial not-spots due to Project Beacon and mobile voice services via broadband. Again, these benefits would be realised under any policy intervention so form a counterfactual against which other options are considered.

Key assumptions/sensitivities/risks **Discount rate (%)**

The first assumption is that Project Beacon delivers the positive changes in connectivity as per its current timescale. It is also assumed that Project Beacon will lead to Vodafone and O2 equalising each others existing coverage whereas in reality there may be a small decrease in total combined coverage as some sites which mostly duplicate each other are rationalised. This would mean there are less partial not-spots but perhaps marginally more total not-spots.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			**In scope of OIOO?**	**Measure qualifies as**
Costs:	**Benefits:**	**Net:**	Yes/No	IN/OUT/Zero net cost

Summary: Analysis & Evidence

Policy Option 2

Description: National roaming

FULL ECONOMIC ASSESSMENT

Price Base Year 2009	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: -346.02	**High:** -27.16	**Best Estimate:** -186.59

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	90.7		23.4	**275.9**
High	181.4		28.8	**399.6**
Best Estimate	136.1		26.1	**337.7**

Description and scale of key monetised costs by 'main affected groups'

The costs of roaming are incurred by the MNOs. Key capital costs are likely to involve IT and network system development, estimated at between £16-£32 million per operator. This implies a total industry cost of £64-£128 million in year one, which has been annuitized using the industry cost of capital. Key operating costs are related to customer services and site rental costs. This is estimated at between £8-10 million for the industry per year.

Other key non-monetised costs by 'main affected groups'

Non-monetised costs relate to potential disruption to existing consumers while they are on national roaming. These include loss of data services through 2G signal lock when roaming, unavailability of voicemail and other services, as well as potential network outage issues. There are also potential losses due to both the disincentive to invest in the 4G network, as well as potential slowing of the 4G roll-out due to diverting resources to national roaming.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0		6.3	**53.6**
High	0		29.4	**248.7**
Best Estimate	0		17.9	**151.1**

Description and scale of key monetised benefits by 'main affected groups'

Benefits have been monetised based on research on willingness to pay (WTP) for mobile services where they are not available, as well as estimating the number of short-trip and overnight visitors to partial not-spot areas, which are estimated to cover 13% of land mass post Project Beacon. It is estimated that there are 26 million short-trips and 7 million overnight trips made to such areas. The total combined WTP benefits per annum are estimated at £7-£33 million per annum.

Other key non-monetised benefits by 'main affected groups'

We estimate approximately 1.5 million consumers live in areas of partial not-spots. The WTP for the choice of multiple operators has not been monetised but we consider this to be a significant benefit of this policy. In addition, the benefits to businesses that operate in partial not-spots have also not been monetised, and the wider economic and social benefits from greater connectivity have also not been monetised.

Key assumptions/sensitivities/risks — **Discount rate (%)** 3.5%

The methodological assumptions in monetising benefits relate to the range of WTP figures calculated by RAND, as well as the assumption on the total number of visitors to partial not-spots. The key economic risks relate to the potential impacts it could have on the roll-out of 4G investment. The technical risks relate to issues such as network and SIM configuration, billing and IT systems and undertaking inter-operator testing.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			In scope of OIOO?	Measure qualifies as
Costs: 33.9	**Benefits:** 0.0	**Net:** -33.9	Yes	IN

Summary: Analysis & Evidence

Policy Option 3

Description: Infrastructure sharing

FULL ECONOMIC ASSESSMENT

Price Base Year 2009	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: -75.19	**High:** -21.98	**Best Estimate:** -48.59

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	37.3		4.7	**72.2**
High	44.4		5.6	**85.9**
Best Estimate	40.9		5.2	**79.1**

Description and scale of key monetised costs by 'main affected groups'

The monetised costs of infrastructure sharing depend on the total number of sites that will be shared, assumed in this analysis to be between 527 and 627. The capital cost per site to undertake infrastructure sharing is estimated at £50,000. This gives a range of total capital costs of £26-£31 million, which has been annuitized using the industry cost of capital. The operating costs are estimated at £10,000 per site, giving an annual opex of £5.3-£6.3 million.

Other key non-monetised costs by 'main affected groups'

The above monetised costs do not take into account the potential costs of delays and risks due to any disputes or negotiations with landowners on access to sites.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0		1.3	**10.7**
High	0		6.1	**50.3**
Best Estimate	0		3.7	**30.5**

Description and scale of key monetised benefits by 'main affected groups'

Benefits have been monetised based on research on willingness to pay (WTP) for mobile services where they are not available, as well as estimating the number of short-trip and overnight visitors to the partial not spot areas which benefit under this proposal (approx 3% of geographic land mass). It is estimated that there are 6 million short-trips and 1.7 million overnight trips made to such areas. The total combined WTP benefits per annum are estimated at £1-£8 million per annum.

Other key non-monetised benefits by 'main affected groups'

A key additional benefit from infrastructure sharing is that the additional coverage it provides is likely to include data in addition to voice. This is in contrast to the other two options analysed here which primarily deal with 2G voice. Infrastructure sharing will also offer greater choice than the Do-Nothing scenario to those located in partial not-spots, and greater social and economic inclusion, but to a smaller number of people than options providing more comprehensive coverage.

Key assumptions/sensitivities/risks — **Discount rate (%)** 3.5%

The assumptions that relate to the calculation of benefits under national roaming also apply here. Technical risks include whether existing sites have the capacity to undertake sharing - for example in terms of the space, load-bearing capacity of towers, tilt and height of antenna and topological features that affect signal quality. Competition concerns would have to be investigated by the relevant authorities, while the legal dimension would depend on the implementation of ECC reform.

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			In scope of OIOO?	Measure qualifies as
Costs: 8.0	**Benefits:**	**Net:** -8.0	Yes	IN

Summary: Analysis & Evidence

Policy Option 4

Description: Multi-operator MVNO

FULL ECONOMIC ASSESSMENT

Price Base Year 2009	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: -59.67	**High:** -21.63	**Best Estimate:** -40.65

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	12.8		1.3	**21.6**
High	12.8		5.8	**59.7**
Best Estimate	12.8		3.5	**40.6**

Description and scale of key monetised costs by 'main affected groups'

Establishing a "full" MVNO capable of roaming across networks is estimated to cost £5 million with ongoing opex of £1-£3 million. This is based on a small niche MVNO targeted at those in and around partial not-spot areas. In addition, MNOs are estimated to face capex costs of £1m each to support the interface between the host radio access network and the MVNO core network as well as ongoing opex costs of at least £100,000 p.a. each. Increased site rental could add £1m p.a. each for three MNOs.

Other key non-monetised costs by 'main affected groups'

There are some minor potential costs to secure resilience of networks as MVNO subscribers could roam onto another network when theirs suffers as outage. However, this is assumed to be manageable given the smaller number of expected subscribers when compared to national roaming.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate				

Description and scale of key monetised benefits by 'main affected groups'

Other key non-monetised benefits by 'main affected groups'

The scale of the benefits would depend on the expected demand. As this is a specific service that must be subscribed to, the total number of consumers benefiting will be smaller than a solution that is available to all. Therefore the overall benefits, while similar in nature to the national roaming model, would be lower. However these benefits have not been quantified yet and this model will be explored further in the consultation.

Key assumptions/sensitivities/risks **Discount rate (%)**

The key assumption here is that there is significant demand from customers for a service offering from a specialist MVNO that offers multi-operator roaming.There is also some technical risk, in that the customer billing and interface for dealing with the multi-operator MVNO roaming can be delivered seamlessly.

BUSINESS ASSESSMENT (Option 4)

Direct impact on business (Equivalent Annual) £m:			In scope of OIOO?	Measure qualifies as
Costs: 4.1	**Benefits:** 0	**Net:** -4.1	Yes	IN

Evidence base for initiatives to address partial not-spots

Problem under consideration

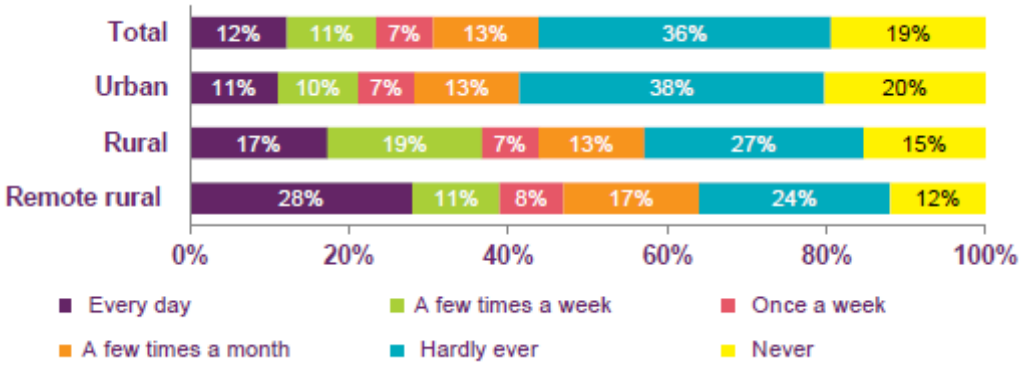
Mobile coverage in the UK is among the best in Europe but we aspire to be better. The Government has set up the Mobile Infrastructure Project (MIP) to tackle complete not-spots in coverage, where there is no coverage provided by any operator. However up to 21% of the UK is affected by partial not-spots, where coverage is provided by some operators, but not all. The problem is often worse in rural areas.

To get maximum efficiency from spectrum (the radio waves mobile phones and other wireless devices use to communicate – a limited and sought after resource), consumers should get a service wherever a signal is available. The Government wants to make sure that everyone can access voice communications wherever this is technically possible.

According to Ofcom, there are less than 1% of premises in the UK without any mobile coverage. However, a large part of the value in owning a mobile phone is that it can be used away from premises and in terms of land mass 11% of the UK has no mobile coverage.

Ofcom's measure of consumer dissatisfaction shows that consumers in rural areas are in general more dissatisfied with their mobile phone experience than their urban counterparts (19% compared to 12%). A number of factors, ranging from price, availability of handsets and customer service are likely to affect overall satisfaction. However, one of the key issues in customer satisfaction is reception or coverage. The issue is especially marked if we look at the frequency of consumers experiencing issues with voice services in urban, rural and remote rural areas. This is provided in Figure 1 below:

Figure 1 - Frequency of having no signal (Ofcom 2014)[1]



As can be seen above, 28% of those in remote rural areas and 17% of those in rural areas experienced no signal on a daily basis compared to 11% in urban areas. Furthermore, if we extend this to lost signal either daily or a few times a week, 21% of urban consumers faced this issue, while over 35% of rural respondents faced this problem. The same analysis also showed that 14% of remote rural consumers and 10% of rural consumers experienced dropped calls every day, compared to 5% in urban areas.

In 2010, Ofcom highlighted five particular aspects of poor or non-existent coverage, referred to as "mobile not-spots":

a) Complete not-spots: Where there are no networks at all – no 2G nor 3G coverage

b) 3G / mobile broadband not-spots – where there is no 3G coverage but 2G coverage

c) Interrupted coverage 'on the move' – not-spots experienced when travelling – 'in transit'

d) Indoor coverage – where there is no (or very poor) coverage inside buildings

e) Partial not-spots – Operator specific not-spots, where there is coverage by some, but not all, operators

A number of existing initiatives are being undertaken to address both complete, mobile data, indoor and 'on-the-move' not-spots. These initiatives are outlined in Table 1 below:

[1] Research question *How often, if at all, have you experienced any of the following when using your main mobile phone?*

Table 1 - Initiatives to deal with Not Spots

Type of not spot	Initiative
Complete not-spots	In October 2011, the Government announced the Mobile Infrastructure Project (MIP) – a £150 million capital expenditure plan to bring mobile network coverage to consumers and businesses in such areas. MIP is targeted at complete not-spots only.
Mobile data not-spots / Indoor not-spots	The large-scale introduction of 4G and the 800MHz and 2.6GHz spectrum auctions are targeted to significantly reduce mobile broadband not-spots. While stopping short of universal coverage, competition for the 4G licenses resulted in commitments by the Mobile Network Operators (MNOs) to match the 98% indoor data coverage obligation placed on spectrum acquired by O2.
In-transit not-spots	Network Rail is in the middle of a £1.9bn digital communications improvement programme to upgrade both its fixed line and mobile infrastructure. A new fibre optic network should be capable of handling up to 192,000 gigabit per second (Gbit/s) of data once the upgrade is complete in June 2014. It is expected that up to 70% of rail passengers by 2019 will benefit, while addressing a number of rail related not-spots.

However, the one area where there is no direct policy initiative is on the issue of partial not-spots. As can be seen from Table 2 below, partial not-spots affect a greater proportion of the country than complete not spots irrespective of how coverage is measured: affecting 3% of UK premises, 10% of A roads, 16% of B roads and 21% of the land mass.

Table 2 - Coverage by MNOs 2014 (Source: Ofcom)

2G Coverage by MNO	EE	O2	VO	Partial not spots	Complete not spots
Premises	98%	99%	99%	3%	<1%
Motorways	100%	100%	100%	<1%	0%
A Roads	93%	94%	95%	10%	1%
B Roads	88%	87%	89%	16%	5%
Land mass	78%	78%	82%	21%	11%

There are two particular costs associated with partial not-spots.

a) First, those who live and work in areas with partial not-spots face limited choice over the mobile products that they can use: Customers living in areas with coverage from multiple MNOs have a wider range of handsets, tariffs, data packages and terms than those not served by all operators

b) Second, those who travel into partial not-spot areas will lose mobile connectivity if the area is not being served by their own operator

Consolidation and commercial initiatives by the MNOs are expected to address some of the issues related to this. The most important such initiatives are industry wide consolidation (such as the merger between Orange and T-Mobile to form EE), as well as the network sharing agreement between O2 and Vodafone (Project Beacon). Given that there already exists an arrangement between Three and EE to allow Three's customers to 'roam' on EE's 2G network in some areas not served by Three's mobile network, the UK will effectively have 2.5 major networks from 2015/2016 when Project Beacon is complete. According to Ofcom this has the potential to reduce the number of partial not-spots as below:

Table 3 - Partial not-spots on completion of Project Beacon (Source: Ofcom)

	2014	2016	Improvement (% point)
Premises	3%	2%	1%
Motorways	<1%	0%	-
A Roads	10%	6%	4%
B Roads	16%	9%	7%
Land area	21%	13%	8%

While the above table shows the potential for improvement, Ofcom also outlines that there are risks associated with this initiative:

a) Firstly, instead of increasing coverage, the MNOs may decide to decommission certain sites where they overlap and concentrate on cost-reduction. Therefore, although partial not-spots would be reduced there may be some marginal increases in total not-spots.
b) Secondly, operators who wish to share sites may have to seek the agreement of landowners, who in turn may respond by refusing permission without an increase in site rental costs. Reform of the Electronic Communications Code, which regulates the legal relationships between landowners and network operators, is being taken forward separately and may help to address these issues over the longer term. However, these changes are unlikely to be applied retrospectively to existing rental contracts so will not substantially change the costs for a proposal which is to be applied in the immediate future.

Rationale for intervention

There are both equity and efficiency arguments for some form of government intervention in the reduction or elimination of partial not spots.

Mobile coverage as an essential service

The provision of basic essential services to all is a key component of government policy. In terms of communication services, certain basic services (e.g. connectivity on a “standard” telephone service) are secured through the legal framework of the Universal Service Directive (2002), the Communications Act (2003), and the Electronic Communications (Universal Service) Order 2003, as implemented by Ofcom.

However, in terms of telecoms more broadly, what is considered an ‘essential’ service is one that changes over time. Recent research by Ofcom[2] notes that “ultimately a service is essential if not having the service results in being excluded from normal social and economic activities” (section 3.4). There were four contexts within which this was identified:

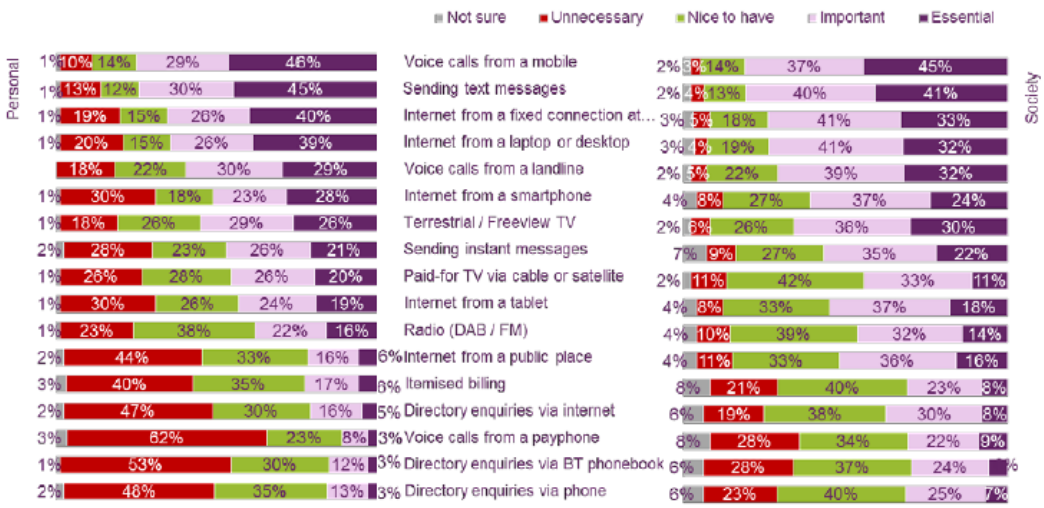
- Safety, and access to emergency services – contacting someone in the event of an emergency, e.g. 112/999 or a family member, seeking rescue, and accessing information that prevents or reduces danger;
- Communication and social inclusion - being able to keep in touch, both to reach others and to be contactable, for physical and emotional well-being;
- Access to information, education and entertainment – for instance, broadcast news and information, education that helps to reduce division in society and breaks down stereotypes, informing people overall, and access to entertainment for social and emotional well-being and to enable bonding with others; and
- Economic livelihood – for instance, gaining access to work opportunities and meeting the expectations set by employers.

These benefits of social and economic inclusion provide value to society beyond the pure private value to the individual. In this light, the research by Ofcom suggested that that “the services seen as most essential by consumers were voice services in general, but mobile services in particular (voice and text), and access to the internet, particularly fixed internet” (Section 1.4). It also noted that “consumers ranked the importance of telecommunications services alongside other ‘key’ essential services, like household utilities”.

As can be seen from the chart below, voice and text messages are considered more essential forms of telecommunications than any other means – including voice calls from a landline, terrestrial/Freeview TV or radio. This is both in terms of consumer’s perception of what is essential to them personally, as well as what is important to society.

[2] http://stakeholders.ofcom.org.uk/binaries/research/affordability/affordability_report.pdf

Figure 2 - Services and devices seen as essential, personally in day to day life (on the left) compared with in society (on the right), by percentage of respondents) Source Ofcom 2014[3]



Source: Jigsaw, *Affordability of Communication Services Essential for Participation*, July 2014

As outlined in Table 1, there are a number of government initiatives to ensure that there is as wide as possible access to these communication services. The options to eliminate partial not-spots on a national scale can be categorised as part of this overall aim.

Value of mobile phone coverage

In addition to providing coverage to a service regarded as essential by the public, access to mobile networks also has benefits over and above the amount that a consumer pays for a service contract.

For private consumers, unpublished research commissioned by Defra and part-funded by DCMS to help inform the MIP business case (RAND "Estimating the value of mobile telephony in mobile network not-spots"), indicates that people who visit, or live or work in mobile not-spots value the ability to access voice and data services over and above the price that they currently pay for it. The average willingness to pay for residents, businesses or visitors in not-spot areas for local 2G services of the same quality of those perceived to be available nearby is:
Residents: £12/month

Local visitors: £6.30/month

Businesses: £20.90/phone/month

Tourists over 65: 40 pence per day

Tourists under 65: 20 pence per day

These figures are in addition to the amount that they would pay for a typical service contract.

As is made clear from above, the disbenefits are not just borne by those living in not-spot areas. Travellers to these areas will also be affected. This might result in further potential for gain as tourists and other businesses avoid these areas, further compounding the negative impacts.

For businesses, mobile phone coverage provides advantages such as:

- Better coordination of business inputs;
- Information gathering;
- Responsiveness of decision making to rapidly changing circumstances; and
- Managing staff and benefitting from flexible working hours.

[3] As part of this analysis survey respondents were asked which of these services they regarded as essential, important, nice to have, unnecessary both for them personally, and for society as a whole. Their separate responses are provided in the two bar graphs.

While it is difficult to quantify the extent of these benefits, the same research for MIP by RAND asked businesses in not-spots to quantify the impact of losses due to poor connectivity. Almost 65% of these businesses estimated losses between £100 and £250 per month. Larger businesses reported monthly losses very much in excess of this.

Businesses not connected to reliable mobile networks may therefore face a significant cost disadvantage over those that do. The wider economic and social costs of moving businesses due to unreliability of the telecommunications networks may be greater than the costs of providing such networks.

The RAND Study looked into the issue of wider benefits to business and society and concluded that

> "The study has not directly examined the extent to which availability of mobile services might affect both business performance and the types of businesses which can operate in remote rural areas. However, this is potentially significant, and it is proposed that the availability of mobile services could be an important factor in ensuring diverse rural economies, and long term sustainability of rural communities"

Rationale for solving the problem of partial not-spots

The fundamental problem with partial not-spots is the loss of mobile phone coverage to a proportion of customers. In this light, the rationale for intervention in a partial not-spot is similar to as for providing mobile phone connectivity to complete not spots. Having a single or limited choice of mobile operators results in a loss of consumer welfare for those who live in these areas, and a loss in service for those (on another network) who travel into these partial not-spots. This is established by the extent to which consumers consider mobile access an essential service, the extent to which they benefit beyond the costs of a service contract and the extent to which society benefits from their inclusion.

As Ofcom's data in Table 3 above shows, it is clear that private incentives do not provide the levels of coverage that consumers desire. This is because there are certain parts of the country where the underlying drivers of demand and supply do not create a commercial case for private operators to invest in mobile infrastructure and provide a service on strictly commercial terms. This partly reflects the benefits of social and economic inclusions which cannot be fully captured by the market.

The model for government intervention via the MIP is to provide the capital cost of mobile infrastructure in some areas where mobile infrastructure would not otherwise be commercially viable. However, unlike with complete not spots, partial not-spots are suitable for innovative solutions because there are ways in which operators can share the existing investments made into their networks. Unlike complete not-spots, the costs of 'solving' the problem are therefore likely to be lower. Undoubtedly, there are technical, commercial and competition related issues involved in encouraging the sharing of a network. However, the potential for the benefits to outweigh these reduced costs are an important reason to consider the various policy options outlined here.

Policy objective

Parts of the UK have mobile coverage from one or more – but not all – mobile operators. This policy aims to eliminate these so-called 'partial not-spots' for voice calls wherever possible and maximise the area in which consumers can make and receive calls within the current combined network coverage footprint of the four UK MNOs. Doing so will provide incremental benefit to local businesses and economic activity, as well as less easily quantified social benefits (e.g. social inclusion and enhanced consumer choice).

Ofcom estimates 21% of the UK land mass is in partial not-spots, and that under current network upgrade plans, this will be reduced to 13% by 2016. This impact assessment looks at options for further reducing partial not-spot areas. DCMS have considered various options for enabling consumers to make and receive voice calls in current partial not-spot areas, including national roaming, a multi-operator MVNO and a form of infrastructure sharing between mobile operators. Shortlisted options are technically feasible (in the sense that they employ demonstrated technologies or approaches), and measurably reduce or eliminate partial not-spots. Acceptable solutions should deliver additional coverage at the earliest point possible, though not at the expense of aggregate coverage improvements. In order to deliver maximum benefit, this should ideally be by the end of 2016**.**

Description of options considered (including do nothing)

Do-Nothing scenario

As outlined above, the Do-Nothing scenario includes the existing changes to the network committed by the MNOs, most notably Project Beacon. However, it is acknowledged that there are risks associated with the outcomes of these initiatives, and this must be considered as part of the analysis of the Do-Nothing scenario.

Project Beacon: Passive Network Sharing between O2 and Vodafone

Vodafone and O2 have formed a new joint venture (TowerCo), into which the parties' base station sites and site management businesses have been transferred along with their related passive mobile network assets. Accordingly, TowerCo will be responsible for the management of a single, optimised grid of base station sites, including liaising with landlords and decommissioning or acquiring sites. The joint venture formalises a pre-existing arrangement between the parties to manage their sites jointly and facilitate site and passive asset sharing. The project also involves entering into contractual arrangements whereby the parties divide the UK into two regions, and each party over time takes responsibility for design, management and maintenance of the Radio Access Network (RAN) equipment in one half of the country (Active Arrangements). In this regard, each party deploys new Multi-Operator RAN equipment that will enable one set of radio equipment to broadcast multiple frequencies.

This represents one of the most significant changes to the UK's mobile network since the merger of Orange and T-Mobile to form EE and has important implications for the overall coverage achieved by the sector. Ofcom has analysed these figures, and their estimate of the impact on partial not-spots coverage is provided in Table 4 below:

Table 4 - Improvements to partial not-spots due to Project Beacon (source: Ofcom)

	2014	2016	Improvement
Premises	3%	2%	1%
Motorways	<1%	0%	-
A Roads	10%	6%	4%
B Roads	16%	9%	7%
Land mass	21%	13%	8%

As can be seen above, Ofcom estimates the total premises in partial not-spots to reduce to approximately 3%. In terms of total land area, Ofcom estimates that the percentage of total land mass that are partial not-spots will decrease from 21% in 2014 to 13% by 2016.

In addition to Project Beacon, there are also a number of internet-based initiatives that are being undertaken that assist in delivering greater connectivity, especially to rural areas. Vodafone, for example, has an initiative called Rural Open Sure Signal, which started in 2011, and uses a broadband internet connection to provide 3G connectivity to rural areas as a community-led trial in 12 communities. The

project has given reliable mobile access to over 8,000 people in the 12 communities which are drawn from across the UK from the Shetlands in Scotland to Newton St Cyres in Devon. Vodafone announced the next phase of the programme in July 2014 to give a further 100 rural communities across the UK the opportunity to have reliable mobile access for the first time.

Such voice connectivity over broadband connections are already offered on smartphones by a number of operators – such as O2's "TuGo" facility, as well as the recent announcement by EE that they would be delivering a voice over WiFi service that works without a separate app.

While these voice over WiFi schemes are of great interest, their key drawback are that they would still only provide services near or around premises where an individual has access to the WiFi. They do not provide a viable solution to connectivity on a geographic scale. Given that the impact of these schemes would therefore be limited, we have primarily taken the improvements in geographic coverage as a result of Project Beacon (as identified by Ofcom above) to be the Do-Nothing scenario for this analysis.

Long-list of options

As part of the analysis, an initial long-list of options were analysed at a qualitative level. These were evaluated on the basis of

a) Impact on partial not-spots

b) Cost

c) Technical feasibility

d) Risk and disruption to the market

There are three main categories of long-listed options:

1. Existing technological solutions
2. Infrastructure sharing
3. Mobile roaming

These are examined further below:

1. Existing technological solutions

There are a number of options that allow consumers to reduce the incidence of partial not-spots through existing technology.

Dual-SIM handsets:

A number of handset manufacturers now provide dual-SIM handsets that allow customers to operate one phone on more than one network. This would mean that customers can take advantage of being reachable in case one network is unavailable. One option would be to encourage greater take-up of these phones through localised marketing campaigns.

The key advantage is that this requires no significant regulatory changes or infrastructure costs. Therefore from a policy perspective, this has **relatively few policy level costs**. They also exist in the market place and therefore have **relatively little risk of significant disruption to the sector**.

Previously, dual SIM phones tended to not have the many features customers generally desire from smartphones. However recent dual-SIM phones offer the same functionality as some of the high-end products in the market.

However, dual-SIM handsets also have a number of disadvantages. Firstly, they are not available on networks as part of a package. This reduces take-up as the large majority of smart-phone users in the UK are on a package rather than buying a phone outright. One of the most popular handset makers, Apple, do not offer a dual-SIM product and are unlikely to do so given their revenue sharing business model with MNOs. In addition, being on two plans would increase costs to consumers, potentially significantly.

It is also unlikely to be attractive to occasional visitors to areas with partial not-spots and customers would still require two separate numbers. Therefore, if they are not reachable by one number, the caller would have to dial a second number. There is also the need to pay for two operators which may be a cost factor that reduces its overall value for money for consumers. The experience would not be seamless, resulting in dropped calls as people move between two partial not-spots. For these reasons, **the impact of dual-SIM** phones to widely address the problem is limited.

Broadband based solutions: Femto / Pico cells

These solutions use fixed-line broadband to relay signals to the mobile network. There are now solutions available targeted to both residential and commercial markets, and further solutions are being tested. As outlined above, Vodafone's Rural Open Sure Signal project is an important development here. WiFi based calling services are already being offered by both independent parties (such as Skype and Viber), while operators themselves have also provided such an offer through apps (O2's TuGo is one such example). Similarly, EE has recently announced an offer of voice and SMS features over WiFi without the need for any additional software. Therefore voice over WiFi is a solution that already exists for those consumers when they have access to a WiFi signal

As with dual-SIM phones, the key advantage is that this too requires no significant infrastructure costs or regulatory changes and therefore can have relatively low costs.

However, the option requires the availability of reasonable quality broadband, (either fixed or 4G), which generally has a smaller geographical footprint than 2G voice connectivity. Therefore the overall impact of such solutions to deal with the problem of low connectivity in partial not-spots may be significantly reduced. The requirement for a broadband network also means that the voice solution is only available in a limited area surrounding specific fixed locations, thereby limiting the impact it could have on those who are not near buildings or travelling. One option may be to use public WiFi, but the availability of these services are also limited, notably in rural areas where the problem of partial not-spots is of greatest concern. Impact of this option is therefore likely to be limited.

Multi-Operator MVNO

A mobile virtual network operator (MVNO) is a service provider that does not own the wireless network infrastructure, but enters into an agreement with an MNO to obtain bulk access and provide services directly to customers on a retail basis. An MVNO could technically agree with multiple MNOs, so as to allow their customers to 'roam' on whichever network is available.

In a sense, the operation is very similar to international roaming – in that it is a third party that deals with all operators to arrange access to their multiple networks. Plum Consulting have advised that international roaming is in fact being used by some consumers to deal with the issue of partial not-spots, such as the uptake of a roaming package from telecoms providers in the Isle of Man. From a technical perspective, such a solution therefore has potential. The option also has the advantage of not necessarily requiring large changes in policy, as well as being able to make a real impact on solving the problem at hand.

However, it must also be noted that a solution of this type has not yet been widely marketed. This implies the existence of commercial obstacles which may be inhibiting the development of such an MVNO. On the one hand, it may be the case that the costs of providing such a service cannot be covered with the potential demand. On the other hand, it may be that commercial agreements between MVNOs and MNOs are stopping the emergence of such a solution due to exclusivity requirements on the part of MNOs.

Nevertheless, this is an option that should be explored in greater detail as part of the short-list of options.

2. Infrastructure sharing

Infrastructure sharing relates to the sharing of common facilities between MNOs.

There are two broad categories of such sharing: passive and active infrastructure sharing. According to the Office of Fair Trading's (OFT's) decision on Project Beacon, passive infrastructure relates to:

> "those physical structures onto which radio transmission equipment (active assets) are fixed. They include masts, towers, head frames, compounds, fences, gates, cabins, plinths, cooling equipment, power, lightning protection, power supply, battery back-up equipment, connectors and cabling".

This is different from active infrastructure sharing, which refers to the use of radio transmission equipment such as antennas, feeder cables, RANs, base transceiver stations (BTSs)/Node Bs, backhaul (transmission) and microwave radio equipment. In short one may consider passive infrastructure as supporting equipment, and active infrastructure as that which actively processes, transmits or receives signals

Infrastructure sharing is primarily a means of reducing costs for enhancing the coverage of networks. Its key advantages are that it does not require significant regulatory or policy level costs on the operators, nor does it result in some of the technical challenges related to mobile roaming (outlined in detail below). The other advantage is that the expansion of a network via network sharing also provides the potential for expanding data services, which a 2G voice-only roaming requirement fails to provide.

The key disadvantage of the infrastructure sharing however is that it may not have the same impact in terms of coverage as a requirement for national roaming. The speed at which infrastructure sharing happens may also be less than that for national roaming. An effective mechanism by which a government or a regulatory body may 'mandate' infrastructure sharing is not fully obvious, though there

are international examples of such mandates that currently exist. Sharing active infrastructure also raises competition issues and so how it is done needs to be carefully assessed, particularly as there has been an emphasis on adequate and effective competition in the rollout of mobile communications

Nevertheless, there is the potential for the scheme to be a viable alternative to national roaming and it is therefore short-listed for further analysis below.

3. National mobile roaming

The third category of options is national mobile roaming; i.e. the ability of a phone on one network to connect to another network when their 'home' network is unavailable.

Under normal use a handset will identify and connect to its home network (i.e. the network with which the customer has their contract) when it is available. For example, when leaving an Underground station a phone will search for and connect to its home network. Where there is no coverage from the home network the handset will try and search for other available networks and request to connect to them. Under existing conditions for national / domestic customers, this request would be denied and the customer would not get service. In contrast, for international roaming customers, the request is allowed and the customer is able to connect to any network.

With national roaming in place the request to connect to the available alternative network will be accepted, allowing the user to make and receive calls in any location where at least one network operator has coverage.

There are two broad types of national roaming available. Seamless national roaming takes place when a call is not dropped as the phone moves between networks as and when one becomes unavailable during a call. Under a non-seamless option, the call is dropped as one network becomes unavailable and the user would have to dial again once connection to the other network is made. A review of national roaming by Analysys Mason found that seamless national roaming, while possible, is both technically complex and likely to be more expensive to implement. As well as the cost element for operators it also reduces the differentiation between operators, as even an operator with poor coverage appears to have good coverage if there is an automatic handover to other operators.

There are three broad reasons to believe that national roaming would have a significant impact in terms of removing partial not-spots. First, the presence of international roaming shows that technically such an outcome is feasible. Second, the networks have also allowed national roaming for emergency 999 calls – i.e. where a consumers' own network may not be available, consumers can use another network to dial 999. Third, national roaming has been, and continues to operate between some of the existing networks. Three already has a national roaming arrangement in place with, originally Orange, and now EE. This allows Three to roam on EE's 2G network in some areas where Three's 3G network is not available. From a technical (rather than commercial) standpoint, the merger between Orange and T-Mobile has also resulted in a roaming arrangement where the customers on one of these legacy networks roamed on their recently merged partner's networks.

However, national roaming is not without its risks and challenges. Firstly, the scale of the above three instances of roaming are quite small. Expanding roaming at a national scale is arguably likely to result in technical challenges, and has never been done on a large scale in any large developed country. Other notable international instances of 'national' roaming have taken place in Australia and France and are detailed in Box 1 below. However, this has been done either as part of a government infrastructure program in localised areas (France) or on a voluntary basis between two operators where customers have to subscribe to that service rather than being an automatic service – albeit with the threat of regulatory action (Australia).

Box 1 - International examples of national roaming (Source Ofcom)

National Roaming in rural France
National roaming to improve coverage of complete not-spots in rural France has been in place since 2003.
New network has been built in areas where none of the operators had existing coverage.
Between 2003 and 2008, a publicly subsidised programme delivered coverage to 3,400 villages in France through a combination of passive sharing and national roaming introduced by agreement between the State and the mobile operators.
Roaming between networks is not seamless.
This is similar to MIP in that new infrastructure is being built. However unlike MIP (where each operator then deploys its own equipment on the new masts) a single operator deploys equipment and then provides roaming to the others.

Roaming in Australia
There have been a number of different 2G roaming arrangements in Australia.
•**Telstra/Vodafone**
Vodafone customers can roam onto Telstra's network in Victoria and Tasmania.
The roaming is not automatic, customers need to pre-register with Vodafone.
Roaming between networks is not seamless.
•**Vodafone/Hutchinson**
Vodafone had a time-limited agreement to provide national roaming to Hutchinson's 3G customers in areas not covered by Hutchinson's 3G network.
Vodafone and Hutchinson subsequently merged.
•**Vodafone/Globalstar**
Vodafone supplied national roaming to Globalstar, a satellite network operator to provide coverage in areas where there was GSM coverage.
Globalstar's customers accessed Vodafone's GSM network using dual mode GSM/satellite handsets.
Although the Australian Competition and Consumer Commission (ACCC, the regulator) did not mandate inter-carrier domestic roaming arrangements it made it clear that a refusal by operators to provide roaming services would result in action by the ACCC.

Initial responses from both the MNOs and technical consultants for the Department suggest that this is more complicated than 'turning-on' national roaming. Therefore, the costs associated with these technical aspects will need to be explored in greater detail if the option is shortlisted.

Second, the investment that is required in order to make national roaming work would have to be found at a time when the networks are rolling out 4G networks. This may take away both resources and management time.

Third, while networks can be provided assurance that national roaming relates only to 2G voice networks, this may cause uncertainty among investors if they feel national roaming may be expanded to data at a later stage. Therefore, any potential disruption to investment must also be considered.

Finally, in terms of risk and disruption to the existing network, the key issues relate to how such roaming is to be incentivised or regulated. Government's preference is for a voluntary agreement to implement roaming. The price at which access is provided between the networks is key to ensuring that there is a workable solution.

In light of the above, national roaming is to be explored in further detail as a shortlisted option.

Table 5 provides a summary of the long list of options. In light of the potential impact, feasibility, costs and disruptions; national roaming, a Multi-Operator MVNO and infrastructure sharing are analysed in greater detail below.

Table 5 - Summary of long-listed options

	Impact	Technical feasibility	Cost	Risk / Disruption	Short-listed
Dual SIM phones	Low	High	Low	Low	X
Broad-band solutions	Low	Medium	Medium	Low	X
Multi-Operator MVNO	Medium	Medium	?	Medium	✓
Infrastructure sharing	Medium	High	?	Low	✓
National roaming	High	Medium	?	High	✓

Note: The costs of the three short-listed options are estimated in the following analysis.

Short-listed options

National roaming

Background

As outlined above, the technical feasibility of mobile roaming can be seen in the fact that international roaming already takes place, as well as 999 emergency dialling, Three's roaming on the EE network, and following the merger of Orange and T-Mobile. This section analyses these issues in greater detail, looking at:

a) A proposed model of national roaming

b) Technical feasibility

c) Commercial feasibility

d) Costs

e) Benefits

A) Proposed model of national roaming

During the initial consultation between MNOs, the Department and Ofcom, the following model was put forward as a 'base-case' arrangement on national roaming:

1. A *voluntary* national roaming scheme where MNOs are to agree amongst themselves on how the roaming scheme would operate. This involves a common obligation to supply and purchase voice roaming to other UK MNOs, limited to 2G, (except where an MNO prefers to offer, or only has, a 3G voice service and is able to separate 3G voice from 3G data).
2. The scheme is to operate within a limited geographic sphere focused exclusively for each operator on those geographic areas where they do not already have coverage and where at least one other operator does have coverage.
3. The proposal did not request a 'seamless' national roaming solution. A seamless call is one where the call does not drop as the caller moves from an area covered by her own home network into an area covered by another network.
4. The costs of providing the scheme could be spread across all mobile minutes purchased in the UK across all operators (MNO and MVNO).

Government's preference remains for a voluntary agreement by MNOs to implement national roaming. If such an agreement cannot be reached, it may be necessary to deliver this option through regulation.

B) Technical feasibility

During initial consultation with MNOs, the following technical concerns about feasibility of national roaming were raised. These have in turn been analysed by independent experts on behalf of the Department on whether these concerns provide a significant barrier or challenge to the successful technical implementation of national roaming. These relate to both issues of the supply-side service delivery complications, as well as overall consumer experience of national roaming.

Consumer Experience of National Roaming

Battery life: MNOs have noted that under national roaming, battery life will be reduced by phones searching for their home network while roaming in a partial not-spot. The issue has to do with the frequency with which a mobile phone searches for a network once it loses connectivity, which is an activity that has a significant impact on battery life. Under existing non-roaming scenarios, when a phone loses signal, the period in which it automatically detects a new signal (when it is not in active mode) can be set at a relatively less frequent interval. Under national roaming, the phone would seek out an alternative network when it has lost connectivity and unless the phone scans for a new network, it would remain on that network even if the home network is available.

Extra time spent on other networks is not just a loss of revenue to the home network, but ultimately raises the cost to the consumer as they would have to “pay” for those national roaming minutes (irrespective of the exact billing arrangements/package they have with their home operator). Therefore it is in the interest of both the operator and consumer that this is reduced. In order to reduce the time spent on a rival network, the phone would have to be set so as to automatically scan for new networks at more regular intervals resulting in greater battery drain.

According to independent analysis by Plum Consulting, it is certainly the case when a device goes out of coverage (whether roaming or not) it will scan periodically to attempt to find a network. This scanning behaviour will have an impact on battery consumption if the phone is frequently going in and out of coverage but it is hard to quantify the magnitude of the impact as it depends on how frequently the phone loses coverage as well as other applications running on the device (assuming it’s a smartphone). This is what happens today in both urban and rural areas so on the one hand it is arguable that it is already part of the counterfactual and not something specific to roaming. Depending on the nature of the roaming solution adopted it may be that consumers can manually override roaming settings, allowing them to balance extra coverage and battery life as needed. Further evidence on this needs to be gathered through the consultation in order to identify the magnitude of this problem.

Dropped calls: MNOs have noted that there will be an increase in dropped calls under roaming. However, the most likely scenario leading to a dropped call is that a customer roams onto another network, makes or receives a call and then reconnects with their home network causing the call to drop. Such calls wouldn’t exist in the absence of roaming so although more are dropped and this may frustrate some customers it would only be impacting on their additional usage, not their existing usage.

The one area where it might impact on existing usage is where a customer is on the edge of their network coverage and without roaming would still be able to make a call but with roaming might bounce between their home network and another network with a stronger signal. It’s likely that this would occur a relatively small amount of the time and it may be possible to mitigate through setting network preferences.

Another issue that has been raised by the MNOs is that dropped calls is a relatively objective means of measuring and improving the consumer experience. With national roaming, it would not be possible to identify whether dropped calls are happening due to internal problems within the networks, which can be improved by the operators, or due to national roaming, which the operator can do nothing about.

Loss of data services through 2G signal lock: This would occur where a customer has a strong 2G signal from another operator and roams onto them, losing their home network’s weak 3G / 4G signal. Plum Consulting have assessed this as being potentially a large cost as consumers value data access higher than voice. However, it may be possible to mitigate this to some extent through setting network preferences.

Unavailability of voice-mail and other features: Under national roaming, some of the added features of a mobile service, such as voicemail, may not be available. However this would depend on the type of arrangements to be put in place between the operators and therefore technological solutions to this could be found. It is also the case that without roaming consumers would not have a signal at these times so would not be able to access these features anyway. Most networks can extend voicemail and major features to overseas networks when roaming internationally, so although one may need to access voicemail etc. in a slightly different way, this is not seen to be a significant issue. The issue would relate to the additional costs associated with installing these additional features and how these are to be paid for.

Customer service and network outage: A further concern that has been raised by the MNOs is the potential results on all networks in the case of a network outage. The issue here is that in the case of a network outage on one network, the subsequent impact on the other networks from roaming on to them would cause problems for their own customers. Without an effective fail-safe this could even lead to other networks being overloaded with traffic, and suffering subsequent outages of their own. Furthermore, in such a case, customers would not be certain of whose ‘fault’ the outage is. This would result in loss of goodwill as well as increased costs of dealing with customer complaints.

Ultimately, this issue is one of balancing risk with investment. Network outages do happen, and therefore some additional investment may be required to deal with the additional strains national roaming put on the response to such outages. However, the extent of this additional investment would be need to be examined in greater detail and fail-safes preventing mass roaming could in theory be developed to minimise this risk. One may for example construct roaming so that in the event of failure of network Y, network Z is allowed to limit traffic roaming from Y (noting that an emergency call from any user would get automatic priority, as at present).

Service Delivery Concerns

Area of coverage for national roaming: The above national model implies that national roaming would be contained within the small proportion of areas that are experiencing partial not-spots. However, the actual operation of national roaming would not be controlled at a per-site basis, and MNOs have argued that it would have to be undertaken over a much larger area thus resulting in greater costs. They note that the minimum area for roaming control is the 'Location Area', and in rural areas this can cover a very large area. Therefore the localised nature of the problem cannot be solved by implementing a solution just in those localised areas.

While this may technically be true, experience of the EE and Three roaming arrangement implies that roaming can be limited to a small number of areas. This is however an issue that must be analysed in greater depth through the consultation.

Network configuration: Currently, there is a non-Location Area specific code that is sent that effectively forbids a mobile phone (SIM) of a different operator to 'roam' on another network.

To allow national roaming, all the access rules for all Location Areas on all core network nodes must be updated to reflect the new policy. Specifically the network must never send the 'forbidden' code because this will be stored in the SIM. Instead, on a Location Area by Location Area basis, it must either allow the connection or reject it with a code that indicates that service is not possible in this Location Area. Network policy would need to be updated to change the access rules for location areas.

Consumer provisioning: The network configuration controls described previously allow the visited network operator to control access to their network. The home network operator also has mechanisms to control which visited network its customers are allowed to use. This configuration is held in the Home Location Register (HLR) and is part of the data provisioned against each customer.

Even if a visited network allows a connection, the HLR will block it unless a customer has been specifically provisioned to allow service in that network. To allow national roaming, there must be a provisioning update to all subscribers to allow service in the competitor networks.

However, the HLR does ultimately control the networks that a device can access when roaming outside of home network coverage. HLRs would therefore have to be updated to allow roaming onto networks in the home network area, which would mean, as stated here, that data for all subscribers that will be allowed to roam nationally will need to be updated.

Consumer device / SIM configuration: In order to enable the above technical steps, an Over-the-Air (OTA) campaign of SIM reconfiguration has to take place. These typically take 3 months to achieve an 80% completion rate with the remaining base needing multiple repeat campaigns to complete. According to Plum Consulting, this is a very valid concern on the part of the MNOs. The logistics are a challenge for an all-subscriber update as there are many millions of SIMS to update over-the-air (usually using SMS). However, the uptake is likely to be higher amongst those in partial not-spots who will benefit most and those who do not benefit may be able to opt-out.

Voice Service Logic / Intelligent Network: Access to a Service Logic / Intelligent Network is required in order to access some services such as shortcode dialling, Pay as You Go and interaction with the Voicemail platform. In practice these interactions require development and extensive testing in order to inter-operate correctly. This has given rise to issues with international roaming for the same reason.

The issues with international roaming and access to services such as voicemail are well known. In some cases the implementation is present to allow such services to work in an international context (e.g. when

roamed onto the home operators network in another country or a partner network of the home operator). Where it is not, customers will need to dial full-length access numbers and use security credentials (e.g. a PIN) to access their services when roaming.

Such issues can be overcome as they must have been addressed when Three roamed for 2G voice coverage but it is unlikely that the service development is currently in place between all UK operators. How serious this problem is depends on how important access to services such as voicemail is perceived to be. In the context of national roaming in partial not-spots this is not likely to be a serious issue (without roaming the subscriber would not be able to access any services).

Retail and wholesale billing systems: A four-way billing mechanism will be required to ensure that roaming minutes are charged between the firms. This needs to be operated for both originated and terminated cases where a national roamer is on a visited network.

In the case of all networks except Three there needs to be both originating and terminating billing for nationally roamed services. Three does not operate a 2G network so there will be no inbound roaming to its network but its customers will be able to roam onto other networks.

For international roaming this is usually addressed through a third party billing entity (a clearing house). It is not clear whether the services of the clearing houses could be used for national roaming (we have no information at present as to whether they will be able to do this).

To provide the billing services associated with national roaming will require the operators to ensure that their billing systems can interface correctly to bill the calls. It is likely that operators will have IT systems procured at different times from different vendors and that development may be required to provide the required functionality.

Inter-operator testing: All the changes described in the previous sections will require extensive testing both internally, within each operator, and then at an inter-operator level.

It will be imperative to each operator that such large-scale system and device changes have had no detrimental impact on their non-roaming customer base. It will be essential to complete inter-operator testing between each combination of operators, this would also need to include some 3-way operator testing where two customers from operator ‘A’ call each other when one is in operator ’B’ coverage and one is in operator ’C’ coverage. This testing can only be carried out when all the participating networks have delivered the required level of change.

As with all network and IT developments providing public service where reliability and integrity are required there is a need for rigorous specification, implementation and testing. Without knowing more about the specific network and implementations of each operator it is not possible to provide a definitive view but it is likely that these developments will take both time and require specialist resources.

C) Commercial feasibility

The supply-side issues mentioned above are however not insurmountable. Nevertheless, they are likely to require investment and operating costs in order to address them. In 2010, Analysys Mason was commissioned by Ofcom to look into some of these issues. The scope of the work was to identify the costs associated with modifications in order to enable national roaming, to understand the technical and commercial challenges MNOs faced, as well as to understand why national roaming has not been implemented to date.

The key conclusion from their findings were that

> "a seamless national roaming solution that effectively allows all UK networks to inter-operate seamlessly to provide a service that maximises coverage and appears to the subscriber as a single network is not technically feasible".

However the report also noted that:

> "However, if the requirement for in-call handover is removed and there is relaxation in the need for service transparency, then a workable solution seems attainable. We consider that national roaming could be considered for basic voice services"

Along with the Analysys Mason report, as part of the initial consultation, MNOs themselves have provided estimates of these costs. These have been independently verified for the Department by Plum Consulting. Table 6 below provides a summary of these findings, which identifies those factors which Plum Consulting believe to be significant and not-significant as far as costs are concerned.

Table 6 - Analysis of the potential costs of national roaming

Costs that are likely to be incurred
Radio access network (base stations and base station controllers): the main factor here is the need to provide additional capacity to support roaming traffic, i.e. additional radio transceivers may need to be installed at some sites, though some reconfiguration of network Location Areas may be required to tailor the roaming area more closely to partial not-spots.
Customer and interconnect billing systems: Although these are already set up to support international roaming, national roaming is likely to add complexity - international roaming is generally handled by specialist third parties using the GSMA TAP3 standard but this is unlikely to be practical or economic for national roaming so alternative arrangements would need to be put in place.
Intelligent network and value added service platforms: There may be issues relating e.g. to voicemail handling though these are unlikely to be significant in cost terms
Customer support: There is likely to be potentially an increased requirement to deal with problems such as degraded data availability (where devices roam on to stronger 2G signals from a weaker 3G signal).
Service transparency: There will likely be additional costs associated with testing and monitoring the performance of the roaming service. It will also likely be necessary to modify the network Location Areas where roaming is activated on an ongoing basis as each network's own coverage improves (for example to avoid excessive 'camping' on 2G networks where the operator has 3G or 4G coverage available).
Roaming implementation: There will be a need to update SIM cards (generally over the air) and additional training of support staff.
Network contagion: relates to the potential need to support large volumes of roaming traffic in the event of a competitor network outage. There is a trade-off here between the need for additional capacity to support such rare events or acceptance of a potential degradation of service. As outlined above, the extent of this will depend on a number of factors but one which we have not yet costed.
Site access: This is regarded as one of the most important components of costs. According to the MNOs, many of the current arrangements with site owners do not allow roaming and therefore roaming agreements may require additional costs.
Costs less likely to be incurred (but raised by the MNOs)
Core network elements (mobile switching centre, home location register etc.): In principle

the impact on the core network should be minimal as this will already be configured to support international roaming.
Base station backhaul: If roaming is limited to voice-only there is unlikely to be a significant impact, though in some cases it may be necessary to upgrade the capacity of existing microwave links (e.g. from 2 Mbps to 8 Mbps), depending on the anticipated volume of traffic.
Signalling transfer point: Unlikely to be a major factor as already supports international roaming.
Core transport network: Impact is unlikely to be significant assuming only voice roaming in limited geographic areas.

Conceptual approach to the cost-benefit analysis

The following approach has been taken towards measuring the costs and benefits of national roaming.

Costs: The Department have requested initial feedback from the MNOs on the likely costs associated with the different activities involved in implementing the different policy options. This has been independently verified and re-estimated by external consultants and estimates have been provided on both the capital and operating costs associated with the different options.
Benefits: Identifying the benefits are understandably more challenging than for costs. As outlined above, we have identified the following benefits associated with reducing / removing partial not-spots. In an ideal situation, we would be monetising the value of these features:

a) Increased choice for existing customers (residents and businesses) in partial not-spot areas. Customers living in areas with coverage from multiple MNOs have a wider range of handsets, prices, data packages and terms than those not served by all operators
b) Increased connectivity to consumers who lose out when visiting a non-home network partial not-spot.
c) The value to society of social and economic inclusion beyond the private benefits to the individual.

Valuing a) and b) would ideally be done using a bespoke ‘willingness to pay’ survey which would reveal the extent to which people valued choice and connectivity which has not been possible in the timeframe. However, using an existing willingness to pay study carried out in total not-spots we do monetise some of the benefits associated with (b) above – i.e. those related to people visiting a non-home network partial not spot.

The social benefits in c) are much more difficult to measure but could be done through further stated preference studies or studies of socio-economic indicators in areas with and without mobile coverage. However, again, this has not been possible in the timeframe.

Further details of the costs and benefits are provided in the sections below.

D) The costs of national roaming

In order to identify the expected costs of roaming, the Department have contacted the MNOs directly to ask them of their expected costs of implementing national roaming. These were subsequently analysed by independent consultants Plum Consulting to arrive at the following estimates.

Capital costs:

The costs associated with national roaming are subject to a degree of uncertainty. Plum Consulting has therefore calculated both a high and low band for the estimates of capital costs.

The key capital costs involved in national roaming are likely to involve IT and network system development. This is estimated at between £16 and £32 million per operator, and therefore expected to cost between £64 and £128 million across the four main MNOs. These costs would occur in year one of

implementing roaming but have been annuitized over the appraisal period (10 years) using the cost of capital for an efficient mobile communications provider as calculated by Ofcom in their Mobile Call Termination model at 6.9%.

It must be noted that the MNOs raised the issue of costs of providing additional capacity and generally dealing with extra demand in the case of a network outage on a competitor network. Independent analysis of this by Plum Consulting however suggests that these costs are unlikely to be in the magnitude proposed by the operators. Nevertheless, there is understandably a trade-off to be made between the investment that is made on the network to ensure greater certainty, and the overall costs to the consumer.

We have not attempted to include a figure for this contingency, but will be investigating this issue further through the consultation.

Operating costs:

Operating costs for mobile operators can include site-related costs such as rentals, rates and other site services (e.g. security) provided on an ongoing basis. They will also usually include costs for electricity, cooling (if applicable), structural maintenance, equipment maintenance and backhaul services. MNOs have also highlighted that national roaming will likely result in an increase in customer service calls, particularly given that the service (as in being non-seamless and without data services) will not match what they receive on their home network.

Often a rule of thumb is used to estimate opex of 10% of the capex value per year. However, this rule of thumb won't fully factor in the potentially high cost of renegotiating site rentals, which have been highlighted by the MNOs. However, it must be noted that given we are referring to 2G and Three already roams on EE for their 2G connectivity, we expect operating costs to be borne primarily by EE, Vodafone and O2. In light of these and the evidence presented by the MNOs to date, customer service costs are estimated at £500,000, while additional site rental costs are estimated at between £8-10 million.

Reform of the Electronic Communications Code, which is being taken forward separately, may help to reduce the site rental costs and need to renegotiate for roaming over the longer term. However, these changes are unlikely to be applied retrospectively to existing rental contracts so will not substantially change the costs for a proposal which is to be applied in the immediate future.

Indirect costs – incentives to invest by MNOs:

The biggest indirect costs associated with national roaming relate to incentives for mobile operators to continually make investments on their network. There are three main elements to this:

- MNOs compete on coverage and therefore removing their ability to compete on this measure reduces their incentives to expand coverage. For 2G this is seen as a minor risk as coverage is now very similar and there is no major expansion planned anyway (although they will continue to invest to some extent to maintain their current network). The potential for roaming to adversely impact on their expansion of 3G and 4G networks is still currently a substantial risk that needs to be managed carefully with appropriate assurances.
- The MNOs are engaging in substantial investment to rollout 4G currently. To carry out additional investment of the scale required to implement roaming will likely lead to an equivalent reduction in the available investment capital for 4G rollout. Therefore, even if pricing can be set correctly and voice roaming effectively ringfenced there is still a risk to 4G investment equivalent to the amount required for implementing roaming.
- While a profitable outcome or opportunity for the MNO's could be found for wholesale access, some MNOs have built their culture and strategy around differentiating their product offering at the retail level. They are therefore likely to resist the change in strategy and culture that a wholesale mast-by-mast pricing regime would demand.

Indirect costs – Law Enforcement

Any solutions to tackling partial not-spots would also need to ensure that they do not have a negative impact on law enforcement or security work that involves requests to MNOs on call data or lawful intercept work. If national roaming is implemented then an assessment will need to be made of the extent to which this increases data requests and related costs for industry and Government.

Consideration will also need to be given to the extent to which this impacts the timing of any planned roll out.

E) The benefits of national roaming

Introduction

We have identified three main benefits of reducing / removing partial not-spots:

a) Increased choice for existing customers (residents and businesses) in partial not-spot areas. Customers living in areas with coverage from multiple MNOs have a wider range of handsets, tariffs, data packages and terms than those not served by all operators;
b) Increased connectivity to consumers who lose out when visiting a non-home network partial not-spot; and
c) The value to society of social and economic inclusion beyond the private benefits to the individual.

However, quantifying the benefits of national roaming is more challenging than the costs.

a) A first challenge relates to quantifying and monetising the value of choice that consumers in partial not-spot areas face. On the one hand, given that these are a small percentage of the total population, they do not face a different menu of options from their individual provider to what is offered to consumers who do not live in a partial not-spot. In a competitive market such as the mobile service market, it is therefore likely that the products available are quite similar. Nevertheless, there is undoubtedly a value that consumers place in being able to make a choice between different providers, as the products on offer are not completely homogenous. However, there is no obvious available data with which to quantify this lack of choice.
b) The second challenge in quantifying the above benefits is the lack of data on the total number of consumers who live in partial not-spot areas or who experience lost connectivity when visiting partial not-spots. Ofcom figures suggest that broadly 3% of premises are affected, but we also know that mobile phone usage can take place outside of premises and that approximately 21% of geographic land mass is affected.

We can however estimate that based on the assumption from Ofcom that 3% of premises are in partial not-spots, and assuming that population is spread evenly amongst these premises, there are approximately 1.5 million customers (out of a total of total 40+ million customer base) who face the problem of partial not spots in their ability to choose mobile phone operators. Even with the improvements achieved under Project Beacon, there is still likely to remain almost 1 million customers in partial not-spots.

Quantifying the benefits

In an ideal situation, survey evidence can help in identifying these consumer numbers, as well as the number of consumers who, while not living in a partial not-spot area, still face this problem when visiting such an area. Primary research would therefore be required in order to do this.

However, in the absence of primary research, we have attempted to use existing research. As outlined in the introduction, an as yet unpublished study quantified WTP for visitors to complete not-spots in research undertaken by RAND. The paper provides WTP estimates for complete “not-spot” environments instead of “partial not-spots”. For those visitors coming to an area and experiencing loss in connectivity, we assume that their willingness to pay would be similar to someone coming into a complete not-spot area.

In the RAND study there are two categories of visitors which may be relevant, “tourists” (over and under 65) and “local visitors”, both of whom have different WTP figures. In our estimates, we make a distinction between those visiting a given local authority for a short 3+ hour trip (day visits) and those lasting a night or more (overnight visits).

The study also provides two WTP figures for each population segment; i) WTP for a weak signal with occasional loss of service, and ii) WTP for a strong signal. Further research is required as to what is the most appropriate of this WTP figure to use, but we have presented both low and high case estimates based on these different assumptions.

Having established a WTP estimate, we need to estimate the total number of visitors to such areas. Ofcom has provided a breakdown of partial not-spot coverage in each local authority (LA) in terms of % of land area as well as a break down for one and two operator partial not spots. Not all of this data breaks down to the local authority level and some is provided at a county level instead. Visitor numbers have been sourced from Visit England, Visit Wales, Visit Scotland and the Department of Enterprise, Trade and Investment in Northern Ireland which give the number of day visits and trip nights by LA. Whilst it would be optimal to have such data at a lower level of geographic disaggregation, such as lower super output area (LSOA), LAs are the most disaggregated level available.

There is no ideal methodology to estimate how many visitors to each LA end up visiting a partial not-spot area. On the one hand, it is in the interest of mobile operators to provide coverage to areas with large inflows of visitors – especially if they are to achieve the significantly higher yield-per-passenger from overseas roaming charges. However, we also know that remote areas which are sparsely populated do have less comprehensive mobile reception. As we do not have a granular picture of where visitors go within each authority, or granular data of location of partial not-spots, we need to make more generalised assumptions in order to achieve a conservative, yet realistic outcome.

Key assumptions

The first assumption is that visitors to local authorities are distributed uniformly in a geographic sense. This has the following implication. If for example we know that 10% of a local authority is a partial not-spot, we estimate that 10% of all visitors to that local authority would be located in a partial not-spot. We acknowledge that travel patterns are unlikely to be so uniform, and we also acknowledge that given the commercial incentive for operators to target areas where people visit, this may lead to an overestimation of the number of visitors in partial not-spots. However, without further granularity on traveller patterns, this is the best analytical approach we can take.

For some geographic areas coverage data was only available at county rather than local authority level as noted above. For these areas it was decided that an assumption of equal distribution of visitors was too coarse as many counties will have big dominant cities that have substantially more visitors than their more rural areas. For these counties we added an additional layer of assumptions that partial not-spots would only occur in rural areas, and therefore only visitors who say they are going to rural areas would be affected. Note that such data only exists at a county level so it could not be applied to the local authority level data. At a local authority level most large towns and cities are local authorities themselves and these tend to have close to zero partial not-spots so very little benefits are measured here anyway.

A further limitation of the Ofcom data is the fact that it does not state which providers are in the partial not spots for each LA. For example, in the Larne LA, 12.7% of the land area is only covered by a single operator, whilst 20.7% has two operators. This therefore leaves the question whether it is EE, Vodafone or O2 which is the single operator and so forth, for which another simplifying assumption is required. Without data to guide us, we have therefore assumed that whenever there is a single operator partial not-spot, it is covered by the largest operator by market share (i.e. EE) and where there is two operator partial not spots, the two largest operators will be assumed to provide such coverage. These proportions of customers are then netted off, assuming they have signal when they travel to these areas. This is the most conservative assumption we could take on who will have signal when travelling to such partial not-spot areas.

With the aforementioned assumptions defined and the data in place, we can then combine it all to provide a monetary assessment of the total WTP. We calculate total WTP for both category of visitors – for those making shorter 3hr+ trips as well as overnight visitors.

This is achieved by multiplying the number of visitors in each LA (for each of the above two categories) per year by the percentage of the LA's land mass which is a single operator partial not-spot. We then multiply this figure by the percentage of customers NOT with the biggest operator (which equates 100% - market share) and the WTP of such visitors. We then do the same for double operator not-spots with the corresponding figure for the percentage of people not on the two biggest operators. For counties the figures are in additional multiplied by the proportion of visitors who identify themselves as visiting a rural location. Combining these figures, we get the total benefit for the visitors visiting each local authority/county per year.

WTP estimates

As with the cost analysis, we have provided upper and lower bound estimates based on the various WTP figures outlined above. The figures are outlined in the table below:

Table 7 - Willingness to pay for benefits of roaming

	Short – trips 3hr+	Overnight trips
Total number of visitors	26 million	7 million
WTP	£0.50 - £0.20	£0.20 - £2.75
Total benefits per annum	£5 million - £13 million	£2 million - £20 million

Therefore, the total benefits per annum range from between £7 million and £33 million. Understandably this is a very broad range of the benefits, but this is a result of the varying WTP figures for different signal strengths as reported as part of the RAND study.

Caveats of the benefits model

The following caveats and assumptions related to the model should be highlighted:

1. The lack of granular data on visitor destinations, means a simplistic assumption is made that visitors are evenly spread across rural areas. This would need to be addressed as part of future research.
2. As stated above, the RAND study provides two WTP figures for both “local visitors” and “tourists”; one for a poor quality signal, and one for an improved quality of signal. The difference in the WTP figures is large and we are unsure which is more suitable for our analysis. We need to do more work to establish whether the visitor figures provided are more relevant to the local visitors segment or the tourists segment of the RAND analysis.

Results of the cost-benefit analysis

According to the above costs and benefits, the central estimate for the Net Present Value (NPV) of quantified costs and benefits is -£187 million (with a range of -£346 million to -£27 million).

However, as outlined above, we have already noted that the value customers place on being able to choose mobile networks has not been quantified or monetised as part of the project. Similarly, the overall impact on businesses that operate in partial not-spot areas is also not quantified. Once again, we do not have data on the total number of businesses that do operate in these areas, nor a good measure of the costs they incur due to this. The RAND survey data relates to businesses that operate in complete not-spot areas, and we cannot make any meaningful inferences on whether these impacts are also felt in partial not-spot areas. In addition, the social benefits from greater social and economic inclusion have not been quantified. Therefore, while the quantified costs estimates provide a good indication of the total costs of national roaming to operators, the quantified benefits do not cover all of the benefits to consumers.

Risks

Overall, the risk factors can be divided into technical and economic. The first relate to the technical complexities related to delivering national roaming, as well as the potential technological changes that may result in reducing the overall impact of the scheme. The second relates to assumptions and data behind the economic case.

Technical risks:

Technical risks associated with national roaming relate to the operational risks of network performance. Examples of higher risk items could be:

a) Technical programmes for national roaming being implemented by each of the mobile operators getting out of step with one another (e.g. one operator runs late in roll out). This in turn would delay detailed testing and therefore the ability to implement the system.
b) There is a failure of a key network element (such as an HLR) at or soon after switch-on of the service.
c) IT and billing system problems. Could arise from poor specification or inadequate test programmes.
d) Handling network failure conditions.

Economic risks

The key economic risks associated with this policy relate to impact on incentives for mobile operators to continually make investments on their network.

Firstly, investments in 2G networks may be reduced given that the competitive advantage of having a ‘better’ network is now no longer available to any individual operator. In fact, it may also result in MNOs reducing their expenditure on maintaining existing 2G networks as they ‘free-ride’ on the networks of others. Any wholesale pricing mechanism may be a remedy against this risk, but it requires very detailed understanding and will also increase regulatory costs for both the operator and the regulator.

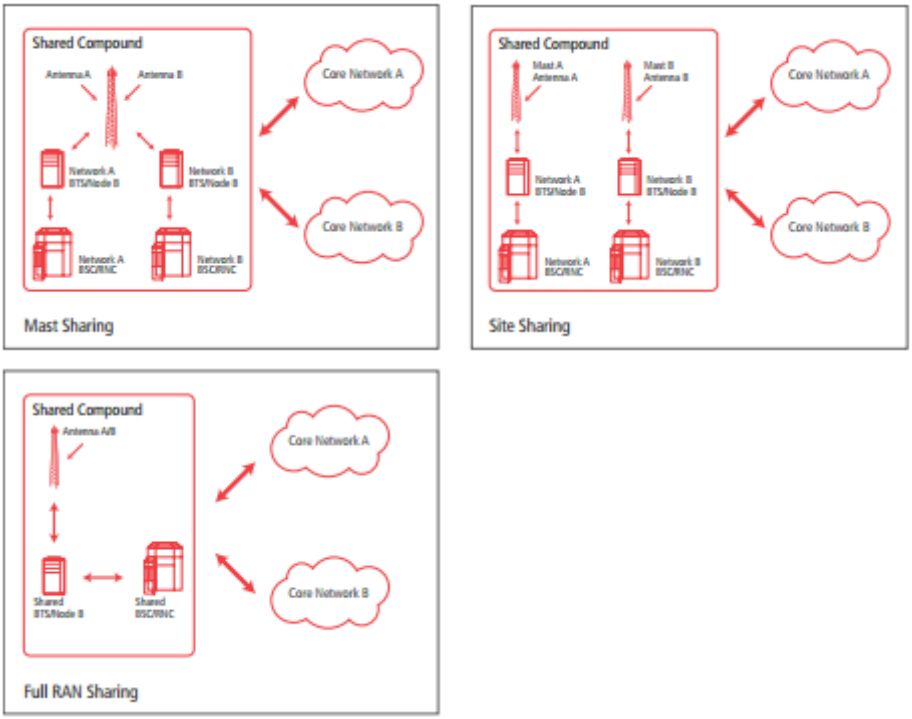
Second, MNOs are currently rolling out 4G and any additional investment in 2G networks could result in capital being diverted from this rollout. Similarly, while national roaming is proposed to be limited to 2G, any directive to mandate this on voice may be seen as setting a precedent for mandating sharing on data networks. This may further increase the investment risk.

Infrastructure sharing

Background

Infrastructure sharing arrangements have existed in a number of countries, including the UK, through either agreements between the MNOs themselves or with an infrastructure provider.[4] Figure 3 below provides a summary of the main infrastructure sharing options that are available to operators:

Figure 3 - Types of infrastructure sharing (Source GSMA)



Infrastructure sharing is ultimately a commercial decision for MNOs. Combined with the need to ensure minimal environmental impact, a variety of infrastructure agreement types have been implemented in both developed and developing countries. The report notes that site and mast sharing (i.e. passive infrastructure sharing) are the most common forms of infrastructure sharing, while RAN sharing (or active infrastructure sharing) was “gaining commercial traction”.

In addition to the technical issues surrounding infrastructure sharing, there are also issues related to regulatory and competition policy. From a regulatory perspective, one issue is whether infrastructure sharing is in some way mandated by authorities and the mechanism through which this is done. From the competition policy perspective, the issue is whether any infrastructure sharing agreement results in substantial lessening of competition for the consumer.

A. Proposed model of infrastructure sharing

As outlined above, there have been both active and passive infrastructure sharing experiences in the UK to date. The most significant example of active infrastructure sharing relates to the merger between Orange and T-Mobile which resulted in the creation of the EE network. EE and Three subsequently entered into an agreement to share costs associated with maintaining the network by forming Mobile Broadband Network Limited (MBNL). As noted above, the biggest example of a passive sharing agreement in the UK is the formation of CTIL by O2 and Vodafone as part of Project Beacon.

The Do-Nothing scenario already includes these developments. The solution proposed for solving the issue of partial non-spots is therefore a passive infrastructure sharing agreement between CTIL and MBNL.

[4] See for example report on Infrastructure Sharing options by GSMA UK available at http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

One such proposal has been put forward by two operators based on some initial radio planning analysis of infrastructure site sharing possibilities. Based on their proposals and their estimated gains in coverage we have analysed a site sharing agreement covering 527-627 masts.

B. Technical feasibility

As outlined above, given that infrastructure sharing already takes place, there are no direct technical issues that restrict infrastructure sharing. However, while technically it could be possible for operators to share any amount of equipment, according to GSMA (2006) implementation can be complex for some forms of sharing, especially on sharing on existing networks that may not have been built to accommodate such arrangements.

These complications include:

a) The load-bearing capacity of towers;
b) Space within sites;
c) Tilt and height of the antenna;
d) Adverse effects on quality of service when antennas are combined;
e) Different standards employed by the equipment vendor;
f) How an operator has implemented their network;
g) The age of component parts of the network; and
h) The provision and capacity of backhaul services.

C. Commercial and regulatory feasibility

The key issue on the commercial feasibility of infrastructure sharing relates to decreasing returns to scale. There are understandably easy wins that any infrastructure sharing arrangement can lead to, but the marginal increase in coverage that can be achieved by mast sharing reduces with each additional site shared.

There are additional costs associated with site sharing, most notably through increased rental to land-owners, as well as the time and costs associated with securing planning permission. Reform of the Electronic Communications Code is being taken forward separately and these changes may help to reduce the site rental costs and need to renegotiate for infrastructure sharing over the longer term. However, these changes are unlikely to be applied retrospectively to existing rental contracts so will not substantially change the costs for a proposal which is to be applied in the immediate future.

By preference, government would look to MNOs to deliver site sharing as a voluntary agreement. However, should the extent of delivery of such an agreement be deemed to be insufficient or at risk of delay government may instead look at regulatory options for enforcing this agreement in the future. This could be in the form of a coverage obligation for each MNO to match the combined 2G voice coverage of all MNOs. This would have the additional benefit of enabling the MNOs to take innovative approaches to meeting this obligation which would not be restricted to just mast sharing.

Another key issue would be whether site sharing has anti-competitive effects. In terms of infrastructure sharing, the OFT's investigation into Project Beacon found passive infrastructure sharing between Vodafone and O2 to not to have any damaging effects on competition. However, it is not clear whether passive sharing between all of the network providers, (or more accurately MBNL and CTIL) would be similarly benign. Nevertheless, the overall effect would once again be the provision of additional services from competitors to consumers who previously had fewer options. Therefore it is not clear how such an arrangement would result in the dampening of competition, as long as the incentives to compete exist between the MNOs.

D. Costs of site sharing

The following cost estimates of infrastructure sharing are based on proposals provided by the MNOs, which have also been independently assessed by Plum Consulting. Unlike with national roaming, the cost estimates depend very much on the number of sites at which sharing is to take place. In other words, infrastructure sharing implies that those partial not-spots that are, for example, not served by

Vodafone would require Vodafone to access and put their equipment on the MBNL network (and vice versa for those not served by EE).

Capital and operating expenditure

First, we have taken estimates by Plum on the average cost of infrastructure enhancement per site, which amounts to £50,000. Second, we take an upper and lower bound of the number of sites that have been proposed by the MNOs as feasible in order to make a significant reduction in the total incidence of not-spots. The total capex calculations for infrastructure sharing are provided below:

Table 8 - Costs of infrastructure sharing

	Low	High
Number of sites requiring improvement	527	627
Cost per site	£50,000	£50,000
Total	£26.35 million	£31.35 million

According to Plum Consulting, the operating expenditure at each site for additional cost sharing is expected to be £10,000 per site per annum. Once again, depending on the number of sites, this is likely to be between £5.27 million to £6.27 million per annum. As with roaming these costs have been annuitized over the appraisal period (10 years) using the cost of capital for an efficient mobile communications provider as calculated by Ofcom in their Mobile Call Termination model at 6.9%.

E. Benefits of infrastructure sharing

The benefits of infrastructure sharing are based on the proportion of total not-spots that are expected to be addressed from this option compared to a complete reduction in not-spots that is achieved with national roaming. This uses the same data and stages of calculation as for national roaming but for a smaller geographic area (3%).

WTP estimates

As with the cost analysis, we have provided upper and lower bound estimates based on the various WTP figures outlined above. The figures are outlined in the table below:

Table 9 - Willingness to pay for benefits of passive infrastructure sharing

	Short – trips 3hr+	Overnight trips
Total number of visitors	6 million	1.7 million
WTP	£0.50 - £0.20	£0.20 - £2.75
Total benefits per annum	£1 million - £3 million	£0 million - £5 million

Therefore, the total benefits per annum range from between £1 million and £8 million. Understandably this is a very broad range of the benefits, but this is a result of the varying WTP figures for different signal strengths as reported as part of the RAND study.

In addition to these benefits, infrastructure sharing also has the following advantages:

1. Availability of 3G and data rather than just 2G: It is likely that any new improvements made by these networks would be 3G rather than 2G. Therefore customers would be able to access data, rather than just voice which is what national roaming aims to provide.
2. Availability of a more seamless customer service with no dropped calls: We have noted that there may be issues of customers experiencing dropped calls if they are moving between different areas under roaming. This is not likely to happen from a technical perspective under an infrastructure sharing option.

Cost benefit analysis

As with the analysis on national roaming, we do not quantify the impact on businesses or the impact on choice as part of the customers. Based on the quantification of visitor benefits, the overall NPV of infrastructure sharing has a central estimate of -£49 million.

Risks of site sharing

1. Time-frame: The evidence from the active infrastructure sharing arrangement between Orange and T-Mobile, even when both parties had a strong incentive to cooperate, took 12-18 months. Therefore, the potential time frame for achieving site sharing through cooperation between two networks, where the potential commercial advantages are not clearly present and when the industry is engaged in the roll-out of 4G service is unclear.
2. Regulatory policy: Should a voluntary agreement be deemed to be insufficient, government may look at regulatory options for enforcing this agreement instead.
3. Competition policy: The extent to which this is compatible with competition policy would need to be investigated.

Ultimately therefore, it would depend on the proposed impact of any sharing arrangement.

4. Multi-Operator MVNOs

Background

A Mobile Virtual Network Operator (MVNO) refers to a range of business models whereby mobile services are retailed by an entity that is (at least to the retail consumer) distinct from the MNO on whose network the service is provided. There are a large number of MVNOs currently operating in the UK, some of whom are independent operators (e.g. Virgin Mobile) and others either jointly or wholly owned by MNOs. In general, these provide "white label" offerings which rely on a single host network for radio connectivity and much of the core network functionality. Examples of UK MVNOs include Virgin Mobile, TalkTalk Mobile and Tesco Mobile.

As a general rule MNOs will not deal directly with aspiring MVNOs unless they can guarantee a minimum number of subscribers. According to Plum Consulting this is typically in the range of 60,000 – 75,000 customer subscriptions per year. Smaller players are likely to have to use an intermediary – these are often referred to as Mobile Virtual Network Enablers who effectively act as aggregators to enable multiple MVNOs to be supported on a single host network.

A 'multi-operator' MVNO (MO-MVNO) would have agreements with two or more MNOs to provide access to their networks. In order to for this to result in improved coverage for a subscriber over use of one of the four MNOs, it would be necessary for the MVNO to enable subscribers to access these multiple networks (as opposed to simply apportioning a different host MNO to different subscribers on that single MNO's coverage). Though we have not been able to identify any regulatory or practical obstacle that prevents such a model arising, such offerings have not yet been made widely available to UK consumers. Niche offerings are available, for example Manx Telecom offers access to the four UK MNOs on the basis of international roaming agreements using UK numbers, though these appear expensive when compared with tariffs offered by other UK MNOs and MVNOs. It is likely that no major UK MVNO has yet provided such an offering because (1) demand has been difficult to assess, and (2) agreements between MNOs and MVNOs generally include exclusivity provisions which prevent the MVNO from reaching simultaneous agreements with other host MNOs.

A. Proposed Model

There are two broad physical models by which an MO-MVNO could be established: through a "full" MVNO with its own core network infrastructure or through international roaming agreements. In the near future, deployment of an IP-based "always best connected" (ABC) approach would also be possible and a fourth, more basic option is to provide a dual-IMSI SIM card that allows the user to select one of two separate home networks. The latter two options are technically possible, but are unlikely to provide a workable option within a 2-3 year period. We have therefore concentrated on the "full" and "international roaming" MO-MVNO model.

Full Roaming MO-MVNO model
Plum Consulting have suggested that a full MVNO with control over its own core network infrastructure (such as a mobile switching centre and home location register) would be able to roam across MNOs. The MO-MVNO would reach agreements with multiple host MNOs and provide a service where subscribers' phones either (1) connect preferentially to the RAN of a single host MNO and to other partner MNOs when the preferred MNO is not available, or (2) connect to the RAN of whichever partner MNO provides the strongest signal. For the consumer this option would feel similar to national roaming but the crucial difference is that it would only be available for those who are subscribers to the MVNO. Therefore the benefits would only accrue to a small group of subscribers rather than all mobile users.

Currently there are no full MVNOs operating in the UK, although they do exist in other countries. Therefore the first step in enabling this option would be for a new or existing MVNO to develop the core network infrastructure of a full MVNO. Plum Consulting note that they are aware of two MVNOs currently gearing up to develop such full MVNO capability, but estimate that this is only likely to happen within a "2-3" year period. There would also need to be negotiation of agreements with at least one host MNO and roaming agreements with others and the development and launch of a retail offering.

International Roaming MO-MVNO model

The international roaming MO-MVNO model already exists and is widely used to offer low cost international roaming services or (less frequently at the moment) enhanced national coverage. Operators from the Isle of Man and Channel Islands have provided such services in the UK, the most prominent being Manx Telecom who offer two specific roaming SIM packages, one aimed at smaller organisations or individuals and the other aimed at larger organisations requiring 100 SIMs or more.

The individual / SME offering is branded as SSM (Strongest Signal Mobile) and can be bought directly from Manx Telecom's mobile sales department, for a monthly subscription of £10 and a per-minute call charge of 36p. The larger organisation offering is branded Chameleon and is primarily aimed at organisations in the public safety, security and utility sectors who require resilient communications. Chameleon is marketed through Manx Telecom's Business Services Department and tariff packages are negotiated individually with the subscribing organisations.

Whist the Manx Telecom roaming solution is effective in terms of providing coverage, it is expensive (data charges are 70p/MB) and incoming callers will pay higher rates than they would when calling a conventional UK mobile number. The Manx Telecom numbers are also likely to be excluded from most UK network inclusive bundles.

B. Technical, regulatory and commercial feasibility

In principle three processes would need to be carried out in parallel to establish the full MO-MVNO option:
1. Provisioning of the MVNO core network infrastructure (Home Location Register, Mobile Switching Centre, etc.);
2. Negotiation of agreements with at least one host MNO and roaming agreements with other MNOs; and,
3. Developing and launching the retail offering.

The first process (core network provisioning) should be relatively straightforward but timing will depend on the nature of the MVNO operator, for example whether the organisation already has expertise internally to manage such a project. If this is the case provisioning may be feasible in as little as 3 – 6 months for a single host network. Catering for multiple host networks or facilitating roaming onto other networks may take considerably longer as there is no international precedent for such a service. Hence bespoke software is likely to be necessary and extensive testing will be needed, which would likely extend the lead time by at least another three months.

Negotiation of agreements with MNOs is likely to be challenging, especially for a smaller MVNO with a limited projected customer base. This could be a lengthy procedure, perhaps lasting a year or more, and with no guarantee that agreements could be reached at all with more than one MNO. There is little incentive for MNOs to establish roaming agreements with MVNOs in the same country, as there is no reciprocal benefit for the MNO in terms of its customers being able to roam onto the MVNO. The situation is different for an MVNO using an offshore network such as Manx Telecom, since the latter already has bilateral international roaming agreements with the UK operators, which are necessary for subscribers of the latter to use their phones abroad.

Launching a new, specialist MVNO of this type would require careful planning in terms of identifying the target market, developing appropriate branding and promoting market awareness. Much of this can only take place once the MVNO is reasonably confident of concluding the necessary MVNO agreements and the network infrastructure is fully up and running. Realistically this could add of the order of three months to the launch timescale. In total it is estimated the proposed solution could be operational in 15 months.

To establish a new provider on the international roaming MVNO model, the following broad steps would be required:
1. Reach agreement with a single MNO partner as an anchor network and SIM provider;

2. Reach international roaming agreements with other MNOs and agree data clearing house solution for billing of services; and,
3. Development and launch of the retail offering

The international roaming MO-MVNO model hinges on striking an agreement with an anchor MNO and international roaming agreements with the remaining MNOs. Such agreements are well established, but remain subject to commercial negotiation and the risk that terms cannot be agreed. The incentive provided by reciprocal international roaming agreements does not apply to MVNOs and may hinder negotiations.

Current commercial arrangements for MVNOs tend to include exclusivity clauses. Enabling the existence of MO-MVNOs may require such arrangements to be prohibited so that MVNOs have the right to negotiate access to all MNOs should they wish. If this is required then an appropriate regulatory vehicle will need to be identified. In addition, should this option be chosen as the preferred option there may be a need to facilitate such offerings.

According to Plum Consulting, an MVNO would normally require between 60-75,000 annual subscribers in order to set up an operation. However, given that a MO-MVNO would likely require higher capital costs, it may be the case that a greater number of annual subscribers may be required to break even.

The commercial viability of the MO-MVNO model would depend on the expected demand for such a business. As this is a specific service that must be subscribed to, the total demand impact would understandably be lower than full scale national roaming that automatically provides roaming for all consumers. The demand would therefore be comparable to other niche MVNOs that provide a specific service to a particular market segment.

The nature of the demand for a MO-MVNO will be explored in further detail during the consultation stage.

C. Cost-benefit analysis

Plum Consulting have estimated that establishment of an MO-MVNO on the “full” model would cost on the order of £5m in capex and £1m-£3m annually in opex. This is based on a small niche MVNO targeted at those in and around partial not-spot areas rather than something marketed to the general population. The capex costs are partly based on the experience of Virgin Media France who recently upgraded from a white label MVNO to a full MVNO at a reported cost of EUR 20 million. This was for a large network (2 million subscribers) and costs have been estimated somewhat lower for a smaller, more specialised operation. Opex costs reflect ongoing infrastructure maintenance costs and operational support, along with customer acquisition and retention costs (marketing, handset subsidies etc.) and the wholesale prices payable to the host networks.

In addition MNOs are estimated to face capex costs of £1m each to support the interface between the host radio access network and the MVNO core network as well as ongoing opex costs of at least £100k p.a. each. Should increased site rental costs need to be paid this could add an additional £1m p.a. in opex each for the three MNOs operating a 2G network. It is likely that these costs would be passed on to the MVNO in higher wholesale prices.

Estimates for establishment of an MO-MVNO on the international roaming model have not been produced yet and this will be explored further in the consultation.

The principle benefits of an MO-MVNO option for reducing partial not-spots include:

- Rapid implementation and comparative absence of practical per-site obstacles to implementation;
- Limited capex and opex costs compared with a national roaming solution (though costings dependent on implementation);
- Limited impact on existing network provisioning by MNOs;
- Limited physical network infrastructure changes; and,
- Possibility of implementing a ‘best signal strength’ solution which is unlikely to be commercially attractive to MNOs using a national roaming solution, although this may have a detrimental impact on battery life.

The principle risks and disadvantages of an MO-MVNO option for reducing partial not-spots include:

- Current agreements between MVNOs and host MNOs generally contain exclusivity provisions that prohibit the MVNO from reaching similar agreements with further host MNOs;
- Benefits of improved coverage are only available to subscribers of the MO-MVNO and not to all mobile users;
- Commercial agreements with multiple host MNOs may be difficult to reach and conclusion of these on mutually favourable terms is dependent on goodwill from all parties;
- Some agreements between landlords or wireless infrastructure providers and MNOs require payment by the MNO or renegotiation for provision of MVNO services from the installed infrastructure. It is conceivable that these costs may in effect be duplicated were multiple MNOs to reach agreements with a single MVNO. This cost would likely fall to the MVNO, though it is not clear that this would exceed the analogous cost arising from an agreement with a single MNO (as this would depend on the basis by which costs are calculated);
- It may not be feasible to provide an MO-MVNO offering on an international roaming model at comparable tariffs to single operator MVNO and MNO offerings due to the third party functions associated with this model; and,
- In order for an existing MVNO to provide a multi-operator service, there would be a requirement for SIM updates and this may pose technical challenges and present a barrier to complete penetration at the consumer level. This barrier would be overcome in time.

Indirect costs – law enforcement

Any solutions to tackling partial not-spots would also need to ensure that they do not have a negative impact on law enforcement or security work that involves requests to MNOs on call data or lawful intercept. If an MVNO model is implemented then an assessment will need to be made of the extent to which this increases data requests and related costs for industry and Government. Consideration will also need to be given as to what extent this impacts on the timing of any planned roll out.

Preferred Option

For the purposes of this consultation and impact assessment the government is not proposing a preferred option. Instead it wishes to gather further evidence and opinion through the consultation to inform a final decision on the most effective solution to reducing or removing partial not-spots.

Small and Micro Business Assessment

The costs borne by business under each option will be borne by the MNOs. The nature of operating large scale infrastructure means that these are all large businesses and it is highly unlikely that a new entrant to the market in the future could be anything other than a large business. As such, there are no costs imposed on small and micro businesses. However, many of the businesses expected to benefit from increased coverage and connectivity will be small, micro businesses and single operators, for example agricultural and tourism firms in remote rural areas.

OITO

The final One In Two Out position will depend on the option chosen and how that option is delivered. Government would prefer national roaming (policy option 2) to be voluntary. If it is necessary to deliver this option through regulation it would be in scope of OITO. In this case the Equivalent Annual Net Cost to Business (EANCB) for this option is estimated as an IN of £33.9m to be borne by the four MNOs. Infrastructure sharing (policy option 3) is likely to be a voluntary and commercial agreement between MNOs and not a regulatory intervention. However, should this option be chosen as preferred and voluntary agreements are not deemed sufficiently binding the government may look at backstop powers for ensuring these agreements are delivered. In this case the option would be in scope of OITO and the current estimated EANCB is an IN of £8.0m. A multi-operator MVNO model (policy option 4) may also be a commercial agreement and it is not yet clear whether any regulatory intervention would be required to underpin this. Currently it is assumed it may be within the scope of OITO with an estimated EANCB IN of £4.1m.

Improving the Evidence Base

The costs and benefits of the different options will be further explored during the consultation to strengthen the evidence base, including a series of questions in the consultation document itself. In addition the department will continue to work with Ofcom and its technical advisors to explore specific issues related to the proposed solutions alongside the consultation.

Specific and Wider Impacts

Statutory Equalities Duties:

Apart from the rural dimension to partial not-spots, there is no direct impact or implication on the statutory equalities duties.

Competition:

Competition is an important component of the options to deal with partial not-spots. The key issue is whether any of the options outlined above would result in a significant lessening of competition in the industry and overall detriment to the consumer.

The MNOs have stated that coverage is one of the elements on which they compete, and therefore mandating national roaming would result in reduced incentives to further invest in the network. However, in the case of 2G, there already exists very high levels of coverage by most operators, and the need for significant further investment in 2G is limited. Furthermore, given that national roaming is to be restricted to marginal areas, the overall impact on incentives to invest in the network is expected to be limited.

We have already noted that we estimate around 1.5 million consumers have limited choice of a mobile operator. Therefore, it could be argued that the elimination of partial not-spots would result in *enhanced* competition and therefore additional benefits to these consumers.

In terms of network sharing, the OFT's investigation into Project Beacon found passive infrastructure sharing between Vodafone and O2 not to have any damaging effects on competition. However, it is not clear whether passive sharing between all of the network providers (or more accurately MBNL and CTIL) would be similarly benign.

Nevertheless, the overall effect would once again be the provision of additional services from competitors to consumers who previously had fewer options. This would therefore result in greater competition. Therefore it is not clear how such an arrangement would result in the dampening of competition, as long as the incentives to compete exist between the MNOs.

Wider Environmental Issues

Environmental issues are relevant in so far as mobile telephone infrastructure sites, particularly in rural areas, have negative environmental impacts. However, given that the policy options outlined here deal with sharing of existing infrastructure, and there is no direct reason to believe additional sites would be constructed, the total impacts are likely to be negligible.

There may be certain infrastructure sharing agreements that require mast heights to be increased, and this may result in some negative environmental effects. However compared to the option of operators building separate infrastructure, sharing such sites would be a less damaging alternative.

Health and Well-being

Research by Ofcom shows that the public regard mobile voice and 2G to be an essential telecommunications service, rated more highly than other services such as radio and fixed line telephones. The willingness to pay data we have looked at also shows that consumers value this service. Qualitative research by Ofcom also shows the important social welfare benefits, in terms of connectivity and social inclusion it provides to remote areas. These include better coordination of social events as well as running of some social services. Therefore, it is true that improving mobile coverage has an impact on welfare by facilitating social inclusion. The impact would not be as strong as providing connectivity to complete not-spots, but for those making visits to partial not-spots and not on the 'home' network of that partial not-spot, the nature of the impact is similar, even if the magnitude is smaller.

Emergency Services

The Emergency Services Network (ESN) will replace the current Emergency Services communications network (Airwave), which is based on terrestrial trunked radio (TETRA) and provides near complete geographic coverage for critical voice and narrowband data services. ESN should be fully rolled out by 2020 and will provide critical voice and broadband data services. Although still

subject to an ongoing procurement, it is possible that a MNO will be able to provide equivalent national coverage by extending their network over a separately procured infrastructure called Extension Services. As currently specified, Extension Services will not provide mobile services for the general public.

National voice roaming could not enable coverage specified for the Extension Services as, by definition, there is no coverage from any operator in these areas. National voice roaming therefore offers no benefit to ESN and conversely ESN will not eliminate partial not-spots as currently specified. National voice roaming may however provide a limited benefit to the Emergency Services and other ESN users as a fall back capability in the event that ESN becomes unavailable, however the priority, pre-emption, push-to-talk and other public safety functionality required by the Emergency Services users would not be available on the roamed network.

Infrastructure sharing, as currently proposed by MNOs, does not impact provision of the Extension Services, but may enable prospective suppliers for ESN's core commercial provision to achieve this more easily, as well as providing additional coverage for the public if the MNOs were able to extend their mobile service into the Extension Services areas.

Human Rights

The options outlined here are unlikely to have a direct relevant impact on issues related to human rights.

Justice System

In terms of infrastructure sharing, there may be additional disputes between operators and owners of sites, although it is also expected that reform of the Electronic Communications Code will provide further clarity on this thereby reducing this burden.

Rural Proofing

There is a very strong rural dimension to this policy, as the majority of partial not-spots are in rural areas. In fact, the primary beneficiaries of this policy will be rural communities.

Data by Ofcom show that over a quarter of consumers who live in remote rural areas, and about a fifth of the consumers that live in rural areas experience instances of no signal or reception on a daily basis. Close to 40% of consumers in rural areas or remote rural areas experience no signal or reception either daily or a few times a week. 20% of rural mobile phone consumers express dissatisfaction with mobile phone reception, and 19% overall dissatisfaction with their mobile phone service, compared to 16% and 12% for urban consumers respectively.

Addressing partial not-spots therefore would be an important contributing factor to providing a fairer availability of essential mobile phone service to both urban and rural areas. In addition, research by RAND point towards the ability for greater connectivity in rural areas to ensuring diverse rural economies, and long term sustainability of rural communities.

Sustainable Development

There is unlikely to be large inter-generational issues related to this policy as this deals with a relatively small marginal area of the overall mobile market. However, there is an element to which more widespread availability of better mobile reception benefits future generations as well as current generations.