From: [redacted]
To: NBP Mapping
Subject: Request to be included in the NBP
Date: 05 September 2019 17:47:29

To whom it may concern:

I live in [redacted].

My house is within the service area of a VDSL cabinet – but it appears that it is right on the limit

I've been told by providers that I can obtain a service of up to 37MB, however, having tried 3 different providers over the years I have never achieved speeds in excess of 30MB.

I regularly experience speeds substantially lower than that (often as low as 5-10) and anytime that the speed is increased I suffer regular line disconnections.

I am a [redacted], and I have the ability to work remotely (my employer actively promotes this), as does my wife's employer, a few days a week but to support this we would need a solid reliable connection approaching 100MB (we both conduct lots of calls and meetings via VOIP and Video).

This would remove another two vehicles from the [redacted] and improve the quality of life for our family however with our current broadband service this is just not a reliable option for us.

We have two young children and so as you can imagine, their bandwidth consumption is increasing as they progress through their education.

It appears that I am not included in the mapping area for the NBP and I'm told that it is therefore unlikely that I will experience any improved service over the next decade – despite the fact that I have offered to fund the cost of running cables or supplying telephone poles from neighbouring sites.

Within 100 metres of my house there are numerous homes with full 1000mb FTTH – and yet I, despite being willing to cover the cost am not permitted to connect, nor am I being considered to be included in the NBP area.

I've tried contacting EIR retail, OpenEir, Vodafone, Sky and anyone else that I can but nobody seems to be willing or able to allow me pay the cost of connecting to FTTH.

1 – Is there any way for me to fund connection, or placement of a new openeir pole so that I can connect to the existing FTTH cables within 100 metres?

2 – I've contacted OpenEir but they refer me back to my current provider who is of no assistance – can I pay anyone for a connection to FTTH services?

3 - Failing either of the options above, may I request to be included in the NBP coverage area as it appears that I am falling between the cracks of alleged service areas.

Regards,

[redacted]

From: [redacted]
To: NBP Mapping
Subject: Request for comment on NGA Services and Broadband
Date: 16 August 2019 16:00:46

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

We have been informed by the PPN Network in Tipperary to notify this e mail address of any issues of obtaining NGA Services in the Light Blue Area of [redacted]

On behalf of ALL Residents and Businesses in [redacted] we are waiting over 10 years for promised Broadband. Cabling was installed early in March 2018 in [redacted] and within the blue area. We we informed connections would follow 6 to 8 weeks later.
I was contacted again early this year by an Eir Installation Supervisor who ws doing a survey between [redacted]. It would appear that the existing underground ducts were to small for the fibre broadband cable. Their solution was to provide a new Next Generation Access (NGA) networks cable on Poles! We have heard nothing since, we still have coils of cable on poles throught this [redacted] much to the amusement of Visitors and Tourists when they inquire what they are for!

We also have virtually no mobile phone coverage in the [redacted], letters have been written on numerous occassions to the Minister of DCCAE, TD's, Tipperary Council, we as a Committee have met many different people over the years, and listened to numerous adverts on Televison, and read in Newspapers offers on the wonderful packages and special offers by signing up for High Speed Broadband. Only to be informed you do not have a connection suitable. We are licky to get 2 to 4 MB on the copper phone lines!

The answers requested in the PPN Network Circular:-

1. Where they cannot secure access to NGA services from any service provider in their area, details of any correspondence with service providers where broadband services were requested, the eircode of their premises and any other relevant information.

Numerous phone and online inquiries to many to list, we have no fibre installed to any properties in the Blue Area on the NGA.

This is the reply we all get from EIR when we put in the Eircode, all other providers give a similar reply.

Great News! [redacted]

We can now confirm you are next in line on our roll out plan for Ireland's fastest broadband! We have a range of speeds to suit you best; 150Mb, 300Mb or Ireland's fastest 1,000Mb. We estimate that we will be in your area between the dates of October and December 2017, after which you'll be ready to get connected.

Enjoy 2 months FREE...

Even better, if you register your interest today, we'll offer you the first two months of our most popular broadband bundle for FREE! That means superfast broadband speeds of up to 150Mb and an UNLIMITED allowance.

Simply fill in your details below, and one of our customer service agents will contact you once you're ready for connection.

2. Whether they have experienced any issues in placing orders, or getting orders/connections implemented for confirmed orders placed to connect premise(s) with an NGA services.

There can be no connections to individual premises in [redacted] unti the cabling installed is connected to the exchange and works started in March 2018 completed!

From: [redacted]
To: NBP Mapping
Subject: Internet net speed
Date: 15 September 2019 10:53:09

I currently have an internet connection from Eir
which has not a sufficient speed to give me an interrupted service as it keeps breaking down

Eir have finally informed the speed available on my line is not sufficient,

I have also contacted Vodafone, the max speed available to me on their line is only 10

Currently there is work being done on the lines very close to me which I believe is upgrading them to fiber, but unfortunately Eir can't tell me what work is being done or if it will extend to my house

Vodafone have also told me they plan to upgrade in my area in the near future, but again don't know if it will extend to me

Yours sincerely

[redacted]

From: [redacted]
To: NBP Mapping
Subject: Next Generation Access Broadband - Mapping
Date: 16 August 2019 15:30:29
[redacted]

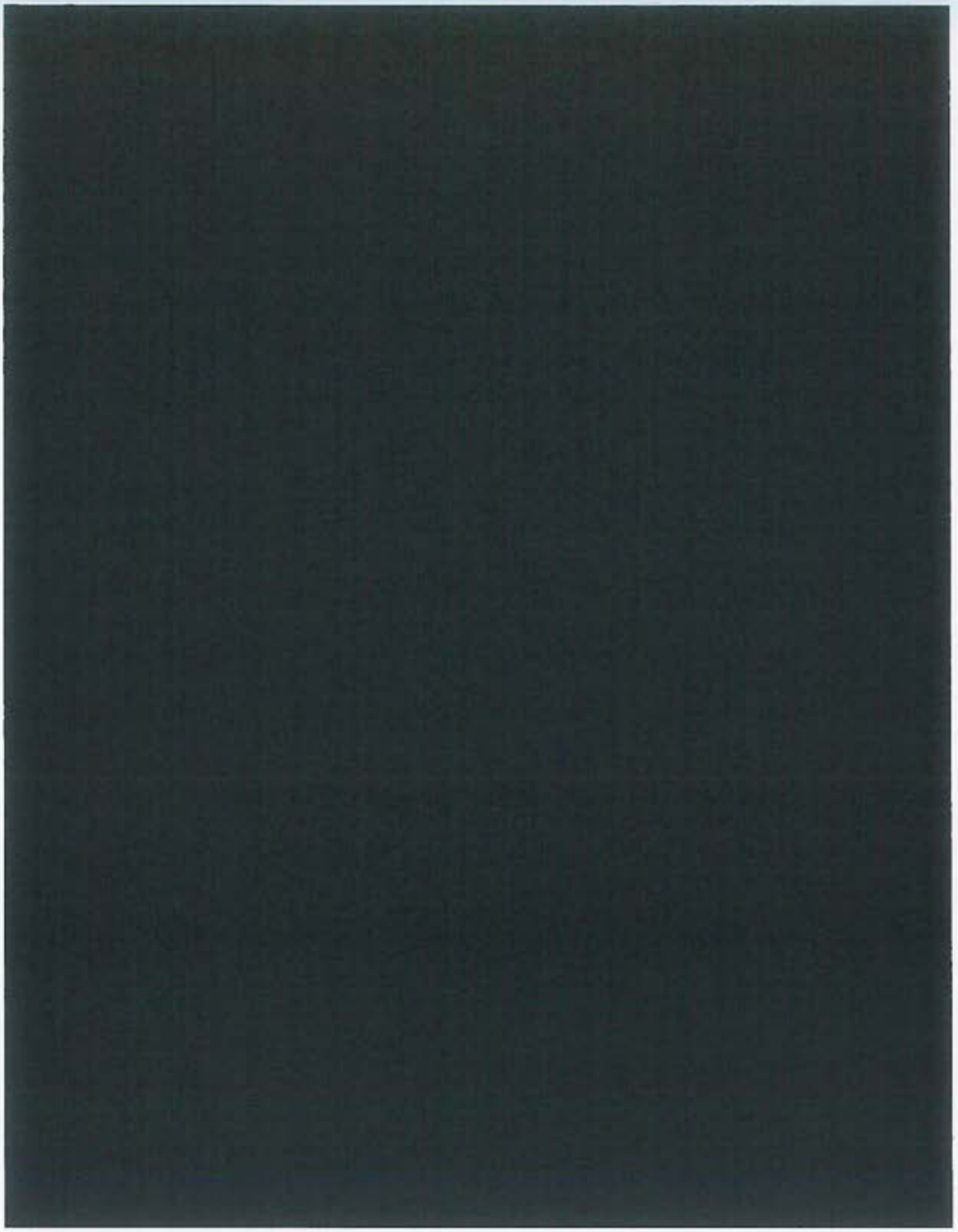
We are consumers and are replying to the following:

The Department is now inviting **retail service providers, premises owners and/or consumers of broadband services** that reside in areas marked as Blue or Light Blue on the NBP Map to submit information in particular on the following:

1. where they cannot secure access to NGA services from any service provider in their area, details of any correspondence with service providers where broadband services were requested. the eircode of their premises and any other relevant information.
2. whether they have experienced any issues in placing orders. or getting orders/connections implemented for confirmed orders placed to connect premise(s) with an NGA service.

We noticed that our area is not even recognized as having internet needs, but there are 4 families living down this road. [redacted] Our internet speed is not great and our upload speed is abysmal

[redacted]



We hope that you will also look at our location.
I work from home and require internet use, and my partner is a Software Developer who is also looking to work from home.

From: [redacted]
To: NBP Mapping
Subject: Broad Band Access - [redacted]
Date: 25 September 2019 20:11:53

I wasn't exactly sure what you were looking for in terms of submission , but if there is an opportunity to have my area flagged as needing some inproved broadband I would be grateful.
I work from here and currently get by on a slow 3G/Weak 4G signal. However this hold my work back a bit as there are some things the connection is just not fast enough to do.
I am sure you have many priorities and possibly some areas where the impact can be greater as we are a very small community here, but if there was an opportunity please consider us.
Kind Regards
[redacted]

Presented by
Real Broadband Ltd

Contents

Preliminary

We regret that due to the very short space of time (comprising a series of ad-hoc extensions) allowed by the Department for this Consultation and due to the very large and time consuming amount of data required to fully comply with its requirements we have been unable to address the totality required. We and other SME FWA ISPs have written to the Department earlier this September explaining the problems that this short time-scale holiday-centred consultation has caused and seeking an extension of time appropriate to a consultation of this kind.

A1 Technical Information

1 Introduction

We have built our network around having good bandwidth with consistent and low latency, so as to support all converged IP services. We support many businesses and homes with Voice over IP VoIP telephony services. In fact our clients have a wider choice of telephony offerings with Voice over IP which helps our customers access other services and reduce cost All of which is great our customers.

The advances in wireless broadband technology in the past 15 years has been very considerable and particularly significant in the last 4-5 years. Those technological advances have included interference mitigation, a feature which the interference related questions in DCCAE's non upgraded 2015 Assessment Criteria by definition fails to recognise. By our company keeping up with the latest in wireless technology we have been able to deliver the benefits of reliable high speed broadband to Rural Ireland and, as a result, there is a wide variety of converged services available to our customers. In fact, more than half of our customer internet traffic is now video based, such as streaming video content from:

- RTE
- Apple TV
- YouTube
- Netflix
- High Resolution CCTV for our customers peace of mind and security and indeed farmers for monitoring their animals' welfare

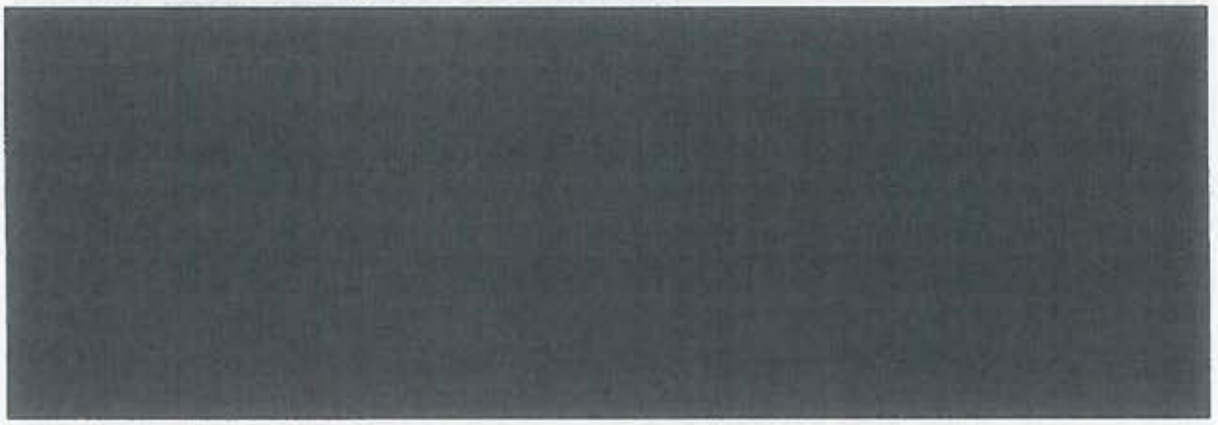
In addition to this we support many businesses / homes with Voice over IP VoIP telephony services.

Like some of our regional ISP colleagues, we have deployed our own IPTV distribution platform exclusivley for our ISP Customers. We are very pleased with the results and we are actively adding extra international channels to enhance the IPTV offering over our own high quality high speed broadband network.

We also support business users with remote working solutions through VPNs, Remote Desktop Environment, cloud-based productivity suites and we provide Hosted Remote Desktops, Hosted MS Exchange based email mailboxes, SPAM Filtering, and online/offsite data backups. Our customers report excellent results with video conferencing which allows for more remote working less commuting, less traffic congestion, reduced carbon footprint and a greater quality of life for our

customers in Rural Ireland. We are delighted that our customers reap the benefits of high speed broadband in Rural Ireland today, benefits, we might add that exist at no cost to the taxpayer.

1.1Description of network Architecture



IPV6 support is being worked on at present and will be enabled to all customers once available, this is expected to comprehensively address the issue of IPv4 exhaustion

1.2.Access network technology

We operate a Fixed Wireless Access (FWA) Network in the ISM 5GHz & License Exempt 5.8GHz bands. We use Ethernet based data link layer technology. For our NGA Access Deployment we have Ubiquiti sectors and client units.

On our Base station sites, we have deployed Sectors with the technical specifications as outlined in the following section. They have already been deployed following the deployment strategy which allows for self-funded organic growth and infill as the site matures and consumers become aware of the improved new service offering available to them.

On a given site that has 360 Degrees field of view (on top of a hill / mountain) we have deployed 4x 90-degree Ubiquiti advanced sector antennas to provide coverage in the area. On a Base station site that has less of a field of view, in that case we have deployed the requisite number of 90-degree Ubiquiti advanced sector antennas to cover that area. Additional capacity has been added by

- using additional sectors in the form of tightly focused sector antennas to maintain NGA levels of speeds that the customers are accustomed to. The tightly focused sector antennas serve to minimise external noise and facilitate frequency reuse.
- Using additional beamforming advanced sector antennas.

As explained above, this additional capacity is added on an ongoing basis to maintain the performance inline with User expectations to ensure NGA Performance during the busy hours

1.2.1 Access network technology and the Specification of the access equipment

[redacted]

1.2.1 Base station Technology Deployed

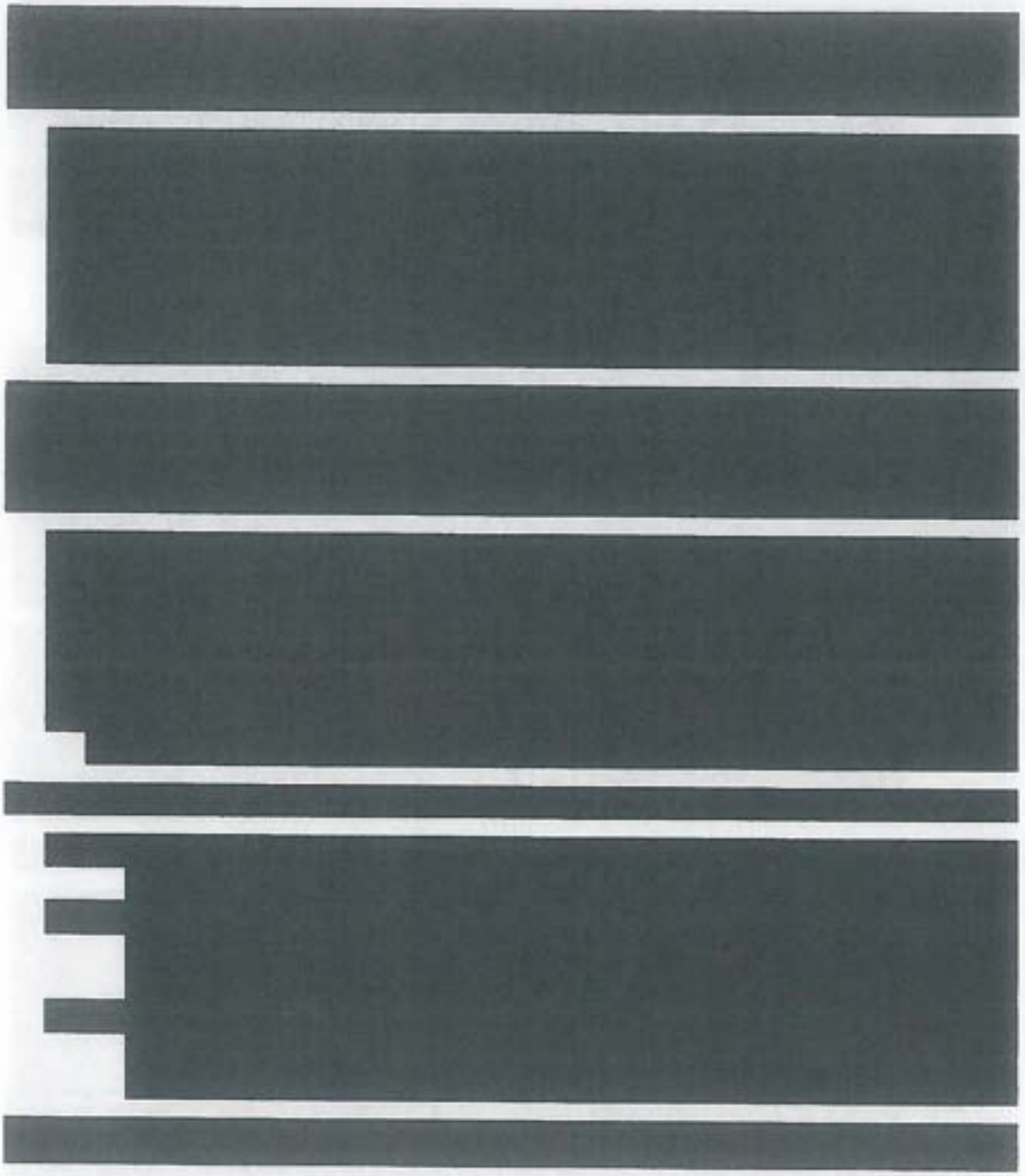
In our Base stations we deploy the equipment described below to support the delivery of quality reliable internet to the customer.

[redacted]

[redacted]

1.2.2 Sector Technology Deployed

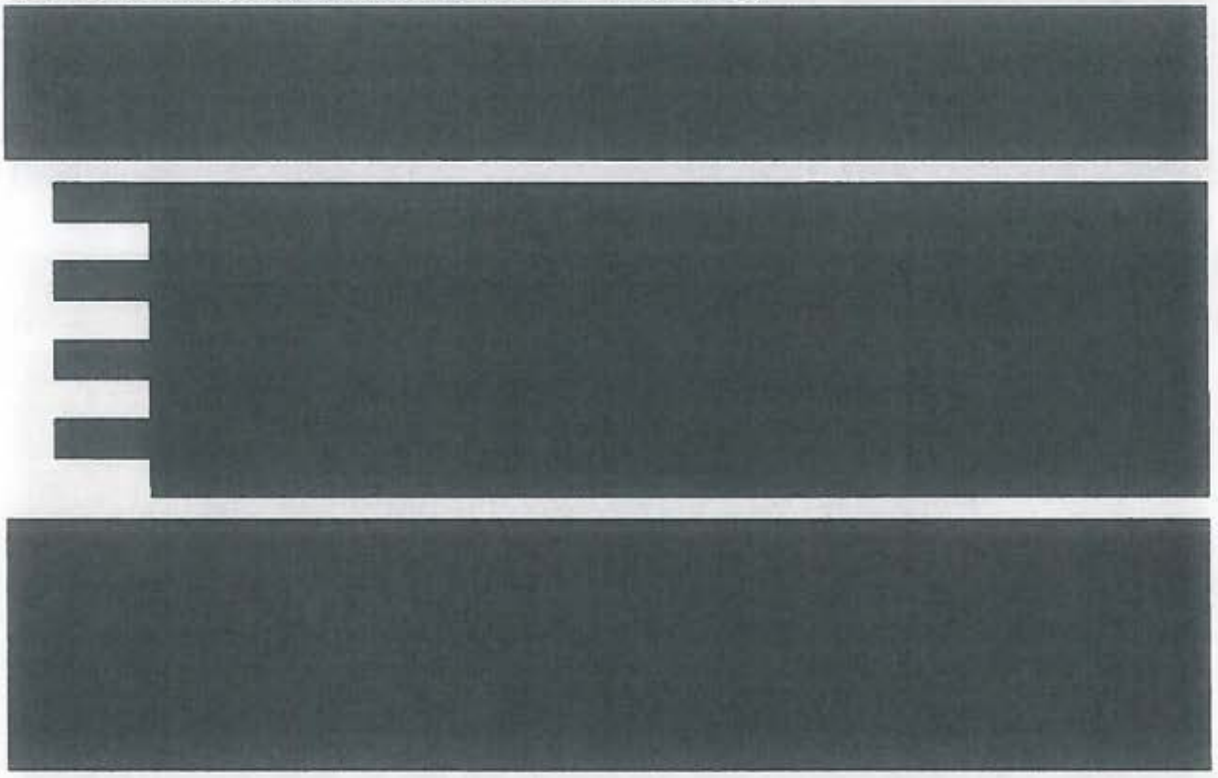
[redacted]



1.3.Backhaul Network Technology and specification of Backhaul Technologies

Our Backhaul is heavily dependent on fiber optic technologies. We use high capacity FDD Links to transfer bandwidth from a fibre POH to a high site.

1.3.1 Short Range Radio Backhaul Network Technology



1.3.2 Long Range Licensed Radio Backhaul Network Technology

[redacted]

1.3.3 Wired / Fibre Backhaul Network Technology

[redacted]

[redacted]

1.3.2.2 ENET

[redacted]

1.3.2.5 Eir Backhaul

We have begun the process of obtaining a WEIL from Eir in the Tralee and Listowel exchanges, this will allow connectivity to all of the supported sub-exchanges in the exchange areas and provide alternate backhaul options

1.3.3 External Edge Capacity

[redacted]

1.4. Design for the national backhaul network including any traffic and capacity assumptions

[redacted]

[redacted]

1.5. The Specification of all types of Customer Premises Equipment

[redacted]

1.6. Coverage data as illustrated in the form of Polygonsed Data set

[redacted]

1.6.1 Table of Location of Base stations

[redacted]

1.6.2 Table of Location of Connected Clients

1.6.3 Table of Location of Premises Passed based on High Resolution LIDAR and DSM data Eircode

1.6.4 LIDAR LOS testing and Methodology

We have engaged WirelessCoverage.com to build a Digital surface model based on high quality LIDAR / DSM data. We have supplied Wirelesscoverage.com a list of Sites and height of sectors to produce a list of premises that would be covered with clear line of sight

Approach according to WirelessCoverage.com

The approach used for this project was designed to be as comprehensive and detailed as possible, using the best quality data and modelling tools available.

Detailed data was prepared to perform this analysis comprising of: -

- The latest EIRCODE dataset, purchased in August 2019
- A Digital Surface Model (DSM) for the whole country from Bluesky International, who have the most contemporary dataset currently available. They hold data at 1m resolution, which was scaled to 2.5m resolution using a bilinear interpolation method. Where any gaps in their coverage were identified SRTM data was used and interpolated to avoid any hard edges in the height data. More information on the data is available in Appendix A.
- Mast Site Data from our ISP
- WISDM Wireless Modelling system, which performs detailed line of sight tests between all properties and all tower sites. Further details on the WISDM Line of Sight Engine are included in Appendix C.

Method according to WirelessCoverage.com

Data from our ISP was collected in September 2019 and imported into WISDM. Sites were classified as Standard or NGA and we also gathered details on future planned sites. The distinction between Standard and NGA sites is based upon the quality and style of equipment currently installed at these sites, along with the backhaul feeds. Those classified as NGA are capable of connecting premises at NGA speeds of 30Mbps download.

Using WISDM, wirelesscoverage ran several coverage passes to all EIRCODE centroids: -

1. All Sites from our ISP at NGA
2. All Sites from our ISP at non-NGA

Within each pass, WISDM takes each Site within the test and performs a Wireless Line of Sight test to each property within a given radius. It is important to note that a Wireless Line of Sight Test differs from an optical test, as it takes into account the Fresnel 1 Zone around the direct (optical) path. This is a more robust means of determining line of sight. In this exercise, we discounted all properties that had more than 15% Fresnel 1 incursion, and therefore does not include properties with Near Line of Sight, which in many cases could successfully be connected.

Where a property does have Wireless Line of Sight, it is excluded from further tests within that pass, in order to avoid double-counting properties.

We then performed analysis of the coverage list from each operator with NGA coverage to identify those properties that could receive NGA service from more than one operator.

NGA Assumptions

Due the variety of equipment mounted at each site for different operators, we have taken a cautious approach to whether a site is capable of delivering NGA speeds. As such, we have taken a worst-case assumption of the type of equipment used for access points or base stations.

We considered the signal level that would be required to get the full modulation rates on the most basic of commonly installed fixed wireless equipment, as well as a significant fade margin. Assuming a nominal operating frequency of 5.7 GHz with regulatory compliant power output (EIRP) from a base station of 33 dBm (2 Watts) and a client receiver with 30cm diameter antenna providing 23 dBi gain, the receive signal level (RSL) with clear line of sight would be -70.1 dBm at 7.5 km. Using a basic radio system, such as the Ubiquiti Rocket M5 access points and associated M5 customer receiver such as NanoBeam M5 system on a 20 MHz channel, and an assumed noise floor of 90 dBm, a client would connect at MCS13, providing a physical interface rate of 104 Mbps and a typical throughput rate of approximately 54 Mbps, which is safely above the NGA threshold and leaves a considerable fade margin assuming the access point is not over-subscribed.

Assumptions and Constraints

As with all modelling approaches to wireless coverage, there are factors which could over-state or under-state coverage. Here is a summary of the key factors as they relate to this project: -

Over-statement factors

- A small percentage of the national map data used was derived from low-resolution (10 to 30m) data, which could mean that obstructions to the wireless signal path calculations were missed. We estimate an error rate of <2% over-statement.
- Since the high-resolution data was produced between 2015 and 2017, it is likely that additional tree growth and new building works will have occurred in the intervening period which means that some wireless paths are now blocked. We estimate a resultant over-statement of <1% from this.
- Whilst it may be possible to receive a high-quality signal at a given property, it is possible that there is no suitable location on the property to mount a receiver due to the construction or location of the property. For example, waterside properties or those with unusual construction such as all-glass exterior can be very challenging.

Under-statement factors

- In this exercise, we performed single-point line of sight tests to each EIRCODE property. In reality, it is possible that the Wireless Line of Sight to that one point may be obscured and therefore reported as no coverage, but if a receiver was mounted at a different point on the property, a connection could be established. We estimate an under-statement of 3-4% from this factor.
- We used a watershed method for wireless line of sight calculation which allows for little or no Near Line of Sight connections. Many modern radio systems using the diversity associated with MIMO transmission allows for high quality connections to be established in Near Line of Sight operation and these have not been incorporated in the model. This is estimated to have an affect of <10%, but it is highly dependent on the technology used by the operator.
- We have assumed that 30cm dishes are used at the customer property to achieve an appropriate signal level. It is common practice to install 40cm dishes or larger, which have higher gain and therefore can receive a good signal at a longer range. Using larger dishes could increase the coverage from each access point substantially.

Multi Dwelling Units (MDUs)

WISDM currently has a design constraint which means that the premises counted in coverage checks shows the same EIRCODE for all properties that have the same physical location (ie. Multi-dwelling units). This means that the coverage lists appear to have duplications. It was not possible to resolve this issue in the time available to complete the project.

LIDAR DSM Data Source coverage according to wirelesscoverage.com

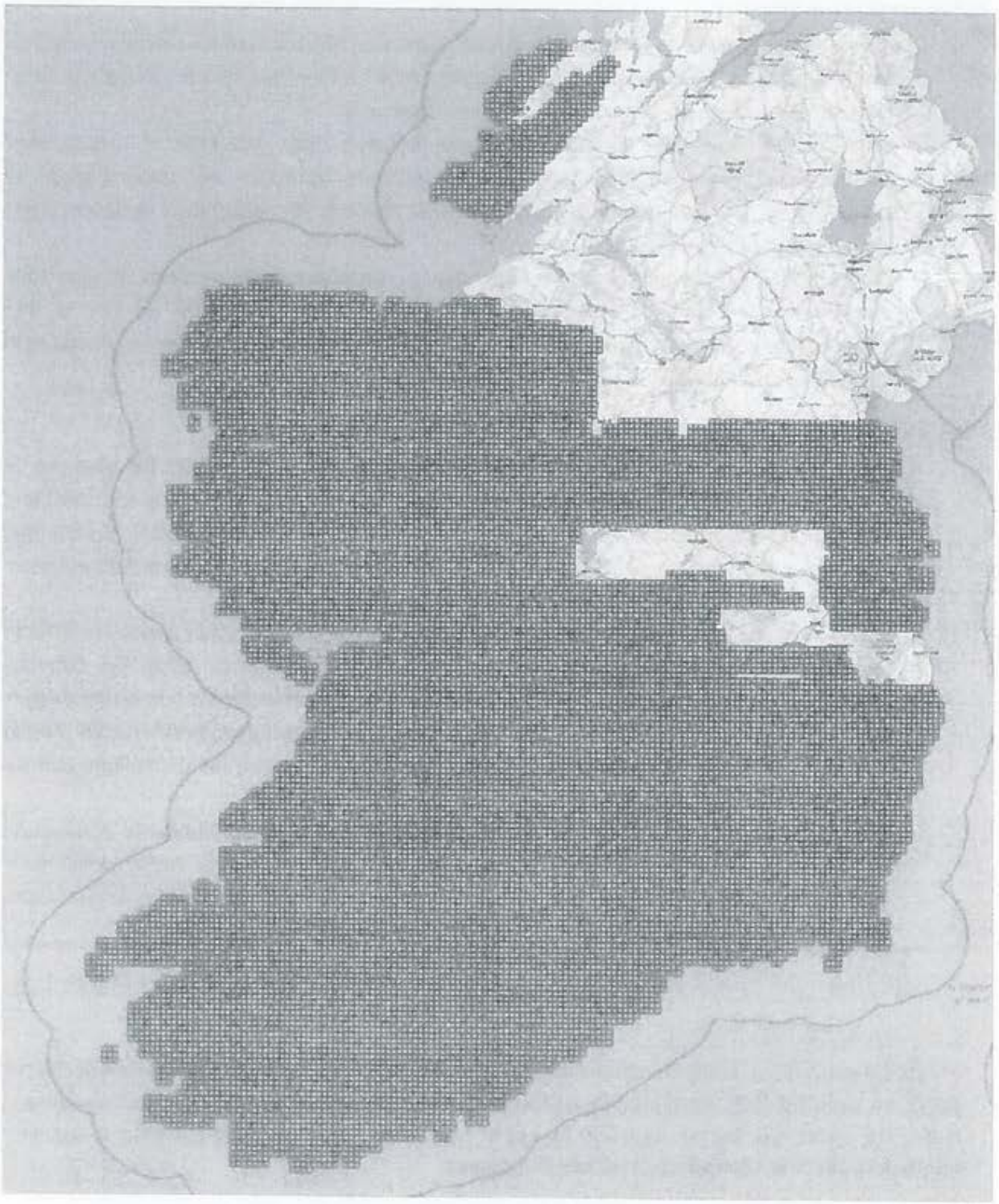


Figure 1. Map of 1m DSM Data from Bluesky International, collected between 2015 and 2017

Figure 2. Example render of DSM Data showing trees, buildings and other surface features.

Wirelesscoverage.com WISDM™ Line of Sight Engine

Highlights

Wireless coverage WISDM comprises of a family of ultra-high performance wireless planning systems developed by Boundless Networks Ltd.

WISDM WISP Edition is an interactive planning and design system built to facilitate the creation of scalable, robust and performant fixed wireless networks for Wireless IPSs. It enables the rapid creation of 'Ideal' wireless networks over very large areas of thousands of square kilometres. It is well suited to rural expanses as well as mixed and urban environments too. Once an Ideal network has been designed, the network can be fine-tuned to consider build constraints and resiliency in real time.

WISDM can also be used to analyse the coverage of an existing wireless network and perform 'what-if' tests to plan ad-hoc extensions to a network to verify potential coverage and backhaul.

Using WISDM, a predictable coverage model can be prepared in hours and **detailed coverage of individual properties** can be predicted with an extremely high level of accuracy. Site planning and acquisition is accelerated by use of the interactive planning tools, allowing rapid decisions about mast location to be made with instant coverage impact reporting.

Overview

WISDM comprises of several components and processes to complete the overall solution. At the heart of the system is a very high performance wireless Line of Sight (LoS) calculation engine. The

LoS engine can calculate over 150 million wireless line of sight tests per second and can use a wide variety of terrain and surface obstruction data sets at any resolution.

Overall, WISDM WISP Edition performs the following tasks: -

1. Site Finder. This creates an 'Ideal' list of sites where masts could be located for optimum coverage for a given number of target premises passed from a target premises dataset. Target premises can be a list of all properties from a comprehensive source, such as Ordnance Survey AddressBase, or a subset of premises in say, a Government Intervention area. Assumptions can be used to set mast profiles which would include mast height and effective wireless range. For example, the Site Finder can be run with parameters which state that 20 locations could be built with 30m towers, then calculate how many 15m towers would be needed to pass a certain quantity of target premises.
2. Backhaul Modelling. The Backhaul Modeller analyses a Site Location dataset and performs line of sight tests between them to create microwave backhaul. Assumptions can be used to help plan for the style of links to be used. For example, links up to 5km can be coloured differently than links from 5km to 17km. This helps when planning a network that has optimum resilience, performance and operating costs due to the potential costs incurred to run licensed microwave links or fibre backbone.
3. Wide Area Network (WAN) Visualizer. The WAN Visualizer provides full-screen mapping to allow users to see the overall shape of a network and the distribution of different sized towers and backhaul connections between sites. The WAN Visualizer can be called from the Site Coverage and Modelling system.
4. Site Coverage and Modelling System. This is an interactive web-based tool that allows planners to review the calculated Ideal Sites and move them on a map. At each point, the user can see instantly the impact of changes to coverage of Target Premises, as well as backhaul connections to other sites.
5. Backhaul Link Capacity Planning. Backhaul links can be described in terms of capacity and latency. Client connection volumes can also be applied to sites and WISDM will predict traffic load and volumes relative to transit or fibre injection points.

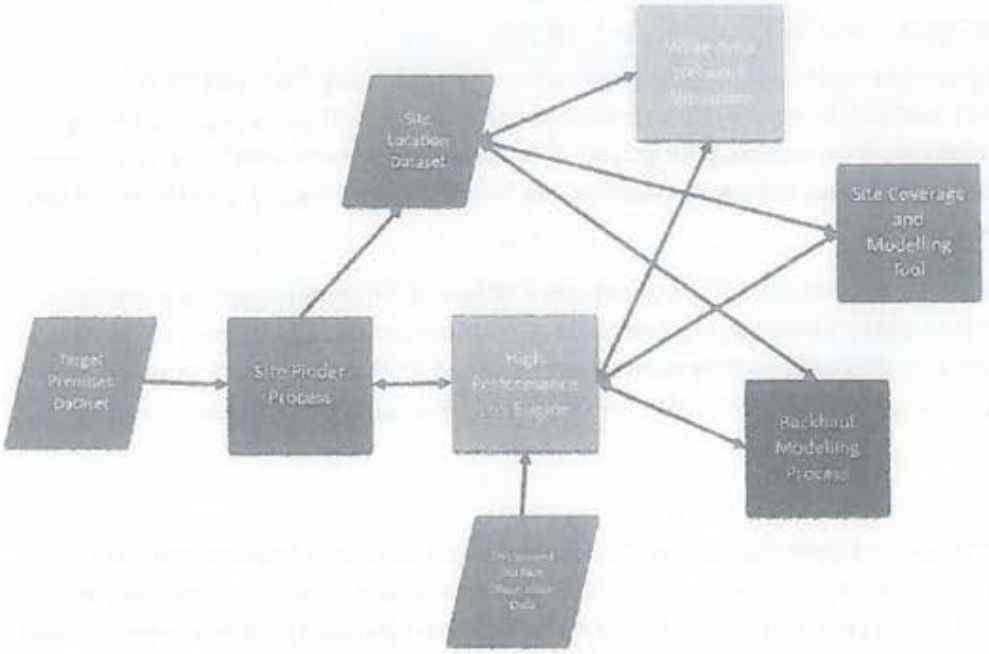


FIGURE 1 WISDM SCHEMATIC SYSTEM OVERVIEW

Wirelesscoverage.com WISDM LoS Engine

The WISDM LoS Engine is a custom-built high performance wireless propagation calculator developed in Native C and CUDA. It is a multi-threaded application, currently running on a server farm at Wireless Coverage and is accessed via a C API. This currently operates with 5,000 GPU cores to achieve around 500 million line of sight transactions per second when creating viewsheds but can be scaled further as required.

The LoS Engine has forward and reverse lookup features that are optimised to illustrate coverage from a single point, or supply from multiple points. These features are so fast that they can be operated in real time and take into consideration precision line of sight calculations as well as frequency, loss (according to ITU recommendations) and 3d antenna patterns for both transmitter and receiver.

Line of Sight Engine Technical Overview

Specific variants of the Line of Sight Engine exist for Forward (Viewshed) and Reverse (Best AP) coverage over large areas at any sample resolution. Below is an example of point to point request, but this is replicated over larger areas for the Forward and Reverse viewshed methods, where a map grid is also specified. The application uses the following parameters as input to each request via an API: -

- Site A Lat/Lon
- Site A transmitter height above ground in metres
- Site A transmitter power dBm
- Site A transmitter antenna gain in dBi
- Transmit frequency in MHz
- Scanning resolution in metres
- Site B Lat/Lon
- Site B receiver height above ground in metres
- Site B receiver antenna gain in dBi
- Percentage of first Fresnel required for partial line of sight in %
- Percentage of first Fresnel required for no line of sight in %
- Antenna Model (used for beam pattern)

The response for each request includes the following: -

- Link distance in metres
- Pass Status (Full Line of Sight, Partial Line of Sight or No Line of Sight)
- Predicted Receive Signal Strength (RSL) in dBm, assuming full Line of Sight
- Azimuth from Site A in degrees from true North
- Azimuth from Site B in degrees from true North
- Elevation from Site A in degrees
- Elevation from Site B in degrees
- Antenna Model (used for beam pattern)
- Optional link ground profile .PNG image file, illustrating the link profile and first Fresnel shape

Point A name: Point A

Point B name: Point B

Coordinates of A: 53.673302°, -2.664143°

Coordinates of B: 53.645783°, -2.573456°

Height of A: 20 m

Height of B: 10 m

Power: 20 dBm

Antenna gain of A: 13 dBi

Antenna gain of B: 23 dBi

RF frequency: 5825 MHz

Estimated RSSi: **-69.37 dBm**

Azimuth from A: **117.05°**

Azimuth from B: **297.05°**

Elevation from A: **1.38°**

Elevation from B: **-1.38°**

Link distance: **6734.22 m**

FIGURE 2 SAMPLE LOS ENGINE INPUT AND OUTPUT

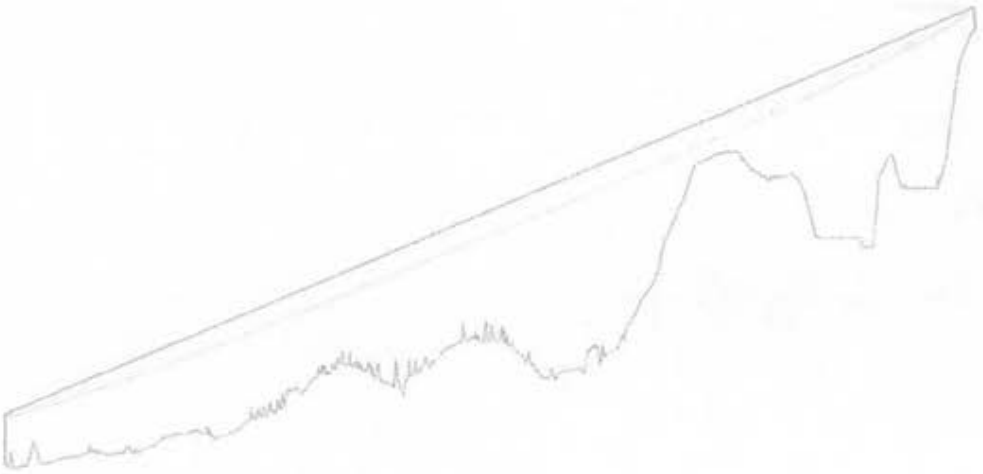


FIGURE 3 SAMPLE LOS GROUND PROFILE IMAGE

Mathematical and Technical LoS Model

A DSM elevation raster (of chosen resolution) of the target area is loaded into memory (~11GB GeoTIFF file equates to around 6,500 sq miles, imported with GDAL C library) into a flat array of 32-bit floats in a geodetic WGS84 latitude / longitude grid. This stays loaded in memory for every call of the function. A function exists to return the height in metres above sea level for any given latitude + longitude using bilinear interpolation in the grid. This allows for very fast indexed surface elevation lookups for any point in target area with high resolution.

64-bit integers are used for indexing coordinates and x87 80-bit floating-point numbers are used in coordinate calculations.

2 functions exist, geodetic_to_ecef and ecef_to_geodetic for converting between ellipsoidal WGS84 coordinates and cartesian ECEF coordinates.

geodetic_to_ecef is an implementation of Section 10.2.1 from B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins' GPS - theory and practice as follows:

$$N(\phi) = \frac{a^2}{\sqrt{a^2\cos^2\phi + b^2\sin^2\phi}}$$
$$X = (N(\phi) + h)\cos\phi\cos\lambda$$
$$Y = (N(\phi) + h)\cos\phi\sin\lambda$$
$$Z = \left(\frac{b^2}{a^2}N(\phi) + h\right)\sin\phi$$

where h is height in metres; ϕ is latitude; λ is longitude; a is the Earth's equatorial radius in metres; b is the Earth's polar radius in metres; (X,Y,Z) is the cartesian ECEF coordinate.

ecef_to_geodetic is an implementation of J. Zhu's "Exact conversion of earth-centred, earth-fixed coordinates to geodetic coordinates" formula as follows:

$$r = \sqrt{X^2 + Y^2}$$
$$E^2 = a^2 - b^2$$
$$F = 54b^2Z^2$$
$$G = r^2 + (1 - e^2)Z^2 - e^2E^2$$
$$C = \frac{e^4Fr^2}{G^3}$$
$$S = \sqrt[3]{1 + C + \sqrt{C^2 + 2C}}$$
$$P = \frac{F}{3\left(S + \frac{1}{S} + 1\right)^2G^2}$$
$$Q = \sqrt{1 + 2e^4P}$$
$$r_0 = \frac{-(Pe^2r)}{1+Q} + \sqrt{\frac{1}{2}a^2(1 + 1/Q) - \frac{P(1 - e^2)Z^2}{Q(1+Q)} - \frac{1}{2}Pr^2}$$
$$U = \sqrt{(r - e^2r_0)^2 + Z^2}$$
$$V = \sqrt{(r - e^2r_0)^2 + (1 - e^2)Z^2}$$
$$Z_0 = \frac{b^2Z}{aV}$$
$$h = U\left(1 - \frac{b^2}{aV}\right)$$
$$\phi = \arctan\left(\frac{Z + e'^2Z_0}{r}\right)$$
$$\lambda = \arctan2(Y, X)$$

where (X,Y,Z) is the cartesian ECEF coordinate; h is height in metres; ϕ is latitude; λ is longitude; a is the Earth's equatorial radius in metres; b is the Earth's polar radius in metres; e is the Earth's first orbital eccentricity; e' is the Earth's second orbital eccentricity.

The 3D cartesian coordinates of each radio is found by sampling the ground elevation of the two points and adding on the mast heights, and then using geodetic_to_ecef. The accurate straight-line distance between the two radios can be found by using $\sqrt{dx^2 + dy^2 + dz^2}$

The straight line between each (x,y,z) position is divided into linear interval points at the desired scan resolution. These points are then converted back into (latitude, longitude, height) WGS84 coordinates using ecef_to_geodetic.

The surface elevation at each of these WGS84 points is sampled and the resulting coordinates + height are converted back into ECEF coordinates.

The resulting 3D ECEF coordinates should mostly be in a flat plane and represent the elevation profile of the terrain under the line between the two radios, including the curvature of the Earth.

These coordinates are transformed into flat 2D coordinates by rotating them through 3 axes using transformation matrices. Once they are rotated to a flat plane against the axes, the resulting Z coordinate will be approximately zero and is discarded to produce 2D coordinates.

A 2D straight line is plotted between the two radio coordinates and perpendicular to this line, points are calculated and plotted for the first Fresnel zone and given threshold percentages within the Fresnel zone. The radius r in metres of the first fresnel zone is calculated using:

$$r = \sqrt{\frac{cd(t-d)}{1000000ft}}$$

where c is the speed of light in ms^{-1}; d is the distance along the line in metres; t is the total distance between the two radios; f is the frequency in megahertz.

Intersection with the surface profile polygon and the plotted Fresnel threshold points is tested using binary search + linear interpolation.

The basic RSL s in decibels is calculated using:

$$l = 92.5 + 20\log_{10}\left(\frac{d}{1000}\right) + 20\log_{10}\left(\frac{f}{1000}\right)$$
$$s = p + g_1 + g_2 - l - t$$

where l is the free-space path loss in decibels; d is the distance in metres; f is the frequency in megahertz; p is the power of the transmitter; $g1$ and $g2$ are the antenna gains of each antenna; t is the transmission line loss, assumed to be 1 decibel. Further ITU-R attenuation models are applied for appropriate bands, but not described in this document.

A2 Deployment Information

Due to the lack of notice, timing of the consultation period in peak holiday season, short initial consultation period and short extensions to the consultation period we have had insufficient time to present our exciting future plans for expanding our network. We will continue to grow our network and invest in new technologies in the same manner as we have done in the past. It is profoundly regrettable that the DCCAE NBP Team wilfully disregarded the best practices document on public consultations that another government department DPER had gone to the trouble of issuing on the topic of running a public consultation. Specifically DCCAE's NBP Team ignored the guidelines around giving more time for a consultation period so that smaller businesses would be given a fair opportunity to respond given the inherent constraints on resources that small business have. A copy of the DPER guidelines can be downloaded from the following url;
https://www.gov.ie/en/publication/e9b052-consultation-principles-and-guidance/

A3 Financial Information

The comments made in A2 are repeated here. More importantly, it is impossible for us and other similarly placed FWA operators to obtain the certainty of financing required by DCCAE's Assessment Criteria until DCCAE has accepted that we are providing NGA service and ruled our coverage area out of the currently proposed NBP .Intervention Area. By definition therefore, because the DCCAE has placed this impossibly high bar in our way, we are blocked as a result from being able to comply with DCCAE's requirements for future plans and therefore any future plans we and other existing FWA operators have can be totally disregarded by DCCAE. We cannot and do not accept that the EU's State Aid Guidelines are intended to be applied in this way.

Regional Telecom Ltd NBP Mapping Consultation Submission

TE

Contents

Preliminary

We regret that due to the very short space of time (comprising a series of *ad hoc* extensions) allowed by the Department for this Consultation and due to the very large and time consuming amount of data required to fully comply with its requirements we have been unable to address the totality required. We and other SME FWA ISPs have written to the Department earlier this September explaining the problems that this short time-scale holiday-centred consultation has caused and seeking an extension of time appropriate to a consultation of this kind. It is most regrettable that to-date only very short extensions have been forthcoming.

A1 Technical Information

1 Introduction

We have built our network around having good bandwidth with consistent and low latency, so as to support all converged IP services. We support many businesses and homes with Voice over IP VoIP telephony services. The advances in wireless broadband technology in the past 15 years has been very considerable and particularly significant in the last 4-5 years. Those technological advances have included interference mitigation, a feature which the interference related questions in DCCAE's non upgraded 2015 Assessment Criteria by definition fails to recognise. By our company keeping up with the latest in wireless technology we have been able to deliver the benefits of reliable high speed broadband to Rural Ireland and, as a result, there is a wide variety of converged services available to our customers. In fact, more than half of our customer internet traffic is now video based, such as streaming video content from:

- RTE
- BBC iPlayer
- Apple TV
- YouTube
- Netflix
- High Resolution CCTV for our customers peace of mind and security and indeed farmers for monitoring their animals' welfare

In addition to this we support many businesses / homes with Voice over IP VoIP telephony services.

We also support business users with remote working solutions through VPNs, Remote Desktop Environment and cloud-based productivity suites. Our customers report excellent results with video conferencing which allows for more remote working less commuting, less traffic congestion, reduced carbon footprint and a greater quality of life for our customers in Rural Ireland. We are delighted that our customers reap the benefits of high speed broadband in Rural Ireland today, benefits, we might add that exist at no cost to the taxpayer.

1.1Description of network Architecture

Data Centre

Our network core is based out of Equinix Kilcarbery, Dublin where we are interconnected with both national and international IP carriers. We are also members of INEX(10 Gb). We primarily use OpenEir for our National Backhaul(10Gb) and Cogent(10Gb) for our international IP transit. We have resilient failover links and secondary IP transit provided both nationally and internationally through Viatel.

Local Aggregation

From our Dublin hubs we are primarily using the OpenEir national backhaul network. Due to time constraints we will not go into detail on the architecture of this network as we believe the department are familiar with this. We breakout fibre locally as close as possible to our Base Stations.

For all nodes that we have submitted as NGA we have a minimum of 1Gb Fibre circuit within 1 wireless link of Base Station. Additional capacity can be added as required.

Base Stations

For our base stations we are either using Cambium EPMP 3000, EPMP 2000 or Rocket Prism 5AC Gen 2 and corresponding client units.

1.2.Access network technology

We operate a Fixed Wireless Access (FWA) Network in the ISM 5GHz & License Exempt 5.8GHz bands. We use Ethernet based data link layer technology. For our NGA Access Deployment we have Cambium and Ubiquity sectors and client units.

On our Base station sites, we have deployed Sectors with the technical specifications as outlined in the following section. They have already been deployed following our network strategy which allows for self-funded organic growth and infill as a site matures and consumers become aware of the improved new service offering available to them. In reference to organic growth we should point out that not all our customers are prepared to pay for NGA service at this time. As a result, whilst we are ready willing and able to provide NGA service to any customers who want it and are prepared to pay our reasonable and competitive charges, we do not at present have to scale our network on the basis that all our customers have be provided with NGA service. Instead, as and when they migrate to NGA we are able to upgrade any necessary parts of our network in order to accommodate that process as we have clearly done in the past.

On a given site that has 360 Degrees field of view (e.g. on top of a hill / mountain) we have deployed 4x 90-degree Cambium and Ubiquiti advanced sector antennas to provide coverage in the area. On a Base station site that has less of a field of view, in that case we have deployed the requisite number of 90-degree Cambium and Ubiquiti advanced sector antennas to cover that area. Additional capacity has been added by

- using additional sectors in the form of tightly focused sector antennas to maintain NGA levels of speeds that the customers are accustomed to. The tightly focused sector antennas serve to minimise external noise and facilitate frequency reuse.
- Using additional beamforming advanced sector antennas.

As explained above, additional capacity is added on an ongoing basis to maintain the performance in line with User expectations and requirements to ensure NGA Performance during the busy hour.

1.2.1 Access network technology and the Specification of the access equipment

We operate in the ISM 5GHz & License Exempt 5.8GHz bands. We use Ethernet based data link layer technology. For our NGA Access Deployment we have Cambium and Ubiquiti sectors and client units. The Cambium and Ubiquiti sectors are powered using Power over Ethernet PoE switches from Mikrotik. Routers are used to forward customer Internet traffic inside Layer 2 Tunnel Overlay on a Redundant layer 3 Routed network.

A schedule of Routers used at each base station would be one or more of the following (depending on the site size:

- Mikrotik RB4011iGS Router for capacity for routing up to 4Gb/s
    - https://i.mt.lv/cdn/rb_files/RB4011-RM-180919132428.pdf

1.2.1 Base station Technology Deployed

In our Base stations we deploy the equipment described below to support the delivery of quality reliable internet to the customer.

A schedule of Routers used at each base station would be one or more of the following (depending on the site size:

- Mikrotik RB4011iGS Router for capacity for routing up to 4Gb/s

1.2.2 Sector Technology Deployed

We deploy sectoral transmitters according to the design and strategy outlined earlier . We utilise Cambium Sectors with beamforming & GPS synchronisation to actively mitigate against Interference. In the case of a Ubiquiti deployment we use horn antennas which greatly mitigate against interference along with the RF filter technology of the prism radio and GPS sync. The GPS Sync allows all sectors at a given base station site to transmit simultaneously and receive simultaneously, thereby eliminating self-interference & co-located interference. When GPS sync is combined with Advanced Antenna Designs it allows an operator to reuse frequencies to increase capacity at a site. The Upload download ratio on the access network is fixed at 25% Up, 75% down. This allows for even better ratio than what is required for NGA. There are other active technologies deployed in the electronics to mitigate against interference through the use of:

  - Integrated Static RF filters
  - Integrated Dynamic tuneable RF filters
  - Advanced digital signal processors
  - Forward error correction FEC mechanisms
  - Adaptive Coding Modulation (ACM)
  - Transmit Power Control (TPC)
  - Subscriber isolation

A schedule of the sector equipment used is outlined below:

- GPS Synchronised dynamic filtering EPMP 3000 4x4 MUMIMO with 90deg Sectors with smart beamforming antenna.
  - https://cdn.cambiumnetworks.com/wp-content/uploads/2018/10/SS_ePMP_3000_10032018-1.pdf
  - https://cdn.cambiumnetworks.com/wp-content/uploads/2018/10/SS_ePMP3000_SectorAntenna_10032018_bleed.pdf

- GPS Synchronised dynamic filtering EPMP2000 2x2 MIMO with 90deg Sectors with smart beamforming antenna.

- https://cdn.cambiumnetworks.com/wp-content/uploads/2018/08/SS_ePMP_2000_06222018.pdf
- https://cdn.cambiumnetworks.com/wp-content/uploads/2017/10/SS-ePMP-Sector-antenna-04062016v1.pdf

- Smart Beamforming Antenna that is used in the EPMP 2000 and EPMP3000
  - https://cdn.cambiumnetworks.com/wp-content/uploads/2017/09/SS_ePMP_SmartAntenna01032017.pdf
- GPS Synchronised EPMP 3000L 2X2 MIMO with 30deg, 40deg, 50deg, 60deg, 90deg scalar horn antennas.
  - https://www.cambiumnetworks.com/products/epmp/epmp-3000l-access-point/

- RF Elements 30 Degree Scalar Horn Sector Antenna HG3-CC-S30
  - https://rfelements.com/assets/Uploads/HG3-CC-S30-Datasheet3.pdf
- RF Elements 40 Degree Scalar Horn Sector Antenna HG3-CC-S40
  - https://rfelements.com/assets/Uploads/HG3-CC-S40-Datasheet3.pdf
- RF Elements 50 Degree Scalar Horn Sector Antenna HG3-CC-S50
  - https://rfelements.com/assets/Uploads/HG3-CC-S50-Datasheet2.pdf
- RF Elements 60 Degree Scalar Horn Sector Antenna HG3-CC-S60
  - https://rfelements.com/assets/Uploads/HG3-CC-S60-Datasheet2.pdf
- RF Elements 30 Degree Asymmetrical Scalar Horn antenna HG3-TP-A20-30
  - https://rfelements.com/assets/Uploads/Datasheet-HG3-TP-A20-30.pdf
- RF Elements 60 Degree Asymmetrical Scalar Horn antenna HG3-TP-A60
  - https://rfelements.com/assets/Uploads/Datasheet-HG3-TP-A60.pdf
- RF Elements 90 Degree Asymmetrical Scalar Horn antenna HG3-TP-A90
  - https://rfelements.com/assets/Uploads/Datasheet-HG3-TP-A90.pdf

- Active RF Filtering Ubiquiti Prism

  https://dl.ubnt.com/datasheets/RocketAC/Rocket_Prism_AC_Gen2_DS.pdf

1.2.3 Client Premises Equipment(CPE) Technology Deployed.

The Client units were chosen because they had the following features to maximise performance and minimise interference:

- Maximise spectral efficiency by utilising a minimum of 2 streams MIMO (on horizontal and Vertical Polarization)
- High Gain Focused Antennas
- Maximise client performance by ensuring adequate processor specification
- Adaptive Coding Modulation (ACM)
- Forward Error Correction (FEC)
- Transmit power Control (TPC)

We also minimise interference by using high gain focused antennas that have the effect of maximising the signal through accurate alignment (by a professionally trained installer) of the antenna's centre line with the base station. Utilising High gain Focused antennas has the following effects:

- Noise behind and beside the antenna minimised to a great extent.
- Minimises interference to other operators because the signal is focused on the base station
- Minimises interference from other operators because the signal is focused on the base station (protection from noisy neighbours)
- Maximises signal to noise ratio (SNR)

A schedule of Client unit equipment deployed:

- Cambium Force 200 25dBi 5GHz Client units supporting throughputs of 80Mb/s down and 27Mb up on 20MHz
    - https://cdn.cambiumnetworks.com/wp-content/uploads/2017/10/SS_ePMP_Force200_06262018.pdf
- Cambium Force 300 25dBi 5Ghz supporting throughputs of up to 125mb/s down and 36mb/s up on 20MHz
    - https://cdn.cambiumnetworks.com/wp-content/uploads/2018/10/SS_ePMP_Force300-25_08212019.pdf
- Upgraded MikroTik LHG5 24.5 dBi Cambium ePMP elevate software installed on it.
    - https://i.mt.lv/cdn/rb_files/LHG-170927115805.pdf
- Ubiquiti Litebeam Gen2 100Mb/s down and 30Mb/s up pn 20Mhz

    https://dl.ubnt.com/datasheets/LiteBeam/LiteBeam_AC_Gen2_DS.pdf

1.3.Backhaul Network Technology and specification of Backhaul Technologies

Our backhaul is heavily dependent on fiber optic technology. We use high capacity FDD Links to transfer bandwidth from a fibre POH to a high site.

1.3.1 Short Range Radio Backhaul Network Technology

We make use of high frequency narrow beam links to bridge short gaps between fibre POHs and high sites. We make use of 17GHz / 24GHz / 60GHz License Exempt bands and Licenced bands for delivery of bandwidth from site to site or from Fibre POH to Site. We also deploy 5.8GHz GPS Synced Backup Backhaul to cover Extreme Weather Events that may affect Higher Frequency Links.

We utilise 60GHz MikroTik 60GLHG for links less than 1.25km delivering 2Gb/s HDX which has 4 channels available for future expansion and redundancy.

  - https://i.mt.lv/cdn/rb_files/LHGG-60ad-190611115231.pdf

- Racom Ray3 17GHz 713Mb/s FDX FDD Radio Link up to 10km
  - https://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray-dsA4-en.pdf
- Ubnt Airfiber 24HD 24GHz 1Gb/s FDX FDD Radio Link up to 6Km
  - https://www.ui.com/downloads/datasheets/airfiber/airFiber_DS.pdf

All of these connections allow for increased bandwidth for our customers. We monitor our network bandwidth flows and network activity on a site by site, link by link and SPE by CPE basis using an advanced monitoring system called Preseem. Our NMS alerts us to network problems so that we usually know about and resolve them before our customers even become aware of them/call us. When our network usage on any of our links regularly and consistently exceed 75% we start a procurement process to upgrade those links and this ensures that upgrades either soft or hard are implemented in time so as to keep our capacity always 20% above of peak demand. We monitor network our usage using various SNMP graphing and latency testing tools in our NMS system as described above).

1.3.3 Wired / Fibre Backhaul Network Technology

For sites and POPS that have 10Gb/s + Capacity we utilise the following routers to forward traffic onto High sites via the Radio Point to Point links described earlier

- Mikrotik CCR1072-1G-8S+ with a forwarding capacity of 50Gb/s
    - https://i.mt.lv/cdn/rb_files/CCR1072-1G-8Splus-1564987483.pdf
- Mikrotik CCR running on an X86-64 Server Hypervisor with a forwarding capacity Defined by the NUMA & PCI-E architecture of the Virtualization Hardware 40Gb/s +
    - https://i.mt.lv/pdf/software_chr.pdf
- Juniper VMX running on an X86-64 Server Hypervisor with a forwarding capacity Defined by the NUMA & PCI-E architecture of the Virtualization Hardware 40Gb/s +
    - https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000522-en.pdf
- BSDRP and FRR running on X86-64 Server Hypervisor with a forwarding capacity Defined by the NUMA architecture of the Virtualization Hardware 40Gb/s +
    - https://bsdrp.net/features
- OpenBSD OpenBGPd Control plane X86-64 Server Hypervisor with a forwarding capacity Defined by the NUMA & PCI-E architecture of the Virtualization Hardware 40Gb/s +
    - https://OpenBSD.org
- Cisco Cloud Services router 1000V running on
    - https://www.cisco.com/c/en/us/products/collateral/routers/cloud-services-router-1000v-series/datasheet-c78-733443.html

For smaller POPs and for POPS with PoE demands we deploy the following schedule of equipment

- Mikrotik RB1100AHx4 Router with a capacity for Routing up to 4Gb/s
    - https://i.mt.lv/cdn/rb_files/RB1100Dx4-171013102032.pdf
- Mikrotik Cloud Core CCR1016-12G Router
    - https://i.mt.lv/cdn/rb_files/ccr1016-12G-190612120511.pdf
- Mikrotik Cloud Core CCR1016-12G Router for routing up to 4Gb/s
    - https://i.mt.lv/cdn/rb_files/ccr1016-12G-190612120511.pdf
- Mikrotik RB4011iGS Router for capacity for routing up to 4Gb/s

- https://i.mt.lv/cdn/rb_files/RB4011-RM-180919132428.pdf

1.3.2 Backhaul Network Technology (National, and Metro) and the specification of the Backhaul Providers

We have several Circuits from national backhaul provider partners

1.3.2.1 OpenEir Backhaul

We have the following Services Contracted from OpenEir:

We have 1 x 10Gb/s Ethernet WEIL Wholesale Ethernet Interconnect Links with OpenEir located at the following locations Equinix DB1

We have checked the OpenEir Congestion Report and we have a clear upgrade path to the full 10G usage on the WSEAs and WEILs

We intend to utilise Wholesale GEA (Gepon Ethernet Access) (from November 2019) for backup backhaul to High sites via eirs GEPON network.

All of these connections allow for increased bandwidth for our customers. We monitor our network bandwidth flows and network activity on a site by site, link by link and CPE by CPE basis using Preseem. Our NMS alerts us to network problems so that we usually know about and resolve them before our customers even become aware of them/call us. When our network usage on any of our links regularly and consistently exceed 75% we start a procurement process to upgrade those links and this ensures that upgrades either soft or hard are implemented in time so as to keep our capacity always 20% above of peak demand. We monitor network our usage using various SNMP graphing and latency testing tools in our NMS system as described above).

1.3.2.5 Viatel Backhaul

We utilise Viatel to deliver Fibre connectivity to parts of our core network outside of Dublin. Viatel deliver circuits as a metro (i.e., within a single MAN) or national (from a MAN to Dublin or to another MAN) service. The circuits we utilise for our core network are National circuits providing connectivity from our Datacentre in Dublin to various core sites in our network. The Viatel circuits are delivered across fibre to our high site, and are terminated on a fibre patch panel.

1.3.3 External Edge Capacity

We have an External Edge capacity of 10 Gb/s

We have 10G IP Transit from Cogent

We have 10G backup IP Transit from Viatel

We have 10G interconnect with INEX LAN1

We have 1G interconnect with INEX LAN2

We have a 24x 7 Managed IP and Transit from Provider A via diverse Circuits and Diverse Equipment. The locations of the Points of Handoff are as follows

1.4. Design for the national backhaul network including any traffic and capacity assumptions

The backhaul network we have built has been designed around using quality backhaul from providers with an SLA that is appropriate for what are considered arterial paths for our network.

We use 182 wireless links spread across multiple providers from Datacentres in urban population centres to provincial towns around our network. From these provincial towns we utilise our own infrastructure built with high capacity ethernet radio links to get the bandwidth up to the nearest high site. We design the radio links with adequate fade margins to achieve 99.95% availability. Where feasible we introduce redundant paths between high sites using radio links so that if there is a fibre break in one provincial town we can fail over via a number of radio links to a fibre link in another provincial town. We also supplement our primary high speed backhaul connections with backup connections over gepon fiber connections as a backup of last resort.

1.5. The Specification of all types of Customer Premises Equipment which the operator is using .

A schedule of Client unit equipment deployed:

- Cambium Force 200 25dBi 5GHz Client units supporting throughputs of 80Mb/s down and 27Mb up on 20MHz
    - https://cdn.cambiumnetworks.com/wp-content/uploads/2017/10/SS_ePMP_Force200_06262018.pdf
- Cambium Force 300 25dBi 5Ghz supporting throughputs of up to 125mb/s down and 36mb/s up on 20MHz
    - https://cdn.cambiumnetworks.com/wp-content/uploads/2018/10/SS_ePMP_Force300-25_08212019.pdf
- Upgraded MikroTik LHG5 24.5 dBi Cambium ePMP elevate software installed on it.
    - https://i.mt.lv/cdn/rb_files/LHG-170927115805.pdf
- Ubiquiti Litebeam Gen2 100Mb/s down and 30Mb/s up pn 20Mhz

    https://dl.ubnt.com/datasheets/LiteBeam/LiteBeam_AC_Gen2_DS.pdf

1.6. Coverage data as illustrated in the form of Polygonsed Data set

Mapping of existing coverage provided in .kml format

File attached RegionalBroadband_NGA_Detail_Confidential.kml

1.6.1 Table of Location of Base stations

List of Base stations that were used in wirelesscoverage.com WISDM LIDAR Line of Sight analysis software.

1.6.1a Location of Base stations as illustrated in a MAP

List of Base stations that were used in wirelesscoverage.com WISDM LIDAR Line of Sight analysis software. See Site_List_Confidential.xls

1.6.2 Table of Location of Connected Clients

See Connected_Clients_Confidential.xls

1.6.3 Table of Location of Covered Premises Physically Tested on Site (eircodes only or GPS coordinates)

See Tested_Premises_Confidential.xls

1.6.4 Table of Location of Premises Passed based on High Resolution LIDAR and DSM data (

Reference RegionalBroadband_NGA_eircodes_Confidential.csv

1.6.4 LIDAR LOS testing and Methodology

We have engaged WirelessCoverage.com to build a Digital surface model based on high quality LIDAR / DSM data. We have supplied Wirelesscoverage.com a list of Sites and height of sectors to produce a list of premises that would be covered with clear line of sight

Approach according to WirelessCoverage.com

The approach used for this project was designed to be as comprehensive and detailed as possible, using the best quality data and modelling tools available.

Detailed data was prepared to perform this analysis comprising of: -

- The latest EIRCODE dataset, purchased in August 2019
- A Digital Surface Model (DSM) for the whole country from Bluesky International, who have the most contemporary dataset currently available. They hold data at 1m resolution, which was scaled to 2.5m resolution using a bilinear interpolation method. Where any gaps in the LIDAR/DSM coverage were identified, the following other Topographical data sources were used in the order of descending preference.
    - Open Topographic Lidar Data from the Irish Government
    - SRTM (Shuttle Radar Topography Mission)
- These data sets were blended and interpolated to avoid any hard edges in the height data. More information on the data is available in detail below. Mast Site Data from our ISP
- WISDM Wireless Modelling system, which performs detailed line of sight tests between all properties and all tower sites. Further details on the WISDM Line of Sight Engine are included in Below

Method according to WirelessCoverage.com

Data from our ISP was collected in September 2019 and imported into WISDM. Sites were classified as Standard or NGA and we also gathered details on future planned sites. The distinction between Standard and NGA sites is based upon the quality and style of equipment currently installed at these sites, along with the backhaul feeds. Those classified as NGA are capable of connecting premises at NGA speeds of 30Mbps download and 6Mbs upload.

Using WISDM, wirelesscoverage ran several coverage passes to all EIRCODE centroids: -

1. All Sites from our ISP at NGA
2. All Sites from our ISP at non-NGA

Within each pass, WISDM takes each Site within the test and performs a Wireless Line of Sight test to each property within a given radius. It is important to note that a Wireless Line of Sight Test differs from an optical test, as it takes into account the Fresnel 1 Zone around the direct (optical) path. This is a more robust means of determining line of sight. In this exercise, we discounted all properties that had more than 15% Fresnel 1 incursion, and therefore does not include properties with Near Line of Sight, which in many cases could successfully be connected.

Where a property does have Wireless Line of Sight, it is excluded from further tests within that pass, in order to avoid double-counting properties.

We then performed analysis of the coverage list from each operator with NGA coverage to identify those properties that could receive NGA service from more than one operator.

NGA Assumptions

Due the variety of equipment mounted at each site, we have taken a cautious approach to whether a site is capable of delivering NGA speeds. As such, we have taken a worst-case assumption of the type of equipment used for access points or base stations.

We considered the signal level that would be required to get the full modulation rates on the most basic of commonly installed fixed wireless equipment, as well as a significant fade margin. Assuming a nominal operating frequency of 5.7 GHz with regulatory compliant power output (EIRP) from a base station of 33 dBm (2 Watts) and a client receiver with 30cm diameter antenna providing 23 dBi gain, the receive signal level (RSL) with clear line of sight would be -70.1 dBm at 7.5 km. Using a basic radio system, such as the Ubiquiti Rocket M5 access points and associated M5 customer receiver such as NanoBeam M5 system on a 20 MHz channel, and an assumed noise floor of 90 dBm, a client would connect at MCS13, providing a physical interface rate of 104 Mbps and a typical throughput rate of approximately 54 Mbps, which is safely above the NGA threshold and leaves a considerable fade margin assuming the access point is not over-subscribed.

Assumptions and Constraints

As with all modelling approaches to wireless coverage, there are factors which could over-state or under-state coverage. Here is a summary of the key factors as they relate to this project: -

Over-statement factors

- A small percentage of the national map data used was derived from low-resolution (10 to 30m) data, which could mean that obstructions to the wireless signal path calculations were missed. We estimate an error rate of <2% over-statement.

- Since the high-resolution data was produced between 2015 and 2017, it is likely that additional tree growth and new building works will have occurred in the intervening period which means that some wireless paths are now blocked. We estimate a resultant over-statement of <1% from this.

- Whilst it may be possible to receive a high-quality signal at a given property, it is possible that there is no suitable location on the property to mount a receiver due to the construction or location of the property. For example, waterside properties or those with unusual construction such as all-glass exterior can be very challenging.

Under-statement factors

- In this exercise, we performed single-point line of sight tests to each EIRCODE property. In reality, it is possible that the Wireless Line of Sight to that one point may be obscured and therefore reported as no coverage, but if a receiver was mounted at a different point on the

property, a connection could be established. We estimate an under-statement of 3-4% from this factor.

- We used a watershed method for wireless line of sight calculation which allows for little or no Near Line of Sight connections. Many modern radio systems using the diversity associated with MIMO transmission allows for high quality connections to be established in Near Line of Sight operation and these have not been incorporated in the model. This is estimated to have an effect of <10%, but it is highly dependent on the technology used by the operator.

- We have assumed that 30cm dishes are used at the customer property to achieve an appropriate signal level. It is common practice to install 40cm dishes or larger, which have higher gain and therefore can receive a good signal at a longer range. Using larger dishes could increase the coverage from each access point substantially.

Multi Dwelling Units (MDUs)

WISDM currently has a design constraint which means that the premises counted in coverage checks shows the same EIRCODE for all properties that have the same physical location (ie. Multi-dwelling units). This means that the coverage lists appear to have duplications. It was not possible to resolve this issue in the time available to complete the project.

LIDAR DSM Data Source coverage according to wirelesscoverage.com

Figure 1. Map of 1m DSM Data from Bluesky International, collected between 2015 and 2017

Figure 2. Example render of DSM Data showing trees, buildings and other surface features.

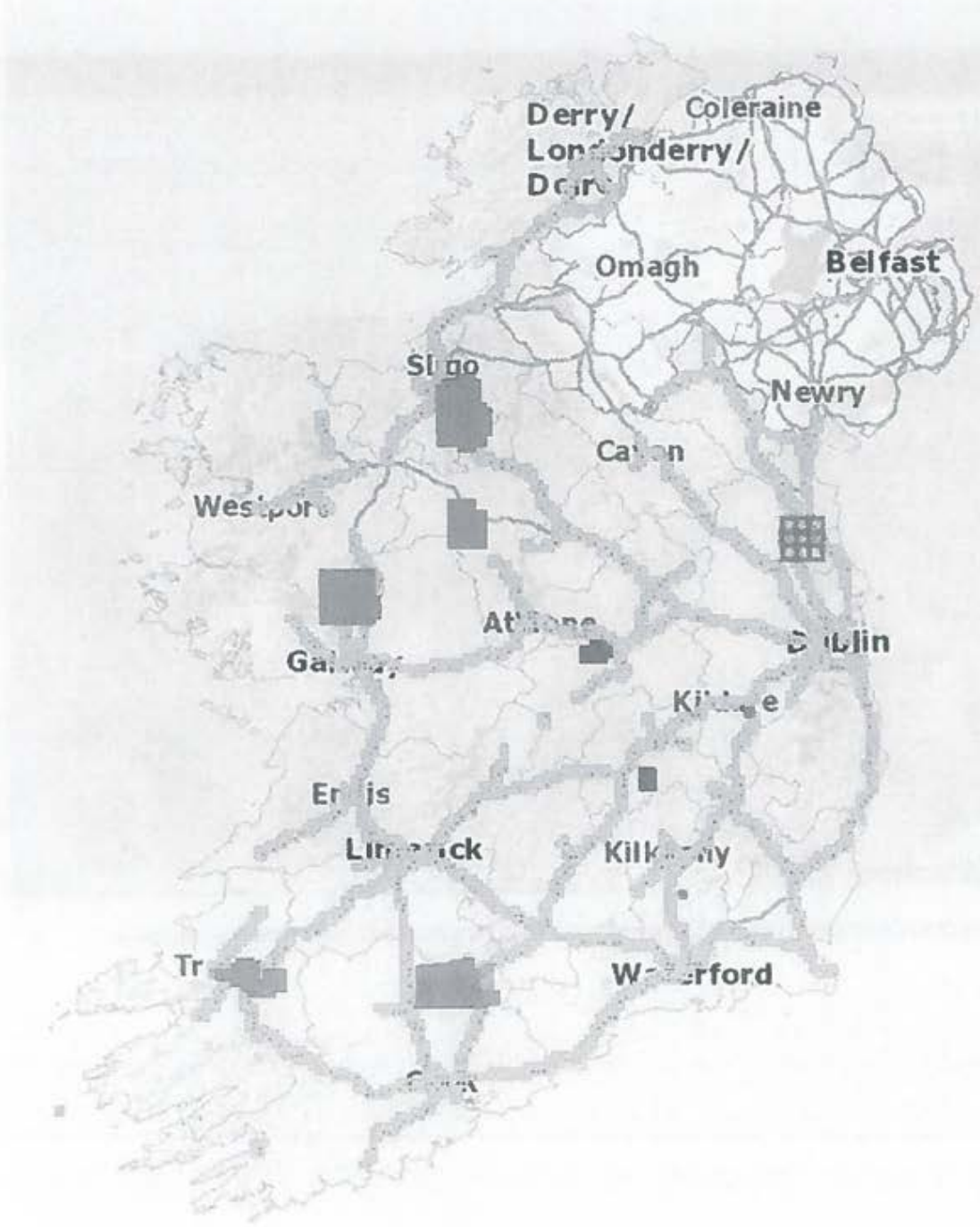


Figure 3. Irish Government published Open LIDAR data areas that supplemented the proprietary LIDAR data.

Figure 4. Example of Open Topographic LIDAR data detail as published on data.gov.ie

Figure5. SRTM topographical data as captured and rendered by NASA

Wirelesscoverage.com WISDM™ Line of Sight Engine

Highlights

Wireless coverage WISDM comprises of a family of ultra-high performance wireless planning systems developed by Boundless Networks Ltd.

WISDM WISP Edition is an interactive planning and design system built to facilitate the creation of scalable, robust and performant fixed wireless networks for Wireless IPSs. It enables the rapid creation of 'Ideal' wireless networks over very large areas of thousands of square kilometres. It is well suited to rural expanses as well as mixed and urban environments too. Once an Ideal network has been designed, the network can be fine-tuned to consider build constraints and resiliency in real time.

WISDM can also be used to analyse the coverage of an existing wireless network and perform 'what-if' tests to plan ad-hoc extensions to a network to verify potential coverage and backhaul.

Using WISDM, a predictable coverage model can be prepared in hours and **detailed coverage of individual properties** can be predicted with an extremely high level of accuracy. Site planning and acquisition is accelerated by use of the interactive planning tools, allowing rapid decisions about mast location to be made with instant coverage impact reporting.

Overview

WISDM comprises of several components and processes to complete the overall solution. At the heart of the system is a very high performance wireless Line of Sight (LoS) calculation engine. The LoS engine can calculate over 150 million wireless line of sight tests per second and can use a wide variety of terrain and surface obstruction data sets at any resolution.

Overall, WISDM WISP Edition performs the following tasks: -

1. Site Finder. This creates an 'Ideal' list of sites where masts could be located for optimum coverage for a given number of target premises passed from a target premises dataset. Target premises can be a list of all properties from a comprehensive source, such as Ordnance Survey AddressBase, or a subset of premises in say, a Government Intervention area. Assumptions can be used to set mast profiles which would include mast height and effective wireless range. For example, the Site Finder can be run with parameters which state that 20 locations could be built with 30m towers, then calculate how many 15m towers would be needed to pass a certain quantity of target premises.

2. Backhaul Modelling. The Backhaul Modeller analyses a Site Location dataset and performs line of sight tests between them to create microwave backhaul. Assumptions can be used to help plan for the style of links to be used. For example, links up to 5km can be coloured differently than links from 5km to 17km. This helps when planning a network that has optimum resilience, performance and operating costs due to the potential costs incurred to run licensed microwave links or fibre backbone.

3. Wide Area Network (WAN) Visualizer. The WAN Visualizer provides full-screen mapping to allow users to see the overall shape of a network and the distribution of different sized

towers and backhaul connections between sites. The WAN Visualizer can be called from the Site Coverage and Modelling system.

4. Site Coverage and Modelling System. This is an interactive web-based tool that allows planners to review the calculated Ideal Sites and move them on a map. At each point, the user can see instantly the impact of changes to coverage of Target Premises, as well as backhaul connections to other sites.

5. Backhaul Link Capacity Planning. Backhaul links can be described in terms of capacity and latency. Client connection volumes can also be applied to sites and WISDM will predict traffic load and volumes relative to transit or fibre injection points.

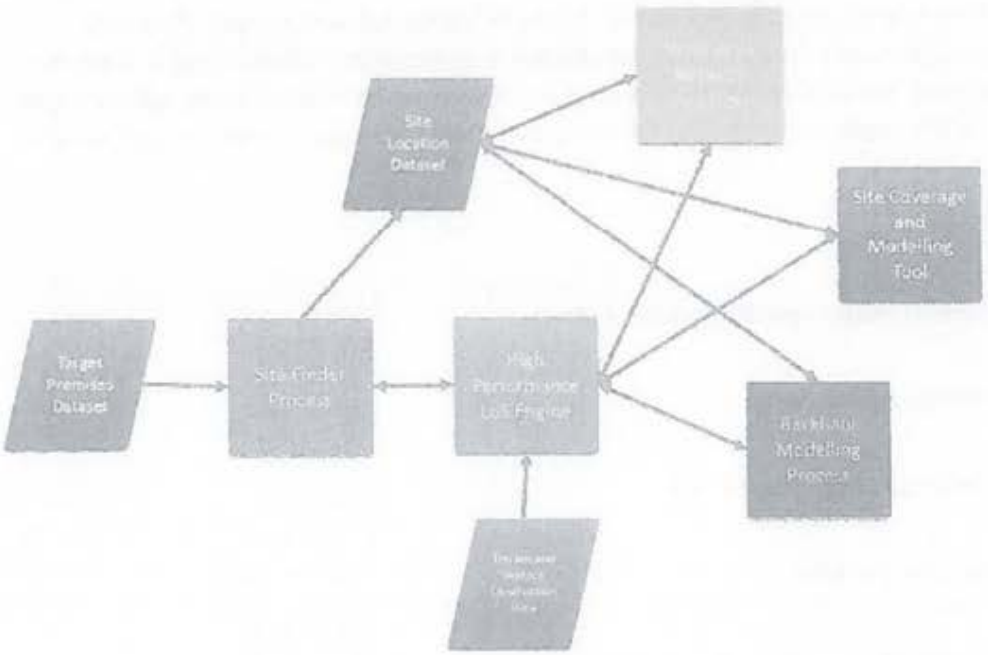


Figure 6. WISDM Schematic System Overview

Wirelesscoverage.com WISDM LoS Engine

The WISDM LoS Engine is a custom-built high-performance wireless propagation calculator developed in Native C and CUDA. It is a multi-threaded application, currently running on a server farm at Wireless Coverage and is accessed via a C API. This currently operates with 5,000 GPU cores to achieve around 500 million line of sight transactions per second when creating viewsheds but can be scaled further as required.

The LoS Engine has forward and reverse lookup features that are optimised to illustrate coverage from a single point, or supply from multiple points. These features are so fast that they can be operated in real time and take into consideration precision line of sight calculations as well as frequency, loss (according to ITU recommendations) and 3d antenna patterns for both transmitter and receiver.

Line of Sight Engine Technical Overview

Specific variants of the Line of Sight Engine exist for Forward (Viewshed) and Reverse (Best AP) coverage over large areas at any sample resolution. Below is an example of point to point request, but this is replicated over larger areas for the Forward and Reverse viewshed methods, where a map grid is also specified. The application uses the following parameters as input to each request via an API: -

- Site A Lat/Lon
- Site A transmitter height above ground in metres
- Site A transmitter power dBm
- Site A transmitter antenna gain in dBi
- Transmit frequency in MHz
- Scanning resolution in metres
- Site B Lat/Lon
- Site B receiver height above ground in metres
- Site B receiver antenna gain in dBi
- Percentage of first Fresnel required for partial line of sight in %
- Percentage of first Fresnel required for no line of sight in %
- Antenna Model (used for beam pattern)

The response for each request includes the following: -

- Link distance in metres
- Pass Status (Full Line of Sight, Partial Line of Sight or No Line of Sight)
- Predicted Receive Signal Strength (RSL) in dBm, assuming full Line of Sight
- Azimuth from Site A in degrees from true North
- Azimuth from Site B in degrees from true North
- Elevation from Site A in degrees
- Elevation from Site B in degrees
- Antenna Model (used for beam pattern)
- Optional link ground profile .PNG image file, illustrating the link profile and first Fresnel shape

Point A name: Point A
Point B name: Point B
Coordinates of A: 53.673302°, -2.664143°
Coordinates of B: 53.645783°, -2.573456°
Height of A: 20 m
Height of B: 10 m
Power: 20 dBm
Antenna gain of A: 13 dBi
Antenna gain of B: 23 dBi
RF frequency: 5825 MHz

Estimated RSSi: **-69.37 dBm**
Azimuth from A: **117.05°**
Azimuth from B: **297.05°**
Elevation from A: **1.38°**
Elevation from B: **-1.38°**
Link distance: **6734.22 m**

Figure 7 Sample LoS Engine Input and Output

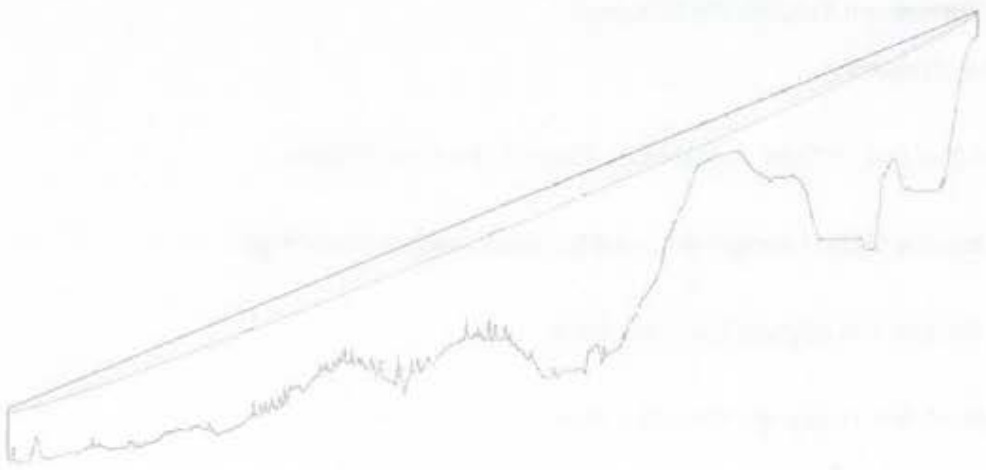


Figure 8 Sample LoS Ground Profile Image

Mathematical and Technical LoS Model

A DSM elevation raster (of chosen resolution) of the target area is loaded into memory (~11GB GeoTIFF file equates to around 6,500 sq miles, imported with GDAL C library) into a flat array of 32-bit floats in a geodetic WGS84 latitude / longitude grid. This data stays loaded in memory for every call of the function. A function exists to return the height in metres above sea level for any given latitude + longitude using bilinear interpolation in the grid. This allows for very fast indexed surface elevation lookups for any point in target area with high resolution.

64-bit integers are used for indexing coordinates and x87 80-bit floating-point numbers are used in coordinate calculations.

2 functions exist, geodetic_to_ecef and ecef_to_geodetic for converting between ellipsoidal WGS84 coordinates and cartesian ECEF coordinates.

geodetic_to_ecef is an implementation of Section 10.2.1 from B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins' GPS - theory and practice as follows:

$$N(\phi) = \frac{a^2}{\sqrt{a^2 \cos^2 \phi + b^2 \sin^2 \phi}}$$
$$X = (N(\phi) + h) \cos \phi \cos \lambda$$
$$Y = (N(\phi) + h) \cos \phi \sin \lambda$$
$$Z = \left(\frac{b^2}{a^2} N(\phi) + h \right) \sin \phi$$

where h is height in metres; ϕ is latitude; λ is longitude; a is the Earth's equatorial radius in metres; b is the Earth's polar radius in metres; (X,Y,Z) is the cartesian ECEF coordinate.

ecef_to_geodetic is an implementation of J. Zhu's "Exact conversion of earth-centred, earth-fixed coordinates to geodetic coordinates" formula as follows:

$$
\begin{aligned}
r &= \sqrt{X^2 + Y^2} \\
E^2 &= a^2 - b^2 \\
F &= 54 b^2 Z^2 \\
G &= r^2 + (1 - e^2) Z^2 - e^2 E^2 \\
C &= \frac{e^4 F r^2}{G^3} \\
S &= \sqrt[3]{1 + C + \sqrt{C^2 + 2C}} \\
P &= \frac{F}{3\left(S + \frac{1}{S} + 1\right)^2 G^2} \\
Q &= \sqrt{1 + 2e^4 P} \\
r_0 &= \frac{-(Pe^2 r)}{1 + Q} + \sqrt{\frac{1}{2} a^2 (1 + 1/Q) - \frac{P(1 - e^2) Z^2}{Q(1 + Q)} - \frac{1}{2} P r^2} \\
U &= \sqrt{(r - e^2 r_0)^2 + Z^2} \\
V &= \sqrt{(r - e^2 r_0)^2 + (1 - e^2) Z^2} \\
Z_0 &= \frac{b^2 Z}{aV} \\
h &= U\left(1 - \frac{b^2}{aV}\right) \\
\phi &= \arctan\left(\frac{Z + e'^2 Z_0}{r}\right) \\
\lambda &= \arctan2(Y, X)
\end{aligned}
$$

where *(X,Y,Z)* is the cartesian ECEF coordinate; *h* is height in metres; ϕ is latitude; λ is longitude; *a* is the Earth's equatorial radius in metres; *b* is the Earth's polar radius in metres; *e* is the Earth's first orbital eccentricity; *e'* is the Earth's second orbital eccentricity.

The 3D cartesian coordinates of each radio is found by sampling the ground elevation of the two points and adding on the mast heights, and then using geodetic_to_ecef. The accurate straight-line distance between the two radios can be found by using $\sqrt{dx^2 + dy^2 + dz^2}$.

The straight line between each *(x,y,z)* position is divided into linear interval points at the desired scan resolution. These points are then converted back into (latitude, longitude, height) WGS84 coordinates using ecef_to_geodetic.

The surface elevation at each of these WGS84 points is sampled and the resulting coordinates + height are converted back into ECEF coordinates.

The resulting 3D ECEF coordinates should mostly be in a flat plane and represent the elevation profile of the terrain under the line between the two radios, including the curvature of the Earth. These coordinates are transformed into flat 2D coordinates by rotating them through 3 axes using transformation matrices. Once they are rotated to a flat plane against the axes, the resulting *Z* coordinate will be approximately zero and is discarded to produce 2D coordinates.

A 2D straight line is plotted between the two radio coordinates and perpendicular to this line, points are calculated and plotted for the first Fresnel zone and given threshold percentages within the Fresnel zone. The radius *r* in metres of the first fresnel zone is calculated using:

$$
r = \sqrt{\frac{cd(t - d)}{1000000 f t}}
$$

where *c* is the speed of light in ms^{-1}; *d* is the distance along the line in metres; *t* is the total distance between the two radios; *f* is the frequency in megahertz.

Intersection with the surface profile polygon and the plotted Fresnel threshold points is tested using binary search + linear interpolation.

The basic RSL *s* in decibels is calculated using:

$$l = 92.5 + 20\log_{10}\left(\frac{d}{1000}\right) + 20\log_{10}\left(\frac{f}{1000}\right)$$
$$s = p + g_1 + g_2 - l - t$$

where *l* is the free-space path loss in decibels; *d* is the distance in metres; *f* is the frequency in megahertz; *p* is the power of the transmitter; *g1* and *g2* are the antenna gains of each antenna; *t* is the transmission line loss, assumed to be 1 decibel. Further ITU-R attenuation models are applied for appropriate bands, but not described in this document.

A2 Future Deployment Information

Due to the lack of notice, timing of the consultation period in peak holiday season, short initial consultation period and short extensions to the consultation period we have had insufficient time to present our exciting future plans for expanding our network. We will continue to grow our network and invest in new technologies in the same manner as we have done in the past. It is profoundly regrettable that the DCCAE NBP Team wilfully disregarded the best practices document on public consultations that another government department DPER had gone to the trouble of issuing on the topic of running a public consultation. Specifically DCCAE's NBP Team ignored the guidelines around giving more time for a consultation period so that smaller businesses would be given a fair opportunity to respond given the inherent constraints on resources that small business have. A copy of the DPER guidelines can be downloaded from the following url;
https://www.gov.ie/en/publication/e9b052-consultation-principles-and-guidance/

A3 Future Financial Information

The comments made in A2 are repeated here. More importantly, it is impossible for us and other similarly placed FWA operators to obtain the certainty of financing required by DCCAE's Assessment Criteria until DCCAE has accepted that we are providing NGA service and ruled our coverage area out of the currently proposed NBP .Intervention Area. By definition therefore, because the DCCAE has placed this impossibly high bar in our way, we are blocked as a result from being able to comply with DCCAE's requirements for future plans and therefore any future plans we and other existing FWA operators have can be totally disregarded by DCCAE. We cannot and do not accept that the EU's State Aid Guidelines are intended to be applied in this way.

From: [redacted]
To: NBP Mapping
Subject: Broadband service
Date: 16 September 2019 16:02:56

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hello,

I have broadband . Supplied by Vodafone. It is very slow.

I do not know if this is what you want to know or not.

[redacted]

[redacted]

From: KilkennyBroadbandOfficer <broadbandofficer@kilkennycoco.ie>
Sent: 18 September 2019 11:22
To: NBP Mapping
Subject: NBP – Conclusion of Mapping Exercise for the Intervention Area Pre Deployment - Kilkenny Broadband Officer
Attachments: KKC-NBPSubmission092019.docx

Follow Up Flag: Follow up
Flag Status: Completed

Hello [redacted]
I'm responding to the mapping exercise as Kilkenny Broadband Officer for multiple areas within County Kilkenny
Attached is the response.
Regards

[redacted]
IS Project Leader - Networks/Infrastructure & Broadband Officer
Kilkenny County Council. [redacted]
EMail [redacted]
Web: http://www.kilkennycoco.ie
Ph: [redacted] |Mob: [redacted] |Fax: [redacted]

NBP – Conclusion of Mapping Exercise for the Intervention Area Pre Deployment'

- Kilkenny Broadband Officer

Across Kilkenny county

The extended delay in the completion of the Eir's light blue 300K Rural FTTH project is causing frustration in many areas. It is unclear how many premises will be affected until the project is completed.

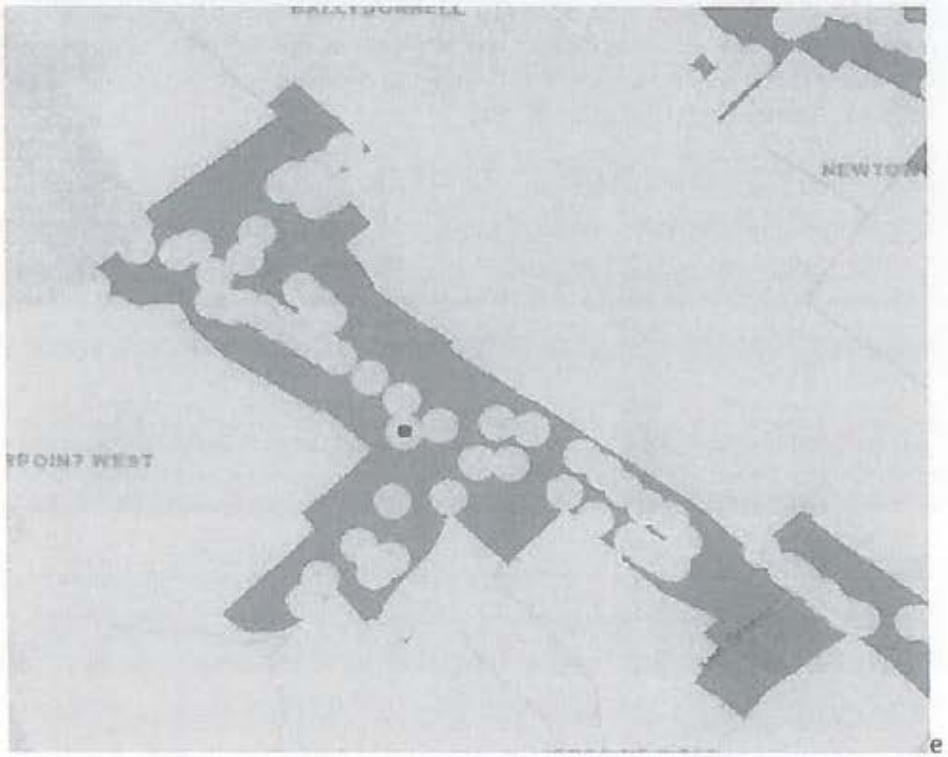
The sporadic updates on Eir's fibrerollout.ie website is adding to the confusion. The timelines for exchange upgrades have not been updated and Eir seem very reluctant to commit to anything.

There has been requests for Eir to extend their RFTTH as premises are a short distance from the end of the line or caught in unserviced areas between the fibre that has come from either end of the road. Example [redacted]

Area Specific

Thomastown

There is an Eir fibre cabinet completed and active in this area – The Greens. It doesn't appear to be cross connected to the copper cabinet next to it. The fibre cabinet is lit, as it can be seen in the City West NOC. Example Eircode: [redacted]

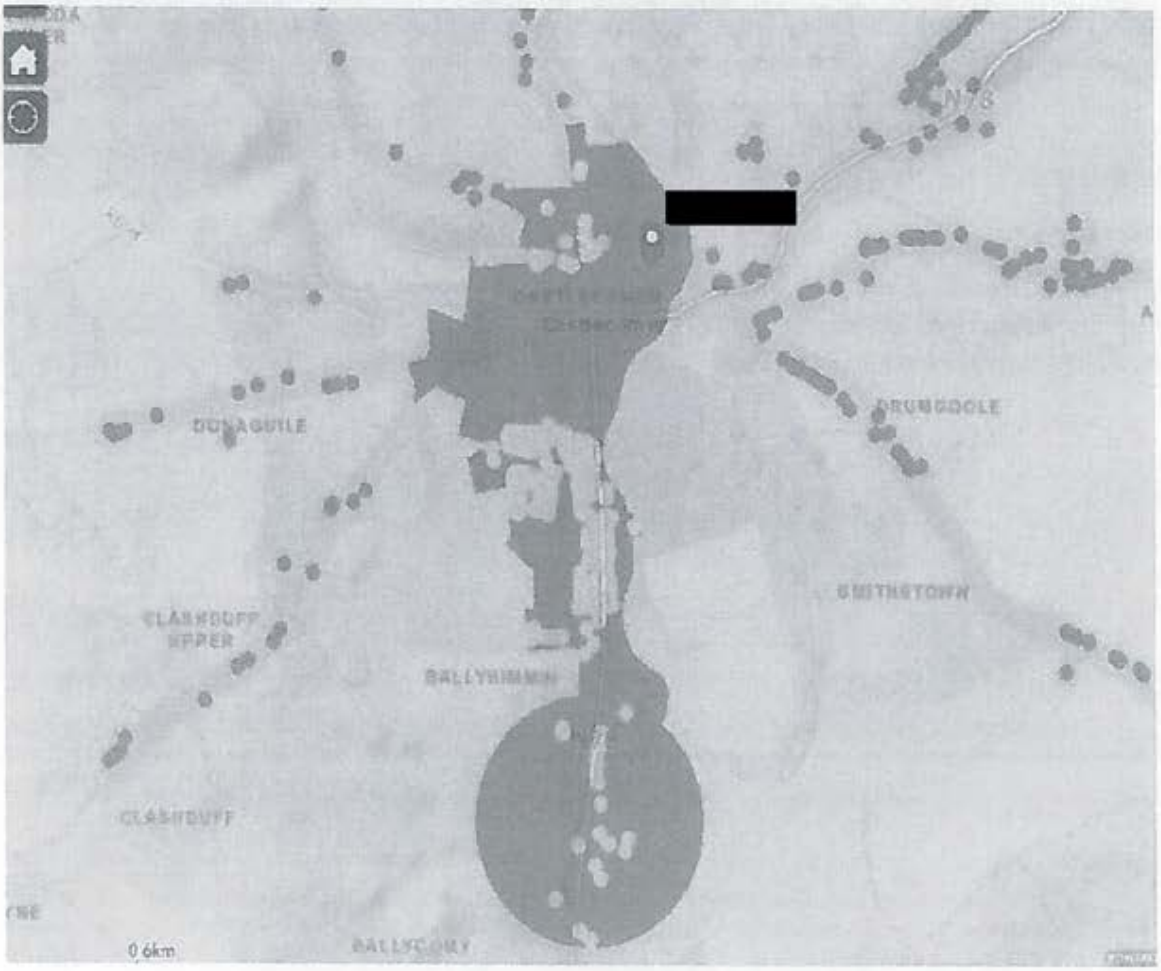


Castlecomer

The premises in the Blue area are unable to get any reliable high speed broadband even though the main exchange is supposed to have been upgraded to FTTC.

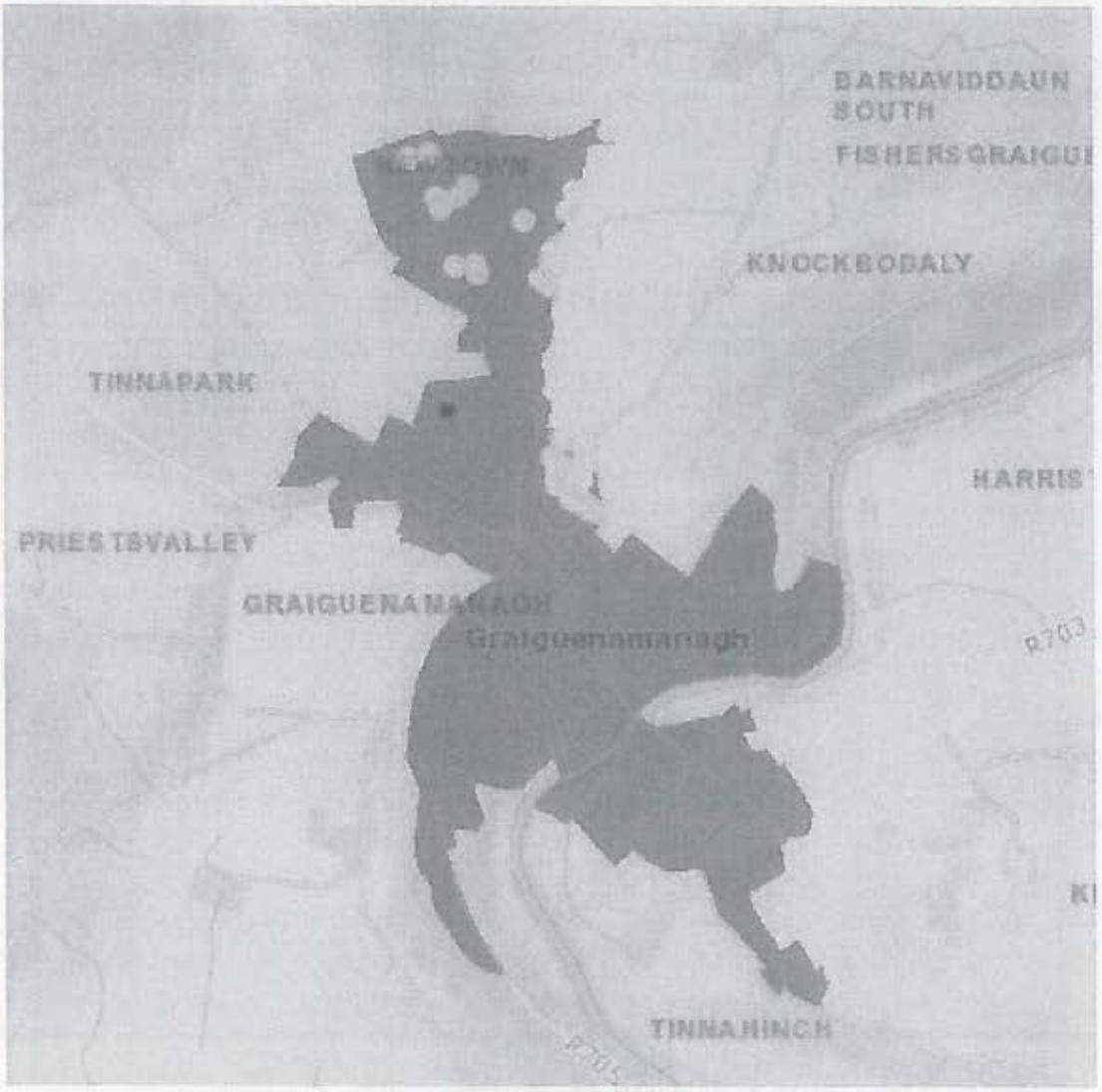
Eircodes identified in the Blue area as examples are [redacted]

This is having a detrimental affect of companies expansion within the town and whether they can continue to be located in the area. There are companies using digital services and the lack of broadband is restricting services they can offer to their global customers.



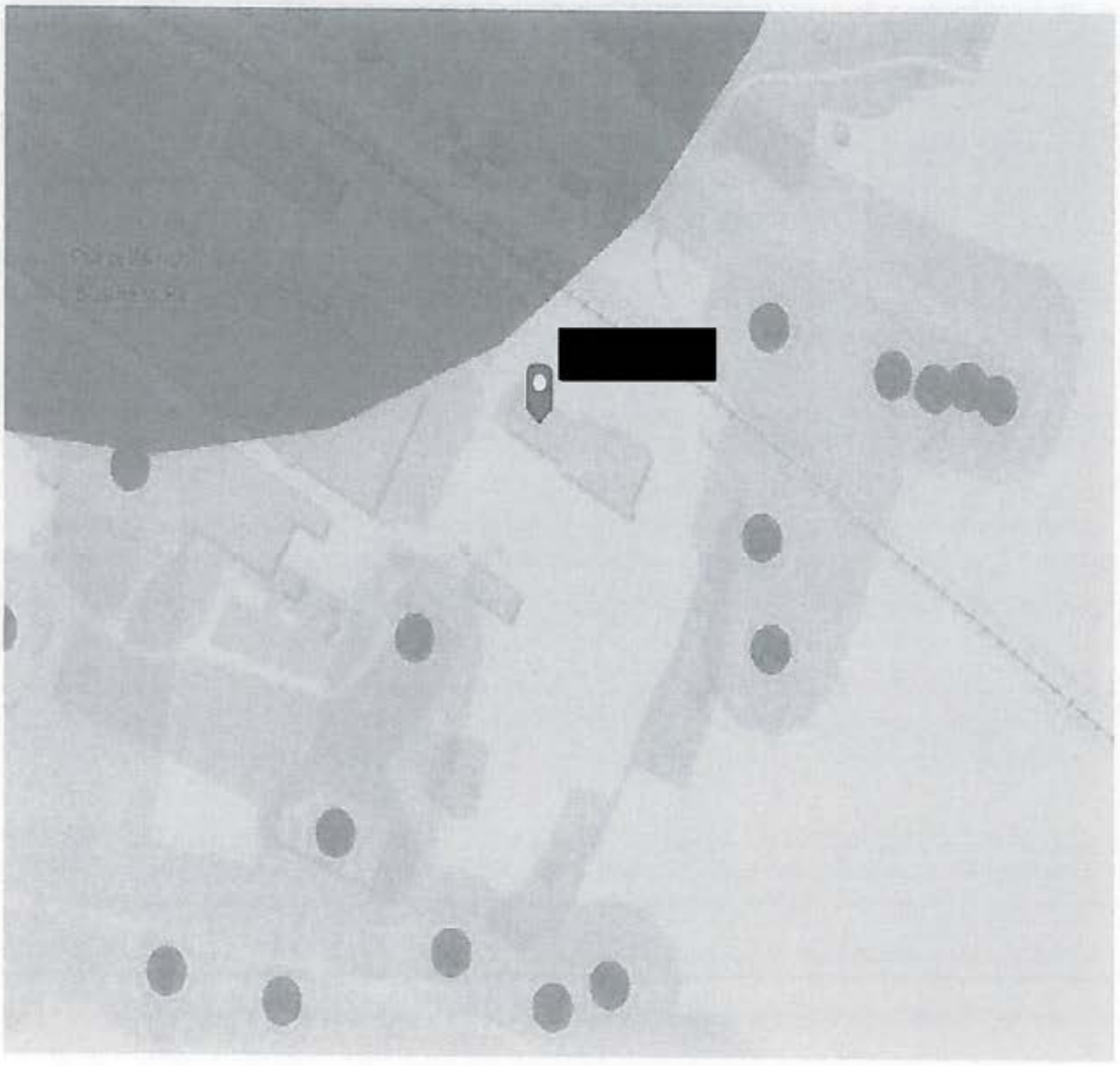
Graiguenamanagh

Blue area is unable to get any high speed broadband, even though cabinet upgraded. Example Eircode: [redacted]



Purcellsinch IDA Business Park, Dublin Road

Businesses at the rear of Purcellsinch IDA Business park appear to have been missed in any form of broadband. Example Eircode: [redacted]



Strictly Private and Confidential
20 September 2019

SIRO RESPONSE TO

NATIONAL BROADBAND PLAN CONCLUSION OF THE MAPPING EXERCISE FOR THE INTERVENTION AREA PRE DEPLOYMENT

of

26TH JULY 2019

Introduction

SIRO is pleased to provide this response to the DCCAE request for submissions on the finalisation of the NBP map.

SIRO has completed its Fibre to the Home network to over [redacted],000 premises in 52 different locations across Ireland. We continue to rollout the network at a rate of between [redacted] - [redacted] homes passed per month, with a target to get to 450,000 in the phase 1 build programme. We are already considering further build phases which would significantly increase SIRO's overall footprint.

1. Existing network

Amber Area: SIRO encloses an excel spreadsheet with the list of premises that SIRO *has already passed* in the proposed Intervention Area (amber area). This file, titled [redacted], includes the eircode, latitude and longitude detail and the SIRO unique identifier for [redacted] premises that SIRO has already passed and which are currently proposed to be included in the Intervention Area.

Purple Area: SIRO also encloses an excel spreadsheet with the list of premises that SIRO has already passed in the areas which have been referenced as the "Purple Area" in the consultation document. This file, titled [redacted], includes the eircode, latitude and longitude detail and the SIRO unique identifier for [redacted] premises that SIRO has already passed and which are currently identified within the consultation as within the Purple Area.

2. Work in Progress

SIRO also includes a list of premises in areas where SIRO are actively working on network build. SIRO has completed design work and entered into a construction contract. Build activity will be undertaken in these areas unless some significant impediment is identified prior to the commencement of the build activity. Based on performance to-date, we would expect to pass between [redacted]% and [redacted]% of these premises. There are some [redacted] premises in this category of which 4,483 premises are within the current intervention area. These are provided in the attached [redacted] file.

There are a further [redacted] premises in this category which are currently contained within the Purple Area. These are provided in the attached [redacted]

3. Planning Network Build

SIRO also includes a list of premises in areas where SIRO are currently *planning network build*. SIRO is undertaking high level design or fibre make ready work in these areas. Build

activity will be undertaken in these areas unless some significant impediment is identified in the planning stage. Based on experience to-date, we would expect that [redacted]% - [redacted]% of these premises will be included in a build contract. As stated above, we would expect to pass between [redacted]% and [redacted]% of premises included in a build contract. There are some [redacted] premises in this category of which [redacted] premises are within the current Intervention Area. These are provided in the attached [redacted] file.

There are a further [redacted] premises in this category which are currently contained within the Purple Area. These are provided in the attached [redacted]

4. Confidentiality

This response and the associated supporting spreadsheets to this response are strictly confidential and commercially sensitive in their entirety between SIRO and the Department and may not be shared in any manner whatsoever, with any third party without the express prior written consent of SIRO.

ENDS