Commission for
Communications Regulation

Assessment of Mobile Network Operators' Compliance with Licence Obligations (Coverage)

Winter 2015

Information Notice

Reference	ComReg 16/27
Version:	Final
Date:	20/04/2016

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Additional Information

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1 Executive Summary

1. This document presents a summary of the results of the Commission for Communication Regulation's ("ComReg") Drive Testing Programme ("Drive Test") carried out between 28 November 2015 and 27 January 2016, by its contractor Advanced Wireless Technologies Group Limited ("AWTG")[1].

2. The Drive Tests are carried out across all of the relevant frequency bands and licence types simultaneously in order to assess the Mobile Network Operators' ("MNO") compliance with the obligations of their respective licences.

3. The MNOs that currently hold licences in Ireland are:

    - Three Ireland Hutchison Limited ("3IHL");
    - Meteor Mobile Communications Limited ("Meteor");
    - Three Ireland Services (Hutchison) Limited ("3ISHL") formerly Telefónica ("O2") Ireland Limited ; and
    - Vodafone Ireland Limited ("Vodafone").

4. The Drive Test is a snapshot of how the MNOs networks performed in relation to their Licence Obligations throughout the test duration and as the test route was driven.

5. Licence Coverage[2], as measured in the Drive Test, represents the ability to place a call at a specific location outdoors at a specific time on the drive test route using a standard handset. All measurements are performed from a vehicle containing a computer controlled measuring system[3], which acts as a 'handset', matching an European Telecommunications Standards Institute ("ETSI") standard handset[4]. It

1 AWTG, were selected following an Invitation To Tender process detailed in ComReg Document No. 14/86a which was published on both e-tenders and in the Official Journal of the European Union.

2 Percentage of population, as measured outdoors.

3 This consists of the Anite Nemo Invex II measurement server, connected to both Samsung Note 4 handsets and the Nemo FSR 1 Multiband Scanner. Measurements are terminated at servers located in Ireland.

4 3GPP TS 36.101

should be borne in mind that in reality, the radio performance of many handsets differs due to a number of factors.

6. Given the differing performance of handsets[5] on the market and other variables that can affect end-user experience, the coverage measured during these Drive Tests cannot always be equated to that experienced by the end-user. The figure below summarises some of the factors that currently affect this end-user experience.

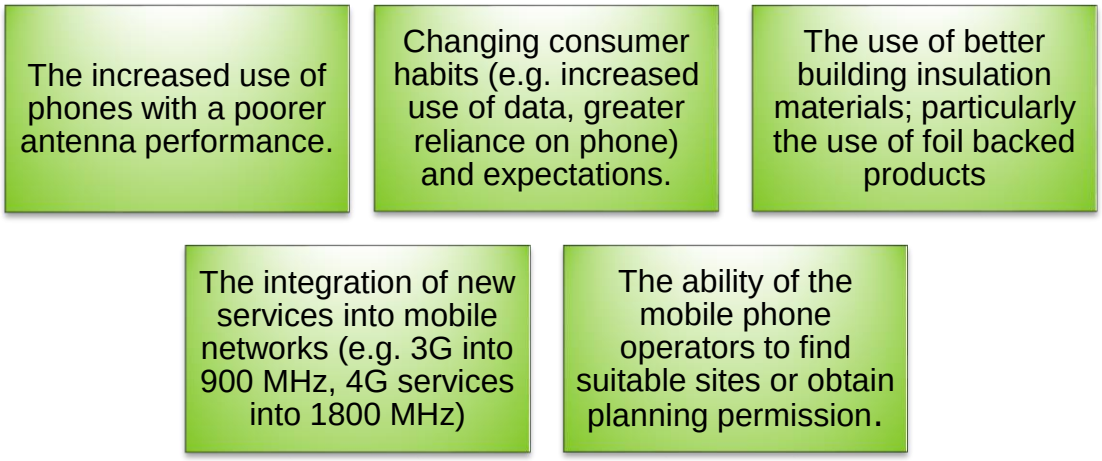

Figure 1 - Factors affecting end-user experience of mobile networks[6], [7]

7. As it is not possible to fully account for the wide range of variables that can affect end-user experience; ComReg sets the minimum requirements in its licence conditions, based on European and International bodies' research.

8. Another factor which can affect the end user experience is the type of service being used, i.e. GSM, 3G, LTE, etc. Services, such as LTE, which provide the user with higher data speeds require higher signal levels to operate than traditional voice

5 https://erhvervsstyrelsen.dk/sites/default/files/media/mobile_phone_antenna_performance_2013_0.pdf

6 Regarding network integration, it is expected that this will improve over time; as the networks stabilise following any upgrades and build out required to let MNO's make full use of the Liberalised Use Licence bands.

7 See Appendix 2 for a summary of typical attenuation factors to a 1GHz radio signal caused by building materials.

services. All digital modulation schemes are reliant on a minimum Signal to Noise Ratio ("SNR") and the higher the data throughput the greater the SNR required.

9. The Drive Test is designed to give an indication of the MNOs performance in relation to licence conditions during the period that the route is driven[8]. However, it should be noted that at the time of the Drive Test, not all of the coverage obligations had come into force[9].

10. To date all networks measured were found to be compliant with the licence conditions in force.

8 It is noted that three of the Winter's six storms occurred during the drive test period: http://www.met.ie/climate/MonthlyWeather/seas1.pdf .

9 There is a rollout period allowed in the licence, full coverage obligations are not required to be met until Q1 2016.

2 Licence Types

11. Licences are issued pursuant to Regulations made under Section 6 of the Wireless Telegraphy Act, 1926 (No. 45 of 1926) (the "Act of 1926") as amended. As such, MNOs are authorised to provide Electronic Communications Services ("ECS") and Electronic Communications Networks ("ECN") under Regulation 4 of the European Communities (Electronic Communications Networks and Services) (Authorisation) Regulations, 2011 (S.I. No. 335 of 2011), (the "Authorisation Regulations") using the spectrum assigned to them in their respective Licences.

12. Licences for GSM have now ceased or expired and while Third Generation ("3G") Licences are still in force, the GSM Licences have been superseded by the Liberalised Use Licences[1] outlined below. The relevant bands are as follows:

- The "800 MHz band" means the 791 to 821 MHz band paired with the 832 to 862 MHz band as set out in Annex 3 to ComReg Document 12/25;
- The "900 MHz band" means the 880 to 915 MHz band paired with the 925 to 960 MHz band as set out in Annex 3 to ComReg Document 12/25;
- The "1800 MHz band" means the 1710 to 1785 MHz band paired with the 1805 to 1880 MHz band as set out in Annex 3 to ComReg Document 12/25; and
- The "2100 MHz band" means the 1920 to 1980 MHz band paired with the 2110 to 2170 MHz band.

13. The following technologies are used in the bands outlined above:

- "GSM" means Global System for Mobile Communications from European Telecommunications Standards Institute ("ETSI");
- "Third Generation" means a mobile and wireless communications system based on a standard within the IMT-2000 system capable of supporting innovative multimedia services beyond the capability of second generation systems such as GSM, and capable of supporting the characteristics referred to in Annex 1 of the UMTS Decision;

[1] Liberalised Use Licences issued pursuant to the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz Bands) Regulations 2012, S.I. 251 of 2012.

- “LTE” means the Long Term Evolution family of standards from ETSI and the Third Generation Partnership Project (“3GPP”); and
- “UMTS” means the Universal Mobile Telecommunications System family of standards from ETSI and 3GPP.

3 Drive Test Route

14. The route is based on the most recent coverage maps which have been submitted to the office by the MNOs and a total of 5500km[10] is driven during the survey.

The route includes:

- Dublin City, including:
    1) *M50 Ring Road*
    2) *North Circular Road*
    3) *South Circular Road*
    4) *R114 from Portobello Bridge to Dame St.*
    5) *O'Connell Street from Eden Quay to Parnell Square East along North Frederick St. to Dorset Street.*
- Waterford City
- Cork City
- Limerick City
- Galway City

All Primary and Secondary National Routes in full[11], including all towns and Motorway sections, along these routes. In addition to this, in order to study the coverage along the Ireland/ North of Ireland (UK) border the following route was driven; the R202 from the N87 at Gortullaghan, until the intersection with the R200, then following the R200 until the intersection with the R206, then following the R206 until the intersection with the N16 at Toam, (near Blacklion/Belcoo).

11 For the avoidance of doubt, this means the complete length of each route within the jurisdiction of Ireland.

4 Presentation of Results

15. Coverage is measured on-route, in order to assess the usable coverage, as defined in the licence conditions, while the route is driven, in terms of the received field strength.

16. ComReg examines mobile network coverage in its full context, as such the coverage requirements set down in the Liberalised Use licence conditions can be met through the use of different bands available to the MNO[12]. It is also noteworthy that the full coverage conditions specified in this licence do not apply for the first three years of the licence to allow for network rollout. This period came to an end in Q1 2016.

17. Licence Coverage, as defined in paragraph 5 above, is determined by the percentage of the population covered; the data available from the Central Statistics Office 2011 Census is used to give an approximation of the population in the areas covered by the Drive Test[13].

18. The following maps provide a graphical representation of the field strengths measured during the Drive Test.

12 See Schedule 1, Part 4, paragraph 3(2)c to the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz Bands) Regulations 2012, S.I. 251 of 2012.

13 ComReg notes that the populations in many areas may differ slightly since the 2011 Census.

4.1 Liberalised Use Licence; 900 & 1800 MHz (GSM)

Figure 2: Meteor Liberalised Use Licence: GSM 900 MHz

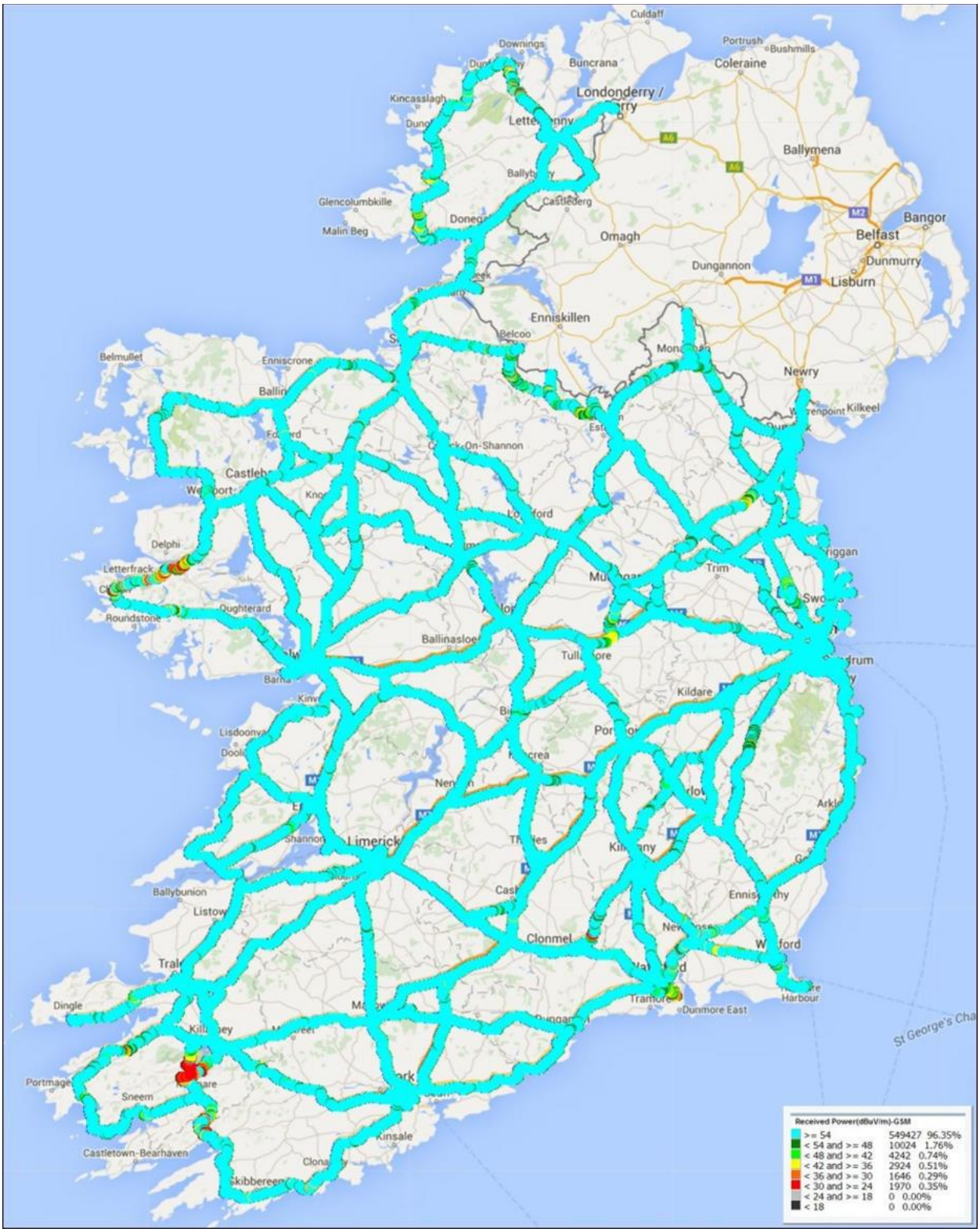

Figure 3: 3ISHL Liberalised Use Licence: GSM 900 & 1800 MHz

Figure 4: Vodafone Liberalised Use Licence: GSM 900 & 1800 MHz

4.2 Third Generation Licence; UMTS (2100 MHz)

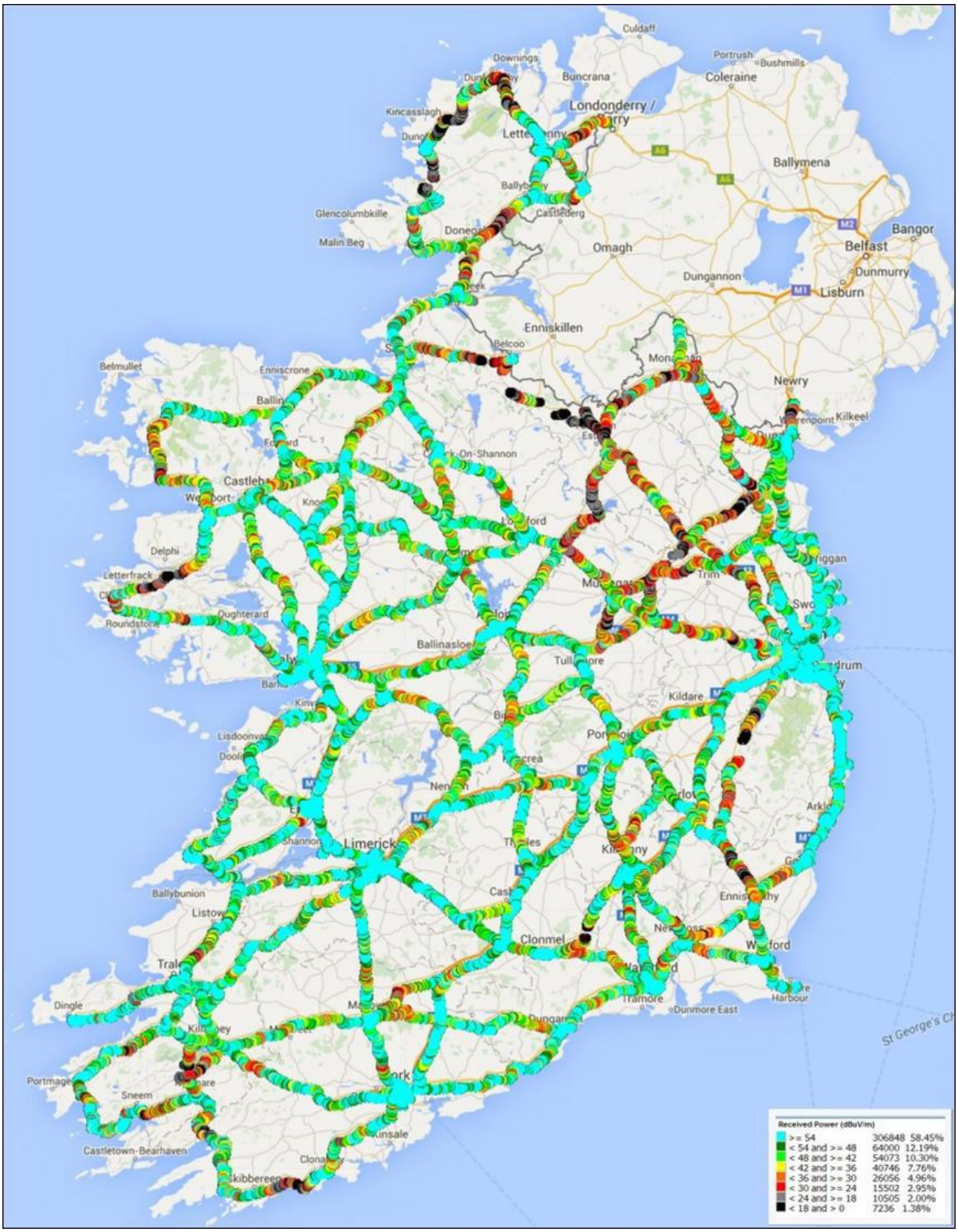

Figure 5: Meteor Third Generation Licence 2100 MHz (UMTS)

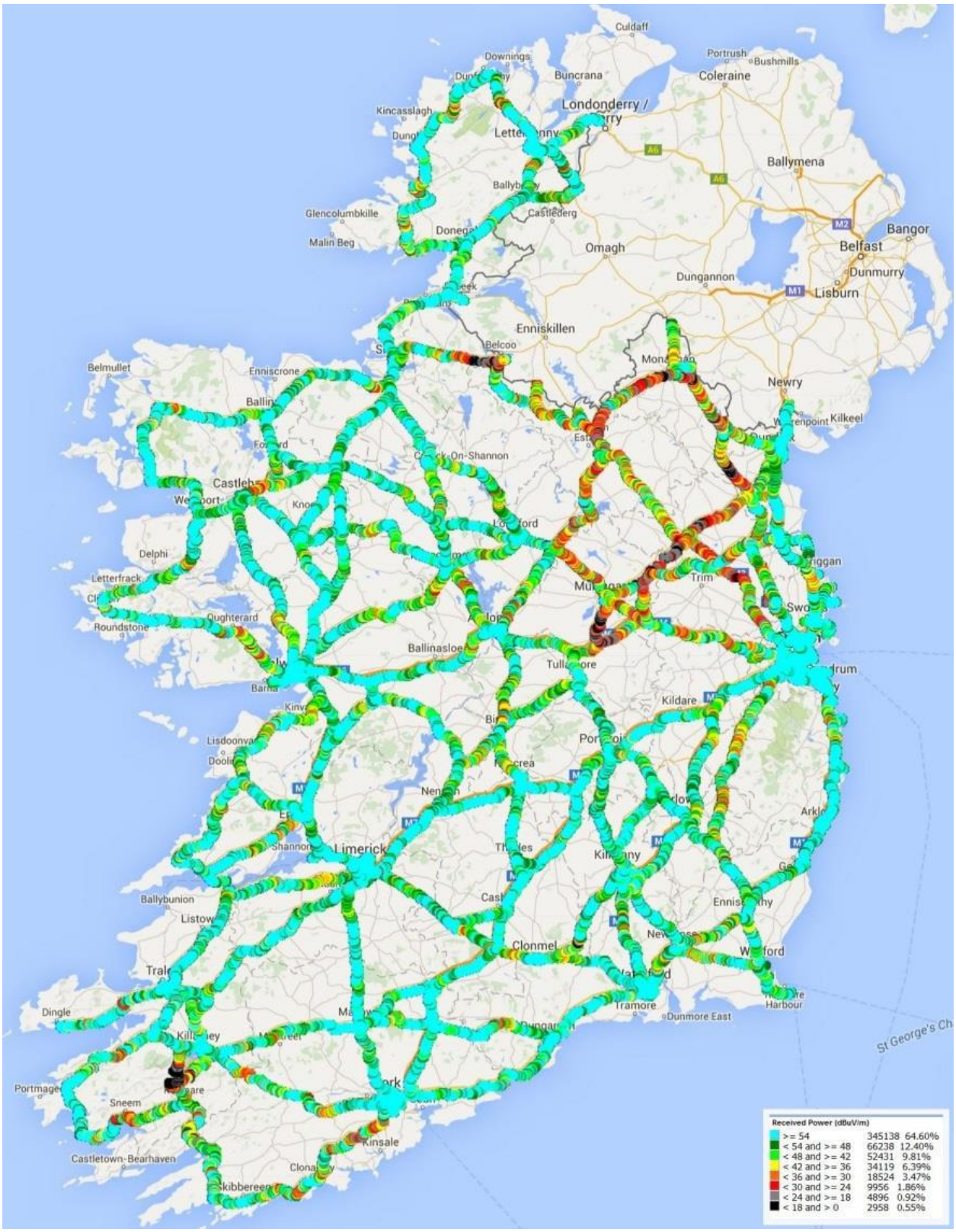

Figure 6: 3IHL Third Generation Licence 2100 MHz (UMTS)

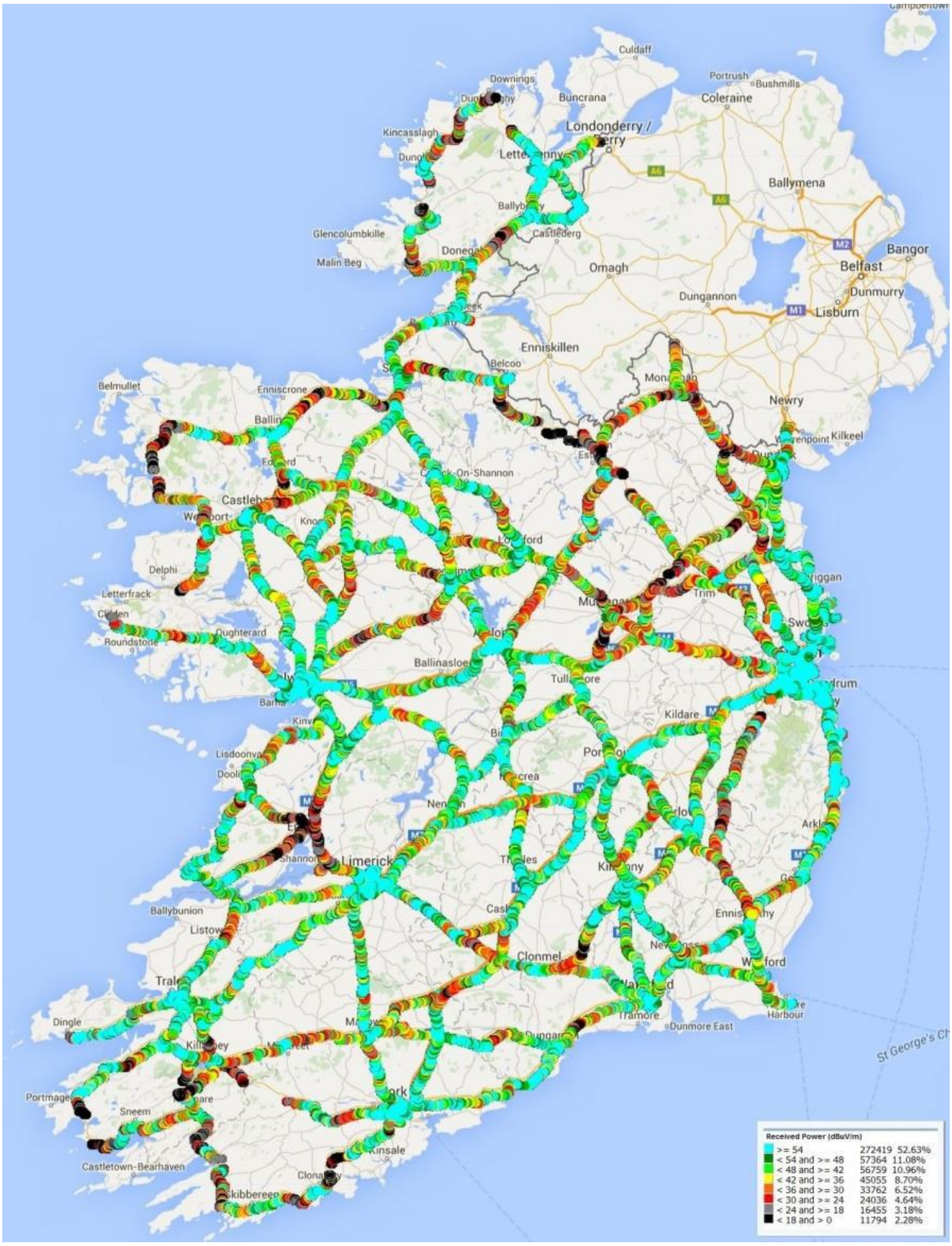

Figure 7: 3ISHL Third Generation Licence 2100 MHz (UMTS)

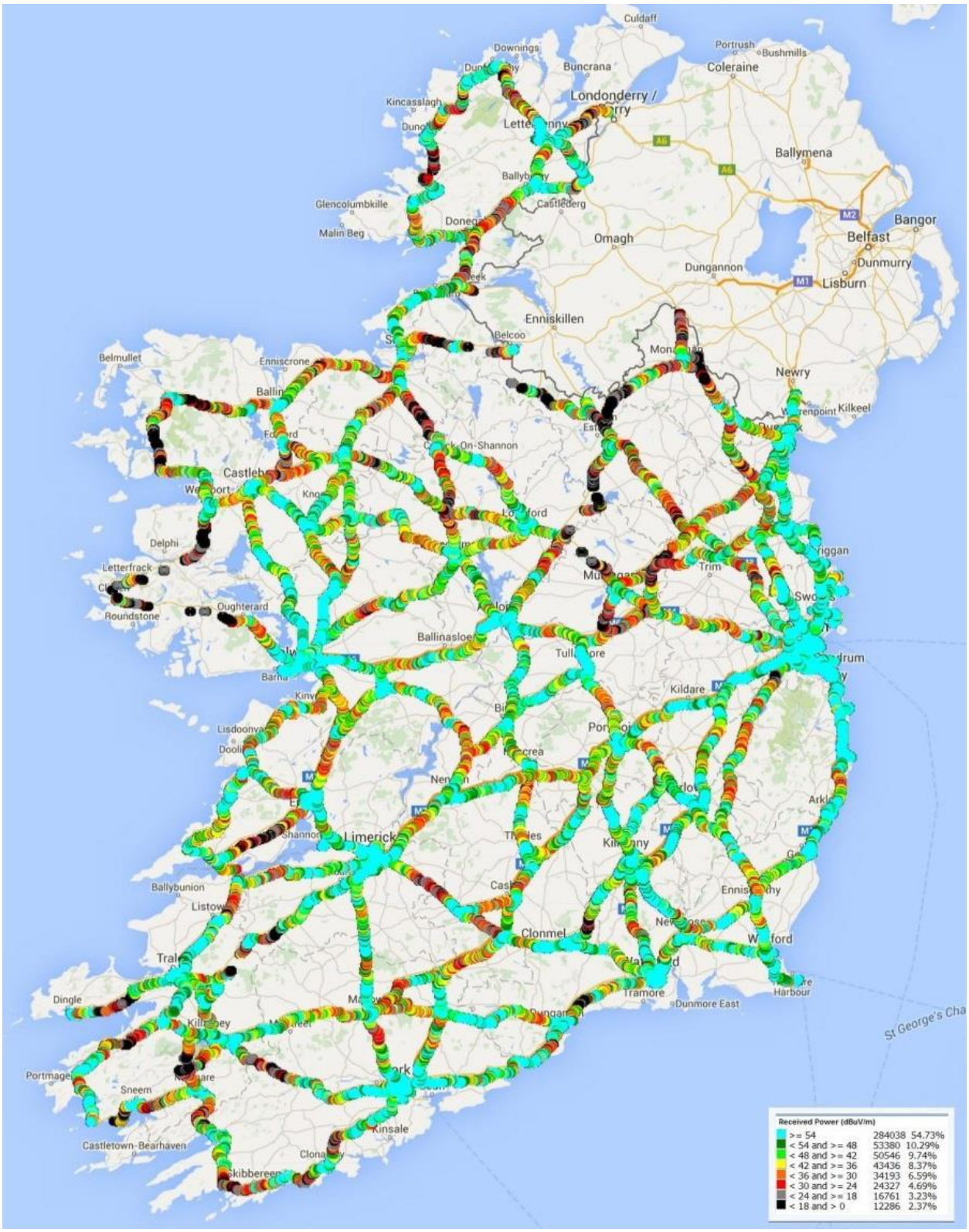

Figure 8: Vodafone Third Generation UMTS 2100 MHz (UMTS)

4.3 Liberalised Use Licence 900 MHz (HSDPA/UMTS)

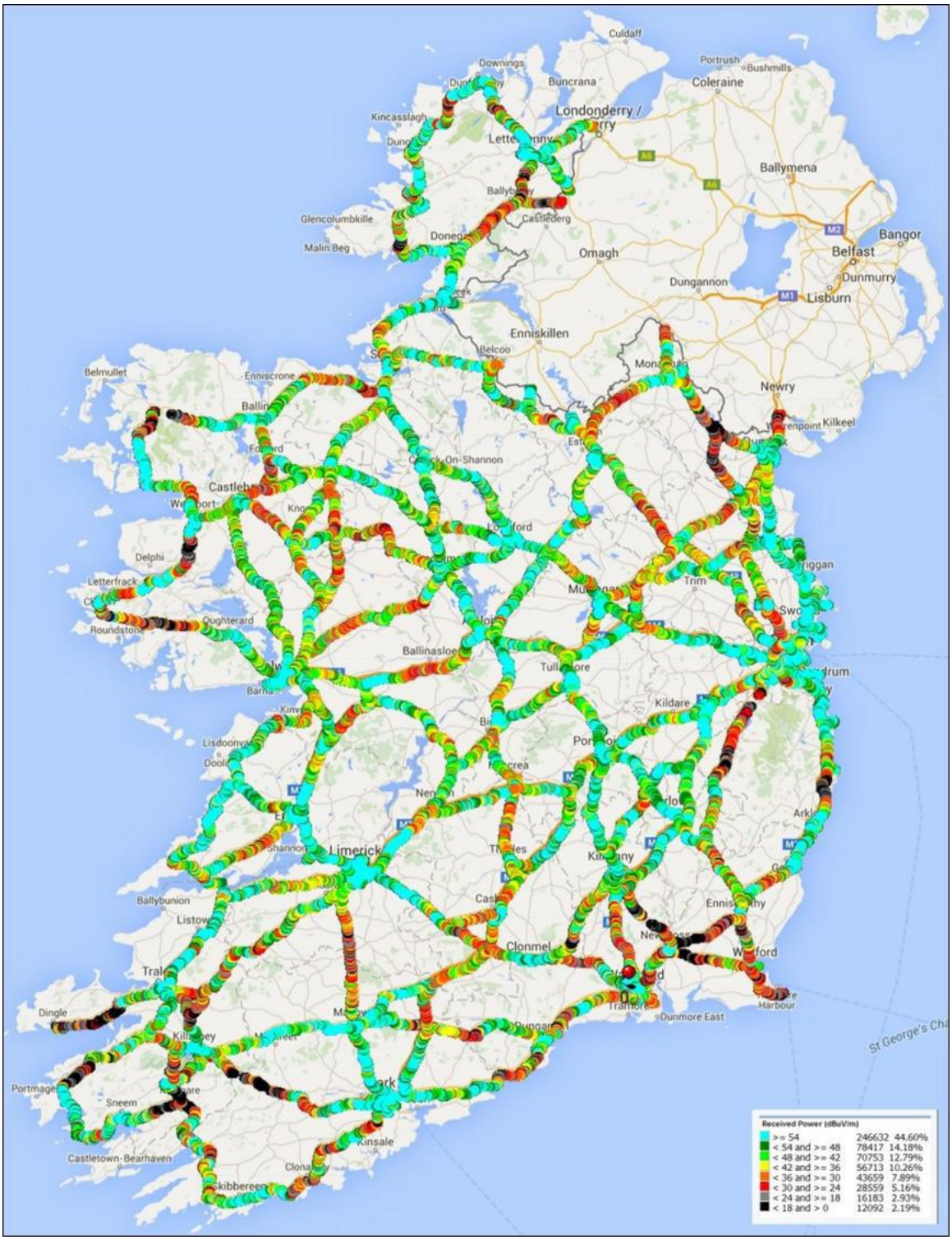

Figure 9: Meteor Liberalised Use Licence; 900 MHz (HSDPA/UMTS)

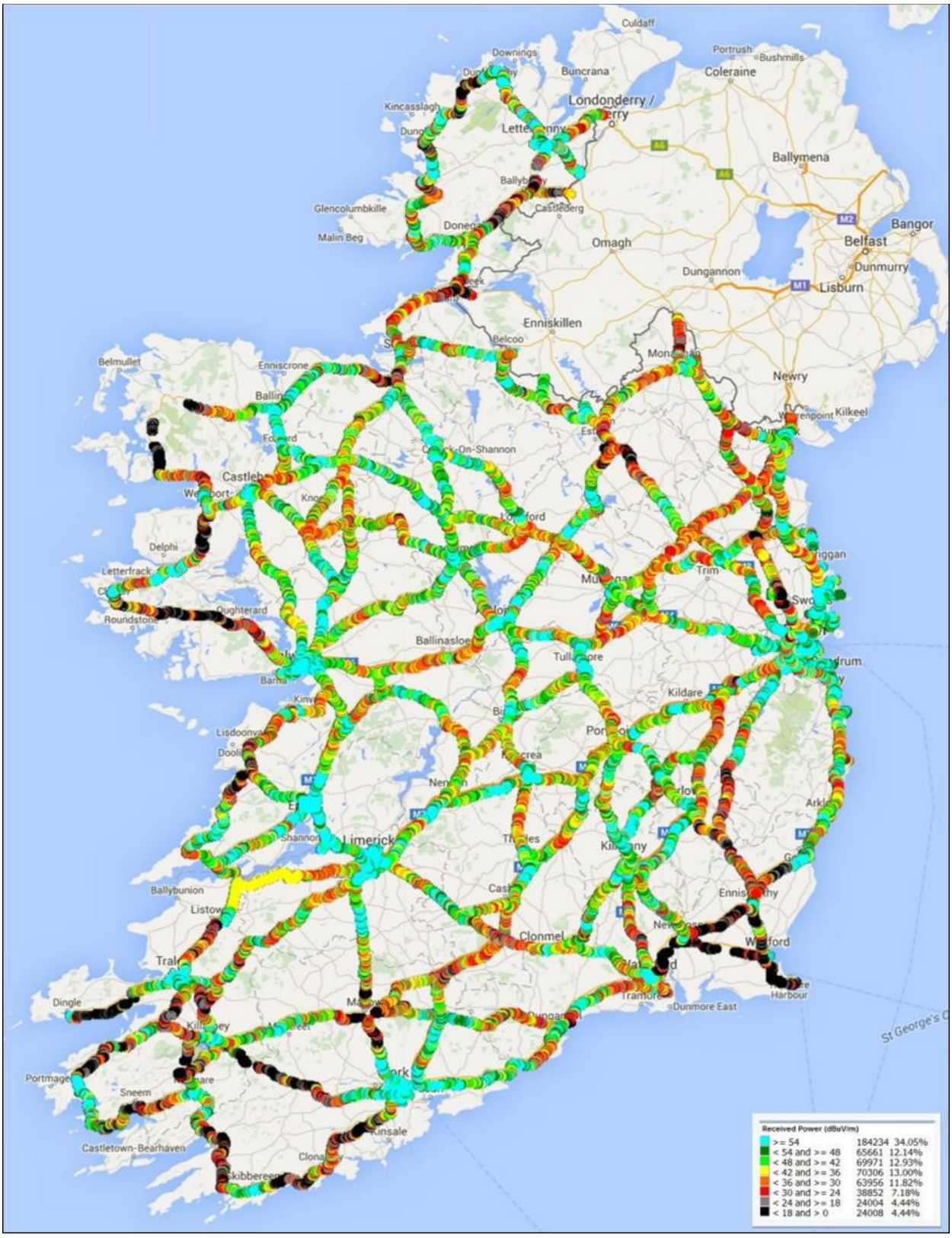

Figure 10: 3IHL Liberalised Use Licence; 900 MHz (HSDPA/UMTS)

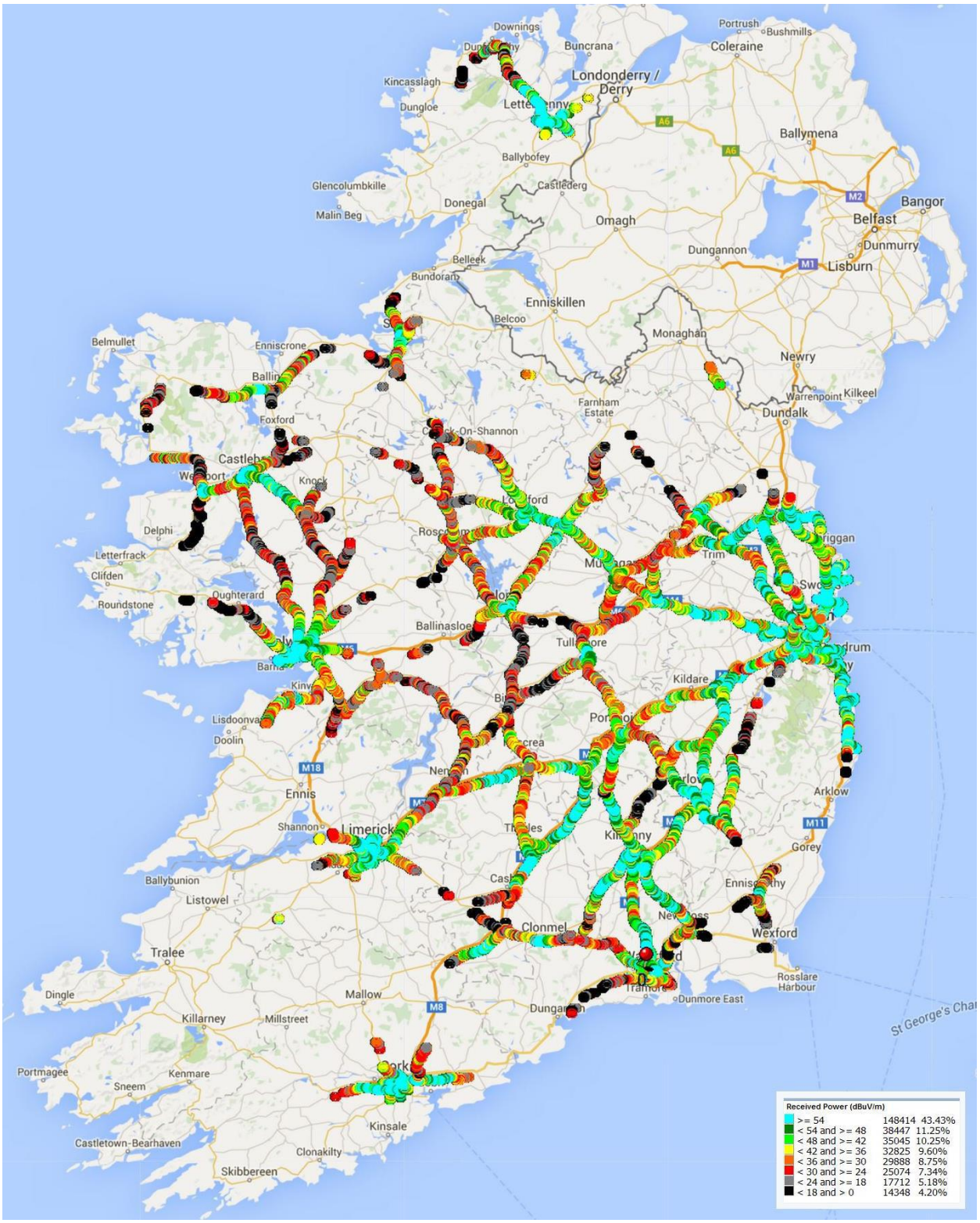

Figure 11: 3ISHL Liberalised Use Licence; 900 MHz (HSDPA/UMTS)

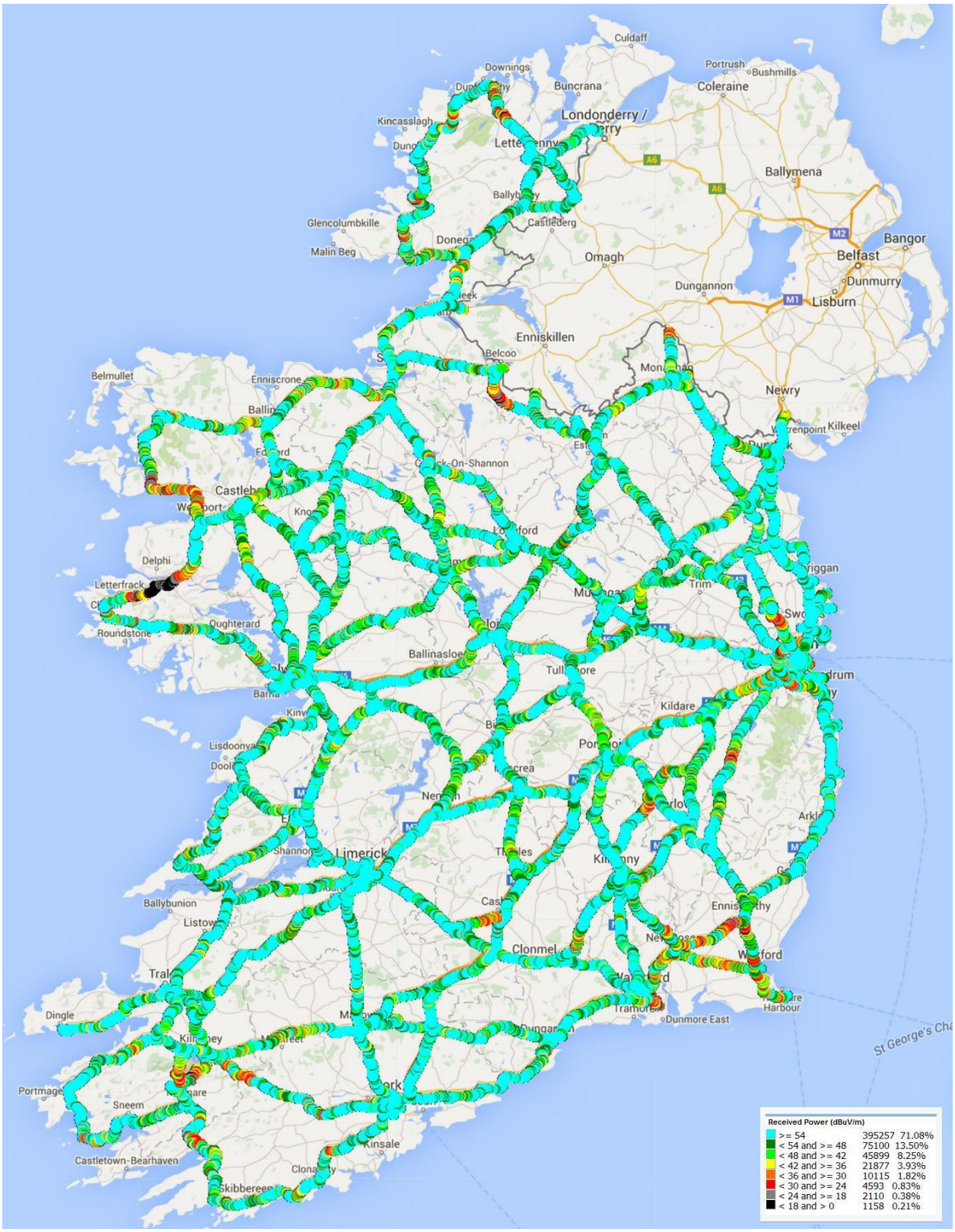

Figure 12: Vodafone Liberalised Use Licence; 900 MHz (HSDPA/UMTS)

4.4 Liberalised Use Licence; 800 & 1800MHz (LTE)

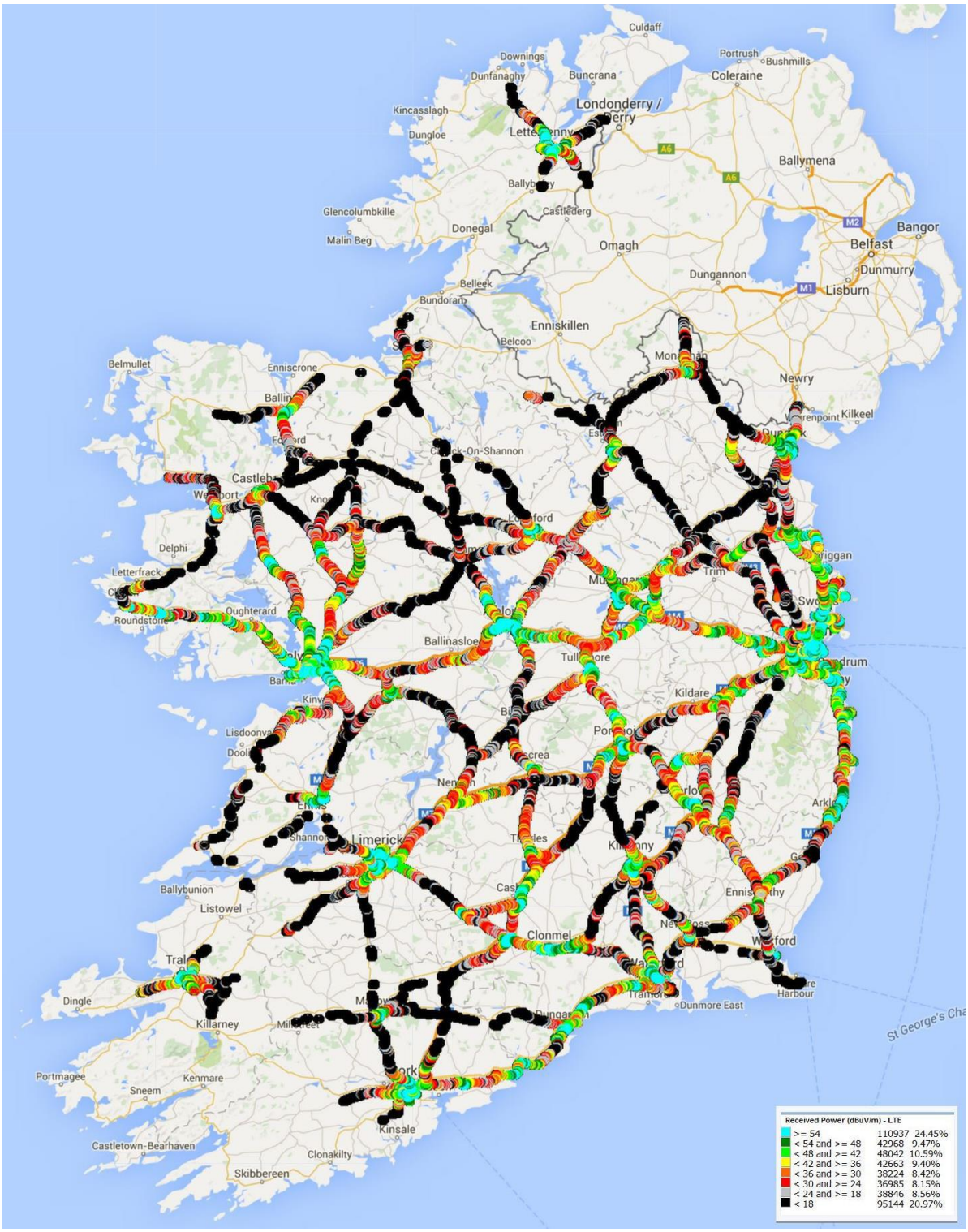

Figure 13: Meteor Liberalised Use Licence; 800 & 1800 MHz (LTE)

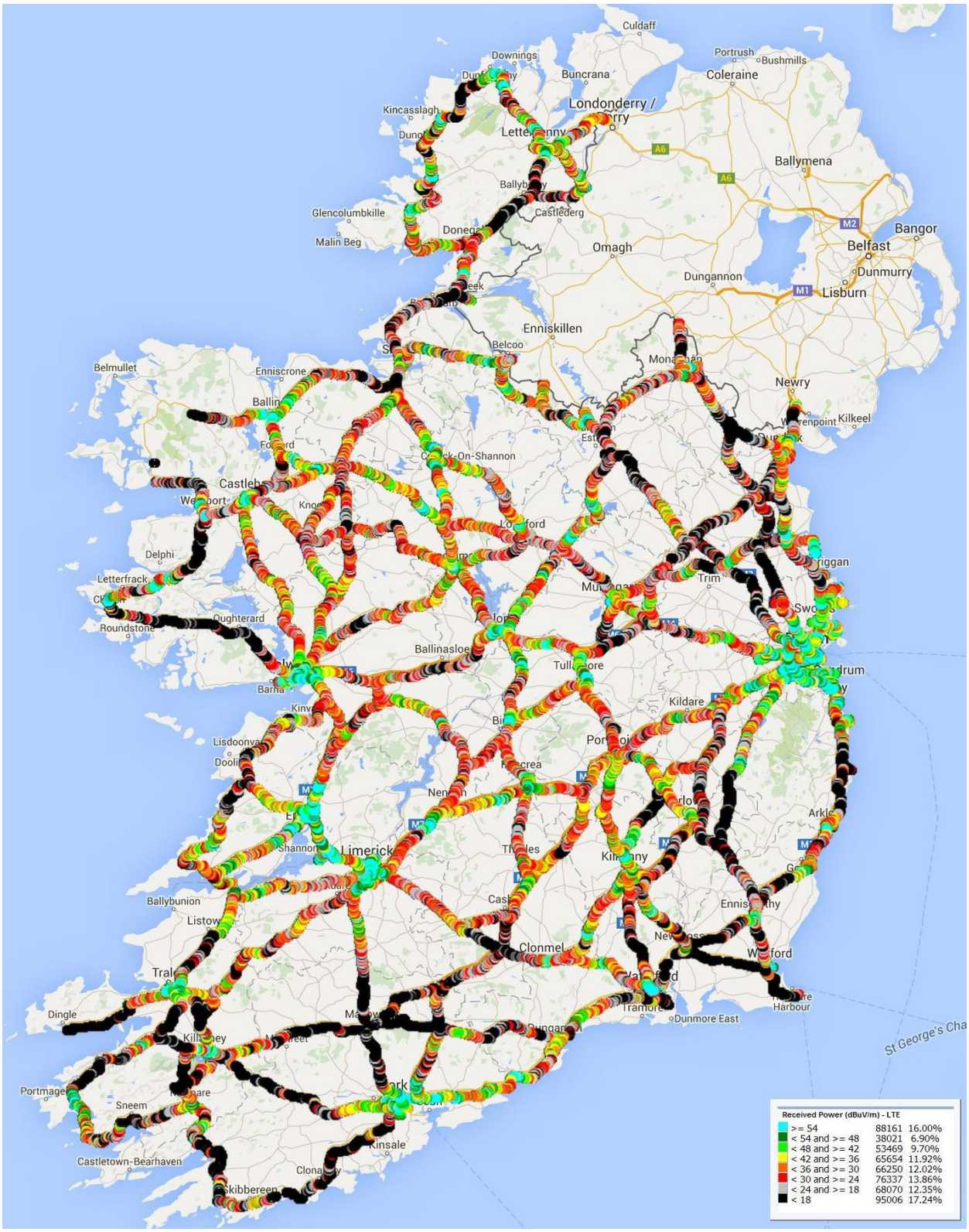

Figure 14: 3IHL Liberalised Use Licence; 800 and 1800 MHz (LTE)

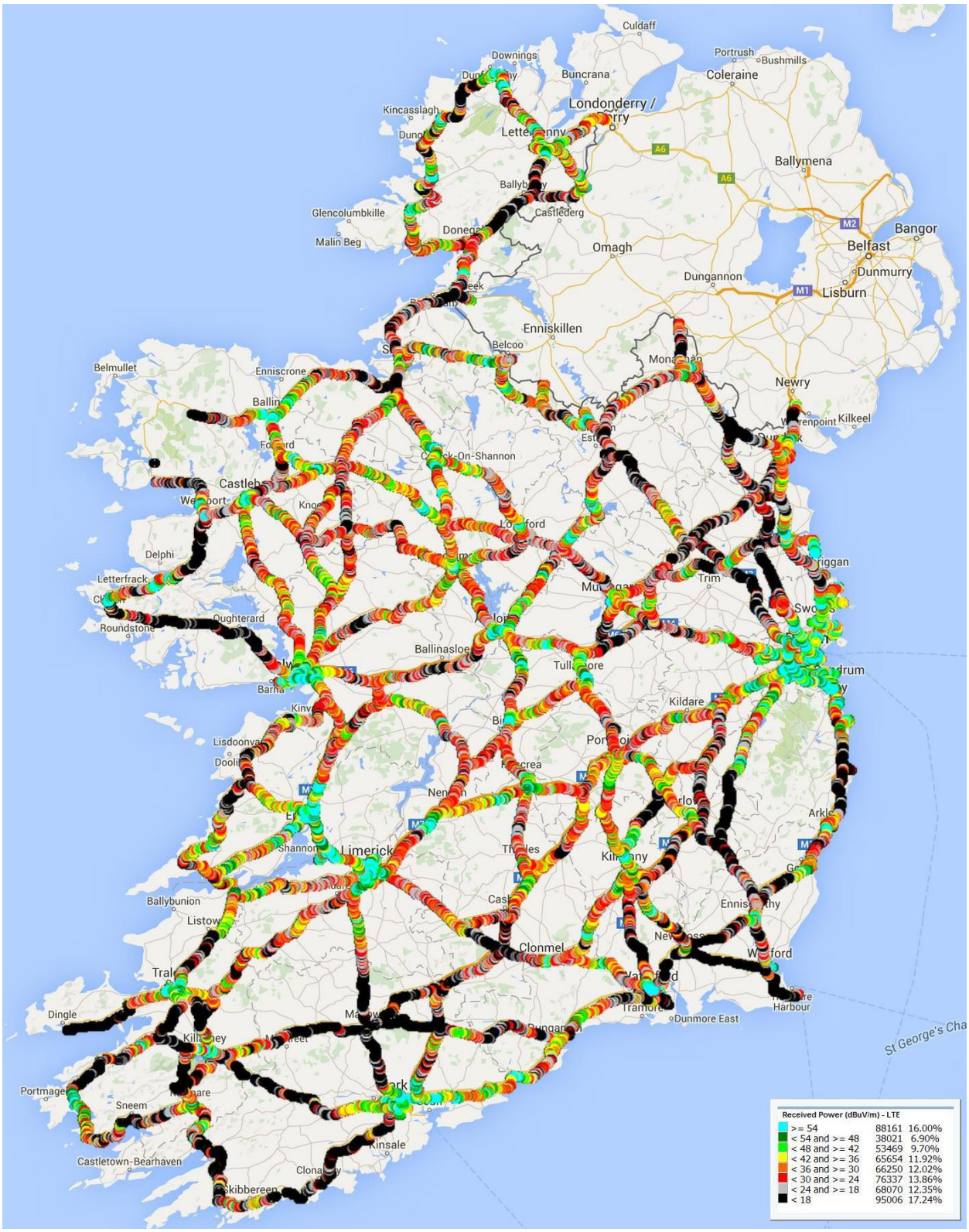

Figure 15: 3ISHL Liberalised Use Licence; 800 and 1800 MHz (LTE)

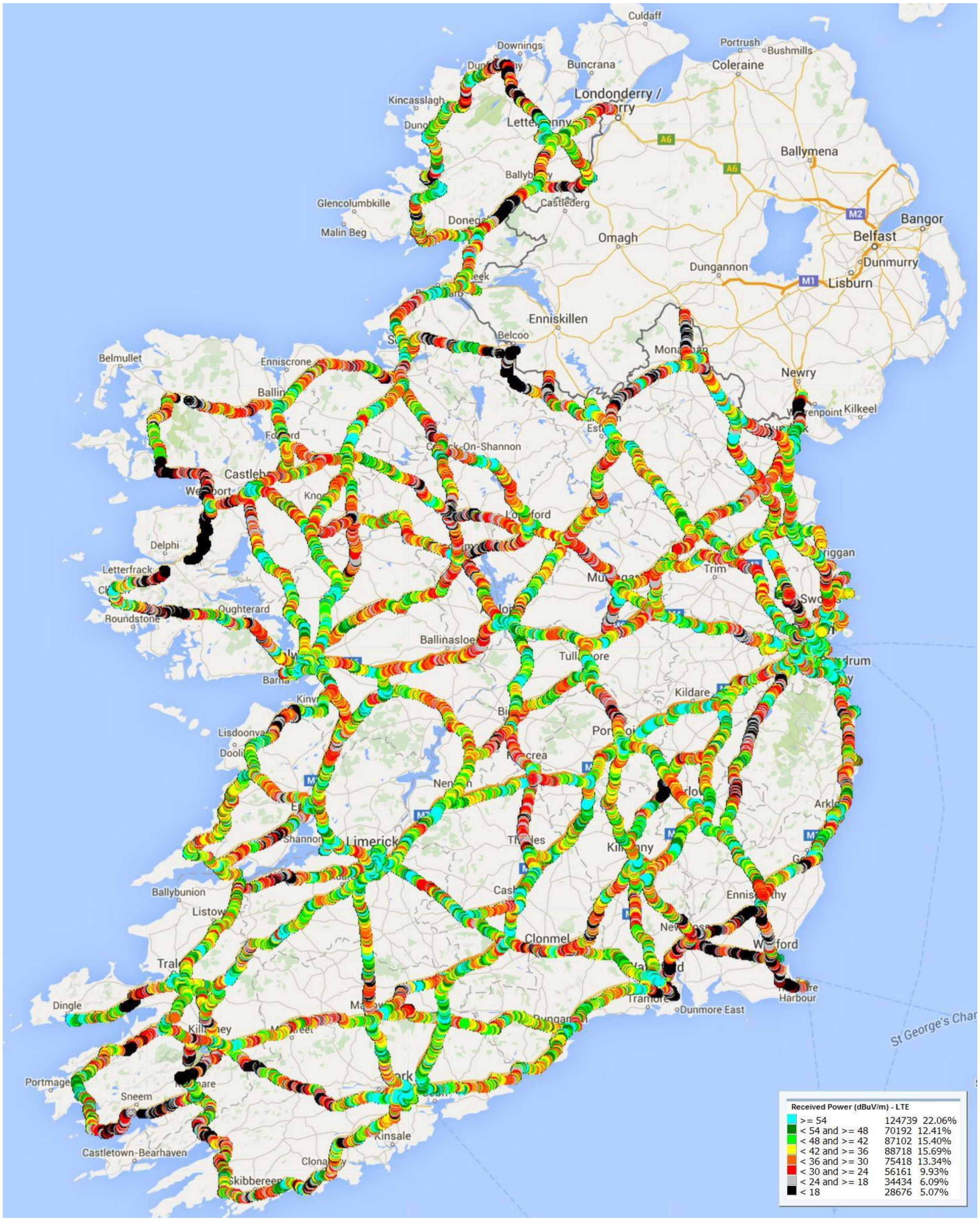

Figure 16: Vodafone Liberalised Use Licence; 800 & 1800MHz (LTE)

5 Conclusions

General Comments

20. ComReg notes the progress made to date in rolling out mobile electronic communications services under the Liberalised Use Licences and that in all cases the coverage criterion has been met.

21. As mentioned previously the mobile networks were still in the rollout period[14] of their licence obligations. ComReg will continue to conduct Drive Tests for each of the Liberalised Use Licences to ensure compliance with licence obligations.

Coverage

22. All Licensees have exceeded their obligations under their respective Licences to date.

23. A simplified, collated version of the coverage results of this Drive Test is outlined in Table 1 below. These results represent the minimum coverage by population[15] achieved during the Drive Test.

	3G UMTS2100	LUL/LTE(800/1800)	LUL/GSM(900/1800)	LUL/3G(900)
Meteor	>90%	>53%	>90%	>53%
3IHL	>90%	>53%		>70%
3ISHL	>90%		>90%	>53%
Vodafone	>90%	>70%	>90%	>90%

Table 1 - Minimum coverage as indicated by the Drive Test

Average Download Speeds

24. While not a Licence Obligation, ComReg notes the average download speeds achieved during the Drive Test. The findings of the stationary portion of the drive test demonstrated that LTE speeds offered are on average 2.6 times faster than those offered by 3G ("HSDPA").

14 See Schedule 1, Part 4, paragraph 3(2)c to the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz Bands) Regulations 2012, S.I. 251 of 2012

15 Coverage can reasonably be expected around an approximate radii varying from 2-3 km (2100MHz to 900 MHz respectively) from the on-route measurement point. This is consistent with predictions from both the Okumura-Hata and ITU-R P. 1546 propagation models.

25. Table 2 below provides an overview of the average of the download speeds achieved throughout the Drive Test. It is acknowledged that speeds greater or less than these may be experienced by users due to factors such as, geographic location and the load on the network in the area concerned.

Licensee	Technology	D/L Stationary (Mbps)	D/L Mobile[16] (Mbps)
Meteor	3G HSDPA	6.811	4.537
	LTE	14.478	14.76
3IHL	3G HSDPA	3.676	3.587
	LTE	10.604	12.26
3ISHL	3G HSDPA	3.899	2.940
	LTE	12.67	14.249
Vodafone	3G HSDPA	8.954	5.994
	LTE	20.409	17.843

Table 2 - Average data speeds achieved during the Drive Test

26. It is normal, particularly with 3G HSPA, that download speeds while moving are generally less than those achieved while stationary. However, while this is generally unavoidable during the winter drive test the effect is less pronounced due to the absence of foliage induced signal loss[17] .

27. It is also important to note, as discussed in section 1 above, that higher data services, such as 3G and LTE are more susceptible to interference and disruption. As such these services require higher signal levels to maintain download speeds and quality.

16 Average Vehicular Speed of 80kmph.

17 See Appendix 2, Other Factors for a summary of this effect.

Appendix 1: Glossary

A 1.1 Terms defined in this Information Notice, unless the context otherwise requires or admits, have the meaning set out below:

3G	Third Generation Mobile System (e.g. UMTS)
2G	Second generation mobile services (e.g. GSM)
3G Licence	A Licence issued under the Wireless Telegraphy (Third Generation and GSM Licence) Regulations, 2002 and 2003 (S.I. 345 of 2002 and S.I. No. 340 of 2003) for 3G services in the 2100 MHz band.
3GPP	Third Generation Partnership Project
3IHL	Three Ireland (Hutchison) Limited
3ISHL	Three Ireland Services (Hutchison) Limited
800MHz band	The frequency range 791 – 821 MHz paired with 832 – 862 MHz
900MHz band	The frequency range 880 – 915 MHz paired with 925 – 960 MHz
1800MHz band	The frequency range 1710 – 1785 MHz paired with 1805 – 1880 MHz
2100 MHz Band	1920 – 1980 MHz paired with 2110 – 2170 MHz, and 1900 – 1920 MHz
ComReg	Commission for Communications Regulation
DCENR	Department of Communications, Energy and Natural Resources
Down Link, D/L	The radio channel from the base station to the user's handset.

Drive Test	Measurements conducted from a vehicle containing a computer controlled measuring system which acts as a 'handset', matching an European Telecommunications Standards Institute ("ETSI") standard handset, which places the calls and transfers the files automatically to a fixed line and references the measurements to GPS ("Global Positioning System"), as the route is driven
EC	European Commission
ETSI	European Telecommunications Standards Institute
EU	European Union
General Authorisation	An authorisation for an undertaking to provide an electronic communications network or service under and in accordance with Regulation 4 of the Authorisation Regulations.
GPS	Global Positioning System
GSM	means Global System for Mobile Communications from the European Telecommunications Standards Institute ("ETSI")
HSDPA	High Speed Downlink Packet Access, 3G Mobile Broadband
Hz	Unit of Frequency
LTE	means the Long Term Evolution family of standards from European Telecommunications Standards Institute ("ETSI") and Third Generation Partnership Project ("3GPP");
Mbps	Mega (One Million) bits per second, a measure of data throughput.
Meteor	Meteor Mobile Communications Limited
MHz	Megahertz, One Million Hertz

MNO	Mobile Network Operator
Third Generation	means a mobile and wireless communications system based on a standard within the IMT-2000 system capable of supporting innovative multimedia services beyond the capability of second generation systems such as GSM, and capable of supporting the characteristics referred to in Annex 1 of the UMTS Decision
Up Link, U/L	The radio channel from the user's handset to the base station.
UMTS	Universal Mobile Telecommunications System.
Vodafone	Vodafone Ireland Limited

Appendix 2: Other Factors

Attenuation due to common building materials

A 2.1 In relation to indoor use, the following table shows the typical attenuation (in dB) of radio signals for commonly found older building techniques and is extracted from the American National Institute of Standards and Technology ("NIST") Report no. NISTIR 6055; as stated previously modern building materials cause significantly higher losses.

Building Material	Attenuation @ 1GHz (dB)	Attenuation @ 2GHz (dB)
Single Skin Brick	3	5
Double Skin Brick	5	7
Brick Faced Concrete (non-reinforced)	14	17
Single Brick and Construction Block	11	10.1
30cm thick plain (non-reinforced) Concrete	35	36

Attenuation due to the full foliage effect

A 2.2 Since beginning UMTS drive testing in 2005 ComReg has consistently noticed an approximate 8 dB difference in drive test measured field strength results between the winter and summer tranches. This is known as the foliage effect, and effects higher bands (such as the 2100 MHz (UMTS) band), along with the more usual climatic effects).

A 2.3 Attenuation happens due to the leaves fully opened on trees and hedgerows[18] . As an example, Pelet et al. observed that there was an additional attenuation of

18 http://www3.ntu.edu.sg/home/eyhlee/Prof%20Lee/PIER%20foliage%20review%202010.pdf

about 5 dB across a cluster of poplar trees at 2.5 GHz when there was a rain fall at a rate of 6 mm/hr.[19]

19 Pelet, E. R., J. E. Salt, and G. Wells, effect of wind on

foliage obstructed line-of-sight channel at 2.5 GHz," IEEE Trans.

Broadcasting., Vol. 50, No. 3, 224-232, 2004; and

Perras, S. and L. Bouchard, Fading characteristics of RF signals due to foliage in frequency bands from 2 to 60 GHz," Proc. 5th Int. Symp. Wireless Personal Multimedia Commun., 267-271, Honolulu, Hawaii, Oct. 2002.

Appendix 3: Drive Test Equipment

A 3.1 The following equipment was used to conduct measurements during this Drive Test. All equipment was within calibration at the time the measurements were taken.

- Nemo Invex II with associated measurement servers
- Nemo FSR1 multi-band scanner
- 2 multi-band antennas
- Laptop with Nemo Outdoor application
- Samsung Note 4 test phone with Nemo Media Router application
- An FTP server based in Dublin
- Relevant SIM cards