Commission for
Communications Regulation

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

Winter 2016

Information Notice

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Additional Information

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Section Page

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 16 November 2016 and 17 December 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")[2];
    - Meteor Mobile Communications Limited ("Meteor"); and
    - Vodafone Ireland Limited ("Vodafone").

4. The Drive Test represents a snapshot of how the individual MNOs networks performed in relation to each of its licence conditions at the point in time during which the test was conducted.

5. Licence Coverage, as measured in the Drive Test, represents the ability to place a call at a specific location at a specific time using a standard handset; all measurements are performed from a vehicle containing a computer controlled

[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] Noting that, 3IHL holds two sets of licences, pursuant to both the Wireless Telegraphy (Third Generation and GSM Licence) Regulations, 2002 and 2003 ("Third Generation Licences") and the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz Bands) Regulations 2012 ("Liberalised use Licences"). In this report, the original set of 3IHL licences are referred to as "3IHL No. 1" and the former Three Ireland Services (Hutchison) Limited[2] licences are referred to as "3IHL No.2".

measuring system[3], which acts as a 'handset', matching a European Telecommunications Standards Institute ("ETSI") standard handset[4]. It should be kept 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][6] and other variables that can affect end-user experience, the coverage that is measured during these Drive Tests cannot always be equated to end-user experience. The figure below outlines some of the factors that currently affect end-user experience of their mobile phones.

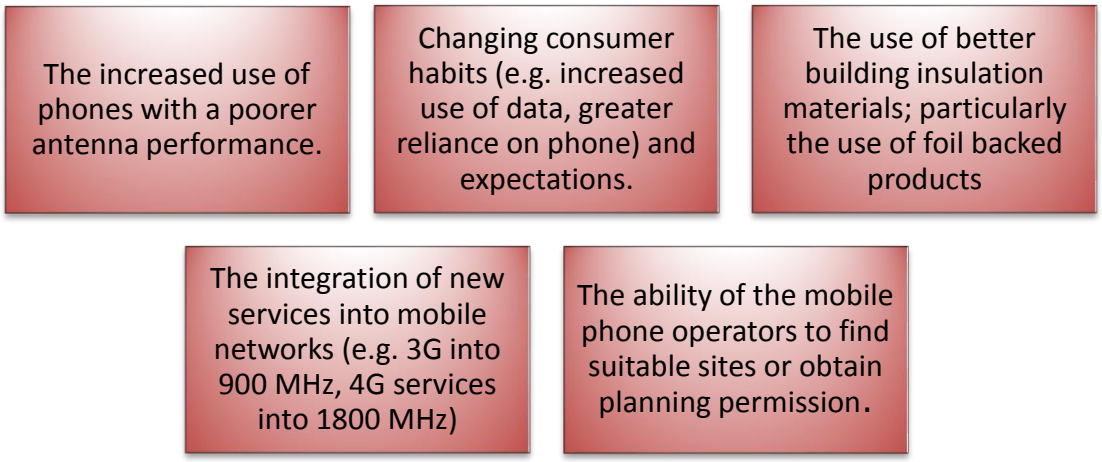

Figure 1 - Factors affecting end-user experience of mobile networks

[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

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

[6] https://www.pts.se/upload/Rapporter/Tele/2016/MobilephoneTest2016-augusti-2016.pdf

7. In particular, ComReg's Radio Spectrum Strategy Statement 16/50[7], stated that ComReg "will endeavour to get a greater understanding of the issues and to seek solutions which can deliver improved outcomes and to support the proposed Government's Task Force on both rural mobile coverage and broadband." Resulting from this, the Report of Mobile Phone and Broadband Task Force[8] made a number of recommendations to carry out regular testing to determine the sensitivity of mobile phone handsets on the market. It was recommended that this work be carried out by ComReg. In a similar manner, ComReg will also conduct research into the radio signal propagation characteristics of common building materials to determine how they affect mobile phone signals in buildings and explore the potential use of mobile phone repeaters to help address in-building coverage issues.

8. While it is not possible to effectively account for the wide range of variables that can affect end-user experience; as such, in its licence conditions ComReg sets minimum requirements, based on European and International bodies' research, for mobile phone coverage assuming a certain level of handset performance and outdoor use.

9. 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 which require higher signal levels to operate than traditional voice 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.

10. The current Drive Test is designed to give an indication of the MNOs' performance in relation to individual licence conditions during the period that the route is driven. Furthermore, the Drive Test does not measure end user experience, as it does not assess how well each MNO has integrated its various technology platforms; which as the end users device roams[9] between them, strongly influences the perceived end user experience.

11. It is noted that due to differences in both handsets and SIM ("Subscriber Identity Module") provisioning, not all end users have the ability to access each of the MNOs' technologies or bands.

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[7] https://www.comreg.ie/?dlm_download=radio-spectrum-management-strategy-2016-2018
[8] http://www.dccae.gov.ie/communications/Lists/Publications%20Documents/Taskforce%20Report.pdf
[9] It should be noted that roaming between mobile technology platforms, is not just a function of the end user's device but also of the type of SIM provisioning carried out by the MNO. In particular, it is noted that end users of the 3IHL No. 2 licences use both of 3IHL's spectrum allocations and similarly that 3IHL No. 1 end users make use of 3IHL No.2's GSM spectrum.

12. All networks measured were found to be compliant with the licence conditions in force.

2 Licence Types

13. 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.

14. The licences currently in force are the Liberal Use Licences[10] and the Third Generation Licences and both are outlined below.

    - 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[11].

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

    - "GSM" means Global System for Mobile Communications from the 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

[10] 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.

[11] Third Generation Licences issued pursuant to the Wireless Telegraphy (Third Generation and GSM Licence) Regulations, 2002 and 2003

systems such as GSM, and capable of supporting the characteristics referred to in Annex 1 of the UMTS Decision;

- "LTE" means the Long Term Evolution family of standards from the European Telecommunications Standards Institute ("ETSI") and Third Generation Partnership Project ("3GPP"); and

- "UMTS" means the Universal Mobile Telecommunications System family of standards from the European Telecommunications Standards Institute ("ETSI") and Third Generation Partnership Project ("3GPP").

3 Drive Test Route

16. 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[12] 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[13,] including all towns and Motorway sections, along these routes.

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

4 Presentation of Results

17. 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.

18. ComReg takes a holistic view on the issue of mobile network coverage, 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[14].

19. 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[15].

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

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

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

Figure 2: Meteor Liberalised Use Licence: 900 MHz (GSM)[16]

[16] Meteor does not operate GSM in the 1800MHz band.

Figure 3: 3IHL No.2, 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)

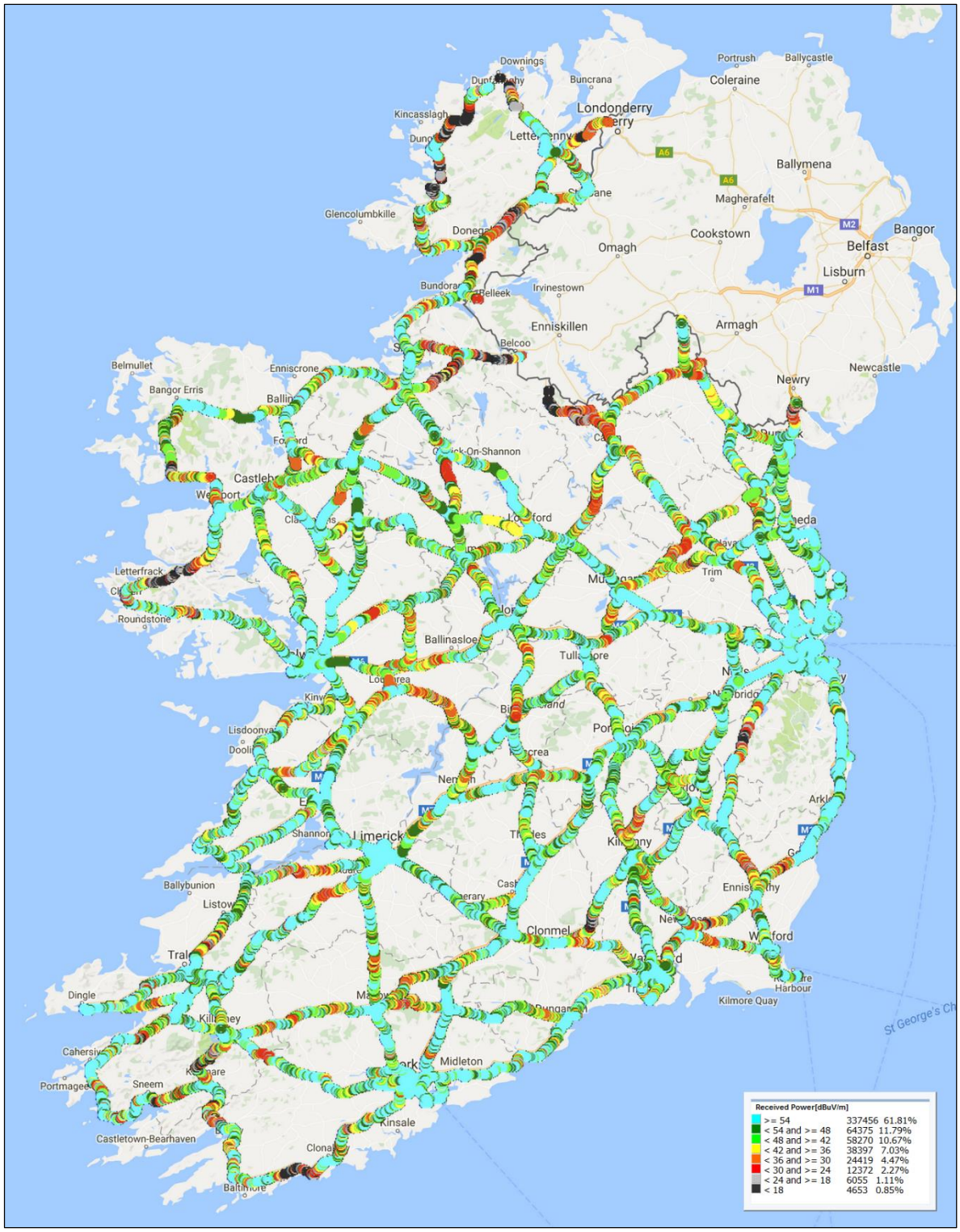

Figure 5: Meteor Third Generation Licence 2100 MHz (UMTS)

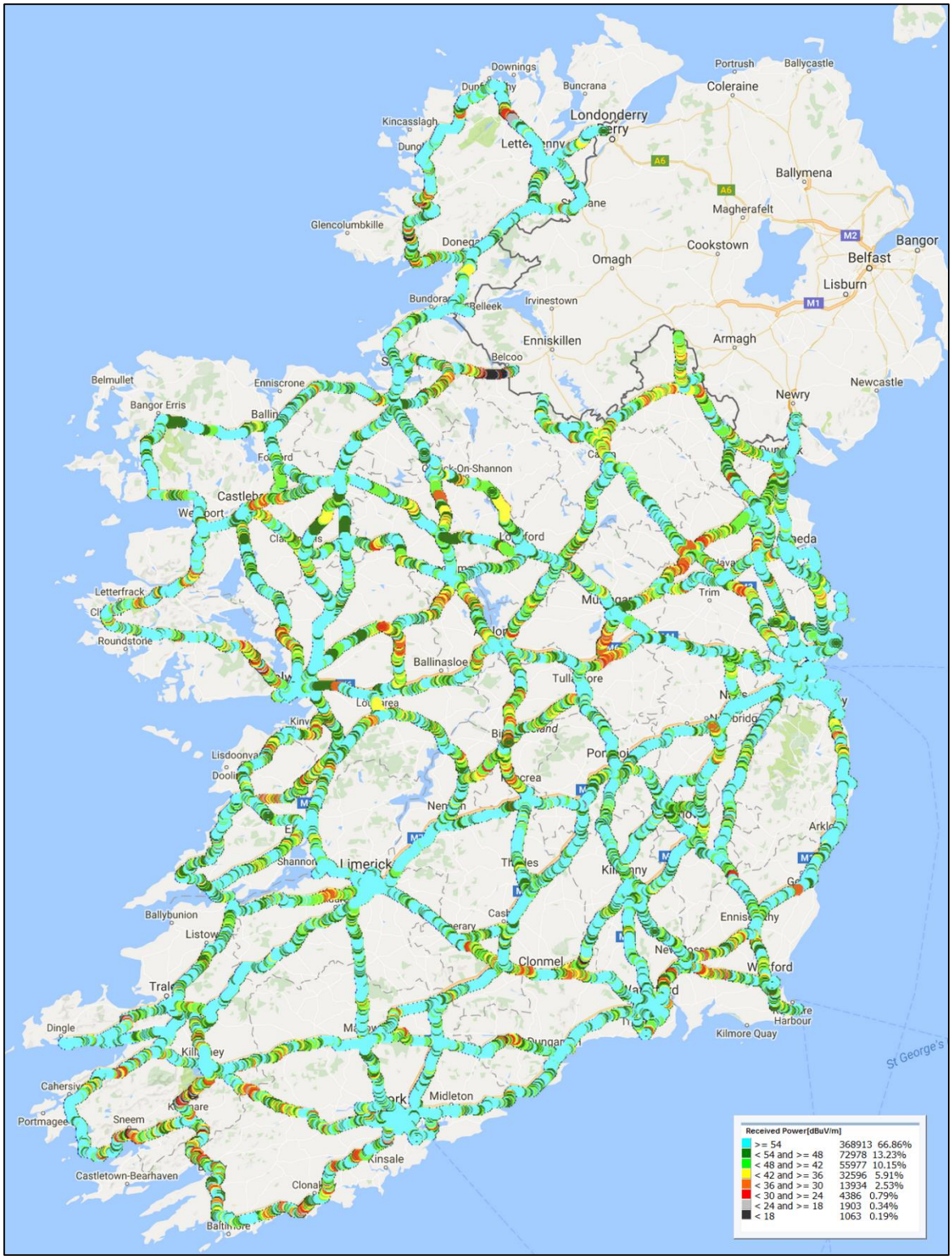

Figure 6: 3IHL No. 1, Third Generation Licence 2100 MHz (UMTS)

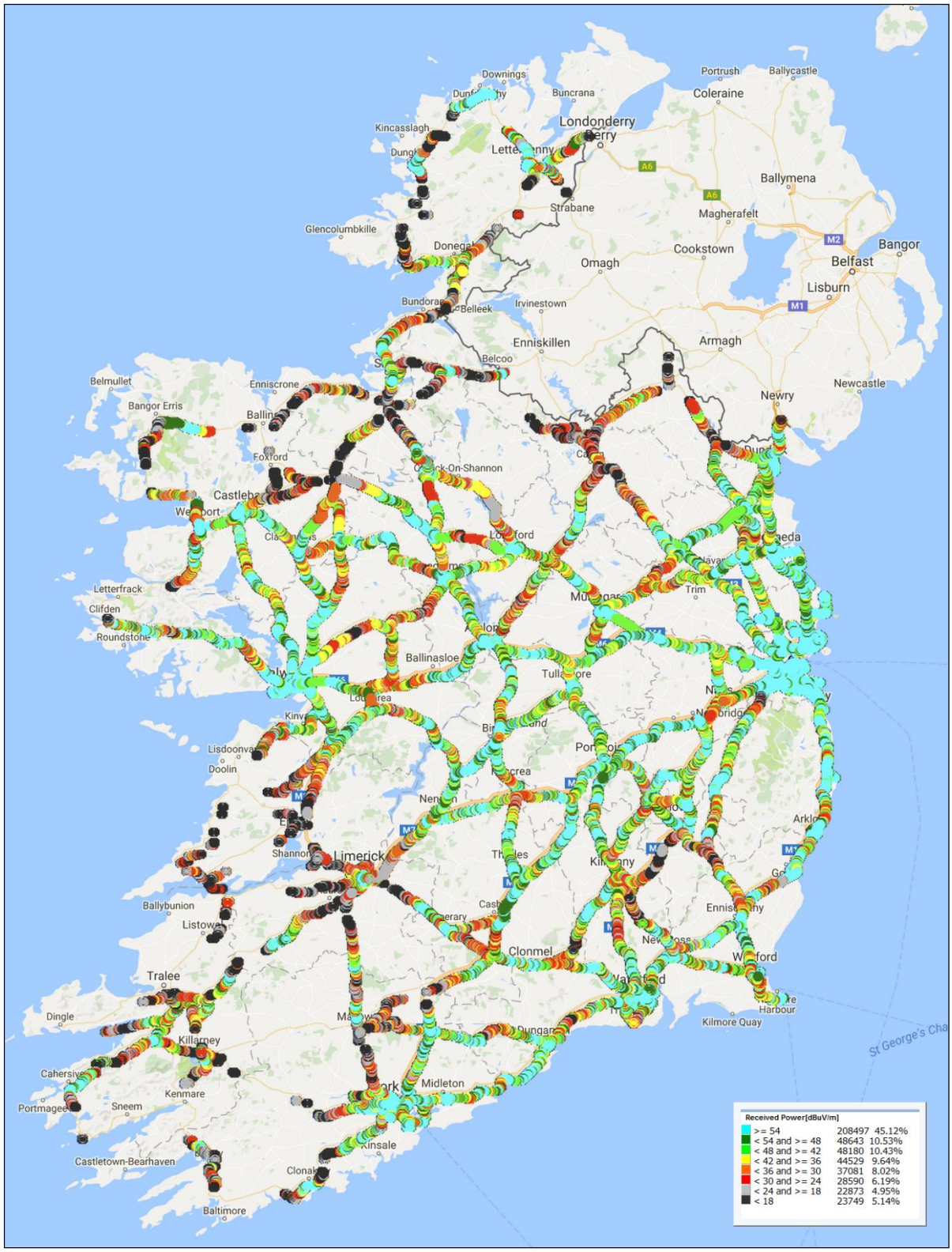

Figure 7: 3IHL No. 2, Third Generation Licence 2100 MHz (UMTS)[17]

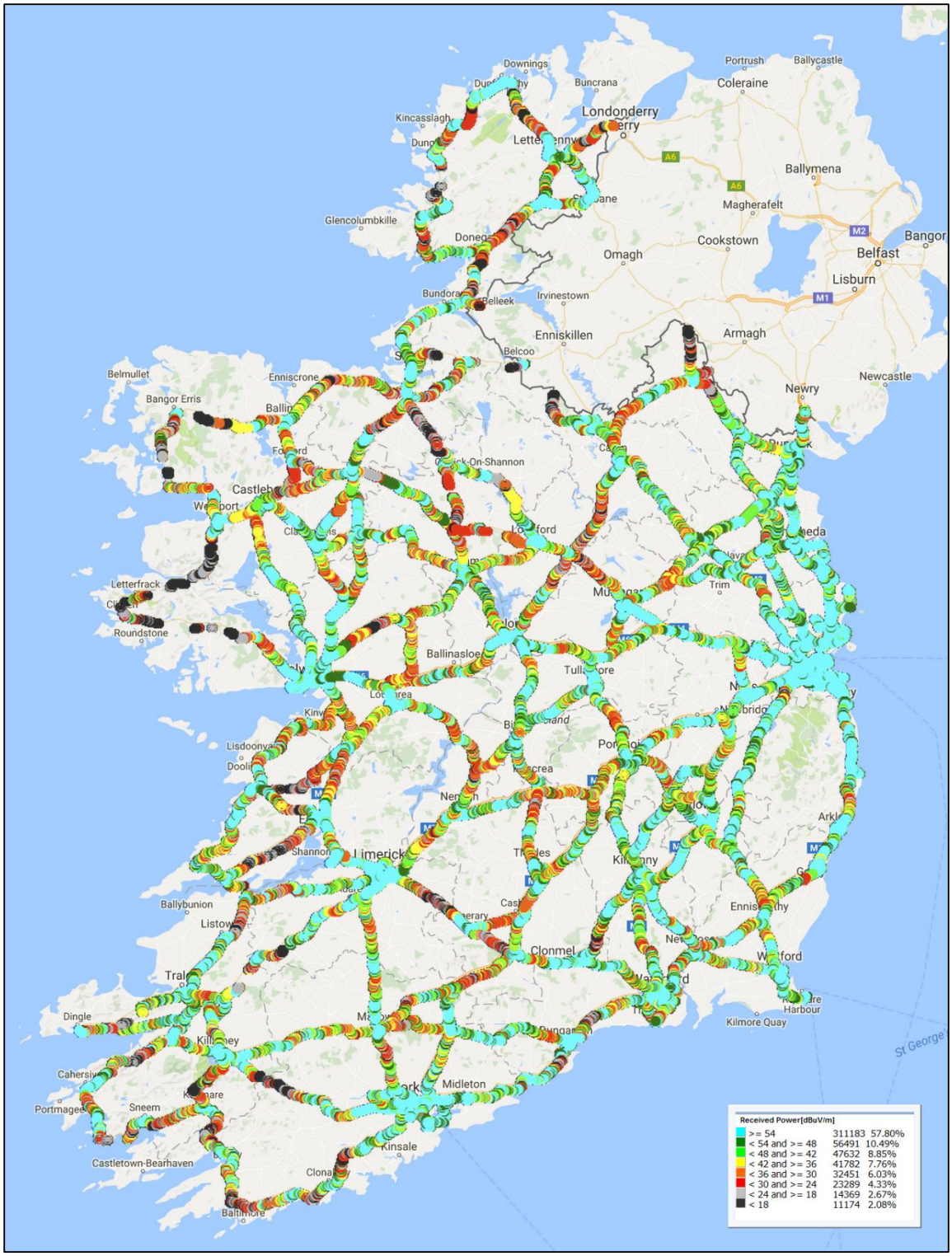

Figure 8: Vodafone Third Generation UMTS 2100 MHz (UMTS)

[17] Customers on 3IHL No.2 get the combined coverage with 3IHL No.1 at 2100 MHz (UMTS)

4.3 Liberalised Use Licence 900 MHz (HSDPA/UMTS)

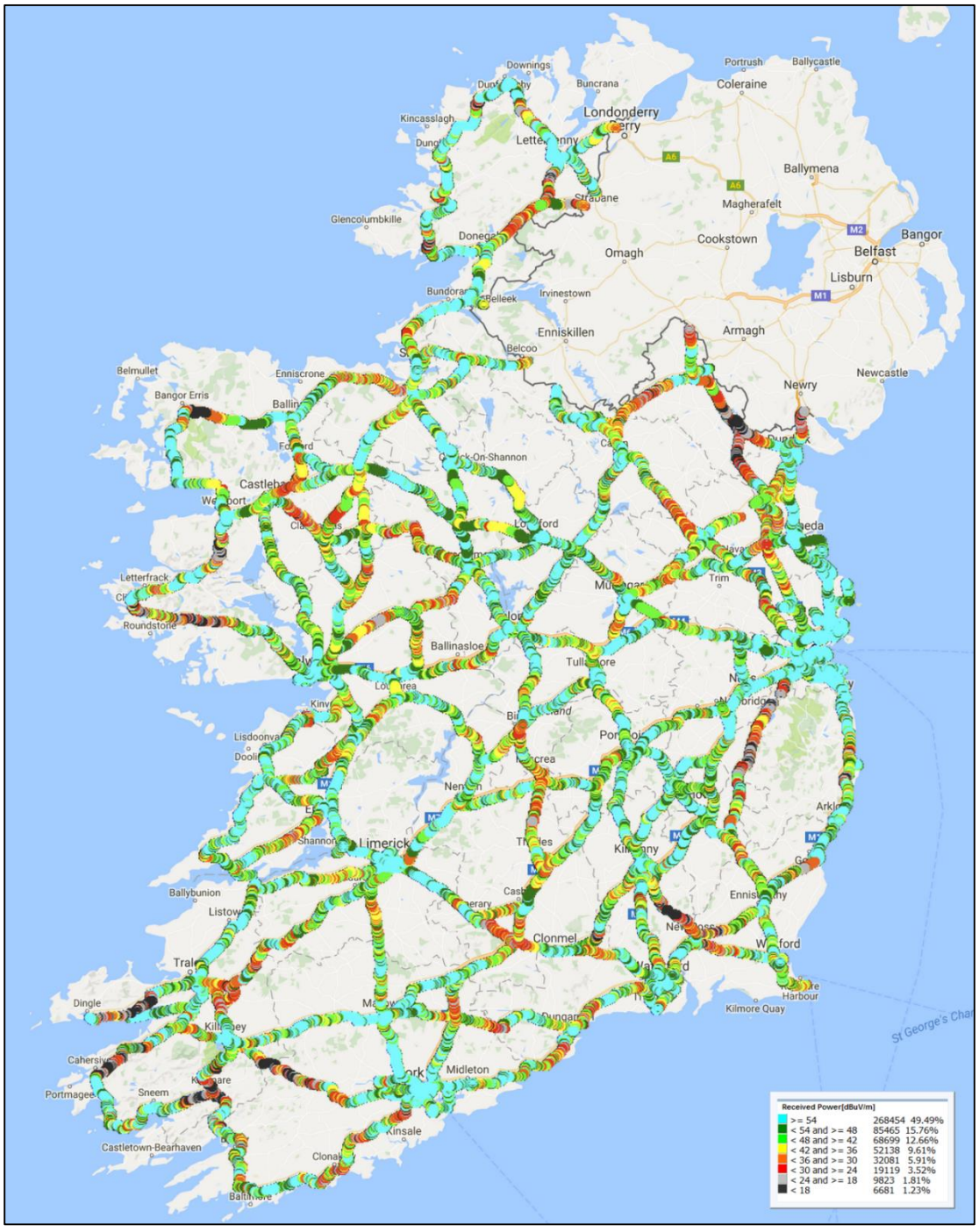

Figure 9: Meteor Liberalised Use Licence: 900 MHz (HSDPA/UMTS)

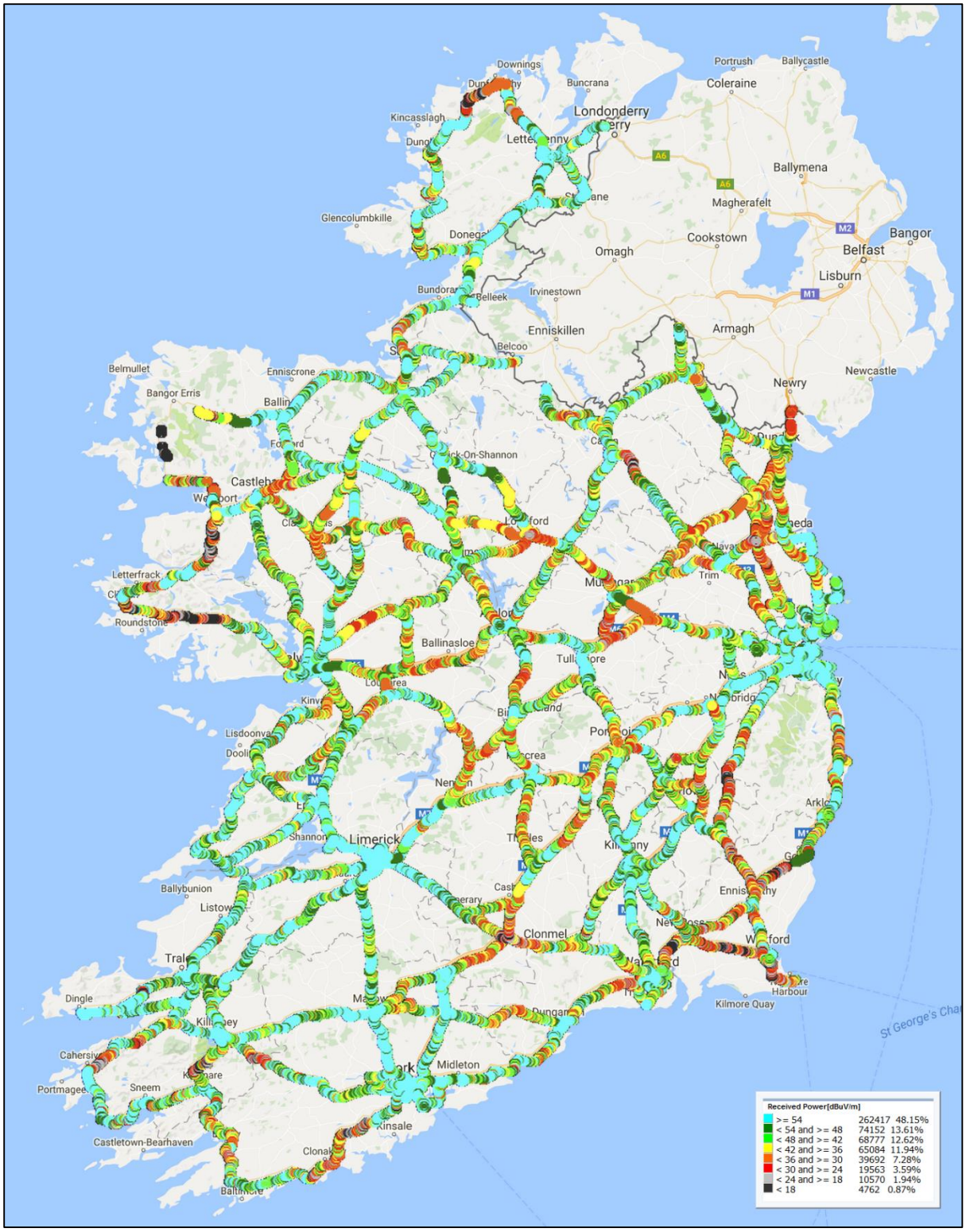

Figure 10: 3IHL No. 1, Liberalised Use Licence; 900 MHz (HSDPA/UMTS)

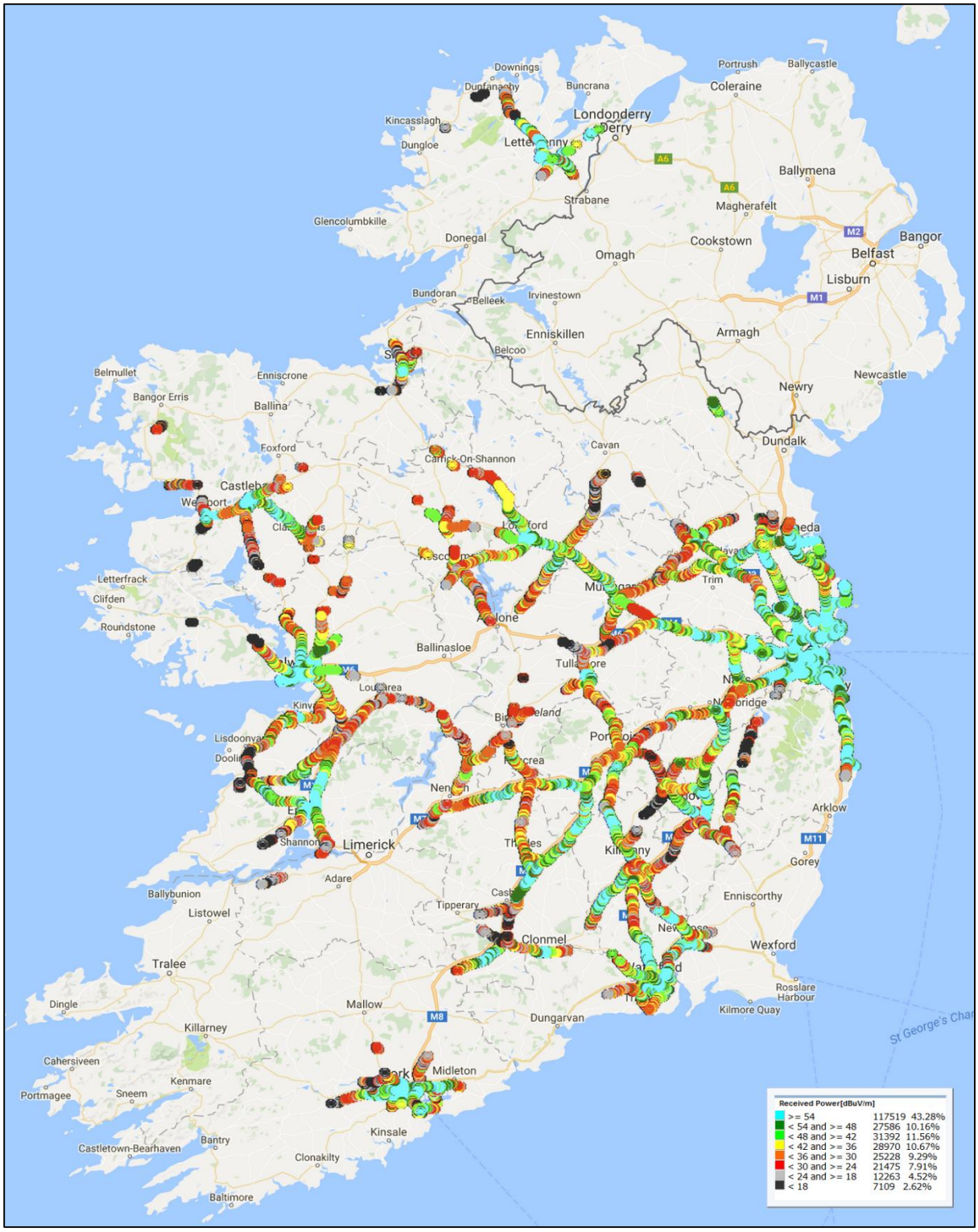

Figure 11: 3IHL No. 2 Liberalised Use Licence: 900 MHz (HSDPA/UMTS)

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

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

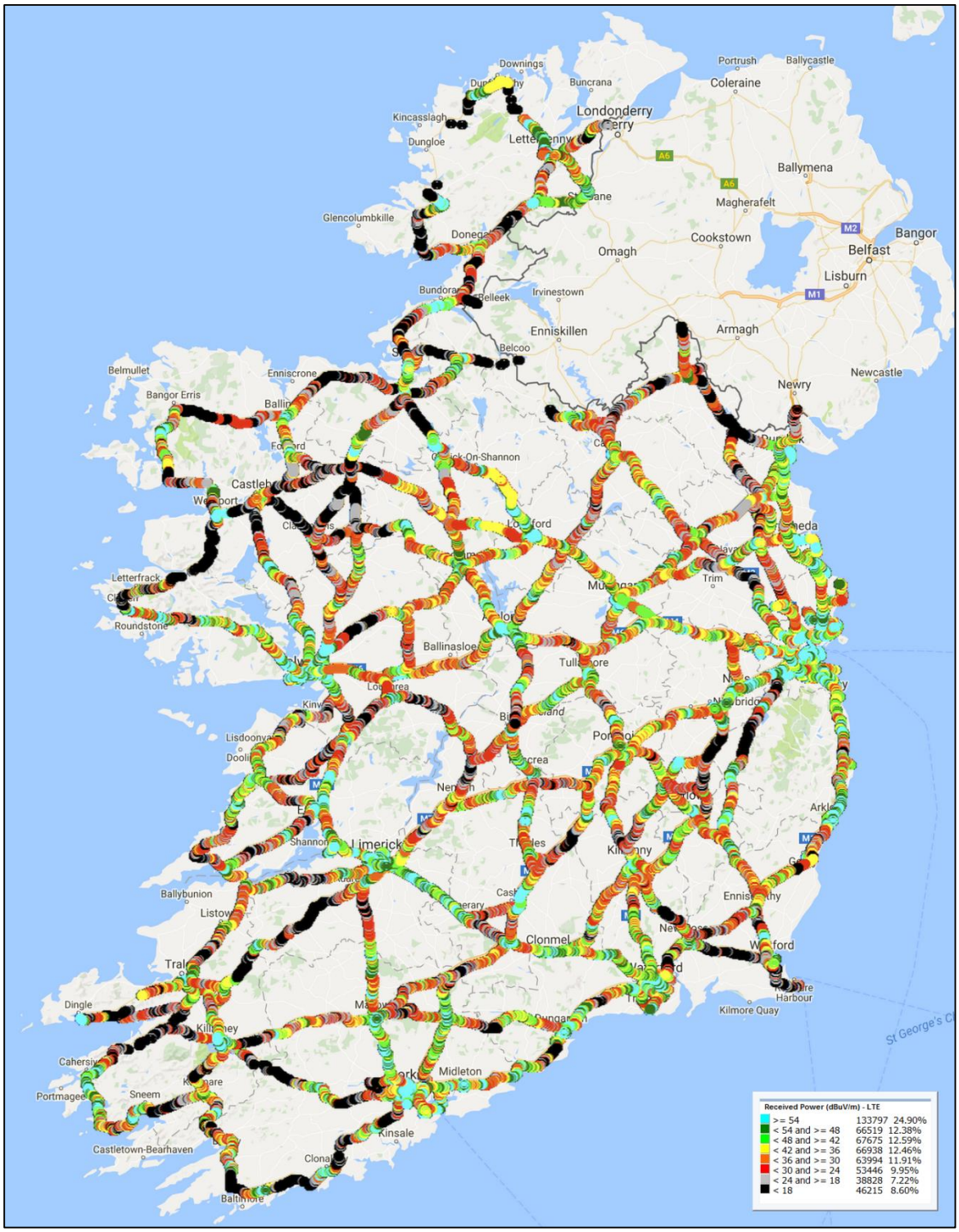

Figure 137: Meteor Liberalised Use Licence: 800 & 1800 MHz (LTE)

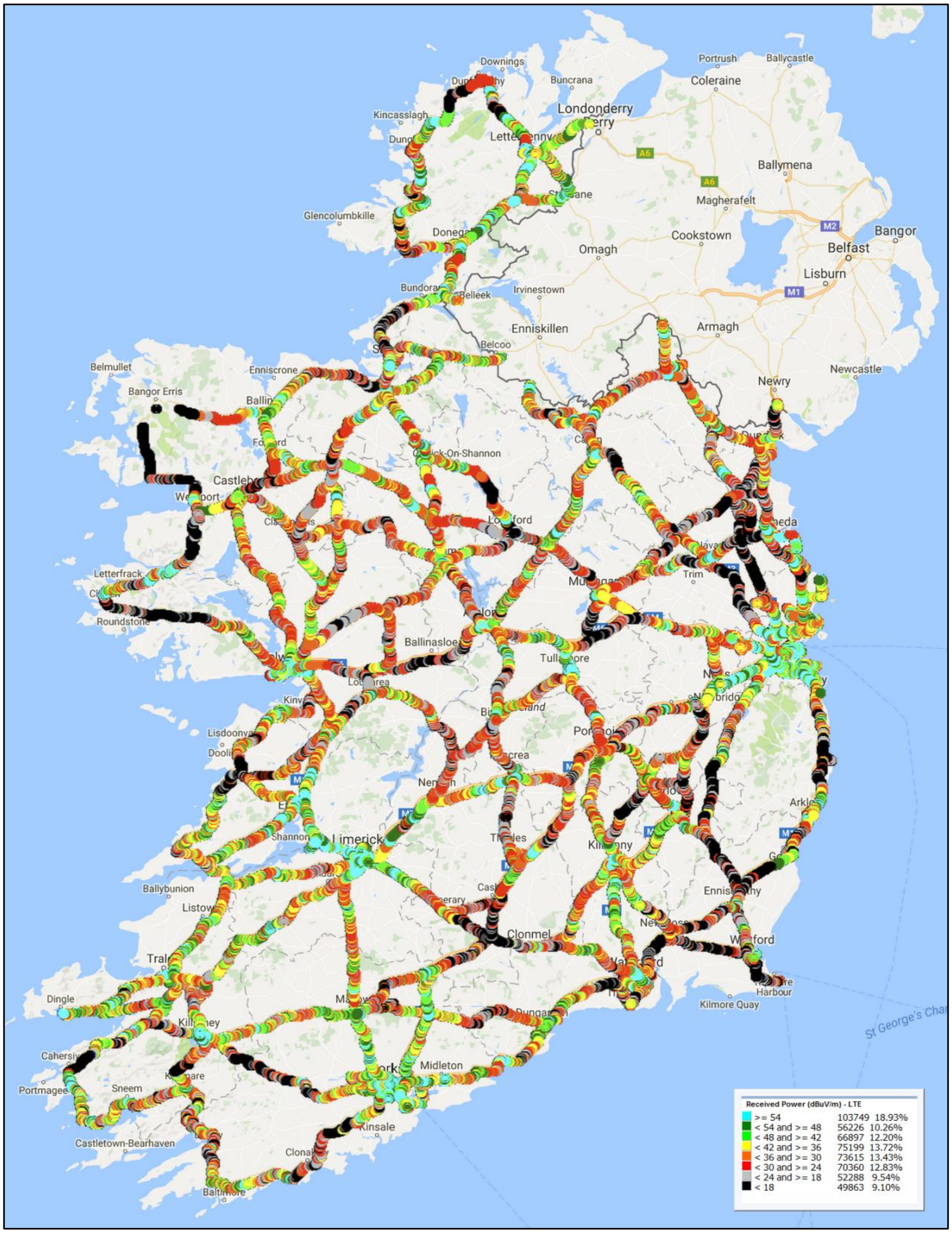

Figure 14: 3IHL No. 1, Liberalised Use Licence: 800 and 1800 MHz (LTE)

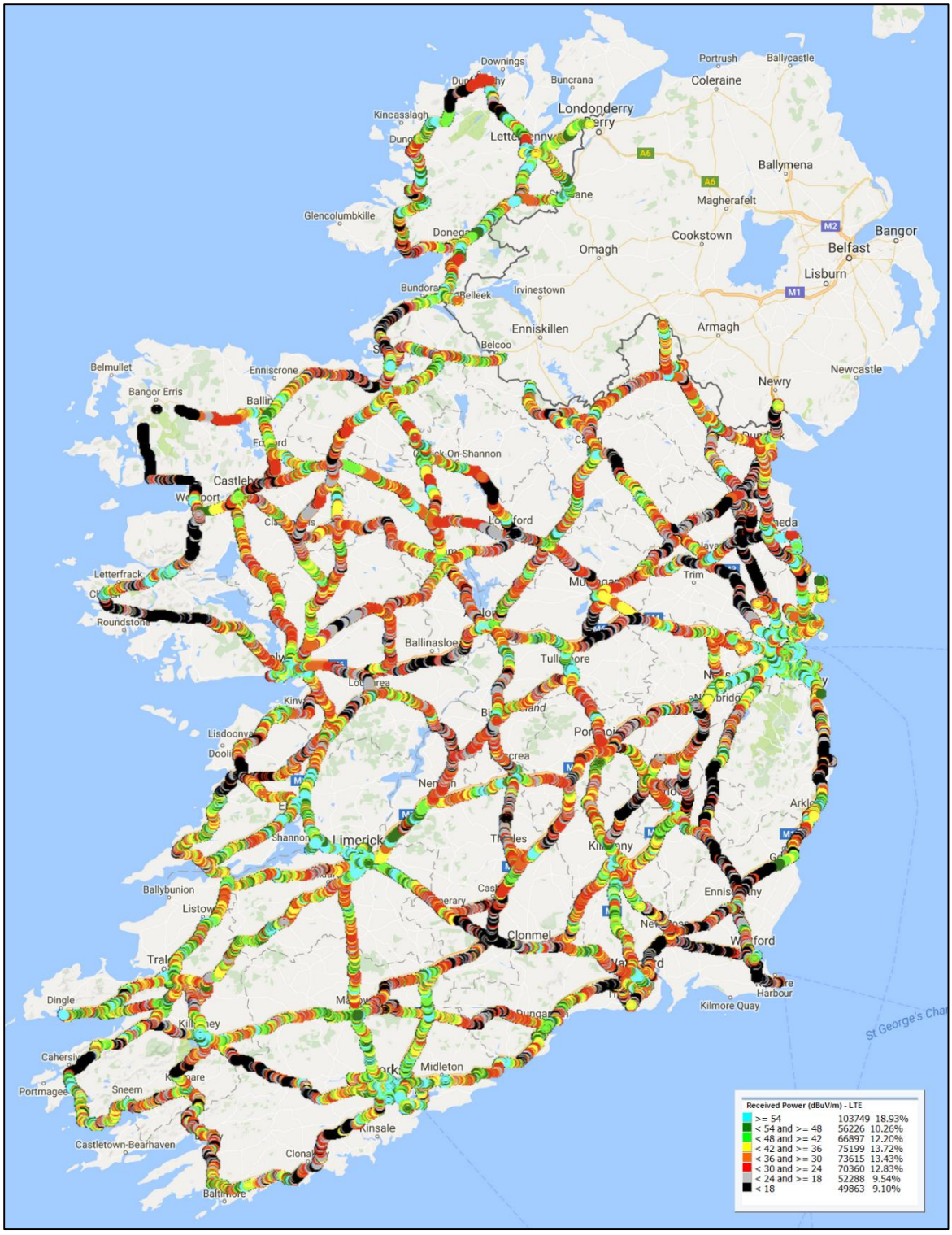

Figure 15: 3IHL No. 2, Liberalised Use Licence: 800 and 1800MHz (LTE)

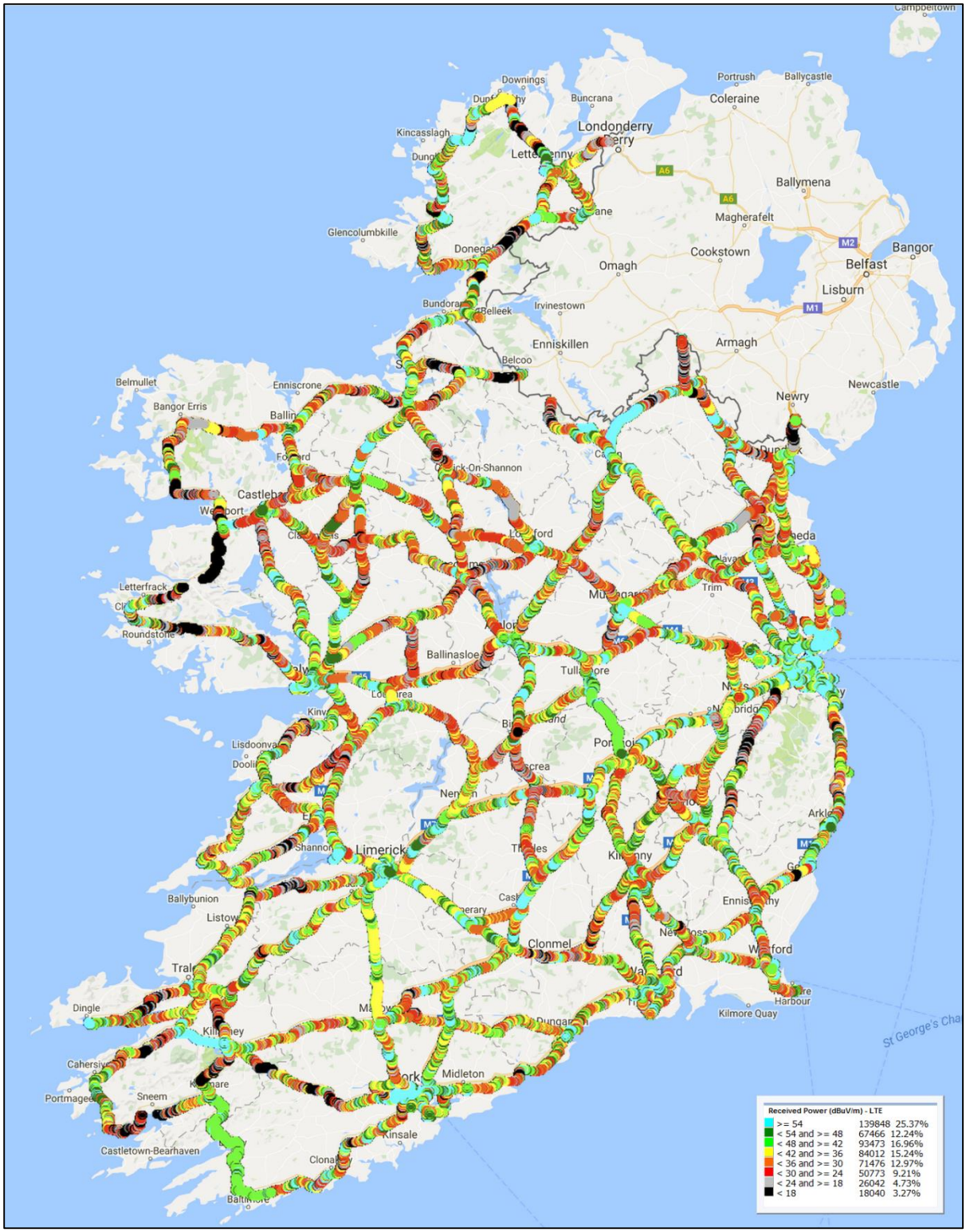

Figure 16: Vodafone Liberalised Use Licence: 800 & 1800MHz (LTE)

5 Conclusions

General Comments

22. ComReg notes the progress made so far in rolling out mobile electronic communications services under the Liberalised Use Licences and that in all cases the coverage criterion has been met. Since the Drive Test programme started, there has been an increase in received Field Strength across all of the MNOs networks and bands, reflecting the roll out of new technologies and bands since 2012's MBSA process. The increase in Field Strength is shown in the table below.

Table 1 – Field Strength by Operator across technologies, June 2015 – December 2016

MNO	GSM June 2015	GSM December 2016	U 2100 R'99 June 2015	U2100 R'99 December 2016	U900, HSPA June 2015	U900, HSPA December 2016	LTE June 2015	LTE December 2016
3IHL No.1	N/A	N/A	FS, 56.83dBuv/m;	FS, **61.96dBuv/m**;	FS, 43.17dBuv/m;	FS, **54.95dBuv/m**;	FS, 33.79dBuv/m	FS, **40.93dBuv/m**
3IHL No.2	FS, 64.78dBuv/m;	FS, **69.75dBuv/m**;	FS, 53.14dBuv/m;	FS, **54.65dBuv/m**;	FS, 47.11dBuv/m;	FS, **50.48dBuv/m**;	N/A	FS, 39.43dBuv/m
Meteor	FS, 66.46dBuv/m;	FS, **71.9dBuv/m**;	FS, 56.33dBuv/m;	FS, **61.30dBuv/m**;	FS, 45.41dBuv/m;	FS, **54.35dBuv/m**;	FS, 39.43dBuv/m	FS, **43.66dBuv/m**
Vodafone	FS, 66.35dBuv/m;	FS, **72.46dBuv/m**;	FS, 55.35dBuv/m;	FS, **59.32dBuv/m**;	FS, 54.04dBuv/m;	FS, **63.08dBuv/m**;	FS, 36.77dBuv/m	FS, **43.29dBuv/m**

23. As the new networks evolve, ComReg will continue to conduct Drive Tests for each of the Liberalised Use Licences as well as the 3G licences to ensure compliance with licence obligations.

Coverage

24. All Licensees have complied with their obligations under their respective Licences to date.

25. A simplified, collated version of the coverage results of this Drive Test is outlined in Table 2 below. These results represent the minimum coverage by population achieved during the Drive Test.

	GSM1800	UMTS2100	LUL/LTE(800/1800)	LUL/GSM(900/1800)	LUL/3G(900)
Meteor	N/A	>90%	>70%	>90%	>70%
3IHL No. 1	N/A	>90%	>70%	N/A	>70%
3IHL No. 2	>70%	>90%	>70%	>90%	>53%
Vodafone	>53%	>90%	>70%	>90%	>90%

Table 2- - Minimum coverage as indicated by the Drive Test

Average Download Speeds

26. 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 2.5 times faster than those offered by 3G ("HSDPA"). Furthermore, ComReg notes that the advantages offered by LTE over 3G in a mobile scenario are now more clearly demonstrated, with LTE being approximately 5.3 times faster than HSDPA.

27. Table 3 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 can be experienced based on, among other factors, geographic location and the load on the network.

Table 3 - Average data speeds achieved during the Drive Test

Licensee	Technology	D/L Stationary[18] (Mbps)	D/L Mobile[19] (Mbps)
Meteor	3G HSDPA	6.886	3.821
	LTE	15.425	17.732
3IHL No.1	3G HSDPA	3.298	2.627
	LTE	8.476	16.531
3IHL No. 2	3G HSDPA	4.148	3.821
	LTE	10.476	19.663
Vodafone	3G HSDPA	7.91	4.496
	LTE	22.326	22.247

28. Normally with 3G HSPA, download speeds while moving are less than those achieved while stationary which is an unavoidable physical phenomenon inherent in this technology.

29. 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. Consequently such services require higher signal levels to maintain speed and quality.

[18] These are the cumulative averages from measurements taken at 55 Locations throughout Ireland.

19 Average Vehicular Speed of 80kmph.

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
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
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

SIM	Subscriber Identity Module
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: Drive Test Equipment

A 2.1 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;
- A FTP server based in Dublin; and
- Relevant SIM cards.

Figure 17: Measurement Set Up Showing Handsets

Figure 18: Nemo Invex, Connected to Handsets