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

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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 22 June and 21 July 2019, by its contractor Advanced Wireless Technologies Group Limited ("AWTG")[1].

1.1 Drive Tests

2. The Drive Test is carried out, across all of the relevant frequency bands and licence types of the Mobile Networks Operators ("MNOs"). This test represents a snapshot of how the individual MNOs' networks performed, in relation to individual licence conditions, at the point in time during which the test is conducted, while the route is driven.

3. All measurements are performed from a vehicle containing a computer controlled measuring system ("Benchmarking System")[2], which acts as a 'handset', matching a European Telecommunications Standards Institute ("ETSI") standard handset[3]. As such, the Benchmarking System is locked to each individual technology, in use by the licensee, on the relevant frequency bands. It should also be kept in mind that the radio performance of many handsets differs at a location, due to a variety of factors, such as those outlined in section 1.2 below.

4. The results of this Drive Test indicate that all of the MNOs' networks meet the licence conditions, currently in force. The MNOs that currently hold licences in Ireland are:

    - Three Ireland Hutchison Limited ("3IHL")[4,5];
    - Eircom Limited ("Eir")[6]; and

1 AWTG, were selected following a Request for Tenders (RFT 135426) which was published on both e-tenders and in the Official Journal of the European Union.

2 This consists of the Nemo Invex II benchmarking tool, connected to Samsung Galaxy S9 mobile handsets and an FSR1 Multiband Scanner. Measurements are terminated at servers located in Ireland.

3 3GPP TS 36.101

4 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) Limited4 licences are referred to as "3IHL No.2".

5 In an e-mail of 17 September 2019, 3IHL confirmed to ComReg that since the completion of its network merger all 3IHL Subscriber Identity Modules SIMs can use all of 3IHLs assigned frequencies. ComReg, also notes that 3IHL has rearranged the 2G (GSM) and UMTS 900 blocks in its two licences since the last drive test, which should be transparent to its customers.

6 While Meteor is the Licensee, it trades as Eir.

- Vodafone Ireland Limited ("Vodafone").

5. Coverage, as measured in the Drive Test, represents the ability to place a call, at a specific location and time, using a standard handset.

6. In addition to the coverage that is measured on the specified routes[7] for the drive test, ComReg has also developed a nationwide outdoor mobile coverage map[8], which is generated using, a standard propagation model and data provided by the Mobile Network Operators: Eir, Three Ireland and Vodafone. The outdoor mobile coverage map also includes data for the mobile virtual network operators ("MVNOs")[9].

7 Chapter 3 of this Document sets out the route that is covered under the Drive Test.

8 https://www.comreg.ie/outdoor-mobile-coverage-map/

9 Service providers whose services are hosted by the main mobile network operators: Eir Mobile, Three Ireland and Vodafone. There are 48 MVNOs, for example Lycamobile, Postmobile, Tesco Mobile and Virgin Media. As it is not a Licence obligation the coverage of MVNOs is not tested during the Drive Test and is a matter of commercial agreement between the MNO and MVNO concerned.

1.2 Factors Affecting End-User Experience

7. As it is not possible to fully account for the wide range of variables that can affect end-user experience, in its licence conditions ComReg therefore sets minimum requirements, based on the relevant standards of European and International bodies[10], for mobile phone coverage, assuming a certain level of handset performance and outdoor use.

8. For better understanding of the factors that currently affect end-user experience, ComReg has conducted research into the antenna performance of the mobile handsets when used for voice[11] and data[12] services. The results of the research show a notable difference in performance, depending on the service used. Importantly, it illustrates that mobile handsets perform differently in areas where coverage is weak.

9. Furthermore, ComReg has also conducted research into the radio propagation characteristics of common building materials, in order to determine how they affect mobile handset signals in building. In August 2018, ComReg published Document 18/73[13] in which ComReg found, that the use of some modern building materials, in particular those containing metals such as foil-backed thermal insulation or windows with metallic frames, can have a significant detrimental effect on the propagation of radio waves as they penetrate a building.

10. This notwithstanding, another factor affecting the end-user experience is the type of service being used; i.e. GSM, 3G and LTE, etc. Services, such as LTE, which provide the user with higher data speeds require higher signal levels to operate than traditional voice services. All digital modulation schemes are reliant on a minimum Signal to Noise Ratio ("SNR")[14] and the higher the data throughput, the greater the SNR required.

11. Figure 1 below, outlines some of the factors, as discussed above that can affect an end-user's experience of their mobile handset.

10 For Example the 3GPP and ETSI standards for Users Equipment and Base Stations.

11 ComReg Document 18/05 – Mobile Handset Performance (Voice), February 2018: https://www.comreg.ie/?dlm_download=mobile-handset-performance-voice

12 ComReg Document 18/82 – Mobile Handset Performance (Data), September 2018: https://www.comreg.ie/publication/mobile-handset-performance-data/

13 https://www.comreg.ie/publication/the-effect-of-building-materials-on-indoor-mobile-performance/

14 Signal to Noise Ratio is a generic engineering term and is the ratio of the Wanted signal to the Unwanted signal.

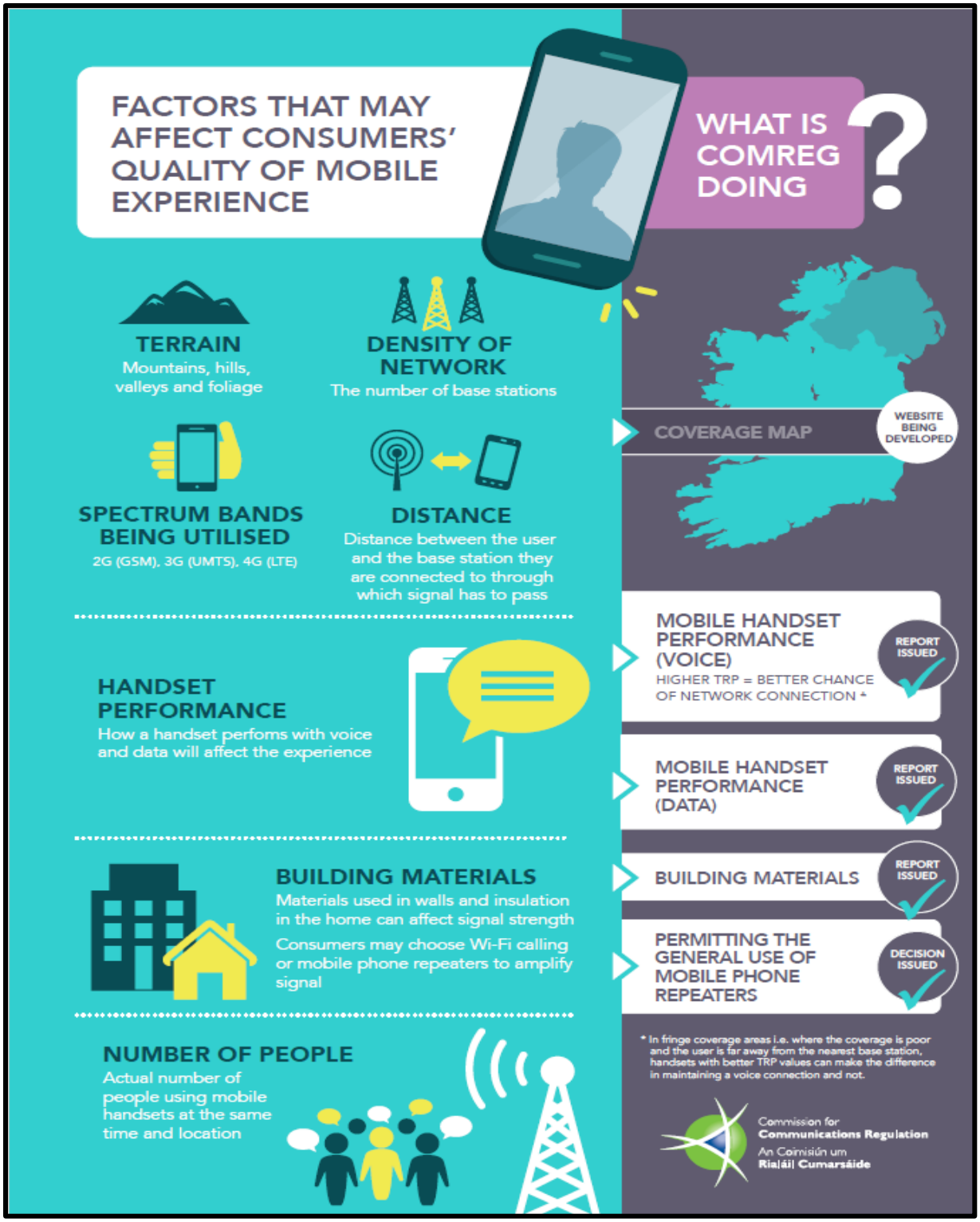

Figure 1: Factors affecting end-user experience of mobile networks.

2 Licence Types

12. 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.

13. The licences and their conditions of use that are currently in force are the Liberal Use Licences ("LUL")[15] and the Third Generation Licences ("TGL")[16]. The frequency bands assigned, pursuant to these licences, are outlined in Table 1 below.

Table 1: Frequency Bands for LUL and TGL

Band (MHz)	Downlink (MHz)	Uplink (MHz)
800[17]	791 - 821	832 - 862
900[18]	925 - 960	880 - 915
1800[19]	1805 - 1880	1710 - 1785
2100[20]	2110 - 2170	1920 - 1980

15 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.

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

17 The "800 MHz band" means the 791 to 821 MHz band paired with the 832 to 862 MHz band.

18 The "900 MHz band" means the 880 to 915 MHz band paired with the 925 to 960 MHz band.

19 The "1800 MHz band" means the 1710 to 1785 MHz band paired with the 1805 to 1880 MHz band.

20 The "2100 MHz band" means the 1920 to 1980 MHz band paired with the 2110 to 2170 MHz band.

14. The following technologies are permitted for use in the frequency 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 systems such as GSM, and capable of supporting the characteristics referred to in Annex 1 of the UMTS Decision[21]; and
- "LTE" means the Long Term Evolution family of standards from the European Telecommunications Standards Institute ("ETSI") and Third Generation Partnership Project ("3GPP").

21 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:31999D0128&from=EN

3 Drive Test Route

15. The Drive Test route covers the full length of Ireland's national primary and secondary (N) road network, including all towns thereon and Motorway sections. The route is approximately 5,500 km long with the coverage levels, of the MNOs' licenced networks in their respective bands, assessed as the route is driven.

16. In addition to these roads, the Drive Test was conducted on the roads emanating from the 5 main city centres across Ireland, including orbital and interlinking roads in the cities of:

- Dublin, including:

  1) M50 Ring Road;

  2) North Circular Road;

  3) South Circular Road;

  4) R114 from Portobello Bridge to Dame St; and

  5) O'Connell Street from Eden Quay to Parnell Square East along North Frederick St. to Dorset Street;

- Waterford City;
- Cork City;
- Limerick City; and
- Galway City

In the cities, detailed above, the Drive Test was primarily conducted during the busy hour, typically between 1700 and 1900 hours and in general, all testing was conducted between 0900 and 2100 Hours.

4 Presentation of Results

1. Coverage is measured in terms of the received field strength, as defined in the licence conditions, while the route is driven.

2. ComReg takes a holistic view[22] 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 the different frequency bands available to the MNO[23].

3. Coverage, as defined in part 4 of the Schedule to the Licences, is determined as the percentage of the population covered; the data available from the Central Statistics Office 2016 Census is used to give an approximation of the population in the areas covered by the Drive Test[24].

4. The following maps provide a graphical representation of the field strengths measured during the Drive Test. The Drive Test results are grouped by Licensee then the technology and frequency used.

22 The coverage under the Liberalised Use Licence is aggregated across the bands, covered by both this and the Third Generation Licence. This notwithstanding, it is also not only contingent on measured field strength but also signal to noise ratio.

23 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.

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

4.1 Eir: Coverage Maps

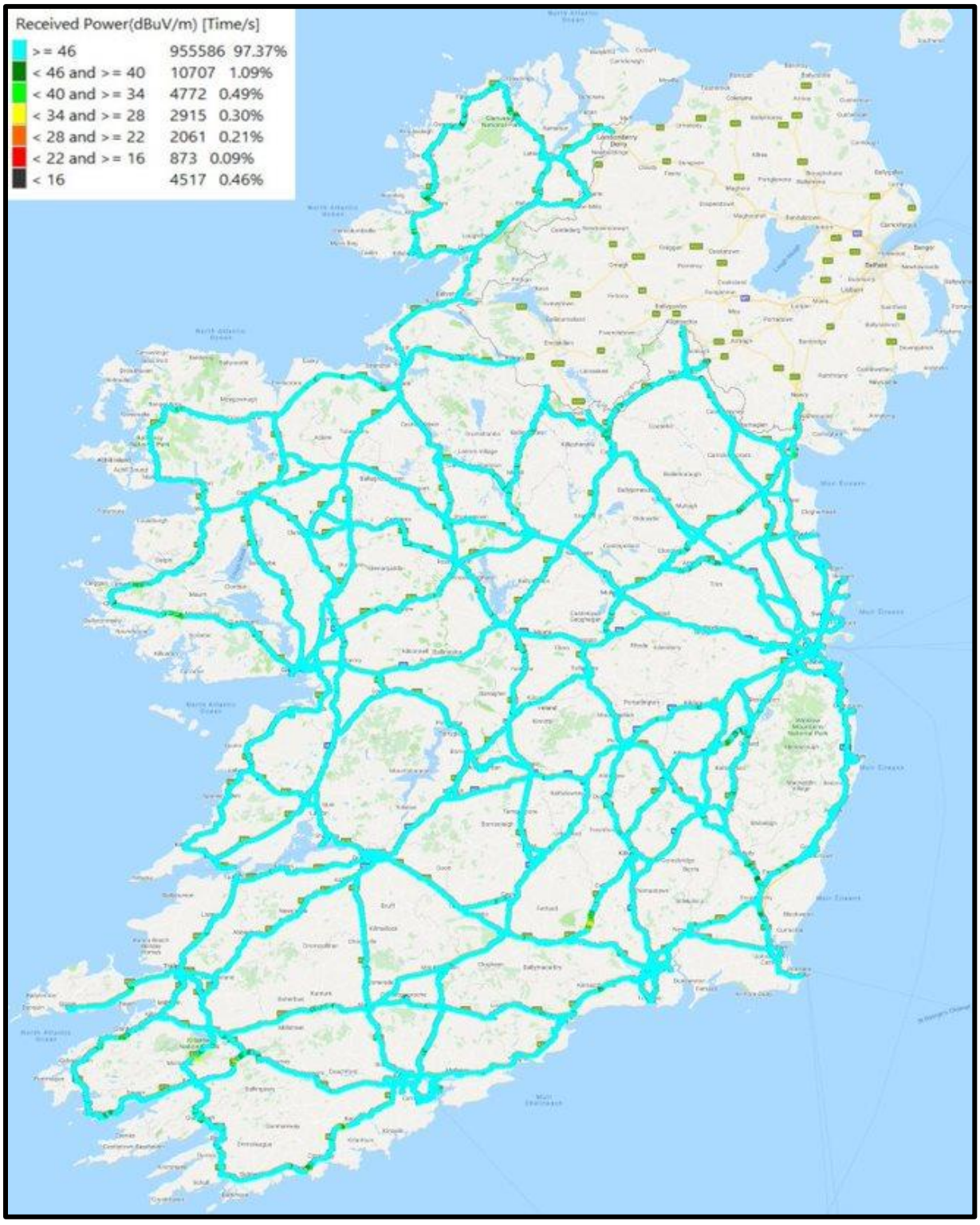

Figure 2: Eir Liberalised Use Licence – 900 MHz (GSM[25]).

25 Eir (Meteor) does not provide any GSM voice services on its 1800 MHz spectrum allocation.

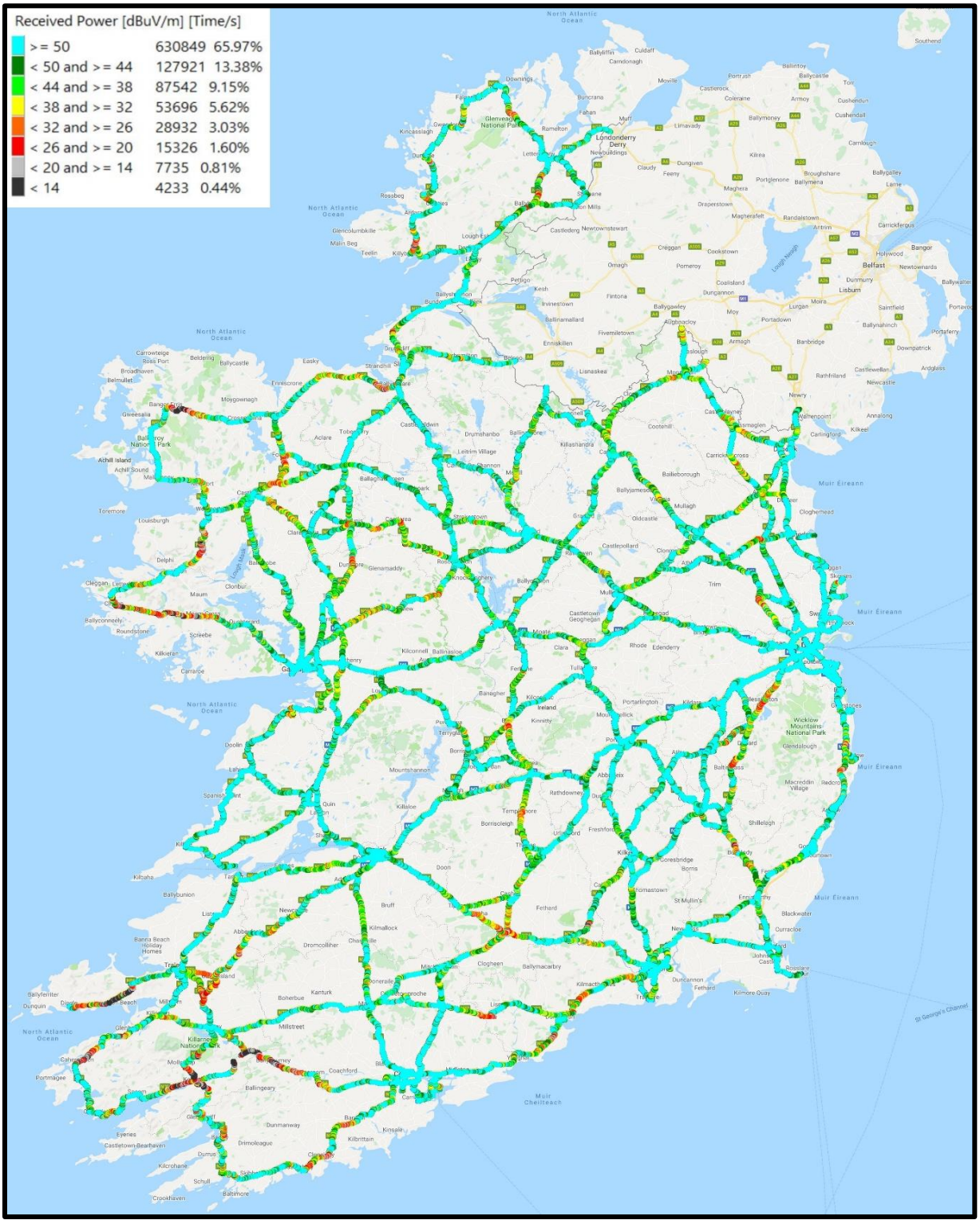

Figure 3: Eir Liberalised Use Licence – 900 MHz (HSDPA/UMTS).

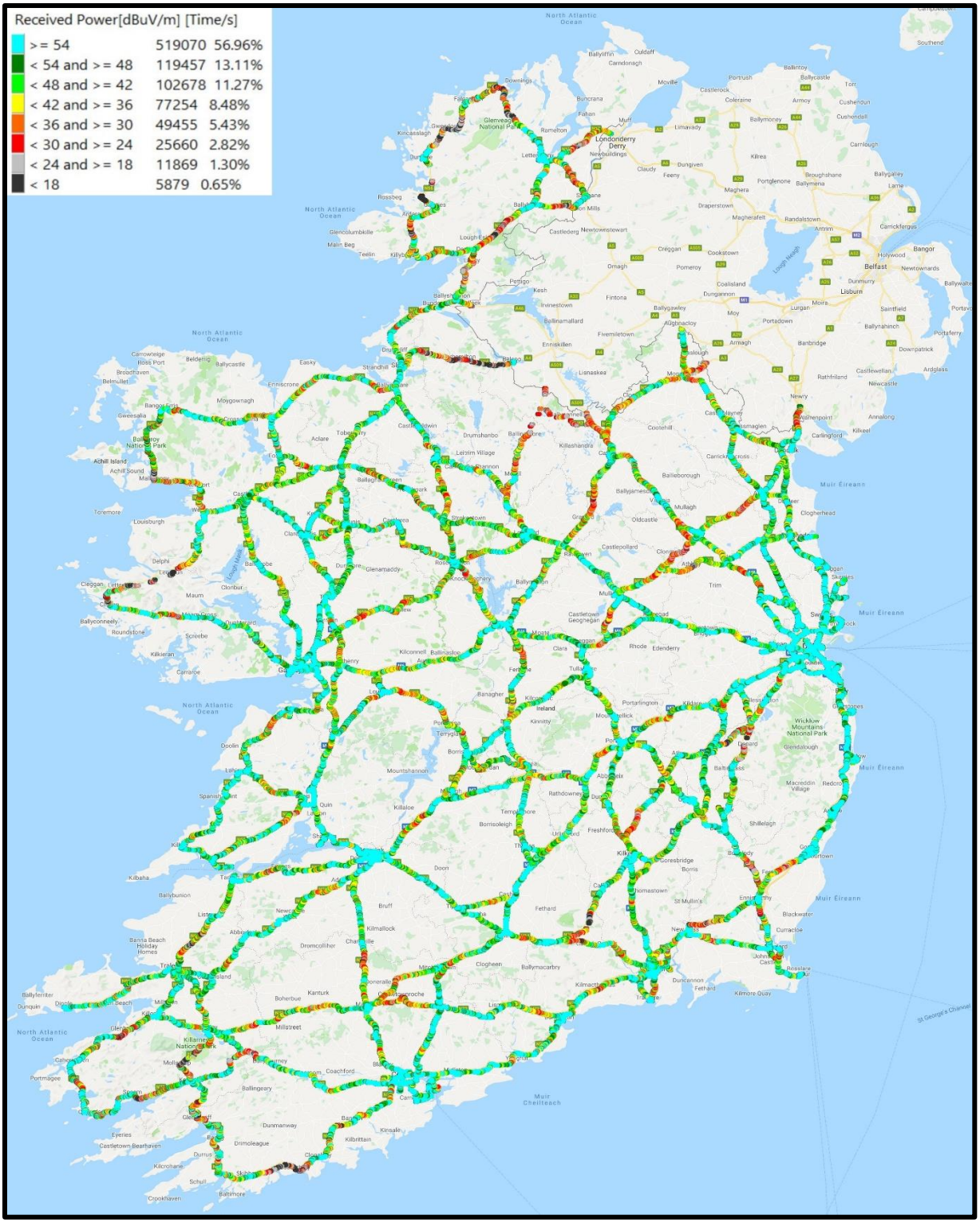

Figure 4: Eir Third Generation Licence – 2100 MHz (UMTS/HSDPA).

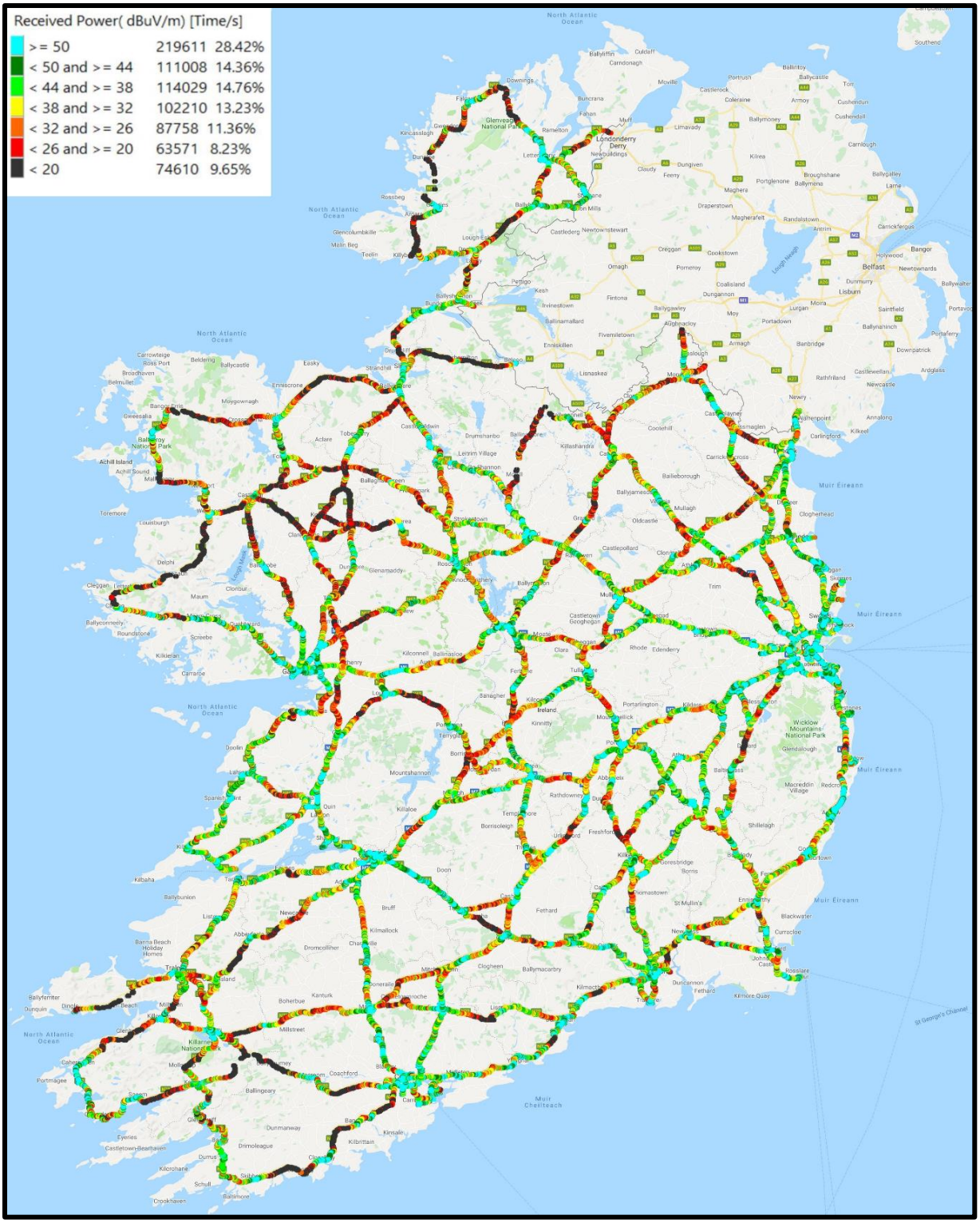

Figure 5: Eir Liberalised Use Licence – 800 MHz & 1800 MHz (LTE).

4.2 3IHL No.1: Coverage Maps

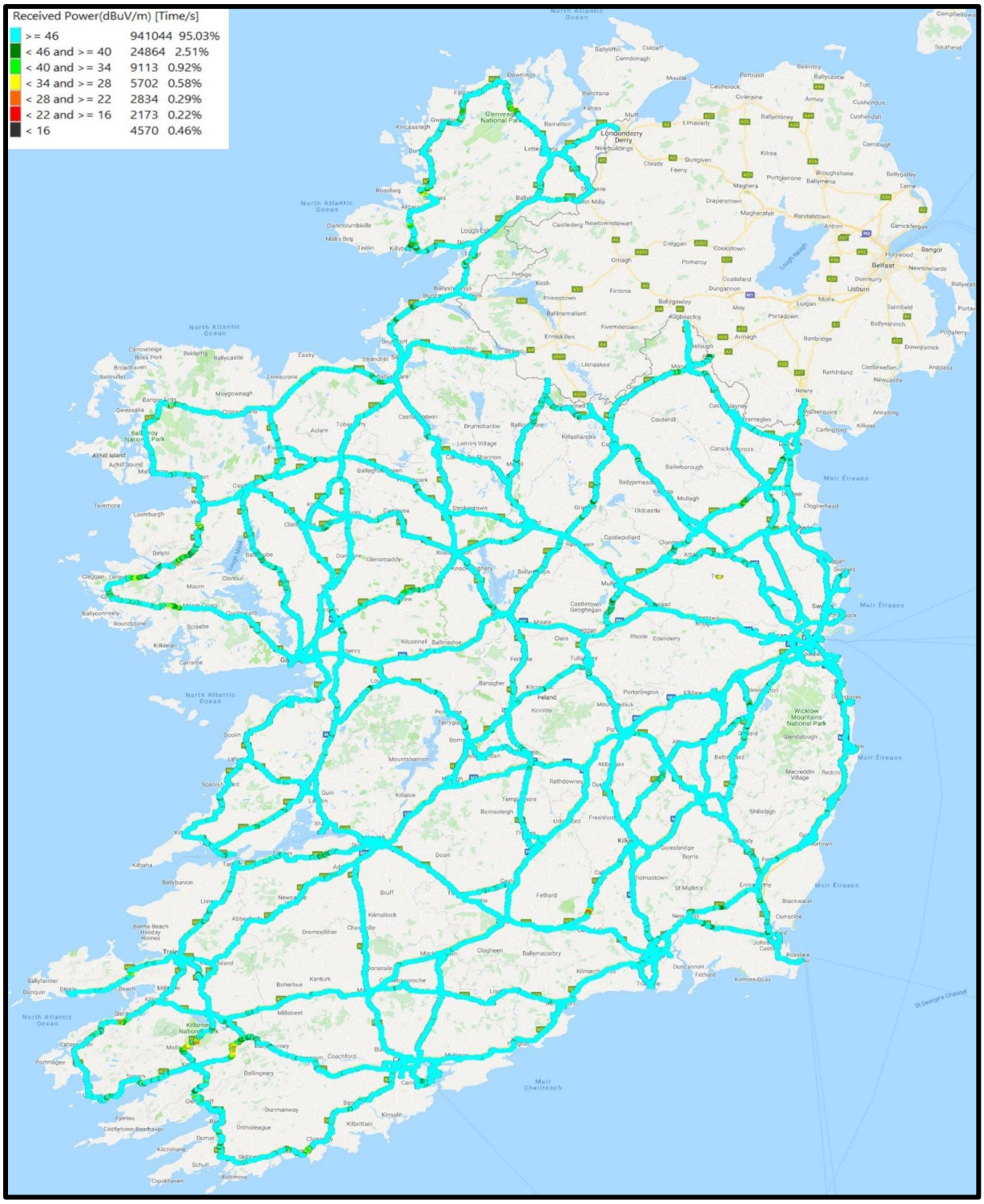

Figure 6: 3IHL No.1 Liberalised Use Licence – 900 MHz (GSM[26]).

26 3IHL No.1 does not have GSM voice services on 1800 MHz.

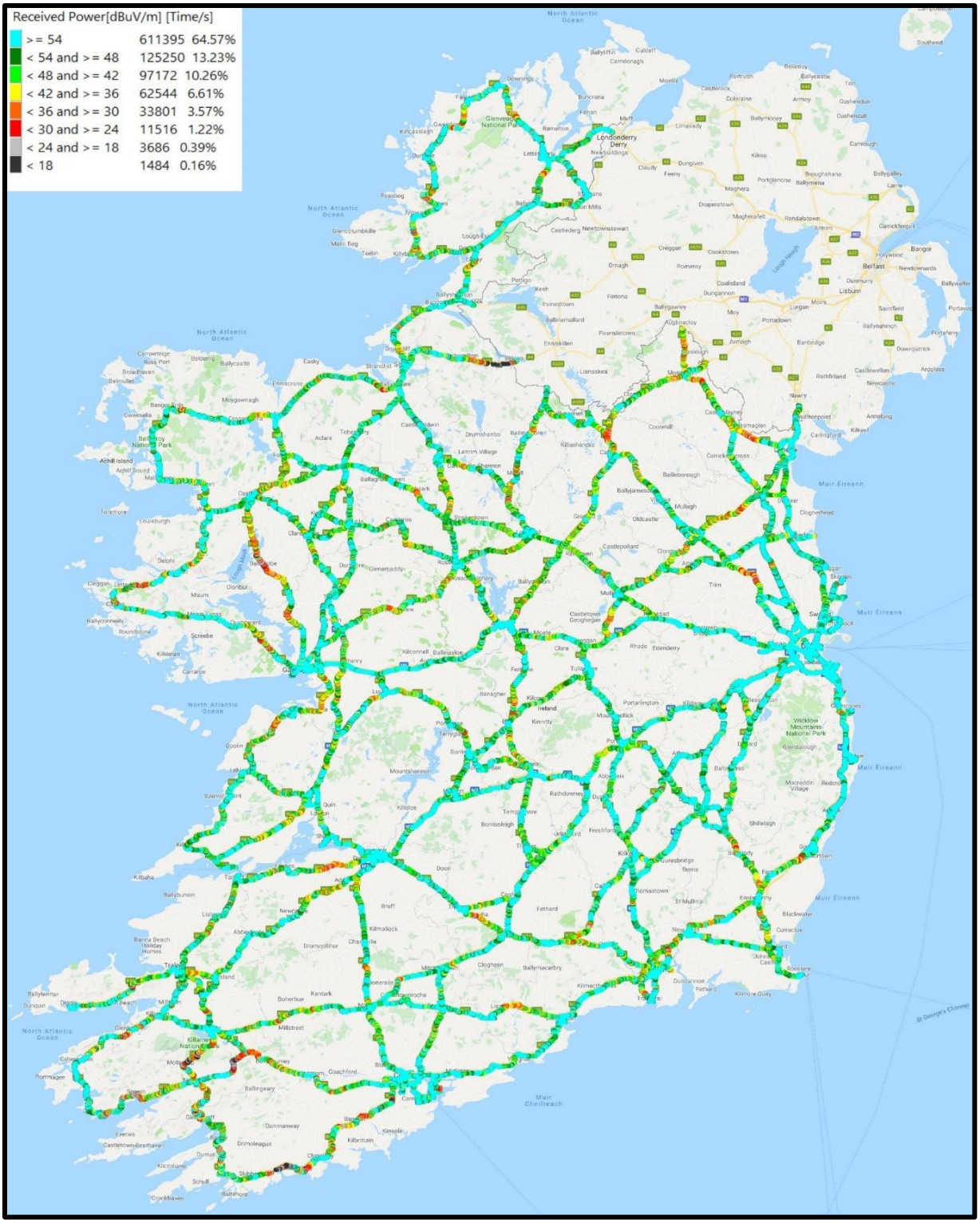

Figure 7: 3IHL No.1 Third Generation Licence – 2100 MHz (UMTS/HSDPA).

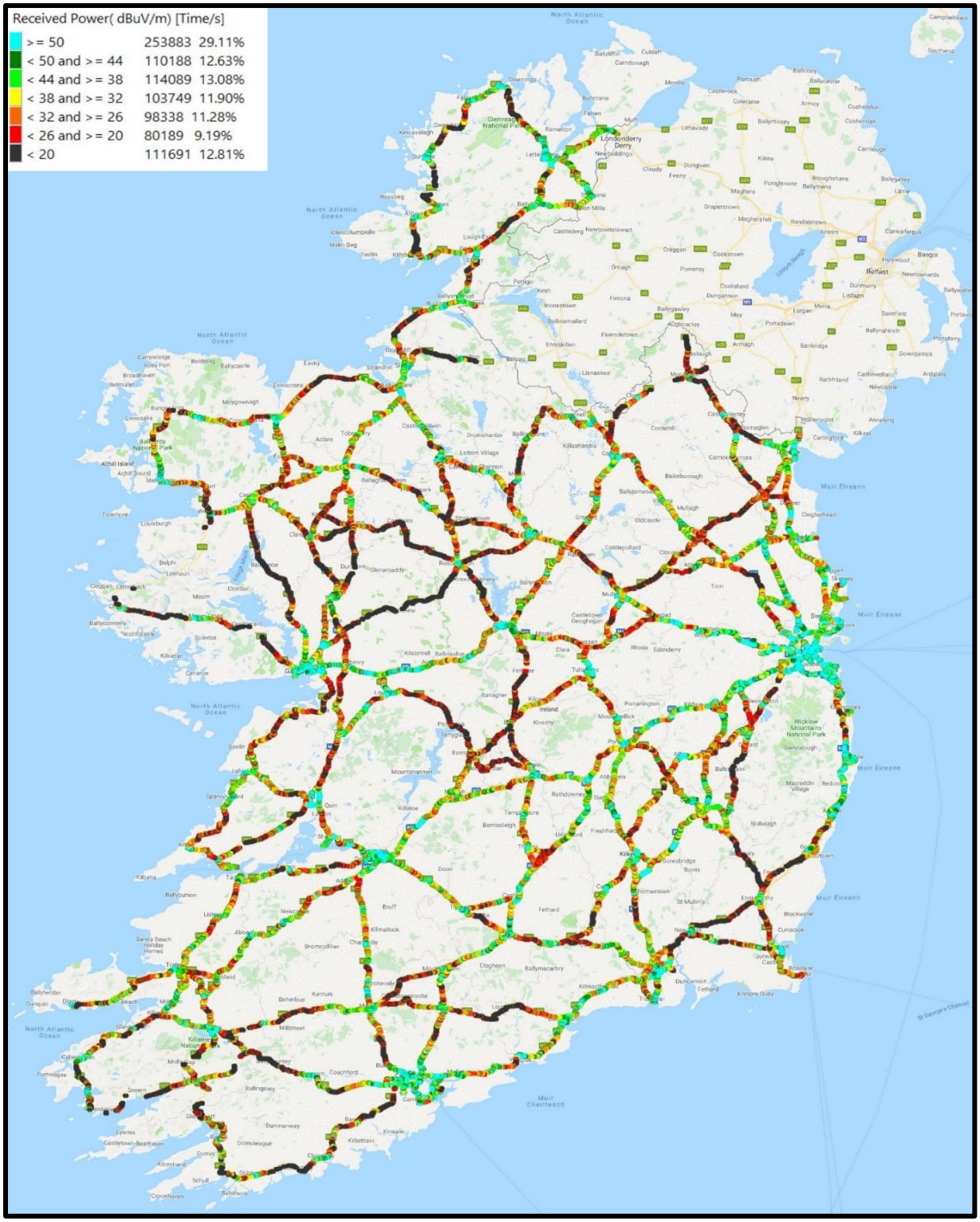

Figure 8: 3IHL No.1 Liberalised Use Licence – 1800 MHz (LTE[27]).

27 3IHL No.1 Licence does not have LTE services on 800 MHz.

4.3 3IHL No.2: Coverage Maps

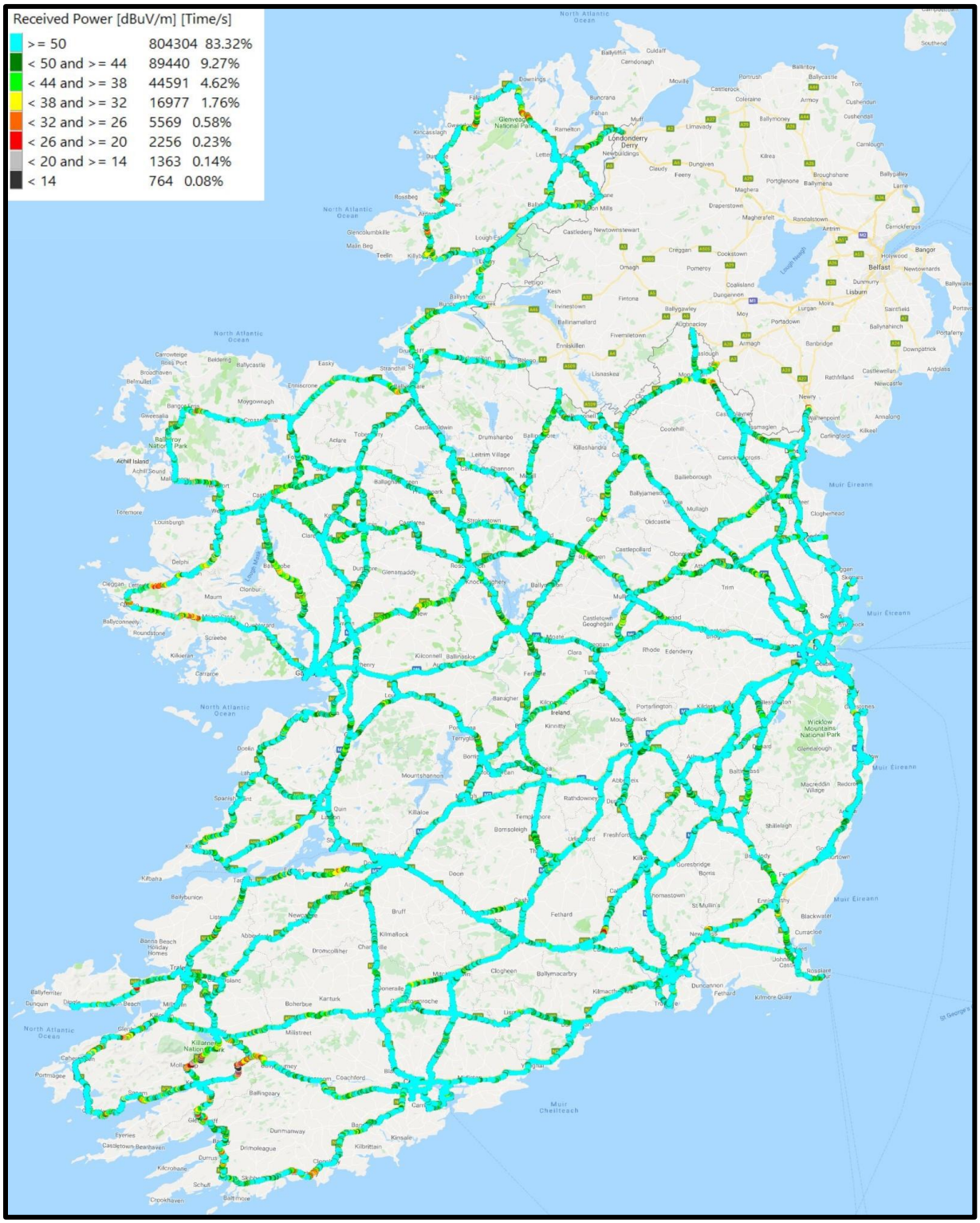

Figure 9: 3IHL No.2 Liberalised Use Licence – 900 MHz (UMTS/HSDPA).

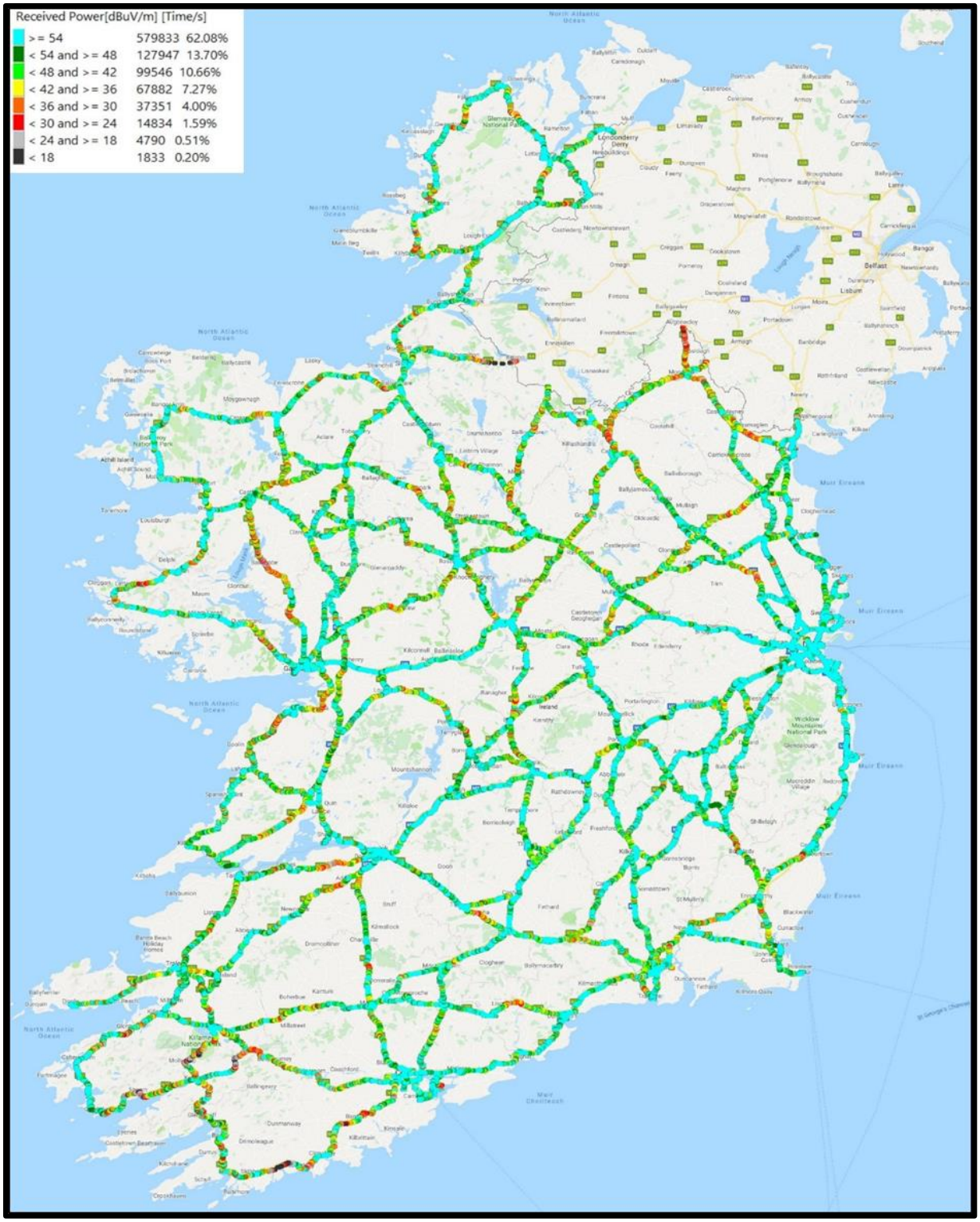

Figure 10: 3IHL No.2 Third Generation Licence – 2100 MHz (UMTS/HSDPA).

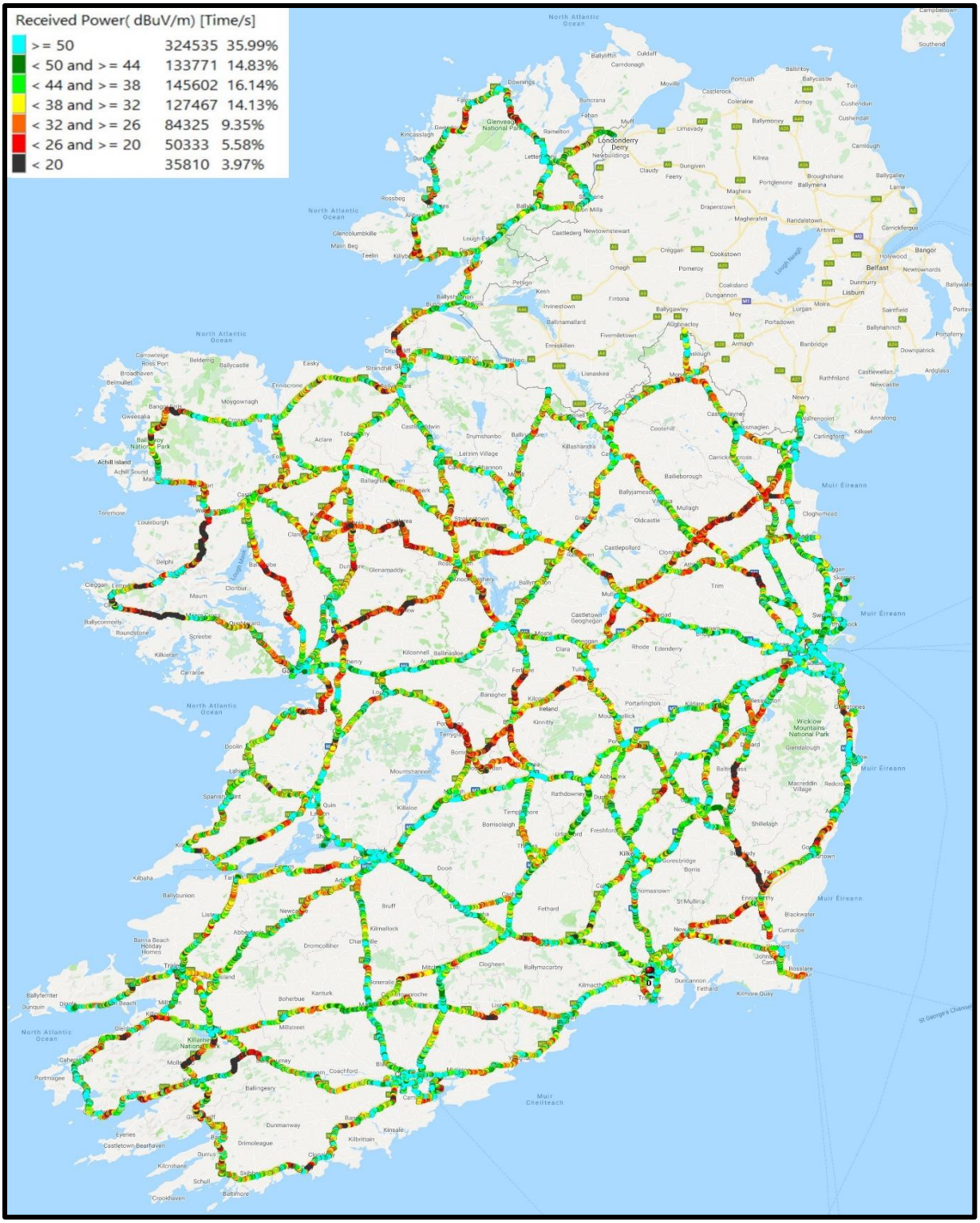

Figure 11: 3IHL No.2 Liberalised Use Licence – 800 and 1800 MHz (LTE).

4.4 Vodafone: Coverage Maps

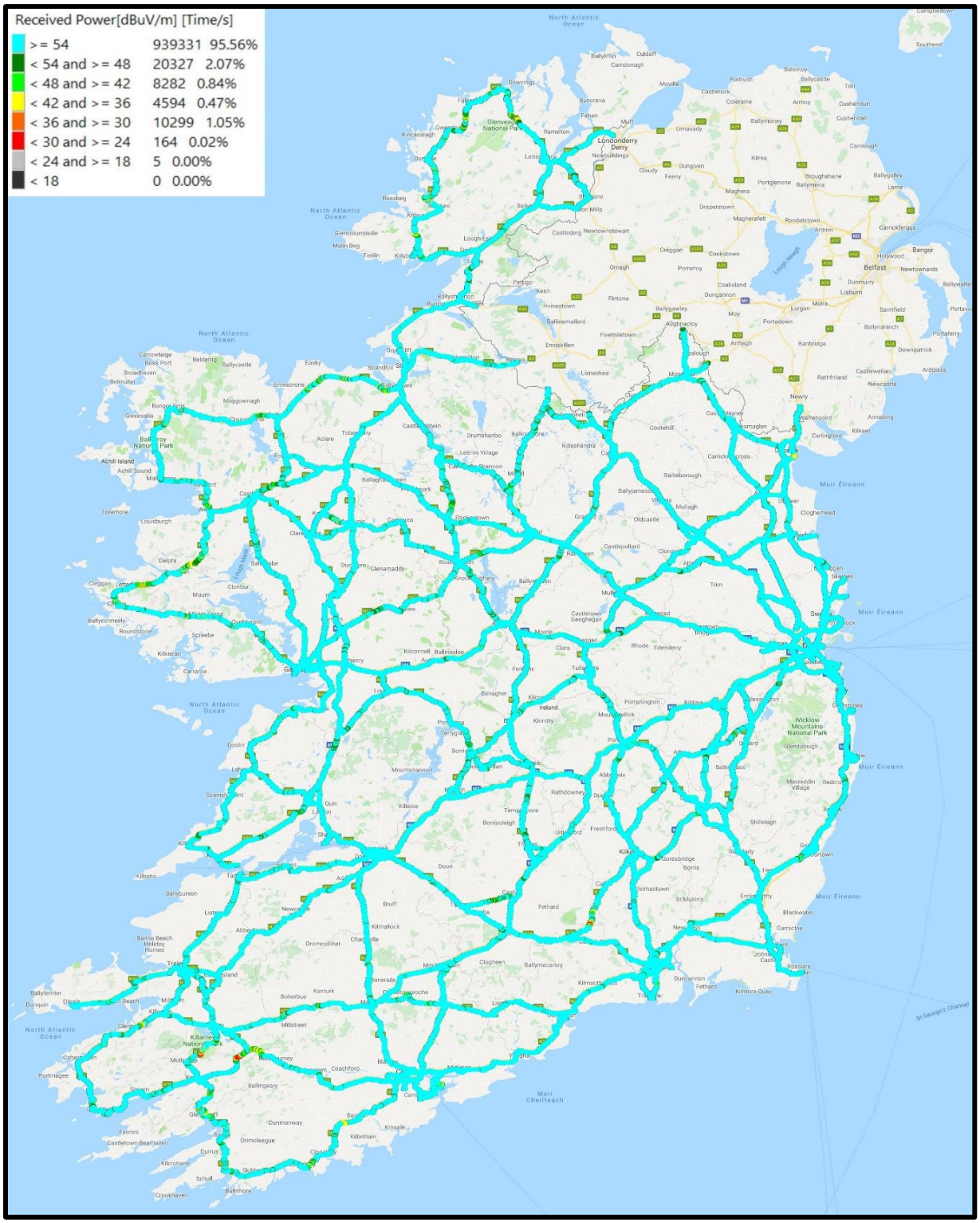

Figure 12: Vodafone Liberalised Use Licence - 900 and 1800 MHz (GSM).

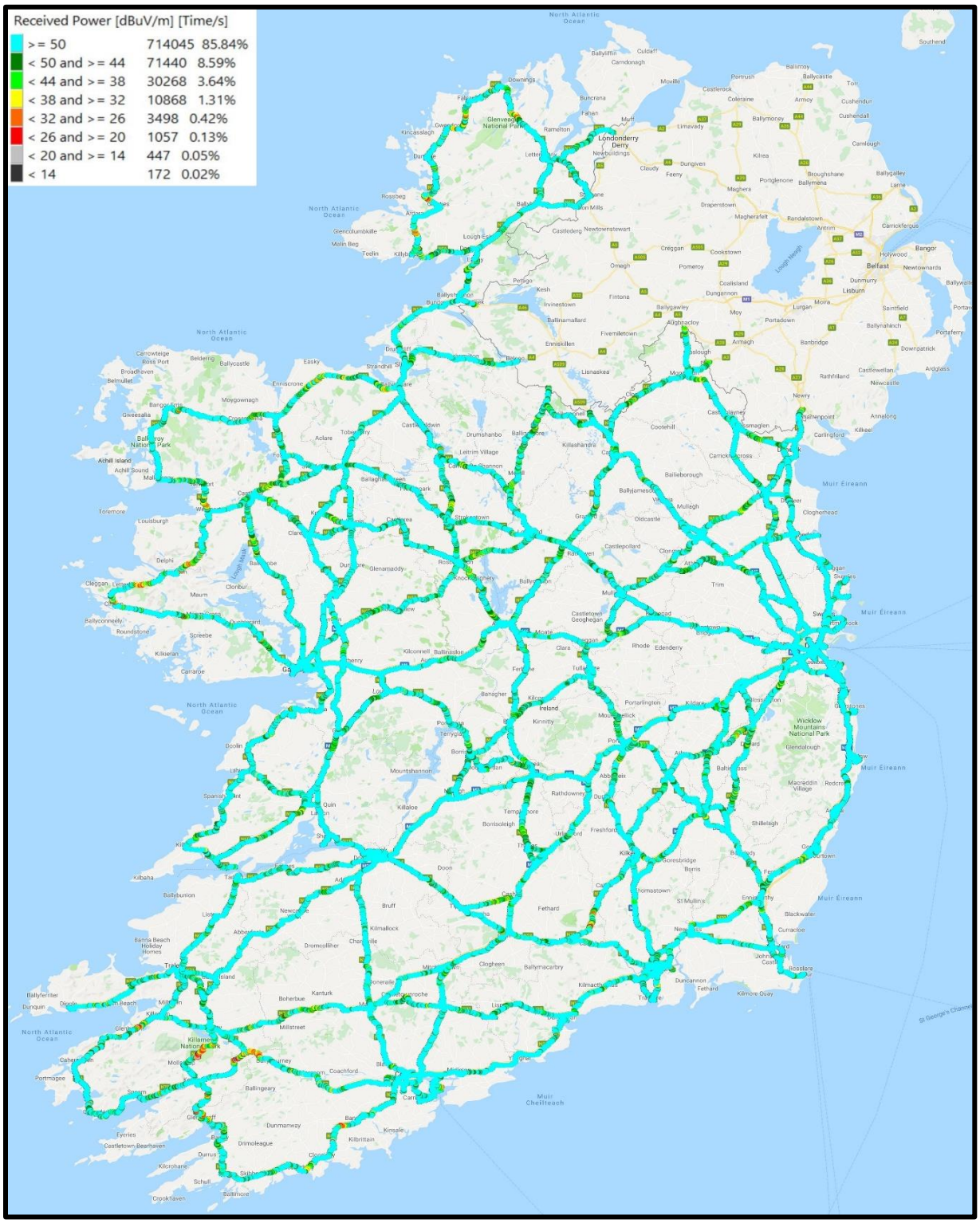

Figure 13: Vodafone Liberalised Use Licence – 900 MHz (UMTS/HSDPA).

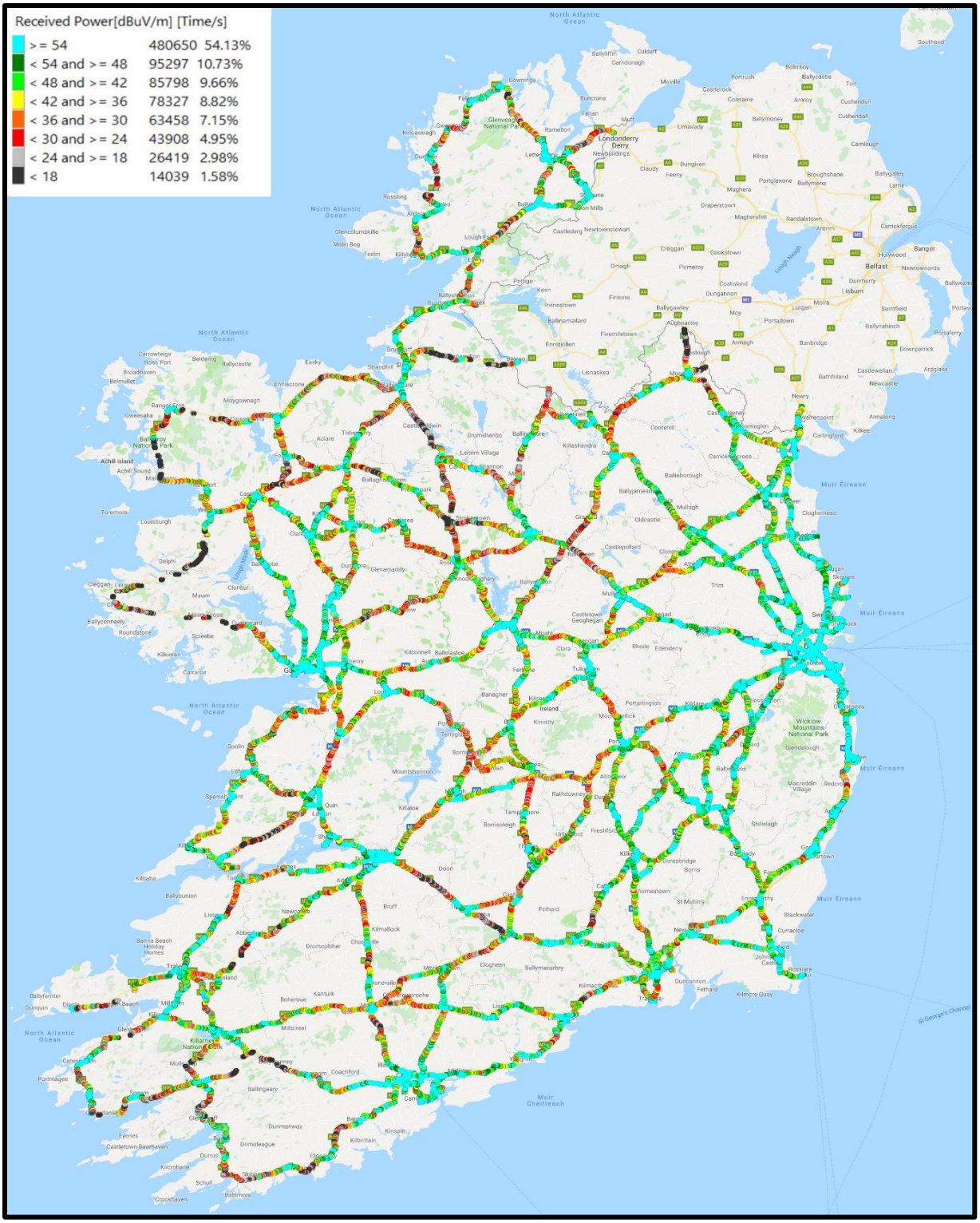

Figure 14: Vodafone Third Generation Licence – 2100 MHz (UMTS/HSDPA).

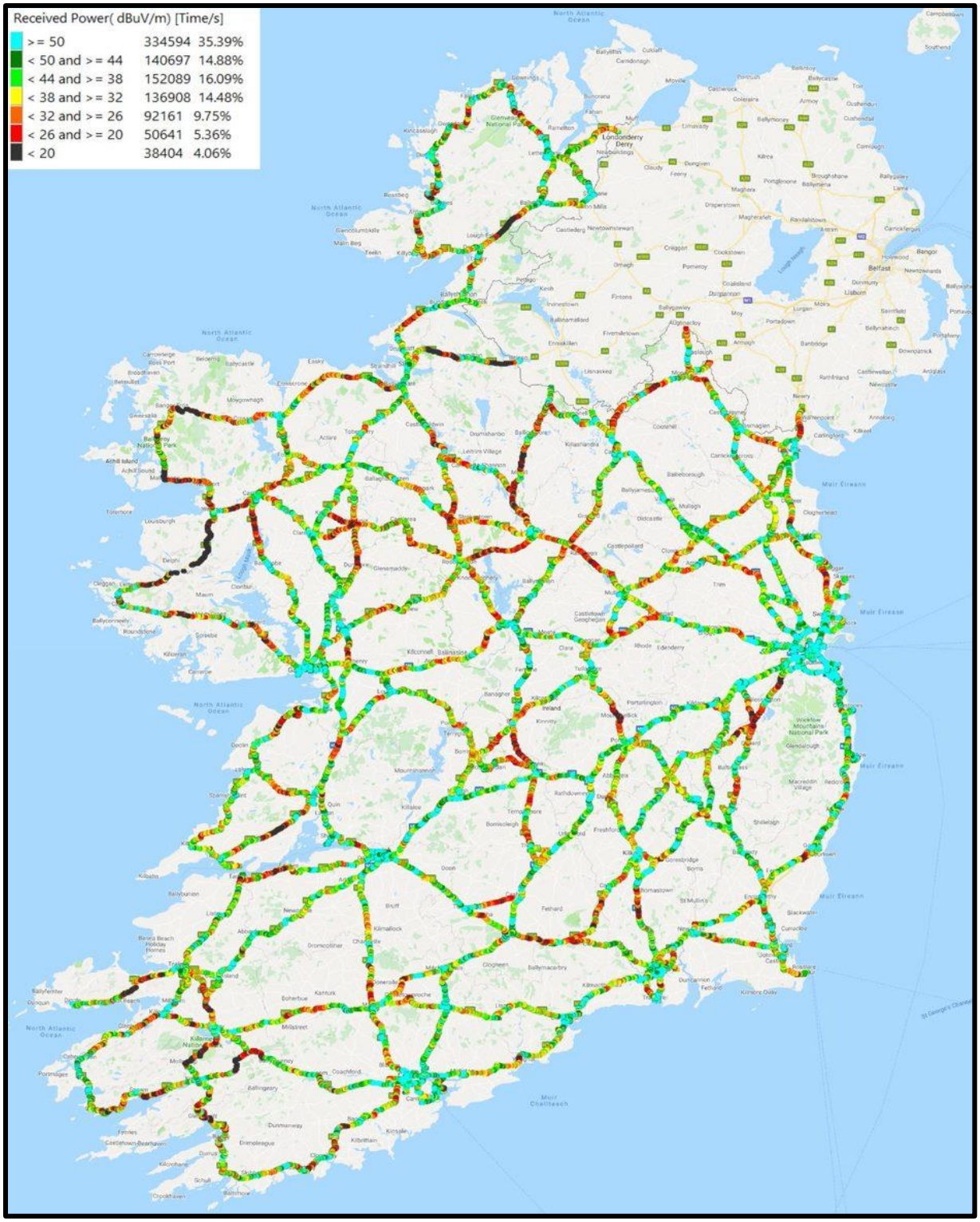

Figure 15: Vodafone Liberalised Use Licence – 800 and 1800 MHz (LTE).

5 Conclusions

5.1 General Comments

5. ComReg concludes that, given the results of the Drive Test that all Licensees have complied with their coverage obligations, under their respective Licences, to date. The results of the Drive Test have been collated and are presented in Table 2 below: as a minimum coverage threshold by population.

Table 2: Minimum Population Coverage.

Licensee	TGL/3G(2100)	LUL/LTE(800/1800)	LUL/GSM(900/1800)	LUL/3G(900)
Eir	>90%	>70%	>90%	>70%
3IHL No. 1	>90%	>70%	N/A	>70%
3IHL No. 2	>90%	>70%	>90%	>70%
Vodafone	>90%	>70%	>90%	>70%

5.2 Average Download Speeds

6. 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 measured are on average 2.4 times faster than those measured by 3G. In the mobile scenario LTE is approximately 2.7 times faster than 3G.

7. 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 from the serving cell, and the load on the network.

Table 3: Average Data Speeds achieved during the Drive Test.

Licensee	Technology	D/L Stationary[28] (Mbps)	D/L Mobile[29] (Mbps)
Eir	**3G**	9.9	7.5
	LTE	25.7	19.9
3IHL[30]	**3G**	9.9	7.9
	LTE	20.8	18.4
Vodafone	**3G**	11.4	7.0
	LTE	31.9	24.9

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

9. It is also important to note, as discussed previously in section 1.2 above, that higher data services, such as 3G and LTE are more susceptible to noise. Consequently such services require higher signal levels to maintain speed and quality.

28 These are the cumulative averages from measurements taken at 55 Locations throughout Ireland.

29 Average Vehicular Speed of 80kmph.

30 Note that as per footnote 5, 3IHL have indicated that all 3IHL Subscriber Identity Modules SIMs can use all of its assigned frequencies under either licence, as a result the Data Speed measurements are common to both 3IHL Licences.

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	The 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

Eir	Eircom Limited
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")
Hz	Unit of Frequency, one vibration per second
LTE	means the Long Term Evolution family of standards from European Telecommunications Standards Institute ("ETSI") and Third Generation Partnership Project ("3GPP");
LUL	Liberalised Use Licence
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
TGL	Third Generation Licence
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 Galaxy S9 test phones with Nemo Media Router application;
- A HTTP and FTP server based in Dublin; and
- Relevant SIM cards.

The equipment configuration is shown in Figure 17 below.

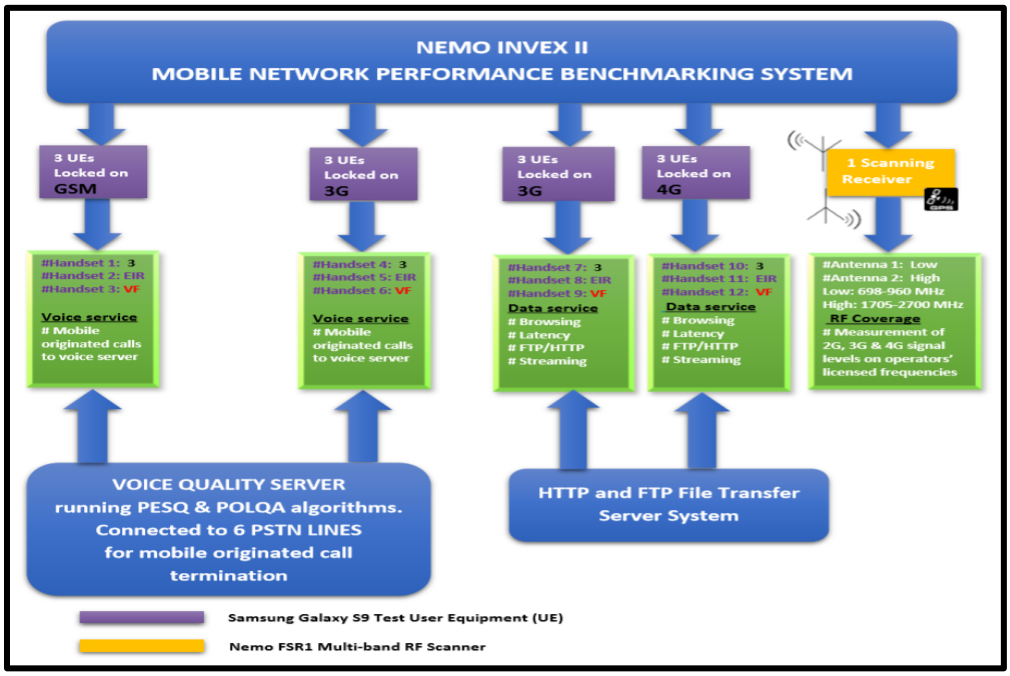

Figure 17: Drive Test Equipment Configuration.

Figures 18 and 19 below show the set up deployed in the measurement vehicle:

Figure 18: Measurement Set Up Showing Handsets.

Figure 19: Nemo Invex II, which connects to the Handsets.