Annex Three

Mobile Roaming Survey

Tests carried out 28 September – 1 October 2004

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Section One

Executive Summary

GSM users in the border regions of Northern/Southern Ireland have reported that they are experiencing situations where their cellphones have inadvertently registered on to a cellular network from across the border thus attracting higher than expected call charges.

As such reports are anecdotal, it is difficult to verify the scale of the problem. In order to attempt to quantify the extent of this problem, measurements were performed on all the GSM networks whilst travelling along a border route. The extensive data gathered confirmed that inadvertent roaming does occur at many locations all along the border and on both sides of the border: it is not confined to any one particular network operator.

Furthermore, roaming is complex and depends on the direction of travel.

It is entirely reasonable for the coverage of a network to extend up to the border of the country being served. It is also impossible to restrict the radio waves used by base stations to communicate with cellphones from extending across the border into the neighbouring country. Roaming occurs when the cellular handset chooses to register with the 'foreign' network as opposed to its preferred 'home' network. In broad terms, this occurs when the coverage and quality of the 'foreign' network is deemed by the handset to be better than the coverage and quality of the 'home' network.

This situation is not unique to Ireland. The UK is fortunate that it does not share land borders with any other country however this issue is commonplace within mainland Europe.

Each network overlaps into the neighbouring country at various locations along the border. The maps suggest that there are particular areas where the coverage provides an inadequate standard of service on a home network. Notable areas include the North shore of Carlingford Lough, the South Armagh – Monaghan border and parts of Fermanagh's border with Cavan, Leitrim and South Donegal. Certain measures to reduce or eliminate this problem which may be taken by the regulator, operators and end users are also considered.

Section Two

Background

GSM customers located in the border areas of Northern Ireland and the Irish Republic have reported instances where their cellular phones have inadvertently ‘roamed’ on to a ‘foreign’ cellular network thus attracting high call charges whilst making or receiving calls.

Ofcom’s Radio Monitoring Station at Baldock was asked if they could provide off-air measurements in an attempt to establish actual figures on an issue which has up to now been based on mainly anecdotal remarks.

ComReg, the Irish regulator, also expressed an interest in this type of survey and requested that similar measurements were performed on the Irish side of the border.

Section Three

Location of Measurements

Monitoring data was required for the full length of the border therefore a nominal route which traversed the border at several locations was planned by Ofcom colleagues in the Belfast office in consultation with ComReg. As far as possible, the same route was driven in both directions.

Local knowledge was used to focus measurements in areas which have attracted the most complaints. These tended to be in areas where a water border exists between the North and the South such as the Lough Foyle in the North and Carlingford Lough in the South East.

The full measurement route is shown in *Appendix 1*.

Section Four

Measurement Rationale and Method

It was considered that the most practical way of determining the extent of the GSM roaming problem was to mimic a GSM handset and monitor a real GSM connection.

As results were required along a large geographical area it was decided that rather than perform the measurements at specific fixed locations it would be more beneficial to gather the data whilst physically driving along a border route. This entailed the addition of a GPS unit in order to log the location of each measurement.

The aim was also to keep the equipment configuration as near as possible equivalent to a standard car fit (i.e. external dedicated GSM antenna on the roof of a vehicle) with a GSM data terminal replacing a standard mobile phone. The GSM data terminal chosen provided specific details relating to the network including the identification and signal strength of the currently registered base station. Additional information logged from the GSM modem included similar details from up to 6 neighbouring cells.

It is not possible to obtain details on one network and interpolate these to the remaining operators therefore data needed to be gathered on each of the four UK networks and the three Irish networks in order to provide a full picture on all networks available along the route.

To achieve the goal of simultaneously gathering data on all seven GSM networks it was necessary to operate with seven sets of independent equipment each containing a SIM card for the chosen GSM operator.

One additional data terminal was included primarily as a back-up unit in case of failure. Data was also gathered from this unit (operated without a SIM card present).

The magnitude of this measurement task dictated that some sort of automated measurements were most appropriate therefore custom software was developed to interrogate the eight GSM data modems and GPS receiver and store the results to disk.

The equipment used to obtain the data is shown in *Appendix Two*.

Section Five

Measurements

Each GSM data modem was configured to output network and signal level information every five seconds and a supplementary command was issued to determine the state of the network registration. Additional information relating to the number of visible and home cells and an estimation of the location of Base Stations was also calculated from the data obtained.

The combined results were stored in an integrated data file relating to each network. A sample of the data recorded and explanation of each field can be found in Appendix Three.

Most GSM handsets default to 'automatic network selection'. This means that when the handset determines that the home network is no longer available it will attempt to roam and register with a 'foreign' network. Once the user has been transferred from their home network to a foreign network, the handset will not return to its original home network until the same logic is followed i.e. the handset determines that the foreign network is unavailable. This means that the handset is effectively 'captured' and could remain roaming even when the home network is available.

In contrast, selecting 'manual network selection' will prevent the handset from roaming by limiting the choice of network only to the one selected manually. In this case, when the handset determines that the home network is not available it will enter a 'searching' mode and try to reconnect to the chosen network. This leaves the handset free to register with its home network whenever it is available again.

To tackle this phenomenon, the equipment was set to automatic network selection and allowed to roam as required on the outward journey but set to manual network registration on the return journey only allowing registration to the native network.

When reviewing the results of the manual network registration it should be noted that a 'home' network will still be recorded even if only one very weak cell (which would not support a conversation) is detected.

Section Six

Results

The data obtained during the measurement period (28th September to 1st October) amounted to around 60MB and was stored on the hard disk of the controlling PC. For each network this text-based original data was imported into Microsoft Excel and stored on two worksheets depicting automatic and manual network selection.

The excel spreadsheets contain full details on all the measurements collected during this exercise. These spreadsheets can be analysed in a number of different ways depending on the type of information required.

It should be noted that the signal level recorded in the result files is a number between 0 (weakest) and 63 (strongest). Whilst it is possible to equate these values to an actual dBm level this has not been performed as it is considered that the uncertainties introduced by the antenna, structure of the vehicle and the physical surroundings did not allow for a calibrated measurement regime.

Section Seven

Data Processing

The data contained in the spreadsheets was further processed by importing it into Microsoft MapPoint (widely available for a cost of around £200) allowing it to be presented in a graphical view by overlaying various parameters on maps.

The significant number of measurement points combined with the broad range of information gathered at each location makes it very difficult to summarise the findings in a concise way.

Appendix Four to this report contains some graphical displays created using MapPoint. They are intended to provide an indication of the type of display possible from the data collected. Additional graphs could be produced from the data on request.

The CD-ROM version of this report contains all the data gathered in both comma-delimited and Excel formats. These files are included as they can be analysed in greater detail with the emphasis based on a specific theme of interest and the results presented in the most suitable way.

The CD-ROM also contains MapPoint processed files used to produce the sample displays in Appendix 5. Using these files within MapPoint it is possible to zoom into an area of interest in order to obtain greater detail.

Section Eight

Additional Remarks and Comments

During this exercise no assessment has been made regarding signal quality. Whilst performing the measurements it was noted that calls received on the car GSM cellphone often exhibited discontinuous (chopped) audio or dropped out even when the measuring systems showed a reasonable signal level and a number of cells available.

It was also not uncommon to witness the situation where native networks from both sides of the border were roaming at the same time i.e. the O2 UK network was roaming to O2 Ireland at the same time as the O2 Ireland network was roaming to O2 UK.

The issue of inadvertent roaming is not limited to the geographical area covered in this report. The opportunity was taken to raise this all-embracing subject during a recent meeting of European monitoring representatives. The response showed that the issue of inadvertent roaming is relevant in all countries with shared borders however there is a varied approach to the problem.

Most countries promote complaints directly to the GSM operators and do not become involved letting market forces prevail. In extreme cases (either through a high level of user complaints or excessive penetration of a foreign network) the matter is referred upwards to the political level. One delegate, who used to work for a continental operator, stated that they actively targeted users in neighbouring countries configuring their network to maximise this source of revenue.

Whilst travelling along the border route collecting the measurement data, it was observed that some base stations were located on elevated terrain within a few hundred metres of the border (such as the Lifford / Strabane area and the prominent hills around Ballyconnell). This will obviously enhance the coverage into the opposite country and only serve to exasperate the problem.

Whilst it may be possible to identify areas from the data gathered where a network in one country has a sizeable penetration into the neighbouring country it is considered that this is broadly equal although, on balance, slightly more base stations on prominent sites were noted to the south of the border.

This is suggested by studying of the maps at the end of Appendix 5 which would suggest that, on balance, the majority of base stations located close to the border area are operated by O2 Ireland and Vodafone Ireland.

As stated previously, it is always possible to find an exception to the rule and it is probable that there are locations where the situation described is reversed.

As a large area was covered (entire length of the border) this exercise must be viewed as a top level review and it may be beneficial to undertake further more detailed observations at key locations at a later date.

It is also acknowledged that, whilst the reasoning behind GSM cell and network handover is universal, individual manufacturers may implement the logic another way thus making discrete handsets behave differently.

Section Nine

Recommendations

The following recommendations are made with a view to reducing or eliminating instances of inadvertent roaming.

End users can:

- Select an operator which has good coverage in the area of interest. Roaming generally takes place when the home network coverage is deficient or absent therefore opting for a network operator with good coverage will reduce this effect.
- Select 'Manual' network selection on the GSM handset. This will prevent roaming taking place and only allow registration on the selected (home) network. It will also prevent incoming roamed calls that the user may be unaware of. It should be recognised that if coverage of the home network is absent then the user will lose communication (except for emergency calls)

Network operators can:

- Investigate the possibility of waiving international call charges on cellphone subscribers who live in the border area. This could either be based on a number of base stations designated to be in the border area or relate to individual subscriber numbers previously notified to the network operators.
- Offer solutions like the suppressing of roaming with operators in the neighbouring country although this may not be acceptable to the end user.
- Improve local coverage if their customers are experiencing inadvertent roaming.

Regulators could:

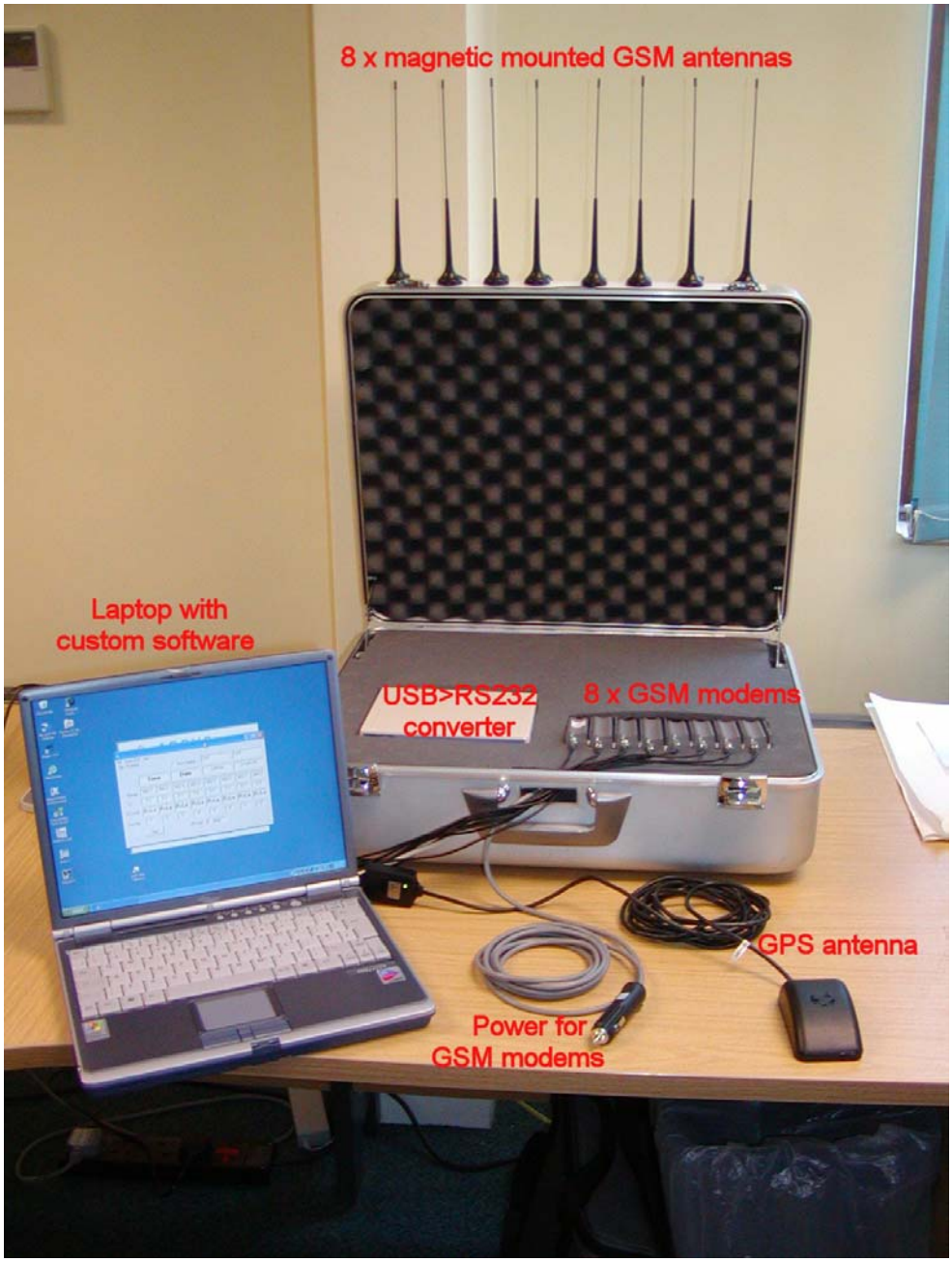
- Promote awareness of the options listed above to the end user.
- Investigate the possibility of hosting 'foreign' base stations with directional antennas in areas such as Carlingford Lough where coverage of one country could best be obtained from another. It is recognised that there will be legal implications surrounding this option which may render it unachievable.

It is recognised that a number of the measures detailed above would not necessarily benefit the 'tourist' or visiting cellphone user.

Appendix 1 – Route taken

The following map details the route taken over the measurement period.

Appendix 2 – Monitoring Equipment



Equipment list:

GSM Magnetic-mount antenna (x 8)	GSM20-ANT
GSM Data Modem (x8)	Maestro 100T modem
USB to 8 x RS232 converter	Quatech ESU100
GPS antenna/receiver	USB GPS Mouse
Logging PC	PC running custom software

GSM Data Modem info at: http://www.rfsolutions.co.uk/acatalog/GSM_Modems.html

Appendix 3 – Sample data from GSM data modem

The command **+CCED** returns information regarding the

This will return something similar to the following:
+CCED:234,33,0287,42f7,41,783,33,,,0,,,0,234,33,0fe3,5d31,10,845,9,234,33
,0287,42f6,47,867,23,234,33,00a0,b345,17,824,22,234,33,003b,071f,55,791,
18,234,33,0fe3,4eb1,14,837,20,234,33,0287,090f,45,812,19,0

This long text line can de difficult to read manually however it is clearer when viewed with a few line feeds and column headings inserted as follows:

MCC	MNC	LAC	CI	BSIC	BCCH	RxLev	Others
234,	33,	0287,	42f7,	41,	783,	33,	,,0,,,0,
234,	33,	0fe3,	5d31,	10,	845,	9,	
234,	33,	0287,	42f6,	47,	867,	23,	
234,	33,	00a0,	b345,	17,	824,	22,	
234,	33,	003b,	071f,	55,	791,	18,	
234,	33,	0fe3,	4eb1,	14,	837,	20,	
234,	33,	0287,	090f,	45,	812,	19,	0

The acronyms above stand for:

MCC	Mobile Country Code	Three digits (234=UK, 272=IRL)
MNC	Mobile Network Code	Two digits (see #1 below)
LAC	Location Area Code	Hex number
CI	Channel Identity	Hex number
BSIC	Base Station Identity Code	'Colour code'
BCCH	Broadcast Control Channel	RF channel (see #2 below)
RxLev	Received power level	0 – 63 (can be converted to dBm)

Note #1
01=Vodafone Ireland, 02=O2 Ireland, 03=Meteor Ireland, 10=O2 UK,
15=Vodafone UK,
30=T-Mobile UK, 33=Orange UK

Note #2
The BCCH (RF) channel can be translated into a frequency using the table listed in *Appendix 4*. e.g. a BCCH of 783 equates to base transmit frequency 1859.4 MHz

This data is combined with Latitude, Longitude, Time (in GMT) and Date information from the GPS receiver plus some calculated fields to produce the final saved data similar to the example given below:

29/09/04,07:45:50,54.1873225068,-6.3773999034,1, 7 ,234,10,048b,573f,18,101,42 (etc)
29/09/04,07:45:55,54.1870258521,-6.3786731858,1, 7 ,234,10,048b,573f,18,101,35 (etc)
29/09/04,07:46:00,54.1867075314,-6.3800214652,1, 7 ,234,10,048b,,18,112,40 (etc)
29/09/04,07:46:05,54.1864175431,-6.3814130762,1, 7 ,234,10,048b,9751,18,112,39 (etc)

Appendix 4 – GSM Channel to frequency decode table

Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile
1	935.2	890.2	36	942.2	897.2	71	949.2	904.2	106	956.2	911.2	527	1,808.2	1,713.2
2	935.4	890.4	37	942.4	897.4	72	949.4	904.4	107	956.4	911.4	528	1,808.4	1,713.4
3	935.6	890.6	38	942.6	897.6	73	949.6	904.6	108	956.6	911.6	529	1,808.6	1,713.6
4	935.8	890.8	39	942.8	897.8	74	949.8	904.8	109	956.8	911.8	530	1,808.8	1,713.8
5	936.0	891.0	40	943.0	898.0	75	950.0	905.0	110	957.0	912.0	531	1,809.0	1,714.0
6	936.2	891.2	41	943.2	898.2	76	950.2	905.2	111	957.2	912.2	532	1,809.2	1,714.2
7	936.4	891.4	42	943.4	898.4	77	950.4	905.4	112	957.4	912.4	533	1,809.4	1,714.4
8	936.6	891.6	43	943.6	898.6	78	950.6	905.6	113	957.6	912.6	534	1,809.6	1,714.6
9	936.8	891.8	44	943.8	898.8	79	950.8	905.8	114	957.8	912.8	535	1,809.8	1,714.8
10	937.0	892.0	45	944.0	899.0	80	951.0	906.0	115	958.0	913.0	536	1,810.0	1,715.0
11	937.2	892.2	46	944.2	899.2	81	951.2	906.2	116	958.2	913.2	537	1,810.2	1,715.2
12	937.4	892.4	47	944.4	899.4	82	951.4	906.4	117	958.4	913.4	538	1,810.4	1,715.4
13	937.6	892.6	48	944.6	899.6	83	951.6	906.6	118	958.6	913.6	539	1,810.6	1,715.6
14	937.8	892.8	49	944.8	899.8	84	951.8	906.8	119	958.8	913.8	540	1,810.8	1,715.8
15	938.0	893.0	50	945.0	900.0	85	952.0	907.0	120	959.0	914.0	541	1,811.0	1,716.0
16	938.2	893.2	51	945.2	900.2	86	952.2	907.2	121	959.2	914.2	542	1,811.2	1,716.2
17	938.4	893.4	52	945.4	900.4	87	952.4	907.4	122	959.4	914.4	543	1,811.4	1,716.4
18	938.6	893.6	53	945.6	900.6	88	952.6	907.6	123	959.6	914.6	544	1,811.6	1,716.6
19	938.8	893.8	54	945.8	900.8	89	952.8	907.8	124	959.8	914.8	545	1,811.8	1,716.8
20	939.0	894.0	55	946.0	901.0	90	953.0	908.0				546	1,812.0	1,717.0
21	939.2	894.2	56	946.2	901.2	91	953.2	908.2	512	1,805.2	1,710.2	547	1,812.2	1,717.2
22	939.4	894.4	57	946.4	901.4	92	953.4	908.4	513	1,805.4	1,710.4	548	1,812.4	1,717.4
23	939.6	894.6	58	946.6	901.6	93	953.6	908.6	514	1,805.6	1,710.6	549	1,812.6	1,717.6
24	939.8	894.8	59	946.8	901.8	94	953.8	908.8	515	1,805.8	1,710.8	550	1,812.8	1,717.8
25	940.0	895.0	60	947.0	902.0	95	954.0	909.0	516	1,806.0	1,711.0	551	1,813.0	1,718.0
26	940.2	895.2	61	947.2	902.2	96	954.2	909.2	517	1,806.2	1,711.2	552	1,813.2	1,718.2
27	940.4	895.4	62	947.4	902.4	97	954.4	909.4	518	1,806.4	1,711.4	553	1,813.4	1,718.4
28	940.6	895.6	63	947.6	902.6	98	954.6	909.6	519	1,806.6	1,711.6	554	1,813.6	1,718.6
29	940.8	895.8	64	947.8	902.8	99	954.8	909.8	520	1,806.8	1,711.8	555	1,813.8	1,718.8
30	941.0	896.0	65	948.0	903.0	100	955.0	910.0	521	1,807.0	1,712.0	556	1,814.0	1,719.0
31	941.2	896.2	66	948.2	903.2	101	955.2	910.2	522	1,807.2	1,712.2	557	1,814.2	1,719.2
32	941.4	896.4	67	948.4	903.4	102	955.4	910.4	523	1,807.4	1,712.4	558	1,814.4	1,719.4
33	941.6	896.6	68	948.6	903.6	103	955.6	910.6	524	1,807.6	1,712.6	559	1,814.6	1,719.6
34	941.8	896.8	69	948.8	903.8	104	955.8	910.8	525	1,807.8	1,712.8	560	1,814.8	1,719.8
35	942.0	897.0	70	949.0	904.0	105	956.0	911.0	526	1,808.0	1,713.0	561	1,815.0	1,720.0

Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile
562	1,815.2	1,720.2	597	1,822.2	1,727.2	632	1,829.2	1,734.2	667	1,836.2	1,741.2	702	1,843.2	1,748.2
563	1,815.4	1,720.4	598	1,822.4	1,727.4	633	1,829.4	1,734.4	668	1,836.4	1,741.4	703	1,843.4	1,748.4
564	1,815.6	1,720.6	599	1,822.6	1,727.6	634	1,829.6	1,734.6	669	1,836.6	1,741.6	704	1,843.6	1,748.6
565	1,815.8	1,720.8	600	1,822.8	1,727.8	635	1,829.8	1,734.8	670	1,836.8	1,741.8	705	1,843.8	1,748.8
566	1,816.0	1,721.0	601	1,823.0	1,728.0	636	1,830.0	1,735.0	671	1,837.0	1,742.0	706	1,844.0	1,749.0
567	1,816.2	1,721.2	602	1,823.2	1,728.2	637	1,830.2	1,735.2	672	1,837.2	1,742.2	707	1,844.2	1,749.2
568	1,816.4	1,721.4	603	1,823.4	1,728.4	638	1,830.4	1,735.4	673	1,837.4	1,742.4	708	1,844.4	1,749.4
569	1,816.6	1,721.6	604	1,823.6	1,728.6	639	1,830.6	1,735.6	674	1,837.6	1,742.6	709	1,844.6	1,749.6
570	1,816.8	1,721.8	605	1,823.8	1,728.8	640	1,830.8	1,735.8	675	1,837.8	1,742.8	710	1,844.8	1,749.8
571	1,817.0	1,722.0	606	1,824.0	1,729.0	641	1,831.0	1,736.0	676	1,838.0	1,743.0	711	1,845.0	1,750.0
572	1,817.2	1,722.2	607	1,824.2	1,729.2	642	1,831.2	1,736.2	677	1,838.2	1,743.2	712	1,845.2	1,750.2
573	1,817.4	1,722.4	608	1,824.4	1,729.4	643	1,831.4	1,736.4	678	1,838.4	1,743.4	713	1,845.4	1,750.4
574	1,817.6	1,722.6	609	1,824.6	1,729.6	644	1,831.6	1,736.6	679	1,838.6	1,743.6	714	1,845.6	1,750.6
575	1,817.8	1,722.8	610	1,824.8	1,729.8	645	1,831.8	1,736.8	680	1,838.8	1,743.8	715	1,845.8	1,750.8
576	1,818.0	1,723.0	611	1,825.0	1,730.0	646	1,832.0	1,737.0	681	1,839.0	1,744.0	716	1,846.0	1,751.0
577	1,818.2	1,723.2	612	1,825.2	1,730.2	647	1,832.2	1,737.2	682	1,839.2	1,744.2	717	1,846.2	1,751.2
578	1,818.4	1,723.4	613	1,825.4	1,730.4	648	1,832.4	1,737.4	683	1,839.4	1,744.4	718	1,846.4	1,751.4
579	1,818.6	1,723.6	614	1,825.6	1,730.6	649	1,832.6	1,737.6	684	1,839.6	1,744.6	719	1,846.6	1,751.6
580	1,818.8	1,723.8	615	1,825.8	1,730.8	650	1,832.8	1,737.8	685	1,839.8	1,744.8	720	1,846.8	1,751.8
581	1,819.0	1,724.0	616	1,826.0	1,731.0	651	1,833.0	1,738.0	686	1,840.0	1,745.0	721	1,847.0	1,752.0
582	1,819.2	1,724.2	617	1,826.2	1,731.2	652	1,833.2	1,738.2	687	1,840.2	1,745.2	722	1,847.2	1,752.2
583	1,819.4	1,724.4	618	1,826.4	1,731.4	653	1,833.4	1,738.4	688	1,840.4	1,745.4	723	1,847.4	1,752.4
584	1,819.6	1,724.6	619	1,826.6	1,731.6	654	1,833.6	1,738.6	689	1,840.6	1,745.6	724	1,847.6	1,752.6
585	1,819.8	1,724.8	620	1,826.8	1,731.8	655	1,833.8	1,738.8	690	1,840.8	1,745.8	725	1,847.8	1,752.8
586	1,820.0	1,725.0	621	1,827.0	1,732.0	656	1,834.0	1,739.0	691	1,841.0	1,746.0	726	1,848.0	1,753.0
587	1,820.2	1,725.2	622	1,827.2	1,732.2	657	1,834.2	1,739.2	692	1,841.2	1,746.2	727	1,848.2	1,753.2
588	1,820.4	1,725.4	623	1,827.4	1,732.4	658	1,834.4	1,739.4	693	1,841.4	1,746.4	728	1,848.4	1,753.4
589	1,820.6	1,725.6	624	1,827.6	1,732.6	659	1,834.6	1,739.6	694	1,841.6	1,746.6	729	1,848.6	1,753.6
590	1,820.8	1,725.8	625	1,827.8	1,732.8	660	1,834.8	1,739.8	695	1,841.8	1,746.8	730	1,848.8	1,753.8
591	1,821.0	1,726.0	626	1,828.0	1,733.0	661	1,835.0	1,740.0	696	1,842.0	1,747.0	731	1,849.0	1,754.0
592	1,821.2	1,726.2	627	1,828.2	1,733.2	662	1,835.2	1,740.2	697	1,842.2	1,747.2	732	1,849.2	1,754.2
593	1,821.4	1,726.4	628	1,828.4	1,733.4	663	1,835.4	1,740.4	698	1,842.4	1,747.4	733	1,849.4	1,754.4
594	1,821.6	1,726.6	629	1,828.6	1,733.6	664	1,835.6	1,740.6	699	1,842.6	1,747.6	734	1,849.6	1,754.6
595	1,821.8	1,726.8	630	1,828.8	1,733.8	665	1,835.8	1,740.8	700	1,842.8	1,747.8	735	1,849.8	1,754.8
596	1,822.0	1,727.0	631	1,829.0	1,734.0	666	1,836.0	1,741.0	701	1,843.0	1,748.0	736	1,850.0	1,755.0

Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile	Chan	Base	Mobile

737	1,850.2	1,755.2	772	1,857.2	1,762.2	807	1,864.2	1,769.2	842	1,871.2	1,776.2	877	1,878.2	1,783.2
738	1,850.4	1,755.4	773	1,857.4	1,762.4	808	1,864.4	1,769.4	843	1,871.4	1,776.4	878	1,878.4	1,783.4
739	1,850.6	1,755.6	774	1,857.6	1,762.6	809	1,864.6	1,769.6	844	1,871.6	1,776.6	879	1,878.6	1,783.6
740	1,850.8	1,755.8	775	1,857.8	1,762.8	810	1,864.8	1,769.8	845	1,871.8	1,776.8	880	1,878.8	1,783.8
741	1,851.0	1,756.0	776	1,858.0	1,763.0	811	1,865.0	1,770.0	846	1,872.0	1,777.0	881	1,879.0	1,784.0
742	1,851.2	1,756.2	777	1,858.2	1,763.2	812	1,865.2	1,770.2	847	1,872.2	1,777.2	882	1,879.2	1,784.2
743	1,851.4	1,756.4	778	1,858.4	1,763.4	813	1,865.4	1,770.4	848	1,872.4	1,777.4	883	1,879.4	1,784.4
744	1,851.6	1,756.6	779	1,858.6	1,763.6	814	1,865.6	1,770.6	849	1,872.6	1,777.6	884	1,879.6	1,784.6
745	1,851.8	1,756.8	780	1,858.8	1,763.8	815	1,865.8	1,770.8	850	1,872.8	1,777.8	885	1,879.8	1,784.8
746	1,852.0	1,757.0	781	1,859.0	1,764.0	816	1,866.0	1,771.0	851	1,873.0	1,778.0			
747	1,852.2	1,757.2	782	1,859.2	1,764.2	817	1,866.2	1,771.2	852	1,873.2	1,778.2			
748	1,852.4	1,757.4	783	1,859.4	1,764.4	818	1,866.4	1,771.4	853	1,873.4	1,778.4			
749	1,852.6	1,757.6	784	1,859.6	1,764.6	819	1,866.6	1,771.6	854	1,873.6	1,778.6			
750	1,852.8	1,757.8	785	1,859.8	1,764.8	820	1,866.8	1,771.8	855	1,873.8	1,778.8			
751	1,853.0	1,758.0	786	1,860.0	1,765.0	821	1,867.0	1,772.0	856	1,874.0	1,779.0			
752	1,853.2	1,758.2	787	1,860.2	1,765.2	822	1,867.2	1,772.2	857	1,874.2	1,779.2			
753	1,853.4	1,758.4	788	1,860.4	1,765.4	823	1,867.4	1,772.4	858	1,874.4	1,779.4			
754	1,853.6	1,758.6	789	1,860.6	1,765.6	824	1,867.6	1,772.6	859	1,874.6	1,779.6			
755	1,853.8	1,758.8	790	1,860.8	1,765.8	825	1,867.8	1,772.8	860	1,874.8	1,779.8			
756	1,854.0	1,759.0	791	1,861.0	1,766.0	826	1,868.0	1,773.0	861	1,875.0	1,780.0			
757	1,854.2	1,759.2	792	1,861.2	1,766.2	827	1,868.2	1,773.2	862	1,875.2	1,780.2			
758	1,854.4	1,759.4	793	1,861.4	1,766.4	828	1,868.4	1,773.4	863	1,875.4	1,780.4			
759	1,854.6	1,759.6	794	1,861.6	1,766.6	829	1,868.6	1,773.6	864	1,875.6	1,780.6			
760	1,854.8	1,759.8	795	1,861.8	1,766.8	830	1,868.8	1,773.8	865	1,875.8	1,780.8			
761	1,855.0	1,760.0	796	1,862.0	1,767.0	831	1,869.0	1,774.0	866	1,876.0	1,781.0			
762	1,855.2	1,760.2	797	1,862.2	1,767.2	832	1,869.2	1,774.2	867	1,876.2	1,781.2			
763	1,855.4	1,760.4	798	1,862.4	1,767.4	833	1,869.4	1,774.4	868	1,876.4	1,781.4			
764	1,855.6	1,760.6	799	1,862.6	1,767.6	834	1,869.6	1,774.6	869	1,876.6	1,781.6			
765	1,855.8	1,760.8	800	1,862.8	1,767.8	835	1,869.8	1,774.8	870	1,876.8	1,781.8			
766	1,856.0	1,761.0	801	1,863.0	1,768.0	836	1,870.0	1,775.0	871	1,877.0	1,782.0			
767	1,856.2	1,761.2	802	1,863.2	1,768.2	837	1,870.2	1,775.2	872	1,877.2	1,782.2			
768	1,856.4	1,761.4	803	1,863.4	1,768.4	838	1,870.4	1,775.4	873	1,877.4	1,782.4			
769	1,856.6	1,761.6	804	1,863.6	1,768.6	839	1,870.6	1,775.6	874	1,877.6	1,782.6			
770	1,856.8	1,761.8	805	1,863.8	1,768.8	840	1,870.8	1,775.8	875	1,877.8	1,782.8			
771	1,857.0	1,762.0	806	1,864.0	1,769.0	841	1,871.0	1,776.0	876	1,878.0	1,783.0			

Appendix 5 – Mapping of data gathered

The following pages contain illustrative maps showing the type of presentations possible based on the data gathered. These are by no means exhaustive and serve only as examples of the type of analysis possible from the data gathered.

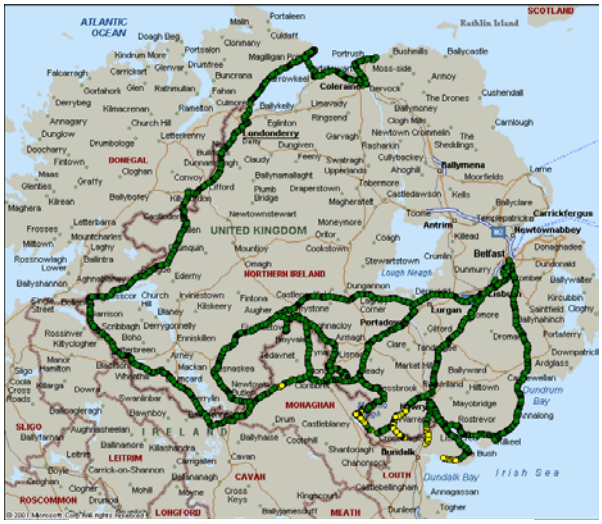
The first set of maps show the network each GSM modem was registered with during the measurements whilst in both manual and automatic network selection modes. Another view has been included to show the number of 'home' cells available to the GSM modem which serves to illustrate where coverage of the home network is patchy by way of lighter shading.

For each representation, the area around Newry has also been shown expanded to indicate that greater detail is possible when viewing the source data using an interactive mapping tool such as MapPoint. It was not practical to include more detailed views of all other areas in this report.

Maps are also included to show further information relating to the roaming pattern of Meteor Ireland due to a distinctive national roaming arrangement allowing roaming within the same country which is not the case with the other networks.

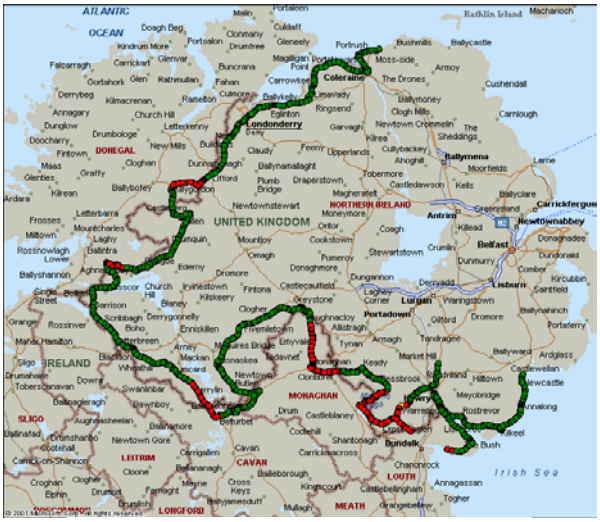
O2 UK

Manual network selection



● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection

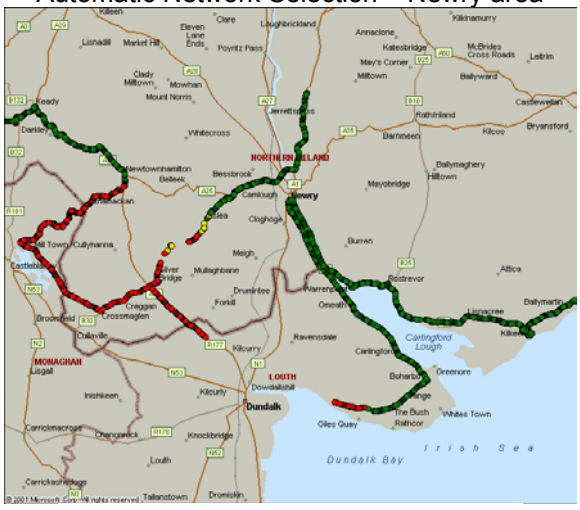


● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area

● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area



● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available

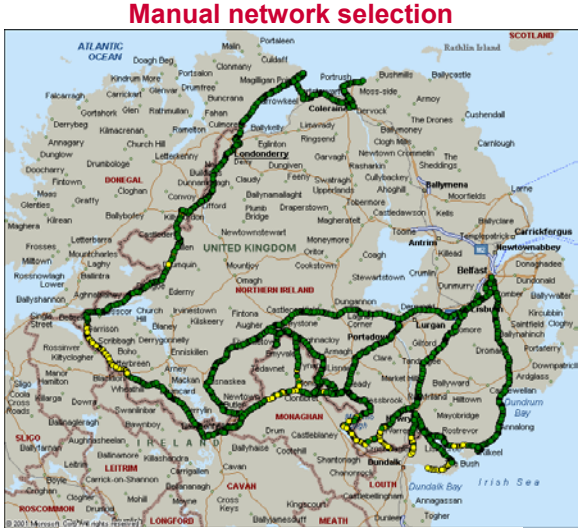
● 5 to 7 ● 3 to 4 ○ 1 to 2

Number of home cells – Carlingford Lough

● 5 to 7 ● 3 to 4 ○ 1 to 2

Vodafone UK

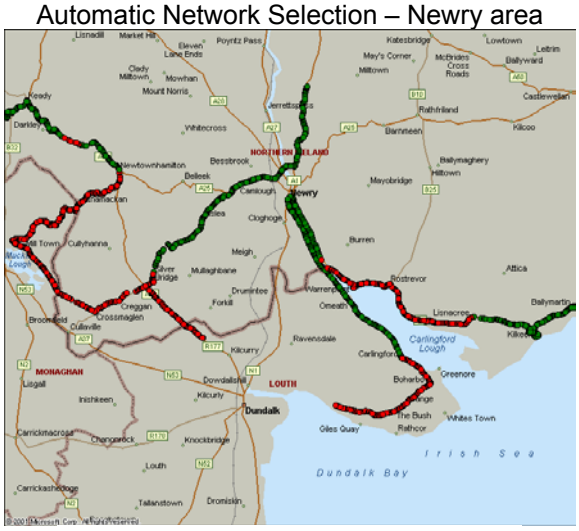
Manual network selection



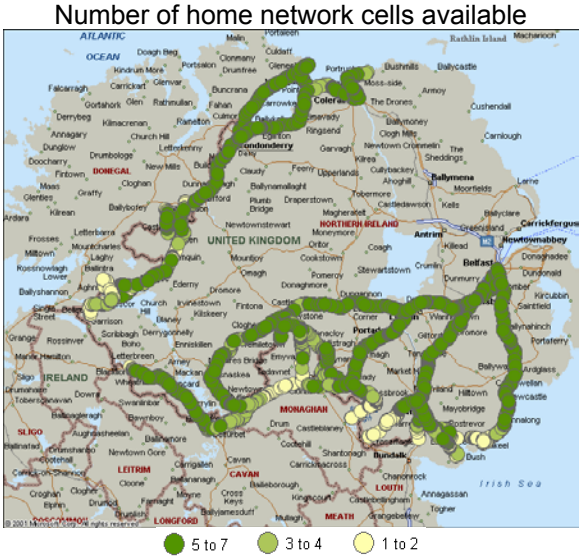
Automatic network selection

Manual Network Selection – Newry area

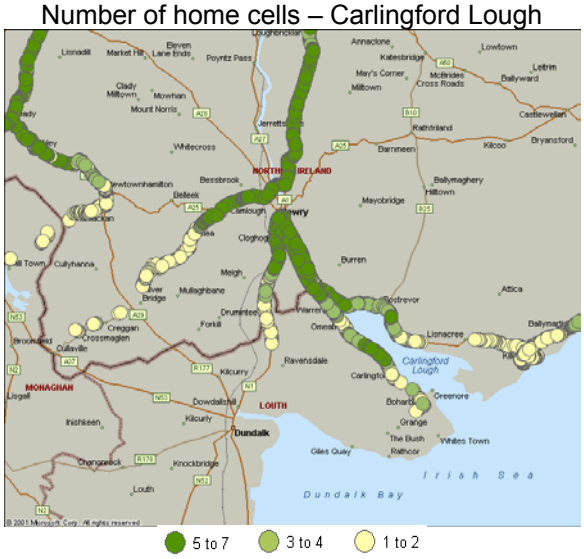
Automatic Network Selection – Newry area



Number of home network cells available

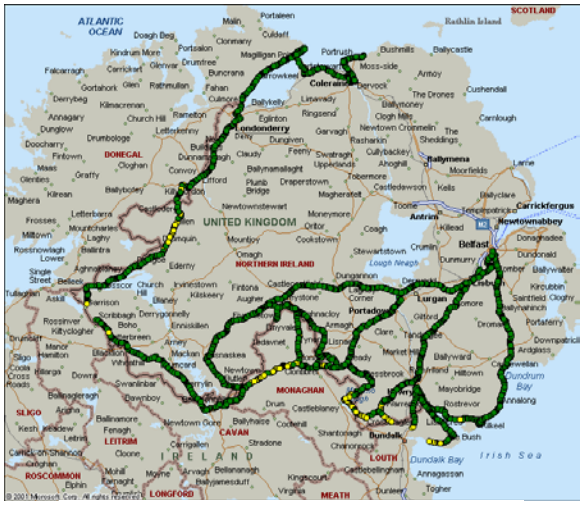


Number of home cells – Carlingford Lough



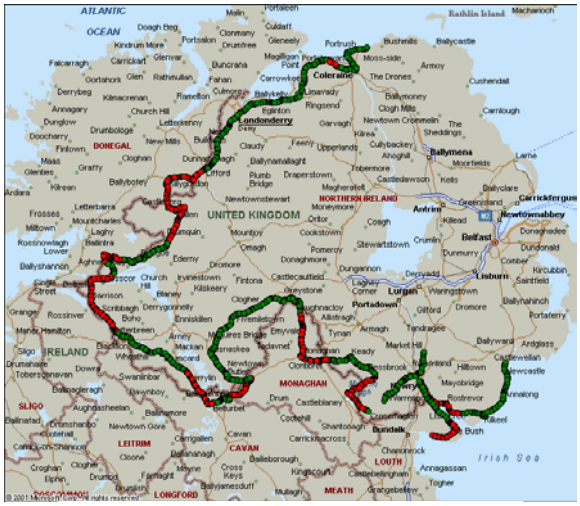
T-Mobile UK

Manual network selection



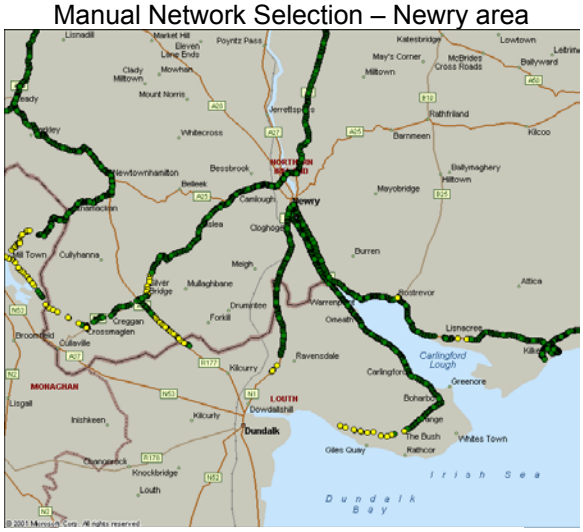
● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection



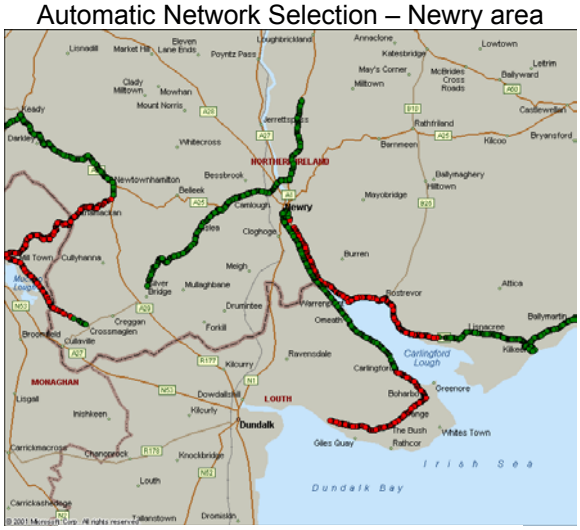
● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area



● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area

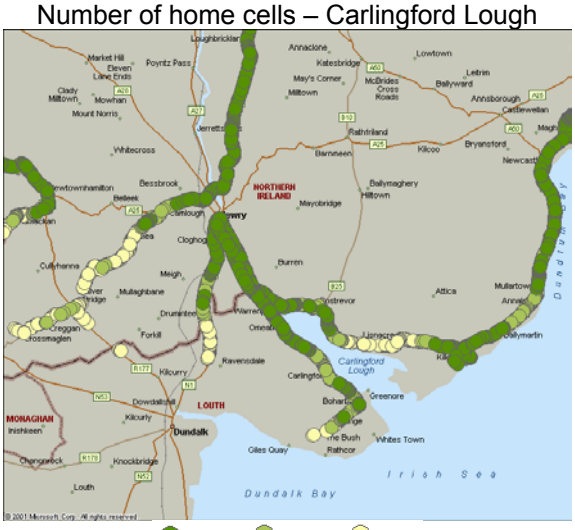


● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available

● 5 to 7 ● 3 to 4 ○ 1 to 2

Number of home cells – Carlingford Lough



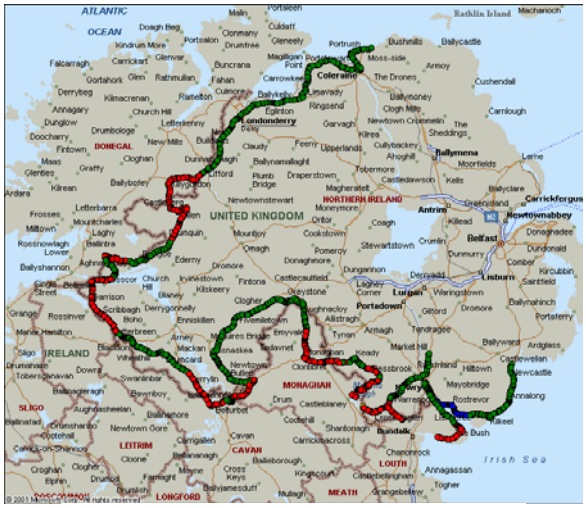
● 5 to 7 ● 3 to 4 ○ 1 to 2

Orange UK

Manual network selection

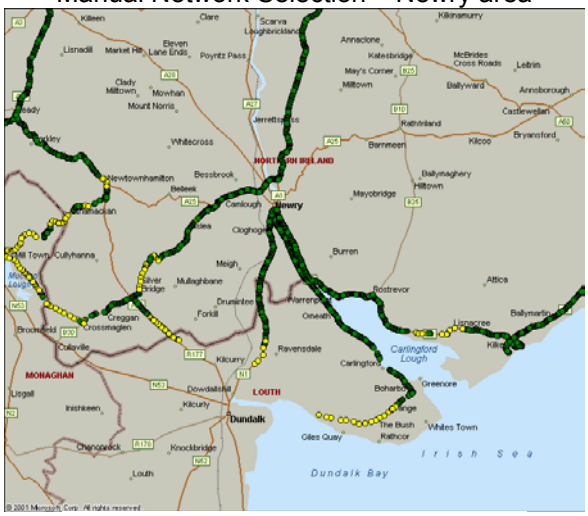
● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection



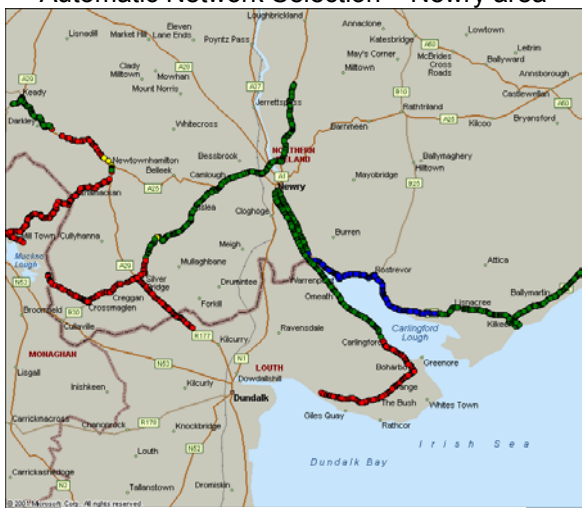
● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area



● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area

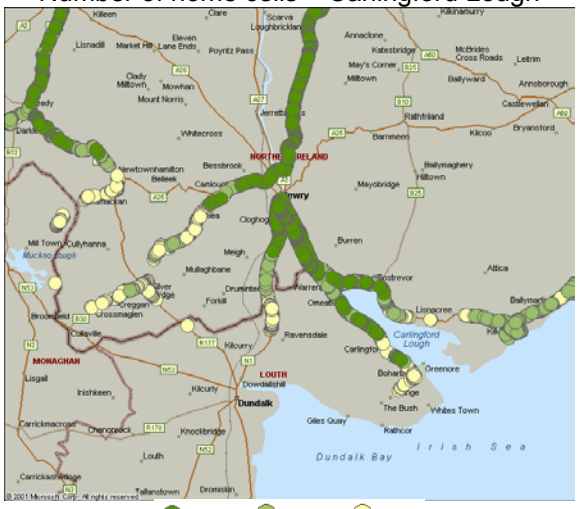


● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available

● 5 to 7 ● 3 to 4 ○ 1 to 2

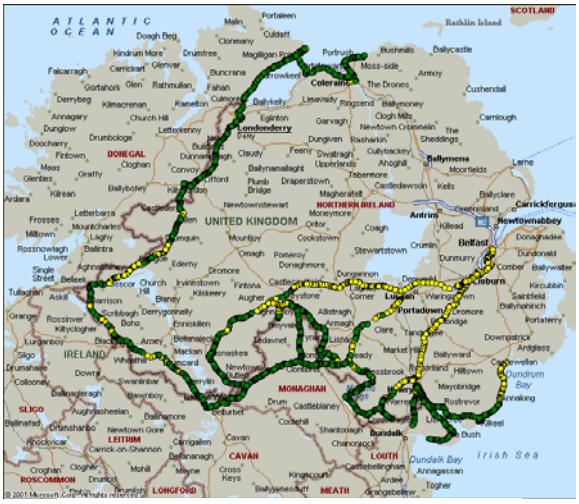
Number of home cells – Carlingford Lough



● 5 to 7 ● 3 to 4 ○ 1 to 2

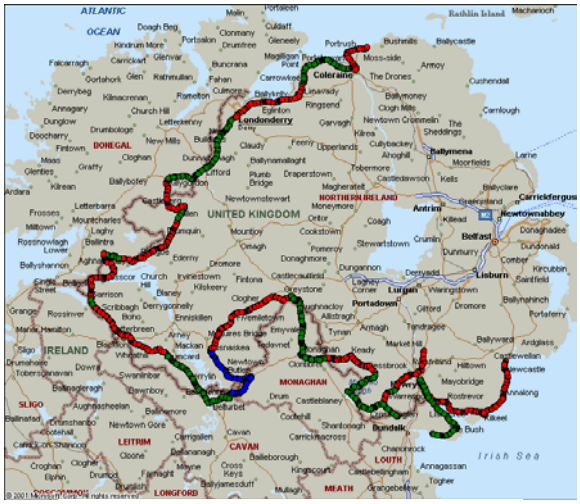
O2 Ireland

Manual network selection



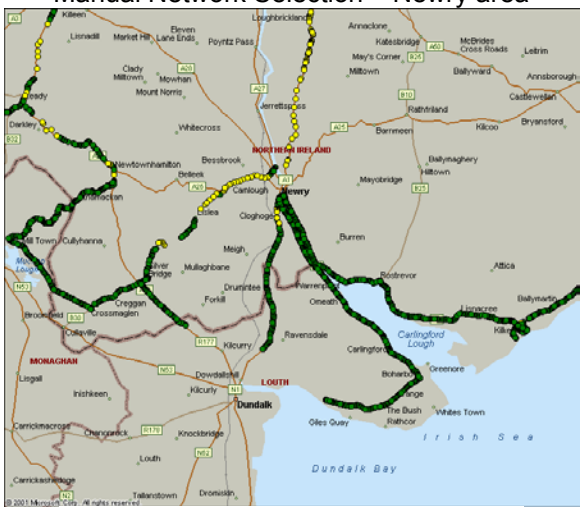
● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection



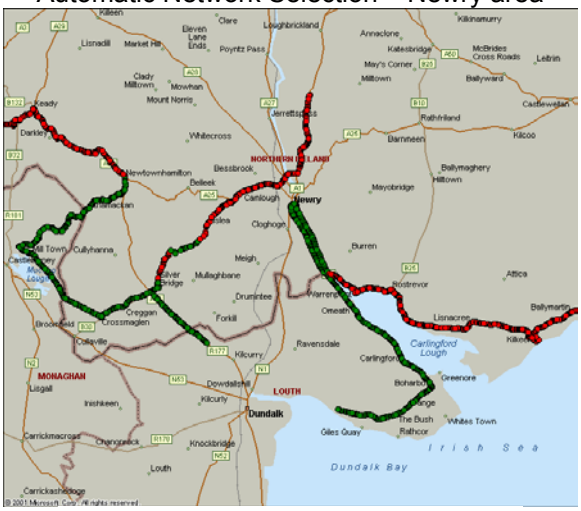
● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area



● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area

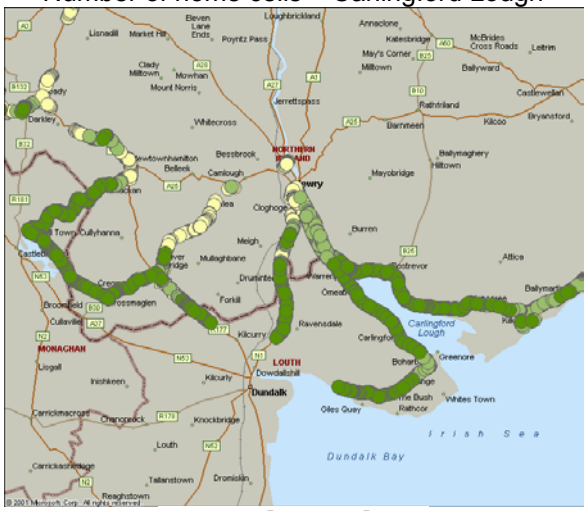


● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available

● 5 to 7 ● 3 to 4 ○ 1 to 2

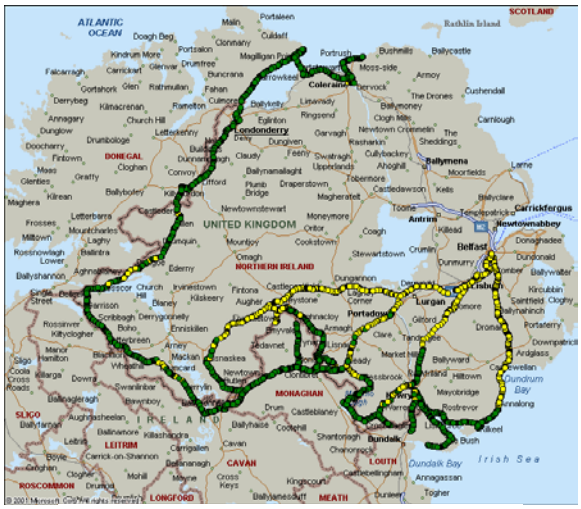
Number of home cells – Carlingford Lough



● 5 to 7 ● 3 to 4 ○ 1 to 2

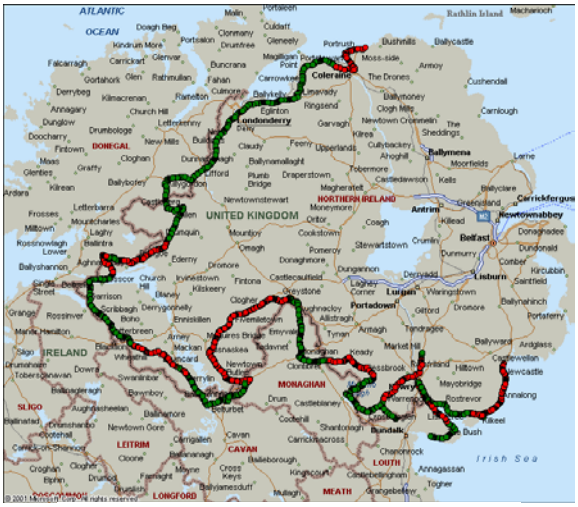
Vodafone Ireland

Manual network selection



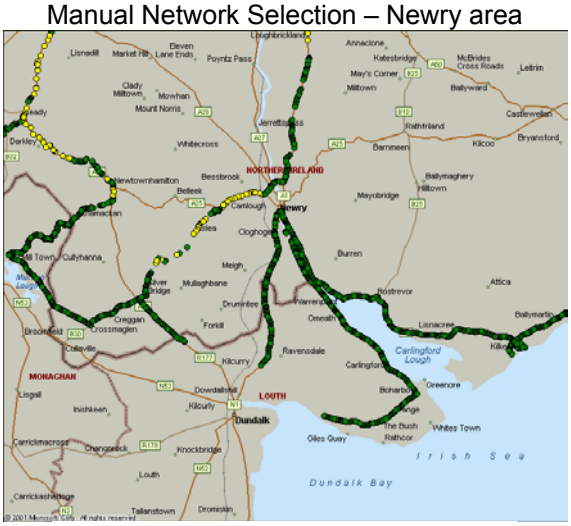
● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection



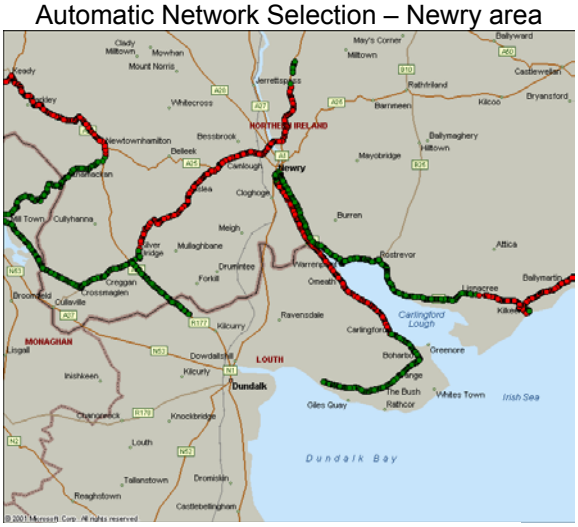
● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area



● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area

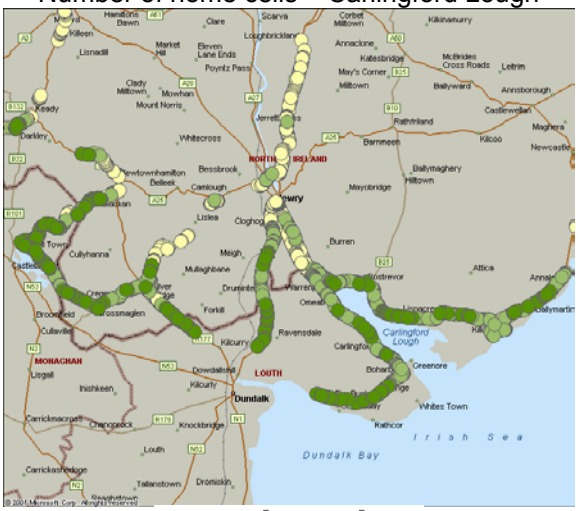


● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available

● 5 to 7 ● 3 to 4 ● 1 to 2

Number of home cells – Carlingford Lough



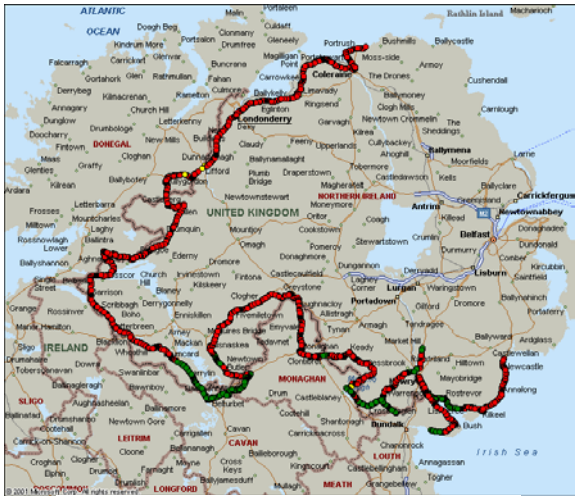
● 5 to 7 ● 3 to 4 ● 1 to 2

Meteor Ireland

Manual network selection

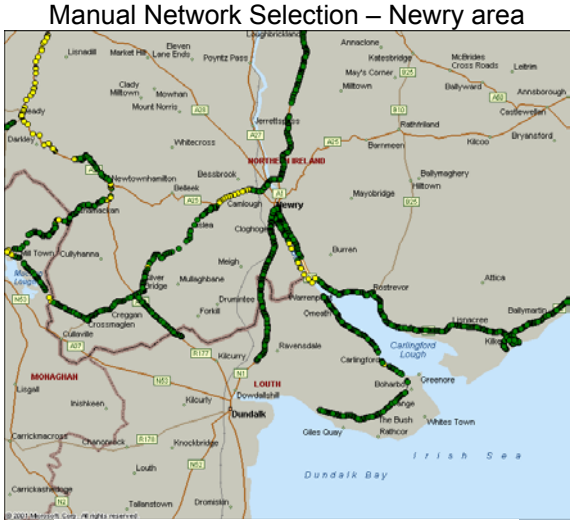
● Roaming ○ Searching ● Home ● Not Registered

Automatic network selection



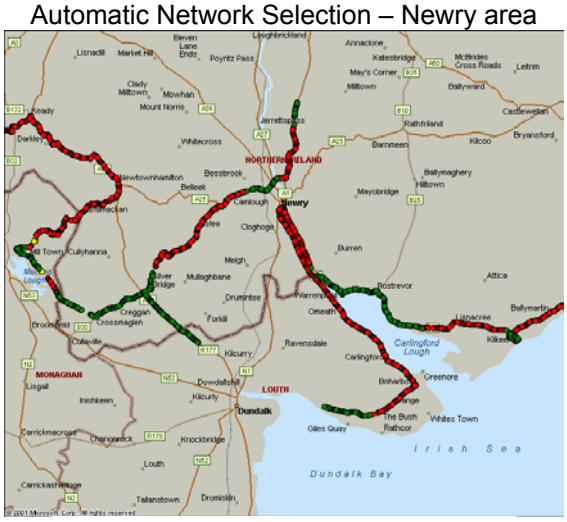
● Roaming ○ Searching ● Home ● Not Registered

Manual Network Selection – Newry area



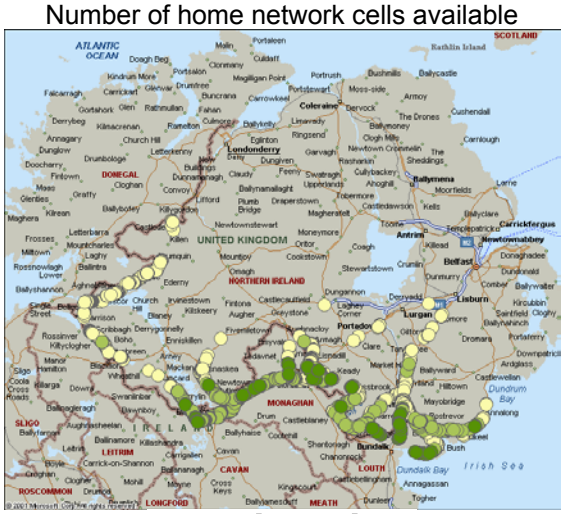
● Roaming ○ Searching ● Home ● Not Registered

Automatic Network Selection – Newry area



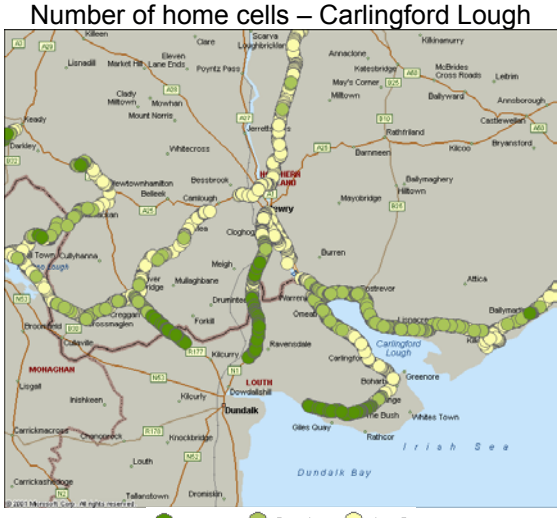
● Roaming ○ Searching ● Home ● Not Registered

Number of home network cells available



● 5 to 7 ● 3 to 4 ○ 1 to 2

Number of home cells – Carlingford Lough

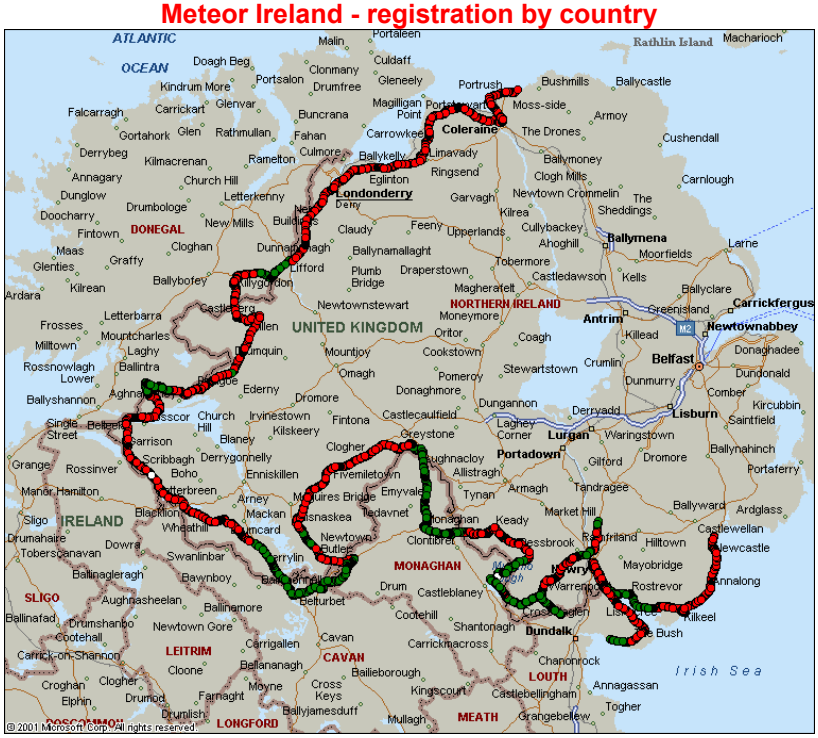


● 5 to 7 ● 3 to 4 ○ 1 to 2

Meteor Ireland (continued)

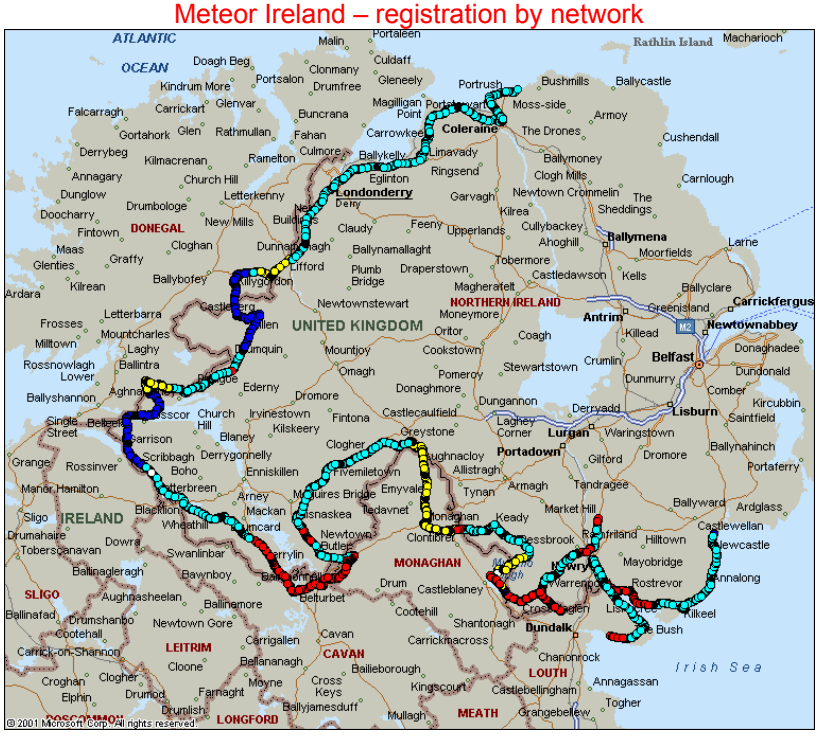
Meteor Ireland was unique in-as-much-as same country roaming occurred through an agreement between Meteor Ireland and O2 Ireland The following maps illustrate the country and network registrations observed when the Meteor Ireland GSM modem was set to automatic network registration.

Meteor Ireland - registration by country



- IRL
- UK

Meteor Ireland – registration by network



- UK Orange
- UK T-Mobile
- UK O2
- IRL Meteor
- IRL O2
- IRL Voda