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Mobile signal strength measurement data from Ofcom's Spectrum Assurance vehicles

Measurement methodology and data description

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Annex

1. Overview

In December 2019, we published mobile coverage measurement data for all four mobile operators gathered along the rail network in England, Scotland and Wales. We collected this data using antennas mounted on the top of four of Network Rail's yellow engineering trains.

After completing this work, we repurposed the systems to gather data on the road network and to measure 5G. We are releasing the data we are collecting with these systems, so that industry and policy makers can explore and make use of the information.

This document outlines how we collect this data and provides guidance on what the data represents.

The data we collected – in brief

- **We are collecting mobile signal data along the road network in Great Britain, and we plan to include Northern Ireland in future.** This data is collected from systems mounted in four Ofcom vehicles that are used by our Spectrum Assurance engineers. The data collection consists of two components: 1) part of the engineers' business as usual duties (BAU); and 2) focus testing where the engineers are tasked to drive specific routes to collect data as part of projects relating to our policy work. The vehicles are rotated around different engineers as they are assigned different areas for their BAU duties.
- **The data represents the strongest mobile signals (per mobile operator) for 4G and 5G received by rooftop antennas.** It does not include signal loss into the vehicle and therefore does not represent what a mobile handset in the vehicle would receive.
- **There are some omissions in the data published.** The data we are making available may not be complete for certain months. This is where we tasked the vehicles to carry out measurements which are out of scope of this work. In addition, we were only able to collect limited data during the Covid-19 public health restrictions.

2. Methodology

2.1 This section explains the methodology which we have used when collecting the measurements data, the equipment we have used, and how we process the data before we publish it.

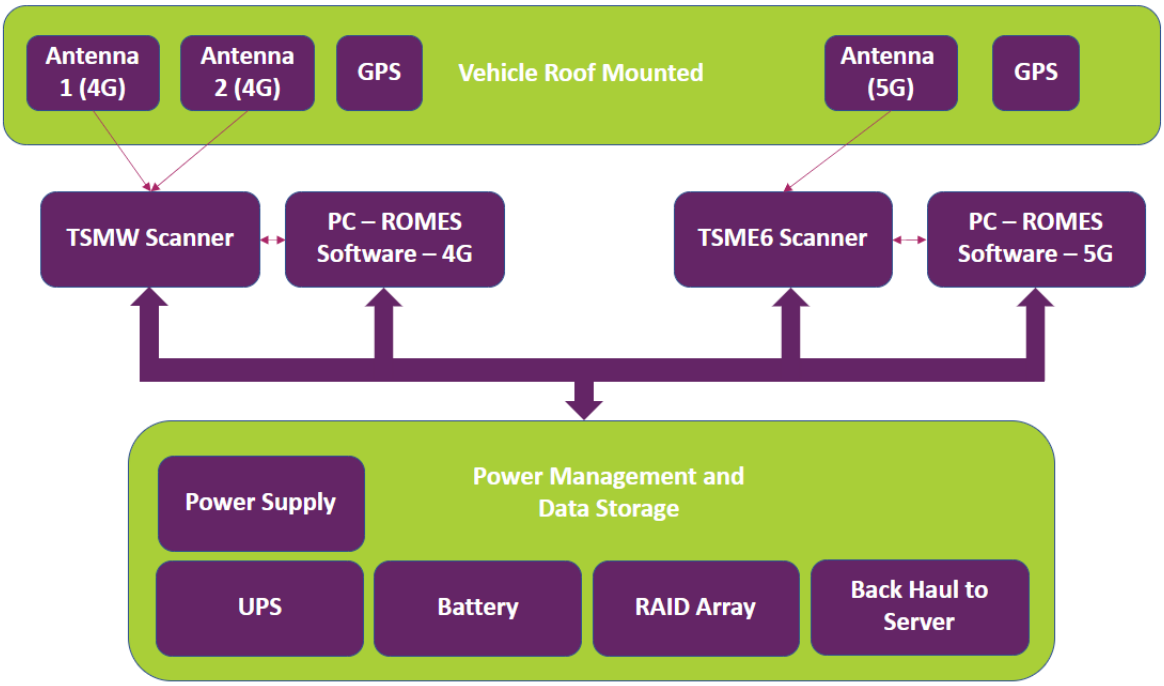
2.2 This data is released under the open government licence (version 3).

The measurement equipment

2.3 We have developed an automated system that uses Rohde & Schwarz scanners for the data collections as shown in Figure 1.

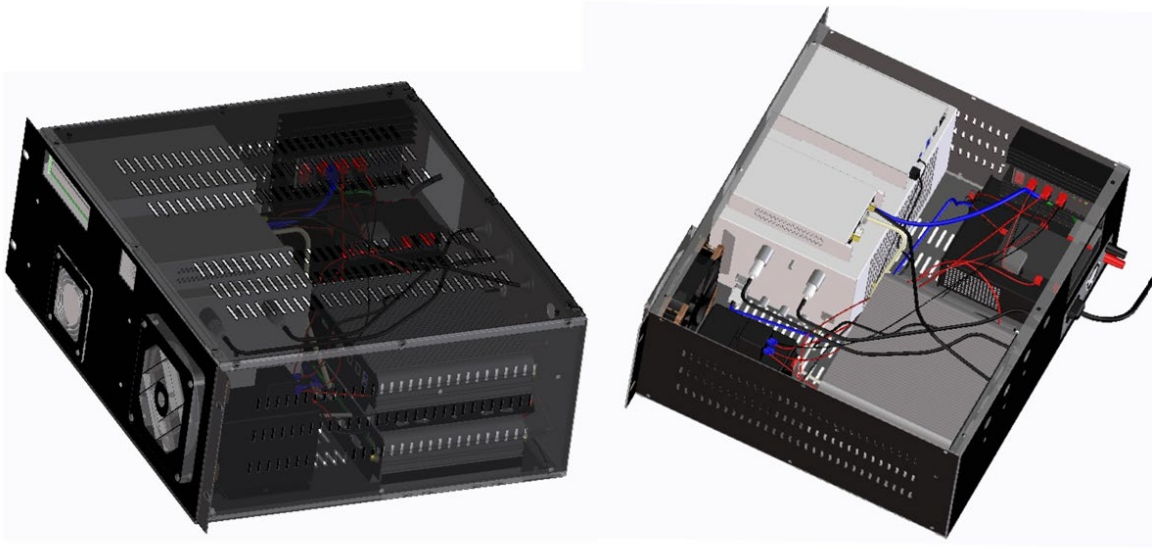
- TSMW is used for 4G
- TSME (6) is used for 5G

Figure 1: Block diagram of the drive test system



2.4 The power management, data storage, scanners and PCs are mounted in a self-contained fan-cooled case, as shown in Figure 2, and are currently fitted on to Renault Kangoo vans, which are part of the Ofcom fleet of vehicles. The vehicles are upgraded on a regular basis and these four are expected to be changed in 2023. We will update this document as appropriate as changes occur, to account for any system recalibration undertaken.

Figure 2: Ofcom drive test system



2.5 The Rohde and Schwarz TSME (6) has one input antenna port and the TSMW uses two ports. Positioning of the antennas on the roof is the same for each of the four vehicles as shown in Figure 3 and 4.

Figure 3: Side view of antennas mounted on a Renault Kangoo

Figure 4: Top view of antennas mounted on a Renault Kangoo

System calibration

2.6 The scanners used for measurements are calibrated at regular intervals. The rooftop antennas used are PCTEL OP278H, and have integrated cables which are connected directly to the scanners. Antenna gain and cable characteristics can be found in the specification. No correction has been made to the published data for antenna gain and cable losses.

Automation

2.7 All the processes which run the system are automated, from when the vehicle is powered up, to when it comes to a stop after its journey. This includes loading up the measurement software with the desired settings, frequent system stability checks, data collection, and export and upload of the data. Multiple scripts and configuration files are pre-installed in order to achieve this.

Remote monitoring

2.8 Measurement systems can be accessed remotely to troubleshoot issues, or any configuration changes required. The system is pinged continuously for status checks and the data files received are monitored automatically for invalid measurements at a later stage.

Data collection

2.9 Raw measurement data are collected continuously when the vehicles are running and once the system has booted up. Every 5 minutes a selected subset of the measurements are exported to an ascii file, compressed and uploaded to an Ofcom server. This is what forms the data that is being published as explained in section 3.

3. Locations and parameters reported

Routes covered

3.1 The routes covered are shown on a map which is available on our website. We plan to update this map to show the additional routes covered in each future data publication. Results affected by the set up and testing of the systems have been removed.

Data retention

3.2 We are releasing this information on a trial basis for an initial period of 12 months from November 2021. We plan to update this information over this period as we collect further data from our vehicles.

3.3 To ensure the findings are sufficiently up-to-date, we plan to archive measurements which are more than two years old.

Parameters reported

3.4 A large number of parameters are collected by the Rohde & Schwarz ROMES system. Due to the constraints of the backhaul from the drive test system, data processing time and data storage, we only upload a targeted subset of all measurements taken. This subset is defined by the schema as explained in 4G and 5G parameters below, and is published as open data.

3.5 The measurement data is sorted into discrete pools based on the mobile operator via mobile network code (MNC) on 4G and NR_ARFCN (carrier centre frequency) on 5G. The ranking of the strongest cell is decided on a rolling 2 second window and chosen using the following power parameters:

a) For LTE it uses the received signal power measured on secondary synchronisation signal. The strongest and next three best cells are included in the data set.

b) For 5G it uses the SS-RSRP and only the strongest cell is included in the data set.

3.6 These are the current settings that we have used in 2021. The data we are releasing for 2020 only includes the strongest cell measured for both LTE and 5G. It should be noted that parameters reported may be subject to change in the future.

3.7 To anonymise the start and stop location of the vehicles:

- Each hour in the month has been replaced with a randomised unique identifier; and
- Each measurement point within the hour has been replaced with an incrementing sequence.

Field	Description
Longitude	Longitude reported by GPS in decimal degrees*

Latitude	Latitude reported by GPS in decimal degrees*
Date	Month/year only
Time	Changed to an hourly randomised unique identifier
rnum	Sequential incrementing number per measurement, in the hour

**The location parameters reported are directly from the scanner and have not been corrected for any inaccuracies. Due to this, a small fraction of measurements may appear not aligned to the road network.*

4G parameters

Field	Description
PCI	Physical Cell Identifier
RSSI	Received power on secondary synchronisation signal
SINR	Signal-to-Interference-plus-Noise Ratio
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
ADD_PLMN	Top N Add PLMNs. Additional PLMNs that share this LTE base station
MCC	Mobile Country Code
MNC	Mobile Network Code
5G_NR	5G NR is supported by this cell

5G parameters

Field	Description
PCI	Physical Cell Identifier
RSSI	Average power of all resource elements carrying OFDM signals, interference and noise within all SS/PBCH Blocks (SSBs) used for carrying out the measurement
SSB_IDX	SSB Index. Serving NR cell beam SS/PBCH Block index
SS_RSRP	Reference signal received power of resource elements of secondary synchronisation signal in SS-PBCH block
SS_RSRQ	Reference signal received quality of resource elements of secondary sync signal in SS-PBCH block

SS_SINR	Signal to Interference & Noise Ratio of resource elements of secondary synchronisation signal in SS-PBCH block
NR_ARFCN	E-UTRA Absolute Radio Frequency Channel Number
ADD_PLMN	Top N Add PLMNs. Additional PLMNs that share this LTE base station
MCC	Mobile Country Code (may not be available as Mobile Operator dependant)
MNC	Mobile Network Code (may not be available as Mobile Operator dependant)
NR_MODE	Top N 5G NR Mode 5G NR operation mode reported by scanner

4. Disclaimer

4.1 This data is a representation of the information and signal levels received using these specific systems with an antenna on the rooftop of the vehicle. In addition to measurement uncertainties, there are several factors which could make these measurements non-representative for any other systems. For instance, the received signal on a handset at a different height to the vehicle rooftop antenna or inside a vehicle may be different.

4.2 As such, this data should be seen as being indicative only, and covering only the circumstances measured in this given way, at a given point in time; it is not suitable for use in safety critical operations.

A1. Data format example

A1.1 The 5G NR measurement results are presented in a repeating sequence. The power, SSB index, EARFCN and MIB information of a PCI are represented in one or more lines, then the RSRP, RSRQ and SINR results for the PCI are displayed on the subsequent lines.

latitude	longitude	month_year	hour_ref	rnum	pci_top1_mno	rssi_top1_mno	ssb_idx_top1_mno	sinr_top1_mno	rsrp_top1_mno	rsrq_top1_mno	earfcn_top1_mno	add_plmn_top1_mno	mcc_top1_mno	mnc_top1_mno	nr_mode_top1_mno
53.999999	-2.999999	01/12/2020	440599829	644											
53.999999	-2.999999	01/12/2020	440599829	645											
53.999999	-2.999999	01/12/2020	440599829	646											
53.999999	-2.999999	01/12/2020	440599829	647	123	-93.1	5				650000				
53.999999	-2.999999	01/12/2020	440599829	648					-121.64						
53.999999	-2.999999	01/12/2020	440599829	649					-121.64						
53.999999	-2.999999	01/12/2020	440599829	650						-12.1					
53.999999	-2.999999	01/12/2020	440599829	651				3.24							
53.999999	-2.999999	01/12/2020	440599829	652					-121.64						
53.999999	-2.999999	01/12/2020	440599829	653				3.24							
53.999999	-2.999999	01/12/2020	440599829	654						-12.1					
53.999999	-2.999999	01/12/2020	440599829	655						-12.1					
53.999999	-2.999999	01/12/2020	440599829	656					-121.64						
53.999999	-2.999999	01/12/2020	440599829	657				3.24							
53.999999	-2.999999	01/12/2020	440599829	658				3.24							
53.999999	-2.999999	01/12/2020	440599829	659					-121.64						
53.999999	-2.999999	01/12/2020	440599829	660						-12.1					
53.999999	-2.999999	01/12/2020	440599829	661					-121.64						
53.999999	-2.999999	01/12/2020	440599829	662				3.24							
53.999999	-2.999999	01/12/2020	440599829	663						-12.1					
53.999999	-2.999999	01/12/2020	440599829	664						-12.1					
53.999999	-2.999999	01/12/2020	440599829	665					-121.64						
53.999999	-2.999999	01/12/2020	440599829	666				3.24							
53.999999	-2.999999	01/12/2020	440599829	667				3.24							
53.999999	-2.999999	01/12/2020	440599829	668						-12.1					
53.999999	-2.999999	01/12/2020	440599829	669					-121.64						
53.999999	-2.999999	01/12/2020	440599829	670				3.24							
53.999999	-2.999999	01/12/2020	440599829	671					-121.64						
53.999999	-2.999999	01/12/2020	440599829	672						-12.1					
53.999999	-2.999999	01/12/2020	440599829	673				3.24							
53.999999	-2.999999	01/12/2020	440599829	674						-12.1					
53.999999	-2.999999	01/12/2020	440599829	675	123	-93.1	5				650000				
53.999999	-2.999999	01/12/2020	440599829	676	123	-93.1	5				650000				
53.999999	-2.999999	01/12/2020	440599829	677											
53.999999	-2.999999	01/12/2020	440599829	678											
53.999999	-2.999999	01/12/2020	440599829	679											
53.999999	-2.999999	01/12/2020	440599829	680	123	-93.1	5				650000				

A1.2 For 4G, all measurements for a PCI are contained on a single line.

latitude	longitude	month_year	hour_ref	rnum	pci_top1_mno	power_top1_mno	sinr_top1_mno	rsrp_top1_mno	rsrq_top1_mno	earfcn_top1_mno	add_plmn_top1_mno	mcc_top1_mno	mnc_top1_mno	nr_top1_mno
51.84728	-0.19842	01/07/2020	200875531	19756	123	-86.30	3.74	-114.57	-20.88	1000		234	99	
51.84721	-0.19848	01/07/2020	200875531	19757										
51.84721	-0.19848	01/07/2020	200875531	19758										
51.84721	-0.19848	01/07/2020	200875531	19759										
51.84721	-0.19848	01/07/2020	200875531	19760										
51.84721	-0.19848	01/07/2020	200875531	19761										
51.84721	-0.19848	01/07/2020	200875531	19762										
51.84721	-0.19848	01/07/2020	200875531	19763										
51.84713	-0.19854	01/07/2020	200875531	19764										
51.84709	-0.19857	01/07/2020	200875531	19765	123	-86.30	3.74	-114.57	-20.88	1000		234	99	
51.84709	-0.19857	01/07/2020	200875531	19766	123	-80.23	4.92	-107.15	-19.41	1000		234	99	