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Electromagnetic Field (EMF) measurements near fixed wireless equipment operating in the 60 GHz band in Liverpool

TECHNICAL REPORT

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Contents

Section

1. Overview

1.1 This document describes the radio frequency electromagnetic field (EMF) measurements we have conducted near fixed wireless equipment operating in the 60 GHz band being used as part of the Liverpool 5G Testbed & Trial for Health and Social Care. Our objective was to measure the EMF levels and determine how these compare with the reference levels for general public exposure in the Guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[1]

1.2 Our measurements have shown that the EMF levels from the fixed wireless systems being used for this trial are well within the reference level for general public exposure from the ICNIRP Guidelines. The highest level we observed was 1.2% of the reference level.

[1] Guidelines for limiting EMF exposure that will provide protection against known adverse health effects are published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is formally recognised by the World Health Organization (WHO). The Guidelines are available on the ICNIRP website.

2. Introduction and background

2.1 The Liverpool 5G Testbed and Trial is one of a number of 5G projects that have received funding from Government with the objective of exploring the benefits and challenges of deploying 5G technologies[2].

2.2 The network in the Liverpool trial is provided by Blu Wireless and uses mmWave frequencies in the 59 to 63 GHz frequency range. The network is made up of multiple distribution nodes installed on lampposts which are linked together to create a mesh network.

2.3 The objective of the EMF measurements presented in this report was to determine how these compare with the reference levels for general public exposure in the ICNIRP Guidelines.

2.4 In the UK, Public Health England (PHE) takes the lead on public health matters associated with EMF and has a statutory duty to provide advice to Government on the health effects of these fields. PHE's main advice about radio waves from base stations is that the guidelines produced by the International Commission on Non-Ionizing Radiation Protection should be adopted[3].

2.5 The reference level for general public EMF exposure for frequencies above 10 GHz specified in the ICNIRP Guidelines is 10 W m^{-2}. This is the level to which we compare our measurements. All our measurements were made over a six minute measurement period.

[2] https://www.gov.uk/government/collections/5g-testbeds-and-trials-programme
[3] See: https://www.gov.uk/government/publications/mobile-phone-base-stations-radio-waves-and-health/mobile-phone-base-stations-radio-waves-and-health

3. Measurement equipment, methodology and results

Measurement equipment

3.1 To make EMF power density measurements, we used a NARDA broadband field meter, model NBM-550, with a triaxial probe, model EF 9091. This equipment measures the aggregate[4] EMF power density in W m^{-2} received at a given location. It is specifically designed for making EMF power density measurements and allows us to compare these directly with the levels from the ICNIRP Guidelines. The probe we used had been calibrated by the manufacturer and had a manufacturer-specified measurement uncertainty of ±1.3 dB.

The measurements

3.2 In the section below, we describe the results of the measurements taken at one 60 GHz fixed wireless link location using the NARDA probe.

NARDA probe measurements

3.3 To allow us to take measurements directly in front of and at the same height as the transmit antennas, we mounted the NARDA probe on a variable height mast.

Figure 1: NARDA probe detail (left) and mounted on a mast directly in front of transmit antenna (right)

[4] This means the aggregate of all emissions within the measured bandwidth received at the location and not just those from the specific transmitter being investigated.

3.4 We conducted three sets of measurements to capture the range of potential geometries that might occur in relation to the position of the transmitter relative to members of the public:

i) **Radial measurements** taken at the same height as the transmitter, in 45-degree increments at a radius of 1.5m from the transmitter.

ii) **Vertical measurements** taken at heights of 1.5m and 5.2m above ground, both at a distance of 1.5m from the transmitter and in the transmitter's boresight.

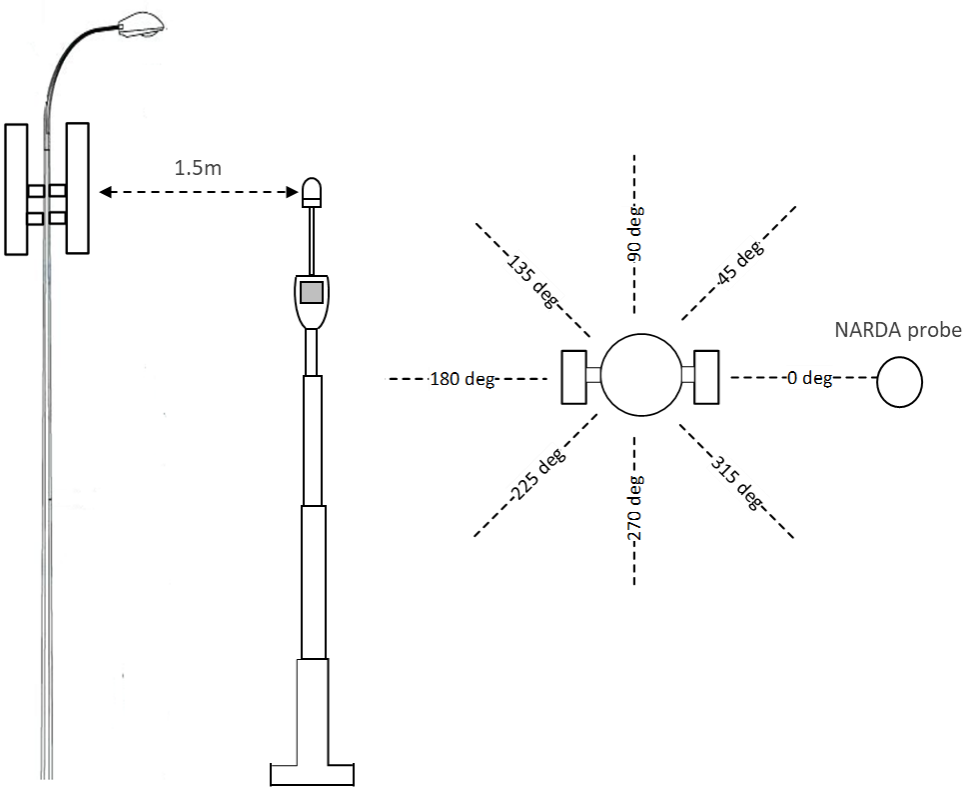
iii) **Horizontal measurements** taken at the same height as the transmitter, in the transmitter's boresight and at distances of 1.5m and 5m from the transmitter.

Radial measurements

3.5 These measurements were taken with the NARDA probe at the same height as the transmitter, and with the probe at a distance of 1.5m from the transmitter. A measurement was then taken in line with the transmitter's boresight, with further measurements made in 45-degree increments around the transmitter, as shown in Figure 2 below.

3.6 This allowed us to measure the power density of transmissions from the main beam, as well as the power density of transmissions from the side lobes as the receiver moves around the transmitter.

Figure 2: Diagram showing radial measurements – side view (left) and top view (right)



3.7 As shown in Table 1 below, the maximum EMF power density measured was at 0 degrees, which corresponds to the boresight of the transmit antenna. This measurement corresponds to 1.2% of the reference level for general public exposure from the ICNIRP Guidelines. The EMF power density measured at all other positions was significantly lower by a factor of at least 130.

Table 1: Average and maximum power density values – radial measurements

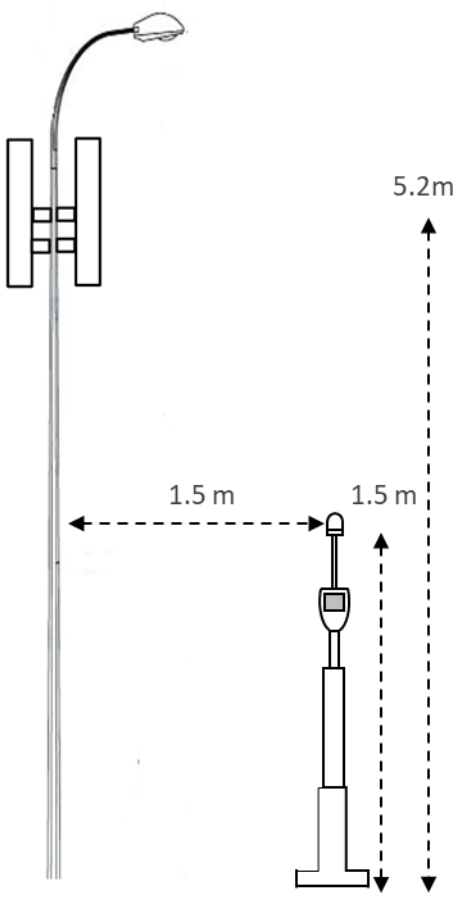
Angle (Degrees)	Average Power Density ($W\ m^{-2}$)	Max Power Density ($W\ m^{-2}$)
0	0.1188	0.1258
45	0.0005	0.0007
90	0.0004	0.0006
135	0.0006	0.0009
180	0.0009	0.0012
225	0.0005	0.0008
270	0.0002	0.0003
315	0.0005	0.0007

Vertical measurements

3.8 These measurements were taken with the NARDA probe positioned 1.5m away from the transmitter, in line with the boresight of the transmitter. Two measurements were taken: one at the same height as the transmitter, at 5.2m above ground level, and one at 1.5m above ground level.

3.9 The first measurement height, at 5.2m, was chosen to represent a scenario where members of the public are located above street level and close to the main beam of the transmitter, e.g. in a double decker bus or similar (although we note that the height of a double decker bus is in fact about a meter lower and that the body of a vehicle would provide additional attenuation against radio waves). The second measurement height, at 1.5m, would represent a scenario where members of the public are located at street level.

Figure 3: Diagram showing vertical measurements, at 5.2m and 1.5m height above ground level



3.10 As shown in Table 2 below, the measured EMF power density level at a height of 5.2m was 1.2% of the ICNIRP Guideline level (i.e. the same as the 0 degree radial measurement described above). The measured level at 1.5m was nearly 200 times lower, at 0.006% of the ICNIRP level.

Table 2: Average and maximum power density values – vertical measurements

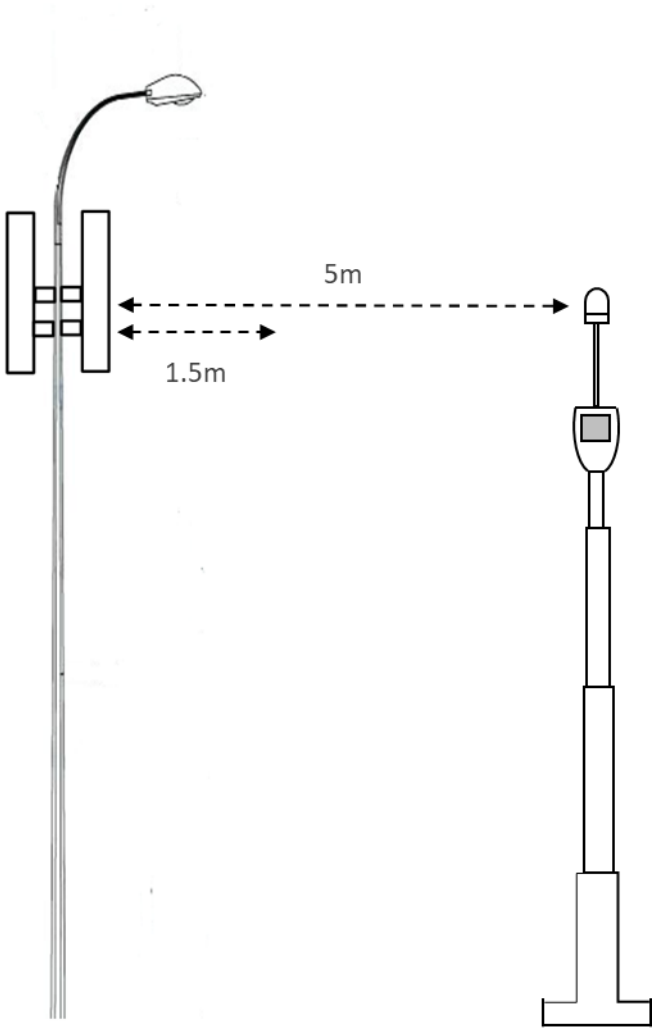
Height (Metres)	Average Power Density ($W\ m^{-2}$)	Max Power Density ($W\ m^{-2}$)
5.2m (Level with transmitter)	0.1188	0.1258
1.5m	0.0006	0.0009

Horizontal measurements

3.11 These measurements were taken with the NARDA probe at the same height as the transmitter, in line with the transmitter boresight but at different distances. One power

density measurement was taken 1.5m away from the transmitter, and a second was taken 5m away from the transmitter.

Figure 4: Diagram showing horizontal measurements made at 1.5m and 5m distance from the transmitter



3.12 As shown in Table 3 below, the measured EMF power density level at a distance of 5m from the transmitter was 0.03% of the ICNIRP Guideline level for general public exposure.

Table 3: Average and maximum power density values – horizontal measurements

Distance (Metres)	Average Power Density ($W\ m^{-2}$)	Max Power Density ($W\ m^{-2}$)
1.5m	0.1188	0.1258
5m	0.0026	0.0031

4. Conclusion

4.1 The EMF power density values for the 60 GHz fixed wireless link that we measured at the Liverpool 5G trial were much lower than the reference level for general public EMF exposure specified in the ICNIRP Guidelines for this frequency band. The maximum level we observed was 1.2% of the reference level.

4.2 The fixed wireless transmissions we measured have a narrow beam width (i.e. a 20 degree elevation beam width and a 10 degree azimuth beam width) and the free space path loss is high compared to lower frequencies (i.e. for frequencies below 6 GHz). The narrow beam width of the transmission leads to a significant drop in EMF power density outside the main beam of the transmitter. This drop in EMF power density was observed from our measurements as we varied the receiver's position both horizontally and vertically relative to the transmitter's main beam. We also saw a significant drop in EMF power density as we increased the distance between the receiver and transmitter from 1.5m to 5m along the transmitter's main beam.