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# RF exposure assessments in proximity of small cells

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## Abstract

The fifth generation of mobile networks will be based on heterogeneous networks composed of long range macro cells and of medium range small cells to face the tremendous increase of mobile data demand. These small cells will be potentially more numerous than the macro ones, closer to the user and less powerful. This paper is interested in RF exposure assessments in proximity of these small cells. A number of normative measurements have been performed on two trials conducted on commercial networks in France.
These measurements have shown that the global average level of exposure induced in an area of 100 meters around the sites is not significantly impacted by the small cells (between 0.17 and 0.55 V/m when small cells are in service and between 0.15 and 0.54 V/m when small cells are off).
Very localized and close to the site, maximum values of E field of 1 to 3 V/m have been measured. These maximum values are comparable with levels that the long range antennas of the actual network can induce: in France, in 2016, 1% of the in situ measurements in urban area are above 5.6 V/m.

## 1. Introduction

The current mobile networks are essentially made up of long-range radio equipment deployed to ensure coverage in the different territories. In the future, this long-range layer will be supplemented by medium-range antennas (see Figure 1) to improve coverage and connectivity for all across the country as the population increasingly uses mobile networks.

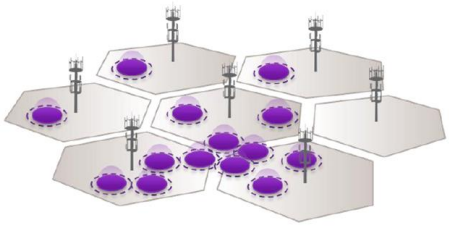

**Figure 1: illustration of a heterogeneous network**

Experiments are carried out to test in full-scale the modalities of a deployment of small antennas.

The range of these small antennas is less than that of the macro antennas; it varies from a few tens of meters to a few hundred meters. Small antennas are deployed on street furniture (bus shelters and billboards). This type of antenna can also be deployed, for example, on streetlights, or building facades. These small antennas are less directive than the macro antennas with gains of the order of 8 dB (compared to 17 dB for a long range antenna). The typical maximum injected power of these antennas is about few watts with a maximum value of 6,3 W (compared to several tens of watts for long range antennas). A small cell site may for example consist of two antennas oriented in two opposite directions to cover a street.

In France, ANFR, the public agency of the French State in charge of radio spectrum management, is conducting a study on the large-scale deployment of a network of small cells complementing the network of long range antennas.
Two pilots on three planned have already been conducted in this study, which aims to measure the contribution of these small antennas for the connectivity of the population and for the exposure. Different configurations will be tested, in particular in terms of street furniture used, technologies and frequency bands used.

In this paper, the methodology to assess RF exposure in the vicinity of small cell is detailed and then the results obtained on the two first pilots are presented.

## 2. Evaluation of RF exposure in the vicinity of a small cell

It is a question of characterizing the influence of the deployment of small antennas on the exposure due on the one hand to the emissions of the access points of the network (long and medium range antennas) and due on the other hand to the mobile equiment. From the device point of view, small cells are expected to reduce emitted power and increase available throughput. Thus, exposure induced by the device is expected to be reduced. Consistently with EN 62232 [1], in situ measurements are performed to determine if the RF exposure levels are in compliance with applicable exposure limits.

The measurement area is an area of 100 m radius to enable to assess the exposure in all the coverage area of

the small cells. This area is separated in 2 sub-areas: a very close one and a further one.
The measurement are performed twice, first with small cells on and then with small cells off to be able to make a comparison.
Two types of measurements are performed:

- Normative measurements performed by an accredited laboratory following French protocol ANFR DR 15 [2] which is in line with EN 62232;
- Complementary field test measurements with trace mobile to record the mobile behavior.

This paper is focused on normative measurements.

The very close sub-area is characterized by a scan over the measurement area at a height of 1,5m above the ground in order to find the location of the maximum exposure. The further sub-area is characterized by paving the area with pre-determined measurement points at a height of 1,5 m to cover all accessible areas in the 100 m radius zone. All the intermediate measurements are reported. The detailed assessment is performed at the location of the maximum exposure when small cells are on. When small cells are off, measurements are performed at the same location (intermediate and detailed measurements).

## 3. Trials

Both trials are conducted in dense urban areas on 4G commercial networks of two different French mobile operators. Trials consist in few sites (around 4) installed on urban furniture as shown on Figure 2. Heights of antennas are between 2.9 m and 5 m.

**Figure 2: illustration of small cells integration in urban furniture.**

## 4. Results

At a large scale (in the 100 m radius zone around each site), the impact of small cells on the mean value of E field measurements with broadband equipment during site analysis is limited as shown by Figure 3.
When small cells are in service, average E field in the 100 m radius zone is between 0.17 and 0.55 V/m and between 0.15 and 0.54 V/m when small cells are off.

All levels of exposure assessed before and after the put into service of the small cells are well below the French regulatory levels [3].

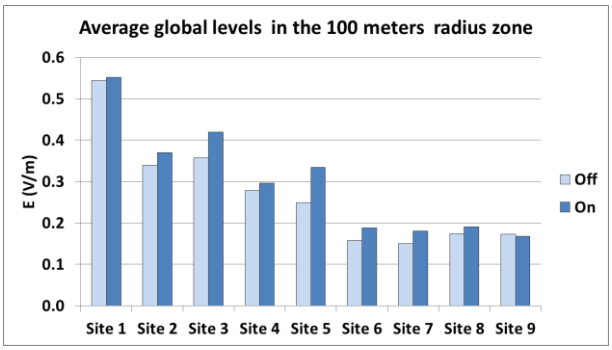


**Figure 3: mean value of E field measurements with broadband equipment at intermediate points for each site**

Very localized and close to the site, maximum values between 1 V/m and 3 V/m have been measured, as shown in Figure 4. These maximum levels of exposure induced in close proximity of small cells are comparable with levels of exposure that can be induced by existing macro antennas. Indeed, in France in 2016, 1% of measured levels in urban area are above 5.6 V/m [4].

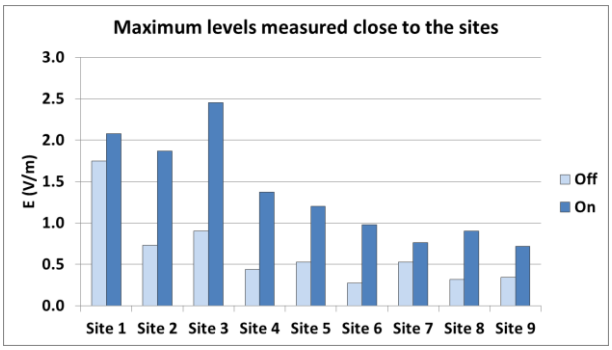


**Figure 4: maximum global E field values measured at close proximity to the sites.**

## 5. Conclusion

Small cells of medium range are one of the solutions planned to face 5G requirements. ANFR, the public agency of the French State in charge of radio spectrum management, has carried on a study to evaluate RF exposure on trials conducted on commercial 4G networks to test deployment of small cells. Normative measurements have been performed by an accredited laboratory following French protocol of measurement in line with EN 62232.
These measurements have shown that the global average level of exposure induced in an area of 100 meters around the sites is not significantly impacted by the small cells (between 0.17 and 0.55V/m when small cells are in service and between 0.15 and 0.54 V/m when small cells are off).

Very localized and close to the site, maximum values of E field of 1 to 3 V/m have been measured. These maximum values are comparable with levels that the long range cells of the actual network can induce. In France, in 2016; 1% of the in situ measurements in urban area are above 5.6 V/m.
These normative measurements have been complemented by field tests with trace mobile to evaluate the impact of the small cell from the device point of view. Connection to small cells is expected to reduce the emitted power by the device and to increase the throughput available. Ongoing analysis of trace mobile data will give a complementary view of the impact of small cells on exposure.

## 6. References


[1] EN 62232 "Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure."

[2] ANFR DR-15 Protocol of RF in situ measurement https://www.anfr.fr/controle-des-frequences/exposition-du-public-aux-ondes/la-mesure-de-champ/protocole-de-mesure/#menu2

[3] Decree No. 2002-775 of 3 May 2002 https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000226401

[4] Analysis of in situ measurements conducted in France in 2016 https://www.anfr.fr/fileadmin/mediatheque/documents/expace/Analyse_mesures_2016_VF_9oct.pdf