Micro-Cells Coverage for Mobile Telephony: An Alternative Way to Reduce EMF Exposures

F. Boella a; L. Giuliani a

a Dipartimento di Venezia, Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro, Corso del Popolo, Venezia, Italy

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Micro-Cells Coverage for Mobile Telephony: An Alternative Way to Reduce EMF Exposures

F. BOELLA AND L. GIULIANI

Dipartimento di Venezia, Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro, Corso del Popolo, Venezia, Italy

The aim of this article is to describe networks that are constituted of micro-cell Based Transceiver Stations (BTS), substituting for the conventional networks that are based on the employment of usual macro plants. Specifically, we present a micro-cells network designed to substitute for a conventional BTS network, in the Don Sturzo Park in the city of Venice, Italy. The lower environmental and healthy impact due to a micro-cells network compared to a conventional network is discussed.

Keywords Best-server; Micro-cells; Minimization; Ray-tracing; Warm-cells.

Introduction

The coverage of cities, from the point of view of the mobile phone service, is usually reached building a network of Based Transceiver Stations (BTS), based on macro plants, the so-called warm-cells (because they require an air conditioned system, usually sited together with the shelter of the plant). They are also called macro-cells or macro sites, as opposed to micro-cells.

We were appointed by the City of Venice to design a network for mobile phone service based on micro-cell BTS instead of conventional warm-cell BTS.

The proposal, on appointment of the City of Venice, has been designed in order to reach:

- EMF exposure minimization,
- environmental impact minimization, and
- conservation of cultural goods like the monumental areas

while not reducing (better, increasing) service and coverage standards for the mobile telephone service.

Plants to be substituted are conventional BTS, placed in the center of the area showed below. Their characterization is provided in Tables 1 and 2.

Address correspondence to F. Boella, Dipartimento di Venezia, Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro, Corso del Popolo, 133, Venezia, 30172 Italy; E-mail: boella@libero.it
Materials and Methods

First we considered the position and the heights of the buildings in the concerned urban area which presents an inhomogeneous distribution of the buildings and an elevated difference between the heights of the buildings (see Figures 1–4). Because the conventional formulas for evaluating the path-loss seemed inadequate, we adopted an advanced industrial software (QuickPlan®) in order to calculate the intensity of the electric field by means of the ray-tracing method (COST 231).

Taking into account the characters of the area, following an iterative process, we found the outdoor places where we could site the micro-cell BTS in such a way to give outdoor and indoor coverage, also satisfying the request, to reach the highest (more restrictive from our point of view) minimum field level usually supplied by providers and fixed in standards (V6.0.1, 1998–07; V6.1.0, 2005–06; V6.9.0, 2005–09). The iterative process ends when the distribution of the emitting antennas, in the concerned area, is found, according to the above restrictions, as shown in Figures 5 and 6.

The exposure levels on the buildings, in proximity to the macro-plants (that are to be substituted for), are shown in the next four images. These levels are calculated under the hypothesis that all the available power of the antennas is employed (i.e., all the channels for communication are fully employed simultaneously). The comparison confirms the lower intensity of the electric field levels (and thus the lower exposures to the general public) that result in the case of the micro-cells network, in the buildings and in open areas as well.

Table 1

| GSM       |
|------------------|------------------|
| Number of sectors | 3                |
| $P_{BCCH}$       | 38 dBM           |
| $P_{TOT/sector}$ | 44 dBM           |
| Height           | 28.8             |
| Antenna          | Kathrein 742265  |
| Gain             | 16 dBi           |
| Mecc. tilt       | 0°               |
| Elect. tilt      | 4°               |

Table 2

| UMTS       |
|------------------|------------------|
| Number of sectors | 3                |
| $P_{CPICH}$      | 33 dBM           |
| $P_{TOT/sector}$ | 43 dBM           |
| Height           | 28.8             |
| Antenna          | Kathrein 742265  |
| Gain             | 18.3 dBi         |
| Mecc. tilt       | 0°               |
| Elect. tilt      | 6°               |
Figure 1. Buildings height >5 m in solid black.

Figure 2. Buildings height >10 m in solid black.

Figure 3. Buildings height >15 m in solid black.
Figure 4. Buildings height >20 m in solid black.

Figure 5. UMTS micro-cells.

Figure 6. GSM micro-cells.
Micro-Cells Coverage for Mobile Telephony

Figure 7. Exposure map – UMTS macroplants (3 sectors) – $P_{\text{TOT}} = 20$ W/sector.

Figure 8. Exposure map – UMTS microcells (13 micro-cells) – $P_{\text{TOT}} = 2.5$ W/cell, Antennas on the rooftops.

Figure 9. Exposure map – GSM macroplants (3 sectors) – $P_{\text{TOT}} = 25.2$ W/sector.
Figure 10. Exposure map – GSM micro-cells (8 micro-cells) – $P_{\text{TOT}} = 2$ W/cell. Antennas on the rooftops.

Figure 11. Exposure map – GSM + UMTS macro plants.

Figure 12. Exposure map – GSM + UMTS micro-cells.
Figure 13. Coverage – UMTS macroplants (3 sectors) – $P_{\text{CPICH}} = 2$ W/sector. Threshold 66 dB$\mu$V/m – INDOOR – $H = 1.5$ m.

Figure 14. Coverage – UMTS micro-cells (13 micro-cells) – $P_{\text{CPICH}} = 0.250$ W/cell Threshold 66 dB$\mu$V/m – INDOOR – $H = 1.5$ m. Antennas on the rooftops.
Figure 15. Coverage – GSM macroplants (3 sectors) – \( P_{\text{BCCH}} = 6.3 \) W/sector Threshold 69 dBµV/m – INDOOR – \( H = 1.5 \) m.

Figure 16. Coverage – GSM micro-cells (8 micro-cells) – \( P_{\text{BCCH}} = 1 \) W/cell Threshold 69 dBµV/m – INDOOR – \( H = 1.5 \) m. Antennas on the rooftops.
Let us compare the results of the computer simulation when we overlay the intensity of the fields generated by UMTS and GSM (note that the colors palette is the same) (Figs. 11 and 12).

To evaluate the indoor coverage of the two solutions, the level of the received electric field in the best-server configuration is calculated. The threshold for service
in the area is the same: the black areas show the indoor coverage of the buildings due to the micro-cells (blue is for the macroplants). The computer simulation shows that the coverage is almost the same in the two cases of macroplants and micro-cells, for UMTS and GSM (Figs. 13–16).

The comparison of the coverage performances leads to a numerical confirmation of the above considerations (pay attention to the following data: in the concerned mapped section of the city, the calculated areas are more extended in the case of micro-cells relating to the case of macro plants) (Figs. 17–23).

From the point of view of the energetic balance, taking into account the total maximum power that is absorbed by the antennas, we can observe the strong reduction achievable due to using micro-cells, even when we do not consider the electric power required to cool the equipment of the macro plant (See Table 3).
Figure 21. Calculated area for macro plants.

Figure 22. Calculated area for GSM micro cells.
Conclusions

Under our hypothesis, the computer simulation concerning a specific area of the city of Venice shows:

- Micro-cells networks instead of conventional BTS-based network results in a strong reduction of personal exposure to electromagnetic fields. In order to reach the minimization of the exposure of the general public, micro-cells networks are preferred to a conventional one (ISPESL, 1997a,b).
- The environmental and esthetical impact of a micro-cells network can be minimized adopting properly sited small antennas, which is not possible using a conventional warm cells network.
- The use of micro-cells results in considerable energy savings.

<table>
<thead>
<tr>
<th>N. cells (sectors)</th>
<th>P_{TOT/cella} (settore)</th>
<th>P_{TOT}</th>
<th>P_{TOT} (GSM+UMTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro GSM</td>
<td>25.2 W (44 dBm)</td>
<td>75.6 W</td>
<td></td>
</tr>
<tr>
<td>Micro GSM</td>
<td>2 W (33 dBm)</td>
<td>16 W</td>
<td></td>
</tr>
<tr>
<td>Macro UMTS</td>
<td>20 W (43 dBm)</td>
<td>60 W</td>
<td>135.6 W</td>
</tr>
<tr>
<td>Micro UMTS</td>
<td>2.5 W (34 dBm)</td>
<td>32.5 W</td>
<td>48.5 W</td>
</tr>
</tbody>
</table>

Table 3
Energetic balance
The case of the City of Venice—today only a design, but tomorrow, it is confident, a realization—demonstrates that an alternate development of the mobile phone service is possible. This alternate mode appears to have less of an impact for both environmental and health profiles. The energy employed is much lower than the energy usually required. We do not know why only the conventional system to build mobile phone plants has been adopted. We suggest that the precautionary principle be adopted to obtain everywhere the changes that are technically possible, as in the example of the above design.

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