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Electromagnetic Radiation from Mobile Telephone (Cell Phone) Transmitter Masts (Towers) in the United Kingdom

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Summary

An outline is given of the Free-Space model, which is used to determine theoretical predictions of the radiation power densities of electromagnetic transmissions from mobile telephone (cell phone) masts (towers). The large variations in actual power density measurements are described, in relation to recent investigations carried out in and near UK school buildings. This is contrasted with the theoretical predictions of the Free-Space model. The conclusion is made that radiation power density predictions of transmissions from mobile telephone masts are highly model dependent.

A. Free-Space Model

1. The theoretical calculation of radiation power densities in mobile communication involves constructing a mathematical model. The modeling process attempts to take into account local conditions: such as the roughness of the ground; the presence of buildings, trees and other obstacles; the topography of the area; etc. However, no single model fits all conditions and locations - and all models by their nature are approximations.

2. The starting point in the modeling process is the so-called free-space path loss formula [1]. This formula gives the radiation strength at a distance from the antenna in ideal conditions on a perfectly flat earth.

3. The formula assumes that the heights of the antenna and radiation target above the ground are negligible compared to the distance from the antenna to the target, *i.e.* the point at which the radiation power is to be determined. This is a major flaw. In the case where the assumption no longer applies then the formula is invalid and the radiation power varies sharply over very short distances (of the order of metres). This spatial inhomogeneous nature of the radiation field means that the power density is highly localised and there exists no unique representative value. In other words, radiation power predictions in the vicinity of a transmitting mast are unreliable if they have been obtained by standard modeling.

4. In practice, the modeling of theoretical predictions of radiation power proceeds along one of two ways. The free space path-loss formula is modified either by use of an algorithm to classify local conditions as one of a set of generalised standard environments [2] – *e.g.*, "desert", "urban", "open country" – or the geographical details of the radio cell are overlaid on a topographical map of the area and local conditions, such as the shape of the ground contours, are averaged from the topographical data. The latter method can be used in the UK, where appropriate data is available from the Ordnance Survey.

5. In either procedure, the accuracy of the predictions - in areas where the free space path-loss formula is valid - depends on how well the actual local conditions have been simulated and how well such simulations can predict appropriate modifications to the free space path-loss formula. No indications of the degree of error associated with the radiation-power prediction data are usually provided by the mobile phone operators. Instead, they often say that their calculations are "based on the worst case scenario". Of course, such a term is meaningless until the exact conditions associated with "the worst case scenario" algorithm are defined.

B. Practical Measurements of Radiation Power Densities

1. In 2001 the United Kingdom's **Radiocommunications Agency (RA)** began an audit of the radiation emitted from base stations sited on school buildings in the UK. The **RA** audit remains one of the few programmes of measurement – as opposed to theoretical modeling – of the radiation associated with mobile radio-communication base stations.

2. On 29 December 2003, the **Radiocommunications Agency** was subsumed into a new agency called the **Office of Communications (Ofcom)**. The activities of the **RA** are referred by **Ofcom** as a "legacy", but it is not clear whether the radiation audit is continuing at the present time (August 2003).

3. A feature of the results of the **RA** audit is the wide variation in the measured radiation power densities within a site. For example, within the confines of Brixham Community College, Brixham, which was audited by the **RA** on 23 July 2001, the highest measured

ICNIRP public exposure level of radiation [3] was nearly ninety (90) times greater than the lowest recorded level. Within the confines of Folkestone School for Girls, Folkestone, which was audited by the **RA** on 23 November 2001, the highest measured ICNIRP public exposure level was over four-thousand (4000) times greater than the lowest recorded level. Again, within the confines of the Everlasting Ministries Nursery School, London, which was audited by the **RA** on 21 November 2002, the highest measured ICNIRP public exposure level was five-hundred-and-eighty (580) times greater than the lowest recorded level.

4. The schools mentioned in Paragraph B3 have been chosen at random from the list of **RA** audited schools. They are given here as a representative sample; but they are indicative of the errors and general arbitrariness associated with radiation power levels. The results in Paragraph B3 illustrate the dangers of assigning a particular value of radiation power density as a definitive indicator of the ICNIRP public exposure level within a location.

5. The **RA** audit also reveals wide variations in the measured radiation power densities between sites. For example, the highest measured ICNIRP public exposure level at Folkestone School for Girls, Folkestone (audited by the **RA** on 23 November 2001) was nearly three-thousand (3000) times greater than the highest measured ICNIRP public exposure level at Countesthorpe Community College, Countesthorpe (audited by the **RA** on 15 February 2001); over seven-hundred (700) times greater than the corresponding level for Carrickfergus Grammar School, Carrickfergus (audited by the **RA** on 24 September 2001); but only one-and-a-half (1.5) times greater than the corresponding level for Brixham Community College, Brixham (audited by the **RA** on 23 July 2001). The antennae associated with all these schools were identical (Rohde and Schwarz, Model HE200.4050.3609.02).

6. As in Paragraph B3, the schools given in Paragraph B5 are presented as a representative sample only. Obviously, it is more problematic to compare the results associated with different schools than those within the confines of the same school. Nevertheless, they illustrate again the wide range in values found in practical, measurements of radiation power density.

C. Conclusions

1. Radiation power density predictions are highly model dependant.

2. In situations where the height of the antenna is not negligible, compared to the distance from the antenna to the target, the free space path-loss formula is invalid. The radiation power density becomes highly localised, with large, spatially-dependant variations.

3. Practical measurements undertaken by the Radiocommunications Agency reveal wide variations in the values of radiation power-densities in real geographical sites. The variations indicate the myriad of factors involved in radiation propagation, and the near-impossibility of assigning a particular value of radiation power density as a definitive indicator of the ICNIRP public exposure level within a particular location.

References

[1] Macario, R. C. V. *Cellular Radio: Principles and Design*. Macmillan, London, (1997).

[2] Lee, W. C. Y. *Mobile Cellular Telecommunications Systems*. McGraw-Hill, London, (1989).

[3] *Health Physics* **74**, 494 (1998). International Commission on Non-Ionizing Radiation Protection.