Directly in front of the antenna this can result in high levels of power flux density. However out of the beam, the radiation level will be much less than that from a non-directional antenna. (The effective gain is less than 1.) In an installation at the top of a church tower it is usually not possible to stand in front of the antenna. In any case warning notices must be displayed to indicate areas of high field strength.

The transmitter power of a cellular base station is not fixed, but increases as the number of calls increases. Also the power level used to support each call is dynamically controlled so as to be just sufficient to maintain a satisfactory level of speech quality. This allows the operator to use the same set of frequencies elsewhere in the network with minimal interference effects.

3.1 Base Station (Cellular Antennae)

The power rating of antennae currently in use is of the order 500 watts and whilst it is very unlikely that a base station would operate at these powers it has been used as worst case in the following calculations. The off axis gain has also been assumed at a relatively high value, in some antennae this is as low as 0.05.

Off axis "gain"	0.25 @ 30 degrees below horizontal
Transmitter Power	500 watts
Distance	2 metres

$$\frac{\text{Antenna Gain} \times \text{Transmitter Power}}{4\pi r^2} = \frac{0.25 \times 500}{4 \times \pi \times 2^2} = 2.4 \text{ W/m}^2$$

This represents a worst case of an antenna with relatively poor directional properties and a high powered transmitter. 2 metres is also closer than one would normally be able to approach. Even so the probable radiation level is less than one tenth of the current guideline figure at 900 MHz; i.e. within that suggested for unrestricted public access.

3.2 Point to Point Links

These operate at much higher frequencies and with much lower power levels. The antennae are usually of the circular "dish" type, which are highly directional, resulting in negligible off axis radiation.

Typical figures are: -

Off axis "gain"	0.01 @ 30 degrees below horizontal
Transmitter Power	0.1 watts
Distance	2 metres

$$\frac{\text{Antenna Gain} \times \text{Transmitter Power}}{4\pi r^2} = \frac{0.01 \times 0.1}{4 \times \pi \times 2^2} = 0.00002 \text{ W/m}^2$$

Although it is not recommended, there is usually no problem, from a safety point of view**,** in going directly in front of such antennae. (The cellular network operator may have other views, as this would most likely block the signal.)

This document has been prepared to meet the immediate demand for guidelines. It will be replaced by a more comprehensive document as and when more information and experience of installations is available.

THE CENTRAL COUNCIL OF CHURCH BELL RINGERS
Towers & Belfries Committee

RADIO TRANSMITTERS
installed in church towers

 Issue 2a

INTRODUCTION

There is a growing tendency for the Mobile Telephone Companies to use Church Towers to house their transmitting equipment. This is proving very profitable for the churches concerned, and in one particular instance, where for other reasons it was desirable to do so, the Company was prepared to re-hang the bells at a lower level in order to free space for their equipment.

This immediately raises questions in the minds of the Ringers, relating particularly to the possible safety hazard arising from the radiation from the equipment. There are, however, other considerations which might well prove to be rather more disturbing.

RADIATION HAZARD

The radiation hazard is taken care of by the legislation relating to the safe level of microwave frequency radio fields. There has been considerable study of this phenomenon since the early days of radar, and the effects are well known. There is no danger to health from an installation carried out in accordance with this legislation. This may place restrictions of access to the areas used for the installation. The radiation from a typical telephone transmitter will be well below the permitted levels; in fact the typical radiation from a microwave cooker, whilst still being within the legislation limits, is greater than that which is likely to be present in a telephone transmitter installation. This is so because the designers of the respective equipments have allowed themselves different margins to ensure they do not exceed the prescribed limits. This is demonstrated in the appendix to this note.

INSTALLATION PROBLEMS

Arising from existing installations, several problems have come to light. The operators of mobile telephone systems generally have no understanding of church bells and their mechanisms. Neither do their technical staff, nor the sub-contractors who carry out the installation, provision, servicing, etc of the equipment. Often these are completely different firms**.** The following must be borne in mind:

1. The diverse people who require access from time to time have no concept of the dangers associated with church bells and the way they are hung.
2. There is no understanding of the bells' operation, so it is not unusual for the odd cable to be fixed passing through the spokes of a wheel.
3. The idea of a bell swinging through a complete circle may not be envisaged by the installers, so that equipment may be mounted in the path of a bell.
4. Bellringers require access to the bells at all times.
5. Access to the equipment through the bells must be denied when the bells are up.
6. Only the church can ensure safe access for technicians where this is via the bell chamber.

7. In the case of an emergency, it may be essential that the church can electrically isolate the equipment (i.e. in the event of a fire, where access may be necessary via the tower roof).
8. Bearing in mind the difficulties of recruitment, it is very possible that some recruits will be deterred by the presence of radiating equipment

SAFETY

In the past 50 years there have been several fatal accidents in church bell chambers these being mainly due to ignorance or carelessness. Thus considerable care is needed in drawing up safety procedures. The telephone company will usually require access at all times. Common sense safety requirements as well as legal responsibility mean that the PCC must ensure that access to the bell chamber and ringing rooms is controlled by the bell ringers. Unsupervised access by anyone not familiar with bell installations could very easily result in a serious accident.

1. **Access to the transmitting equipment may not be via the Bell Chamber or Ringing Chamber; and any equipment or cables requiring maintenance should not be located there.**
2. **Thus access to telephone equipment must be either directly from a spiral staircase or via separate (external) ladders; and the Bell Chamber and Ringing Chamber must be isolated from the access path.**
3. **In no circumstances should a key to the bell chamber be allocated to the telephone company.**
4. **Means should be provided to electrically isolate the tower in an emergency.**

PRECAUTIONS

All of these items can be taken care of by careful thought at the time of drawing up of contracts, and it essential that the bellringers are involved. Assistance in this may be obtained from the Central Council of Church Bell Ringers, if required.

Make sure that the priorities of access and the dangers associated with bells are understood and agreed by the company, and that they are aware of the responsibility they hold for the safety of their contractors.

Get a statement from the operator of the likely radiation levels before agreeing to the installation.

As part of the contract with the telephone company insist that the position of equipment and cables are agreed and that measurements of field strengths are made in areas of concern at the conclusion of the commissioning and that a certified written record of measurements is provided after the installation is complete. This should include around the top of the tower, in the bell chamber and in the ringing chamber. (But remember that the power level will vary according to the number of calls in progress and the location of the mobiles, so this must be done under simulated conditions representing likely maximum field strengths). All operators are required to fix warning notices showing the exclusion zones around their antennae. Ensure that these are in place and that everybody who has access to the vicinity of the antennae understands their meaning and obeys them.

RADIATION LEVELS

The mobile telephone system in use in this country operates at microwave frequencies. Radiation at these frequencies was first studied in connection with the use of Radar immediately prior to and during the war, and guidelines were established for their safe working. The recognised safe level of field strength is 3.3 mW/cm^2. (See Appendix: paragraph 2.)

Radio frequency electromagnetic fields are non-ionising, and thus molecular damage does not take place. Current safety guidelines are based on the heating effects of microwave radiation. There are no guidelines relating to any other effects. This effect is demonstrated in domestic microwave cookers where applying the guidelines dictates that radiation for this purpose is retained within a screened metal enclosure, which in a microwave cooker reduces the field strength to a safe level.

A typical emission from a microwave cooker is some 2 mW/cm^2 **(= 20 W/m^2)** measured 2 cm away from the case.

As a comparison the field strength associated with microwave transmitters for mobile telephones, measured at accessible points, is some 0.02 mW/cm^2 **(= 0.2 W/m^2).**

APPENDIX: Radiation Levels at Cellular Telephone Base Stations

1. Summary

There are two possible sources of radiation from base stations, the antennae transmitting to the handsets and the microwave point to point links that are used to link the base stations to the network. In both cases radiation levels are well below the current recommended levels, as shown by the calculations in the following sections.

2. Radiation Guidelines

The UK National Radiological Protection Board (NRPB) specifies "Investigation Limits" in terms of power flux density measured in watts per square metre. Provided that these are not exceeded, in an area, it may be assumed that the area is safe. Higher levels do not automatically mean that the area is unsafe, but detailed measurements are required to establish its safety, or otherwise.

For areas to which small children may have access, the investigation limits are: -

900 MHz	33 W/m^2	or	3.3 mW/cm^2
1550 MHz to 100 GHz	100 W/m^2	or	10 mW/cm^2

In the UK no distinction is made as to whether the access to an area is restricted to workers or open to the public. Within Europe there is a move to reduce these levels by a factor of 5, where the public have access to an area.

Current networks operate at both 900 & 1800 MHz and the proposed 3rd generation networks will operate at 2100 MHz.

3. Likely Radiation Levels

The radiation levels are calculated by considering the power flowing through a 1 metre square on the surface of a sphere, of radius r, that is centred on the antenna.

If the antenna radiates equally in all directions, the power flowing through this square is given by: -

$$\text{Power Flux Density} = \frac{\text{Transmitted Power}}{4\pi r^2}$$

All antennae used at base stations are directional. This means that the energy radiated is concentrated in one direction. This is true even for so called omni-directional antennae, which although they radiate equally over 360 degrees in azimuth radiate very little upwards or downwards.

Within the beam of the antenna the power flux density is given by: -

$$\frac{\text{Antenna Gain x Transmitter Power}}{4\pi r^2}$$