
The Impact of Large Buildings and Structures (including Wind Farms) on Terrestrial Television Reception



The Impact of Large Buildings and Structures (Including Wind-Farms) on Terrestrial Television Reception

Preface

It is well known that large buildings and other structures such as wind farms can adversely affect terrestrial television reception. The broadcasters, the BBC and Ofcom, are keen to ensure that disruption to both analogue and digital terrestrial television distribution and reception is kept to a minimum.

To achieve this, the broadcasters wish to bring to the attention of architects, building developers and planning authorities the potential for problems. Typically, the type of buildings that cause reception problems are those with a sizeable side elevation over 15 metres high. Mechanical constructions such as wind turbines, cranes, non-domestic satellite ground stations, etc., can also cause difficulties. There are two services the broadcasters wish to protect; permanent broadcast links and domestic reception.

- **Permanent broadcast links**

In the UK, television programme distribution links are provided to more than 1300 transmitters by means of land-lines, microwave links and ‘UHF In-Band’ re-broadcast links (RBLs). It is the latter that form the major part of the distribution system. Both microwave and re-broadcast links, between sites which can be up to 70 km apart, may be affected. The map in Appendix I illustrates the density of transmitters and RBL paths only. The transmission network within the UK is provided and operated on behalf of the broadcasters by National Grid Wireless and Arqiva.

- **Domestic television reception**

Domestic television may be affected at distances up to 20 km from the large buildings causing the problem. Wind turbines affect reception up to a maximum distance of 5 km.

Terrestrial analogue television within the UK is the joint responsibility of the BBC and Ofcom. The UK is sub-divided into areas for which one or other organisation is responsible. The map in Appendix II shows the two areas. The responsibility for digital terrestrial television is shared equally between the BBC and Ofcom.

Contact details for the BBC Reception Advice, Ofcom, Arqiva and National Grid Wireless are given in Appendix III.

This document discusses the measures that can be taken to minimise the effects of large buildings and other structures, and what can be done to restore viewers’ reception.

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1.0 FOREWORD

The development of large buildings and other structures can cause television reception difficulties - a matter of concern to viewers, broadcasters and developers alike. Whilst it is often impossible to avoid such problems completely, the following text aims to provide a source of general guidance to help minimise the adverse impact of such developments on broadcast services.

2.0 INTRODUCTION

Both theory and practical experience have shown that large developments can have a disruptive effect on television reception. Reports of picture degradation linked with the construction of masts, towers, wind-turbines, and of domestic, commercial or industrial buildings¹, are unfortunately not uncommon.

This document contains a general consideration of how such problems can arise, and how, with care, they can be minimised. Both analogue and digital terrestrial reception can be affected.

A full analysis of any case requires detailed information about the design and dimensions of the structure, along with knowledge of the local terrain. If this information is available, computer modelling by experts will, in most cases, enable an assessment to be made of whether a given structure is likely to cause problems. It will also be possible to predict the areas where reception difficulties are likely to occur, and to estimate the number of households that could be affected. It will also be possible in most cases to offer suggestions on how potential problems could be minimised.

There are some complex circumstances however where even modern computing techniques do not give the whole answer. When this is the case, local measurements might be needed to help assess the impact of a development and the possible steps necessary to reduce any problems which might arise.

In some very complex cases, accurate prediction, by any method, is extremely difficult; in such cases careful judgement made by those experienced in this field can however still be helpful.

Wind farms, with their added complexity of moving blades, require additional consideration to static structures and this specific type of development is dealt with in Section 7.

3.0 MECHANISMS THAT CREATE TELEVISION RECEPTION PROBLEMS

Any structure will produce two zones of potential disruption to television reception. One zone is where the development creates a 'shadow' and the other where it gives rise

¹ For the purpose of this document, the contents of this list will be generically referred to as 'structures'.

to a 'reflection'. At the frequencies used for broadcasting, the processes of creating a 'shadow' or a 'reflection' are somewhat more complicated than with visible light, but thinking of the problem in these terms is still a helpful way of approaching the matter.

3.1 'SHADOWING' EFFECTS

In an area behind the structure, the television transmitter is effectively screened from the viewer and the strength of the signal is reduced; see Figs. 1 and 2.

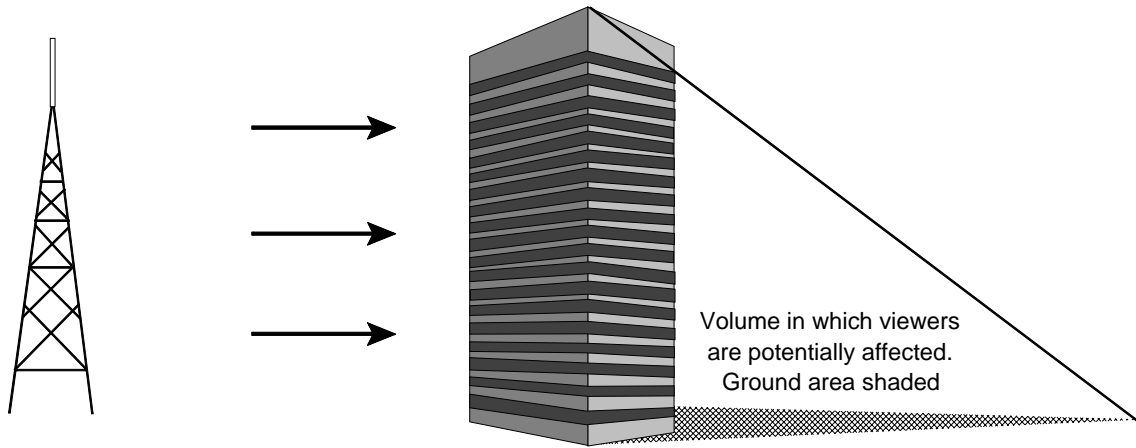


Fig. 1: Affected area in the 'shadow' zone behind the structure

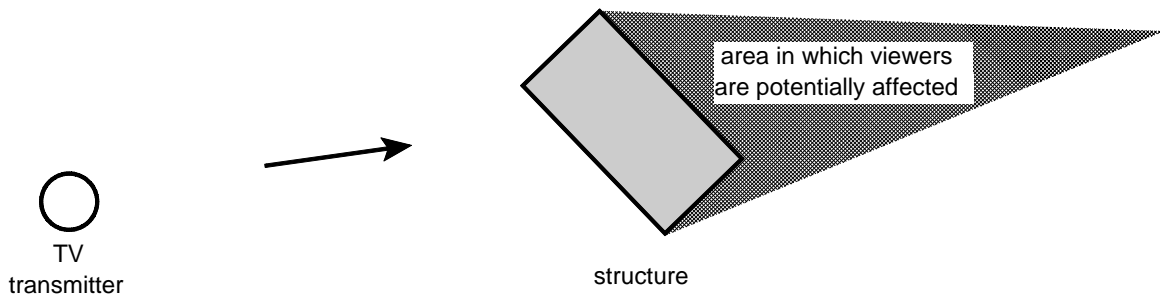


Fig. 2: Plan view of the 'shadow' zone

Television signals do not create such a 'hard' shadow as visible light, and for the purposes of explanation, a 'shadow' zone must be considered which is divided into three sub-zones.

- i. Within a few tens of metres from a solid structure, over the region where optical view of the transmitter is lost, the reduction in signal strength is critically dependent on the specific design and composition of the structure. For most brick and concrete buildings the reduction is severe and in some cases almost total. For non-solid structures such as metallic

lattice towers, the signal reduction is dependent on the density of the lattice and the wavelength of the signal.

ii. Further away from the structure (say beyond 250 m, but this varies depending on its size) the limit of the ‘shadow’ zone and the signal reduction are determined by diffraction at the edges of the structure and reflection off surrounding structures. The simple condition of whether or not a location has an optical view of the transmitter is not enough to classify the potential interference zone adequately. In general, the effect is that the signal appears to bend around the sides of the structure; the shadow zone reduces in size and the signal strength is reduced by much less than simple ray optics would suggest.

iii. Even further away from the structure (say 5 km) complex multiple reflections and diffraction, caused by structures in the locality, may result in the ‘shadow’ zone becoming almost non-existent.

3.2 ‘REFLECTION’ EFFECTS

The second zone of potential interference is produced by ‘reflection’ or ‘scattering’ of the incident signal, see Fig. 3. Analogue reception is more likely to be affected than digital terrestrial reception, which is more robust.

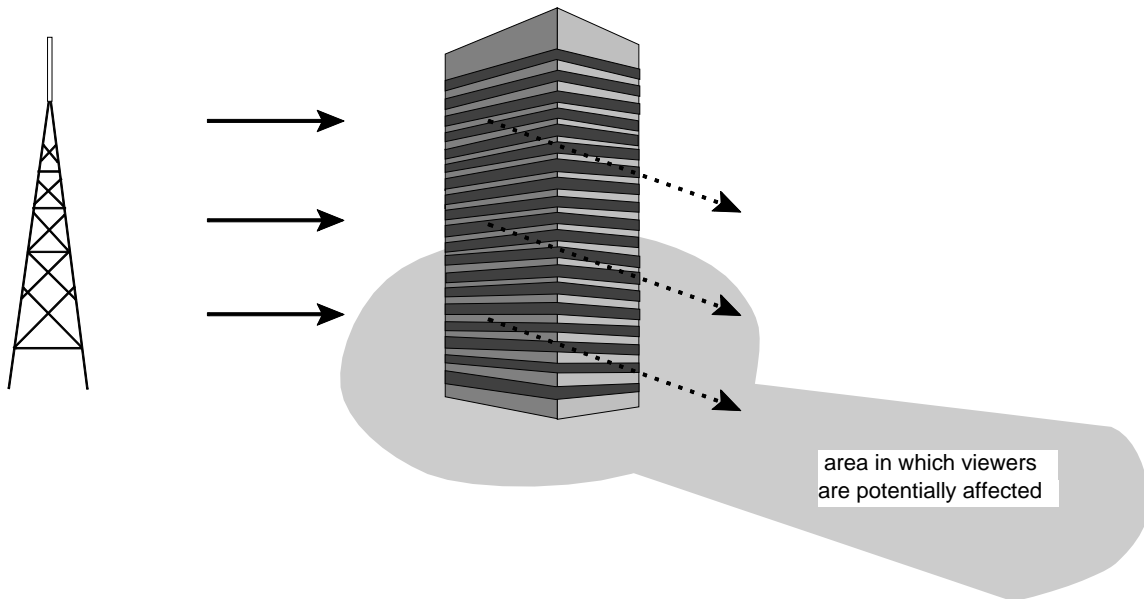


Fig. 3: Affected areas in the ‘reflected’ zone of the structure

As can be seen in Fig. 4, (shown on the following page) the direct signal travels a distance D_1 to the viewer, whilst the signal reflected from the structure travels slightly further, a distance $D_2 + D_3$. Even though television signals travel at the speed of light, the different path lengths can mean that one signal arrives with a significant delay relative to the other. This results in a second image appearing on the viewer’s screen,

displaced from the first. This type of interference is known as 'delayed image' or, 'ghosting'. If the reflecting signal is complex, several such ghost images can result. Photograph 1 shows the 'ghost' image produced as a direct consequence of a building development in London.

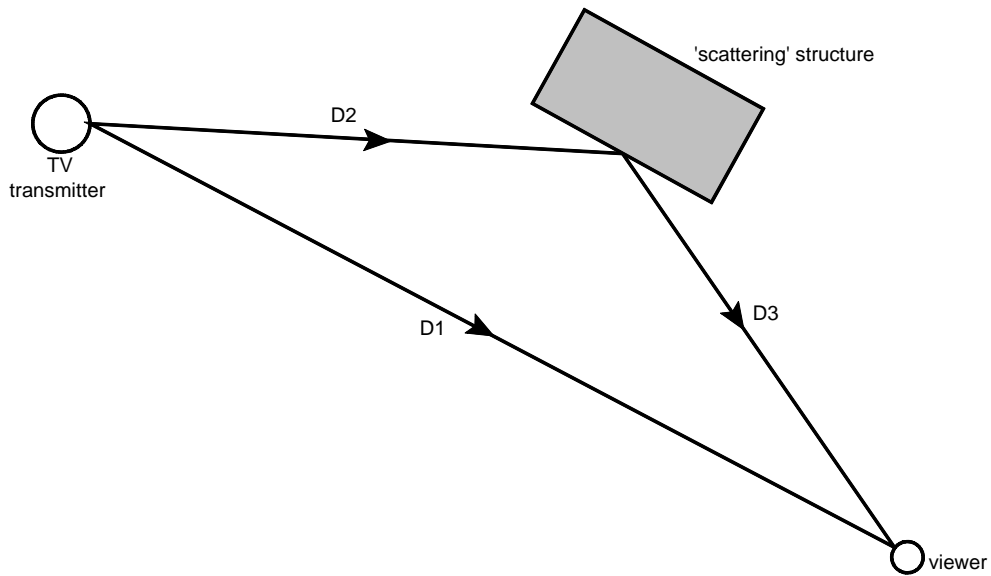


Fig. 4: Plan view showing how delayed images (ghosts) are produced on a television picture



Photograph 1: An example of severe delayed image interference or 'ghosting' affecting analogue television reception.

The general location of the ‘reflection’ zone depends on the angle of the incoming signal and the orientation of the structure. The extent of the zone and the degree of interference within the zone depend on the relative strengths of the direct signal and the reflected signal, determined by the radio-frequency reflectivity of the structure, and also on the delay between the two signals.

The greater the relative strength of the reflected signal, and the longer the delay, the more subjectively intrusive this problem becomes. Appendix IV indicates the levels of impairment introduced for different amounts of delay and different strengths of reflected signal relative to the wanted signal, within the range of impairments which is generally acceptable.

Another factor which significantly affects the size and shape of the ‘scattered’ or ‘reflected’ interference zone is the radiation pattern of the viewer’s receiving aerial. Consider a location where the delayed signal has a relative amplitude and delay consistent with unacceptable interference. If the angle between the source of the direct signal and the source of the delayed signal is greater than about 45° , an aerial whose pointing is optimised to receive the direct signal will discriminate against the delayed signal. For critical applications, a very narrow beamwidth aerial may be used to reduce the strengths of delayed images to acceptable levels. The internationally-recommended minimum performance for receiving aerials is reproduced in Fig. 5.

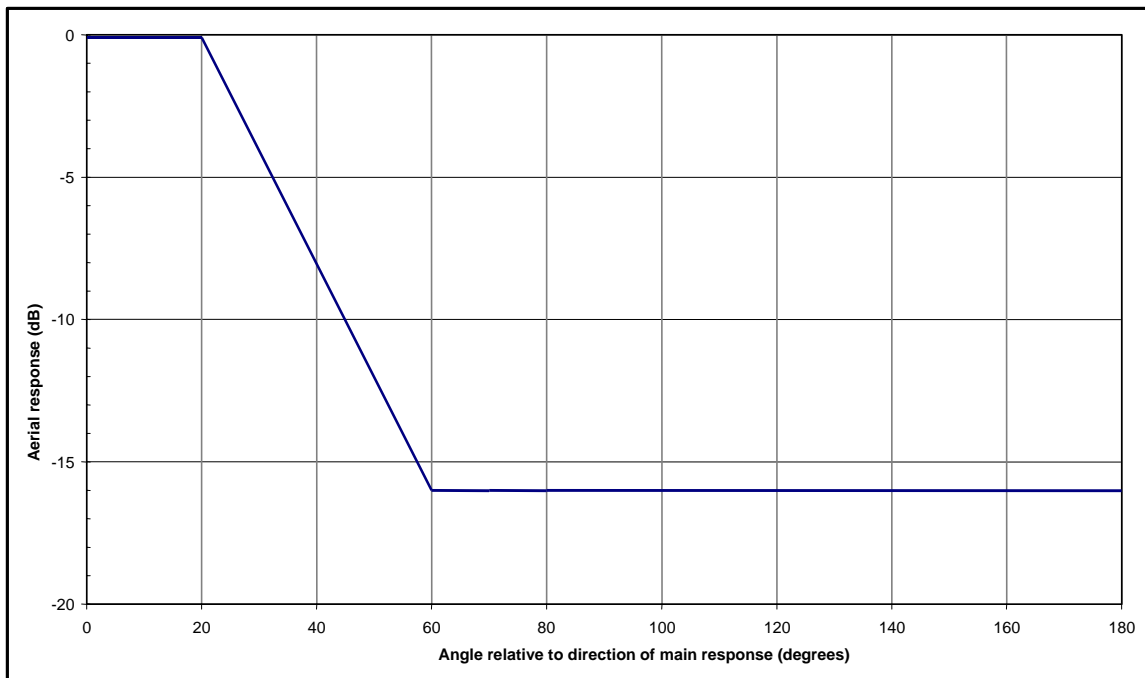


Fig. 5: Discrimination obtained by use of directional receiving aerials in broadcasting.

In practice, domestic receiving aerials have performances similar to those shown in Figs. 6 and 7. The radiation patterns indicate the aerial response (dB) on the radial axis versus the azimuth. In the case of the narrow beam-width aerial there is an arc about 20 degrees wide over which the response is at a maximum, and in the case of the wide beam-width aerial this is about 40 degrees wide. The smaller peaks in aerial response away from the main beam are known as side-lobes. These are unwanted, and in order to reject reception of the reflecting signal (as shown in Fig. 4) they should be as small as possible.

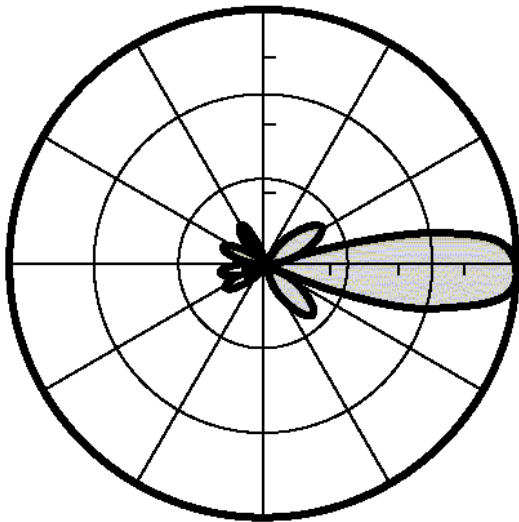


Fig. 6: Typical Narrow Beam-Width Aerial Radiation Pattern

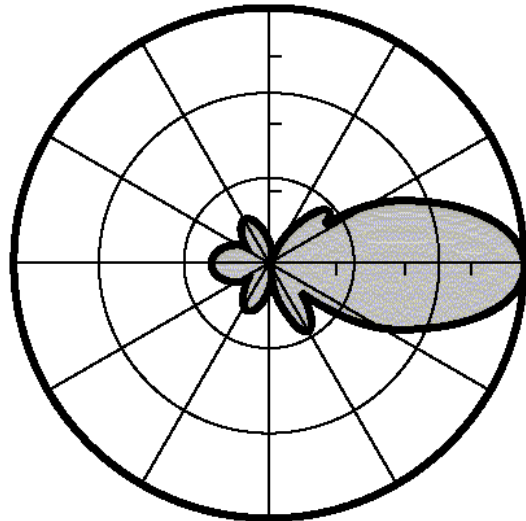


Fig. 7: Typical Wide Beam-Width Aerial Radiation Pattern

4.0 ASSESSING IMPACT

One useful ‘rule of thumb’ to judge the likelihood of a problem is the ‘sky-line check’. If, from a given location, the proposed structure significantly modifies the sky-line, then there is the possibility that it may cause television reception difficulties at that location. This is equally true in a dense urban environment where the sky-line already consists of large structures which themselves might already create some reception difficulties, but for which viewers have already made attempts to cope.

5.0 REDUCTION OF IMPACT

The ‘shadow’ region, of any solid structure is mainly determined by its size. Very little can be done, either at the design stage or after development, to reduce these effects themselves, but the damage done can sometimes be ‘made-good’ by providing those affected with an alternative means of receiving television. More information on this is offered in Section 6.2.

The ‘reflected’ interference region is entirely dependent on the structure design. If the face of a structure is shaped so that it distributes its reflected signal over a large region,

the resulting reflected signal strength is less than if it were concentrated over a small region.

A large area of structure presenting a single flat face will concentrate signals over a small region. The same area consisting of several smaller flat faces at differing angles will distribute the signals over as many geographical regions. A convex reflecting surface will disperse signals equally over an arc.

It may also be possible to arrange the structure's face(s) to direct the reflected signal(s) away from large areas of population, or to direct the reflected signals such that the receiving aerials can adequately discriminate against them.

The choice of building materials will also affect the strength of the reflected signal. For materials such as bricks, concrete, etc., the reflection coefficient is low; the reflectivity of the total structure being determined more by the metallic content, steel joists, steel reinforcing members, window frames, etc. In modern constructions, the density of metal, throughout the structure, may be sufficiently high to increase the reflection coefficient dramatically.

Metallic cladding in conjunction with metallised windows has been known to produce the worst reflections, with nearly the whole incident signal being reflected.

In practice, the avoidance of large flat areas is the best overall approach. The deliberate dispersion of signals by non-flat services, or the direction of reflected signals away from populated areas, are the best ways of avoiding significant 'ghosting' problems.

6.0 REDUCTION OF RECEPTION PROBLEMS AFTER DEVELOPMENT

Remedial action can either be taken at the structure, or at the homes affected. Usually the former is of limited value and the latter offers the only practical way forward.

6.1 ON THE STRUCTURE ITSELF

Whilst changes at the structure seldom offer the most practical way of minimising problems once they have occurred, it is nonetheless useful to assess this option first, because, if practical, it addresses the problem at source. The possibilities are shown below, and their applicability to specific structures should be addressed on a case-by-case basis. They only address the problem caused by reflections, and offer no solution to those in the shadow of a new development.

- **Use a radio absorbing coating**

This technique has been considered prohibitively expensive. However, we are aware of isolated instances of large buildings utilising radio absorbing coatings to reduce the level of reflected signals.

- **Construct 'irregularities' on flat walls**

Provided that the irregularities are of an appropriate size, this would tend to scatter the incident signal. If the wall were a truly irregular structure, the signal would be scattered over much of the hemisphere containing the direction of the incident

signal. The strength of the reflected signal, in any direction, should then be below the value expected to cause interference. In view of the size of the walls of typical structures of concern, and the wavelengths of the incident signals, this is not really a practical option.

- **Angled cladding**

Fig. 4 shows the geometry of a location affected by a signal reflected from the face of a building. It might be thought that the reflected signals could be re-directed to a less critical area or even upwards by applying, to the face of the building, a large number of individual strips or panels, at an angle different from that of the overall angle of the face of the building. Such measures should be treated with some caution; the angle at which the signals are actually reflected from the building is not dependent solely on the angle of the cladding, but also on the size and position of elements of cladding, and also the wavelength of the signal. Whilst in some circumstances this may indeed change the angle of reflection and the area affected, it is unlikely to result in the angle of reflection or the area of interference expected and it is entirely possible to end up with angled cladding making absolutely no difference.

- **Pebbledash**

This is an often-quoted solution which, practically, is unlikely to show any benefit whatsoever.

6.2 IN THE LOCATION OF THE AFFECTED VIEWERS

- **Replace receiving aerials for affected households**

Receiving aerials with superior performance to the discrimination template shown in Fig. 5 are available. These can produce a narrower receiving beam-width (so they will discriminate better against unwanted signals arriving from other directions) and also a higher gain (so the receiver can be made to work in areas of lower signal strength). Log-periodic aerials, which have the ability to reject signals arriving from the sides and rear of the transmission path, are also known to be effective in combating reflections. Clearly, these measures will not work if the reflected signal is coming from the same direction as the transmitter.

- **Re-tuning television receivers at affected households**

If the affected area is served adequately by transmissions from an alternative transmitter, receivers can simply be re-tuned to the unaffected service. This will also require changing the direction in which the receiving aerials are pointing, and maybe even replacement of the receiving aerial as most aerials will not cover the entire range of broadcast frequencies.

- **Construction of a new ‘analogue’ television transmitter station**

This solution has been used in the past but now, apart from in rural areas, offers few opportunities. The channels used for any proposed new station must avoid mutual interference with existing services. Throughout the UK, all television channels are re-used many times, and therefore meeting this requirement is, in many instances not possible. Only in exceptional circumstances would the broadcasters consider this solution.

- **Construction of a new ‘digital’ television transmitter station**

Coverage of Digital Terrestrial Television (DTT) is not yet complete across the UK, and the final roll-out of digital transmitters can only happen when analogue TV services are switched off in a particular region. Therefore it will only be possible for the broadcasters to consider the provision of new low powered ‘self-help television’ transmitting stations (to be constructed by developers or small communities) after the roll-out of DTT in their region is complete.

- **Replacement of terrestrial television reception by ‘digital satellite’ or ‘cable television’ services**

Digital satellite offers near-universal geographic coverage of the UK, and is not subject to many of the reception problems which can affect terrestrial television. Satellite reception offers the main 'public-service' TV channels on a subscription-free basis, although a charge is made for a ‘viewing card’ to enable reception of ‘Channel 4’ and ‘Five’ as their transmissions are encrypted. Each affected household would need a properly installed satellite dish, cabling and receiver(s). If affected households are served by an commercial cable TV company, this may also offer an alternative, though a monthly subscription is likely to be required.

- **Provision of a ‘self-help : cable system’**

Self-help cable systems, also known as CATV systems, are ideally suited for compact groups of houses. A single ‘master receiving aerial’ able to receive a signal that is free of interference, feeds an RF signal, by way of a cable and series of amplifiers, to each of the properties affected.

If any of these solutions are chosen, the developer may be required to fund, construct, and where appropriate maintain, the remedial measures. This may be required as part of an agreement between the planning authority and the developer, and enforceable under Section 106 of the Town and Country Planning Act 1990 (England and Wales) or Section 75 of the Town and Country Planning Act 1997 (Scotland).

7.0 WIND TURBINES AND WIND-FARMS

Photograph 2 shows the type of wind turbine referred to in this section. Virtually all commercially available machines, currently in operation, are of this general type having a horizontal axis of rotation with two or three blades.

Generally, turbines have a number of common characteristics. These are:

1. rarely sited closer than 250 metres away from domestic properties
2. the nacelle (the generator housing at the centre of blade rotation) and the blades are typically mounted on a narrow, cylindrical, concrete tower
3. normally, the blades are constructed of non-metallic material such as GRP, although they invariably contain metallic components such as a strengthening member, lightning conductor and balancing weights
4. the orientation of the blades corresponds to the wind direction
5. the usual speed of blade rotation is between 15 and 30 RPM

In practice rarely does the tower or nacelle have any effect on reception; the impact on reception is solely on account of the rotating turbine blades. As the blades are moving objects, in terms of both their rotational speed and orientation, their effect is variable and hard to predict. When the combined effects of a number of turbines that comprise a wind farm are considered, the result is considerably more difficult to predict.



Photograph 2: Typical wind turbines in a wind-farm

7.1 SHADOWING AND REFLECTION EFFECTS

The two mechanisms responsible for the interference, as with buildings, are ‘shadowing’ effects and ‘reflection’ effects, as described in sections 3.1 and 3.2, respectively.

The size of the ‘shadow’ zone is dependent on the orientation of the blades and is at a maximum when the axis of the rotor is in line with the direction of the transmitted signal. The received signal strength varies in a cyclic manner, in time with the blades’ rotation.

‘Reflection’ effects vary with the rotation of the blades and the orientation of the nacelle. To complicate matters further, the strength of the reflected signal is dependent on the length and area of the metallic components inside the blade.

7.2 THE AREA AFFECTED

Interference to analogue television reception is shown as a characteristic flickering of the picture. The affected area around the turbine, a combination of the ‘shadow’ zone, and the ‘reflection’ zone, is roughly shaped like a keyhole (like that shown in Fig. 3). The actual shape and size of this is dependent on the type of turbine and the topography between: the broadcasters’ transmitter and the turbine; the broadcasters’ transmitter and the viewers’ receiving aerials; and the turbine and the viewers’ receiving aerials. Nevertheless, for the purposes of assessing the likelihood of interference, the ‘shadow’ zone may be considered to be a sector with a radius up to about 5 km, and the ‘reflection’ zone a circle of radius of about 500 m.

7.3 REDUCTION OF INTERFERENCE

The siting of the turbine or turbines can reduce the severity of interference. If possible, turbines should be at least 500 metres from any viewer. Interference caused by wind farms with more than one turbine may be reduced if one turbine could be placed within the ‘shadow’ area of another. The measures to reduce interference at the location of the affected viewers, outlined in Section 6.2, are also relevant to interference from wind turbines. Appendix V illustrates the reflection effect, and explains in which situations a more directional receiving aerial can be used to reduce the level of delayed image interference.

7.4 ASSESSMENT OF INTERFERENCE

The potential impact on television reception of one or more wind turbines can be predicted using the BBC’s web-based wind-farm assessment tool. The BBC no longer carries out manual assessments for developers but provision of this online tool enables developers to carry out evaluations for themselves.

The wind-farm assessment tool can be found at <http://windfarms.kw.bbc.co.uk>

After entering the turbine locations, the user is sent, by e-mail, an estimate of populations that may suffer interference from the proposed wind-farm. The tool is not

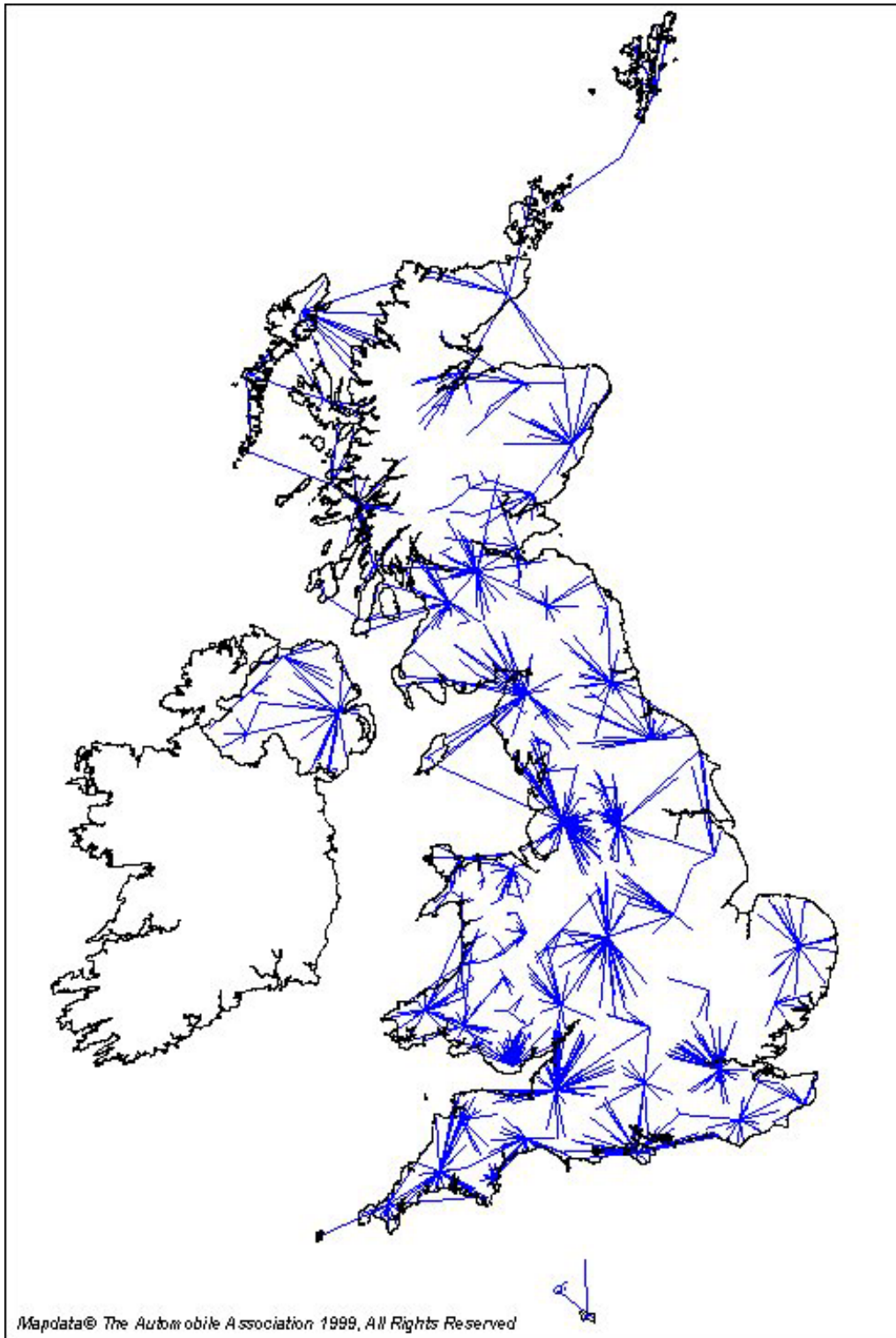
intended to be a substitute for an on-site survey, commissioned by the developer, by which the potential for disruption to television services may more accurately be assessed.

If there is potential for interference to television reception (predicted or measured) then local authorities will usually expect wind farm developers to take remedial action. This will typically require an on-site survey to determine appropriate remedial measures; the options are the same as those given in Section 6.2 of this document.

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APPENDIX I

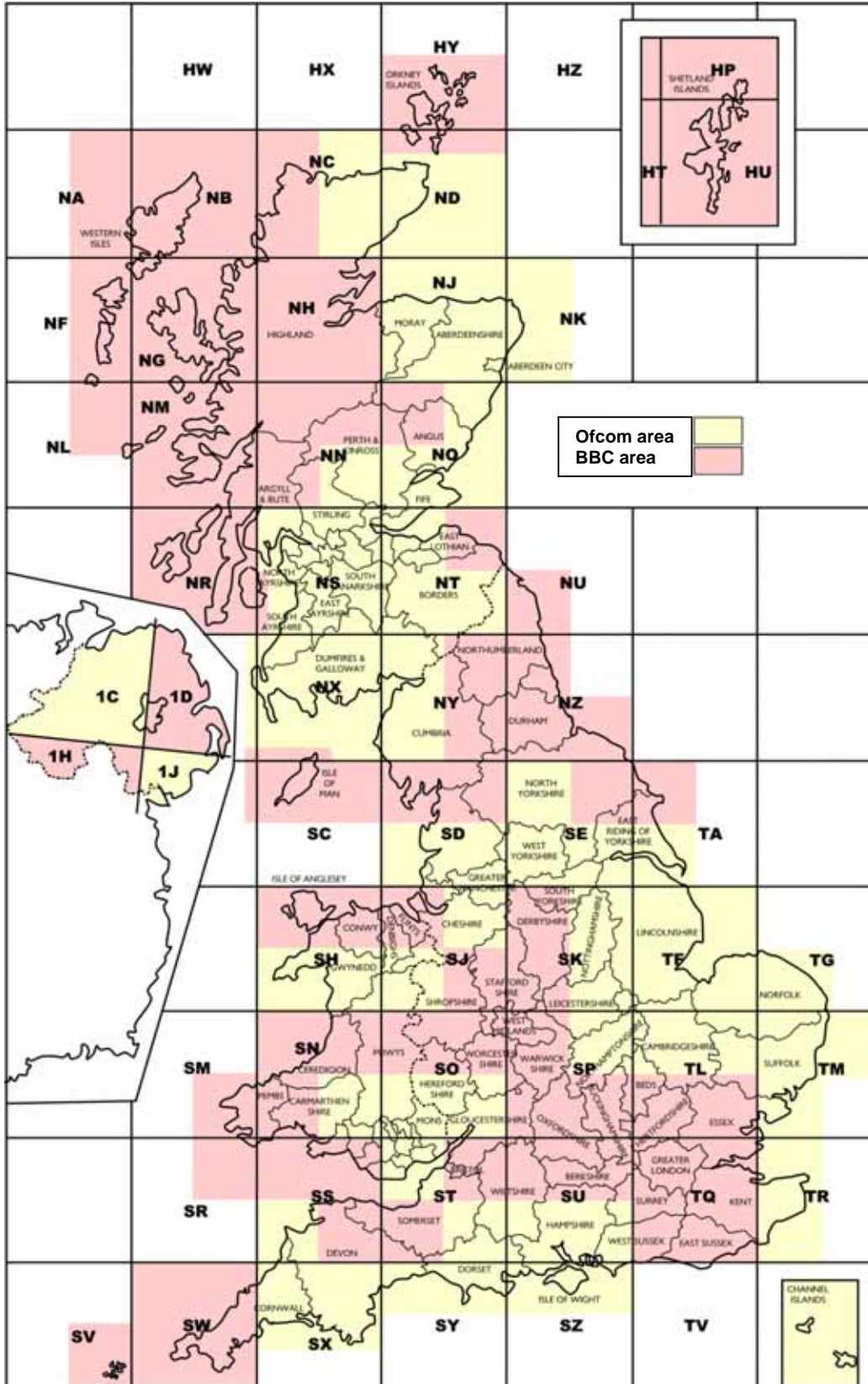
UHF TELEVISION - TRANSMITTER SITES AND RE-BROADCAST LINKS



This map is indicative of the RBL network and is subject to change.

APPENDIX II

TELEVISION PLANNING RESPONSIBILITY MAP



APPENDIX III

CONTACT DETAILS

For BBC Reception Advice, Ofcom, Arqiva and National Grid Wireless these are:

BBC Reception Advice,
PO Box 1922,
Glasgow
G2 3WT
e-mail: reception@bbc.co.uk

Ofcom,
Broadcast Technical Policy,
Riverside House,
2a Southwark Bridge Road,
London
SE1 9HA
e-mail: broadcast.technical@ofcom.org.uk

Spectrum Planning (Buildings and Wind Farms),
National Grid Wireless UK Ltd.,
Wireless House,
Warwick Technology Park,
Heathcote Lane,
Warwick
CV34 6DD

Spectrum Planning Department (Buildings and Wind Farms),
Arqiva,
Crawley Court,
Winchester,
Hants
SO21 2QA

*Please note that **Arqiva** is the new name for **ntl broadcast** and **National Grid Wireless** is the new name for **Crown Castle UK Ltd.***

APPENDIX IV

‘SUBJECTIVE IMPACT OF GHOSTING’

For an acceptable picture, the maximum permissible strength of the ‘reflected’ signal relative to the direct signal (known as the ‘protection ratio’) varies according to the length of the delay. The International Telecommunication Union is the organisation responsible for world radio standards, and ITU-R Report 478-1 contains the following results obtained experimentally.

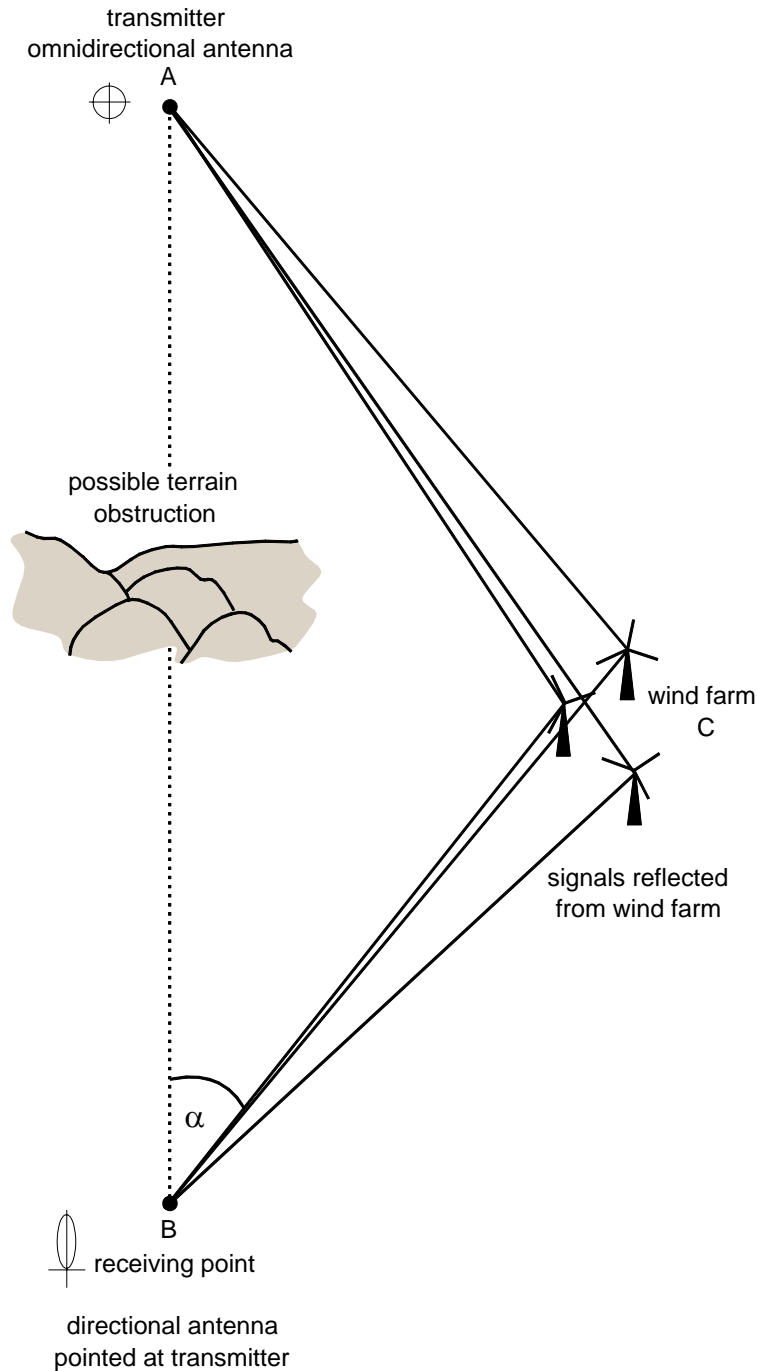
<i>Impairment Grade ITU-R (Rec. 500)</i>	<i>Protection ratio (dB) for delay:</i>		
	<i>0.4 μs*</i>	<i>0.8 μs*</i>	<i>1.4 μs*</i>
<i>5 (imperceptible)</i>	<i>18</i>	<i>26</i>	<i>30</i>
<i>4 (just perceptible)</i>	<i>12</i>	<i>18</i>	<i>20</i>

* Note that 0.4 μ s, 0.8 μ s and 1.4 μ s correspond approximately to the ‘ghost’ being offset to the right from the main picture by 3 mm, 7 mm and 12 mm on a screen of a television set which is 50 cm (20 inches) wide.

APPENDIX V

REFLECTION EFFECTS FROM A WIND-FARM

The figure and text below shows the geometry associated with reflected signals from a wind-farm, and how directional receiving aerials provide rejection of the unwanted signal.



- The problem will be worse if path AB is more obstructed by terrain than paths AC and CB.
- The spacing of the delayed image (ghost) is dependent on the path difference $(AC+CB)-AB$. A path difference of 2 km gives a delayed image of one eighth of the picture width.
- If α is greater than 60° a standard aerial will normally provide sufficient discrimination against the reflected signals.
For α between 15° and 60° , a more directional receiving aerial can be used to reduce the level of reflected signals 'seen' by the receiver.
For α less than 15° even changing to the best available aerial will not help.