European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

SHARING THE BAND 11.7 GHz - 12.5 GHz BETWEEN ENG/OB AND DIRECT-TO-HOME TV BROADCASTING SATELLITES

Chester, October 1995

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1. INTRODUCTION

At WARC-77, the band 11.7 GHz to 12.5 GHz was allocated, in Region 1, to Broadcasting Satellite. The band also contained a primary allocation to Fixed and a secondary allocation to Mobile (excluding aeronautical mobile). A footnote to the allocation gave the Broadcasting Satellite Service protection from harmful interference from the other services. In the UK and throughout Europe, ENG/OB video links operated in the band. It was understood by ENG/OB operators that the use of this band would be progressively restricted as the Broadcasting Satellite Service was introduced. In a later EC directive, the Broadcasting Satellite Service was limited to the use of the MAC format. This decision was unpopular with the BSS developers who in some cases launched services using conventional PAL in the band 10.7 GHz to 11.7 GHz, contrary to the allocation table in the Radio Regulations. Many of these services are still operated in this band. As a consequence the 11.7 GHz to 12.5 GHz band remains under used and ENG/OB use continues.

The restrictions on Broadcasting Satellite usage of 11.7 GHz to 12.5 GHz are currently being reviewed and it is understood that new analogue and digital television services will occupy the band.

This paper presents a study which examines the potential for sharing the band 11.7 GHz to 12.5 GHz, assuming that new services are to be introduced.

2. ENG/OB OPERATIONS FOR CONSIDERATION

The Band 11.75 GHz to 12.5 GHz is used by the broadcasters and programme makers for temporary point-to-point fixed video links and also for cordless camera links.

Fixed links will generally use an e.r.p. of 40 dB (Watt) operating with 0.6 or 1.2m diameter parabolic dishes at both transmit and receive terminals.

Cordless cameras are much lower power systems and typically transmit less than 0 dB (Watt) e.r.p.. Transmitting antennas are either omni-directional or directional with some form of beam tracking. Receive antennas are normally small (circa. 0.5m diameter) parabolic dishes. The current generation of cordless camera systems use an array of antennas which are electronically switched to provide the optimum received signal. In order that the cameraman is aware of the technical quality of his pictures, it is common practice nowadays to use a second radio channel to transmit the video back from the receiving site to the cameraman, to be displayed in his viewfinder. This enables the cameraman to adjust his position slightly to avoid locations producing local ‘nulls’ at the receiving site. The return link uses a transmit power of around 20 dB (Watt) and uses a diplexer to employ the same 0.5m diameter parabolic dish for both receiving and transmitting. It is important that this type of equipment is considered in sharing studies as both the outgoing and return video links may cause interference and may be subject to interference.

3. INTERFERENCE ANALYSIS

Interference into both Domestic Receiving Installations and ENG/OB receivers is calculated for co-channel operation. The interference scenarios for consideration are shown in Figures 1, 2 and 3. For simplicity, the transmitted power bandwidth and the receiver bandwidth of all systems is assumed to be the same. A value of 20 MHz is used which is representative of all systems.

3.1. Interference into a Domestic Satellite Receiving Installation from ENG/OB operations

The maximum permissible level of interference at the domestic satellite receiver is derived from noise considerations. Values for the antenna gain and off axis discrimination are taken from Appendix 30 of the Radio Regulations. A value for co-ordination distance is then derived using procedures outlined in Appendix 28 of the Radio Regulations (Appendix 28 concerns earth station co-ordination and considers the case of a terrestrial station interfering with a earth station receiver). For scenarios where Appendix 28 produces co-ordination distances below its minimum value, free space propagation incorporating a site shielding factor is applied.

The noise power in the receiver bandwidth of 20 MHz is kTB where

k, Boltzmann's constant = -228.6 dB (Watt)/Hz/K

T, effective noise temperature = 20 dBk
(effective antenna temperature 20 K with 1.0 dB noise figure receiver)[1]

B, Bandwidth = 20 MHz = 73 dB Hz

So noise power = -136 dB (Watt)

If the limit for unacceptable interference is a 0.5 dB decrease in Carrier to Noise + Interference margin, the maximum permissible interference becomes -146 dB (Watt).

Appendix 28 of the Radio Regulations uses the concept of a minimum permissible transmission loss, based on the premise that the attenuation of an unwanted signal is a monotonically increasing function of distance.

From Appendix 28 the transmission loss is calculated as:

$$\text{Transmission loss} = A_o + (ß \times \text{co-ord dist}) + A_h$$

where $A_o = 120 + 20 \log f$ (in GHz) dB = 141.6 dB at 12 GHz

A_h is the horizon angle correction which may be taken as 0 dB.

ß includes terms for attenuation due to water vapour, oxygen and other effects. For a path consisting entirely of land, at 12 GHz,

$$ß = 0.232 \text{ dB/km}$$

So equating the path loss to the required transmission loss,

$$ß \times \text{co-ord dist} + 141.6 = \text{Transmitter E.I.R.P.} + \text{Receiver antenna gain} - \text{Permissible Interfering Power}$$

[1] This is significantly better than the figure shown in Appendix 30 of the Radio Regulations but reflects current performance

From Appendix 30, receiver antenna gain is 38 dBi and antenna discrimination to signals arriving beyond 10° from boresight is 33 dB. (For terrestrial transmissions interfering with a satellite receiving installation the full discrimination is appropriate for most of Europe).

Appendix 28 states that the value for gain of the receiving antenna is the actual gain in the direction of the interferer, whereas the E.I.R.P. of the transmitter is taken to be the maximum value.

So, substituting figures from above,

ß x co-ord dist + 141.6 = Transmitter E.I.R.P. + (38 - 33) - (-146)

ß x co-ord dist = Transmitter E.I.R.P. + 5 + 146 - 141.6

ß x co-ord dist = Transmitter E.I.R.P. + 9.4

$$\text{Co-ord dist} = \frac{\text{Transmitter E.I.R.P.} + 9.4}{ß}$$

Using this expression, table 1 shows the co-ordination distance for ENG/OB operations with E.I.R.P.'s of 40 dB (Watt) down to 0 dB (Watt). The value of 40 dB (Watt) relates to an ENG/OB fixed link transmitter, the value of 20 dB (Watt) to the return link to a cordless camera unit and the value of 0 dB (Watt) to the low power outgoing link from a cordless camera.

E.I.R.P. of ENG/OB Transmitter dB Watt	Co-ordination Distance km
40	213
30	169
20	126
10	83
0	40

Table 1: Co-ordination distances for ENG/OB

It is clear that ENG/OB temporary point-to-point links using the higher value of E.I.R.P. and the return link to cordless camera units using an E.I.R.P. of 20 dB (Watt) offer little hope for co-ordination. Below an E.I.R.P. of 15 dB (Watt) the co-ordination distances calculated are less than the minimum value shown in Appendix 28, in which case according to Appendix 28, the minimum value of 100 km should be used. Obviously, this is not realistic for low power cordless cameras and it is probably true that Appendix 28 was never intended to cover such operations.

In practice, cordless cameras will be operated in football grounds, sports stadiums etc. these are generally enclosed areas and some degree of site shielding may be taken into account. If this site shielding is incorporated in the E.I.R.P. of the cordless camera, a free space path loss may then be applied to determine the interfering distance.

Using the parameters shown above for the domestic satellite receiving antenna,

Gain 10° off axis = (38 -33) = 5 dBi

Which equates to an effective area of -38 dB (m^2)

The maximum permissible interfering PFD is,

-146 + 38 = -108 dB (Watt/m^2)

Table 2 shows the interfering distance for a cordless camera operation using an E.I.R.P. of 0 dB (Watt) and allowing 0 dB, 10 dB and 20 dB of site shielding.

Site Shielding	Effective E.I.R.P.	Free Space Interfering Distance (km)
0 dB	0 dB (Watt)	71
10 dB	-10 dB (Watt)	22
20 dB	-20 dB (Watt)	7

Table 2: Free Space Interfering distances for ENG/OB

Whilst the density of domestic receiving installations in the locality of the cordless camera site remains low, co-existence between them and the low power outgoing link from the camera, may be considered possible.

3.2. Interference to ENG/OB from Broadcasting Satellite Emissions

The maximum level of interference at the ENG/OB receiver is derived using the same method as above.

The noise power in the receiver bandwidth of 20 MHz is kTB where

k, Boltzmann's constant = -228.6 dB (Watt)/Hz/K

T, effective noise temperature = 32 dBk
(effective antenna temperature 290 K with 7 dB noise figure receiver)

B, Bandwidth = 20 MHz = 73 dB Hz

So noise power = -123.6 dB (Watt)

If the limit for unacceptable interference is a 0.5 dB decrease in Carrier to Noise + Interference margin, the maximum permissible interference becomes -134 dB (Watt).

The IFRB notification documents show that within the satellite service area, a PFD of around -107 dB (Watt/m^2) is produced and this is shown to be similar for both the analogue and digital transmissions.

Firstly considering the case where a simple cordless camera transmitter is received by a 0.5 m diameter parabolic antenna.

On axis, a 0.5 m antenna has an effective area of -7 dB (m^2).

For compatibility, the off axis discrimination of the antenna must be better than:

134 - 107 -7 = 20 dB

This may be achieved if the pointing of the receiving antenna is restricted to angles of greater than about 20° relative to the interfering satellite orbital location, or general geostationary orbit avoidance. Practically this means ensuring that the area of operation of the cordless camera is to the north of the receiving installation.

Note. If the potentially high outgoing interference from temporary point-to-point link transmitters does not exclude their use, their receivers may be protected by using the same orbit avoidance techniques as outlined above.

Secondly, consider the cordless camera system of the type currently used. This requires a return signal from the receiving installation to the radio camera for both the viewfinder and also for its antenna selection control systems.

To protect the link, radio-camera to receiver, it is necessary that the above criterion is met i.e. avoidance of orbit. However, the return link back to radio-camera, must also be protected. The receiving antenna on the radio-camera may be pointing directly towards the interfering signal, but has a much lower gain (smaller aperture).

A realistic gain value for the radio camera antenna is 6 dBi.

On axis, this equates to an effective area of -37 dB (m^2).

If this antenna points directly at the satellite, the resulting power from the antenna is:

-107 - 37 dB (Watt) = -143 dB (Watt)

This is less than the permissible interference limit of -134 dB (Watt).

4. CONCLUSIONS

Depending on geographic separation, ENG/OB video links in the band 11.7 GHz-12.5 GHz may interfere with domestic satellite receiving installations. Low power operations such as ‘simple’ uni-directional cordless cameras have significantly less potential to cause interference and whilst the density of domestic receiving installations in the locality of the cordless camera site remains low, their co-existence may be considered possible.

Interference to ENG/OB operations from the Broadcasting Satellite will occur within the service area of the satellite but may be reduced to tolerable levels if the ENG/OB receiving terminal is able to apply geostationary orbit avoidance. This may be possible at certain ENG/OB locations.

As for the current type of bi-directional ENG/OB cordless camera systems, providing a ‘live’ viewfinder image, the situation is more complex. Although the return link to the cameraman is not subject to interference from the satellite, it has the potential to cause significant interference to a domestic satellite receiver. The practical value of these operations along with the strategy behind technical implementation must be the subject of a more detailed study.

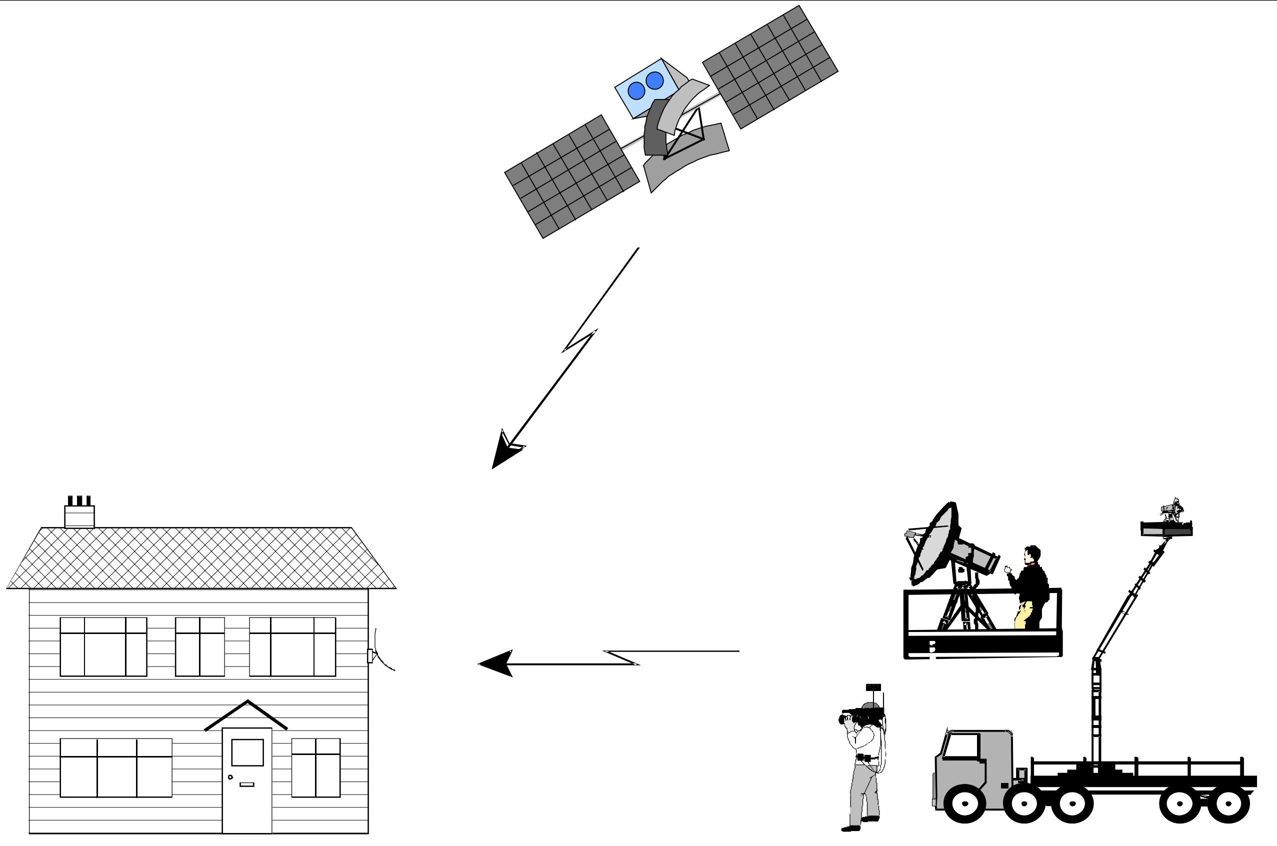

Figure 1 : ENG/OB Interfering with a Domestic Broadcasting Satellite Receiver

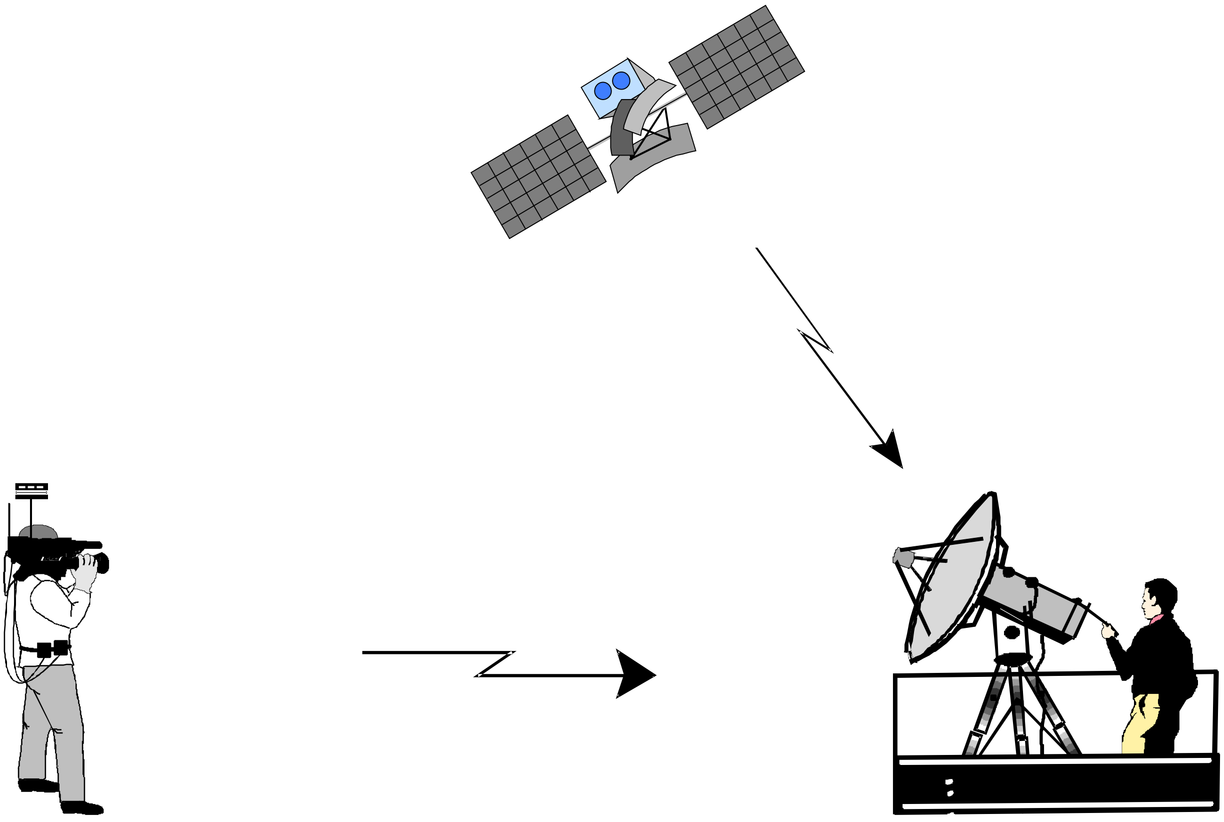

Figure 2 : Broadcasting Satellite Interfering with a simple Cordless Camera System

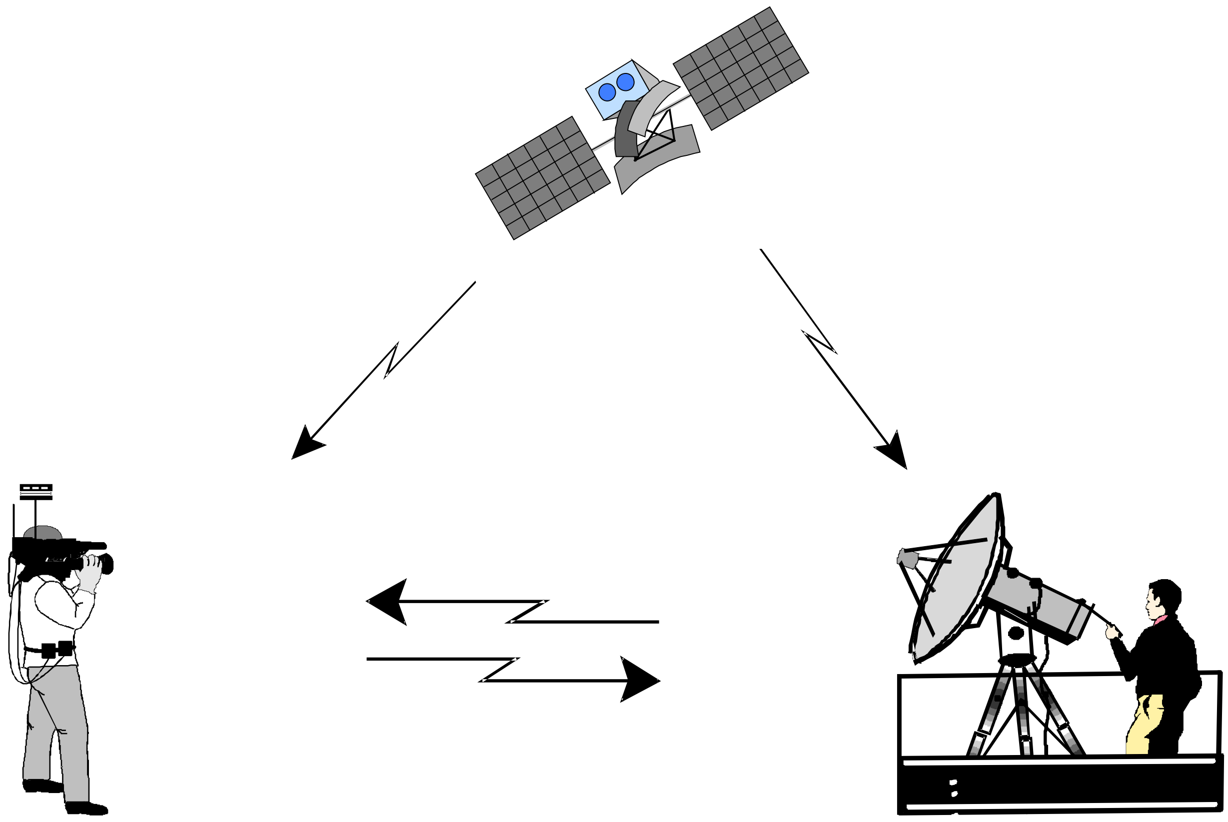

Figure 3 : Broadcasting Satellite Interfering with a complex Cordless Camera System using a Return Link