Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

PROTECTION OF THE BROADCASTING SERVICE FROM BROADCASTING SATELLITE SERVICE TRANSMISSIONS IN THE BAND 620 – 790 MHz

Galati, May 2004

EXECUTIVE SUMMARY

This report derives the protection levels required by Broadcasting Service (BS) systems, including analogue TV and DVB-T (fixed and portable outdoor reception), from co-frequency operated Broadcasting Satellite Service (BSS) systems. This report focuses on HEO and GSO BSS systems, which are assumed to use digital transmissions and circular polarisation and to operate with elevation angles (in the BSS coverage areas) above 60° only.

Table 1 below summarises the total pfd levels which should not be exceeded by the aggregation of all interfering BSS space stations transmitting in the same band. The values provided depend upon the angle δ of incidence of the BSS signal at the BS antenna, with linear interpolation of the pfd level for values of δ between the quoted values.

Broadcasting service and reception type	Maximum interfering pfd level (dBW/m^2) in 8 MHz	Maximum interfering pfd level (dBW/m^2) in 8 MHz
Fixed reception of the analogue BS, nominal coverage areas (Notes 1, 2)	-129.3 for δ ≤ **30°**	-115.8 for δ ≥ **70°**
Fixed reception of the analogue BS, fringe coverage areas (Note 1)	-134.3 for δ ≤ **20°**	-120.8 for δ ≥ **60°**
Fixed reception of the digital BS (Notes 2, 3)	-116.5 for δ ≤ **30°**	-103.0 for δ ≥ **70°**
Portable outdoor reception of the digital BS (Note 3)	-109.5 for δ ≤ **20°**	-109.5 for δ ≥ **60°**

Table 1: Maximum interfering pfd levels at BS receivers

NOTES:
(1) BS nominal coverage areas are the areas where coverage complies with Recommendation ITU-R SM. 851-1, and BS fringe coverage areas are areas where opportunistic viewers can benefit from satisfying quality of service whilst receiving lower field strength (see also note 1 in section 3.1).
(2) This report assumes a nominal value of 10° for the BS receiving antenna tilt angle in the case of fixed reception of the BS in nominal coverage areas and the fixed reception of the digital BS. This value is considered to be representative for cases of BS reception where the transmitter is at a high elevation angle relative to the receiver. It should however be noted that worst case conditions with a tilt angle up to 20° may occur in Europe.
(3) Digital BS pfd requirements are based on considered parameters of DVB-T systems.

It should be noted that the Report has not addressed the impact on BSS systems in the band 620-790 MHz in meeting these required pfd levels.

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1 OVERVIEW OF THE CONTEXT

Frequency sharing between Broadcasting Satellite Service (BSS) transmissions and Broadcasting Service (BS) reception in the band 620-790 MHz is covered by No. 5.311, Resolution 545 (WRC-03) and Recommendation 705 (WARC-79) of the ITU Radio Regulations. RR No. 5.311 was modified at WRC-03 and further studies, already called for by ITU-R Rec. 705, were invited to be urgently carried out on sharing criteria for the protection of terrestrial television BS from BSS systems planned for operation in the band 620-790 MHz (see WRC-07 agenda item 1.11).

As those original provisions were established several years ago, the sharing studies supporting them did not specifically take into account the protection requirements of the terrestrial digital BS (DVB-T), neither the emergence of BSS systems using digital transmissions.

Terrestrial digital television services have already developed in a number of European countries (in this frequency range) and it is expected that digital television services will be deployed in a number of other countries in a near future. It is also expected that terrestrial analogue television services will continue in many countries for many years, possibly 20 to 25. Protection of the analogue BS is likely to be rather more difficult than is the case for digital BS. This is especially true for those countries where television networks have not yet been fully developed, where the man-made noise levels are low and where the protection requirements are more stringent simply because the noise and the existing interference levels are low.

The new BSS systems, which can use both geostationary and non-geostationary orbits, transmit signals with uniform spectral distribution, so significantly differing from typical analogue modulations. Annex 1 presents information on these BSS systems.

As a matter of fact, spectrum spreading (via energy dispersion) is already mentioned in Recommendation 705 (see "considering *g*") as a possible way to reduce the protection ratio of the BS systems.
Terrestrial digital television services will continue to be deployed over a period of very many years, it is therefore extremely important that the possible existence of satellite based television transmission and reception in the same band should not in any way interfere with such deployment. In particular, it will be necessary to ensure that once satellite-based services become operational, they cannot claim protection of their reception as a reason to prevent the installation of new terrestrial digital television transmitters.

This report proposes a methodology to study the protection requirements for BS reception, including DVB-T and analogue BS, this methodology is presented in Section 2. Section 3 provides numerical applications of this methodology for analogue TV, as well as DVB-T fixed and portable outdoor reception. The analogue BS compatibility study may be critical, and additional work is needed on the analogue BS reception parameters. The results can be compared to the pfd requirements as defined in ITU-R Rec. 705 (assuming the levels in this Recommendation are based on an 8 MHz bandwidth for BS, these levels are -129 dBW/m^2 for $\delta \leq$ **20°** and -113 dBW/m^2 for $\delta \geq$ **60°** respectively).

2 PROTECTION CRITERIA FOR BS RECEPTION

The methodology used in this Report for assessing the protection criteria of the BS reception from BSS is derived from the general method described in the Chester ’97 Agreement.
With Free Space propagation conditions for BSS signals, the protection criteria of Analogue and Digital BS receivers can be derived from the following formulas:
→ For Analogue BS receivers,

$$E_{max\ int} = E_{min} - PR + D_{dir} + D_{pol} \tag{1a}$$

→ For Digital BS receivers,

$$E_{max\ med\ int} = E_{min\,med} - \mu\sqrt{\left(\sigma_w^2 + \sigma_i^2\right)} - PR + D_{dir} + D_{pol} \tag{1b}$$

where:

$E_{max\ int}$ is the maximum permissible interfering BSS field strength at the wanted (BS) receiving antenna [dBμV/m]

$E_{max\ med\ int}$ is the maximum median permissible interfering BSS field strength at the wanted (BS) receiving antenna and $E_{max\ med\ int} = E_{max\ int} - \mu\ \sigma_i$ [dBμV/m]

E_{min} is the minimum BS field strength at the wanted (BS) receiving antenna [dBµV/m]

$E_{min\ med}$ is the minimum median BS field strength at the wanted (BS) receiving antenna and $E_{min\ med} = E_{min} + \mu\sigma_w$ [dBµV/m].

σ_w is the standard deviation of the lognormal distribution of the wanted signal (digital BS signals) [dB].

σ_i is the standard deviation of the lognormal distribution of the interfering signal (digital BSS signals) [dB]. It should be noted that if σ_i is assumed to be 0 dB, $E_{max\ med\ int}$ is numerically equal to $E_{max\ int}$. This assumption is made in the calculations undertaken in this report.

μ is the linearly expressed distribution factor (obtained from the complementary cumulative inverse lognormal function) being 0.52 for 70 % of locations and 1.64 for 95 % of locations.

$\mu\ \sigma_w$ is the "location correction factor" (CH 97 terminology) for the digital BS signal[dB]

$\mu\ \sigma_i$ is the "location correction factor" (CH 97 terminology) for the BSS signal[dB]

$\mu\sqrt{(\sigma_w^2 + \sigma_i^2)}$ is the "propagation correction factor" (CH 97 terminology) and is numerically equal to $\mu\ \sigma_w$ in the case where σ_i is assumed to be zero.[dB]

PR is the appropriate protection ratio [dB]

D_{dir} is the BS receiving antenna directivity discrimination with respect to the BSS signal [dB]

D_{pol} is the BS receiving antenna polarisation discrimination with respect to the BSS signal [dB]

With the conversion from field strength E in dBµV/m to power flux density Φ in dBW/m²,

$$E = \Phi + 120 + 10\log_{10}(120\pi) = \Phi + 145.8$$

equation (1a) becomes:

$$\Phi_{max\ int} = E_{min} - 145.8 - PR + D_{dir} + D_{pol} \qquad (2a)$$

equation (1b) becomes:

$$\Phi_{max\ med\ int} = E_{min} + \mu\sigma_w - \mu\sqrt{(\sigma_w^2 + \sigma_i^2)} - 145.8 - PR + D_{dir} + D_{pol} \qquad (2b)$$

If $\sigma_i = 0$ then equation (2b) can be simplified:

$$\Phi_{max\ int} = \Phi_{max\ med\ int} = E_{min} - 145.8 - PR + D_{dir} + D_{pol}$$

where:

$\Phi_{max\ int}$ is the maximum permissible interfering BSS power flux density at the BS receiving antenna in dBW/m² per 8 MHz Channel (8 MHz being the assumed BS channel bandwidth in the band 620-790 MHz).

$\Phi_{max\ med\ int}$ is the corresponding maximum permissible interfering BSS median power flux density at the BS receiving antenna in dBW/m² per 8 MHz Channel.

3 BS PROTECTION REQUIREMENTS

3.1 Protection requirements for fixed reception of terrestrial analogue television in the 620-790 MHz band

(Note 1)	**BS nominal coverage areas**		**BS fringe coverage areas**	
(Note 2)	**δ ≤ 20°+x°**	**δ ≥ 60°+x°**	**δ ≤ 20°**	**δ ≥ 60°**
Nominal Bandwidth (MHz)	8	8	8	8
Minimum field strength (dBμV/m) (Note 1)	58	58	53	53
Derived power flux density (dBW/m^2)	-87.8	-87.8	-92.8	-92.8
Receiving antenna directivity discrimination D_{dir} (dB) (Note 6)	0	16	0	16
Receiving antenna polarisation discrimination D_{pol} (dB) (Note 3)	2.5	0	2.5	0
Required protection ratio (dB) (Note 4)	44	44	44	44
Maximum interfering power flux density $\Phi_{max\ int}$ (dBW/m^2) (Note 5)	-129.3	-115.8	-134.3	-120.8
Maximum interfering field strength (dBμV/m) $E_{max\ int}$ (Note 5)	16.5	30	11.5	25

<u>NOTES</u>

1) *BS nominal coverage areas* are the areas where coverage complies with Recommendation ITU-R SM. 851-1, which contains the "minimum field strength to be protected" of 58 dBμV/m (at edge of coverage area, 50% time and 90% of locations), to be used to determine the protection margin for the BS when it is operated simultaneously with either the fixed or mobile service in shared bands.
BS fringe coverage areas are areas where opportunistic viewers can benefit from satisfying quality of service whilst receiving lower field strength. In some fringe areas man-made interference is very low. Therefore the values for minimum field strength to be protected may be more stringent (reduced by 5 dB). It is also noted that minimum field strength thresholds and associated reception installations should be considered jointly in this case (lower field strength may require the use of higher gain antennas to achieve a good reception: in this regard, the receiving antenna directivity discrimination D_{dir} , and minimum field strength to be protected may need further elaboration; the possible use of low noise pre-amplifiers would also need to be taken into account).

2) the factor x° is indicated here as a reminder that the receiving antenna discrimination is obtained using directly ITU-R Rec. BT.419-4, hence assuming a typical tilt angle of 0° for these antennas. Investigations have shown that this assumption does not remain valid in hilly environments, and that a representative average tilt angle (x°) of 10° can be used to cover this phenomenon. It should however be noted that worst case conditions with a tilt angle up to 20° may occur in Europe. A combination of the two worst case conditions (10° tilt angle and fringe area coverage) is not considered due to its very low probability of occurrence.

3) It is assumed that BSS systems under consideration in this Report would benefit from having service areas served with high elevation angles. It is also assumed that BS signals are linearly polarised, and BSS systems circularly polarised. As a consequence, polarization discrimination situation will experience two situations:
   - for angles of arrival ≥ **60**° (or 60° + x°) , the BSS interferer transmits in its main beam, and the BS victim receives in its side and backlobes : in this case, ITU-R Rec. BT.419 indicates that polarization discrimination is already taken into account.
   - for angles of arrival ≤ **20**° (or 20° + x°) , the victim BS receives in its mainlobe, and the BSS interferer transmits in the worst case in its first sidelobe, with a maximum "own" XPD of -10dB, resulting in a BSS/BS polarization discrimination of 2.5 dB.

4) It has been assumed that the interfering BSS signal will use digital modulation and in that case it can be considered as a white-noise-like signal, and Recommendation ITU-R BT 1368 is taken as a basis to derive the relevant protection ratios. This Recommendation contains a 41 dB protection ratio (PR) value for the case of continuous interference, although for the purpose of this Recommendation the term "continuous" means 50% of time. When interference is really continuous, i.e. 100% of time, as is the case for satellite-based interfering signals, then 3 dB should be added to the relevant PR values given for 50 % of time. This value may need further elaboration.

5) The quoted pfd and field strength are the maximum total pfd and field strength tolerable within the television channel. These pfd and field strength levels should not be exceeded by the aggregation of all interfering BSS space stations transmitting in the same band. Further studies will be required to assess realistic multiple BSS space stations scenarios.

6) It is assumed that Recommendation BT.419-4 can be used in both horizontal and vertical planes.

3.2 Protection requirements for fixed reception of terrestrial digital television (DVB-T) in the 620-790 MHz band

DVB-T fixed reception is defined as reception where a directional receiving antenna mounted at roof level is used.

	QPSK 1/2		**16QAM 2/3**		**16QAM 3/4**		**64QAM 2/3**	
(Note 7)	**δ ≤ 20+x °**	**δ ≥ 60+x °**	**δ ≤ 20+x °**	**δ ≥ 60+x °**	**δ ≤ 20+x °**	**δ ≥ 60+x °**	**δ ≤ 20+x °**	**δ ≥ 60+x°**
Nominal Bandwidth (MHz)	8	8	8	8	8	8	8	8
Required C/N ratio (dB) (Note 1)	7	7	14.6	14.6	16	16	20.1	20.1
Minimum field strength (dBμV/m) (Note 2)	33.8	33.8	41.4	41.4	42.8	42.8	46.9	46.9
Derived power flux density (dBW/m^2)	-112.0	-112.0	-104.4	-104.4	-103	-103	-98.9	-98.9
Receiving antenna directivity discrimination D_{dir} (dB) (Note 9)	0	16	0	16	0	16	0	16
Receiving antenna polarisation discrimination D_{pol} (dB) (Note 3)	2.5	0	2.5	0	2.5	0	2.5	0
Location correction factor for the BS signal(dB) (Note 4)	9	9	9	9	9	9	9	9
Location correction factor for the BSS signal(dB) (Note 4)	0	0	0	0	0	0	0	0
Required protection ratio (dB) (Note 5)	7	7	14.6	14.6	16	16	20.1	20.1
Propagation correction factor (dB) (Note 4)	9	9	9	9	9	9	9	9
Maximum interfering power flux density $\Phi_{max\ int}$ (dBW/m^2) (Note 6, 8 and 10)	-116.5	-103.0	-116.5	-103.0	-116.5	-103.0	-116.5	-103.0
Maximum interfering field strength $E_{max\ int}$ (dBμV/m) (Note 6, 8 and 10)	29.3	42.8	29.3	42.8	29.3	42.8	29.3	42.8

NOTES

1) The required C/N values are stated in the ITU Digital Terrestrial Television Handbook and in ETSI EN 300 740 V1.4.1 for fixed and portable digital television reception (Rice and Rayleigh channels, respectively). In fact, it is not really critical which values of C/N ratio are used here as the same value must be used as the protection ratio in a later part of the calculations.

2) The minimum field strength values for digital terrestrial television have been calculated for the frequency of 700 MHz as per the voltage method included in Rec. ITU-R BT.1368-3. The usage of the voltage method stipulates that the value for the maximum interfering field strength does not depend on the DVB-T system variant. However, a few variants are listed in the Table for demonstration purpose.

3) It is assumed that BSS systems under consideration in this Report would benefit from having service areas served with high elevation angles. It is also assumed that BS signals are linearly polarised, and BSS systems circularly polarised. As a consequence, polarization discrimination situation will experience two situations :
- for angles of arrival ≥ **60°** (or 60° + x°) , the BSS interferer transmits in its main beam, and the BS victim receives in its side and backlobes : in this case, ITU-R Rec. BT.419 indicates that polarization discrimination is already taken into account.
- for angles of arrival ≤ **20°** (or 20° + x°) , the victim BS receives in its mainlobe, and the BSS interferer transmits in the worst case in its first sidelobe, with a maximum own XPD of -10dB, resulting in a BSS/BS polarization discrimination of 2.5 dB.

4) As described in Annex 1 to Chester-97, the DVB-T signal follows a log-normal distribution, with a standard deviation of 5.5 dB for outdoor reception (fixed and portable outdoor). In order to ensure a coverage of 95% of locations, μ is 1.645.The standard deviation of the BSS signal, σ_i, is assumed to be 0dB[1], so the propagation correction factor equals $\mu\sigma_w$.

5) The protection ratio for terrestrial digital signals has been taken from the Rec. ITU-R BT.1368-3, corresponding to the PR for co-channel interference from a digital signal to the digital signal. Because of the very rapid transition to failure for digital signals, there is no need to distinguish between different percentages of time. The same protection ratio values apply to all percentages of time.

6) The quoted pfd and field strength are the maximum total median pfd and median field strength tolerable within the television channel. These pfd and field strength levels should not be exceeded by the aggregation of all interfering BSS space stations transmitting in the same band. Further studies are required to assess realistic multiple BSS space stations scenarios.

7) The factor x° is indicated here as a reminder that the receiving antenna discrimination is obtained using directly ITU-R Rec. BT.419-4, hence assuming a typical tilt angle of 0° for these antennas. Investigations have shown that this assumption does not remain valid in hilly environments, and that a representative average tilt angle (x°) of 10° has been used to cover this phenomenon. It should however be noted that worst case conditions with a tilt angle up to 20° may occur in Europe.

8) From these calculations, it can be seen that the maximum interfering field strength and pfd values are identical for all DVB-T modulations. This is to be expected as the relationship between C/N ratio and minimum field strength is independent of the type of modulation. Consequently, these results will also be valid for other DVB-T modulations.

9) It is assumed that Recommendation BT.419-4 can be used in both horizontal and vertical planes.

10) In this case, maximum and maximum median pfd or field strength values are numerically equal.

3.3 Protection requirements for portable outdoor reception of terrestrial digital television (DVB-T) in the 620-790 MHz band

DVB-T portable outdoor reception is defined as reception by a portable receiver with an attached or built-in antenna, which is used outdoors at no less than 1.5 m above ground level. It is assumed that:

- optimal receiving conditions may be found by moving the receiver with antenna for up to 0.5 m in any direction;
- the portable receiver is not moved during reception and large objects near the receiver are also not moved.

[1] As a receiving antenna is situated at around 10 m above the ground the most important contribution to the received signal comes from the line-of-sight signal from the satellite. Although there may exist shadowing and multipath contributions, they are believed to be insignificant. Therefore, the satellite signal standard deviation is assumed to be 0 dB.

It should be noted that the results for DVB-T portable outdoor reception could be used for DVB-T mobile reception.

	QPSK 1/2	**16QAM 2/3**	**16QAM 3/4**	**64QAM 2/3**
Nominal Bandwidth (MHz)	8	8	8	8
Required C/N ratio (dB) (Note 1)	8.4	17.2	19.7	22.3
Minimum field strength (dBμV/m) (Note 2)	42.2	51.0	53.5	56.1
Derived power flux density (dBW/m^2)	-103.6	-94.8	-92.3	-89.7
Receiving antenna directivity discrimination (dB) (Note 3)	0	0	0	0
Receiving antenna polarisation discrimination (dB) (Note 4)	2.5	2.5	2.5	2.5
Location correction factor for the BS signal (dB) (Note 5)	9	9	9	9
Location correction factor for the BSS signal (dB) (Note 5)	0	0	0	0
Required protection ratio (dB) (Note 6)	8.4	17.2	19.7	22.3
Propagation correction factor (dB) (Note 5)	9	9	9	9
Maximum interfering power flux density $\Phi_{max\ int}$ (dBW/m^2) (Notes 7 and 9)	-109.5	-109.5	-109.5	-109.5
Maximum interfering field strength (dBμV/m) $E_{max\ int}$ (Notes 7, 8 and 9)	36.3	36.3	36.3	36.3

<u>NOTES</u>

1) The required C/N values are stated in the ITU Digital Terrestrial Television Handbook and in ETSI EN 300 740 V1.4.1 for fixed and portable digital television reception (Rice and Rayleigh channels, respectively). In fact, it is not really critical which values of C/N ratio are used here as the same value must be used as the protection ratio in a later part of the calculations.
2) The minimum field strength values for digital terrestrial television have been calculated for the frequency of 700 MHz as per the voltage method included in Rec. ITU-R BT.1368-3. The usage of the voltage method stipulates that the value for the maximum interfering field strength does not depend on the DVB-T system variant. However, few variants are listed in the Table for demonstration purpose.
3) For the case of portable reception, non directional antennas are used. Therefore no directivity discrimination has been considered.
4) It is assumed that BSS systems under consideration in this Report would benefit from having service areas served with high elevation angles. It is also assumed that BS signals are linearly polarised, and BSS systems circularly polarised. The receiver antenna polarisation discrimination is determined by the BS low elevation angle case. In this case, the victim BS is receiving within its main beam, and the BSS interferer is transmitting on its first sidelobe, with a maximum own XPD of -10dB, resulting in a BSS/BS polarization discrimination of 2.5 dB.
5) As described in Annex 1 to Chester-97, the DVB-T signal follows a log-normal distribution, with a standard deviation of 5.5 dB for outdoor reception (fixed and portable outdoor). In order to ensure a coverage of 95% of locations, μ is 1.645. The standard deviation of the BSS signal, σ_i, is assumed to be 0dB[2], so the propagation correction factor equals $\mu\sigma_w$.

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[2] The signal distribution is a combination of log-normal, Rice and Rayleigh statistics at mobile terminals. The log-normal shadowing has a standard deviation, which can be estimated using empirical or statistical modelling equations and lies in the range of 0 – 5 dB depending on the elevation angle. In the case of portable outdoors terminals, a standard deviation of

6) The protection ratio for terrestrial digital signals has been taken from the Rec. ITU-R BT.1368-3, corresponding to the PR ratio for co-channel interference from a digital signal to the digital signal. Because of the very rapid transition to failure for digital signals, there is no need to distinguish between different percentages of time. The same protection ratio values apply to all percentages of time.

7) The quoted pfd and field strength are the maximum total pfd and field strength tolerable within the television channel. These pfd and field strength levels should not be exceeded by the aggregation of all interfering BSS space stations transmitting in the same band. Further studies are required to assess realistic multiple BSS space stations scenarios.

8) From these calculations, it can be seen that the maximum interfering field strength values are identical for all DVB-T modulations. This is to be expected as the relationship between C/N ratio and minimum field strength is independent of the type of modulation. Consequently, these results will also be valid for other DVB-T modulations.

9) In this case, maximum and maximum median pfd or field strength values are numerically equal.

4 SUMMARY OF RESULTS.

The results provided in the section 3 are summarised in Figure 1 below. It has been assumed that the maximum interfering pfd level will follow a linear variation between the elevation angles under consideration in section 3, and that, for the fixed reception of the analogue BS in nominal coverage areas and the fixed reception of the digital BS, a representative value of 10° for the BS receiving antenna elevation tilt angle has been used to cover the particular case of BS transmissions in a hilly environment.

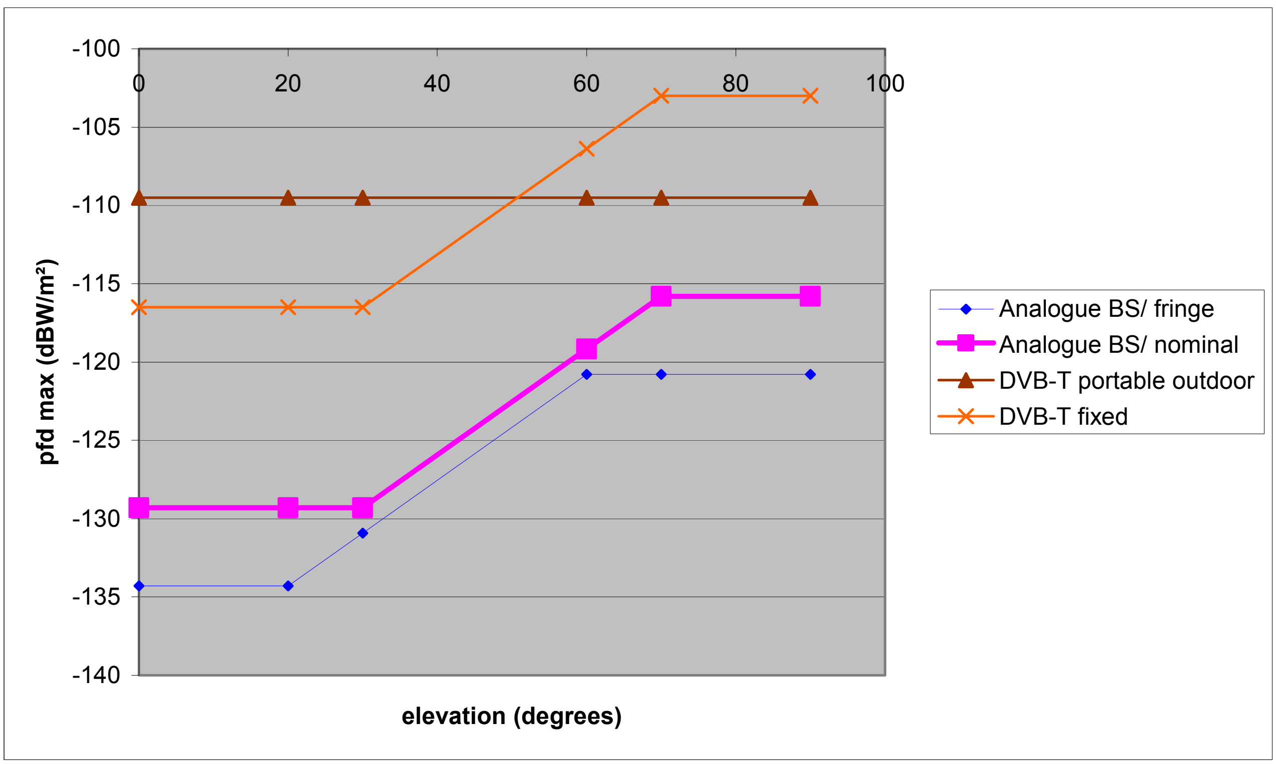

Figure 1: Maximum interfering pfd levels at BS receivers

0dB for BSS signals is assumed for simplicity and is also felt representative given the nature of the BS and BSS systems envisaged here.

5 CONCLUSION

Table 1 below summarises the pfd levels which should not be exceeded by the aggregation of signals from all interfering BSS space stations transmitting in the same band. The values provided depend upon the angle δ of reception of the BSS signal at the BS antenna with linear interpolation of the pfd level for values of δ between the quoted values..

Broadcasting service and reception type	**Maximum interfering pfd level (dBW/m^2) in 8 MHz**	**Maximum interfering pfd level (dBW/m^2) in 8 MHz**
Fixed reception of the analogue BS, nominal coverage areas (Notes 1, 2)	-129.3 for δ ≤ **30°**	-115.8 for δ ≥ **70°**
Fixed reception of the analogue BS, fringe coverage areas(Note 1)	-134.3 for δ ≤ **20°**	-120.8 for δ ≥ **60°**
Fixed reception of the digital BS (Notes 2, 3)	-116.5 for δ ≤ **30°**	-103.0 for δ ≥ **70°**
Portable outdoor reception of the digital BS (Note 3)	-109.5 for δ ≤ **20°**	-109.5 for δ ≥ **60°**

Table 1: Maximum interfering pfd levels at BS receivers

NOTES:
(1) BS nominal coverage areas are those areas where coverage complies with Recommendation ITU-R SM. 851-1, and BS fringe coverage areas are those areas where opportunistic viewers can benefit from satisfying quality of service whilst receiving lower field strength (see also note 1 in section 3.1).
(2) This report assumes a nominal value of 10° for the BS receiving antenna tilt angle in the case of fixed reception of the BS in nominal coverage areas and the fixed reception of the digital BS. This value is considered to be representative for cases of BS reception where the transmitter is at a high elevation angle relative to the receiver. It should however be noted that worst case conditions with a tilt angle up to 20° may occur in Europe.
(3) Digital BS pfd requirements are based on considered parameters of DVB-T systems.

It should be noted that the Report has not addressed the impact on BSS systems in the band 620-790 MHz in meeting these required pfd levels.

ANNEX 1: BSS SYSTEMS CHARACTERISTICS

HEO BSS systems may be operated in accordance with RR No. 5.311 in the band 620-790 MHz. This Report focuses on HEO and GSO BSS systems, which are assumed to use digital transmissions and circular polarisation and to operate with elevation angles above 60° only.

The following is provided for information on the characteristics envisaged for GSO and HEO BSS systems:

Satellite antenna and power management
The satellite antenna will be designed to meet a number of requirements during the active transmissions periods:

- Iso-flux transmission over the service area

  The satellite will use an iso-flux antenna to optimize its power requirements and to cope with the power-flux density limits in the service area. It means that the satellite antenna gain within the service area will be such that the power-flux density at the Earth's surface will be kept constant, irrespective of the position of a terminal within the service area.

- Beam zooming

  The solid angle with which a satellite sees the service area will vary with time, as function of its altitude. In order to cope with this "zooming effect" and to reduce the overall power requirements, the satellite will also adjust the power and the shape of its beam as function of its altitude.

Consequently, the pfd on the ground will be kept constant, irrespective of time and location of the terminal within the service area.

Constellation parameters (for HEO BSS only)
The constellation parameters are optimized to offer satisfactory visibility conditions to all users within the service area. The example below illustrates the case of a Tundra constellation, covering Western European countries with 3 satellites orbiting in a 24 hour period:

- Semi-major axis: 42 164 km
- Eccentricity: 0.2684
- Inclination: 63.4°
- Argument of perigee: 270°
- Right ascension of ascending node: 110°, 230° and 350°
- Mean anomaly: 340°, 220° and 100°

Figure A1.1 illustrates the satellite's ground track on the Earth's surface.

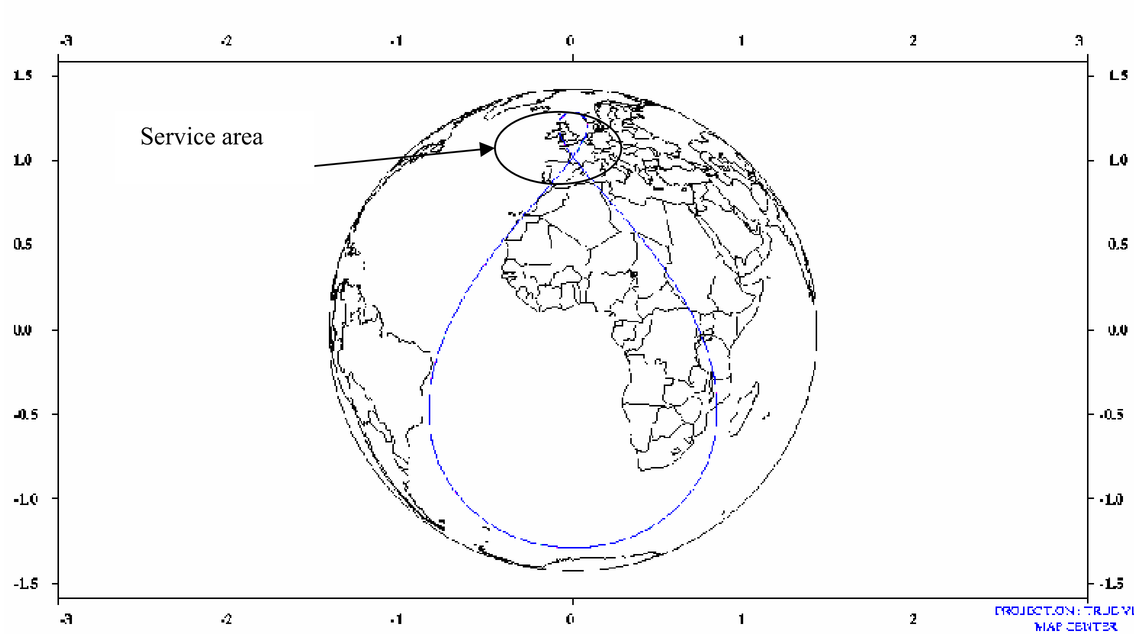

Figure A1.1: HEO constellation ground track

Times of satellite activity (for HEO BSS only)

With the orbital parameters of an HEO constellation, a given satellite is in visibility of the service area with an elevation angle better than 60° only 1/3 of the time:

- Over its 24-hour orbit period, the satellite will be in visibility of the service area with an elevation angle better than 60° during a continuous period of 8 hours, after which 16 hours will be spent in "non-visibility".
- Satellites will be programmed to be inactive during their 16-hour long periods of "non-visibility". This means that only one satellite will be transmitting towards the service area at a given time.