



Recommendation ITU-R SF.1486
(05/2000)

**Sharing methodology between fixed
wireless access systems in the fixed service
and very small aperture terminals in the
fixed-satellite service in the
3 400-3 700 MHz band**

SF Series
**Frequency sharing and coordination between
fixed-satellite and fixed service systems**

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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R SF.1486*,**

**SHARING METHODOLOGY BETWEEN FIXED WIRELESS ACCESS SYSTEMS
IN THE FIXED SERVICE AND VERY SMALL APERTURE TERMINALS
IN THE FIXED-SATELLITE SERVICE IN THE 3 400-3 700 MHz BAND**

(2000)

Scope

This Recommendation provides a methodology to facilitate the sharing between fixed wireless access (FWA) systems in the fixed service (FS) and very small aperture terminals (VSATs) in the fixed-satellite service (FSS) in the band 3 400-3 700 MHz. In particular, Annex 1 provides a methodology for calculating separation distances between FSS VSATs and point-to-multipoint (P-MP) FWA systems, and Annex 2 provides interference mitigation methods for the shared deployment of FSS VSATs and FWA terrestrial systems.

The ITU Radiocommunication Assembly,

considering

- a) that the frequency band 3 400-3 700 MHz is allocated worldwide on a primary basis to the fixed service (FS) and the fixed-satellite service (FSS);
- b) that this band is also in use by the FSS, particularly by systems using very small aperture terminals (VSATs) and such use is still increasing;
- c) that this band is used for terrestrial point-to-multipoint (P-MP) systems operating in the FS for providing fixed wireless access (FWA) and that this use is growing rapidly in many countries;
- d) that there is a need to protect co-primary services, e.g. the radiolocation service in Regions 2 and 3, and to assess further the sharing conditions between FWA systems and these services,

noting

- a) that there is interest in harmonized use of FWA systems in this band;
- b) that co-frequency sharing between VSAT and P-MP systems may be difficult for VSATs operating at low elevation angles;
- c) that some FWA systems are capable of using a range of frequencies, but in some administrations only part of the 3 400-3 700 MHz band may be available;
- d) that frequency block arrangements are recommended in Recommendation ITU-R F.1488 for FWA systems in the range 3 400-3 800 MHz,

recommends

1 that to facilitate sharing between VSAT earth stations in the FSS and FWA stations in the FS in the band 3 400-3 700 MHz, the methodology as outlined in Annex 1 should be used;

2 that to facilitate substantial frequency sharing within the coordination distance, administrations are encouraged to adopt precautions during the planning and deployment of such systems, taking into account the interference mitigation methods described in Annex 2, and in particular those for the installation at the VSAT and P-MP central and terminal stations, including judicious location of antennas to exploit natural and man-made features or the use of diffraction screens close to the VSAT antennas (see Note 1).

NOTE 1 – Co-frequency sharing between such systems depends to a considerable extent on the usage of this band by the two services, especially on the density of deployment, on geographical and other factors.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 3.

** Radiocommunication Study Group 5 made editorial amendments to this Recommendation in December 2009 in accordance with Resolution ITU-R 1.

Methodology for calculating separation distances for sharing in the 3 400-3 700 MHz range between FSS VSATs and P-MP FWA systems

1 Introduction

Generally it is acknowledged that the 3.5 GHz range is suitable for P-MP FWA systems. For FSS systems the range 3 400-3 700 MHz is commonly referred to as extended C-band. The characteristics of typical VSAT and (TDMA based) P-MP FWA systems in this band are given in Tables 1 and 2.

The two modes of possible concern are:

- a) interference from P-MP central station (CS) and/or terminal station (TS) into the FSS earth station (VSAT) receiver;
- b) interference from the FSS spacecraft into the P-MP CS and/or TS receivers.

The methodology addressed in this Annex is for interference mode a), and makes certain general assumptions regarding system characteristics and propagation conditions. Other methodologies employing the actual system parameters and path loss specific to the case under study may provide a more precise separation distance.

Interference mode b) is currently addressed by the power flux-density (pfd) requirements of the relevant provisions of the RR, but may require future studies.

1.1 Interference criteria

It is considered that interference to the FSS terminal is significant when the victim receiver (VSAT) is subjected to an interference level equivalent to a degradation of the thermal noise floor by 0.4 dB, corresponding to an interference level 10 dB below the receiver thermal noise floor for more than 20% of any month.

2 Sharing methodology

2.1 System parameters

P-MP FWA system parameters used for calculations are shown in Table 1. The FWA example described here uses TDMA, but generally the calculations for other FWA technologies may be considered similar in this context.

The technology is designed for wireless access for the delivery of telephony and data services to businesses and residential users.

Typical VSAT parameters for this band are given in Table 2.

The antennas used in 3 400-3 700 MHz VSATs and those used in FWA CSs and TSs, are not sufficiently large to afford substantial off-beam rejection; side-lobe discrimination levels are modest due to the apertures involved. Nevertheless the type of VSAT antenna typically used for this band is of parabolic reflector type with good offset horn type feed. However, practical FWA TS and CS antennas are predominately of planar design, of relatively lower efficiency and side-lobe performance. Terrestrial P-MP FWA systems normally feature air-side traffic concentration, which from a RF viewpoint may be considered deployed in a manner similar to that of terrestrial mobile cellular, that is in a contiguous cellular arrangement using frequency reuse.

2.2 FWA TS interference into VSAT station

The example P-MP FWA system occupies the frequencies 3 475-3 492 MHz (CS to TS) and 3 425-3 442 MHz (TS to CS). Because the e.i.r.p. of the TSs is higher than that of the CS, as well as their greater number and distribution and hence the greater likelihood that the TS will be directed towards the VSAT station (downlink band), it is appropriate to calculate the interference from the TS. From Table 1, the e.i.r.p. from the FWA TS = $27 + 18 - 30 = 15$ dBW. The TS directional antenna typically has a nominal beamwidth of 20° (at -3 dB).

TABLE 1
P-MP FWA system parameters

Transmission frequency band (TS to CS) (MHz)	3 425-3 442
Reception frequency band (CS to TS) (MHz)	3 475-3 492
Channel spacing (kHz)	307.2
Access technique	TDMA
Duplex spacing (MHz)	50 or 100
Number of frequency channels	48
Modulation	$\pi/4$ DQPSK
Traffic channel bit rate/time slot (kbit/s)	32
CS ⁽¹⁾ transmit power (dBm)	29
CS antenna gain (dBi)	10 (omnidirectional), 12 (tri-sector)
Receiver sensitivity (dBm)	-102
TS ⁽²⁾ transmit power, maximum (dBm)	27
TS antenna gain (dBi)	18
TS feeder loss (dB)	0
TS height (m)	10

(1) CS: P-MP FWA central (base) station.

(2) TS: terminal (subscriber or remote) station.

TABLE 2
Typical VSAT system parameters

Frequency band (GHz)	3.4-3.7
Transmit rate (kbit/s)	64
Modulation	2-PSK
FEC rate	1/2
Channel bandwidth (kHz)	153.6
Antenna diameter (m)	1.8/2.4
Antenna gain (dBi)	35.7/38.2
Noise temperature (K)	114.8
Tx e.i.r.p. (maximum) (dBW)	38
Receiver sensitivity (dBm)	-126.1
Height of VSAT station (m)	10

The interference level depends upon the FWA TS transmit output power, antenna gain, antenna height and the direction of the antenna main beam. The FWA TS interference can be determined as a function of the separation distance, d , and the off-axis angles of the VSAT (φ) and FWA TS (α) for various assumptions regarding the digital modulation techniques for the VSAT and FWA systems, side-lobe envelope, power level of the FWA TS carrier, centre frequency offset between carriers, required protection ratio, and the amount of shielding of the VSAT stations.

The total interference power, I , from the FWA TS at the VSAT input to the antenna, is given by:

$$I = e.i.r.p.FWA(\alpha) - L_{FWA}(d) + G_{VS}(\varphi) - R - F \quad (1)$$

where:

- a) $e.i.r.p.FWA(\alpha)$: off-axis e.i.r.p. from the FWA TS transmitter (dBW)
- $$\begin{aligned} &= P + G_{max} - 2.5 \times 10^{-3} (D \alpha/\lambda)^2 && \text{for } 0^\circ < \alpha < \alpha_m \\ &= P + G_1 && \text{for } \alpha_m \leq \alpha < 100 \lambda/D \\ &= P + 52 - 10 \log(D/\lambda) - 25 \log \alpha && \text{for } 100 \lambda/D \leq \alpha < 48^\circ \\ &= P + 10 - 10 \log(D/\lambda) && \text{for } 48^\circ \leq \alpha \leq 180^\circ \end{aligned}$$

where (see Recommendation ITU-R F.699):

$$\alpha_m = 20(\lambda/D) (G_{max} - G_1)^{1/2}$$

$$G_1 = 2 + 15 \log(D/\lambda)$$

P : FWA TS transmitter carrier level at the antenna input. In this case, D/λ is much less than 100 (Recommendation ITU-R F.699)

$$\begin{aligned} e.i.r.p.FWA(\alpha) &= P + 18 - 2.5 \times 10^{-3} (3.27 \alpha)^2 && \text{for } 0^\circ < \alpha < 17.6^\circ \\ &= P + 9.7 && \text{for } 17.6^\circ \leq \alpha < 30.6^\circ \\ &= P + 46.9 - 25 \log \alpha && \text{for } 30.6^\circ \leq \alpha < 48^\circ \end{aligned} \quad (2)$$

for the parameters given in Table 1.

- b) $L_{FWA}(d)$: path loss between the VSAT and FWA TS antennas.

Recommendation ITU-R P.452 defines the clear-air propagation models for the evaluation of interference between microwave stations at frequencies above 0.7 GHz considering all the factors such as diffraction, tropospheric scattering, ducting/layer reflection and clutter losses.

In this P-MP FWA/VSAT interference environment, a line-of-sight propagation model with the end clutter option applied to one FWA TS end is considered reasonable. Therefore:

$$L_{FWA}(d) = 92.5 + 20 \log(f) + 20 \log(d) + A_h \quad \text{dB} \quad (3)$$

where A_h is the clutter loss and is given in Recommendation ITU-R P.452 as:

$$A_h = 10.25 e^{-d_k} \left\{ 1 - \tanh \left[6 \left(\frac{h}{h_a} - 0.625 \right) \right] \right\} - 0.33 \quad \text{dB} \quad (4)$$

where:

h_a : nominal clutter height (m)

d_k : nominal clutter distance (km)

h : height of the FWA TS (assumed = 10 m)

We consider urban and dense urban areas. For urban areas ($h_a = 20$ m and $d_k = 0.02$ km), $A_h = 16.1$ dB and for dense urban areas ($h_a = 25$ m and $d_k = 0.02$ km), $A_h = 18.5$ dB. For the purpose of explanation below, we use the clutter loss for a dense urban area.

- c) $G_{VS}(\varphi)$: VSAT off-axis antenna receive gain in the direction of the interfering FWA TS transmitter
- $$= 32 - 25 \log \varphi \quad \text{for } 100 \lambda/D \leq \varphi < 48^\circ$$

At 3.5 GHz, $\varphi > 4.8^\circ$ for 1.8 m and $\varphi > 3.6^\circ$ for 2.4 m.

- d) R : the isolation from the site shielding. One study found that up to 40 dB of isolation may be obtained by providing physical or natural shielding at the VSAT stations. However, this may not be achievable at all earth station sites, so we illustrate here the results of 20, 30 and 40 dB shielding.
- e) F : centre frequency offset factor. Depending upon the FWA frequency plan, it may be possible to select a VSAT carrier centre frequency which is completely outside of the assigned bandwidth of an interfering FWA carrier. In this example, we assume 0 dB frequency offset improvement factor, the worst case.

2.3 Required protection distance

The required protection distance, d , can be found from:

$$20 \log (d) = C/I - C + P + (\text{sidelobe pattern in equation (2)}) - 92.5 - 20 \log (f) - 18.5 + 32 - 25 \log (\varphi) - R \quad \text{for } \alpha < 48^\circ \text{ and } \varphi < 48^\circ \quad (5)$$

where:

C/I : required protection ratio for the VSAT downlink.

C is based on the assumed values for C/N corresponding to:

- clear-sky BER $< 1 \times 10^{-10}$
- 99.96% availability
- 10% noise budget allocation for FWA interference.

It is assumed that the required clear-sky C/N will be reduced by 0.4 dB due to the interference (see Recommendation ITU-R SF.558).

From the link budget for the VSAT with 1.8 m antenna (64 kbit/s downlink with 2-PSK, 1/2 rate FEC),

$$\begin{aligned} C/I &= 10 + 5.7 = 15.7 && \text{dB} \\ C &= C/N + 10 \log (k T_s B) = 5.7 + (-228.6 + 20.6 + 51.9) \\ &= -150.4 && \text{dBW} \end{aligned}$$

From equation (5):

$$\begin{aligned} 20 \log (d) &= 15.7 + 150.4 - 3 + (\text{sidelobe pattern in equation (2)}) - 92.5 - 20 \log (f) - 18.5 + 32 - 25 \log \varphi - R \\ &= 73.2 + 18 - 0.0267 \alpha^2 - 25 \log \varphi - R && \text{for } 0^\circ < \alpha < 17.6^\circ \\ &= 73.2 + 9.7 - 25 \log \varphi - R && \text{for } 17.6^\circ \leq \alpha < 30.6^\circ \\ &= 73.2 + 46.9 - 25 \log \alpha - 25 \log \varphi - R && \text{for } 30.6^\circ \leq \alpha < 48^\circ \end{aligned}$$

These equations are valid over the range $4.8^\circ \leq \varphi < 48^\circ$.

Figure 1 indicates the required separation distances, derived according to this methodology, between the FWA TSs and the VSAT stations, based on the following systems parameters:

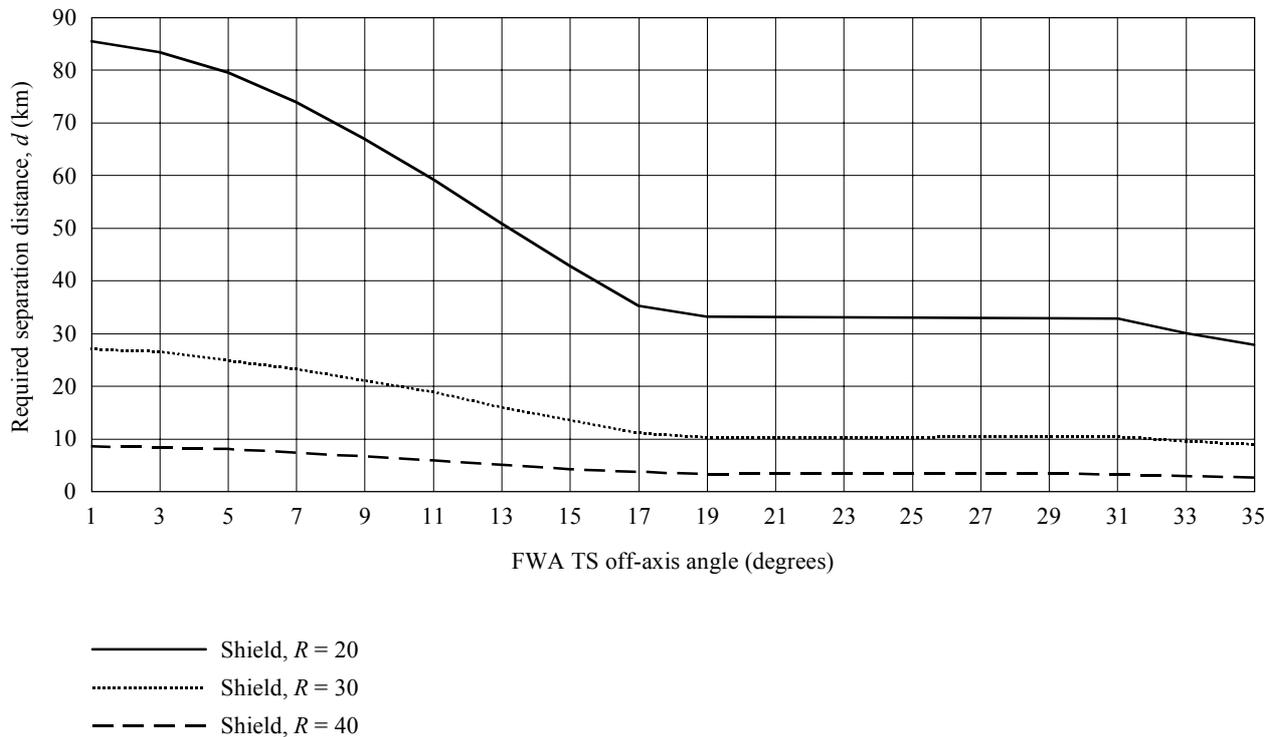
- FWA terminal station height: 10 m
- VSAT elevation angle: 20°
- FWA system characteristics: as per § 2.1
- VSAT system characteristics: as per § 2.1
- Additional interference attenuation due to the site shielding isolation at the VSAT terminal: 20, 30 and 40 dB

It should be noted that in some cases the FWA TS units may be sited higher than the VSAT and require considerable antenna downtilt. In these cases the separation distances will be increased equivalent to a corresponding reduction in the VSAT elevation angle.

2.4 FWA CS interference into VSAT station

The FWA CS, despite having an e.i.r.p. some 5 dB lower than that of the TS, is usually located higher to clear the local clutter, has an antenna with wide sectoral coverage, and a higher probability of activity than the TS end. Similar analysis is required for sharing between the FWA CS and VSATs, and care is needed in selecting an appropriate propagation model (including duct type fading).

FIGURE 1
Required separation distances
(20° elevation angle)



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2.5 Site shielding

To provide insight into the practicality of affording shielding isolation in a range about 30 dB, Appendix 1 addresses the possible isolation calculated in accordance with Recommendation ITU-R P.526. The advantages of mounting the VSAT antenna closer to the ground can be appreciated, together with typical isolation values for diffraction edge to VSAT spacings that would be consistent with mounting near to, say, a one-story building wall, etc.

APPENDIX 1

TO ANNEX 1

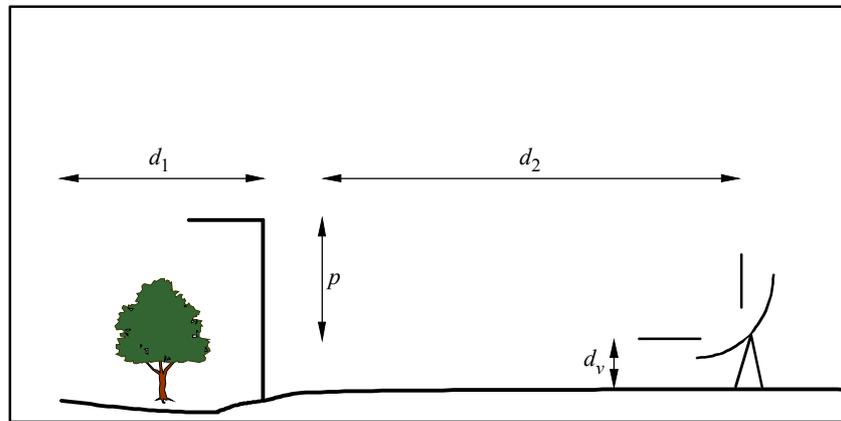
Examples of shielding isolation attainable by suitable measures at the VSAT

To effect tolerable separation distances, use normally needs to be made of additional diffraction or other losses in the vicinity of the VSAT. For analysis a single edge diffraction can be taken to approximate the case of a building, tree grove or similar which is not too close (see Fig. 2).

Clearly the diffraction source should be clear of the Fresnel zone. For guidance, at this frequency this can be taken as extending in a cone some 9 m out from the VSAT reflector dish to a diameter of some 3.2 m and then of this same diameter out to at least 17 m from the antenna. The calculated sensitivity of the diffraction loss with transmitter/edge distance, d_1 may readily be shown to be negligible for all practical cases here. Predicted diffraction losses for a notional single edge model calculated and summarized within the examples studied here are in the range 2-33 dB; this covers plausible situations corresponding to values for p of 5 m, spacings d_2 of 5 to 20 m and heights d_v of 1 to 6 m.

The TS units are generally seldom sited higher than around 10 m. A common situation is that of exposed roof-top mounting for a VSAT, and the effect of this rather than the more desirable siting at ground level protected by suitable shielding can be approximately 33 dB, as calculated in accordance with Recommendation ITU-R P.526.

FIGURE 2
Edge diffraction loss



1486-02

ANNEX 2

Interference mitigation methods for the shared deployment of FSS VSATs and FWA terrestrial systems

The following are suggested as an initial basis, where satellite elevation angles may permit co-location in the same geographical area as described in Annex 1 (see Note 1):

- VSATs, wherever possible, should be sited so as to maximize shielding from possible FWA interferers;
- VSATs and P-MP FWA stations should not be sited higher than is necessary for the application;
- where practicable, FWA TSs should generally be sited such as to reduce rear radiation, for example by mounting against walls, below roof lines, etc. and by avoiding reflections back in the direction of the VSAT;
- when deploying such FS and FSS systems, economical use should be made of available terrain, i.e. depressions, natural screening to increase obstructive/diffraction losses;
- if no natural screening exists use should be made of artificial obstructions such as judicious siting of systems amongst buildings, etc.;
- in some cases it may be possible to tailor the pattern of the VSAT antenna feeds to provide greater interference rejection;
- advantage may be taken in some cases by use of more directional FWA TS or CS antennas.

NOTE 1 – Although it is possible to exploit orthogonal polarization as an inter-sector and/or inter-cell discriminant within the FWA systems (typically some 5 dB), it is not possible to use this feature to minimize the interference into the VSAT due to the widespread use of circular polarization in the space-to-Earth link for these FSS systems.