RECOMMENDATION ITU-R F.1613[*,**]

Operational and deployment requirements for fixed wireless access systems in the fixed service in Region 3 to ensure the protection of systems in the Earth exploration-satellite service (active) and the space research service (active) in the band 5 250-5 350 MHz

(Questions ITU-R 113/9 and 218/7)

(2003)

The ITU Radiocommunication Assembly,

considering

a) that the frequency band 5 250-5 350 MHz is allocated to the Earth exploration-satellite service (EESS) (active) and space research service (SRS) (active) for spaceborne active sensors and to the radiolocation service on a primary basis;

b) that the allocations in the frequency band 5 250-5 350 MHz will be reviewed by WRC-03 under agenda item 1.5 with a view to allocating this band to the fixed service in Region 3 on a primary basis;

c) that some administrations in Region 3 have proposed using the band 5 250-5 350 MHz for licence-based fixed wireless access (FWA) systems in the fixed service;

d) that these FWA systems operating outdoors may cause unacceptable interference to the EESS/SRS (active) in the above band;

e) that there is a need to specify operational and deployment requirements for FWA systems in Region 3 in order to protect spaceborne active sensor systems,

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[*] This Recommendation was developed jointly by Radiocommunication Study Groups 7 and 9, and any future revision will also be undertaken jointly.

[**] This Recommendation should be brought to the attention of Radiocommunication Study Groups 7 and 8.

noting

a) that the interference from EESS/SRS (active) systems into FWA systems with the characteristics described in Annex 1 is considered to be acceptable,

recognizing

a) that it is difficult for FWA and other types of wireless access systems (including radio local area networks (RLANs)) to operate simultaneously on a co-coverage, co-frequency basis,

recommends

1 that the aggregate interference from FWA systems (sum of the directional e.i.r.p. towards the satellite) should be smaller than –7.6 dB(W/20 MHz) at the Earth's surface within the footprint of the active sensor of the EESS/SRS satellite (see Notes 1, 2 and 3);

2 that the methodology described in Annex 1 should be used to assess the aggregate interference level from FWA systems;

3 that, based on the FWA system characteristics presented in Table 4 for Region 3, a maximum density of 23 FWA base stations per 220 km^2 should be allowed within a satellite active sensor footprint. Variation of the maximum e.i.r.p., antenna pattern and frequency planning would imply a variation in the maximum allowed density of FWA base stations;

4 that the maximum e.i.r.p. of each FWA station should be no more than 3 dB(W/20 MHz) (see Notes 4 and 5);

5 that administrations should control these systems to ensure that the deployment requirements for FWA systems specified in the above *recommends* are satisfied.

NOTE 1 – This aggregate interference level is derived from the interference threshold of –132.35 dB(W/20 MHz) at the satellite receiver specified for the SAR4 in Table 5.

NOTE 2 – The footprint of the active sensor of the EESS/SRS the satellite referred to here has an area of about 220 km^2.

NOTE 3 – The aggregate interference from FWA systems toward the spaceborne active sensor satellite depends on such parameters as transmit power of the FWA systems, the antenna directivity and the number of the FWA base stations using the same RF channel within the satellite active sensor footprint.

NOTE 4 – If the main beam direction is above 10° in elevation, a 6 dB lower e.i.r.p. limit should apply, i.e. a maximum e.i.r.p. of –3 dB(W/20 MHz).

NOTE 5 – The direction of FWA station antennas should be controlled in order to avoid accidental direct illumination to the satellite due to misalignment of antenna direction, for example, a remote station not pointing towards the base station.

NOTE 6 – Additional guidance should be developed in order to facilitate the application of this Recommendation. This matter requires further study.

Annex 1

Frequency sharing between FWA systems and spaceborne active sensor systems in the EESS (active) and the SRS (active) in the band 5 250-5 350 MHz

1 Introduction

The frequency band 5 250-5 350 MHz is considered to be suitable for FWA systems in the fixed service to provide high-speed Internet or other multimedia service applications. Since the frequency band is allocated in the ITU Radio Regulations to the EESS (active) and the SRS (active) on a worldwide basis, sharing feasibilities between FWA systems and systems in the EESS/SRS (active) needs to be determined.

In this frequency band various types of spaceborne synthetic aperture radar (SAR), spaceborne radar altimeter and spaceborne scatterometer systems in the EESS/SRS (active) are operating.

This Annex deals with sharing consideration between FWA systems and these spaceborne active sensors, using typical system parameters that are currently available or being considered in the developmental stage.

2 Technical characteristics of spaceborne active sensors

Technical characteristics of spaceborne active sensors in the 5 250-5 350 MHz are given in Tables 1 to 3.

TABLE 1

5.3 GHz typical spaceborne SAR characteristics

Parameter	Value		
	SAR2	**SAR3**	**SAR4**
Orbital altitude (km)	600 (circular)	400 (circular)	
Orbital inclination (degrees)	57		
RF centre frequency (MHz)	5 405	5 305	5 300
Peak radiated power (W)	4 800	1 700	
Polarization	Horizontal and vertical (HH, HV, VH, VV)		
Pulse modulation	Linear FM chirp		
Pulse bandwidth (MHz)	310		40
Pulse duration (μs)	31	33	

TABLE 1 (*end*)

Parameter	Value		
	SAR2	**SAR3**	**SAR4**
Pulse repetition rate (pps)	4 492	1 395	
Duty cycle (%)	13.9	5.9	
Range compression ratio	9 610	10 230	1 320
Antenna type (m)	Planar phased array 1.8 × 3.8	Planar phased array 0.7 × 12.0	
Antenna peak gain (dBi)	42.9	42.7/38 (full focus/beamspoiling)	
Antenna median side-lobe gain (dBi)	−5		
Antenna orientation (degrees)	20-38 from nadir	20-55 from nadir	
Antenna beamwidth	1.7 (El), 0.78 (Az)	4.9/18 (El), 0.25 (Az)	
Antenna polarization	Linear horizontal/vertical		
Receiver noise figure (dB)	4.62		
Receiver front end 1 dB compression point referred to receiver input	−62 dBW input		
Receiver input maximum power handling (dBW)	+7		
Operating time	30% of the orbit		
Minimum time for imaging (s)	15		
Service area	Land masses and coastal areas		
Image swath width (km)	20	16/320	
Footprint (km^2)	159.03	76.5	76.5-220
Receiver bandwidth (MHz)	356.5		46.00
Interference threshold (dB)	$I/N = -6$		

TABLE 2

5.3 GHz typical spaceborne altimeter characteristics

Jason mission characteristics	
Lifetime	5 years
Altitude (km)	1 347 ± 15
Inclination (degrees)	66
Poseidon 2 altimeter characteristics	
Signal type	Pulsed chirp linear frequency modulation
C band PRF (Hz)	300
Pulse duration (µs)	105.6
Carrier frequency (GHz)	5.3
Bandwidth (MHz)	320
Emission RF peak power (W)	17
Emission RF mean power (W)	0.54
Antenna gain (dBi)	32.2
3 dB aperture (degrees)	3.4
Side-lobe level/Maximum (dB)	–20
Back-side-lobe level/Maximum (dB)	–40
Beam footprint at –3 dB (km)	77
Interference threshold (dBW)	–118

TABLE 3

5.3 GHz typical spaceborne scatterometer characteristics

Parameter	**Value**	
System name	Scatterometer 1	Scatterometer 2
Orbital altitude (km)	780	800
Inclination (degrees)	81.5	
Centre frequency (GHz)	5.3	5.255
Pulse width	70 µs (mid) 130 µs (fore/aft)	8 ms (mid) 10.1 ms (fore/aft)
Modulation	Interrupted CW	Linear FM (chirp)
Transmitter bandwidth (kHz)	15	500
PRF (Hz)	115 (mid) 98 (fore/aft)	29.4
Antenna type	Slotted waveguide	

TABLE 3 (*end*)

Parameter	Value			
Antenna gain (dBi)	31 (mid) 32.5 (fore/aft)		28.5 (mid) 29.5 (fore/aft)	
Antenna main beam orientation (degrees)	Incidence angles: 18-47 (mid) 24-57 (fore/aft)		Incidence angles: 25.0-54.5 (mid) 33.7-65.3 (fore/aft)	
Antenna beamwidth (–3 dB) elevation (degrees) Azimuth beamwidth (degrees)	24 (mid) 1.3	26 (fore/aft) 0.8	23.6 (mid) 1.1	23.9 (fore/aft) 0.8
Instrument elevation angle (degrees)	29.3		37.6	
Antenna polarization	Vertical			
Transmitter peak power	4.8 kW		120 W	
Receiver noise figure (dB)	3			
Service area	Oceanic and coastal areas, land masses			
Interference threshold (dB(W/Hz))	–207			

3 Technical features of FWA systems

Technical parameters of FWA systems should be decided to meet both the high-speed Internet service requirements and the sharing criteria with other services.

When FWA systems are to operate in the band 5 250-5 350 MHz, the following points have to be considered:

– FWA systems are composed of a base station and many remote stations within the service coverage, in other words a cell. It is assumed that all the remote stations communicate to the base station only during the assigned time slot (in case of time division multiple access (TDMA)) or accessible timings (in case of carrier sense multiple access (CSMA)). This means that within a cell only one station is transmitting at any instant in time. Therefore, the deployment density (per km^2) of FWA base stations will affect the interference to a spaceborne active sensor satellite station.

– The antenna directivity for high elevation angle is important. If the antenna at the FWA stations has enough upward discrimination, the interference power will be sufficiently suppressed.

– Active ratio of a group of FWA transmitters in a cell may become 100% in the worst case.

– Licence-based measures will be required to control the deployment density of FWA systems.

Considering the aforementioned features, examples of technical parameters for FWA systems are assumed as shown in Table 4 for the purpose of preliminary studies in this Annex.

The characteristics chosen in this analysis are those which would result in the worst-case interference to a narrow-band SAR receiver. For this type of FWA system, if the antenna boresight is pointed approximately along the horizon for a point-to-multipoint connection, the angle from the boresight becomes the elevation angle. At nadir angles of 20° to 55°, FWA station elevation angles directed towards a spaceborne SAR range from 69° to 30°.

TABLE 4

Technical characteristics of FWA system at 5.3 GHz

	Base station	**Remote station**
Frequency band (MHz)	5 250-5 350	
Operational mode	Point-to-multipoint	
Cell radius (km)	1-2	
Maximum transmit e.i.r.p./power (W)	2/0.2	2/0.063
Antenna gain/ characteristics	10 dBi/ Rec. ITU-R F.1336 Omnidirectional pattern (k = 0) (Fig. 1)	15 dBi/ Rec. ITU-R F.1336 Low-cost, low-gain antenna (Fig. 2)
Bandwidth (MHz)	20	
Receiver noise figure (dB)	8	
Interference threshold	I/N = −6 dB or −128.8 dB(W/20 MHz)	
Polarization	Vertical or horizontal	
Active ratio (%)	90	10

FIGURE 1

Base station antenna pattern

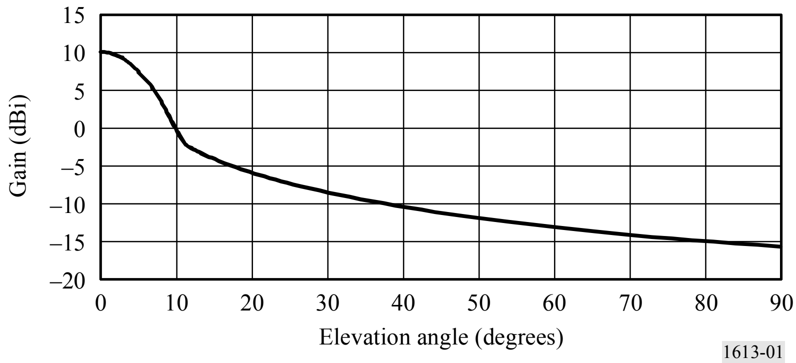
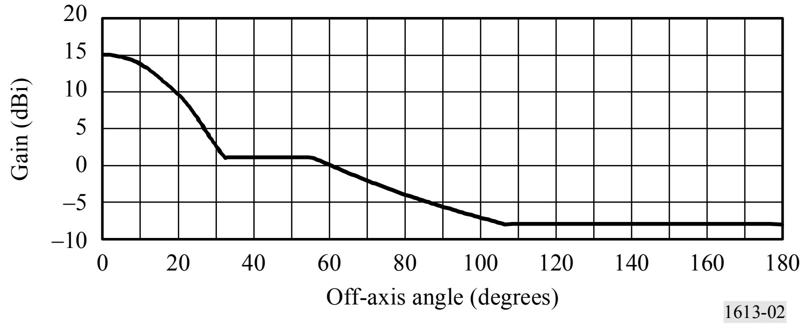


FIGURE 2

Remote station antenna pattern



4 Frequency sharing between spaceborne active sensors and FWA systems

4.1 Sharing between SAR and FWA

4.1.1 Interference from FWA into SAR

Table 5 presents a calculation result of interference from an FWA system with parameters in Table 4 to SAR4 in Table 1. Although SAR2, SAR3 and SAR4 provide the equivalent interference threshold per MHz, the analysis hereafter refers to SAR4 with the most stringent requirement in absolute value. In calculating the interference, the side-lobe effect of the FWA antenna and the scattering effect at the surface/building are considered. With regard to the side-lobe interference from remote stations, the average e.i.r.p. towards the satellite from all remote stations surrounding the base station is calculated (see Appendix 1 to Annex 1). Note that the frequency reuse factor of 4 is assumed in Table 5.

The surface scattered contribution or eventual scattering from nearby buildings will be possible sources of interference. This is dependent on the area where these systems are deployed and on which altitude they will be placed (top or side of buildings), etc. It can be envisaged that FWA systems are present in high-density urban areas where by definition scattering from a wide range of objects will occur, so besides surface scattering these other cases will have to be taken into account. One could especially envisage modern office buildings, which are constructed out of metal where the possibility of a high reflectivity into the direction of the sensor cannot be excluded. As the worst-case approach, a scattering coefficient is taken as –18 dB. This assumption may need to be reviewed.

The above analysis is based on the hypothesis of having only FWA transmitters not using sector antennas. The presence of sector antennas would deteriorate the sharing scenario related to scattering.

The result indicates that 23 FWA cells can be operated in the SAR4 footprint within an area of 220 km^2 while the interference to the SAR satellite receiver is smaller than the acceptable level. If the parameters of FWA systems are different from those listed in Table 4, including the case where sector antennas are employed at the base stations, the number of cells allowed within the satellite footprint would be different. Table 5 should be recalculated with the actual parameters.

TABLE 5

Interference from an FWA system to SAR4

Parameter			20° from nadir		55° from nadir	
			Value	**dB**	**Value**	**dB**
Interfering e.i.r.p. due to FWA antenna side lobe	From base station	Transmitted peak power (W)	0.2	–7.00	0.2	–7.00
		Transmit antenna gain (dBi)		–14.20		–8.80
		Active ratio	90%	–0.46	90%	–0.46
		e.i.r.p. (dBW)		–21.66		–16.26
	From remote station	Transmitted peak power (W)	0.063	–12.00	0.063	–12.00
		Average transmit antenna gain (dBi)		–4.96		–2.34
		Active ratio	10%	–10.00	10%	–10.00
		e.i.r.p. (dBW)		–26.96		–24.34
	Total e.i.r.p. due to side lobe (dBW)			–20.54		–15.63
Interfering power due to scattering at the surface	From base station	Transmitted peak power (W)	0.2	–7.00	0.2	–7.00
		Active ratio	90%	–0.46	90%	–0.46
		Transmitted power (dBW)		–7.46		–7.46
	From remote stations	Transmitted peak power (W)	0.063	–12.00	0.063	–12.00
		Active ratio	10%	–10.00	10%	–10.00
		Transmitted power (dBW)		–22.00		–22.00
	Total transmitted power (dBW)			–7.31		–7.31
	Scattering coefficient (dB)			–18.00		–18.00
	Total scattered e.i.r.p. (dBW)			–25.31		–25.31
Total interfering e.i.r.p. from a cell (dBW)				–19.29		–15.19
Interference power received at SAR	Receive antenna gain (dBi)			42.70		42.70
	Polarization loss (dB)			–3.00		–3.00
	Free space loss (dB)		(427 km)	–159.55	(749 km)	–164.43
	Power received (dBW)			–139.14		–139.92
SAR receiver sensitivity	Noise figure (dB)			4.62		4.62
	kT		4.0×10^{-21}	–203.98	4.0×10^{-21}	–203.98
	Receiver bandwidth (MHz)		20.0	73.01	20.0	73.01
	Noise power (dBW)			–126.35		–126.35
	SAR interference threshold ($I/N = -6$ dB) (dBW)			–132.35		–132.35
Allowable number of FWA cells	Margin (dB)			6.79		7.57
	Maximum number of FWA cells using the same RF channel within the SAR footprint		4.78		5.71	
	Maximum number of FWA cells assuming frequency reuse factor of 4		19.1		22.8	

4.1.2 Interference from SAR into FWA

The first step in analysing the interference potential from spaceborne SARs into FWA systems is to determine the signal power from spaceborne SARs side lobes onto the Earth's surface. For this analysis the median side-lobe gain has been used since these side lobes give a substantially larger footprint than the peak gain and will result in a longer duration interference. Table 6 shows the interference levels caused from SAR4 satellite side lobes into FWA. SAR4 was selected to represent the worst case. This Table shows a positive margin in the order of 20 dB and would result in a positive sharing scenario as far as side lobes are concerned.

TABLE 6

Interference from SAR4 side lobes into FWA

Parameter	20° from nadir		55° from nadir	
	Interference into base station	Interference into remote station	Interference into base station	Interference into remote station
Transmitted power (dBW)	32.3		32.3	
Transmit antenna gain (dBi)	−5.0		−5.0	
Free space loss (dB)	−159.5 (427 km)		−164.4 (749 km)	
Receive antenna gain (dBi)	−14.2	−2.2	−8.8	2.3
FWA feeder loss (dB)	−5.0	−10.0	−5.0	−10.0
Power received (dBW)	−151.4	−144.4	−150.9	−144.8
Bandwidth reduction (dB)	−3.0		−3.0	
Power received (dB(W/20 MHz))	−154.4	−147.4	−153.9	−147.8
FWA interference threshold (dB(W/20 MHz))	−128.8		−128.8	
Margin (dB)	25.6	18.6	25.1	19.0

However, the peak antenna gain is 43-47.7 dB higher than the average side-lobe gain of −5 dBi. Therefore, for the duration of the flyover the interference levels at the surface would be above the FWA interference threshold. Although the threshold is exceeded, the frequency and duration of this excess interference are estimated once per 8-10 days and 0.5-1 s per event, respectively.

4.1.3 Summary

It is demonstrated that frequency sharing between the SAR system and an FWA system is feasible in the band 5 250-5 350 MHz under certain operational and deployment requirements for the FWA system. FWA systems may experience short periods of high interference from SAR systems during their flyover periods. This interference is considered to be acceptable, given the assumed small joint probability of SAR interference and fading by the FWA systems. However, further studies may be required on the detailed interference effects on FWA systems.

4.2 Sharing between spaceborne altimeter and FWA

4.2.1 Interference from FWA into spaceborne altimeter

Table 7 shows the interference calculation from FWA into the spaceborne altimeter. The result shows an ample margin of 42.6 dB with respect to a −118 dBW threshold, and thus it can be concluded that FWA systems will not cause unacceptable interference to the spaceborne altimeter operation.

TABLE 7

Interference from FWA into spaceborne altimeter

<table>
<tr><th colspan="3" rowspan="2">Parameter</th><th colspan="2">From nadir</th></tr>
<tr><th>Value</th><th>dB</th></tr>
<tr><td rowspan="9">Interfering e.i.r.p. due to FWA antenna side lobe</td><td rowspan="4">From base station</td><td>Transmitted peak power (W)</td><td>0.2</td><td>–7.00</td></tr>
<tr><td>Transmit antenna gain (dBi)</td><td></td><td>–15.84</td></tr>
<tr><td>Active ratio</td><td>90%</td><td>–0.46</td></tr>
<tr><td>e.i.r.p. (dBW)</td><td></td><td>–23.30</td></tr>
<tr><td rowspan="4">From remote station</td><td>Transmitted peak power (W)</td><td>0.063</td><td>–12.00</td></tr>
<tr><td>Average transmit antenna gain (dBi)</td><td></td><td>–5.71</td></tr>
<tr><td>Active ratio</td><td>10%</td><td>–10.00</td></tr>
<tr><td>e.i.r.p. (dBW)</td><td></td><td>–27.71</td></tr>
<tr><td colspan="2">Total e.i.r.p. due to side lobe (dBW)</td><td></td><td>–21.96</td></tr>
<tr><td rowspan="9">Interfering power due to scattering at the surface</td><td rowspan="3">From base station</td><td>Transmitted peak power (W)</td><td>0.2</td><td>–7.00</td></tr>
<tr><td>Active ratio</td><td>90%</td><td>–0.46</td></tr>
<tr><td>Transmitted power (dBW)</td><td></td><td>–7.46</td></tr>
<tr><td rowspan="3">From remote stations</td><td>Transmitted peak power (W)</td><td>0.063</td><td>–12.00</td></tr>
<tr><td>Active ratio</td><td>10%</td><td>–10.00</td></tr>
<tr><td>Transmitted power (dBW)</td><td></td><td>–22.00</td></tr>
<tr><td colspan="2">Total transmitted power (dBW)</td><td></td><td>–7.31</td></tr>
<tr><td colspan="2">Scattering coefficient (dB)</td><td></td><td>–18.00</td></tr>
<tr><td colspan="2">Total scattered e.i.r.p. (dBW)</td><td></td><td>–25.31</td></tr>
<tr><td colspan="3">Total interfering e.i.r.p. from a cell (dBW)</td><td></td><td>–20.31</td></tr>
<tr><td rowspan="4">Interference power received at altimeter receiver</td><td colspan="2">Receive antenna gain (dBi)</td><td></td><td>32.20</td></tr>
<tr><td colspan="2">Polarization loss (dB)</td><td></td><td>–3.00</td></tr>
<tr><td colspan="2">Free space loss (dB)</td><td>(1 347 km)</td><td>–169.53</td></tr>
<tr><td colspan="2">Power received (dBW)</td><td></td><td>–160.64</td></tr>
<tr><td colspan="3">Altimeter interference threshold (dBW)</td><td></td><td>–118.00</td></tr>
<tr><td colspan="3">Margin (dB)</td><td></td><td>42.64</td></tr>
</table>

4.2.2 Interference from spaceborne altimeter into FWA

Table 8 shows interference levels from the spaceborne altimeter main beam into a base station and a remote station. There are sufficient margins in both cases.

TABLE 8

Interference from spaceborne altimeter into FWA

Parameter	To nadir	
	Interference into base station	**Interference into remote station**
Transmitted power (dBW)	12.3	
Transmit antenna gain (dBi)	32.2	
Free space loss (dB)	−169.5 (1 347 km)	
Receive antenna gain (dBi)	−15.8	−5.7
FWA feeder loss (dB)	−5.0	−10.0
Power received (dBW)	−145.8	−140.7
Bandwidth reduction (20 MHz/320 MHz) (dB)	−12.0	
Power received (dB(W/20 MHz))	−157.8	−152.7
FWA interference threshold (dB(W/20 MHz))	−128.8	
Margin (dB)	29.0	23.9

4.2.3 Summary

It has been demonstrated that frequency sharing between spaceborne altimeter system and FWA systems is feasible in the band 5 250-5 350 MHz.

4.3 Sharing between scatterometer and FWA

4.3.1 Interference from FWA into scatterometer

Table 9 shows an interference analysis from FWA into Scatterometer 1. Scatterometer 1 is selected to represent the worst case. Table 9 shows that the interference from FWA does not cause unacceptable interference.

4.3.2 Interference from scatterometer into FWA

Table 10 shows an analysis of interference from the scatterometer into FWA. The negative margins mean that FWA systems may experience short periods of high interference during the flyover of the scatterometer system.

TABLE 9

Interference from FWA into Scatterometer 1

Parameter			18° from nadir (El: 69.7°)		57° from nadir (El: 19.7°)	
			Value	dB	Value	dB
Interfering e.i.r.p. due to FWA antenna side lobe	From base station	Transmitted peak power (W)	0.2	–7.00	0.2	–7.00
		Transmit antenna gain (dBi)		–14.20		–5.94
		Active ratio	90%	–0.46	90%	–0.46
		e.i.r.p. (dBW)		–21.66		–13.40
	From remote station	Transmitted peak power (W)	0.063	–12.00	0.063	–12.00
		Average transmit antenna gain (dBi)		–4.93		0.64
		Active ratio	10%	–10.00	10%	–10.00
		e.i.r.p. (dBW)		–26.96		–21.36
	Total e.i.r.p. due to side lobe (dBW)			–20.54		–12.76
Interfering power due to scattering at the surface	From base station	Transmitted peak power (W)	0.2	–7.00	0.2	–7.00
		Active ratio	90%	–0.46	90%	–0.46
		Transmitted power (dBW)		–7.46		–7.46
	From remote stations	Transmitted peak power (W)	0.063	–12.00	0.063	–12.00
		Active ratio	10%	–10.00	10%	–10.00
		Transmitted power (dBW)		–22.00		–22.00
	Total transmitted power (dBW)			–7.31		–7.31
	Scattering coefficient (dB)			–18.00		–18.00
	Total scattered e.i.r.p. (dBW)			–25.31		–25.31
Total interfering e.i.r.p. from a cell (dBW)				–19.29		–12.53
Interference power received at SAR	Receive antenna gain (dBi)			31.00		32.50
	Polarization loss (dB)			–3.00		–3.00
	Free space loss (dB)		(825 km)	–165.27	(1 745 km)	–171.78
	Power received (dBW)			–156.56		–154.81
	Power received (dB(W/Hz))			–229.57		–227.82
Scatterometer interference threshold (dB(W/Hz))				–207.00		–207.00
Margin (dB)				22.57		20.82

TABLE 10

Interference from Scatterometer 1 into FWA

Parameters	18° from nadir (El: 69.7°)		57° from nadir (El: 19.7°)	
	Interference into a base station	Interference into a remote station	Interference into a base station	Interference into a remote stations
Transmitted power (dBW)	36.8		36.8	
Transmit antenna gain (dBi)	31.0		32.5	
Free space loss (dB)	−165.3 (825 km)		−171.8 (1 745 km)	
Receive antenna gain (dBi)	−14.2	−4.9	−5.9	0.6
FWA feeder loss (dB)	−5.0	−10.0	−5.0	−10.0
Power received (dBW)	−116.7	−112.4	−113.4	−111.9
FWA interference threshold (dBW)	−128.8		−128.8	
Margin (dB)	−12.1	−16.4	−15.4	−16.9

4.3.3 Summary

It has been demonstrated that frequency sharing between scatterometer systems and FWA systems is feasible. FWA systems may experience short periods of high interference from Scatterometer systems during their flyover periods. This interference is considered to be acceptable, given the assumed small joint probability of scatterometer interference and fading by FWA systems. However, further studies may be required on the detailed interference effects on FWA systems.

5 Conclusion

Frequency sharing between EESS/SRS (active) and FWA is possible under the condition that deployment of FWA systems is controlled so that the total interference e.i.r.p. from FWA to the EESS/SRS satellite does not exceed −7.6 dB(W/20 MHz) within the footprint of the active sensor of the satellite. FWA systems may experience short periods of interference from active sensor systems of EESS/SRS satellites during their flyover periods. This interference is considered to be acceptable for this band, given the assumed small joint probability of the active sensor interference and fading by FWA systems.

It is noted that these conclusions apply only to sharing between FWA and EESS/SRS (active), and do not address the possible increased aggregate interference to EESS/SRS (active) from the effects of mobile devices which may also operate in the EESS/SRS (active) footprint. However, studies have indicated that it is difficult for FWA and other types of wireless access systems (including RLANs) to operate simultaneously on a co-coverage, co-frequency basis. This matter is under further study and it is assumed not to impact on the conclusions of this Recommendation.

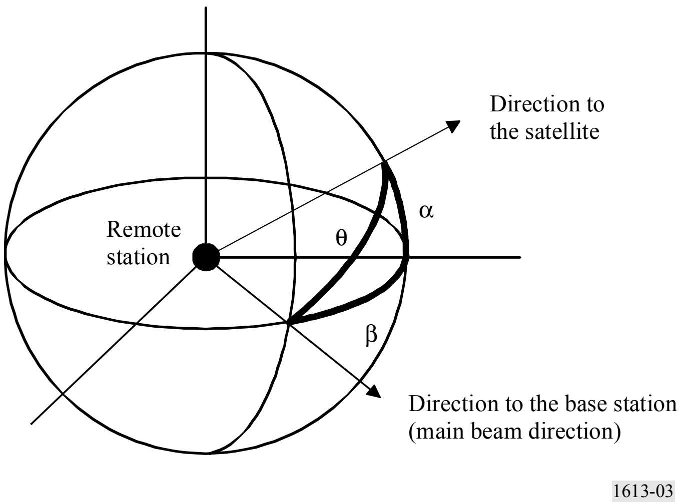
Appendix 1
to Annex 1

Interference into the spaceborne active sensor caused by side lobes of FWA remote stations

In an FWA cell, remote stations are scattered around the base station. It is assumed that remote stations surround the base station uniformly in terms of azimuth angles observed from the remote station. Since the main beam of remote stations are directed to the base station, the angle from the main beam of remote station is larger than the elevation angle towards the EESS/SRS satellite due to the azimuth separation as shown in Fig. 3.

FIGURE 3

Off-beam angle: θ towards the EESS/SRS satellite at the remote station



The off-beam angle: θ towards the satellite at the remote station is calculated by the following relation, assuming that the elevation of remote station antenna is 0°:

$$\cos \theta = \cos \alpha \cdot \cos \beta$$

where:

α: elevation angle towards the satellite

β: azimuth separation angle between the satellite and the base station directions.

Assuming β to be uniformly distributed over 0° to 360°, the average gain towards the satellite is calculated as shown in Table 11.

TABLE 11

Average antenna gain of remote stations towards the satellite

Satellite elevation (degrees)	70	30
Average gain (dBi)	–4.96	–2.34

Appendix 2
to Annex 1

List of abbreviations

Az	Azimuth
BW	Bandwidth
CSMA	Carrier sense multiple access
CW	Continuous wave
EESS	Earth exploration-satellite service
El	Elevation
FM	Frequency modulation
FWA	Fixed wireless access
PRF	Pulse repetition frequency
RF	Radio frequency
RLAN	Radio local area network
SAR	Synthetic aperture radar
SRS	Space research service
TDMA	Time division multiple access