

REPORT ITU-R RS.2095

**Sharing of the 36-37 GHz band by the fixed and mobile services
and the Earth exploration-satellite service (passive)**

(2007)

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1 Introduction

The purpose of this report is to summarize the result of the studies on sharing the 36-37 GHz band by the fixed and mobile services and the Earth exploration-satellite service (EESS) (passive)

2 EEES (passive)

2.1 Applications

The band 36-37 GHz is of primary interest to measure rain, snow, ocean ice and water vapour. This band is also called a window. This band is essential for the precise knowledge of the hydrological cycle or global water circulation.

For the measurement of surface parameters, some radiometric window channels must be selected to determine the corresponding expected parameters for the ocean or land surfaces.

For ocean surfaces, the main parameters that are measured over the ocean surfaces are: salinity, wind speed, liquid clouds, water vapour and sea surface temperature. Liquid clouds are obtained via measurements at 36 GHz. Five frequencies (6, 10, 18, 24 and 36 GHz) are necessary for determining the above main parameters.

For land surfaces, the problem is more complex due to high temporal and spatial variability of surface characteristics (from snow/ice covered areas to deserts and tropical rain forests). Over this kind of surface, the retrieved parameters are: vegetation biomass, cloud liquid water, integrated water vapour, soil moisture and surface roughness. The use of the 36 GHz allows the retrieval of the contents of the cloud liquid vapour and of the snow covered areas. It has been shown that this band is the most suitable band for snow detection and has been used for the last 20 years for climatological studies of snow, sea ice, soil moisture, microwave vegetation index and land surface temperature. Measurements at 36 GHz have shown the capability to derive the snow water equivalent. The use of spaceborne remote sensing techniques offers a way to complement and extend conventional ground based measurements of snow to regional and global scales. There is a continuing need to determine the snow water equivalent and its variability over large areas for climatological and hydrological applications. In addition to the snow water equivalent, it is also possible to derive from spaceborne microwave remote sensing measurements, the snow depth based on the physics of the microwave radiation.

The 36-37 GHz band measurements also provide auxiliary parameters for other remote sensing instruments. Spaceborne radar altimeters are currently operated on a global basis above ocean and land surfaces, with important applications in oceanography and climatology. In order to remove refraction effects due to the atmosphere, the utilization of highly accurate altimetric data require that they are complemented with a set of auxiliary passive measurements around 18.7, 23.8 and 36.5 GHz. In that case, the goal of the 36 GHz band measurements is to compute the tropospheric delay in order to enhance the accuracy of the data retrieved through the altimeters.

It is to be noted that all the above usages are fully operational.

2.2 Passive sensor parameters

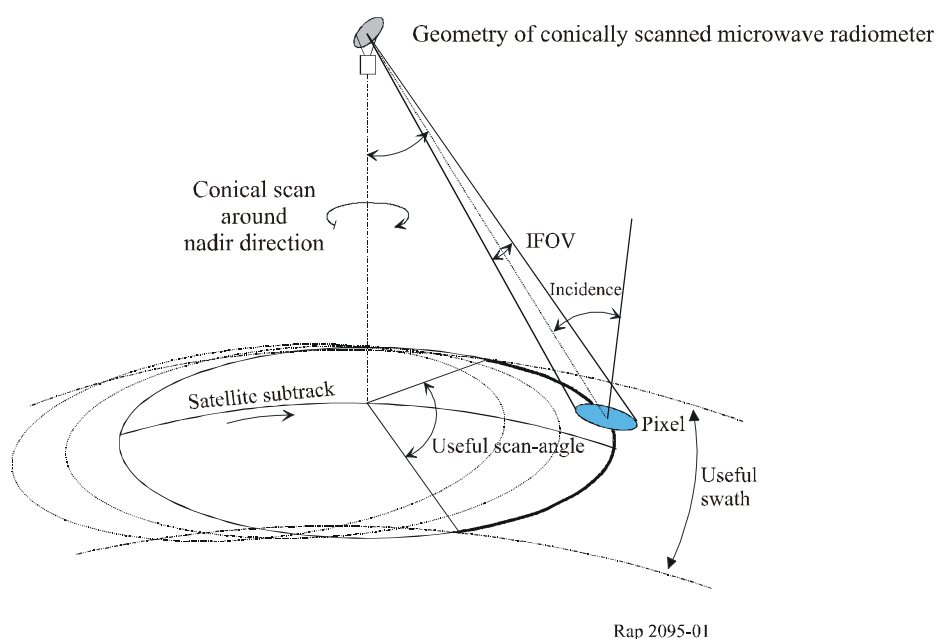
Table 1 summarizes the parameters of conical scanning passive sensors that are or will be operating in the 36-37 GHz band as illustrated in Fig. 1.

TABLE 1
Passive sensor parameters

Type of sensor	MADRAS	AMSR-E	CMIS
Channel bandwidth (GHz)	1	1	1
Pixel size across track (diameter of the pixel) (km)	38	7.8	12
Incidence angle i at footprint centre (degrees)	52.3	55	55.7°
Offset angle to the nadir or half cone angle α (degrees)	44.5	47.5	47
Polarization	H	H,V	H,V
Altitude of the satellite (km)	817	705	833
Maximum antenna gain (dBi)	45	53	55
Reflector diameter (m)	0.65	1.6	2.2
Half power antenna beamwidth θ_{3dB} (degrees)	1.8	0.4	0.52
Useful swath (km)	1 607	1 450	1 782
Antenna pattern	Fig. 2	Fig. 3	N/A

FIGURE 1

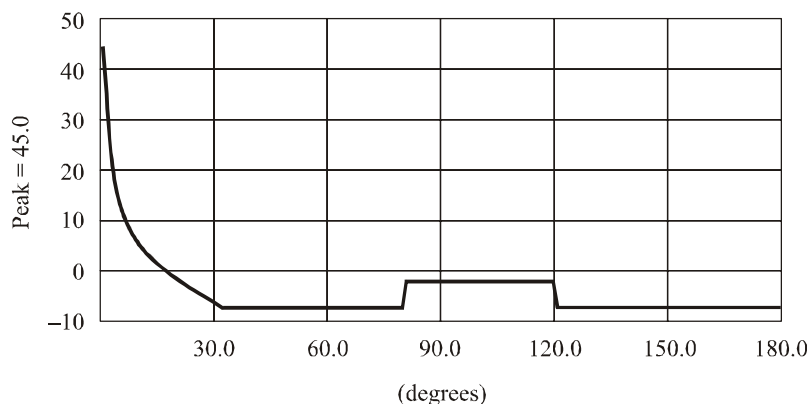
Geometry of conical scan passive microwave radiometers



The antennas of passive sensors are modelled according to the following figures.

FIGURE 2

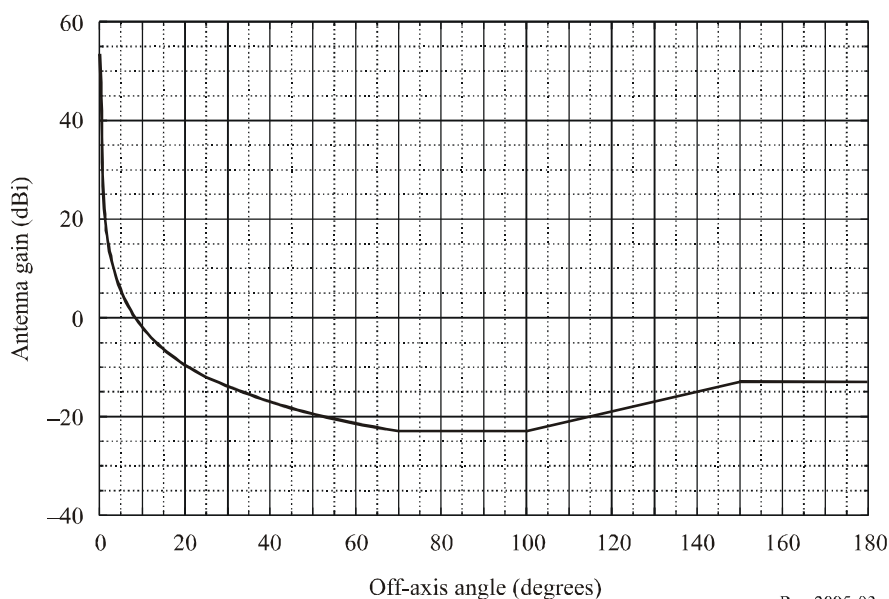
MADRAS antenna gain pattern at 36 GHz



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FIGURE 3

AMSR-E antenna gain pattern at 36 GHz



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2.3 Interference criteria

Recommendation ITU-R RS.1029 – Interference criteria for satellite passive remote sensing recommends permissible interference levels and reference bandwidths for use in any interference assessment or sharing studies. The permissible interference levels for the 36-37 GHz band are –156 dBW in a reference bandwidth of 100 MHz for current passive sensors, and –166 dBW in a reference bandwidth of 100 MHz for future passive sensors that are more sensitive than the currently operational passive sensors. The first number is indicated for sharing conditions circa 2003; while the second number is for scientific requirements that are technically achievable by sensors in the next 5-10 years. Recommendation ITU-R RS.1029 also specifies that these interference levels should not be exceeded for more than 0.1% of sensor viewing area, described as a measurement area of a square on the Earth of 10 000 000 km² unless otherwise justified.

3 Fixed and mobile service parameters

3.1 Fixed service (FS)

FS systems in this band can generally be characterized as either point-to-point (P-P) or point-to-multipoint (P-MP) systems.

Table 2 summarizes the parameters of P-P system that could operate in the 36-37 GHz that were considered in these studies.

TABLE 2
P-P FS station parameters

Parameter	FS-1	FS-2
Modulation type		O – QPSK
Distance between stations (one hop length) (km)	Around 2	From 0.5 to 20 Point-to-point
Channel capacity (Mbit/s)		2.048; 8.448; 34.368
Receiver sensitivity (BER up to 10^{-6}) (dBW)		Up to –117
Transmitter power (dBW)	–18.24 dBW/30 MHz (= 15 mW/30 MHz)	–13 to –7
Antenna gain (dBi)	37	39-42
Antenna diameter (m)		0.4-0.5
Antenna type		Parabolic
Antenna pattern		Rec. ITU-R F.1245
Max. feeder loss (dB)		0.5
Frequency grid		Rec. ITU-R F.749

Table 3 summarizes the parameters of one possible type of terrestrial P-MP station that could operate in the 36-37 GHz.

TABLE 3
P-MP FS station parameters

Parameter	Central (hub) station	Customer terminal station
Modulation	QPSK	
Access method	Time division multiplex (TDM)	
Bandwidth/carrier (MHz)	28	28
Antenna type	Sectoral antenna	Dish
Antenna gain (dBi)	17	39
Antenna beamwidth (degrees)	45	1.4
Number of active carriers/sector	4	4
Number of sectors	8	–

TABLE 3 (*end*)

Parameter	Central (hub) station	Customer terminal station
Path length (km)	0.1 – 6	
Maximum transmit power per carrier (dBW)	–5	–10
Receiving system line loss (dB)	0	0

3.2 Mobile service (MS)

Technical characteristics of systems in the MS operating in the band 36-37 GHz are shown in Table 4. As for the antenna pattern, Recommendation ITU-R F.1245 – Mathematical model of average radiation patterns for line-of-sight point-to-point radio-relay system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 to about 70 GHz is used in the simulation.

MS-1 and MS-2 systems are used mainly for video transmission in nomadic applications. Their corresponding activity factor is 3%.

In European countries, the band 36-37 GHz is allocated to the MS and the FS for the usage of government applications. Due to the specific operation, the MS-3 system which is used for government point-to-point links can be considered as MS systems due to their portable usage. It is noted that the characteristics of such MS stations are very similar to the FS station characteristics assumed in the dynamic simulations, so that the conclusions of the FS studies are generally assumed to be applicable to the MS.

TABLE 4

Mobile service station parameters

Parameter	MS-1	MS-2	MS-3
Antenna input power	–7 dBW/17 MHz (= 0.2W/17 MHz)	–3 dBW/17 MHz (= 0.5W/17 MHz)	–10 dBW (max) –15 dBW (typical)
Antenna gain (dBi)	37	37	44 (typical)
Antenna diameter (m)	0.3	0.3	0.3
Antenna type	Parabolic/Cassegrain	Parabolic	Parabolic
Feeder loss (dB)	0	0	0
Polarization	H/V	H	H/V
3 dB beam width (degrees)	2	2	1

NOTE 1 – Elevation angles are not specified because of its nomadic usage. This means that the transmitting antenna has a possibility to point any elevation and azimuth angles. However, the antenna is fixed during its operation.

NOTE 2 – MS-1: More than 30 transmitting stations are in operation and it is foreseen that the number of the stations will not increase rapidly in some administrations. MS-2: More than one transmitting station is in operation and it is foreseen that the number of the stations will not increase rapidly in some administrations.

4 Simulation studies

4.1 General simulation methodology

These sharing studies employ dynamic model simulations with the results required by Recommendation ITU-R RS.1029 concerning the percentage of the area over a 10 million km² measurement area that exceed the permissible interference power level. These dynamic model simulations develop cumulative distribution functions (CDFs) of received interference levels on the basis of such measurement areas so that such interference statistics can be directly compared with the specified interference criteria.

4.2 Simulation study number 1

This simulation assumes a deployment of 200 P-P FS stations evenly spread over an area defined by 40° N latitude, 0° longitude, 60° N latitude, and 20° E longitude. The transmitter power is –10 dBW and the antenna gain is 41 dBi, corresponding to an e.i.r.p. of 31 dBW. The propagation model includes atmospheric attenuations and the time increment for simulation is 2 s. The simulation results are given in Fig. 4 and Table 5 for the MADRAS passive sensor, in Fig. 5 and Table 6 for AMSR-E, and in Fig. 6 and Table 7 for CMIS.

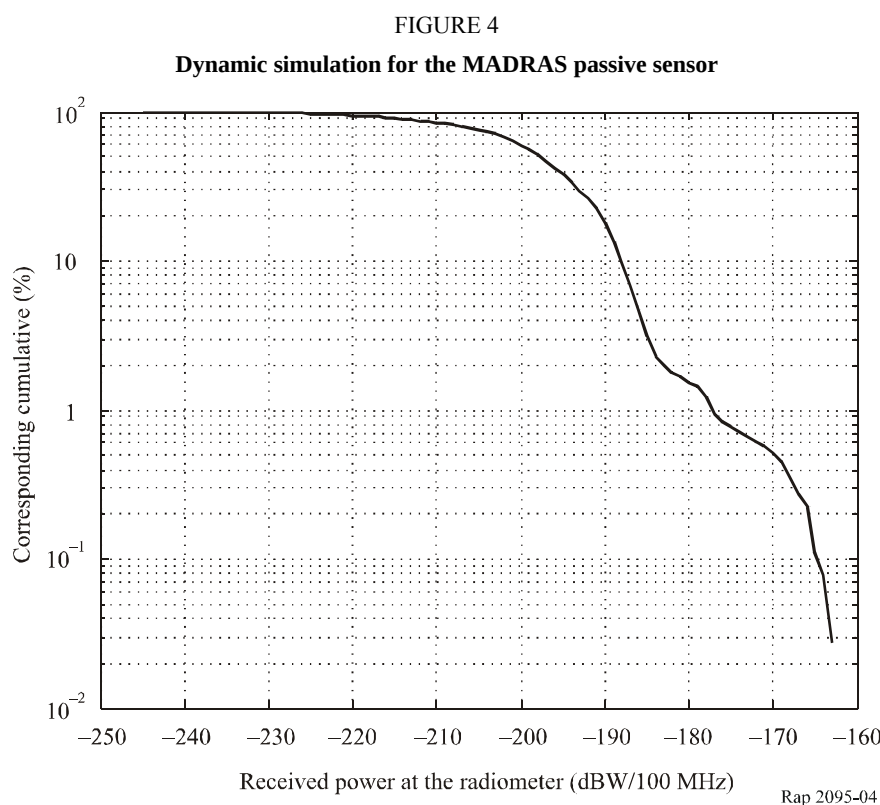


TABLE 5

Result of dynamic simulation corresponding to Fig. 4

Cumulative percentage (%)	1	0.2	0.1	0.02
Corresponding received power at the input of the radiometer in dBW for MADRAS for a 100 MHz bandwidth	–177	–167	–166	–163

FIGURE 5

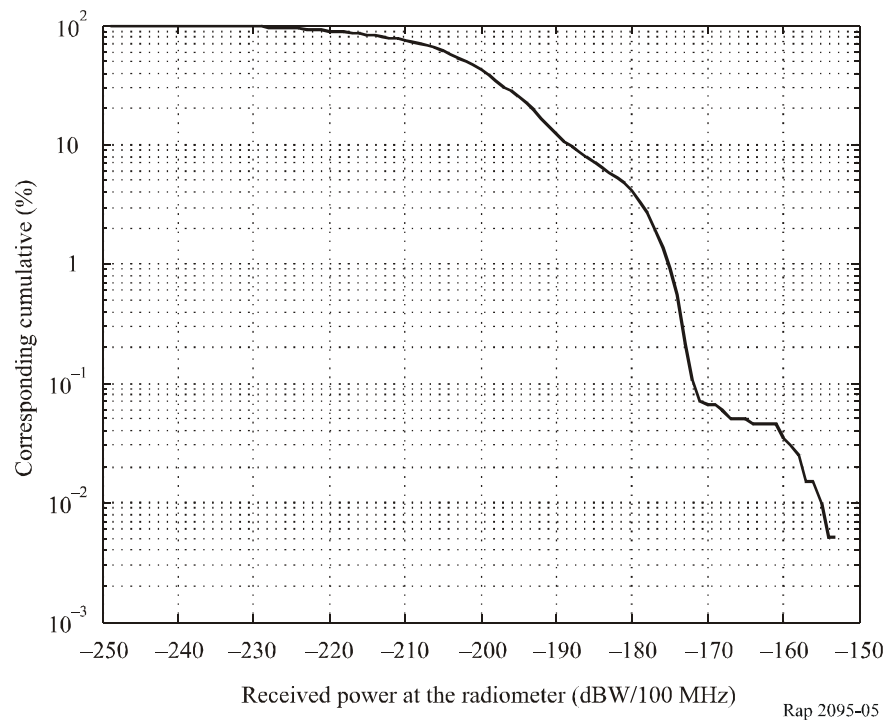
Dynamic simulation for the AMSR-E passive sensor

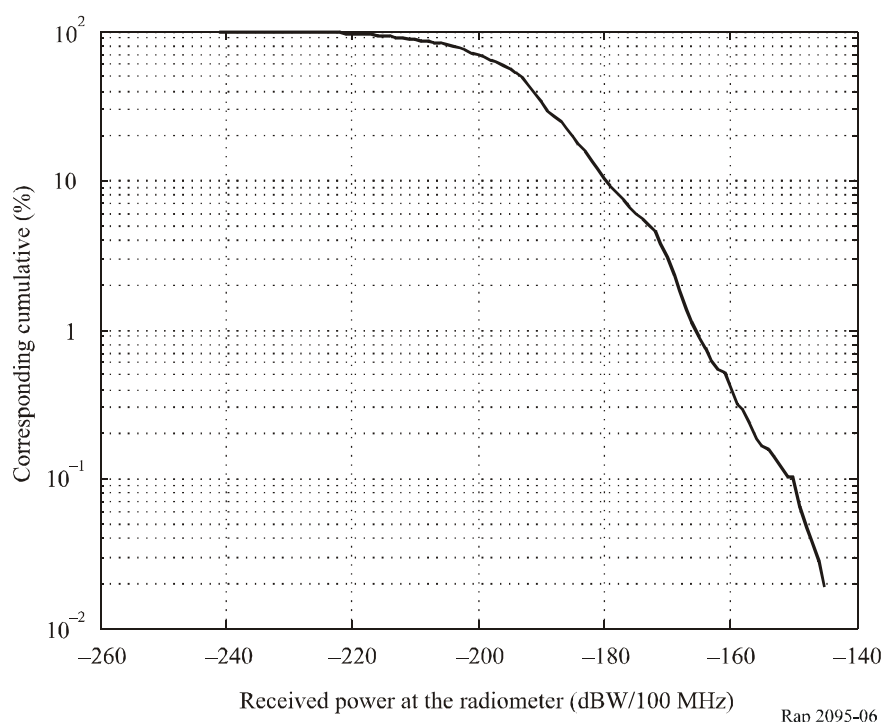
TABLE 6

Result of dynamic simulation corresponding to Fig. 5

Cumulative percentage (%)	10	1	0.1	0.05
Corresponding received power at the input of the radiometer in dBW for AMSR-E	-188	-175	-172	-156

FIGURE 6

Dynamic simulation for the CMIS passive sensor:
200 P-P stations in operation



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TABLE 7

Result of dynamic simulation corresponding to Fig. 6

Cumulative percentage (%)	10	2	1	0.1	0.02
Corresponding received power at the input of the radiometer in dBW for CMIS	-180	-166	-165	-152	-145

4.3 Simulation study number 2

This simulation is designed to develop a relationship between FS station deployment density and the EESS (passive) interference level. The simulation was conducted for the AMSR-E passive sensor, and each FS station was assumed to have a -11 dBW transmitter power and to employ a 40.5 dBi antenna whose side-lobe conform to the reference antenna pattern given in Recommendation ITU-R F.1245 for a 3 dB beamwidth of 1.5°.

In this simulation model, a large range of FS station deployment densities was achieved by assuming that between 1 and 20 two-way FS links were randomly distributed around 74 cities in and around the 10⁷ km² passive sensor measurement area illustrated in Fig. 7. Of the 74 cities in the simulation area in central Asia illustrated in Fig. 10, 66 were located within the 10⁷ km² passive sensor measurement area itself. The FS station density, N_{FS} , within this area is calculated as:

$$N_{FS} = 2 \text{ (stations/link)} \times \text{FS (links/city)} \times 66 \text{ (cities)}$$

where FS is the number of FS links/city assumed for the particular interference CDF.