RECOMMENDATION ITU-R M.1091

REFERENCE OFF-AXIS RADIATION PATTERNS FOR MOBILE EARTH STATION ANTENNAS OPERATING IN THE LAND MOBILE-SATELLITE SERVICE IN THE FREQUENCY RANGE 1 TO 3 GHz

(Question ITU-R 88/8)

(1994)

The ITU Radiocommunication Assembly,

considering

a) that, for statistical assessment of interference and for use in coordination between land mobile earth stations and the space stations of different satellite systems sharing the same frequency bands, it is appropriate to use a single radiation pattern for each type of land mobile earth station antenna;

b) that the reference radiation patterns for mobile earth station antennas operating in the land mobile-satellite service depend on the type of antenna and the earth station system performance requirements, in particular the gain and the associated beamwidth for different LMSS services;

c) that the types of antennas to be considered should include a:

i) transportable or vehicle-mounted antenna producing an axis-symmetric or near-symmetric beam;

ii) vehicle-mounted vertical array antenna producing a toroidal antenna pattern (360° in azimuth, narrow in elevation);

iii) vehicle-mounted array antenna having a horizontal profile and producing a vertical fan-beam pattern (narrow in azimuth, wide in elevation);

iv) vehicle-mounted near-omnidirectional antenna;

d) that the reference radiation pattern should result in achievable side-lobe limits for each type of antenna;

e) that the vehicle structure upon which these antennas will be mounted will distort the radiation pattern, particularly at low elevation angles, and that this effect will vary from vehicle to vehicle;

f) that in the mobile environment, other non-electrical factors, such as size, wind profile, mechanical stability, consumer acceptance, and cost, must be taken into account in the antenna design, and will limit the choice of available designs;

g) that the interference to other systems is related to the absolute level of radiation in directions other than the boresight;

h) that the use of an antenna with a good radiation pattern, i.e. one with the lowest side-lobe levels within § d), e) and f) will lead to the most efficient use of the radio-frequency spectrum and the geostationary orbit;

j) that an antenna of type iii) produces a pattern with minimum symmetry and that side lobes of a level sufficient to cause interference may occur along planes other than the principal planes,

recommends

1. that the reference radiation pattern in Annex 1 should be used for transportable or vehicle-mounted antennas producing an axis-symmetric or near-symmetric beam and operating in the frequency range allocated for mobile-satellite systems between about 1 and 3 GHz;

2. that the reference radiation pattern in Annex 2 should be used for vehicle-mounted vertical array antennas which produce a toroidal antenna pattern, and operate in the frequency range allocated for mobile-satellite systems between about 1 and 3 GHz;

3. that the reference radiation pattern in Annex 3 should be used for vehicle-mounted tracking array antennas which have a horizontal profile, produce a vertical fan-beam pattern, and operate in the frequency range allocated for mobile-satellite systems between about 1 and 3 GHz, and that the measurement principle given in Annex 5 should be used for such antennas;

4. that the reference radiation pattern in Annex 4 should be used for vehicle-mounted near-omnidirectional antennas operating in the frequency range allocated for mobile-satellite systems between about 1 and 3 GHz;

5. that when these reference radiation patterns are used for interference calculations, allowances must be made to the values derived to take account of the variances introduced by the vehicle movement and tolerances in the pointing accuracy and the tracking mechanism;

6. that the following Notes should be regarded as part of this Recommendation.

Note 1 – The reference radiation patterns given in the Annexes apply for all beam positions.

Note 2 – In addition to antennas of type iii), it may be appropriate to use the measurement principle of Annex 5 for other antennas which have a non-symmetric radiation pattern either intrinsically or due to the effect of a ground plane.

Note 3 – For vehicle-mounted antennas, the proximity of the vehicle acts as a ground plane and may have a significant effect on the radiation pattern of the antenna.

Note 4 – Antennas for handheld terminals are expected to have nearly omnidirectional patterns which provide very little angular discrimination and are not specified in this Recommendation.

Note 5 – Other antenna types than the four described above may be developed for mobile earth station use; administrations are requested to supply information as it becomes available.

ANNEX 1

Reference radiation pattern for transportable or vehicle-mounted near-axis symmetric earth station antennas with a gain of 12 to 18 dBi and with an operating frequency within the range of about 1 to 3 GHz for use in the land mobile-satellite service

θ: angle (degrees) between the direction of maximum gain and the side-lobe direction

G: absolute gain relative to an isotropic antenna.

$G \leq 44 - 25 \log \theta$	dBi	for $40° < \theta < 90°$
$G \leq -5$	dBi	for $\theta \geq 90°$

ANNEX 2

Reference radiation pattern for vehicle-mounted earth station antennas with a vertical profile and producing a toroidal pattern with gain in the range of 7 to 13 dBi and with an operating frequency within the range of about 1 to 3 GHz for use in the land mobile-satellite service

E: elevation angle (degrees) of the side-lobe direction

E_o: elevation angle (degrees) of the maximum gain

G_{max}: peak gain of the antenna

G: absolute gain relative to an isotropic antenna

The antenna is omnidirectional in azimuth.

$$G \leq G_{max} - 10 \quad \text{dBi} \quad \text{for} \quad E - E_0 > 45°$$
$$G \leq G_{max} - 0.3\ ((E - E_0)/10)^{2.3} \quad \text{dBi} \quad \text{for} \quad 20° \leq E - E_0 \leq 45°$$
$$G \leq G_{max} - 0.3\ ((E_0 - E)/10)^{2.3} \quad \text{dBi} \quad \text{for} \quad 20° \leq E_0 - E \leq 50°$$
$$G \leq G_{max} - 13 \quad \text{dBi} \quad \text{for} \quad E_0 - \text{E} > 50°$$

ANNEX 3

Reference radiation pattern for vehicle-mounted tracking earth station antennas with a low profile which typically have a fan-beam pattern and with an operating frequency within the range of about 1 to 3 GHz for use in the land mobile-satellite service

Maximum gain is in the direction (AZMAX, ELMAX).

The point in consideration is (AZ, EL).

G is the absolute gain relative to an isotropic antenna.

$$A = |AZ - AZMAX|$$

$$G(AZ, EL) \leq 4 \text{ dBi} \quad \text{for} \quad \begin{cases} 0° \leq EL \leq 60° \\ 30° + k(EL)° \leq A \leq 180° \end{cases}$$

Antenna type			
Typical minimum antenna G/T (dB(K^{-1}))	Relative gain class	Approximate peak gain (dBi)	Width constant (k)
–18	Low	9-11	Note 1
–14	Medium	11-13	0.33
–12	High	13-15	0.33

Note 1 – Further work is needed to develop appropriate values for low-gain fan-beam antennas. It has been suggested that a width constant of 0.67 might be appropriate.

ANNEX 4

Reference radiation pattern for vehicle-mounted near-omnidirectional antennas with an operating frequency within the range of about 1 to 3 GHz for use in the land mobile-satellite service

E: elevation angle (degrees)

G: absolute gain relative to an isotropic antenna.

$$G \leq 5 \quad \text{dBi} \quad \text{for } E \geq -20°$$
$$G \leq 0 \quad \text{dBi} \quad \text{for } E < -20°$$

ANNEX 5

Recommended measurement principle for vehicle-mounted horizontal array antennas used in the land mobile-satellite service

It is important to measure the antenna pattern with a method that samples the entire hemisphere surrounding the antenna. These antennas have a pattern which is, at best, symmetric across a vertical plane and which is not adequately sampled by measurements along the two principal planes. Side lobes of a level sufficient to cause interference may not necessarily occur along the principal planes.

One such method is to measure along a series of conical cuts, that is, through 360° in azimuth at a constant elevation with respect to a horizontal plane (for example, the vehicle roof), as shown in Fig. 1. These conical cut measurements should be made at a sufficient number of elevation angles to reasonably sample the pattern of the antenna.

Alternatively, a series of elevation cuts through zenith at various azimuth angles could be used to characterize the pattern.

A complete set of such measurements should be made for each different configuration (e.g. elevation settings, switched beams) of the antenna.

Because the ground plane effect of the vehicle structure has a significant effect on the antenna pattern, an appropriate ground plane should be used when measuring the antenna.

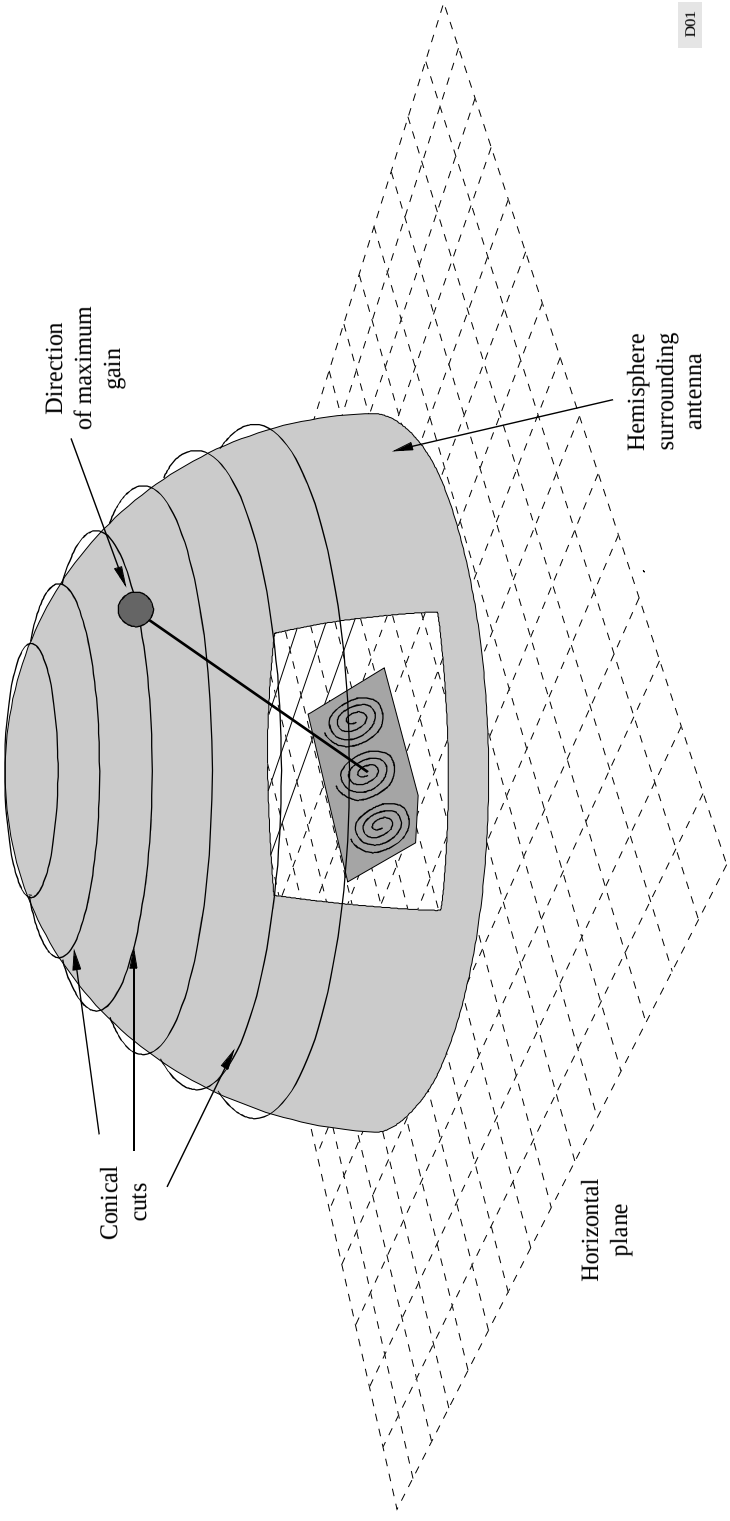

FIGURE 1
Measurement method