International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R M.1470
(05/2000)

Methodology of sharing between MSS systems (Earth-to-space) and existing RNSS systems (space-to-Earth) in the frequency bands 149.9-150.05 MHz and 399.9-400.05 MHz

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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SM	Spectrum management
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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 M.1470*

Methodology of sharing between MSS systems (Earth-to-space) and existing RNSS systems (space-to-Earth) in the frequency bands 149.9-150.05 MHz and 399.9-400.05 MHz

(Question ITU-R 201/8)

(2000)

The ITU Radiocommunication Assembly,

considering

a) that WRC-97 allocated the band 149.9-150.05 MHz to the MSS on a co-primary basis in the Earth-to-space direction, worldwide, with the radionavigation-satellite service (RNSS);

b) that WRC-97 allocated the band 399.9-400.05 MHz to the MSS on a co-primary basis in the Earth-to-space direction, worldwide, with the radionavigation-satellite service (RNSS);

c) that according to RR No. 5.224A, the use of the bands 149.9-150.05 MHz and 399.9-400.05 MHz by the MSS (Earth-to-space) is limited to the LMSS (Earth-to-space) until 1 January 2015;

d) that an existing RNSS system operates in the bands 149.9-150.05 MHz and 399.9-400.05 MHz in the space-to-Earth direction;

e) that according to RR No. 5.220, the MSS shall not constrain development and use of the RNSS in the bands 149.9-150.05 MHz and 399.9-400.05 MHz;

f) that according to RR No. 5.224B, the allocation of the bands 149.9-150.05 MHz and 399.9-400.05 MHz to the RNSS shall be effective until 1 January 2015,

recognizing

a) that RR No. 4.10 applies to the use of these bands by the RNSS,

further recognizing

a) that RR No. 4.5 states that "The frequency assigned to a station of a given service shall be separated from the limits of the band allocated to this service in such a way that, taking into account the frequency band assigned to a station, no harmful interference is caused to services to which frequency bands immediately adjoining are allocated", and that it is necessary to protect the existing RNSS system from harmful interference caused by other services,

recommends

1 that the technical information for RNSS and MSS (Earth-to-space) systems, which are planned to work within LMSS (Earth-to-space) in the frequency bands 149.9-150.05 MHz and 399.9-400.05 MHz, outlined in Annex 1 be used as baselines and criteria for the RNSS system protection from LMSS (Earth-to-space) systems;

2 that the methodology of Annex 2 could be used for estimating interference to the RNSS system from the LMSS (Earth-to-space) systems;

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* Radiocommunication Study Group 8 made editorial amendments to this Recommendation in 2004 in accordance with Resolution ITU-R 44.

3 that the methods described in Annex 3 be used in developing approaches to facilitate the sharing of the 149.9-150.05 MHz and 399.9-400.05 MHz bands by LMSS (Earth-to-space) and existing radionavigation-satellite systems.

Annex 1

Characteristics of the existing RNSS system to be used in evaluating interference between LMSS (Earth-to-space) and RNSS

1 Description of the TSYKADA space navigation system

The TSYKADA space navigation system consists of three basic segments. They are: space segment, ground control segment and user segment.

1.1 The space segment

The TSYKADA system is made up of seven satellites placed into seven orbital planes with one satellite in each plane. The planes are equally separated by ascending node longitude along the equator. The inclination of the orbits is 83°. The orbital period is 1 h 45 min. The altitude of the orbit is 1 000 km. The orbit is a circular, near-polar one. The transmitting antenna gain is shown in Figs. 1 and 2.

1.2 The ground control segment

The ground control segment consists of the system control centre and ground monitoring station network. All of them are located in the Russian Federation territory.

The monitoring stations are used to measure satellites' orbital parameters and their on-board clock shifts in relation to the system master clock. Those data are relayed to the system control centre. The centre calculates ephemerides of the satellites and data for their clock updating. That information is relayed to the satellites via the monitoring stations every day.

1.3 The user segment

The user segment consists of navigation equipment installed in maritime ships. The user terminal is made up of antenna, receiver, processor and input/output module. A computer included in the user terminal automatically calculates ship position in relation to a satellite and derives the ship coordinates.

The system uses the passive Doppler position fixing method.

Table 1 shows technical characteristics of the RNSS system in the 150 MHz and 400 MHz frequency bands.

1.4 Criteria for protection of the RNSS receiving earth stations

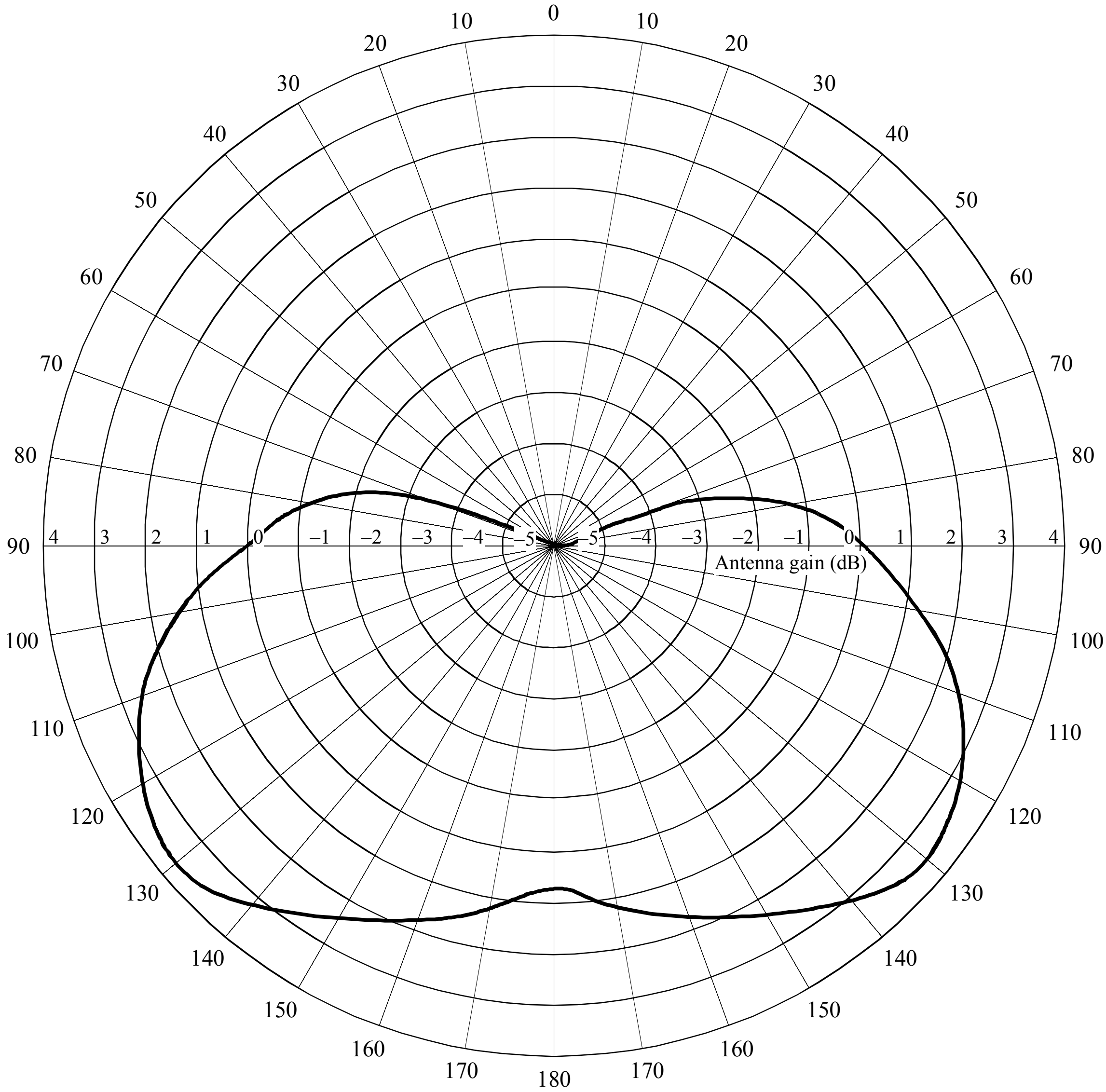
Permitted aggregate maximum pfd produced by the MSS stations at the front end (input) of the RNSS earth station receiving antenna in the 4 kHz bandwidth may be used as a criterion for protection of the RNSS earth stations:

– -153 dB(W/(m^2 · 4 kHz)) in the 149.9-150.05 MHz frequency band;

– -156 dB(W/(m^2 · 4 kHz)) in the 399.9-400.05 MHz frequency band.

FIGURE 1

Transmitting antenna gain for the frequency 150 MHz of the RNSS space station



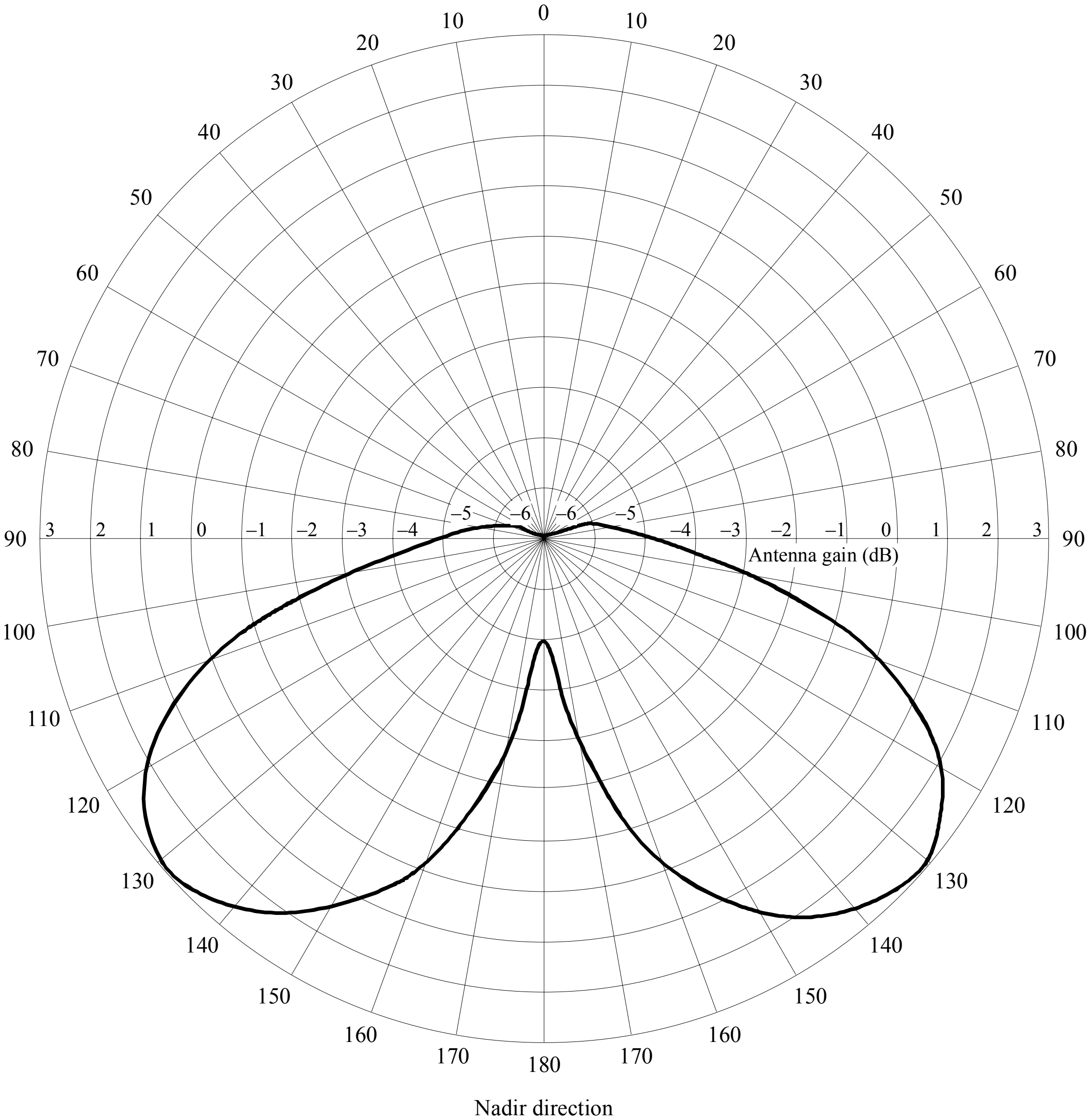
Nadir direction

G_{max} = +3.5 dB

1470-01

FIGURE 2

Transmitting antenna gain for the frequency 400 MHz of the RNSS space station



Nadir direction

G_{max} = +3.0 dB

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TABLE 1

Parameters of the existing RNSS system

Parameter	RNSS	
Orbital		
Number of satellites	7	
Altitude (km)	1 000	
Inclination (degrees)	83	
Orbit planes	7	
Satellite/plane	1	
Right ascension of ascending node (degrees)	0, 51, 103, 154, 206, 257, 309	
Downlink		
Band (MHz)	149.9-150.05	399.749-400.131
Tx power (W)	4.8	4.8
Tx e.i.r.p. (dBW)	8.3	7.8
Maximum Tx antenna gain (dB)	3.5	3.0
Tx antenna pattern	Fig. 1	Fig. 2
Channel BW (kHz)	0(1), 14, 127	0(1), 22, 254
Rate (kbit/s)	0.05/FSK	0.05/FSK
Polarization	RHCP	RHCP
dSub Rx G/T (dB(K^{-1}))	200-400	200-400
Maximum Rx antenna gain	0	0
Rx antenna pattern	Not determined	Not determined

(1) Unmodulated carrier.

Annex 2

1 Methodology for estimating the effects of interference from the LMSS transmitting earth stations to the RNSS receivers

The RNSS stations use the frequency bands 149.9-150.05 MHz and 399.9-400.05 MHz in the space-to-Earth direction and therefore interference could occur to receiving earth stations in the RNSS from MSS transmitting ground-based earth stations in the course of co-frequency operation of LMSS (Earth-to-space) and the RNSS stations in those bands.

To estimate feasibility of sharing between LMSS earth stations (Earth-to-space) and RNSS earth stations a method of determining the required coordination distances between LMSS transmitting earth stations and RNSS receiving earth stations could be used. Beyond those distances interference caused by LMSS transmitting earth stations to RNSS receiving earth stations may be considered acceptable. Within those distances, detailed calculation of interference is required.

Required attenuation between a transmitting earth station in the LMSS and a receiving earth station in the RNSS may be estimated as:

$$L_{req} = (P_t + G_t + 36) - I_r \tag{1}$$

where:

L_{req}: required attenuation between a transmitting earth station in the LMSS and a receiving earth station in the RNSS (dB)

P_t: maximum power spectral density for a transmitting earth station in the LMSS (dB(W/Hz))

G_t: maximum antenna gain for a transmitting earth station in the LMSS (dBi)

I_r: permitted interference level produced at the RNSS earth station receiver input in a reference bandwidth of 4 kHz (dB(W/4 kHz)).

The required interference level at the input of an earth station receiver in the RNSS may be estimated as:

$$I_r = (pfd)_r + S_r = (pfd)_r + G_r + 20 \log \lambda - 10 \log (4\pi) \quad (2)$$

where:

S_r: effective antenna surface area (dB(m^2))

G_r: maximum antenna gain for a receiving earth station in the RNSS (dBi)

λ: wavelength (m).

The estimation results for I_r are presented in Table 2.

TABLE 2

Parameter	Frequency band (MHz)	
	149.9-150.05	399.9-400.05
$(pfd)_r$ (dB(W/(m^2 · 4 kHz)))	–153	–156
G_r (dB)	0	0
λ (m)	2	0.75
10 log (4π) (dB)	11	11
I_r (dB(W/4 kHz))	–158	–169.5

Substituting I_r values in equation (1) results in an opportunity to define required attenuation between a transmitting earth station in the LMSS and a receiving earth station in the RNSS as:

– for the frequency band 149.9-150.05 MHz:

$$L_{req} = (P_t + G_t + 36) + 158 \quad (3)$$

– for the frequency band 399.9-400.05 MHz:

$$L_{req} = (P_t + G_t + 36) + 169.5 \quad (4)$$

In the case of land mobile earth stations, relationships between the required attenuation, L_{req}, and the distance, d, may be estimated using equations (5) to (8):

– for the frequency 150 MHz:

$$L_{req} = 86 + 20 \log d + 0.0674\, d \quad \text{for } d > 100 \text{ km} \quad (5)$$

$$L_{req} = 70.5 + 40 \log d - 0.178\, d \quad \text{for } 10 \text{ km} < d \leq 100 \text{ km} \quad (6)$$

– for the frequency 400 MHz:

$$L_{req} = 75.1 + 40 \log d \quad \text{for } 10 \text{ km} < d \leq 400 \text{ km} \quad (7)$$

$$L_{req} = 55.1 + 40 \log d + 0.05\, d \quad \text{for } 400 \text{ km} < d < 700 \text{ km} \quad (8)$$

Then to estimate coordination distances the following Figures may be used. They are:

– Fig. 3 (for 150 MHz and distance $d > 100$ km),
– Fig. 4 (for 150 MHz and distance 10 km $< d \leq 100$ km),
– Fig. 5 (for 400 MHz and distance 10 km $< d \leq 400$ km),
– Fig. 6 (for 400 MHz and distance 400 km $< d < 700$ km).

FIGURE 3

Attenuation as function of distance (for 150 MHz and $d \geq 100$ km)

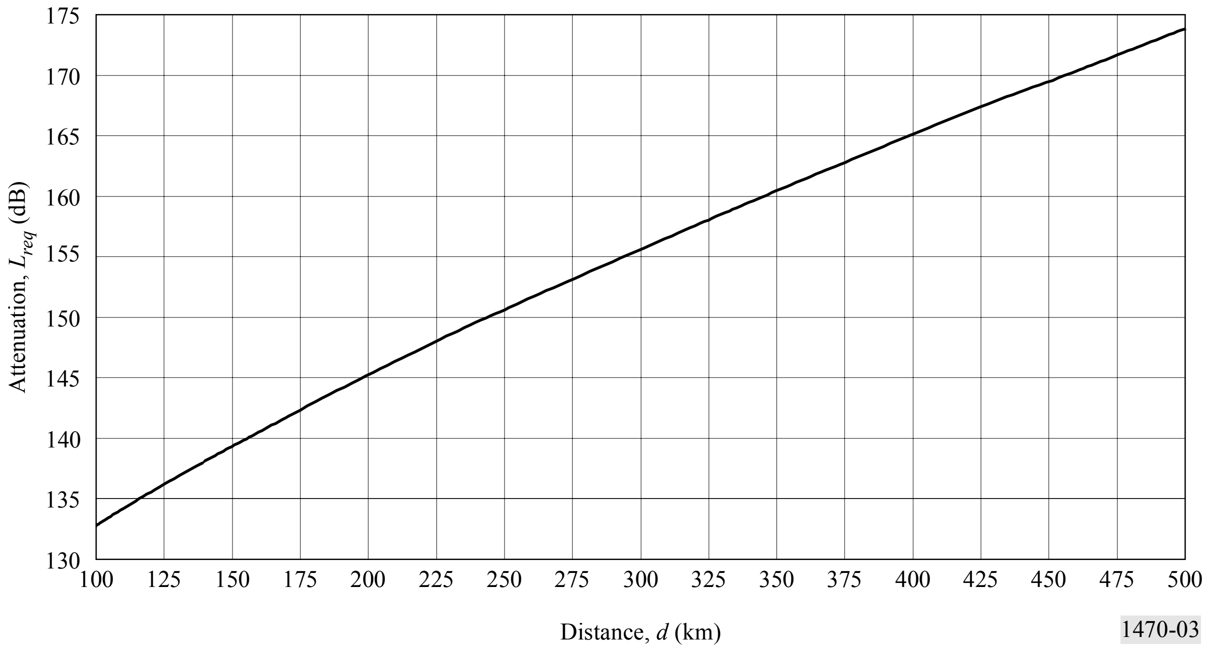

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FIGURE 4

Attenuation as function of distance (for 150 MHz and 10 km $< d \leq 100$ km)

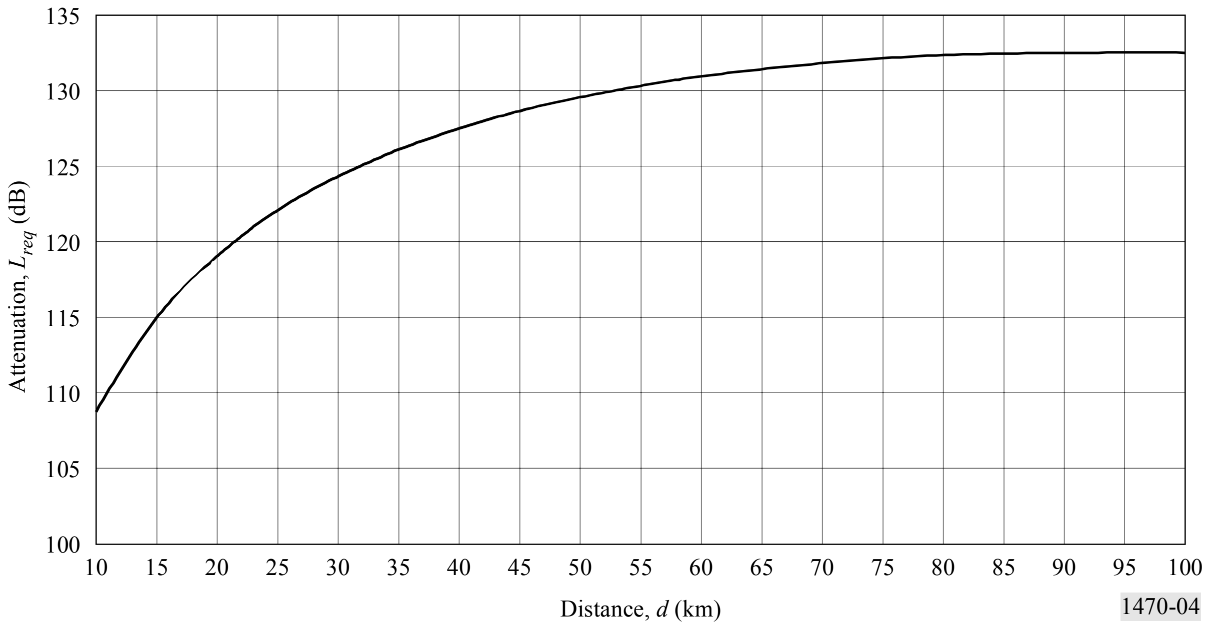

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FIGURE 5

Attenuation as function of distance (for 400 MHz and 10 km < $d \leq$ 400 km)

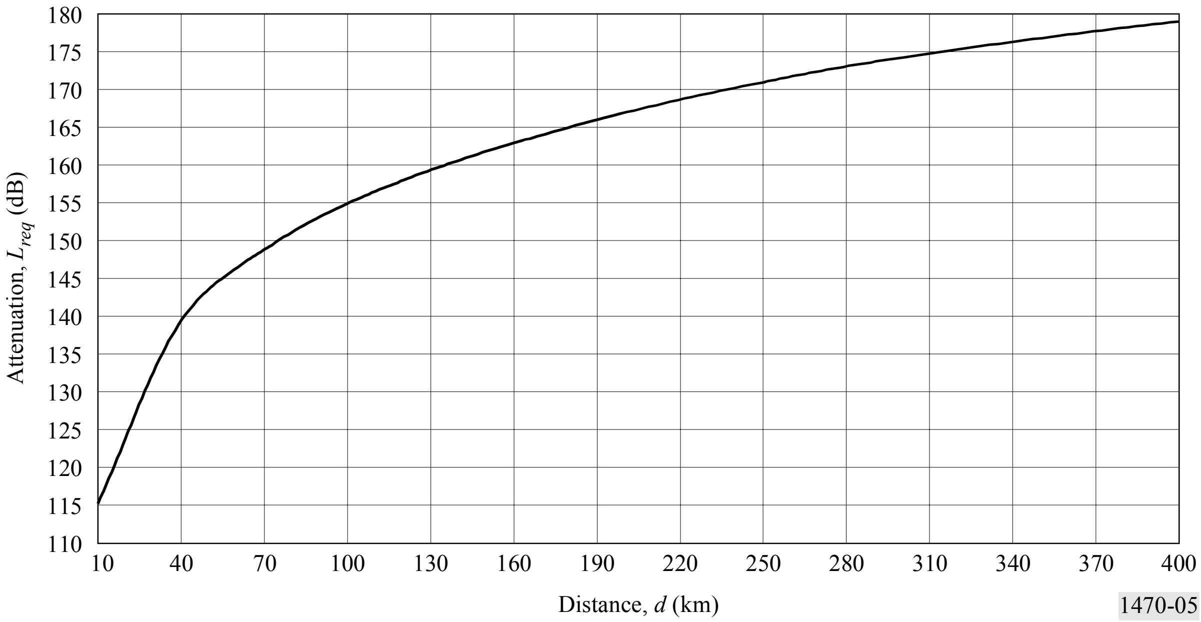
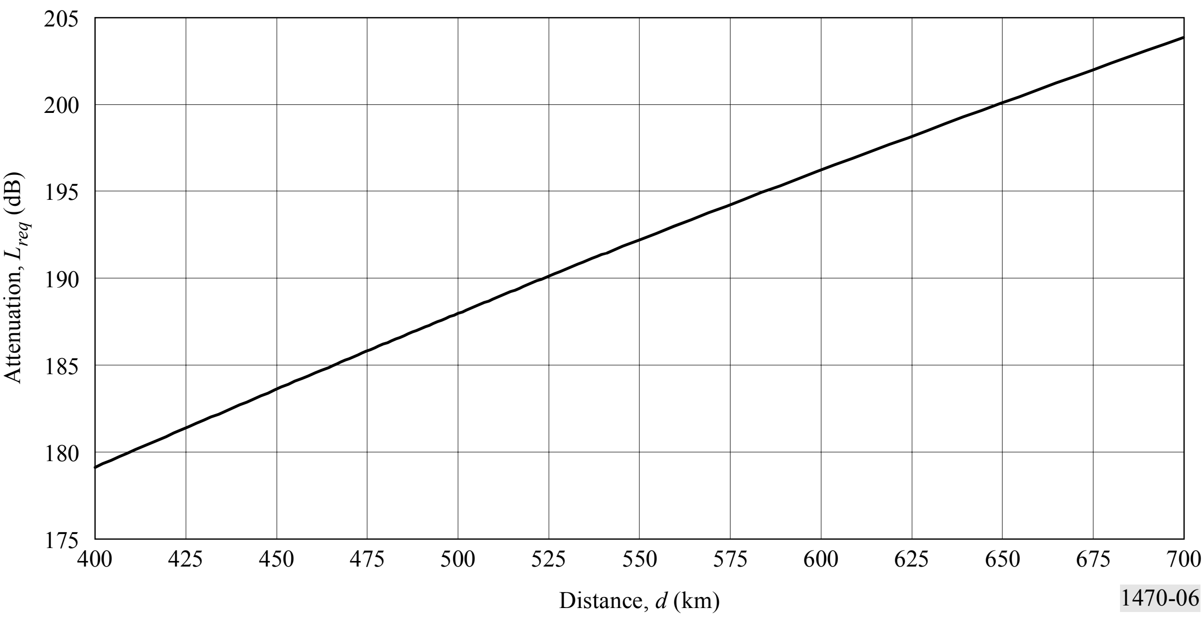


FIGURE 6

Attenuation as function of distance (for 400 MHz and 400 km < d < 700 km)



For estimating the coordination distance between MSS gateway earth stations at specific locations and earth stations in the RNSS operating in the 149.9-150.05 MHz band, equation (9) may be used:

$$L_{req} = 69 + 40 \log d + 30 \log f - 20 \log (h_1 h_2) + 10 \log (0.02 p) \left(1 - \exp(-0.1 d)\right)^2 \quad (9)$$

where the attenuation must not be less than the free-space loss (dB) by:

$$L_{req} = 32.5 + 20 \log d + 20 \log f \qquad (10)$$

where:

p: percentage time for which the field strength will be exceeded, in the range 1 to 50%. In this case, the appropriate value is 5%

h_1, h_2: terminal heights (m) for the transmitting and receiving antennas, each having a minimum value of 1 m, with the product (h_1 h_2) limited to 300 m^2. In this case, the appropriate value for h_2 ranges from 5 to 60 m.

The terrain clearance angle correction factor is a loss (dB) and can be expressed as follows:

$$\text{Correction factor} = 8.1 - \left[6.9 + 20 \log\left(\sqrt{(v - 0.1)^2 + 1} + v - 0.1\right)\right] \qquad (11)$$

where:

$$v = -\theta \sqrt{(4000 \times 95)/300}$$

θ: angle (rad) between the horizontal at the transmitting antenna and the line which just clears all obstacles within 16 km in the direction of the receiver. θ is negative for angles above the horizontal.

Annex 3

Methods which can be utilized to facilitate sharing between LMSS (Earth-to-space) and RNSS in the frequency bands 149.9-150.05 MHz and 399.9-400.05 MHz

Frequency band (MHz)	Methods
149.9-150.05 and 399.9-400.05	– Maintaining a coordination distance – Using MES-controlled frequency avoidance techniques to avoid transmission on the same frequency during periods of RNSS transmission in the same area – Limiting minimum elevation angle for LMSS gateway earth stations with azimuth directed towards navigable waterways

NOTE 1 – It should be regarded that interference may occur between TSYKADA transmitters and LEO MSS spaceborne receivers. LEO MSS operators will have to understand that this interference may curtail their operations during spacecraft mutual visibility events. In addition MSS system operators must ensure that their spacecraft receivers are designed to accommodate strong interfering signals without damage.