

RECOMMENDATION ITU-R F.1706

Protection criteria for point-to-point fixed wireless systems sharing the same frequency band with nomadic wireless access systems in the 4 to 6 GHz range

(Question ITU-R 133/9)

(2005)

Scope

This Recommendation provides the protection criteria for point-to-point (P-P) fixed wireless systems (FWS) from nomadic wireless access systems (NWAS) in the 4 to 6 GHz range operating in areas near international borders. Annex 1 gives the basic analysis factors and simulation examples of separation distances to protect P-P FWS from interference caused by NWAS.

The ITU Radiocommunication Assembly,

considering

- a) that in many parts of the spectrum the fixed service and the mobile service are sharing the same frequency bands;
- b) that, with appropriate sharing criteria and geographical separation, both systems can efficiently coexist and use frequency spectrum;
- c) that the necessary separation distance to protect P-P FWS from interference caused by NWAS has not been determined in many frequency bands including the 4 to 6 GHz range;
- d) that in many parts of the above frequency range, FWS are also sharing the same band with space services,

noting

- a) that P-P FWS and NWAS sharing the same frequency band in the 4 to 6 GHz range may operate in mutually close area beyond international borders,

recommends

1 that the protection criteria for P-P FWS sharing the same frequency bands with NWAS should be as follows:

- the maximum aggregate interference from the NWAS including base station and terminal stations should be such that the degradation to an FWS receiver threshold does not exceed 0.5 dB under free space propagation conditions (equivalently the aggregate interference noise should not exceed one-tenth of the thermal noise level of the FWS receiver) (see Note 1);

2 that for additional information Annex 1 can be referred to, including the separation distance to protect FWS from interference caused by NWAS.

NOTE 1 – This criterion is derived taking into account *considering c)*, as well as a number of system parameters for sharing studies given in Recommendation ITU-R F.758 in the 4-6 GHz range.

Annex 1

Consideration on separation distance to protect P-P FWS from interference caused by NWS sharing the same frequency band in the 4 to 6 GHz range

1 Introduction

In many parts of the spectrum the fixed service and the mobile service are sharing the same frequency bands. Studies on compatibility between both services will become more important including the bands above 3 GHz.

Recently use and applications of terrestrial wireless communication systems are so increasingly expanding that some countries may consider future use of the bands above 3 GHz for wireless access systems including nomadic/mobile applications. It should be noted that many frequency bands in the 4 to 6 GHz range are widely used for traditional radio-relay systems in the fixed service. Therefore, review of the spectrum use requires careful consideration on compatibility of both existing and new applications. Also the impact of deploying a new application on other systems should be evaluated, in some cases, beyond international borders.

This Annex provides consideration on the necessary separation distance to protect conventional digital radio-relay systems (DRRS) from unacceptable interference caused by NWS in the 5 GHz frequency band.

2 Basic factors to be considered in the analysis

The analysis made in the later sections takes into account the following factors:

- in the frequency range around 5 GHz, e.g. 4 400-5 000 MHz, DRRS are densely deployed around urban cities;
- system parameters used in the analysis should, as far as possible, be based on those given in other ITU-R Recommendations on sharing studies;
- NWS can be operated in both outdoor and indoor environments;
- DRRS are usually operated utilizing most of the available bandwidth and therefore it is difficult to apply interference mitigation measures to NWS such as dynamic frequency selection (DFS) within the shared band;
- interference paths from NWS to DRRS, are basically considered.

Furthermore, the analysis is conducted for both theoretical models and practical examples.

3 System parameters of DRRS and NWS

3.1 Parameters of DRRS

Examples of the technical parameters of DRRS are given in Table 1, which are based on those in Table 13 in Recommendation ITU-R F.758.

TABLE 1
DRRS parameters

Parameter	Symbol	Value and unit	Reference
Centre frequency of operation	f	5 000 MHz	
Antenna height above ground	H_D	70 m	⁽¹⁾
Maximum antenna gain	–	42.5 dB	Rec. ITU-R F.758 ⁽²⁾
Antenna radiation pattern	$G_D(\theta)$	– dB	Rec. ITU-R F.699
Feeder loss	L_{f-}	3.5 dB	Rec. ITU-R F.758
Receiver bandwidth	B_D	30.2 MHz	
Receiver thermal noise	N_{thD}	–97.5 dBm	
Transmitter power	P_{tD}	33 dBm	

⁽¹⁾ The agreed value in the sharing study between the fixed service and earth station on board vessels (ESVs) in Recommendation ITU-R SF.1650.

⁽²⁾ A single antenna is commonly used for the receiver and the transmitter.

3.2 Parameters of NWAS

Examples of the technical parameters of NWAS are given in Table 2, which are based on those for HiperLAN (Type-2) used in the sharing study between the radio local area network (RLAN) and the Earth exploration-satellite service (EESS) described in Recommendation ITU-R M.1653.

TABLE 2
NWAS parameters reference

Parameter	Symbol	Value and unit		Reference
		Outdoor	Indoor	
Centre frequency of operation	f	5 000 MHz	5 000 MHz	
Antenna height above ground	H_N	10 m	30 m	⁽¹⁾
Maximum antenna gain	G_{NWAS}	0 dBi	0 dBi	⁽²⁾
Antenna radiation pattern	–	Omni	Omni	
Receiver bandwidth	B_N	16 MHz	16 MHz	
Minimum receive level	P_{rminN}	–85 dBm	–68 dBm	
Transmitter e.i.r.p.	P_{tN}	30 dBm	20 dBm ⁽³⁾	
Active ratio (worst case)	–	100 % ⁽⁴⁾	5 % or less	

⁽¹⁾ The height of the NWAS base station antenna.

⁽²⁾ Recommendation ITU-R M.1653.

⁽³⁾ Transmitter power control effect (3 dB) is considered.

⁽⁴⁾ Total effect of a base station and terminals operating within its coverage is considered.

In the case that NWA is operated in the outdoor environment, each base station forming a service coverage with a radius of about 100 m. Within this coverage, several or more nomadic wireless access (NWA) terminals are operating. If all the antennas (of a base station and the terminals) are designed in the omni-type, the total interference effect on DRRS stations located at sufficiently long distance could be approximated by that from the base station at the coverage centre, assuming that only a single transmitter is active (actually transmits a signal) at any instantaneous time. Thus the total effect of a base station and all the terminals within its coverage may lead to a worst-case active ratio of 100%. However, it requires further study whether the worst-case active ratio of 100% is appropriate.

In the case of indoor environments, for active ratio (transmit-to-silent ratio) of RLANs a value of 5% is assumed in general sharing studies. This number has been derived from a wide range of environments including in-building office networks. In this Recommendation it is assumed that one building contains a number of NWA/RLAN terminals operating in the same frequency as DRRS. The number of the terminals and their aggregate interference effect are assumed as given in Table 3.

TABLE 3
Operational condition for indoor NWA

Active ratio	5% or less
Number of the terminals operating in the same frequency as victim DRRS within one building	several tens
Aggregate effect of all the terminals	$\Delta Ag = +5$ dB
Building blockage loss	$L_B = 12$ dB ⁽¹⁾

⁽¹⁾ Recommendation ITU-R M.1454 gives a range of 7-17 dB for the low to high elevation angle satellite interference.

3.3 Interference criteria for DRRS

It is assumed that DRRS and NWA are operating in the band to which both the fixed and mobile services are allocated on a primary basis. Therefore, an interference criterion of $I/N = -10$ dB could be applied to the fixed service DRRS for the long-term interference. Therefore the maximum permissible interference level, I_{maxD} , for the DRRS is given by:

$$I_{maxD} = N_{thD} - 10 = -107.5 \quad \text{dBm} \quad (1)$$

3.4 Interference from DRRS to NWA

Interference criteria for NWA have not yet been defined in an ITU-R Recommendation. As an example, NWA based on the HiperLAN (type-2) specification has the minimum operation carrier level, P_{minN} , of -85 dBm, or -68 dBm (at 6 Mbit/s capacity or 54 Mbit/s capacity, respectively),

according to Recommendation ITU-R M.1653. In this case, the maximum permissible interference level, I_{maxN} , for NWAS is derived from required C/I of 8 dB (for BPSK), or 24 dB (for 64-QAM) as follows.

$$I_{maxN} = P_{rminN} - 8 = -93 \quad \text{dBm} \quad (\text{for outdoor system}) \quad (2a)$$

$$I_{maxN} = P_{rminN} - 24 = -92 \quad \text{dBm} \quad (\text{for indoor system}) \quad (2b)$$

In this Annex, these limits are regarded only as examples and not precisely considered.

4 Theoretical interference model

4.1 General assumptions

In the later sections the analysis is made on the following assumptions:

For interference between DRRS and outdoor NWAS:

- a) An NWAS base station is allowed to operate if it does not give interference above the specified criterion to any existing DRRS stations.
- b) Effects of NWA terminals operating within the coverage of a base station are converged to the location point of the base station, and that they are represented by the interference from the base station with high active ratio (100% for the worst case).
- c) The interference path loss between two stations (one NWAS base station and one DRRS station) follows line-of-sight (LoS) free-space condition.
- d) Effects of interference mitigation options for NWAS, e.g. transmitter power control (TPC) or DFS, are not considered.
- e) Aggregate effect of more than one NWAS base stations on a DRRS station is not taken into account. (This requires further study.)

For interference between DRRS and indoor NWAS:

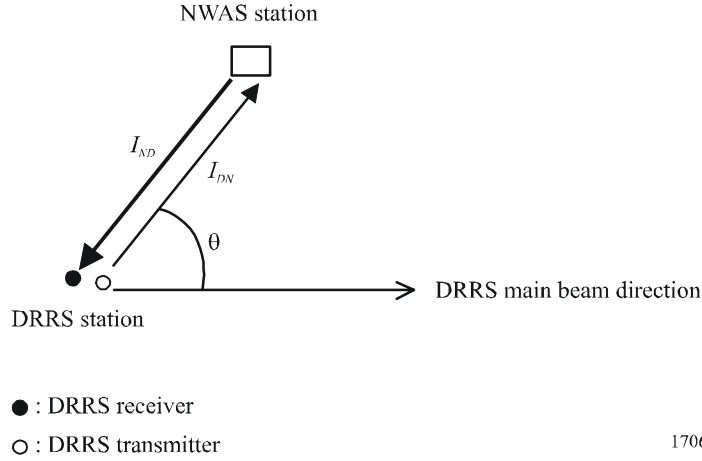
- f) NWAS deployed in one building is allowed to operate if it does not give interference above the specified criterion to any existing DRRS stations under the conditions given in Table 3.
- g) The interference path loss between two systems, other than building blockage loss in Table 3, follows LoS free-space condition.
- h) Effect of TPC of NWAS is taken into account as the equivalent power reduction of 3 dB (i.e. 20 dBm in Table 2).
- i) Aggregate effect of more than one building containing NWAS on a DRRS station is not taken into account. (This requires further study.)

4.2 Separation distance for a single station

A basic interference model of one DRRS station and a single NWAS base station is given in Fig. 1.

FIGURE 1

Basic interference model



An NWAS base station point is considered “possible” for the NWA service coverage when the interference level of I_{ND} is smaller than the specified level I_{maxD} .

$$\text{For outdoor NWAS: } I_{ND} = P_{tN} - L_S - L_f - G_D(\theta) \quad (< I_{maxD} = -107.5 \text{ dBm}) \quad (3a)$$

$$\text{For indoor NWAS: } I_{ND} = P_{tN} - L_B + \Delta Ag - L_S - L_f - G_D(\theta) \quad (< I_{maxD} = -107.5 \text{ dBm}) \quad (3b)$$

In actual cases, the NWA service coverage may further be determined by the following conditions:

$$\text{For outdoor NWAS: } I_{DN} = P_{tD} - L_S - L_f - G_D(\theta) - \Delta B \quad (< I_{maxN} = -93 \text{ dBm}) \quad (4a)$$

$$\text{For indoor NWAS: } I_{DN} = P_{tD} - L_S - L_f - L_B - G_D(\theta) - \Delta B \quad (< I_{maxN} = -92 \text{ dBm}) \quad (4b)$$

where:

L_S : free space loss

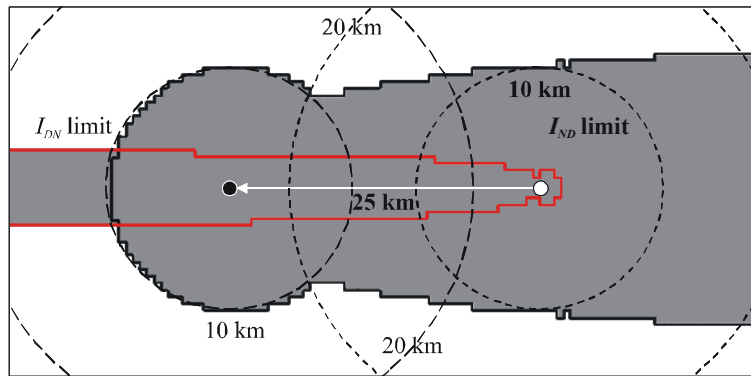
ΔB : bandwidth adjustment factor

$$10 \log (30.2/16) = 2.75 \quad \text{dB} \quad (5)$$

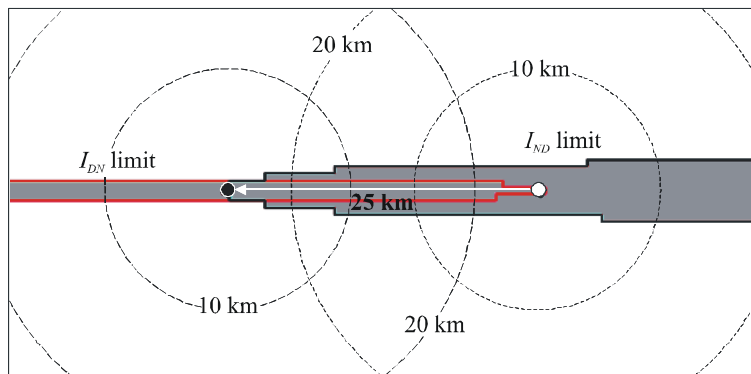
NOTE 1 – The numbers of I_{maxN} are an example only for HiperLAN Type-2.

The possible NWA service coverage can be illustrated as the area outside the shaded portion in Figs. 2a) and 2b) for a couple of DRRS stations with a certain hop distance (Fig. 2 is calculated from the parameters given in Tables 1, 2 and 3, and indicates the case of a 25 km hop). The necessary separation distance depends mainly on the antenna characteristics of the DRRS stations for both outdoor and indoor NWAS environments.

FIGURE 2
Possible NWA service coverage



a) Service coverage for outdoor NWAS



b) Service coverage for indoor NWAS

- : DRRS receiver
- : DRRS transmitter
- Coverage limit by I_{ND}
- Coverage limit by I_{DN}

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It should be noted that the shaded portion in which NWA service is not allowed may be limited by the LoS condition depending on the antenna heights of both stations. This LoS limit is about 50 km according to the parameters in Tables 1 and 2.

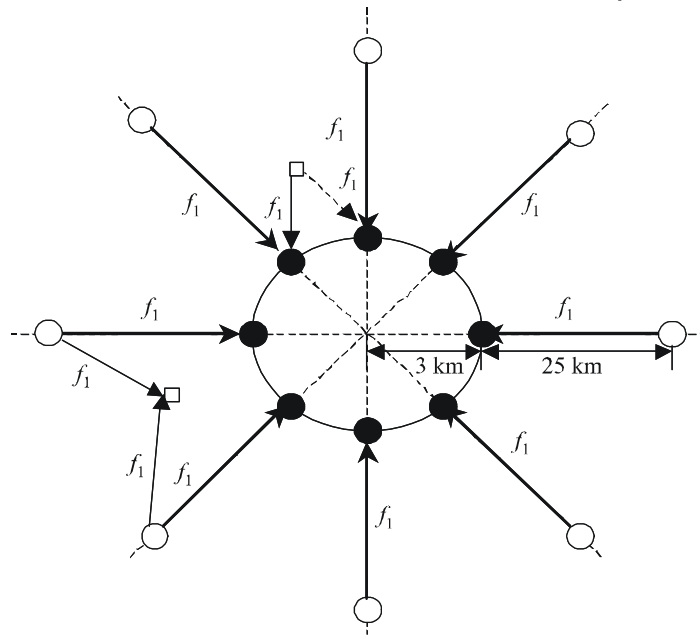
4.3 Composite DRRS link models around urban cities

The possible NWA service coverage given in Fig. 2 may work as a baseline for the sharing study. However, it is desirable to provide other analytical results based on more practical models.

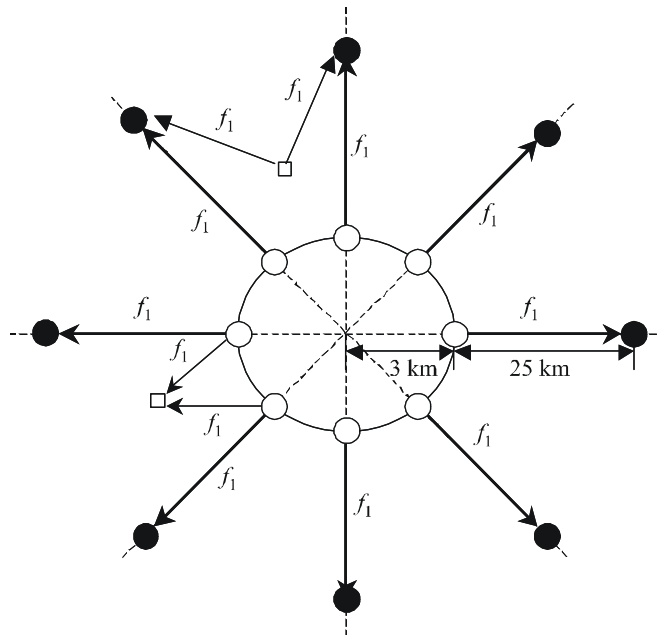
Usually, many DRRS links are geographically converged around urban cities. In the model given in Fig. 3, n DRRS stations are located near the city centre, with an equal separation, in a circular deployment with a radius of 3 km (Fig. 3 illustrates the examples of $n = 8$).

FIGURE 3

Theoretical DRRS link model around an urban city



a) Pattern A



b) Pattern B

- DRRS transmitter
- DRRS receiver
- NWS base station

For such a composite link model there are two frequency use patterns as shown in Figs. 3a) and 3b). In Pattern A, the same frequency is used by NWA stations (in TDD mode) and the receivers at DRRS stations near the city centre. On the other hand, in Pattern B, the transmitters at these DRRS stations share the same frequency as NWA stations.

Utilizing the parameters in Tables 1 to 3 as well as equations (3a) and (3b), calculations of I_{ND} have been conducted for both indoor and outdoor NWA deployed at a large number of points around the cities based on the models in Table 4.

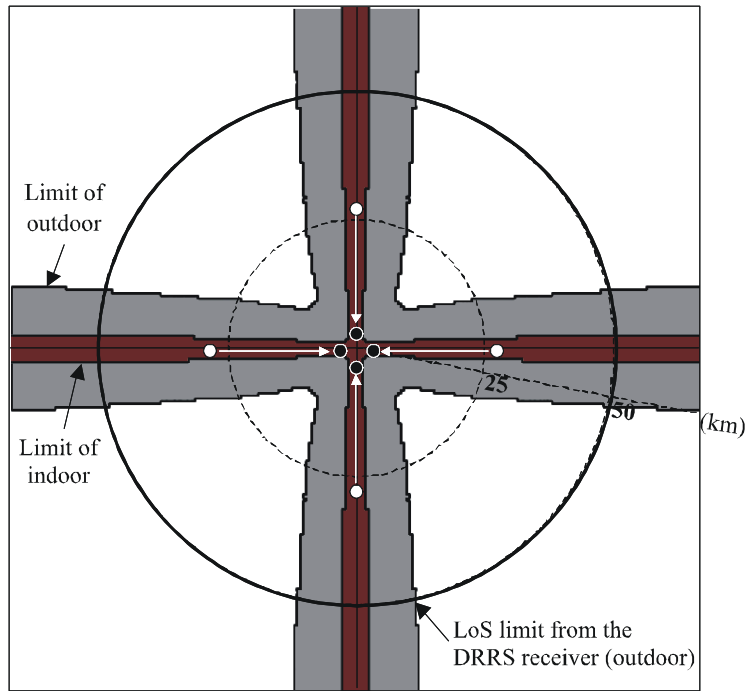
TABLE 4
Calculation model for composite DRRS links

<i>n</i> (number of DRRS stations deployed around the city)	Frequency use pattern (in Fig. 3)	Result of the calculation
4	Pattern A	Figure 4a)
	Pattern B	Figure 4b)
8	Pattern A	Figure 5a)
	Pattern B	Figure 5b)
12	Pattern A	Figure 6a)
	Pattern B	Figure 6b)

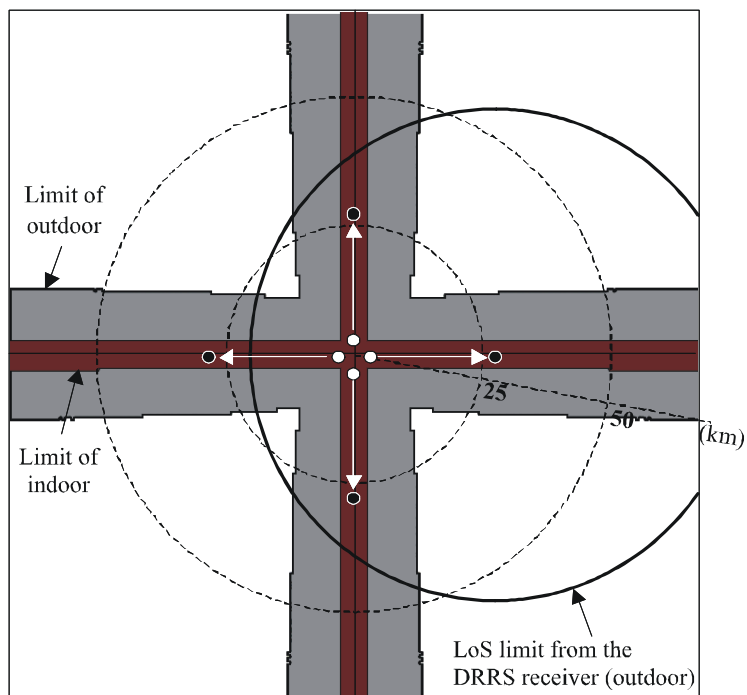
Assuming from Figs. 2a) and 2 b) that the possible area for NWA service is decided by I_{ND} , i.e. the interference from NWA to DRRS, in all the cases, Figs. 4 to 6 only illustrates I_{ND} limits for indoor and outdoor NWA applications. It should be noted that the LoS limit of the models ($H_D = 70$ m, $H_N = 10$ m for outdoor NWA) is 47.5 km (under the equivalent Earth radius $K = 4/3$), and that the “prohibited” area for outdoor NWA would be limited by this condition. The possible area is slightly wider in the Pattern A compared to the Pattern B. The frequency use of Pattern B imposes more restrictive condition to the NWA deployment.

FIGURE 4

Possible NWA service coverage for theoretical model ($n = 4$)



a) Pattern A (4 stations)

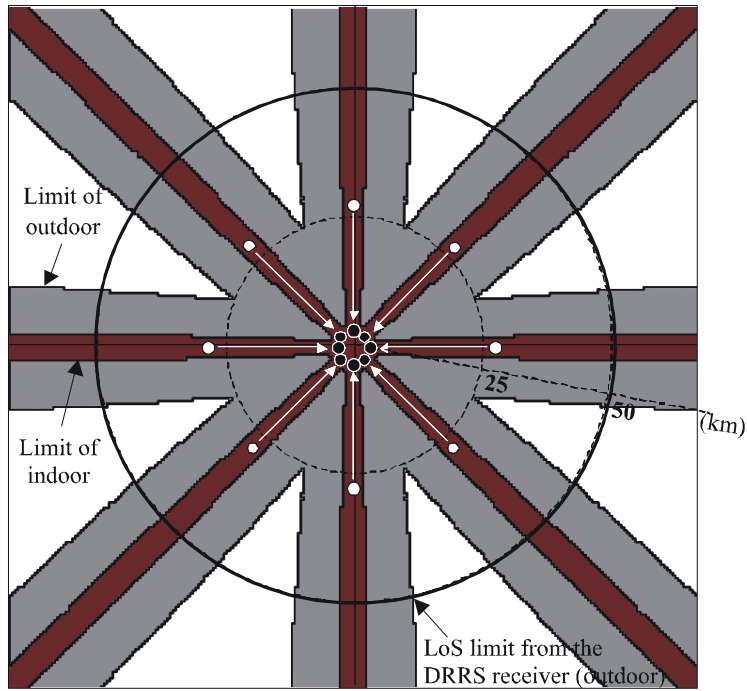


b) Pattern B (4 stations)

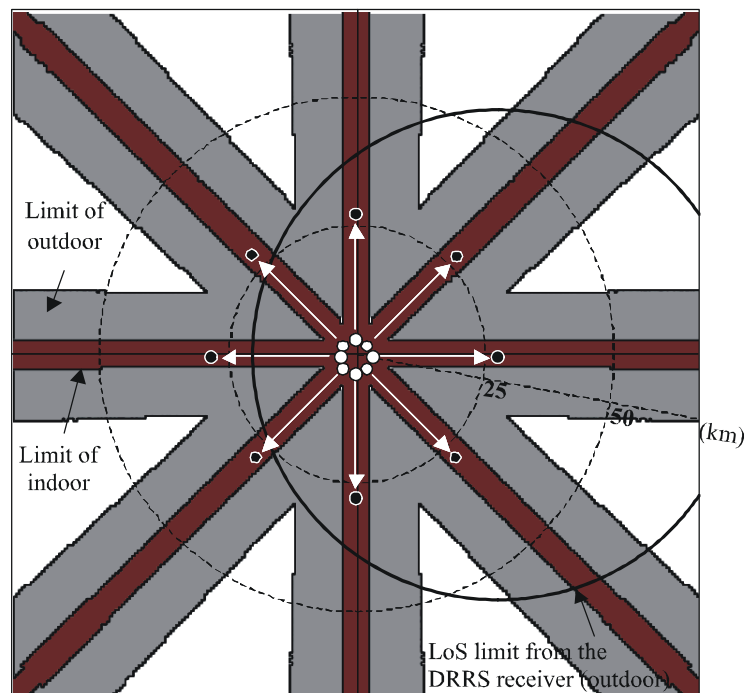
Area where NWA service is not allowed

FIGURE 5

Possible NWA service coverage for theoretical model ($n = 8$)



a) Pattern A (8 stations)

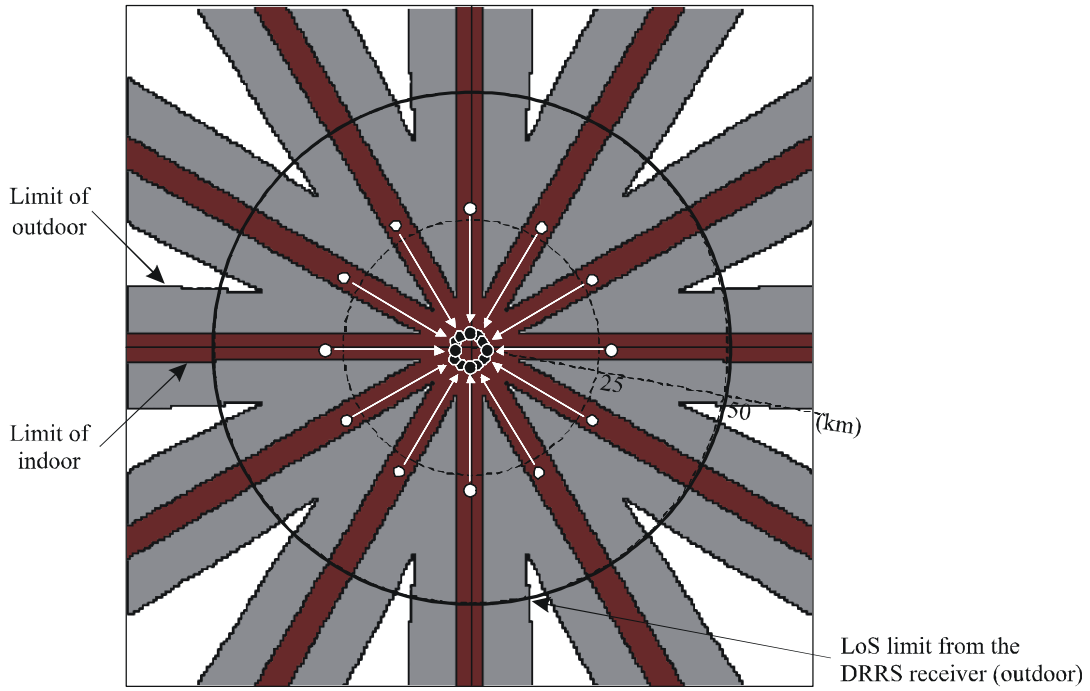


b) Pattern B (8 stations)

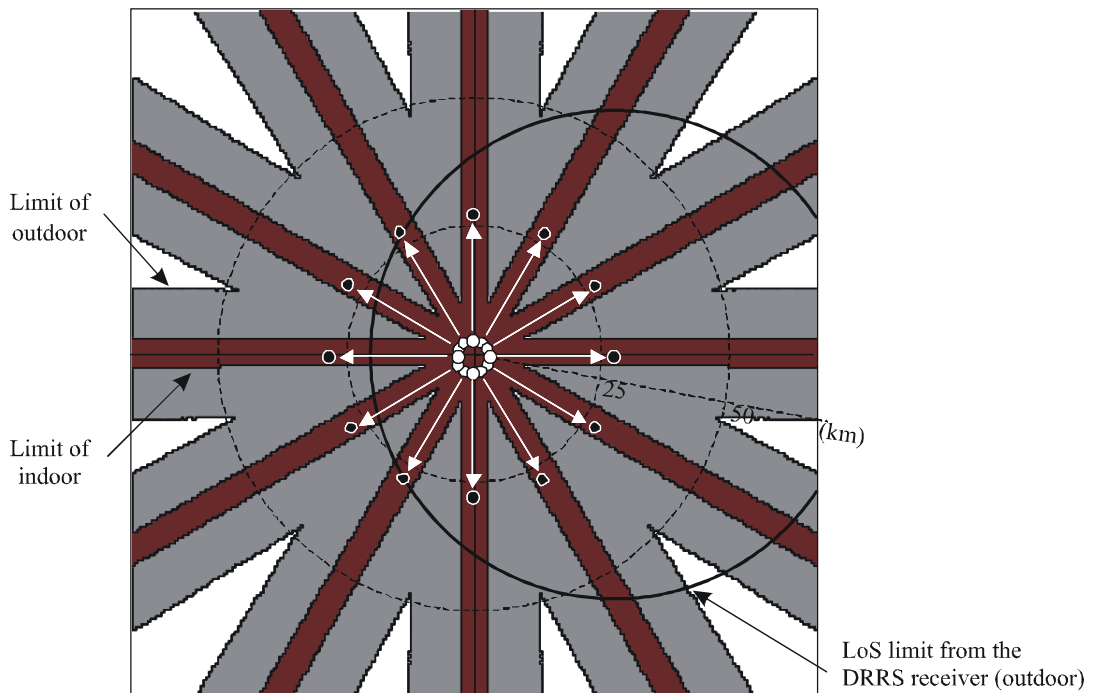
Area where NWA service is not allowed

FIGURE 6

Possible NWA service coverage for theoretical model ($n = 12$)



a) Pattern A (12 stations)



b) Pattern B (12 stations)

Area where NWA service is not allowed

5 Simulation based on the practical city models

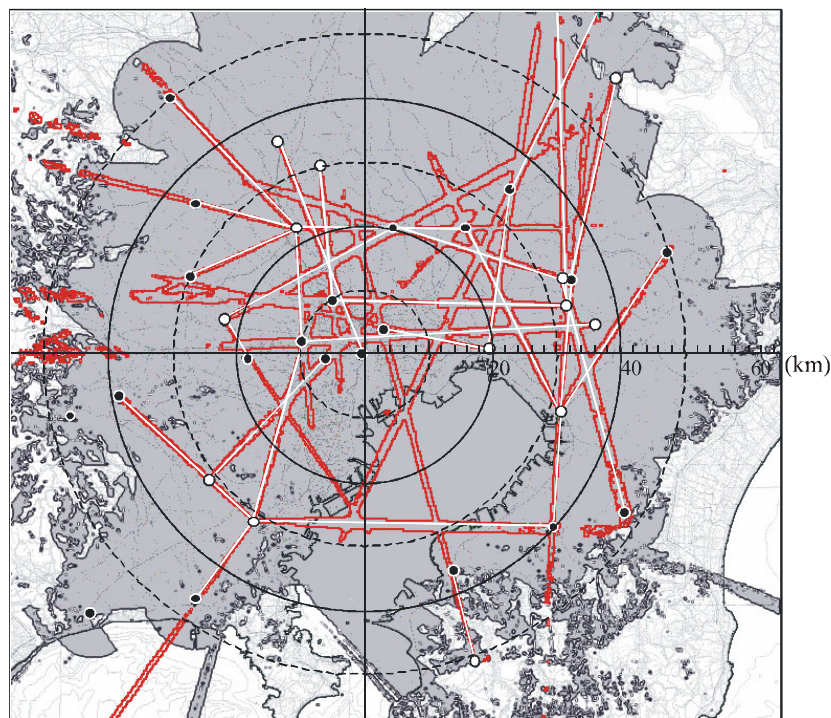
The methodology given in § 4 can be applied to existing DRRS networks deployed in actual cities. The simulation is made for three cities in Japan, where the DRRS links have such deployment parameters as shown in Table 5.

TABLE 5
Calculation model of actual city environments

City	Number of DRRS stations around the city	Number of DRRS links deployed around the city	Frequency use pattern (Fig. 3)	Result of the calculation
Tokyo	5	15	Pattern A	Figure 7
Osaka	4	13	Pattern B	Figure 8
Nagano	3	6	Pattern A	Figure 9

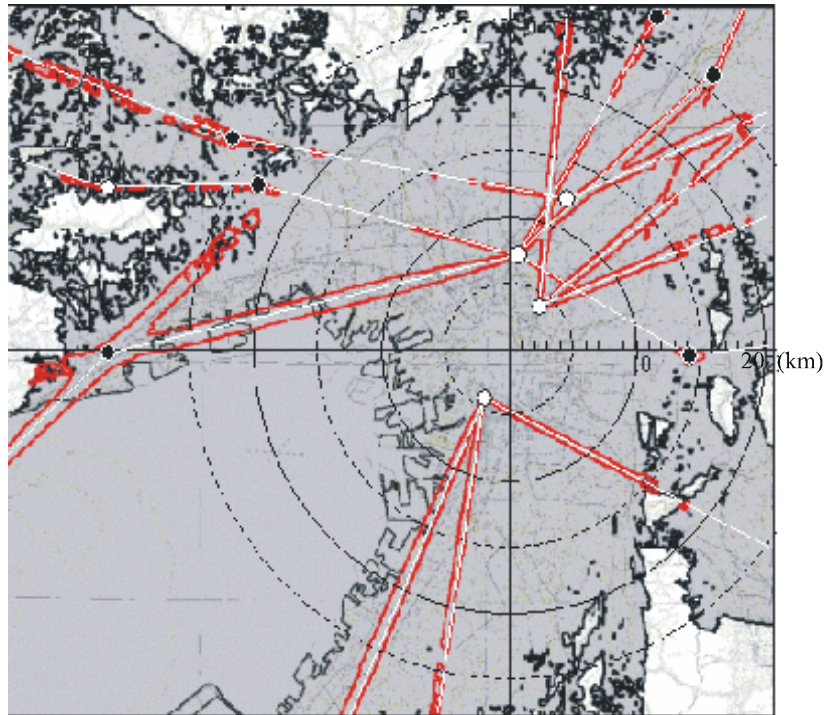
In addition to the assumptions in § 4.1, interference shielding or reducing effects due to natural geographical environments are taken into account in this simulation, while the effects of artificial objects (e.g. buildings) are not considered.

FIGURE 7
Possible outdoor NWA service coverage (Tokyo)



 Area where NWA service is not allowed

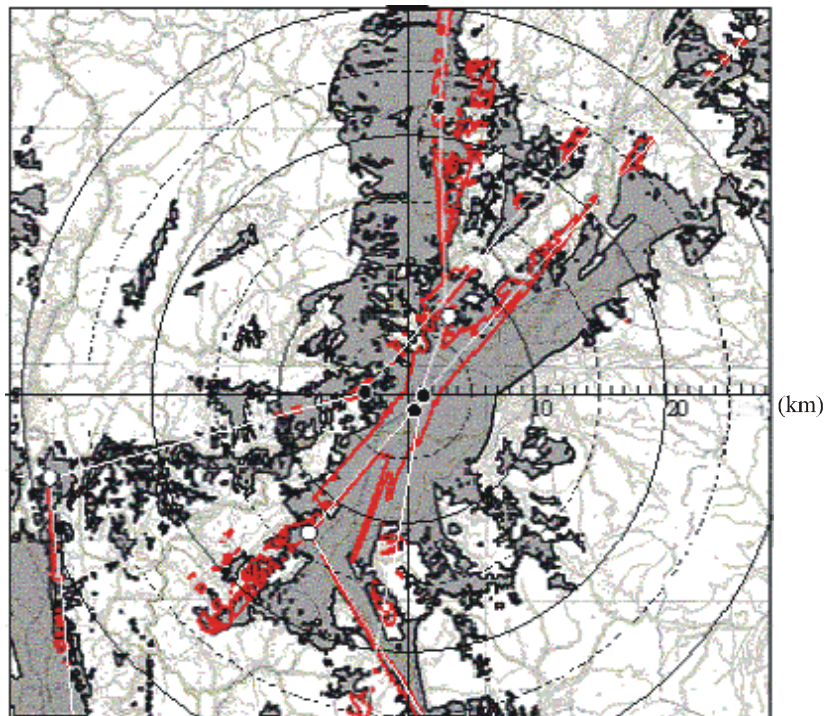
FIGURE 8
Possible outdoor NWA service coverage (Osaka)



Area where NWA service is not allowed

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FIGURE 9
Possible outdoor NWA service coverage (Nagano)



Area where NWA service is not allowed

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6 Conclusion

With regard to the simulation results in this Annex, they were directed to protect FWS from NWAS between borders. The following observations may be reached:

- Around urban cities where only a few DRRS links are converged, it may be possible to deploy NWAS in the area with a separation distance of about 10 km (for indoor NWAS) to 20 km (for outdoor NWAS) from the city centre.
- Around urban cities where several or more DRRS links are converged, it may be difficult to deploy NWAS unless a separation distance between both systems is longer than the Los limit (around 40-50 km from the city centre).

Items for further study include the following:

- effect of aggregate interference to a DRRS station from more than one NWAS stations using the same radio channel;
 - interference shielding effect of artificial objects (e.g. buildings) in the urban environments;
 - more detailed analysis including effect of transmit-to-silent ratio for NWAS terminals.
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