



Report ITU-R BT.2383-4
(03/2022)

Typical frequency sharing characteristics for digital terrestrial television broadcasting systems in the frequency band 470-862 MHz

BT Series
Broadcasting service
(television)



Documents
Document Sharing Hub

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at <http://www.itu.int/publ/R-REP/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management

***Note:** This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2022

© ITU 2022

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

REPORT ITU-R BT.2383-4

**Typical frequency sharing characteristics for digital terrestrial television
broadcasting systems in the frequency band 470-862 MHz**

(2015-2016-2019-2021-2022)

TABLE OF CONTENTS

	<i>Page</i>
1 Introduction	2
2 Broadcasting coverage area and service area planning	3
3 Definition of reception location probability	3
4 Broadcasting protection criteria.....	3
5 Quality of service requirements.....	4
6 Assessment of interference impact on the broadcast coverage	4
6.1 Introduction.....	4
6.2 Standard Broadcast Planning Practise	4
7 DVB-T and DVB-T2 reference broadcasting networks	6
7.1 Single transmitter case (assignments).....	6
7.2 Out of band mask.....	8
7.3 Single frequency networks (Allotments) ^(GE06)	8
8 ATSC Reference broadcasting networks.....	12
8.1 DTTB System A (ATSC) or ATSC 3.0 single transmitter	13
9 ISDB-T reference broadcasting networks	14
9.1 DTTB System C (ISDB-T) single transmitter	14
9.2 Vertical radiation pattern	14
10 DTMB Reference broadcasting networks	16
10.1 Single transmitter case (Assignments).....	16
11 DTTB reception modes	17
11.1 Fixed DTTB reception.....	17

	<i>Page</i>
11.2 Portable DTTB reception ^(GE06)	20
11.3 Mobile DTTB reception.....	22
11.4 Reference planning configurations for DVB-T and DVB-T2 ^(GE06)	24
11.5 Interpolation of reference field strength values ^(GE06)	24
12 System parameters for DTTB Systems	24
12.1 System parameters related to DVB-T (8 MHz)	24
12.2 System parameters related to DVB-T2 (8 MHz)	25
12.3 System parameters related to ATSC 1.0 and ATSC 3.0 (both 6 MHz)	26
12.4 System parameters and protection requirements related to ISDB-T (6 MHz/8 MHz)	27
12.5 System parameters and protection requirements related to DTMB (8 MHz).....	28
12.6 Correction of protection ratio figures for different ACLR values	29
13 Propagation considerations.....	29
14 Aggregation of interference.....	30
15 Comparative evaluations	30
16 Inclusion of noise in interference assessments	30
Annex 1 – List of relevant ITU-R texts	31
Annex 2 – DTTB link budgets.....	33
A2.1 DVB-T	33
A2.2 DVB-T2	36
A2.3 ISDB-T.....	39
A2.4 ATSC 3.0	40

1 Introduction

This Report contains a summary of the frequency sharing characteristics for digital terrestrial television broadcasting (DTTB) broadcast systems, operating in the frequency range 470-862 MHz, required for relevant compatibility studies¹.

¹ Characteristics of Band III broadcast systems can be found in Report ITU-R BT.2469 – Typical frequency sharing characteristics of digital terrestrial broadcasting systems in the frequency band 174-230 MHz.

In many places in this Report, material was extracted from the Final Acts of the RRC 2006 in Geneva. For these cases, the following symbol is added to illustrate the reference: ^(GE06)

Quotes from existing text in ITU-R are highlighted though the use of *Italics*.

It should be noted that for Band I, II, III, IV and V systems broadcasters quote antenna gains and effective radiated power (ERP) relative to a dipole. So, for example, a DTT receiving antenna with a quoted gain of 7 dB has a gain of 9.15 dBi when referenced to an isotropic source. Also, a broadcast station with a quoted ERP of 200 kW (53 dBW) has an e.i.r.p. of 85.15 dBm.

2 Broadcasting coverage area and service area planning

Recommendation ITU-R V.573-5 No. A51b defines “*coverage area*” as the “*area associated with a transmitting station for a given service and a specified frequency within which, under specified technical conditions, radiocommunications may be established with one or several receiving stations*”.

Note 4 of No. A51b explains that “*the term ‘service area’ should have the same technical basis as for ‘coverage area’, but also include administrative aspects*”.

Reference to the administrative aspects in the definition of service area is understood to mean that in that service area protection is required.

For the case of broadcast services which are usually planned with multiple overlapping transmissions from different transmitter sites, it is usual to protect only the best coverage. Furthermore, spill-over coverage into international neighbours or adjacent regions of a country do not usually form part of the intended service area and may not require protection.

3 Definition of reception location probability

Reception location probability is defined in Report ITU-R BT.2265-2, § 2 as “the percentage of locations within a small area, referred in this document as “pixel”², where the wanted signal is high enough to overcome noise and interference for a given percentage of time taking into account the temporal and spatial statistical variations of the relevant fields.”

In digital terrestrial broadcasting the coverage area is defined in Report ITU-R BT.2265-2 Annex 2 as “the area that comprises all pixels, where a given reference reception location probability (e.g. 95%) is reached or exceeded for a predetermined percentage of the time.”

4 Broadcasting protection criteria

Broadcasting protection criteria are based on local interference considerations such as reception location probability, degradation to reception location probability in the presence of additional interference, *I/N* limitation and degradation to *C/N*.

Details about the protection requirements for the broadcasting service can be found in particular in Recommendation ITU-R BT.1895 – Protection criteria for terrestrial broadcasting systems, and Report ITU-R BT.2265 – Guidelines for the assessment of interference into the broadcasting service. Further references are listed in Annex 1.

² Pixel is a small area of typically about 100 m × 100 m where the percentage of covered receiving locations is indicated.

5 Quality of service requirements

Planning of terrestrial television broadcasting services is required by many administrations to cover a high percentage of the population/households (e.g. 98%) or geographic regions (e.g. the entire country), in accordance with statutory requirements or commercial agreements, with all reception in the area defined by this coverage requirement essentially stipulated for continuous use to a specified time availability, within the hours of transmission. This coverage requirement (as distinct from the coverage area of the broadcast transmission) applies within the service area that is licenced and to be protected.

Within the broadcast service area, interference effects can be assessed in many ways, but the overriding issue is how they may translate in terms of reducing the capacity to meet the coverage requirement of the broadcasting service. A reduction in capacity to meet the coverage requirement effectively translates to a loss of access to broadcast receiving stations at the specified time availability. Broadcast service planning methods are based on meeting a prescribed coverage requirement.

Specifically, the broadcast service delivery to the target population within the broadcast service area has been based on the expectation of a signal quality with minimum interruption³.

6 Assessment of interference impact on the broadcast coverage

6.1 Introduction

In order to assess the impact of interference into broadcast networks, it is necessary to apply the broadcast planning criteria with the new level of interference and compare the relative change in quality-of-service requirement before and after the introduction of the new source of interference. The issues that arise from the combination of this process and sharing studies are highlighted in § 6.2.

6.2 Standard Broadcast Planning Practise

Planning of the digital terrestrial television broadcasting service is based on specified parameters and requirements and providing a service that is quasi-error-free (QEF). These form the basis for the protection of the existing digital terrestrial broadcast networks.

A Quasi Error Free (QEF) condition of a digital television broadcasting signal means less than one uncorrected error event per hour and a corresponding BER can be calculated for an assumed transmission bit rate. For example, for a DTTB transmission with a bit rate of about 28 Mbit/s, QEF corresponds to BER less than 10^{-11} after the whole error correction process.

In the case of DVB-T, ATSC 1.0 and ISDB-T, this corresponds to BER less than 2×10^{-4} after Viterbi decoder or BER less than 10^{-11} after Reed-Solomon decoder.

In the case of DVB-T2, ATSC 3.0, DTMB and DTMB-A, this corresponds to BER less than 10^{-7} before BCH decoder or BER less than 10^{-11} after BCH decoder.⁴

Any study of interference into a DTTB system must take account of QEF and the hour time window. Information on the use of Monte Carlo simulation to model interference to DTTB and application of a time window can be found in Recommendation ITU-R BT.2136 and Report ITU-R BT.2470.

For planning terrestrial television broadcasting services, it is important to take into consideration the different elements of interference and the implications of temporal variations to separately identify

³ Refer to Recommendations ITU-R BT.500 and ITU-R BT.1735.

⁴ For ATSC 3.0, this is achieved using 256-QAM Non-Uniform Constellation and rate 10/15 64K-LDPC

when interference into the broadcast service arises from protection ratio failure and blocking due to overloading.

Spectrum planners are aware that a relaxation in the value or exclusion of certain interference assessment factors would reduce the ability to meet the television broadcast coverage quality requirement. A relaxation of more than one of these parameters could result in a significant cumulative reduction in the extent to which a service area can be covered.

In the simple conceptual example below of planning the broadcasting service, it is assumed that the area covered by the broadcast transmission is circular and that up to four of the above interference assessment factors have been relaxed. Each reduction in the level of protection afforded by one of the broadcast interference assessment factors is represented by a ring identifying the potential percentage of the existing population or country that can no longer be reached under the television broadcast coverage requirement, as a result of interference arising from the relaxation in the interference assessment factor(s).

A simplification of the spectrum planning process⁵ is provided for illustrative purposes in the diagram below. A service area with an existing broadcast provision that has been planned in accordance with the broadcast planning criteria and meets or exceeds the prescribed coverage requirement is represented in Fig. 1A by the dotted circle. That part of the service area in Fig. 1A, where the planned broadcast coverage has been reduced or lost due to the level of the interfering signal arising from the relaxation in one of the interference assessment factor(s) is shown in Fig. 1B.

In Fig. 1C the relaxation of multiple (in this case 4) interference assessment factors is aggregated to show the consequential impact on the planned broadcast service area, with the dotted area the only part of the planned broadcast service area in Fig. 1A, that remains covered by the planned broadcast transmission parameters. Not only is the effective broadcast service area significantly reduced but the target population within the planned service area is no longer served.

FIGURE 1A
Original area covered

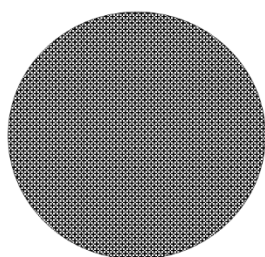


FIGURE 1B
Reduction in area covered
(relaxation of one factor)

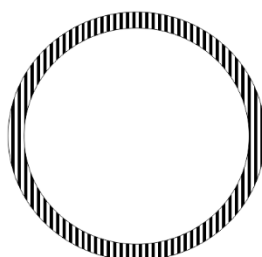
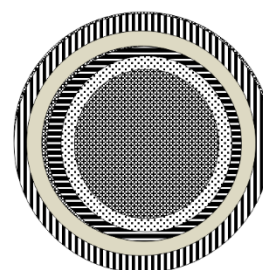


FIGURE 1C
Resulting area covered
(relaxation of four factors)



Report BT.2383-01

In practise, a television broadcast service area is unlikely to be circular and the population lost to broadcast coverage will not be located in convenient rings around the edge of that service area. Both areas will be influenced by topographical factors, population distribution and the respective locations of the wanted and interfering transmitters.

⁵ Refer to Report ITU-R BT.2248.

Transmissions in adjacent bands/channels may also cause interference. Recommendations ITU-R BT.1368 and ITU-R BT.2033 as well as Reports ITU-R BT.2215 and ITU-R BT.2248 contain additional information on this case.

7 DVB-T and DVB-T2 reference broadcasting networks

Reference broadcast transmitter configurations are provided that are representative of actual deployments in the case of assignments or are the reference configurations used in the GE06 Agreement for allotment planning.

7.1 Single transmitter case (assignments)

- High power
 - ERP: 200 kW
 - Effective antenna height: 300 m
 - Antenna height a.g.l.: 200 m
 - Antenna pattern:
 - Horizontal: Omnidirectional
 - Vertical antenna aperture: based on 24λ aperture with 1° beam tilt
- Medium power
 - ERP: 5 kW
 - Effective antenna height: 150 m
 - Antenna height a.g.l.: 75 m
 - Antenna pattern:
 - Horizontal: Omnidirectional
 - Vertical: based on 16λ aperture with 1.6° beam tilt
- Low power
 - ERP: 250 W
 - Effective antenna height: 75 m
 - Antenna height a.g.l.: 30 m
 - Antenna pattern:
 - Horizontal: Directional (cardioid)
 - Vertical: based on 4λ aperture with 3° beam tilt

The attenuation (A_θ) of the horizontal radiation pattern with azimuth angle (θ) is given by:

$$A_\theta = 20 \log_{10}(2B - B^2) \text{ dB}$$

where:

$$B = \frac{1 + k + \cos(\theta)}{2 + k}$$

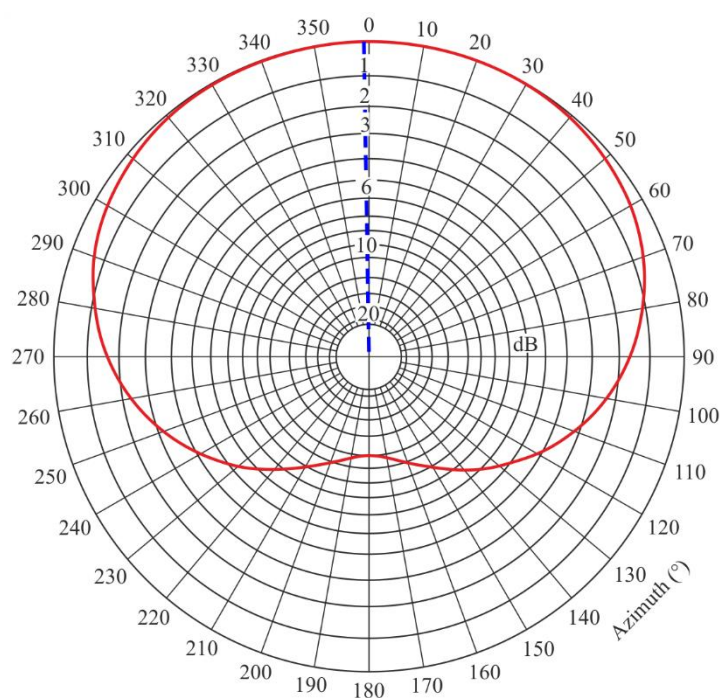
where:

θ : azimuth angle

k : 0.4187 for 10 dB pattern minima.

The resulting pattern is shown in Fig. 2:

FIGURE 2
Low power DTT



Report BT.2383-02

Unlike high and medium power antennas which are usually omnidirectional, very few low power DTT antenna are omnidirectional. Low power DTT antennas typically have a directional horizontal radiation pattern usually of a type cardioid (dipoles mounted on a pole) or consisting of one or more panel, Yagi or log-periodic elements. These antennas typically have minima in the HRP that are 10 dB or more below the maximum and may have lobes that occur at various azimuth angles, lobes typically being aligned with the desired service area.

As patterns of low power antenna vary considerably modelling all combinations of pattern in generic compatibility studies is usually not practical. Therefore, to better represent the horizontal radiation pattern of low power DTT it is proposed to base the generic model on the pattern of a cardioid antenna with a 10 dB minimum. Depending on the compatibility study being undertaken the orientation of the pattern (angle of azimuth) can be varied as required.

The overall gain of the low power DTT antenna is unchanged given that the gain of the proposed 4λ cardioid is approximately the same as that of an 8λ omnidirectional antenna. The decrease in vertical aperture of a 4λ cardioid relative to an 8λ cardioid (reduction in gain of 3 dB) is offset by the directivity of the cardioid's horizontal radiation pattern (nominal gain of 3 dB).

7.1.1 Vertical radiation patterns

The normalised field strength in the vicinity of the broadcast transmitting station is a function of the vertical radiation pattern of the transmitting antenna. The equation below is an approximation to be used for sharing studies.

$$E(\theta) = abs\left(\frac{\sin \Psi}{\Psi}\right)$$

where:

$$\Psi = \pi A \sin(\theta - \beta)$$

and

A : the antenna vertical aperture in wavelengths

β : the beam tilt radians below the horizontal.

To allow for null fill the value of $E(\theta)$ should not go below the value shown in Table 1.

TABLE 1

Null fill values to be applied to vertical radiation patterns

	Limit on $E(\theta)$
First null	0.15
Second null	0.1

For the third null and at all angles of θ beyond the third null the value of $E(\theta)$ should not fall below 0.05.

$E(\theta)$ given above are linear values, to convert them to reduction values in dB the following equation is used:

$$\text{Reduction in dB} = 20 * \log_{10}\{E(\theta)\}$$

7.2 Out of band mask

Information on transmitter spectrum masks to be used in compatibility studies is provided in Recommendation ITU-R BT.1206.

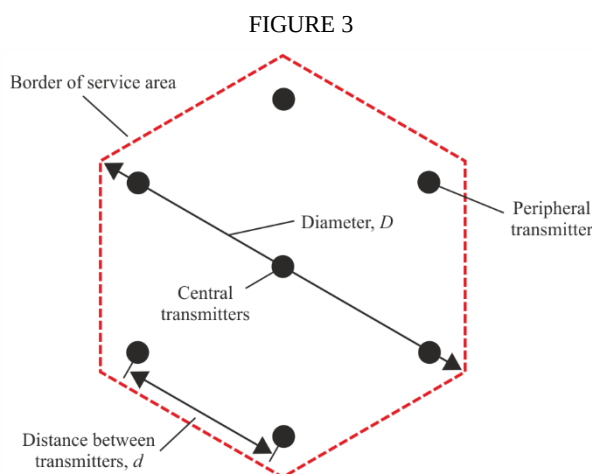
7.3 Single frequency networks (Allotments) ^(GE06)

Three reference networks (RN) for DTT services in Region 1 will be used as described in Appendix 3.6 of Chapter 3 of the GE06 Agreement. This information is reproduced in part below.

For sharing studies within the service area of an SFN the same vertical diagrams as provided in § 7.1 above should be applied for each transmitter.

7.3.1 Reference network 1 (large service-area SFN)

The network consists of seven transmitters situated at the centre and at the vertices of a hexagonal lattice. An open network type has been chosen, i.e. the transmitters have non-directional antenna patterns and the service area is assumed to exceed the transmitter hexagon by about 15%. The geometry of the network is given in Fig. 3. This reference network (RN 1) is applied to different cases: fixed (RPC 1), outdoor/mobile (RPC 2) and indoor (RPC 3) reception, for Bands IV and V. RN 1 is intended for large service area SFN coverage. It is assumed that main transmitter sites with an appropriate effective antenna height are used as a backbone for this type of network. For portable and mobile reception, the size of the real service areas for this type of SFN coverage is restricted to 150 to 200 km in diameter because of self-interference degradation, unless very rugged DVB-T system variants are used, or the concept of dense networks is employed.



Report BT.2383-03

For the guard interval length, the maximum value $1/4 T_u$ of the 8k FFT mode is assumed. The distance between transmitters in an SFN should not significantly exceed the distance equivalent to the guard interval duration. In this case, the guard interval duration is 224 μ s, which corresponds to a distance of 67 km. The distance between transmitters for RPC 1 is taken as 70 km. For RPC 2 and RPC 3, 70 km is too large a distance from a power budget point of view. Therefore, smaller values for the distance between transmitters have been selected, 50 km for RPC 2 and 40 km for RPC 3.

The parameters and the power budgets of RN 1 given in Table 2 should be used.

TABLE 2
Parameters of RN 1 (large service area SFN)

RPC and reception type		RPC 1 fixed antenna	RPC 2 portable outdoor and mobile	RPC 3 portable indoor
Type of network		Open	Open	Open
Geometry of service area		Hexagon	Hexagon	Hexagon
Number of transmitters		7	7	7
Geometry of transmitter lattice		Hexagon	Hexagon	Hexagon
Distance between transmitters d (km)		70	50	40
Service area diameter D (km)		161	115	92
Tx effective antenna height (m)		150	150	150
Tx antenna pattern		Non-directional	Non-directional	Non-directional
e.r.p.* dB(W)	Band IV/V	42.8	49.7	52.4

* The e.r.p. values indicated in this Table incorporate an additional power margin of 3 dB.

The e.r.p. is given for 650 MHz in Bands IV/V; for other frequencies (f in MHz) the frequency correction factor added is: $20 \log_{10}(f/650)$ for RPC 1 and $30 \log_{10}(f/650)$ for RPC 2 and RPC 3.

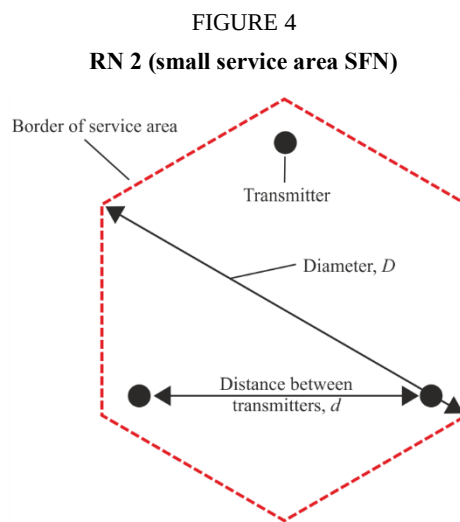
7.3.2 Reference network 2 (small service area SFN, dense SFN)

The network consists of three transmitters situated at the vertices of an equilateral triangle. An open network type has been chosen, i.e. the transmitters have non-directional antenna patterns. The service area is assumed to be hexagonal, as indicated in Fig. 4.

This reference network (RN 2) is applied to different cases: fixed (RPC 1), outdoor/mobile (RPC 2) and indoor (RPC 3) reception, for both Bands IV and V.

RN 2 is intended for small service area SFN coverage. Transmitter sites with appropriate effective antenna heights are assumed to be available for this type of network and self-interference restrictions are expected to be small. Typical service area diameters may be from 30 to 50 km.

It is also possible to cover large service areas with this kind of dense SFN. However, a very large number of transmitters is then necessary. It therefore seems reasonable to have large service areas being represented by RN 1, even if a dense network structure is envisaged.



Report BT.2383-04

In RN 2 the inter-transmitter distance is 40 km for RPC 1 and 25 km in the case of RPCs 2 and 3. The parameters and the power budgets of the RN 2 given in Table 3 should be used.

TABLE 3
Parameters of RN 2 (small service area SFN)

RPC and reception type		RPC 1 Fixed antenna	RPC 2 portable outdoor and mobile	RPC 3 portable indoor
Type of network		Open	Open	Open
Geometry of service area		Hexagon	Hexagon	Hexagon
Number of transmitters		3	3	3
Geometry of transmitter lattice		Triangle	Triangle	Triangle
Distance between transmitters d (km)		40	25	25
Service area diameter D (km)		53	33	33
Tx effective antenna height (m)		150	150	150
Tx antenna pattern		Non-directional	Non-directional	Non-directional
e.r.p.* (dBW)	Band IV/V	31.8	39.0	46.3

* The e.r.p. values indicated in this Table incorporate an additional power margin of 3 dB.

The e.r.p. is given for 650 MHz in Bands IV/V; for other frequencies (f in MHz) the frequency correction factor added is: $20 \log_{10}(f/650)$ for RPC 1 and $30 \log_{10}(f/650)$ for RPC 2 and RPC 3.

7.3.3 Reference network 3 (small service area SFN for urban environment)

The geometry of the transmitter lattice of reference network 3 (RN 3) and the service area are identical to those of RN 2. (See Fig. 4 above.)

RN 3 is applied to different cases: fixed (RPC 1), outdoor/mobile (RPC 2) and indoor (RPC 3) reception, for both Bands IV and V.

RN 3 is intended for small service area SFN coverage in an urban environment. It is identical to RN 2, apart from the fact that urban-type height loss figures are used. This increases the required power of the SFN transmitters by about 5 dB for RPC 2 and RPC 3.

The parameters and the power budgets of the RN 3 given in Table 4 should be used.

TABLE 4

Parameters of RN 3 (small service area SFN for urban environment)

RPC and reception type		RPC 1 fixed antenna	RPC 2 portable outdoor and mobile	RPC 3 portable indoor
Type of network		Open	Open	Open
Geometry of service area		Hexagon	Hexagon	Hexagon
Number of transmitters		3	3	3
Geometry of transmitter lattice		Triangle	Triangle	Triangle
Distance between transmitters d (km)		40	25	25
Service area diameter D (km)		53	33	33
Tx effective antenna height (m)		150	150	150
Tx antenna pattern		Non-directional	Non-directional	Non-directional
e.r.p.* (dBW)	Band IV/V	31.8	44.9	52.2

* The e.r.p. values indicated in this table incorporate an additional power margin of 3 dB.

The e.r.p. is given for 650 MHz in Bands IV/V; for other frequencies (f in MHz) the frequency correction factor added is: $20 \log_{10}(f/650)$ for RPC 1 and $30 \log_{10}(f/650)$ for RPC 2 and RPC 3.

8 ATSC Reference broadcasting networks

Reference broadcast transmitter configurations are provided that are representative of actual deployments of DTTB System A (ATSC) or ATSC 3.0⁶ in the cases of the assignments or the reference configurations used for allotment planning.⁷ The configurations depend on both the ‘system-independent’ planning factors and the ‘system dependent’ planning factors, that were used in regulatory allotments by those countries adopting the system. Included are such factors as the maximum power permitted in a 6 MHz channel, the maximum height (HAAT) at which that power level can be used, threshold signal levels for reception in the several television broadcast frequency bands, and so forth. There is only a single operating point with respect to the required signal-to-noise ratio for the threshold of reception at a specific bitrate.

Countries adopting DTTB System A or ATSC 3.0 should use the broadcast transmitter configurations and planning factors provided here.

⁶ DTTB System A, also known as “ATSC 1.0,” is defined in Recommendation ITU-R BT.1306-8. ATSC 3.0 is defined in Recommendation ITU-R BT.1877-3.

⁷ Values were derived from the Consolidated Data Base System (CDBS) of the U.S. Federal Communications Commission (FCC). This system was the predecessor to the Licensing and Management System (LMS) of the FCC currently in use and available at: <https://enterpriseefiling.fcc.gov/dataentry/login.html>