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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
Parameters for IMT studies on 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5 GHz
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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

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3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

should indicates a recommendation to do something

should not indicates a recommendation not to do something

may indicates permission to do something

need not indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can indicates that something is possible

cannot indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

will indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document is a technical report for the study item on IMT parameters for 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5GHz [2], covering the study on transmitter and receiver characteristics for both NR BS and NR UE, and related parameters for answering requests from ITU-R WP5D.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-200513: "Study on IMT parameters for 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5GHz".

[3] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[4] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[5] 3GPP TR 38.820, “NR; 7-24 GHz frequency range”

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

N_{RB} Transmission bandwidth configuration, expressed in resource blocks

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AAS	Active Antenna System
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
AWGN	Additive White Gaussian Noise
BS	Base Station
BW	Bandwidth
FDD	Frequency Division Duplex
FR	Frequency Range
FRC	Fixed Reference Channel
ITU-R	Radiocommunication Sector of the International Telecommunication Union
LA	Local Area
MR	Medium Range
NR	New Radio
OTA	Over The Air
RB	Resource Block
RF	Radio Frequency
SCS	Sub-Carrier Spacing
TDD	Time division Duplex
WA	Wide Area

4 Co-existence study

4.1 Co-existence simulation scenarios

Table 4.1 summarizes the proposed scenarios to be considered for 6.425-7.125GHz and 10.0-10.5 GHz.

Table 4-1: Summary of considered scenario

No.	Usage scenario	Aggressor	Victim	Direction	Simulation frequency	Deployment Scenario	Note
1	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	7 GHz	Urban macro	
2	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	7 GHz	Indoor hotspot	
3	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	7 GHz	Dense urban	Down-prioritized
4	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	7 GHz	Urban macro	
5	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	7 GHz	Indoor hotspot	
6	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	7 GHz	Dense urban	Down-prioritized
7	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	10 GHz	Urban macro	
8	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	10 GHz	Indoor hotspot	
9	eMBB	NR, 100MHz	NR, 100MHz	DL to DL	10 GHz	Dense urban	Down-prioritized
10	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	10 GHz	Urban macro	
11	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	10 GHz	Indoor hotspot	
12	eMBB	NR, 100MHz	NR, 100MHz	UL to UL	10 GHz	Dense urban	Down-prioritized

4.2 Co-existence simulation assumption

4.2.1 Network layout model

4.2.1.1 Urban macro

Details on urban macro network layout model are listed in Tables 4.2.1.1-1 and 4.2.1.1-2.

Table 4.2.1.1-1: Single operator layout for urban macro

Parameters		Values	Remark
Network layout		hexagonal grid, 19 macro sites, 3 sectors per site with wrap around	
Inter-site distance		0.45 km (urban) 0.9 km (suburban)	Based on cell radius: 0.3 km (urban) 0.6 km (suburban)
BS antenna height		20 m (urban) 25 m (suburban)	
UE location [6]	Outdoor/indoor	Outdoor and indoor	
	Indoor UE ratio	20%	
	Low/high Penetration loss ratio	50% low loss, 50% high loss	
	LOS/NLOS	LOS and NLOS	

	UE antenna height	Same as 3D-UMa in TR 36.873	
UE distribution (horizontal)		Uniform	
Minimum BS - UE distance (2D)		35 m	
Channel model		UMa	
Shadowing correlation		Between cells: 1.0 Between sites: 0.5	

Table 4.2.1.1-2: Multi operators layout for urban macro

Parameters	Values	Remark
Multi operators layout	coordinated operation (0% Grid Shift) and un-coordinated operation (100% Grid Shift)	RAN4 has long been using un-coordinated operation in below 6GHz coexistence simulation

Coordinated Operation: each network with co-location of sites

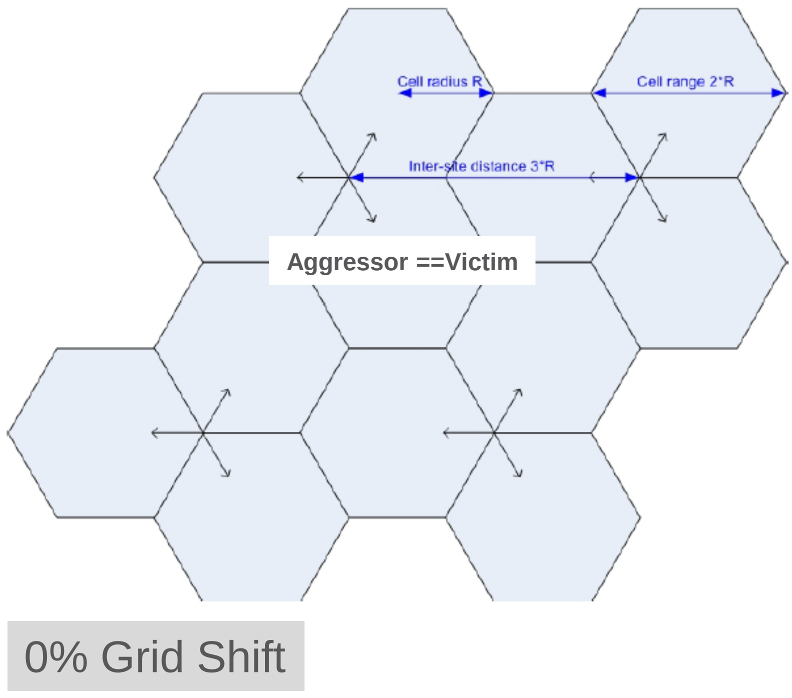


Figure 4.2.1.1-1: Coordinated operation

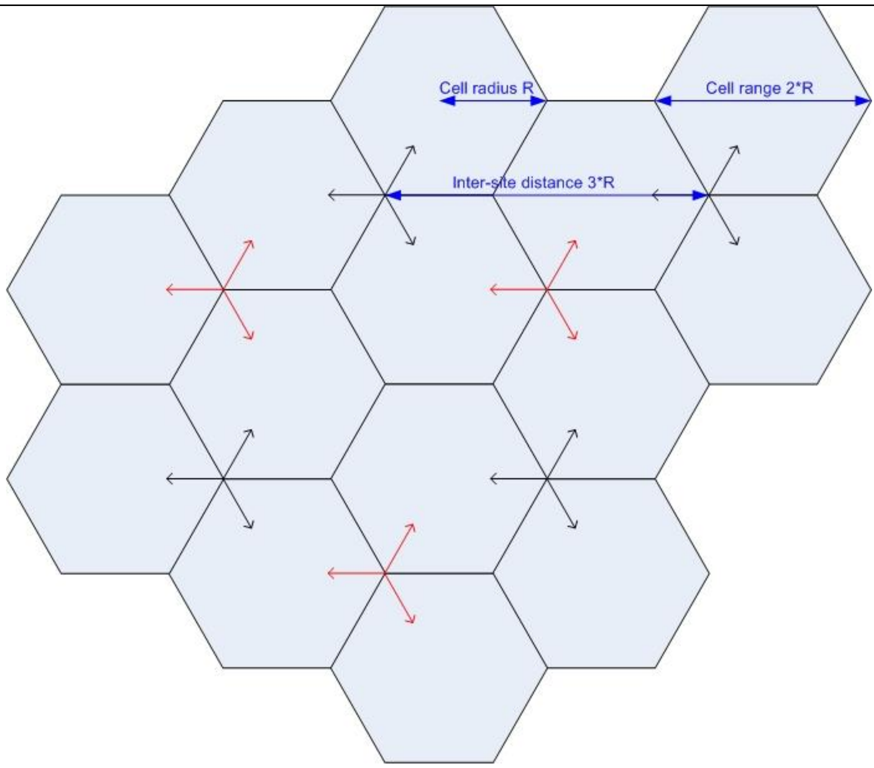
Uncoordinated Operation: second network's sites are located at the first network's cell edge	

Figure 4.2.1.1-2: Uncoordinated operation

4.2.1.2 Dense urban

It is agreed to down-prioritized the dense urban scenario in this coexistence study, because it has the least demanding ACIR requirements among the three simulated scenarios in TR 38.803.

4.2.1.3 Indoor

Details on indoor network layout model are listed in Tables 4.2.1.3-1 and 4.2.1.3-2.

Table 4.2.1.3-1: Single operator layout for indoor

Parameters		Values	Remark
Network layout		50m x 120m, 12BSs	
Inter-site distance		20m	
BS antenna height		3 m	ceiling
UE location	Outdoor/indoor	Indoor	
	LOS/NLOS	LOS and NLOS	
	UE antenna height	1 m	
UE distribution (horizontal)		Uniform	
Minimum BS - UE distance (2D)		0 m	
Channel model		Indoor Office	
Shadowing correlation		NA	

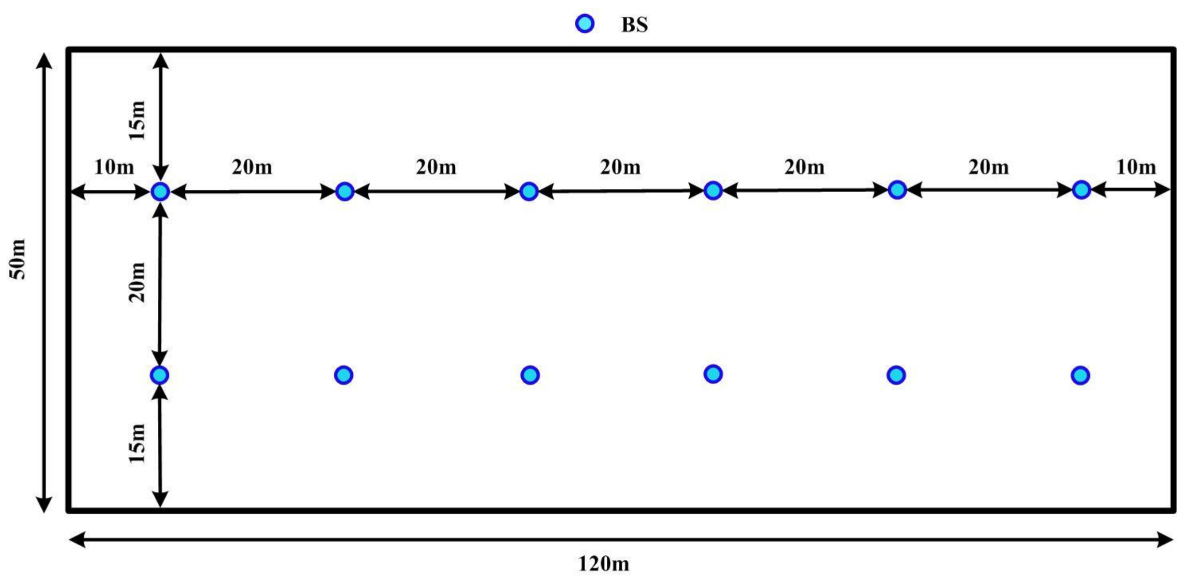


Figure 4.2.1.3-1: Network layout for indoor

Table 4.2.1.3-2: Multi operators layout for indoor

Parameters	Values	Remark
Multi operator layout	Coordinated operation (0% Grid Shift)	

4.2.2 Propagation model

4.2.2.1 Path loss

The pathloss models are summarized in Table 4.2.2.1-1 and the distance definitions are indicated in Figures 4.2.2.1-1 and 4.2.2.1-2. Note that the distribution of the shadow fading is log-normal, and its standard deviation for each scenario is given in Table 4.2.2.1-1.

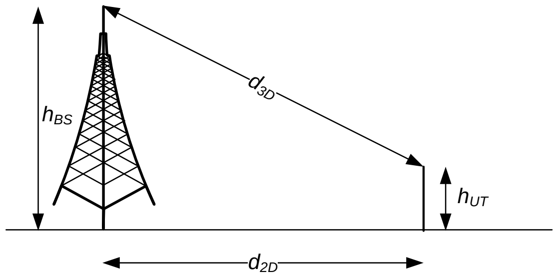


Figure 4.2.2.1-1: Definition of d_{2D} and d_{3D} for outdoor UTs

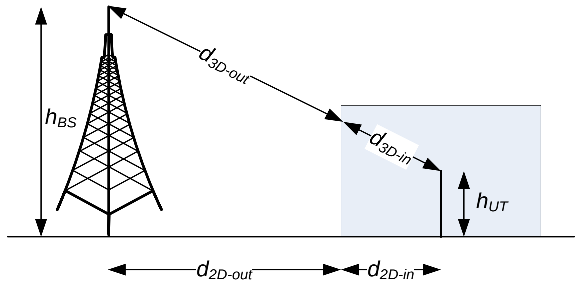


Figure 4.2.2.1-2: Definition of $d_{2D\text{-}out}$, $d_{2D\text{-}in}$ and $d_{3D\text{-}out}$, $d_{3D\text{-}in}$ for indoor UTs.

Note that

$$d_{3D-out} + d_{3D-in} = \sqrt{(d_{2D-out} + d_{2D-in})^2 + (h_{BS} - h_{UT})^2} \quad (4.2.2\text{-}1)$$

Table 4.2.2.1-1: Pathloss models

Scenario	LOS/NLOS	Pathloss [dB], f_c is in GHz and d is in meters, see note 4	Shadow fading std [dB]	Applicability range, antenna height default values
UMa	LOS	$PL_{UMa-LOS} = \begin{cases} PL_1 & 10m \le d_{2D} \le d'_{BF} \\ PL_2 & d'_{BP} \le d_{2D} \le 5\text{km} \end{cases}$, see note 1 $PL_1 = 28.0 + 22 \log_{10}(d_{3D}) + 20 \log_{10}(f_c)$ $PL_2 = 28.0 + 40 \log_{10}(d_{3D}) + 20 \log_{10}(f_c) - 9 \log_{10}((d'_{BP})^2 + (h_{BS} - h_{UT})^2)$	$\sigma_{SF} = 4$	$1.5m \le h_{UT} \le 22.5m$ $h_{BS} = 25\text{m}$
	NLOS	$PL_{UMa-NLOS} = max(PL_{UMa-LOS}, PL'_{UMa-NLOS})$ for $10m \le d_{2D} \le 5\text{km}$ $PL'_{UMa-NLOS} = 13.54 + 39.08 \log_{10}(d_{3D}) + 20 \log_{10}(f_c) - 0.6(h_{UT} - 1.5)$	$\sigma_{SF} = 6$	$1.5m \le h_{UT} \le 22.5m$ $h_{BS} = 25\text{m}$ Explanations: see note 3
		Optional $PL = 32.4 + 20 \log_{10}(f_c) + 30 \log_{10}(d_{3D})$	$\sigma_{SF} = 7.8$	

InH - Office	**LOS**	$PL_{\text{InH-LOS}} = 32.4 + 17.3\log_{10}(d_{3D}) + 20\log_{10}(f_c)$	$\sigma_{SF} = 3$	$1m \le d_{3D} \le 150m$
	NLOS	$PL_{\text{InH-NLOS}} = \max(PL_{\text{InH-LOS}}, PL'_{\text{InH-NLOS}})$ $PL'_{\text{InH-NLOS}} = 38.3\log_{10}(d_{3D}) + 17.30 + 24.9\log_{10}(f_c)$	$\sigma_{SF} = 8.03$	$1m \le d_{3D} \le 150m$
		Optional $PL'_{\text{InH-NLOS}} = 32.4 + 20\log_{10}(f_c) + 31.9\log_{10}(d_{3D})$	$\sigma_{SF} = 8.29$	$1m \le d_{3D} \le 150m$

Note 1: Breakpoint distance $d'_{BP} = 4\, h'_{BS}\, h'_{UT}\, f_c/c$, where f_c is the centre frequency in Hz, $c = 3.0\times10^8$ m/s is the propagation velocity in free space, and h'_{BS} and h'_{UT} are the effective antenna heights at the BS and the UT, respectively. The effective antenna heights h'_{BS} and h'_{UT} are computed as follows: $h'_{BS} = h_{BS} - h_E$, $h'_{UT} = h_{UT} - h_E$, where h_{BS} and h_{UT} are the actual antenna heights, and h_E is the effective environment height. For UMi $h_E = 1.0$m. For UMa h_E=1m with a probability equal to $1/(1+C(d_{2D}, h_{UT}))$ and chosen from a discrete uniform distribution uniform(12,15,…,(h_{UT}-1.5)) otherwise. With $C(d_{2D}, h_{UT})$ given by

$$C(d_{2D}, h_{UT}) = \begin{cases} 0 & , h_{UT} < 13m \\ \left(\frac{h_{UT}-13}{10}\right)^{1.5} g(d_{2D}) & , 13m \le h_{UT} \le 23m \end{cases},$$

where

$$g(d_{2D}) = \begin{cases} 0 & , d_{2D} \le 18m \\ \frac{5}{4}\left(\frac{d_{2D}}{100}\right)^3 \exp\left(\frac{-d_{2D}}{150}\right) & , 18m < d_{2D} \end{cases}.$$

Note that h_E depends on d_{2D} and h_{UT} and thus needs to be independently determined for every link between BS sites and UTs. A BS site may be a single BS or multiple co-located BSs.

Note 2: The applicable frequency range of the PL formula in this table is $0.5 < f_c < f_H$ GHz, where f_H = 30 GHz for RMa and f_H = 100 GHz for all the other scenarios. It is noted that RMa pathloss model for >7 GHz is validated based on a single measurement campaign conducted at 24 GHz.

Note 3: UMa NLOS pathloss is from TR36.873 with simplified format and $PL_{\text{UMa-LOS}}$ = Pathloss of UMa LOS outdoor scenario.

Note 4: f_c denotes the center frequency normalized by 1GHz, all distance related values are normalized by 1m, unless it is stated otherwise.

4.2.2.2 LOS probability

The Line-Of-Sight (LOS) probabilities are given in Table 4.2.2.2-1.

Table 4.2.2.2-1 LOS probability

Scenario	LOS probability (distance is in meters)
UMa	$Pr_{\text{LOS}} = \begin{cases} 1 & , d_{\text{2D-out}} \leq 18m \\ \left[\frac{18}{d_{\text{2D-out}}} + exp\left(-\frac{d_{\text{2D-out}}}{63}\right)\left(1-\frac{18}{d_{\text{2D-out}}}\right)\right]\left(1 + C'(h_{\text{UT}})\frac{5}{4}\left(\frac{d_{\text{2D-out}}}{100}\right)^3 exp\left(-\frac{d_{\text{2D-out}}}{150}\right)\right) & , 18m < d_{\text{2D-out}} \end{cases}$ where $C'(h_{\text{UT}}) = \begin{cases} 0 & , h_{\text{UT}} \leq 13m \\ \left(\frac{h_{\text{UT}}-13}{10}\right)^{1.5} & , 13m < h_{\text{UT}} \leq 23m \end{cases}$
Indoor - Mixed office	$Pr_{\text{LOS}} = \begin{cases} 1 & , d_{\text{2D-in}} \leq 1.2m \\ exp\left(-\frac{d_{\text{2D-in}}-1.2}{4.7}\right) & , 1.2m < d_{\text{2D-in}} < 6.5m \\ exp\left(-\frac{d_{\text{2D-in}}-6.5}{32.6}\right)\cdot 0.32 & , 6.5m \leq d_{\text{2D-in}} \end{cases}$
Indoor - Open office	$Pr_{\text{LOS}} = \begin{cases} 1 & , d_{\text{2D-in}} \leq 5m \\ exp\left(-\frac{d_{\text{2D-in}}-5}{70.8}\right) & , 5m < d_{\text{2D-in}} \leq 49m \\ exp\left(-\frac{d_{\text{2D-in}}-49}{211.7}\right)\cdot 0.54 & , 49m < d_{\text{2D-in}} \end{cases}$
Note: The LOS probability is derived with assuming antenna heights of 3m for indoor, 10m for UMi, and 25m for UMa	

4.2.2.3 O-to-I penetration loss

4.2.2.3.1 O-to-I building penetration loss

The pathloss incorporating O2I building penetration loss is modelled as in the following:

$$\text{PL} = \text{PL}_b + \text{PL}_{\text{tw}} + \text{PL}_{\text{in}} + N(0, \sigma_P^2) \qquad (4.2.2\text{-}2)$$

where PL_b is the basic outdoor path loss given in Section 4.2.2.1, where d_{3D} is replaced by $d_{3D-\text{out}} + d_{3D-\text{in}}$. PL_{tw} is the building penetration loss through the external wall, PL_{in} is the inside loss dependent on the depth into the building, and σ_P is the standard deviation for the penetration loss.

PL_{tw} is characterized as:

$$\text{PL}_{\text{tw}} = \text{PL}_{npi} - 10\, log_{10} \sum_{i=1}^{N}\left(p_i \times 10^{\frac{L_{material\_i}}{-10}}\right) \qquad (4.2.2\text{-}3)$$

PL_{npi} is an additional loss is added to the external wall loss to account for non-perpendicular incidence;

$L_{material\ i} = a_{material\ i} + b_{material\ i} \cdot f$, is the penetration loss of material *i*, example values of which can be found in Table 4.2.2.3-1; p_i is proportion of *i*-th materials, where $\sum_{i=1}^{N} p_i = 1$; and *N* is the number of materials.

Table 4.2.2.3-1: Material penetration losses

Material	Penetration loss [dB]
Standard multi-pane glass	$L_{\text{glass}} = 2 + 0.2f$
IRR glass	$L_{\text{IIRglass}} = 23 + 0.3f$
Concrete	$L_{\text{concrete}} = 5 + 4f$
Wood	$L_{\text{wood}} = 4.85 + 0.12f$
Note: f is in GHz	

Table 4.2.2.3-2 gives PL_{tw}, PL_{in} and σ_P for two O2I penetration loss models. The O2I penetration is UT-specifically generated and is added to the SF realization in the log domain.

Table 4.2.2.3-2: O2I building penetration loss model

	Path loss through external wall: PL_{tw} in [dB]	Indoor loss: PL_{in} in [dB]	Standard deviation: σ_P in [dB]
Low-loss model	$5 - 10\log_{10}\left(0.3 \cdot 10^{\frac{-L_{\text{glass}}}{10}} + 0.7 \cdot 10^{\frac{-L_{\text{concrete}}}{10}}\right)$	$0.5\, d_{\text{2D-in}}$	4.4
High-loss model	$5 - 10\log_{10}\left(0.7 \cdot 10^{\frac{-L_{\text{IIRglass}}}{10}} + 0.3 \cdot 10^{\frac{-L_{\text{concrete}}}{10}}\right)$	$0.5\, d_{\text{2D-in}}$	6.5

$d_{\text{2D-in}}$ is minimum of two independently generated uniformly distributed variables between 0 and 25 m for UMa and UMi-Street Canyon, and between 0 and 10 m for RMa. $d_{\text{2D-in}}$ shall be UT-specifically generated.

Both low-loss and high-loss models are applicable to UMa and UMi-Street Canyon.

Only the low-loss model is applicable to RMa.

Only the high-loss model is applicable to InF.

4.2.2.3.2 O-to-I car penetration loss

The pathloss incorporating O2I car penetration loss is modelled as in the following:

$$\text{PL} = \text{PL}_b + N(\mu, \sigma_P^2) \qquad (4.2.2\text{-}4)$$

where PL_b is the basic outdoor path loss given in Section 4.2.2.1. $\mu = 9$, and $\sigma_P = 5$. The car penetration loss shall be UT-specifically generated. Optionally, for metallized car windows, $\mu = 20$ can be used. The O2I car penetration loss models are applicable for at least 0.6-60 GHz.

4.2.3 Antenna and beam forming pattern modelling

The BS antenna is modelled as described in subclause 8.1.1 using parameters for different BS deployments listed in subclause 8.1.2.

4.2.4 Transmission power control model

For downlink scenario, no power control scheme is applied.

For uplink scenario, TPC model specified in Section 9.1 TR 36.942 is applied with following parameters.

- $CL_{x\text{-ile}}$ = 88 + 10*log10(200/X) + 11 – Y, where X is UL transmission BW (MHz) and Y is the BS noise figure
- γ = 1

4.2.5 Received power model

The received power in downlink and uplink scenarios is defined as below:

RX_PWR = TX_PWR – Path loss + G_TX + G_RX

where:

RX_PWR is the received power

TX_PWR is the transmitted power

G_TX is the transmitter antenna gain (directional array gain)

G_RX is the receiver antenna gain (directional array gain).

4.2.6 ACLR and ACS modelling

For DL it seems reasonable from the perspective of simulating worst case scenarios that we assume BS ACLR is modelled as flat in space, and the UE ACS can be modelled flat in space.

If this assumption is for DL, then the similar assumption could be made for the UL because:

- UE has a much small number of antennas, thus the effect of directivity should be smaller for ACLR (or the adjacent channel interference). It can also be reasonably assumed that the UE ACLR will play a dominant role than the BS ACS in the adjacent channel interference.
- Again, BS ACS flat in space might mean worse coexistence performance than actual performance because BS has better capability of steering its receive antennas to suppress interference.

If a UE occupies a smaller bandwidth than the channel bandwidth for transmission, a two stop ACLR model could be considered in frequency to avoid overly estimating interference, as done in E-UTRA coexistence study (as recorded in TR 36.942).

Therefore, it is assumed that both ACLR (or the adjacent channel interference) and ACS are flat in both space and frequency. The ACIR model can be express as

$$ACIR = \frac{1}{\frac{1}{ACLR} + \frac{1}{\mathrm{ACS}}}$$

(assuming ACLR, ACS and ACIR to be linear).

4.2.7 Link level performance for 5G NR coexistence

The throughput of a modem with link adaptation can be approximated by an attenuated and truncated form of the Shannon bound. (The Shannon bound represents the maximum theoretical throughput than can be achieved over an AWGN channel for a given SNIR). The following equations approximate the throughput over a channel with a given SNIR, when using link adaptation:

$$Throughput\ (SNIR), bps/Hz = \begin{cases} 0 & for\ SNIR < SNIR_{MIN} \\ \propto \cdot S(SNIR) & for\ SNIR_{MIN} \le SNIR < SNIR_{MAX} \\ \propto \cdot S(SNIR_{MAX}) & for\ SNIR \ge SNIR_{MAX} \end{cases}$$

Where:

S(SNIR) Shannon bound, S(SNIR) =$\log_2$(1+SNIR) bps/Hz
α Attenuation factor, representing implementation losses

$SNIR_{MIN}$ Minimum SNIR of the code set, dB
$SNIR_{MAX}$ Maximum SNIR of the code set, dB

The parameters α, $SNIR_{MIN}$ and $SNIR_{MAX}$ can be chosen to represent different modem implementations and link conditions. The parameters proposed in Table 4.2.7-1 represent a baseline case, which assumes:

- 1:1 antenna configuration
- AWGN channel model
- Link Adaptation (see Table 4.2.7-1 for details of the highest and lowest rate codes)
- No HARQ

Table 4.2.7-1: Parameters describing baseline Link Level performance for 5G NR

Parameter	DL	UL	Notes
α, attenuation	0.6	0.4	Represents implementation losses
$SNIR_{MIN}$, dB	-10	-10	Based on QPSK, 1/8 rate (DL) & 1/5 rate (UL)
$SNIR_{MAX}$, dB	30	22	Based on 256QAM 0.93(DL) & 64QAM 0.93 (UL)

Note that the parameters proposed in Table 4.2.7-1 are targeted for eMBB coexistence scenario.

4.2.8 Other simulation parameters

Table 4.2.8-1: Other simulation parameters

Parameters	Indoor	Urban macro	Dense urban
Carrier frequency	7GHz, 10GHz	7GHz, 10GHz	Down-prioritized
Channel bandwidth	100MHz	100MHz	Down-prioritized
Scheduled channel bandwidth per UE (DL)	98.28MHz	98.28MHz	Down-prioritized
Scheduled channel bandwidth per UE (UL)	32.76MHz	32.76MHz	Down-prioritized
The number of active UE (DL) (Note 1)	1	1	Down-prioritized
The number of active UE (UL) (Note 1)	3	3	Down-prioritized
Traffic model	Full buffer	Full buffer	Down-prioritized
DL power control	NO	NO	Down-prioritized
UL power control	YES	YES	Down-prioritized
BS max TX power in dBm	24	43	Down-prioritized
UE max TX power in dBm	23 or 20 (Note 2)	23 or 20 (Note 2)	Down-prioritized
UE min TX power in dBm	-33	-33	Down-prioritized
BS Noise figure in dB	14 (@7GHz) 15 (@10GHz)	6 (@7GHz) 7 (@10GHz)	Down-prioritized
UE Noise figure in dB	9	9	Down-prioritized
Handover margin	3dB	3dB	Down-prioritized
Note 1 Same as the number of BS beam(s) Note 2: 20dBm as optional case where $CL_{x\text{-ile}}$ should be reduced by 3dB			

4.2.9 Co-existence simulation methodology

Adopt following simulation steps.

1. Aggressor and victim network are generated.
   - UEs are distributed randomly across the network.
2. UE associations: UEs are associated to base station based on coupling loss.
   - Associations are made assuming a single element at both UE and BS.

3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.
4. Throughput is computed in the victim systems without considering ACI as below:
   - $Thput_{\text{NO ACI}}[bpshz] = f(SINR_{ICI}) = f\left(\frac{S}{N+I_{ICI}}\right)$, where I_{ICI} is the inter-cell interference.
5. Throughput is computed considering ACI as below:
   - $\text{Thput}_{\text{ACI}}[\text{bpshz}] = \text{f}(\text{SINR}_{\text{ICI+ACI}}) = \text{f}\left(\frac{\text{S}}{\text{N}+\text{I}_{\text{ICI}}+\text{I}_{\text{ACI}}}\right)$, where I_{ACI} is the adjacent channel interference.
6. RF parameters are determined based on the degradation cause by ACI as below:
   - $Loss_{ACI} = 1 - \frac{\text{Thput}_{\text{ACI}}}{\text{Thput}_{\text{SINGLE}}}$.

4.3 Co-existence simulation results

5 General parameters

5.1 Duplex mode

For both frequency ranges, even if FDD is not precluded, it's most likely that TDD should be used in these frequency ranges.

5.2 Channel Bandwidth

A pragmatic, simple and non-ambiguous answers should be provided to ITU-R. While a number of channel bandwidth would be specified for these frequency ranges, 100MHz has been considered as a representative channel bandwidth that will be used.

5.3 Signal Bandwidth

The signal bandwidth for a 100MHz channel bandwidth signal is calculated based on the NR spectrum utilization for 30kHz SCS:

Signal bandwidth = NRB x SCS x 12

with N_{RB}: Number of Resource block for 100 MHz channel bandwidth and 30kHz SCS, as specified in TS 38.104 [3].

5.4 SINR operating range

The throughput of a modem with link adaptation can be approximated by an attenuated and truncated form of the Shannon bound. (The Shannon bound represents the maximum theoretical throughput than can be achieved over an AWGN channel for a given SNIR). The following equations approximate the throughput over a channel with a given SNIR, when using link adaptation:

$$Throughput\ (SNIR), bps/Hz \ = \begin{cases} 0 & for\ SNIR \\ \propto \cdot\ S(SNIR) & for\ SNIR_{MIN} \le SNIR < SNIR_{MAX} \\ \propto \cdot\ S(SNIR_{MAX}) & for\ SNIR\ \ge\ SNIR_{MAX} \end{cases}$$

Where:

S(SNIR) Shannon bound, $S(SNIR) = \log_2(1+SNIR)$ [bps/Hz]
α Attenuation factor, representing implementation losses
$SNIR_{MIN}$ Minimum SNIR of the code set, dB
$SNIR_{MAX}$ Maximum SNIR of the code set, dB

The parameters α, $SNIR_{MIN}$ and $SNIR_{MAX}$ can be chosen to represent different modem implementations and link conditions. The parameters proposed in table 5.4-1 represent a baseline case, which assumes:

- 1:1 antenna configurations
- AWGN channel model
- Link Adaptation (see table 5.4-1 for details of the highest and lowest rate codes)
- No HARQ

Table 5.4-1: Parameters describing baseline Link Level performance for 5G NR

Parameter	DL	UL	Notes
α	0.6	0.4	Represents implementation losses
$SNIR_{MIN}$, dB	-10	-10	Based on QPSK, 1/8 rate (DL) & 1/5 rate (UL)
$SNIR_{MAX}$, dB	30	22	Based on 256QAM 0.93(DL) & 64QAM 0.93 (UL)

6 BS parameters

6.1 Transmitter characteristics

6.1.1 Power dynamic range

There is no power control in downlink and fixed power per resource block is assumed in the co-existence simulation. Hence 0 dB power dynamic range was agreed for the LS reply.

6.1.2 Spectral mask

6.1.3 ACLR

6.1.4 Spurious emissions

6.1.5 Maximum output power

The maximum output power will be provided in the antenna parameter table. It was agreed to be aligned with antenna characteristics.

The Total Radiated Power for two polarizations was agreed as shown in table 6.1.5-1 below.

Parameter	Macro Sub-urban	Macro Urban	Micro Urban
Total Radiated Power for two polarizations (dBm)	46	46	37

6.1.6 Average output power

It was agreed the average output power won't be mentioned in the reply LS.

6.2 Receiver characteristics

6.2.1 Noise figure

From the TR 38.820 [5] for 7-24 GHz, the typical Noise Figure for a Wide Area BS operating at 10 GHz is 7dB (12dB for Medium Range BS and 15dB for Local Area BS).

Table 5.5.1.1-1 of TR 38.820: Typical noise figure for 7 – 24 GHz example frequencies

Example frequency (GHz)	Typical NF values for NR BS (dB)	Typical NF values for NR UE (dB)
10	7	9
15	8	10
20	9	10

For 6.425-7.125 GHz, the typical Noise Figure for a Wide Area BS operating at 6 GHz was agreed to be 6dB (11dB for Medium Range BS and 14dB for Local Area BS).

6.2.2. Sensitivity

As it is not clear if it will have a conducted sensitivity requirement for both frequency ranges, however the OTA sensitivity requirement will be needed either way and will be based on the NF and the antenna gain:

$$EIS_{REFSENS} = P_{kT} + 10 * log_{10}(BW) + NF + IM + SNR - G \quad (dBm)$$

Where: BW is the configured bandwidth of the FRC, NF is the noise figure, IM is implementation margin not related to antenna array, SNR is the required SNR to reach 95% throughput and G is the antenna gain including RF losses and 3dB off peak margin.

However, the sensitivity is not a critical parameter for sharing and compatibility studies. It was agreed to not mention any value for this parameter.

6.2.3 Blocking response

6.2.4 ACS

7 UE parameters

7.1 Transmitter characteristics

7.2 Receiver characteristics

8 Antenna characteristics

8.1 BS antenna characteristics

8.1.1 Array antenna model

In Table 8.1.1-1, the parameters used by the parameterized array antenna model are described.

Table 8.1.1-1: Parameters of the parameterized array antenna model

Parameter	Symbol	Unit
Front to back ratio	A_m	dB
Side lobe suppression	SLA_v	dB
Horizontal HPBW	φ_{3dB}	Degrees
Vertical HPBW	θ_{3dB}	Degrees
Array element peak gain	$G_{E,max}$	dBi
Number of radiating elements rows and columns	(M, N)	Integer
Horizontal element separation	d_h	m
Vertical element separation	d_v	m
Electrical down-tilt angle	θ_{etilt}	Degrees
Electrical scan angle	φ_{escan}	Degrees

The parameterized antenna model is built around array antenna model where the element factor, array factor and linear phase progressing is characterized as described by equations in Table 8.1.1-2.

Table 8.1.1-2: Array antenna model details

Description	Equation	Unit
Peak normalized element radiation pattern	$A(\theta,\varphi) = -\min\left[-\left(-\min\left[12\left(\frac{\varphi}{\varphi_{3dB}}\right)^2, A_m\right] - \min\left[12\left(\frac{\theta-90}{\theta_{3dB}}\right)^2, SLA_v\right]\right), A_m\right]$	dB
Peak gain normalized element radiation pattern	$A_E(\theta,\varphi) = G_{E,max} + A(\theta,\varphi)$	dBi
Composite array radiation pattern	$A_A(\theta,\varphi) = A_E(\theta,\varphi) + 10\log_{10}\left(\left\|\sum_{m=1}^{M}\sum_{n=1}^{N} w_{m,n} v_{m,n}\right\|^2\right)$, where $v_{m,n} = \exp\left(j2\pi\left((n-1)\frac{d_v}{\lambda}\cos(\theta) + (m-1)\frac{d_h}{\lambda}\sin(\theta)\sin(\varphi)\right)\right)$ $w_{m,n} = \frac{1}{\sqrt{MN}}\exp\left(j2\pi\left((n-1)\frac{d_v}{\lambda}\sin(\theta_{etilt}) - (m-1)\frac{d_h}{\lambda}\cos(\theta_{etilt})\sin(\varphi_{escan})\right)\right)$	dBi

8.1.2 Array antenna parameters

In Table 8.1.2-1, base station array antenna parameters for different deployment scenarios is listed. Element parameters have been selected to produce correct element peak gain.

Table 8.1.2-1: BS array antenna parameters

Parameter	Rural	Macro Sub-urban	Macro Urban	Micro Urban
A_m (dB)	N/A	30	30	30
SLA_v (dB)	N/A	30	30	30
φ_{3dB} (deg.)	N/A	90	90	90
θ_{3dB} (deg.)	N/A	65	90	90
$G_{E,max}$ (dBi)	N/A	6.4	5.5	5.5
L_E (dB)	N/A	2.0	2.0	2.0
(M, N)	N/A	(16, 8)	(16, 8)	(8,8)
d_h (m)	N/A	0.5λ	0.5λ	0.5λ
d_v (m)	N/A	0.7λ	0.5λ	0.5λ
Horizontal coverage range (deg.)	N/A	+/- 60	+/- 60	+/- 60
Vertical coverage range (deg.)	N/A	90 to 100	90 to 120	90 to 120
Total Radiated Power (dBm)	N/A	46	46	37
Mechanical downtilt (deg.)	N/A	6	10	N/A
Note 1: MxN means there are M vertical and N horizontal elements Note 2: L_E is included in $G_{E,max}$ Note 3: TRP includes the powers from two polarizations Note 4: The vertical coverage range includes the mechanical downtilt.				

8.2 UE antenna characteristics

The outcome of the RAN4 study for collecting technical background information relevant for the frequency range 7 to 24 GHz indicated that the frequency range 7.25-[10-13] GHz would have "FR1 like" requirements, and as such we can assume that in the 10-10.5GHz range this applies. The UE will most likely therefore have a conducted interface with an assumed isotropic radiation pattern antenna and no beam forming.

9 Other Information relevant for the sharing and compatibility studies

Annex <X> (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2020-03	RAN4#94 bis-e	R4-2004477				TR skeleton	0.0.1
2020-08	RAN4#96 -e	R4-2010370				1. Agreed Text Proposal in RAN4#95-e: R4-2008928, “TP to TR 38.9xx: System level simulation methodology and assumptions for study on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz” 2. A new clause is added on general parameters	0.1.0
2020-10	RAN4#97 -e	R4-2015675				Agreed Text Proposal in RAN4#96-e: R4-2011829, “TP to TR 38.921: BS IMT technology related parameters” R4-2011830, “TP to TR 38.921: Addition of BS antenna model and parameters in subclause 4.2.3 and subclause 8.1”	0.2.0