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TECHNICAL REPORT

5G;
Study on International Mobile Telecommunications (IMT) parameters for 6.425 - 7.025 GHz, 7.025 - 7.125 GHz and 10.0 - 10.5 GHz
(3GPP TR 38.921 version 17.1.0 Release 17)

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Contents

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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

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can	indicates that something is possible
cannot	indicates that something is impossible

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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

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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.

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[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] ITU-R Recommendation SM.329: "Unwanted emissions in the spurious domain"

[6] ERC Recommendation 74-01, "Unwanted emissions in the spurious domain"

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].

array element: subdivision of a passive *antenna array*, consisting of a single radiating element or a group of radiating elements, with a fixed radiation pattern

beamwidth: beam which has a half-power contour that is essentially elliptical, the half-power beamwidths in the two pattern cuts that respectively contain the major and minor axis of the ellipse

front-to-back ratio: ratio of maximum directivity of an antenna to its directivity in a specified rearward direction

gain: ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically

NOTE: If the direction is not specified, the direction of maximum radiation intensity is implied.

3.2 Symbols

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

A	Peak normalized array element pattern in dB
A_A	Composite *antenna array* pattern in dBi
A_E	*Array element* pattern in dBi
A_m	Front to back ratio in dB
d_h	Horizontal element separation in meters
d_V	Vertical element separation in meters
$G_{E,max}$	Array element peak gain in dBi
SLA_V	Side lobe suppression in dB
φ_{3dB}	Horizonal half power beamwidth
θ_{3dB}	Vertical half power beamwidth
θ_{etilt}	Electrical down-tilt angle in degrees (defined from antenna array normal and downwards)
φ_{escan}	Electrical scan angle in degrees
φ	Horizontal angle (defined between -180° and 180°).
θ	Vertical angle of the signal direction (defined between -0° and 180°,90° represents the direction perpendicular to the antenna array
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
LOS	Line-Of-Sight
MR	Medium Range
NR	New Radio
OTA	Over The Air
O-to-I	Outdoor-to-Indoor
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 4.1-1 summarizes the proposed scenarios to be considered for 6.425-7.125GHz and 10.0-10.5 GHz.

Table 4.1-1: 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) (Note 1) 0.9 km (suburban)	Based on cell range: 0.3 km (urban) 0.6 km (suburban)
BS antenna height		20 m (urban) 25 m (suburban)	
UE location	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	
Note: Results with 0.4 km ISD at 10 GHz can also be provided if simulation results show 5%-tile throughput cannot be achieved with 0.45 km ISD at 10 GHz.			

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 6 GHz coexistence simulation

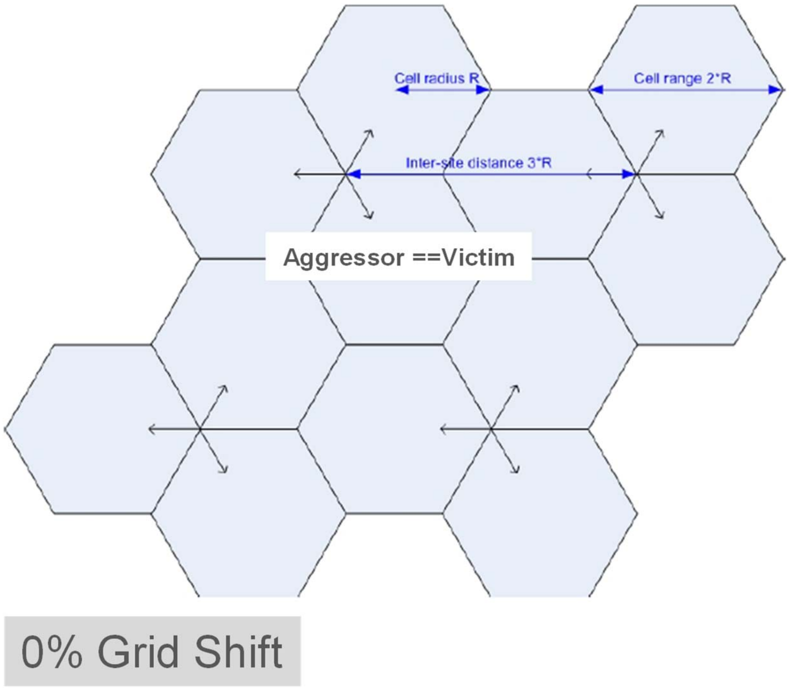

Figure 4.2.1.1-1: Coordinated operation: each network with co-location of sites

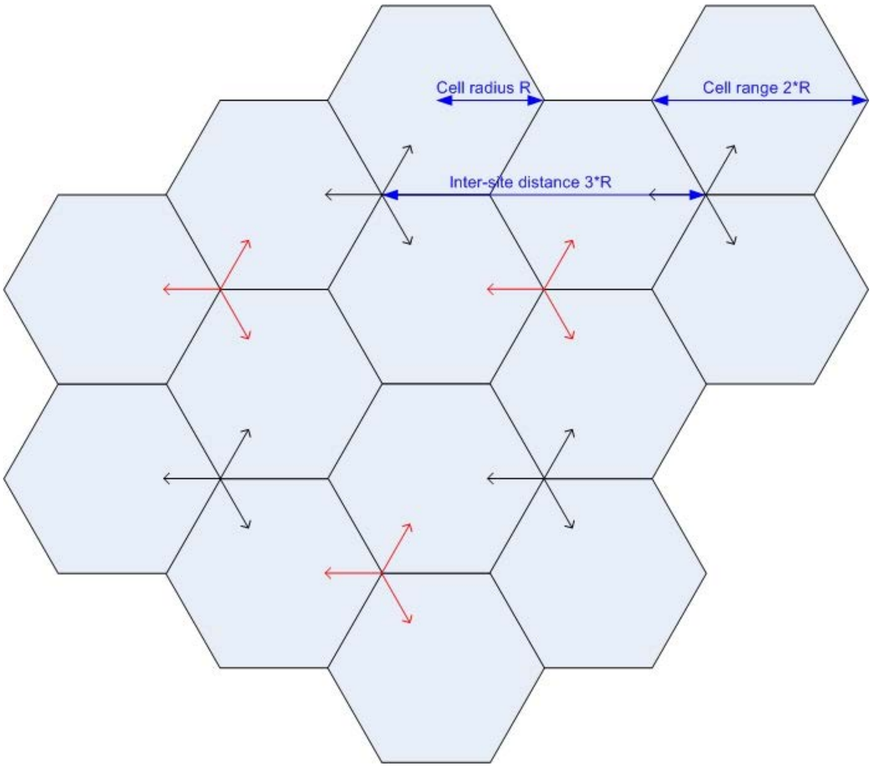

Figure 4.2.1.1-2: Uncoordinated operation: second network's sites are located at the first network's cell edge

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		50 m x 120 m, 12 BSs	
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	

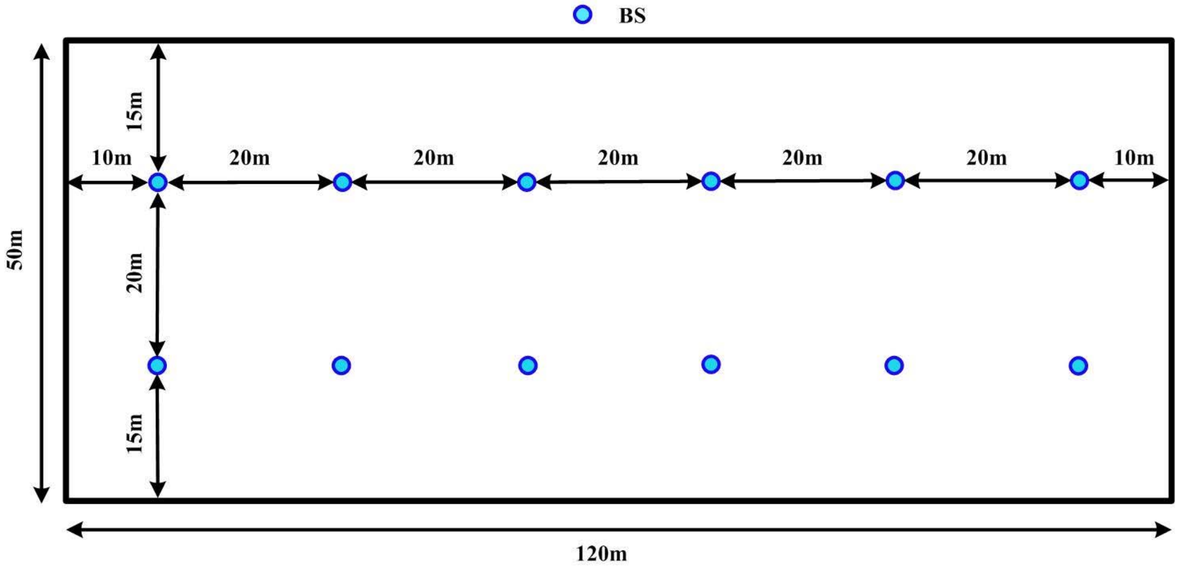

Figure 4.2.1.3-1: Network layout for indoor

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.

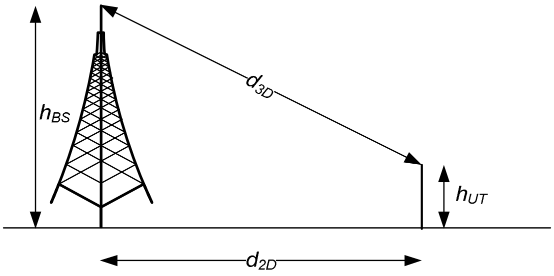

Figure 4.2.2.1-1: Definition of d_{2D} and d_{3D} for outdoor UTs

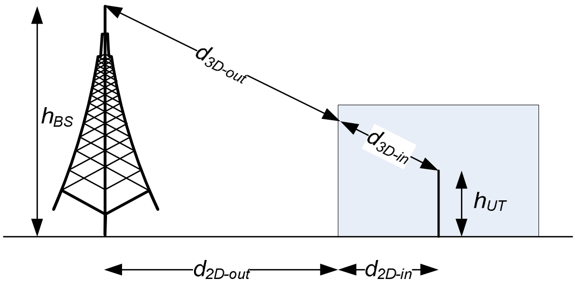

Figure 4.2.2.1-2: Definition of $d_{2D\text{-}out}$, $d_{2D\text{-}in}$ and $d_{3D\text{-}out}$, $d_{3D\text{-}in}$ for indoor UTs

Note that

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

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	$PL_{\text{UMa-LOS}} = \begin{cases} PL_1 & 10m \le d_{\text{2D}} \le d'_{\text{BP}} \\ PL_2 & d'_{\text{BP}} \le d_{\text{2D}} \le 5\text{km} \end{cases}$, see note 1 $PL_1 = 28.0 + 22\,log_{10}(d_{\text{3D}}) + 20\,log_{10}(f_c)$ $PL_2 = 28.0 + 40\,log_{10}(d_{\text{3D}}) + 20\,log_{10}(f_c) - 9\,log_{10}((d'_{\text{BP}})^2 + (h_{\text{BS}} - h_{\text{UT}})^2)$	$\sigma_{\text{SF}} = 4$	$1.5m \le h_{\text{UT}} \le 22.5m$ $h_{\text{BS}} = 25\text{m}$
	NLOS	$PL_{\text{UMa-NLOS}} = max(PL_{\text{UMa-LOS}}, PL'_{\text{UMa-NLOS}})$ for $10m \le d_{\text{2D}} \le 5\text{km}$ $PL'_{\text{UMa-NLOS}} = 13.54 + 39.08\log_{10}(d_{\text{3D}}) + 20\log_{10}(f_c) - 0.6(h_{\text{UT}} - 1.5)$	$\sigma_{\text{SF}} = 6$	$1.5m \le h_{\text{UT}} \le 22.5m$ $h_{\text{BS}} = 25\text{m}$ Explanations: see note 3
		Optional $\text{PL} = 32.4 + 20\,log_{10}(f_c) + 30\,log_{10}(d_{\text{3D}})$	$\sigma_{\text{SF}} = 7.8$	
InH - Office	LOS	$PL_{\text{InH-LOS}} = 32.4 + 17.3\,log_{10}(d_{\text{3D}}) + 20\,log_{10}(f_c)$	$\sigma_{\text{SF}} = 3$	$1m \le d_{\text{3D}} \le 150m$
	NLOS	$PL_{\text{InH-NLOS}} = max(PL_{\text{InH-LOS}}, PL'_{\text{InH-NLOS}})$ $PL'_{\text{InH-NLOS}} = 38.3\,log_{10}(d_{\text{3D}}) + 17.30 + 24.9\,log_{10}(f_c)$	$\sigma_{\text{SF}} = 8.03$	$1m \le d_{\text{3D}} \le 150m$
		Optional $PL'_{\text{InH-NLOS}} = 32.4 + 20\,log_{10}(f_c) + 31.9\,log_{10}(d_{\text{3D}})$	$\sigma_{\text{SF}} = 8.29$	$1m \le d_{\text{3D}} \le 150m$

Note 1: Breakpoint distance $d'_{\text{BP}} = 4\, h'_{\text{BS}}\, h'_{\text{UT}}\, f_c/c$, 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: $h'_{\text{BS}} = h_{\text{BS}} - h_{\text{E}}$, $h'_{\text{UT}} = h_{\text{UT}} - h_{\text{E}}$, where h_{BS} and h_{UT} are the actual antenna heights, and h_{E} is the effective environment height. For UMi $h_{\text{E}} = 1.0$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

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

where

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

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 $0.5 < f_c < f_{\text{H}}$ 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 $\text{PL}_{\text{UMa-LOS}}$ = 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	$Pr_{\mathrm{LOS}} = \begin{cases} 1 & , d_{\mathrm{2D-out}} \leq 18m \\ \left[\frac{18}{d_{\mathrm{2D-out}}} + exp\left(-\frac{d_{\mathrm{2D-out}}}{63}\right)\left(1 - \frac{18}{d_{\mathrm{2D-out}}}\right)\right]\left(1 + C'(h_{\mathrm{UT}})\frac{5}{4}\left(\frac{d_{\mathrm{2D-out}}}{100}\right)^3 exp\left(-\frac{d_{\mathrm{2D-out}}}{150}\right)\right) & , 18m < d_{\mathrm{2D-out}} \end{cases}$ where $C'(h_{\mathrm{UT}}) = \begin{cases} 0 & , h_{\mathrm{UT}} \leq 13m \\ \left(\frac{h_{\mathrm{UT}} - 13}{10}\right)^{1.5} & , 13m < h_{\mathrm{UT}} \leq 23m \end{cases}$
Indoor - Mixed office	$Pr_{\mathrm{LOS}} = \begin{cases} 1 & , d_{\mathrm{2D-in}} \leq 1.2m \\ exp\left(-\frac{d_{\mathrm{2D-in}} - 1.2}{4.7}\right) & , 1.2\mathrm{m} < d_{\mathrm{2D-in}} < 6.5m \\ exp\left(-\frac{d_{\mathrm{2D-in}} - 6.5}{32.6}\right) \cdot 0.32 & , 6.5m \leq d_{\mathrm{2D-in}} \end{cases}$
Indoor - Open office	$Pr_{\mathrm{LOS}} = \begin{cases} 1 & , d_{\mathrm{2D-in}} \leq 5m \\ exp\left(-\frac{d_{\mathrm{2D-in}} - 5}{70.8}\right) & , 5m < d_{\mathrm{2D-in}} \leq 49m \\ exp\left(-\frac{d_{\mathrm{2D-in}} - 49}{211.7}\right) \cdot 0.54 & , 49m < d_{\mathrm{2D-in}} \end{cases}$
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:

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

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

$\mathrm{PL}_{\mathrm{tw}}$ is characterized as:

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

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	$L_{\mathrm{glass}} = 2 + 0.2f$
IRR glass	$L_{\mathrm{IIRglass}} = 23 + 0.3f$
Concrete	$L_{\mathrm{concrete}} = 5 + 4f$
Wood	$L_{\mathrm{wood}} = 4.85 + 0.12f$
Note: f is in GHz.	

Table 4.2.2.3-2 gives $\mathrm{PL}_{\mathrm{tw}}$, $\mathrm{PL}_{\mathrm{in}}$ 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: $\mathrm{PL}_{\mathrm{tw}}$ **in [dB]**	**Indoor loss:** $\mathrm{PL}_{\mathrm{in}}$ **in [dB]**	**Standard deviation:** σ_P **in [dB]**
Low-loss model	$5 - 10\,log_{10}\left(0.3 \cdot 10^{\frac{-L_{\mathrm{glass}}}{10}} + 0.7 \cdot 10^{\frac{-L_{\mathrm{concrete}}}{10}}\right)$	0.5 $d_{\mathrm{2D-in}}$	4.4
High-loss model	$5 - 10\,log_{10}\left(0.7 \cdot 10^{\frac{-L_{\mathrm{IIRglass}}}{10}} + 0.3 \cdot 10^{\frac{-L_{\mathrm{concrete}}}{10}}\right)$	0.5 $d_{\mathrm{2D-in}}$	6.5

$d_{\mathrm{2D-in}}$ 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. $d_{\mathrm{2D-in}}$ should 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:

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

where PL_b is the basic outdoor path loss given in clause 4.2.2.1. μ = 9, and σ_P = 5. The car penetration loss should be UT-specifically generated. Optionally, for metallized car windows, μ = 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 clause 8.1.1 using parameters for different BS deployments listed in clause 8.1.2.

The UE antenna is modelled as described in clause 8.2 using isotropic antenna pattern.

4.2.4 Transmission power control model

For downlink scenario, no power control scheme is applied.

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

- $\mathrm{CL}_{\text{x-ile}}$ = 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.

1 user scheduling is baseline assumption for coexistence evaluation and the two step ACLR model shown in Table 4.2.6-1 could be used for 3 uplink user scheduling simulation, where a UE occupies a smaller bandwidth than the channel bandwidth for transmission, to avoid overly estimating interference, similar as done in E-UTRA coexistence study (as recorded in TR 36.942).

Table 4.2.6-1: Uplink ACIR value

Frequency offset between aggressor (91RBs) and victim (91RBs)	ACIR value
0 - 90 RBs	30 + X
91 - 181RBs	43 + X
> 181RBs	43+ X

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:

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

Where:

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

The parameters α, $\mathrm{SNIR}_{\mathrm{MIN}}$ and $\mathrm{SNIR}_{\mathrm{MAX}}$ 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	7 GHz, 10 GHz	7 GHz, 10 GHz	Down-prioritized
Channel bandwidth	100 MHz	100 MHz	Down-prioritized
Scheduled channel bandwidth per UE (DL)	98.28 MHz	98.28 MHz	Down-prioritized
Scheduled channel bandwidth per UE (UL)	98.28 MHz (1 user, Note 4) 32.76 MHz (3 user)	98.28 MHz (1 user, Note 4) 32.76 MHz (3 user)	Down-prioritized
The number of active UE (DL) (Note 1)	1	1	Down-prioritized
The number of active UE (UL) (Note 1)	1 or 3	1 or 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 (Note 3)	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 (@7 GHz) 15 (@10 GHz)	6 (@7 GHz) 7 (@10 GHz)	Down-prioritized
UE Noise figure in dB	9 or 13 (Note 5)	9 or 13 (Note 5)	Down-prioritized
Handover margin	3 dB	3 dB	Down-prioritized
Note 1 Same as the number of BS beam(s); Note 2: 20 dBm as optional case where $CL_{x\text{-}ile}$ should be reduced by 3 dB; Note 3: BS max TX power is defined per polarization; Note 4: 1 user scheduling is a baseline assumption for coexistence evaluation; Note 5: NF of 9 dB is a baseline assumption and NF of 13 dB is as optional case.			

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 BS and UE with isotropic antenna.
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:
    - $Thput_{\mathrm{NO\ ACI}}[bpshz] = f(SINR_{ICI}) = f\left(\frac{S}{N+I_{ICI}}\right)$, where I_{ICI} is the inter-cell interference.
5. Throughput is computed considering ACI as below:
    - $\mathrm{Thput_{ACI}[bpshz] = f(SINR_{ICI+ACI}) = f\left(\frac{S}{N+I_{ICI}+I_{ACI}}\right)}$, where I_{ACI} is the adjacent channel interference.
6. RF parameters are determined based on the degradation cause by ACI as below:
    - $Loss_{ACI} = 1 - \frac{\mathrm{Thput_{ACI}}}{\mathrm{Thput_{SINGLE}}}$.

4.3 Co-existence simulation results

4.3.1 Urban Macro scenario

4.3.1.1 Downlink

For Urban macro scenarios, simulation results for DL throughput loss with baseline assumption ACLR = 45 dBc at BS and ACS = 33 dBc at UE are summarized in Table 4.3.1.1-1/2/3/4.

Table 4.3.1.1-1: DL throughput loss of victim UE for 6425 – 7125 MHz [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	1.65	1.89	2.10	2.33	2.63	2.99
		5%-tile throughput loss in % (7 GHz)	4.39	5.18	5.98	7.07	7.87	9.06
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	1.11	1.28	1.48	1.70	1.94	2.21
		5%-tile throughput loss in % (7 GHz)	6.22	6.23	6.24	7.51	8.99	9.23
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	1.04	1.39	1.47	1.77	2.30	2.39
		5%-tile throughput loss in % (7 GHz)	3.00	4.63	4.96	6.37	6.78	7.16

Table 4.3.1.1-1a: DL throughput loss of victim UE for 6425 – 7125 MHz [Absolute ACIR value]

	ACIR (dB)	23	24	25	26	27	28	29	30	31	32	33
Ericsson	Throughput lost at Average	2.7	2.4	2.1	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.7
	Throughput lost at 5%-tile	13.1	10.6	10.0	8.3	6.6	6.1	5.5	4.7	3.1	2.2	2.1
CATT	Throughput lost at Average	2.945446	2.615785	2.318919	2.050108	1.808206	1.592518	1.399160	1.226961	1.073971	0.936971	0.814444
	Throughput lost at 5%-tile	11.345302	10.038643	8.745891	7.593149	6.594121	5.813514	5.023313	4.235969	3.589495	3.063706	2.576903
Qualcomm	Throughput lost at Average			3.0285	2.6700	2.3630	2.0876	1.8414	1.6318	1.4200		
	Throughput lost at 5%-tile			12.3347	10.6516	9.2041	7.9086	6.7639	5.8122	4.9061		

Table 4.3.1.1-2: DL throughput loss of victim UE for 10 - 10.5 GHz [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	1.52	1.68	1.93	2.12	2.31	2.62
		5%-tile throughput loss in % (7 GHz)	3.36	3.79	4.79	5.78	6.41	7.63
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	1.03	1.20	1.38	1.60	1.83	2.09
		5%-tile throughput loss in % (7 GHz)	4.38	4.38	4.86%	5.23	6.01	7.40
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	1.21	1.22	1.30%	1.72	1.99	2.44
		5%-tile throughput loss in % (7 GHz)	3.04	3.33	4.14%	5.06	6.41	8.67

Table 4.3.1.1-2a: DL throughput loss of victim UE for 10-10.5GHz [Absolute ACIR value]

	ACIR (dB)	23	24	25	26	27	28	29	30	31	32	33
Ericsson	Throughput lost at Average	2.1	1.9	1.7	1.4	1.3	1.1	0.9	0.8	0.7	0.6	0.5
	Throughput lost at 5%-tile	11.8	10.0	9.6	9.4	7.8	6.3	4.8	4.7	4.2	3.9	3.5
CATT	Throughput lost at Average	2.874567	2.547846	2.252212	1.986030	1.748135	1.537007	1.348903	1.181463	1.032390	0.899829	0.782843
	Throughput lost at 5%-tile	9.975828	8.600968	7.468747	6.454207	5.566782	4.750499	4.068893	3.494199	2.988947	2.552896	2.076688
Qualcomm	Throughput lost at Average			2.788	2.4497	2.1611	1.9031	1.6734	1.4787	1.2825		
	Throughput lost at 5%-tile			11.0936	9.6118	8.3690	7.2691	6.2895	5.4504	4.5726		

In addition, coexistence simulation results for UE with NF 13 dB is summarized in Table 4.3.1.1.3 and 4.3.1.1.4.

Table 4.3.1.1-3: 7 GHz ACIR with 13 dB NF [Qualcomm, R4-2016236]

ACIR [dB]	31	30	29	28	27	26	25
Average throughput loss (7 GHz)	1.3706%	1.5769%	1.7811%	2.0213%	2.2902%	2.5902%	2.9408%
5%-tile throughput loss (7 GHz)	4.5693%	5.4639%	6.3517%	7.4031%	8.5919%	9.9359%	11.5323%

Table 4.3.1.1-4: 10 GHz ACIR with 13 dB NF [Qualcomm, R4-2016236]

ACIR [dB]	31	30	29	28	27	26	25
Average throughput loss (10 GHz)	1.2320%	1.4223%	1.6112%	1.8344%	2.0853%	2.3663%	2.6961%
5%-tile throughput loss (10 GHz)	3.2501%	3.9646%	4.7371%	5.6903%	6.7960%	8.0620%	9.5717%

Based on the above simulation results, the required DL ACIR for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz for urban macro scenarios are in summarized in Table 4.3.1.1-5.

Table 4.3.1.1-5: DL simulation results for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz

	ACIR (dB)	
Company	**6.425 - 7.125 GHz**	**10.0 - 10.5 GHz**
	Urban macro uncoord.	**Urban Macro uncoord.**
CATT	29.5	28
Nokia	32.7	30.7
Huawei	30.7	29.7
Ericsson	30	29
ZTE	31.7	29.7
Qualcomm	30.9	30.5
Average	30.9	29.6
Average after removing highest and lowest values	30.9	29.5

4.3.1.2 Uplink

For Urban macro scenarios, simulation results for UL throughput loss with baseline assumption ACLR = 30 dBc at UE and ACS = 46 dBc at BS are summarized in Table 4.3.1.2-1/2/3/4.

Table 4.3.1.2-1: UL throughput loss of victim BS for 6425-7125MHz [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.99	1.09	1.23	1.40	1.55	1.76
		5%-tile throughput loss in % (7 GHz)	2.72	2.84	5.28	6.01	6.71	7.20
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	1.08	1.24	1.43	1.65	1.89	2.15
		5%-tile throughput loss in % (7 GHz)	1.01	1.68	3.14	3.98	5.76	8.08
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	0.64	0.69	0.69	0.92	1.01	1.07
		5%-tile throughput loss in % (7 GHz)	3.8	4.3	5.0	6.2	7.6	8.7

Table 4.3.1.2-1a: UL throughput loss of victim BS for 6425 – 7125 MHz [Absolute ACIR value]

	ACIR (dB)	**23**	**24**	**25**		**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Ericsson	Throughput lost at Average	1.5	1.3	1.1		1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.3
	Throughput lost at 5%-tile	6.3	6.2	5.5		4.3	2.3	1.6	1.5	1.4	0.8	0.6	0.5
CATT	Throughput lost at Average	1.489821	1.301164	1.134213		0.986689	0.856389	0.741773	0.641199	0.553419	0.476770	0.409968	0.351849
	Throughput lost at 5%-tile	7.283069	6.142583	5.227730		4.495608	3.745409	3.051767	2.429319	1.621495	0.968716	0.671695	0.526234
Qualcomm	Throughput lost at Average	1.5	1.2	1.0		0.9	1.0	0.9	0.8	0.6	0.5		
	Throughput lost at 5%-tile	4.3	3.4	2.4		2.2	2.4	2.2	1.8	1.5	1.3		

Table 4.3.1.2-2: UL throughput loss of victim BS for 10 - 10.5 GHz [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.79	0.87	1.11	1.23	1.41	1.59
		5%-tile throughput loss in % (7 GHz)	N/A	N/A	N/A	N/A	N/A	N/A
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	0.90	1.04	1.21	1.39	1.60	1.84
		5%-tile throughput loss in % (7 GHz)	1.98	2.27	2.28	3.90	4.00	6.41
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	0.53	0.59	0.61	0.76	0.91	1.05
		5%-tile throughput loss in % (7 GHz)	1.7	2.3	3.3	4.0	5.3	6.4

Table 4.3.1.2-2a: UL throughput loss of victim BS for 10 - 10.5 GHz [Absolute ACIR value]

	ACIR (dB)	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Ericsson	Throughput lost at Average	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3
	Throughput lost at 5%-tile	3.0	2.3	1.3	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.2
CATT	Throughput lost at Average	1.535229	1.345764	1.177367	1.027196	0.894277	0.777219	0.673935	0.582684	0.502769	0.432740	0.371237
	Throughput lost at 5%-tile	9.496269	7.816610	6.444894	5.273296	4.180206	3.433665	3.082907	2.691289	2.325946	2.024768	1.625941
Qualcomm	Throughput lost at Average	1.5	1.2	1.0	0.9	0.8	0.6	0.5	0.4			
	Throughput lost at 5%-tile	4.0	3.5	2.9	2.6	2.2	2.0	1.6	1.4			

In addition, coexistence simulation results for UE with Tx power 20 dBm is summarized in Table 4.3.1.2.3 and 4.3.1.2.4.

Table 4.3.1.2-3: ACIR results at 7 GHz with 20 dBm UE max Tx power [Qualcomm, R4-2016601]

ACIR [dB]	30	29	28	27	26	25	24	23	22
Average throughput loss (7 GHz)	0.4%	0.5%	0.6%	0.8%	0.9%	1.0%	1.2%	1.5%	1.8%
5%-tile throughput loss (7 GHz)	0.8%	1.2%	1.6%	1.8%	2.2%	2.5%	3.4%	4.2%	5.0%

Table 4.3.1.2-4: ACIR results at 10 GHz with 20 dBm UE max Tx power [Qualcomm, R4-2016601]

ACIR [dB]	30	29	28	27	26	25	24	23	22	21
Average throughput loss (10 GHz)	0.3%	0.4%	0.5%	0.6%	0.7%	0.8%	1.0%	1.2%	1.4%	1.6%
5%-tile throughput loss (10 GHz)	0.8%	1.2%	1.4%	1.8%	2.1%	2.3%	3.2%	4.0%	4.7%	5.6%

Based on the above simulation results, the required UL ACIR for 6.425-7.125GHz and 10.0-10.5 GHz for urban macro scenarios are summarized in Table 4.3.1.2-5.

Table 4.3.1.2-5: UL simulation results for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz

	ACIR (dB)	
Company	6.425 - 7.125 GHz	10.0 - 10.5 GHz
	Urban macro uncoord.	Urban Macro uncoord.
CATT	26	26.2
Nokia	26.9	25.9
Huawei	27.9	25.9
Ericsson	27	23
ZTE	27.9	24.9
Qualcomm	22 (Note 1)	22 / 21.5(Note 1, 2)
Average value	26.3	24.6
Average after removing highest and lowest values	27	24.9

Note 1: 3 UL UEs are assumed, where the same antenna gain derived by the BS beam forming pattern modelling described in clause 8.1.1 is used for all UEs.

Note 2: 22 with 23 dBm UE maximum Tx power and 21.5 with 20 dBm UE maximum Tx power.

4.3.2 Indoor scenario

4.3.2.1 Downlink

For indoor scenarios, simulation results for DL throughput loss with baseline assumption ACLR = 45 dBc at BS and ACS = 33 dBc at UE are summarized in Table 4.3.2.1-1/1a/2/2a/3/3a/4/4a.

Table 4.3.2.1-1: DL throughput loss of victim UE for 6425 – 7125 MHz with omni antenna [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	Omni based BS	Average throughput loss in % (7 GHz)	0.1371	0.1724	0.2168	0.2726	0.3425	0.4302
		5%-tile throughput loss in % (7 GHz)	0.1429	0.1798	0.2263	0.2847	0.3123	0.3427
Nokia	Omni based BS	Average throughput loss in % (7 GHz)	0.13	0.17	0.21	0.26	0.33	0.41
		5%-tile throughput loss in % (7 GHz)	0.07	0.09	0.11	0.14	0.20	0.33

Table 4.3.2.1-1a: DL throughput loss of victim UE for 6425 – 7125 MHz with omni antenna [Absolute ACIR value]

	ACIR (dB)	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**
Ericsson	Throughput lost at Average						1.8	2.2	2.8	3.5	4.3	5.4
	Throughput lost at 5%-tile						0.9	1.1	1.4	1.8	2.3	2.8
CATT	Throughput lost at Average							3.198061	3.945391	4.852136	5.946106	7.258307
	Throughput lost at 5%-tile							1.970774	2.470131	3.106864	3.901198	4.918388
Qualcomm	Throughput lost at Average	0.59	0.76	0.9	1.1	1.4	1.8	2.3	2.9	3.6	4.4	5.4
	Throughput lost at 5%-tile	0.31	0.39	0.44	0.53	0.66	0.8	1.1	1.4	1.9	2.5	3.1

Table 4.3.2.1-2: DL throughput loss of victim UE for 6425 – 7125 MHz with AAS antenna [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.3043	0.3817	0.4775	0.5947	0.7378	0.9123
		5%-tile throughput loss in % (7 GHz)	0.0054	0.0067	0.0085	0.0107	0.0135	0.1421
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	0.15		0.30		0.36	
		5%-tile throughput loss in % (7 GHz)	0.02		0.06		0.07	
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	0.27	0.33	0.42	0.52	0.65	0.81
		5%-tile throughput loss in % (7 GHz)	0.05	0.06	0.08	0.10	0.12	0.16

Table 4.3.2.1-2a: DL throughput loss of victim UE for 6425 – 7125 MHz with AAS antenna [Absolute ACIR value]

	ACIR (dB)	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**
Ericsson	Throughput lost at Average											
	Throughput lost at 5%-tile											
CATT	Throughput lost at Average							4.311783	5.036284	5.868329	6.803309	7.846610
	Throughput lost at 5%-tile							0.988785	1.284747	1.673493	2.221040	2.921901
Qualcomm	Throughput lost at Average	1.27	1.57	1.88	2.27	2.72	3.24	3.87	4.52	5.29	6.16	
	Throughput lost at 5%-tile	0.17	0.26	0.34	0.46	0.60	0.77	1	1.2	1.6	1.9	

Table 4.3.2.1-3: DL throughput loss of victim UE for 10 - 10.5 GHz with omni antenna [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	Omni based BS	Average throughput loss in % (7 GHz)	0.1561	0.1956	0.2447	0.3058	0.3815	0.4750
		5%-tile throughput loss in % (7 GHz)	0.1096	0.1380	0.1736	0.2369	0.3323	0.4823
Nokia	Omni based BS	Average throughput loss in % (7 GHz)	0.13	0.17	0.21	0.26	0.33	0.41
		5%-tile throughput loss in % (7 GHz)	0.09	0.11	0.13	0.16	0.19	0.23

Table 4.3.2.1-3a: DL throughput loss of victim UE for 10 - 10.5 GHz with omni antenna [Absolute ACIR value]

	ACIR (dB)	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**
Ericsson	Throughput lost at Average						1.8	2.2	2.8	3.5	4.3	5.4
	Throughput lost at 5%-tile						0.9	1.1	1.4	1.8	2.3	2.8
CATT	Throughput lost at Average							3.122018	3.855086	4.745063	5.820303	7.109105
	Throughput lost at 5%-tile							1.938403	2.462824	3.109281	3.943454	4.927987
Qualcomm	Throughput lost at Average	0.59	0.76	0.94	1.18	1.4	1.85	2.3	2.9	3.6	4.46	5.4
	Throughput lost at 5%-tile	0.5	0.66	0.7	0.83	0.9	1.18	1.4	1.9	2.4	3.0	3.72

Table 4.3.2.1-4a: DL throughput loss of victim UE for 10 - 10.5 GHz [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.3188	0.3979	0.4950	0.6133	0.7587	0.9337
		5%-tile throughput loss in % (7 GHz)	0.0481	0.0553	0.0645	0.0760	0.0969	0.1978
Huawei	AAS based BS	Average throughput loss in % (7 GHz)	0.13		0.21		0.32	
		5%-tile throughput loss in % (7 GHz)	0.01		0.07		0.09	
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	0.27	0.34	0.43	0.54	0.67	0.82
		5%-tile throughput loss in % (7 GHz)	0.00	0.00	0.00	0.01	0.01	0.01

Table 4.3.2.1-4b: DL throughput loss of victim UE for 6425 – 7125 MHz with AAS antenna [Absolute ACIR value]

	ACIR (dB)	26	25	24	23	22	21	20	19	18	17	16
Ericsson	Throughput lost at Average											
	Throughput lost at 5%-tile											
CATT	Throughput lost at Average							4.235205	4.964440	5.793027	6.735404	7.788678
	Throughput lost at 5%-tile							1.414406	1.703417	2.085369	2.595632	3.227734
Qualcomm	Throughput lost at Average	1.2	1.5	1.8	2.2	2.6	3.1	3.8	4.4	5.2	6.0	
	Throughput lost at 5%-tile	0.26	0.3	0.307	0.31	0.312	0.314	0.4	0.64	0.93	1.28	

Based on the above simulation results, the required DL ACIR for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz for indoor hotpot scenarios are in summarized in Table 4.3.2.1-5.

Table 4.3.2.1-5: DL simulation results for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz

DL simulations					
	ACIR (dB) for Indoor				Can we keep agreed BS ACLR (38-37) and UE ACS (32-31) for indoor?
	6.425 - 7.125 GHz		10.0 - 10.5 GHz		
ACIR for macro BS	31.0		30.0		
	Omni	AAS	Omni	AAS	
CATT	18	20	18	19	Yes
Huawei		<25.9		<25.9	Yes
Nokia	<ACIR - 5	<ACIR – 5	<ACIR - 5	<ACIR - 5	Yes
ZTE	<ACIR – 5	<ACIR - 5	<ACIR – 5	<ACIR - 5	Yes
Ericsson	17		17		Yes
Qualcomm	16	18	16	18	Yes

4.3.2.2 Uplink

For indoor scenarios, simulation results for UL throughput loss with baseline assumption ACLR = 30 dBc at UE and ACS = 46 dBc at BS are summarized in Table 4.3.2.2-1/1a/2/2a/3/3a/4/4a.

Table 4.3.2.2-1: UL throughput loss of victim BS for 6425 – 7125 MHz with omni antenna [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	Omni based BS	Average throughput loss in % (7 GHz)	0.1433	0.1794	0.2245	0.2805	0.3499	0.4356
		5%-tile throughput loss in % (7 GHz)	0.0078	0.0098	0.0123	0.0155	0.0212	0.0246
Nokia	Omni based BS	Average throughput loss in % (7 GHz)	0.30	0.37	0.46	0.58	0.73	0.91
		5%-tile throughput loss in % (7 GHz)	0.05	0.08	0.10	0.12	0.19	0.27

Table 4.3.2.2-1a: UL throughput loss of victim BS for 6425 – 7125 MHz with omni antenna [Absolute ACIR value]

	ACIR (dB)	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**
Ericsson	Throughput lost at Average	1.8	2.2	2.8	3.5	4.3	5.3	6.6	8.1	9.9		
	Throughput lost at 5%-tile	1.2	1.5	1.9	2.4	3.1	3.9	4.8	5.8	7.4		
CATT	Throughput lost at Average		2.392580	2.954531	3.639646	4.471517	5.476805	6.684997	8.127856	9.843106	11.858804	14.204583
	Throughput lost at 5%-tile		1.391922	1.752115	2.163126	2.636267	3.216128	3.893275	4.758722	6.027059	7.603577	9.503131
Qualcomm	Throughput lost at Average		2.5	3.0	4.0	5.0	6.0	7.0	8.5	11.0	13.0	15.0
	Throughput lost at 5%-tile		0.8	1.0	1.5	1.8	2.0	2.5	3.0	4.5	5.5	6.5

Table 4.3.2.2-2: UL throughput loss of victim BS for 6425 – 7125 MHz with AAS antenna [Relative ACIR value]

Company	**Simulation scenarios**	**Throughput loss**	**Relative ACIR offset**					
			0	**-1**	**-2**	**-3**	**-4**	**-5**
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.1414	0.1770	0.2211	0.2759	0.3437	0.4275
		5%-tile throughput loss in % (7 GHz)	0.0033	0.0042	0.0053	0.0378	0.0880	0.1511
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	0.16	0.20	0.24	0.30	0.38	0.47
		5%-tile throughput loss in % (7 GHz)	0.04	0.05	0.07	0.08	0.10	0.13

Table 4.3.2.2-2a: UL throughput loss of victim BS for 6425 – 7125 MHz with AAS antenna [Absolute ACIR value]

	ACIR (dB)	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**
Ericsson	Throughput lost at Average											
	Throughput lost at 5%-tile											
CATT	Throughput lost at Average							3.165202	3.814549	4.575053	5.458766	6.477323
	Throughput lost at 5%-tile							2.151940	2.644977	3.314275	4.158239	5.164969
Qualcomm	Throughput lost at Average		2.0	2.5	3	3.5	4.5	5.0	5.5	7.5	9.0	
	Throughput lost at 5%-tile		0.7	1.0	1.5	1.8	2.0	2.4	3.0	4.0	5.0	

Table 4.3.2.2-3: UL throughput loss of victim BS for 10 - 10.5 GHz with omni antenna [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	Omni based BS	Average throughput loss in % (7 GHz)	0.1510	0.1892	0.2367	0.2957	0.3689	0.4593
		5%-tile throughput loss in % (7 GHz)	0.0214	0.0347	0.0362	0.0382	0.0407	0.1147
Nokia	Omni based BS	Average throughput loss in % (7 GHz)	0.30	0.38	0.47	0.59	0.74	0.92
		5%-tile throughput loss in % (7 GHz)	0.07	0.09	0.12	0.19	0.37	0.59

Table 4.3.2.2-3a: UL throughput loss of victim BS for 10 - 10.5 GHz with omni antenna [Absolute ACIR value]

	ACIR (dB)	21	20	19	18	17	16	15	14	13	12	11
Ericsson	Throughput lost at Average	1.8	2.2	2.8	3.5	4.3	5.3	6.6	8.1	9.9		
	Throughput lost at 5%-tile	1.2	1.5	1.9	2.4	3.1	3.9	4.8	5.8	7.4		
CATT	Throughput lost at Average		2.260160	2.793478	3.445105	4.238153	5.198868	6.356444	7.742539	9.400835	11.352258	13.623966
	Throughput lost at 5%-tile		1.537452	1.949692	2.435648	2.994580	3.642921	4.428238	5.338709	6.554238	8.002240	9.693387
Qualcomm	Throughput lost at Average		2.5	3.0	4.0	5.0	6.0	7.0	9	11.0	13.0	15.0
	Throughput lost at 5%-tile		0.8	1.0	1.5	1.8	2.2	2.5	3.5	5	5.5	7.0

Table 4.3.2.2-4: UL throughput loss of victim BS for 10 - 10.5 GHz with AAS antenna [Relative ACIR value]

Company	Simulation scenarios	Throughput loss	Relative ACIR offset					
			0	-1	-2	-3	-4	-5
ZTE	AAS based BS	Average throughput loss in % (7 GHz)	0.1536	0.1920	0.2395	0.2983	0.3709	0.4602
		5%-tile throughput loss in % (7 GHz)	0.0900	0.0904	0.0910	0.0918	0.0927	0.0938
Nokia	AAS based BS	Average throughput loss in % (7 GHz)	0.16	0.20	0.25	0.31	0.38	0.48
		5%-tile throughput loss in % (7 GHz)	0.00	0.01	0.01	0.01	0.02	0.02

Table 4.3.2.2-4a: UL throughput loss of victim BS for 10 - 10.5 GHz with AAS antenna [Absolute ACIR value]

	ACIR (dB)	21	20	19	18	17	16	15	14	13	12	11
Ericsson	Throughput lost at Average											
	Throughput lost at 5%-tile											
CATT	Throughput lost at Average							3.302668	3.975666	4.761144	5.670780	6.715829
	Throughput lost at 5%-tile							2.197258	2.860650	3.679917	4.658938	5.877432
Qualcomm	Throughput lost at Average		2.0	2.5	3.0	4.0	4.5	5.0	6.0	7.5	9.0	10.5
	Throughput lost at 5%-tile		0.5	1.0	1.5	1.8	2.0	2.4	3.0	4.0	4.8	5.5

Based on the above simulation results, the required UL ACIR for 6.425-7.125GHz and 10.0-10.5 GHz for indoor hotpot scenarios are in summarized in Table 4.3.2.1-5.

Table 4.3.2.2-5: UL simulation results for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz

UL simulations					
	ACIR (dB) for Indoor				Can we keep agreed UE ACLR (26-24) and BS ACS (42-40) for indoor?
	6.425-7.125GHz		10.0-10.5GHz		
Macro urban	25.9		23.9		
	Omni	AAS	Omni	AAS	
CATT	17	13	17	13	Yes
Huawei		<23.9		<23.9	Yes
Nokia	<ACIR - 5	<ACIR - 5	<ACIR – 5	<ACIR - 5	Yes
ZTE	<ACIR – 5	<ACIR – 5	<ACIR - 5	<ACIR - 5	Yes
Ericsson	17		17		Yes
Qualcomm	17	15	17	15	Yes

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, 100 MHz has been considered as a representative channel bandwidth that will be used.

5.3 Signal Bandwidth

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

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

Existing FR1 operating band unwanted emission mask is the same as for LTE (5 MHz ~ 20 MHz CBW). For both 6.425 - 7.125 GHz and 10.0 - 10.5 GHz band, it is foreseen the smaller channel bandwidth such as less than 50 MHz CBW is less attractive. Hence the basic limits for OOB emission mask should be updated as below. It is agreed that it does not mean that 50 MHz will be the minimum channel bandwidth when RAN4 specified the channel bandwidth and emission requirements.

Table 6.1.2-1: Wide Area BS operating band unwanted emission limits for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz for Category A

Frequency offset of measurement filter -3dB point, Δf	Frequency offset of measurement filter centre frequency, f_offset	Basic limits	Measurement bandwidth
0 MHz ≤ Δf < 50 MHz	0.05 MHz ≤ f_offset < 50.05 MHz	$-7\mathrm{dBm}-\frac{7}{50}\left(\frac{f_{offset}}{MHz}-0.05\right)$	100 kHz
50 MHz ≤ Δf < min(100 MHz, Δf_{max})	50.05 MHz ≤ f_offset < min(100.05 MHz, f_offset_{max})	-14 dBm	100 kHz
100 MHz ≤ Δf ≤ Δf_{max}	100.5 MHz ≤ f_offset < f_offset_{max}	-13 dBm	1MHz

Table 6.1.2-2: Wide Area BS operating band unwanted emission limits for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz for Category B

Frequency offset of measurement filter -3dB point, Δf	Frequency offset of measurement filter centre frequency, f_offset	Basic limits	Measurement bandwidth
0 MHz $\leq \Delta f <$ 50 MHz	0.05 MHz $\leq$ f_offset < 50.05 MHz	$-7\mathrm{dBm}-\frac{7}{50}\left(\frac{f_{offset}}{MHz}-0.05\right)$	100 kHz
50 MHz $\leq \Delta f <$ min(100 MHz, Δf_{max})	50.05 MHz $\leq$ f_offset < min(100.05 MHz, f_offset_{max})	-14 dBm	100 kHz
100 MHz $\leq \Delta f \leq \Delta f_{max}$	100.5 MHz $\leq$ f_offset < f_offset_{max}	-15 dBm	1MHz

6.1.3 ACLR

According to the simulation results in clause 4.3, it is agreed to specify 38 dB ACLR for 6.425 - 7.125 GHz and 37 dB ACLR for 10.0 - 10.5 GHz.

For 6425 – 7125 MHz and 10 - 10.5 GHz, the ACLR should be higher than the value specified in table 6.1.3-1.

Table 6.1.3-1: Base station ACLR limit

BS channel bandwidth of lowest/highest carrier transmitted $BW_{Channel}$ (MHz)	BS adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted	Assumed adjacent channel carrier (informative)	Filter on the adjacent channel frequency and corresponding filter bandwidth	ACLR limit
20, 25, 30, 40, 50, 60, 70, 80, 90,100	$BW_{Channel}$	NR of same BW (Note 2)	Square (BW_{Config})	38 dB for 6425-7125 MHz 37 dB for 10-10.5 GHz
	2 x $BW_{Channel}$	NR of same BW (Note 2)	Square (BW_{Config})	38 dB for 6425-7125 MHz 37 dB for 10-10.5 GHz
NOTE 1: $BW_{Channel}$ and BW_{Config} are the BS channel bandwidth and transmission bandwidth configuration of the lowest/highest carrier transmitted on the assigned channel frequency. NOTE 2: With SCS that provides largest transmission bandwidth configuration (BW_{Config}).				

6.1.4 Spurious emissions

From the Rel-15 discussion, the offset Δf_{OBUE} for the boundary between OBUE and spurious emissions is the most demanding parameters for OTA or Hybrid limits AAS BS. Based on the implementation evaluation and regulatory consideration, it is agreed to adopt Δf_{OBUE} = 100 MHz for both 6.425 - 7.125 GHz and 10.0 - 10.5 GHz.

Regarding spurious emission requirements for 6.425 - 7.125 GHz, as this frequency range is still within FR1 band definition, it is agreed to reuse the existing spurious emission requirements defined in TS 38.104 [3] and further update needed are to define upper frequency of Tx spurious emission to be 26 GHz instead of 5th harmonic of DL frequency according to ITU-R SM 329-10 [5] recommendation. The general spurious emissions for 6.425-7.125 GHz is defined in Table 6.1.4-1 and Table 6.1.4-3.

Regarding spurious emission requirements for 10-10.5 GHz, according to ERC 74-01 report [6], the lower frequency limit could be defined as 30 MHz. Without any specified spurious limit for AAS BS in between 6 and 24 GHz in ERC 74-01 [6], in relation to the existing frequency ranges specified, with observations of the foreseen implementation of AAS BS and how they are to be deployed and used, the spurious limits specified for above 24 GHz with upper frequency limited to 26 GHz will be used for 10.0-10.5 GHz as defined in Table 6.1.4-2 and Table 6.1.4-4.

Table 6.1.4-1: BS spurious emission limits for 6.425 - 7.125 GHz for Category B

Spurious frequency range	Basic limit	Measurement bandwidth
9 kHz – 150 kHz	-36 dBm	1 kHz
150 kHz – 30 MHz		10 kHz
30 MHz – 1 GHz		100 kHz
1 GHz – 26 GHz	-30 dBm	1 MHz

Table 6.1.4-2: BS spurious emission limits for 10 - 10.5 GHz for Category B

Spurious frequency range	Limit	Measurement bandwidth
30 MHz – 1 GHz	-36 dBm	100 kHz
1 GHz – 18 GHz	-30 dBm	1 MHz
18 GHz – 26 GHz	-20 dBm	10 MHz

Table 6.1.4-3: BS spurious emission limits for 6.425 - 7.125 GHz for Category A

Spurious frequency range	Basic limit	Measurement bandwidth	Notes
9 kHz – 150 kHz	-13 dBm	1 kHz	Note 1
150 kHz – 30 MHz		10 kHz	Note 1
30 MHz – 1 GHz		100 kHz	Note 1
1 GHz 12.75 GHz		1 MHz	Note 1, Note 2
12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz		1 MHz	Note 1, Note 2, Note 3
NOTE 1: Measurement bandwidths as in ITU-R SM.329, s4.1. NOTE 2: Upper frequency as in ITU-R SM.329, s2.5 table 1. NOTE 3: This spurious frequency range applies only for operating bands for which the 5th harmonic of the upper frequency edge of the DL operating band is reaching beyond 12.75 GHz.			

Table 6.1.4-4: BS spurious emission limits for 10 - 10.5 GHz for Category A

Frequency range	Limit	Measurement Bandwidth	Note
30 MHz – 1 GHz	-13 dBm	100 kHz	Note 1
1 GHz – 2nd harmonic of the upper frequency edge of the DL operating band		1 MHz	Note 1, Note 2
NOTE 1: Bandwidth as in ITU-R SM.329, s4.1 NOTE 2: Upper frequency as in ITU-R SM.329, s2.5 table 1.			

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.

Table 6.1.5-1: The Total Radiated Power

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

Table 6.2.1-1: 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 7 GHz was agreed to be 6 dB (11 dB for Medium Range BS and 14 dB 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

The in-band blocking requirement should apply from $F_{UL,low}$ - Δf_{OOB} to $F_{UL,high}$ + Δf_{OOB}, excluding the downlink frequency range of the FDD *operating band*. It is agreed to adopt Δf_{OOB} = 100 MHz for both 6.425 - 7.125 GHz and 10.0 - 10.5 GHz. The in-band blocking levels are reused from existing FR1 requirements.

Table 6.2.3-1: Base station general blocking requirement

BS channel bandwidth of the lowest/highest carrier received (MHz)	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Interfering signal centre frequency minimum offset from the lower/upper Base Station RF Bandwidth edge or sub-block edge inside a sub-block gap (MHz)	Type of interfering signal
20, 25, 30, 40, 50, 60, 70, 80, 90, 100	$P_{REFSENS}$ + 6 dB	Wide Area BS: -43 Medium Range BS: -38 Local Area BS: -35	±30	20 MHz DFT-s-OFDM NR signal 15 kHz SCS, 100 RBs
NOTE: $P_{REFSENS}$ depends on the RAT.				

The out-of-band blocking requirement apply from 1 MHz to $F_{UL,low}$ - Δf_{OOB} and from $F_{UL,high}$ + Δf_{OOB} up to 12750 MHz for FR1 bands. -15 dBm CW interfering signal is reused for out-of-band blocking for both 6.425-7.125GHz and 10.0-10.5GHz.

6.2.4 ACS

According to the simulation results in clause 4.3, it is agreed to specify 42 dB ACS for 6.425 - 7.125 GHz and 40 dB ACLR for 10.0 - 10.5 GHz.

7 UE parameters

7.1 Transmitter characteristics

7.1.1 Power dynamic range

The minimum controlled output power of the UE is defined as the power in the channel bandwidth for all transmit bandwidth configurations (resource blocks), when the power is set to a minimum value. For existing FR1 bands, the minimum output power is -33 dBm for 100 MHz channel bandwidth. The minimum output power can be reused for both frequency ranges, 6.425 - 7.125 GHz and 10.0 - 10.5 GHz, i.e. power dynamic range is 56 dB for 100 MHz channel bandwidth.

7.1.2 Spectral mask

The spectral mask for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz is defined in below table which is relaxed general NR FR1 spectrum at the F_{OOB} edge ± 0 – 5 MHz by 3 dB.

Table 7.1.2-1: Spectrum emission mask for 6.425 - 7.125 GHz and 10.0 - 10.5 GHz

	Spectrum emission limit (dBm) / Channel bandwidth										
Δf_{OOB} (MHz)	**20 MHz**	**25 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**60 MHz**	**70 MHz**	**80 MHz**	**90 MHz**	**100 MHz**	**Measurement bandwidth**
± 0-1	-10	-10	-10	-10							1 % channel bandwidth
± 0-1					−21	−21	−21	−21	−21	−21	30 kHz
± 1-5	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	1 MHz
± 5-6	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	
± 6-10											
± 10-15											
± 15-20											
± 20-25	-25										
± 25-30		-25									
± 30-35			-25								
± 35-40											
± 40-45				-25							
± 45-50											
± 50-55					-25						
± 55-60											
± 60-65						-25					
± 65-70											
± 70-75							-25				
± 75-80											
± 80-85								-25			
± 85-90											
± 90-95									-25		
± 95-100											
± 100-105										-25	

For the last 5 MHz of UE SEM, it is agreed that we might revisit the value pending MRP definition in WI phase.

7.1.3 ACLR

According to the simulation results in clause 4.3, it is agreed to specify 26 dB ACLR for 6.425 - 7.125 GHz and 24 dB ACLR for 10.0 - 10.5 GHz.

7.1.4 Spurious emissions

The general spurious emissions defined in TS 38.101-1 [4] clause 6.5.3.1 can apply to both frequency ranges, 6.425 - 7.125 GHz and 10.0 - 10.5 GHz.

- 30 MHz ≤ f ≤ 1 GHz: - 36 dBm / 100 kHz
- 1 GHz ≤ f ≤ 26 GHz: - 30 dBm / 1 MHz

7.1.5 Maximum output power

TR 38.820 indicates that 23 dBm is feasible at 10 - 10.5 GHz and this is an assumption for co-existence analysis. Hence the UE maximum output power for the considered frequency ranges could be 23 dBm. Other UE power classes are not precluded for both frequency ranges, 6.425 - 7.125 GHz and 10.0 - 10.5 GHz.

7.1.6 Average output power

It was agreed the average output power won't be mentioned in the reply LS to WP5D.

7.2 Receiver characteristics

7.2.1 Noise figure

The noise figure of 9 dB is the baseline assumption and 13 dB is the optional assumption for co-existence study for 6425 – 7125 MHz and 10 - 10.5 GHz.

A noise figure in the [9, 13] dB interval was finally agreed for reporting to ITU WP5D sharing studies. Note that the noise figure value in [9, 13] dB interval should be used only for WP5D response. The actual noise figure to be used to define RF requirements should be further studied in the WI phase.

7.2.2. Sensitivity

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

7.2.3 Blocking response

The blocking characteristic specified in clause 7.6 of TS 38.101-1 [4] for frequency larger than 3300 MHz could be applied for 6425 – 7125 MHz and 10 - 10.5 GHz.

7.2.4 ACS

According to the simulation results in clause 4.3, adjacent channel selectivity (ACS) is agreed as 32 dBc for 6425 – 7125 MHz and 31 dBc for 10 - 10.5 GHz.

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	$A_A(\theta,\varphi) = A_E(\theta,\varphi) + 10\log_{10}\left(\left\lvert\sum_{m=1}^{M}\sum_{n=1}^{N} w_{m,n}v_{m,n}\right\rvert^2\right)$, where $v_{m,n} = \exp\left(j2\pi\left((m-1)\frac{d_v}{\lambda}\cos(\theta) + (n-1)\frac{d_h}{\lambda}\sin(\theta)\sin(\varphi)\right)\right)$ $w_{m,n} = \frac{1}{\sqrt{MN}}\exp\left(j2\pi\left((m-1)\frac{d_v}{\lambda}\sin(\theta_{etilt}) - (n-1)\frac{d_h}{\lambda}\cos(\theta_{etilt})\sin(\varphi_{escan})\right)\right)$	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 determined by calculating the directivity from a given geometry including beam widths. The element directivity can be calculated based on the pattern described by Table 8.1.2-1 in dBi as:

$$G_{E,max} = D_{E,max} - L_E \qquad (8.1.2\text{-}1)$$

, where the peak directivity $D_{E,max}$ is calculated from given values on φ_{3dB}, θ_{3dB}, d_h and d_v as:

$$D_{E,max} = 10\log_{10}\left(\frac{4\pi[A_{lin}(\theta,\varphi)]_{\max}}{\int_{-\pi}^{\pi}\int_{0}^{\pi}A_{lin}(\theta,\varphi)\sin(\theta)\mathrm{d}\theta\mathrm{d}\varphi}\right) \quad (8.1.2\text{-}2)$$

, where $A_{lin}(\theta,\varphi)$ is defined in linear scale as:

$$A_{lin}(\theta,\varphi) = 10^{\frac{A(\theta,\varphi)}{10}} \quad (8.1.2\text{-}3)$$

Table 8.1.2-1: BS array antenna parameters

Parameter	**Macro Sub-urban**	**Macro Urban**	**Micro Urban**	**Small cell indoor**
A_m (dB)	30	30	30	30
SLA_v (dB)	30	30	30	30
φ_{3dB} (deg.)	90	90	90	90
θ_{3dB} (deg.)	65	90	90	90
$G_{E,max}$ (dBi)	6.4	5.5	5.5	5.5
L_E (dB)	2.0	2.0	2.0	2.0
(M, N)	(16, 8)	(16, 8)	(8,8)	(4, 4)
Number of supported polarizations, P	2	2	2	2
d_h (m)	0.5λ	0.5λ	0.5λ	0.5λ
d_v (m)	0.7λ	0.5λ	0.5λ	0.5λ
Horizontal coverage range (deg.)	+/- 60	+/- 60	+/- 60	N/A
Vertical coverage range (deg.)	90 to 100	90 to 120	90 to 120	N/A
Conducted power (before ohmic loss) per antenna element, P_{tx} (dBm)	22 (Note 4)	22 (Note 4)	16 (Note 5)	9 (Note 6)
Mechanical downtilt (deg.)	6	10	N/A	N/A (Note 7)

Note 1: MxN means there are M vertical and N horizontal elements
Note 2: L_E is included in $G_{E,max}$
Note 3: The vertical coverage range includes the mechanical downtilt.
Note 4: The conducted power per element assumes 16x8x2 elements (i.e. power per H/V polarized element).
Note 5: The conducted power per element assumes 8x8x2 elements (i.e. power per H/V polarized element).
Note 6: The conducted power per element assumes 4x4x2 elements (i.e. power per H/V polarized element).
Note 7: Boresight direction is perpendicular to the ceiling.

Based on the array parameters sets fundamental characteristics such as peak EIRP can be derived. For radiated power considerations peak Equivalent Isotropic Radiated Power (EIRP) is calculated in logarithmical scale calculated as:

$$EIRP = P_{tx} + G_{E,max} + 20log_{10}(MN) + 10log_{10}(P) \quad \text{(Eq. 8.1.2-4)}$$

, where P, M, N, P_{tx}, $G_{E,max}$ is given by Table 8.1.2-1.

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 - 10.5 GHz range this applies. The UE will most likely therefore have a conducted interface with an assumed isotropic radiation pattern antenna and no beamforming.

9 Other information relevant for the sharing and compatibility studies

9.1 Spatial emission

Traditionally, antenna data sheets provide information on not only the antenna peak gain in the intended direction but also the gain in unwanted directions. To describe characteristics in unintended directions the following metrics are used:

1. The antenna front-to-back ratio, which is the power ratio of radiative power in the main beam directions to the power radiated in the backward direction.

2. The antenna side lobe ratio, which is the power ratio between the main beam direction and the power of the strongest side lobe.

However, for an AAS base station it is clear that these traditional metrics of antenna characteristics are not directly relevant, since an AAS base station has the ability to adaptively shape the spatial characteristics to maintain optimum network throughput. Therefore, additional declarations were defined in TS 38.141-2 [x], Annex G. The additional declarations include information on how much power is radiated outside the intended coverage region in relation to the power radiated with in the intended coverage region.

9.2 Interference management

9.2.0 General

Given an antenna array with M multiplied by N identical elements, the radiation pattern of the array antenna can be described according to the pattern multiplication theorem as:

$$R(\theta,\varphi) = R_E(\theta,\varphi)R_A(\theta,\varphi) \qquad \text{(Eq. 9.2.0-1)}$$

, where R_E is the radiation pattern for the array elements and R_A is the radiation pattern associated to the array factor. The element patten, $R_E(\theta,\varphi)$ is based on a parameterized Gaussian shaped element, with floors to model for side-lobe levels and front-to-back ratio. The element peak gain is directivity normalized, hence the peak element gain $G_{E,max}$, element loss L_E and half power beam widths θ_{3dB} and φ_{3dB} should be selected carefully to maintain correct antenna gain, as described in subclause 8.1.2.

It can be noticed that both the element factor and the array factor can be used to shape the composite radiation pattern. The element pattern can be used to suppress side-lobe characteristics. For a limited steering range, a sub-array element can be used to suppress side-lobes better than a single element configuration. Typically for an AAS base station implementation the element radiation pattern and the array factor are customized to optimize the coverage within a specific coverage range for a given deployment scenario.

For a general array antenna, the array factor radiation pattern for transmitting array antenna with MN element per polarization can be expressed as:

$$R_A(\theta,\varphi) = \left|\sum_{n=1}^{MN} w_n e^{j\mathbf{kr}}\right|^2 \qquad \text{(Eq. 9.2.0-2)}$$

, where

- w_n is the complex array excitation,
- k is the wave vector of the transmitted wave, and
- r is the element location matrix.

From Eq. 9.2.0-1 it can be noticed that both the element factor and the array factor can be used to shape the composite radiation pattern, which will be further described later. The element pattern can be used to suppress side-lobe characteristics. Typically for an AAS base station implementation the element radiation pattern and the array factor are customized to optimize the coverage within a specific coverage range and coexistence with other services for a given deployment scenario.

For an array antenna with element separation 0.5λ or less the first side-lobe is the strongest. For uniform amplitude excitation the first side lobe power level is approximately 13 dB below the main beam power level. For array antenna with element separation larger than 0.5λ folding effects will create grating lobes in the side lobe region. The angular location of the grating lobe is determined by the element separation and steering angle and the power level of the grating lobes is determined by the element factor. As an example, in Figure 9.2.0-1, the impact of element separation is visualised for an 8x8 element Uniform Rectangular Array (URA) where the vertical beam steering directions is set to 130 degrees.

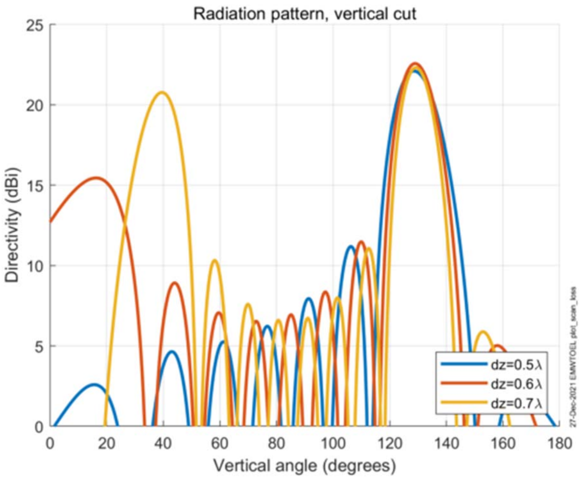

Figure 9.2.0-1: Impact of element separation on vertical radiation pattern

The array factor described by Eq. 9.2.0-2 will produce maximum directivity for the wanted carrier for which the system is calibrated minimizing the excitation error. For unwanted emission outside the carrier the directivity will roll-off gradually to a point where the array factor directivity is lost.

The relation between array excitation correlation and directivity can be modelled as described in TR 37.840, subclause 5.4.4.1.4. The average radiation pattern for different correlation values is plotted in Figure 9.2.0-2. The maximum directivity is achieved for correlation equal to 1 and the minimum directivity equal to the element directivity is achieved for correlation equal to 0.

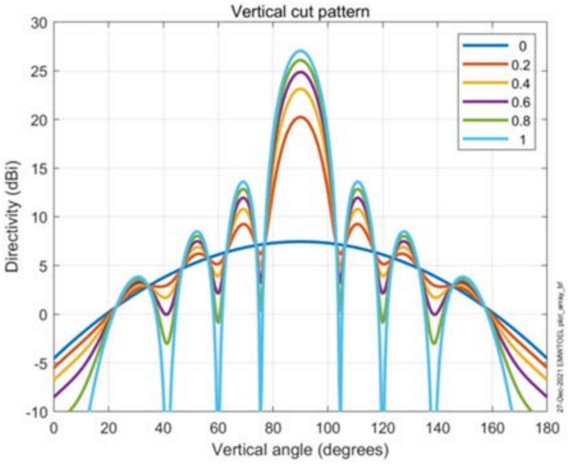

Figure 9.2.0-2: Relation between excitation correlation and directivity

To be able to conduct accurate coexistence analysis the unwanted emission directivity roll-off characteristics is required. The decorrelation effect in an array antenna will together with traditional filters provide suppression of unwanted emission EIRP levels required to guarantee coexistence with other adjacent services.

There is no single general solution available to mitigate all possible interference situations. Depending on situation one or more mitigation techniques described in following section can be used to guarantee coexistence between AAS base stations and other services operating in adjacent spectrum.

9.2.1 Beam nulling

Beam nulling technology is used to suppress the unwanted spatial emission by inserting nulls in the radiation pattern for the direction of the interference. One typical applicable scenario is multiple beams transmission. As shown in Figure 2 as one example, Beam 1 is the serving beam of UE 1 but the side lobe of beam 1 would interfere the UE2. The SINR for UE2 will be affected. In order to support high order modulation scheme such as DL 256 QAM, using beam nulling technology, a null can be placed at the direction to UE2 for beam 1. The weight of each antenna array of beam 1 can be obtained by specific algorithms so that SINR of beam1 is maximized in the direction to UE1 and the transmission power in the main lobe is maintained, and the side lobe are suppressed in the direction to UE2. Beam nulling can also be used in the inter-cell or inter system scenarios as long as the location or direction of the protected station is known.

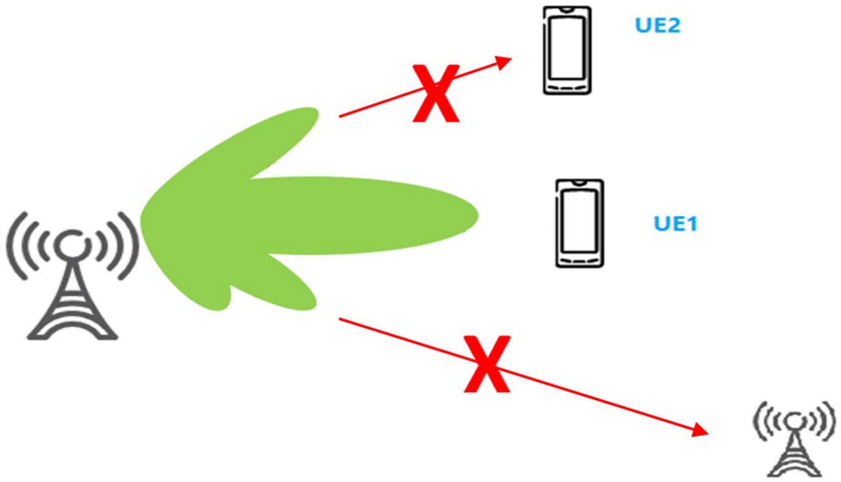

Figure 9.2.1-1: Side lobe interference

9.2.2 Amplitude weighting/tapering

AAS offer a wide range of opportunities on optimizing the directivity patterns through amplitude and phase control. High directivity antenna array also has side lobes which are often undesirable since they may cause intra-cell or inter-cell interference. Side lobe levels can be reduced via tailoring the amplitude across the antenna array which is often referred as amplitude weighting technology. Whilst amplitude weighting/tapering reduces the side lobes it also makes the main lobe wider and hence reduces gain. It needs tradeoff between antenna gain and side lobe suppression. For example:

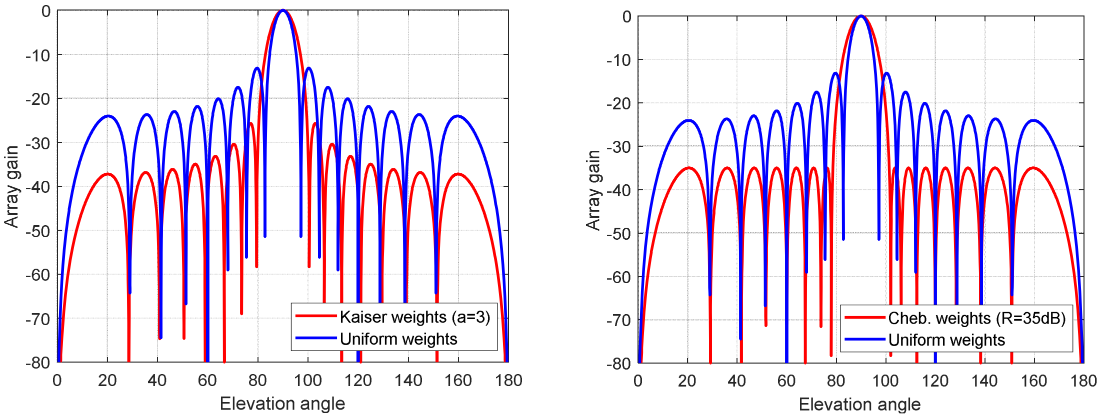

Figure 9.2.2-1: Examples for amplitude weighting/tapering: left: Kaiser (a=3), right: Chebwin (R=35dB)

Applying tapering electrically for the complete array will results in a main beam peak EIRP drop due to the amplitude window itself. In addition, the directivity will also reduce as an effect of a wider beam, as seen in Figure 9.2.2-1.

If tapering is applied at sub-array level the power can be redistributed between elements in the sub-array, hence no power loss due to tapering will be introduced.

9.2.3 Asymmetric side lobe shaping

In addition to beam tapering, it is possible to manipulate the amplitude and the phase of the window (for example using modified Taylor series) to modify the side lobe levels asymmetrically. This technique is widely used with passive BS arrays to make the ground side lobes larger to fill in the angles between the main beam and the antenna. The same technique can be used to minimise radiation in specified unwanted directions. For example:

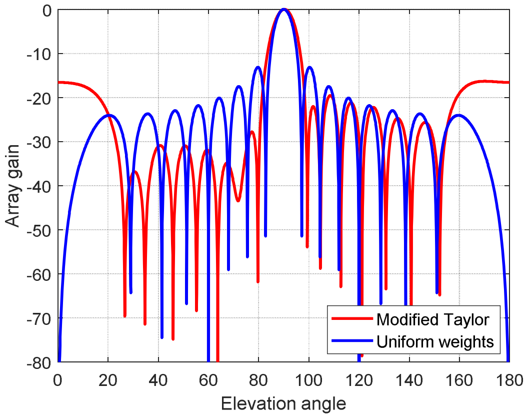

Figure 9.2.3-1: Example for modified Taylor window

9.2.4 Beam restrictions

Depending on base station implementation and intended deployment scenario different types of beamforming schemes can be considered. For AAS base stations operating within FR1 (410 to 7125 MHz) typically codebook or reciprocity-based beamforming will be used for transmitted down link beams, while for AAS base stations operating within FR2 (24250 to 52600 MHz) typically grid of beams beamforming concepts will be used for transmitted downlink beams. By restricting the angular range for which the beams can be transmitted, interference power in unintended directions can be limited. For codebook-based beamforming codes in the codebook associated to large beam steering angles can be disabled and prohibited from being used for transmission. The same principle can be adopted for grid of beams systems. For reciprocity-based beam forming, modification to the applied excitations needs to be carried out to avoid steering directions associated to generation of unintended interference in the side lobe region.

By limiting the vertical beam steering range within a certain interval, it is possible to control the level of the grating lobe to a level similar to other sidelobes. Not using specific beams with large down tilts angles does not affect the network performance since, other beams can be used by proving sufficient power using sidelobes close to the base station. The vertical range in which the side lobe level is guaranteed will depend on the array antenna geometry used by a specific base station. As an example (4x8 array, with 3x1 sub-array), in Figure 9.2.4-1 the results of beam restrictions are visualised. In the left figure all beams are plotted, while in the right figure beams causing interference towards the sky have been disabled.

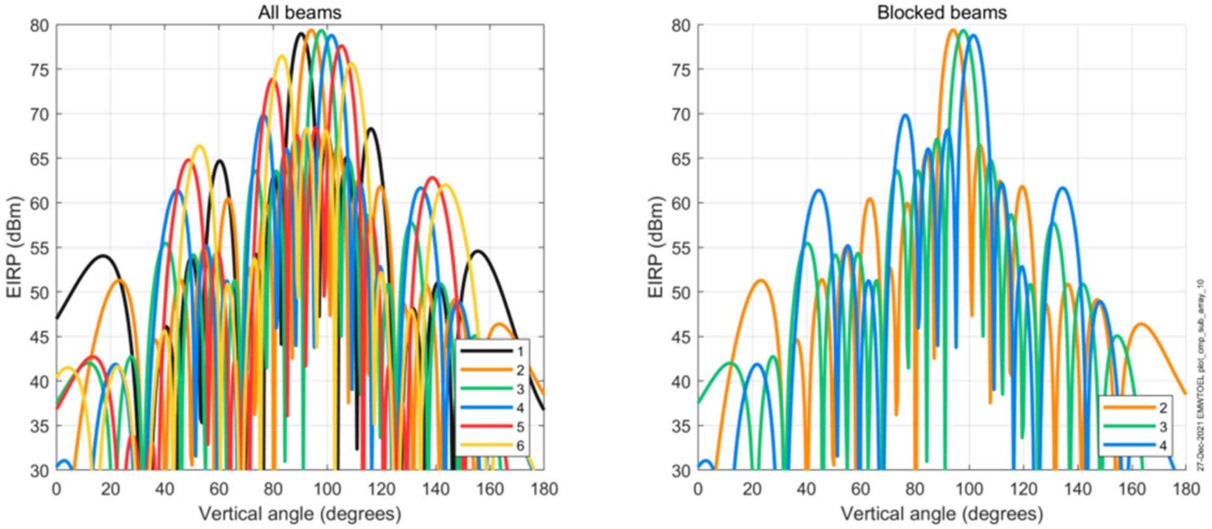

Figure 9.2.4-1: Controlling interference using beam restrictions

9.2.5 Irregular array geometries

Instead of using uniform array geometries where all the elements are assumed to be equal and the elements are located in a rectangular lattice with given vertical and horizontal element spacing, irregular array geometries can be used to suppress unintended radiation in the side lobe region. One example is when the grating lobe response is suppressed by shifting the columns with a vertical column offset. The offset can be selected in a way so that the grating lobe reduces. Instead of concentrating the power in one specific direction the grating lobe power is spread out in the sidelobe region. The penalty is that the array antenna aperture size slightly growth compared to the non-shifted case, as showed in Figure 9.2.5-1. Other examples on irregular array structures are where different element factor is used for different locations in the array.

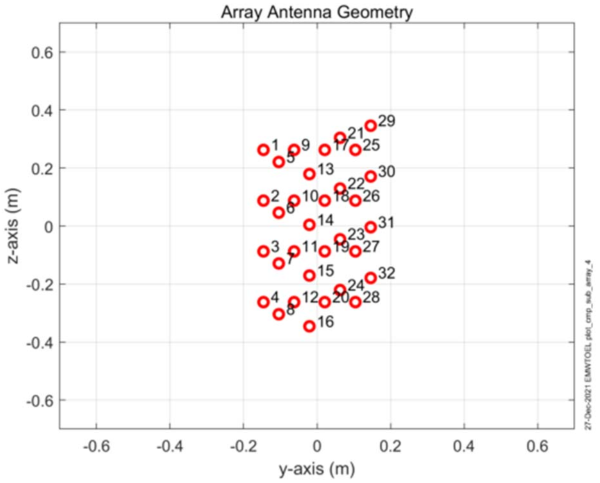

Figure 9.2.5-1: Offset applied to columns

As an example (4x8 array, 3x1 sub-array), in Figure 9.2.5-2 the vertical radiation pattern for 0 degrees down tilt (reference direction) and 12 degrees down tilt (maximum down-tilt direction) is visualized for uniform structure and irregular structure. For the irregular structure elements columns have been shifted up and down by an offset vector equal to [0, -0.5, 0, -1, 0, 0.5, 0, 1] wavelengths.

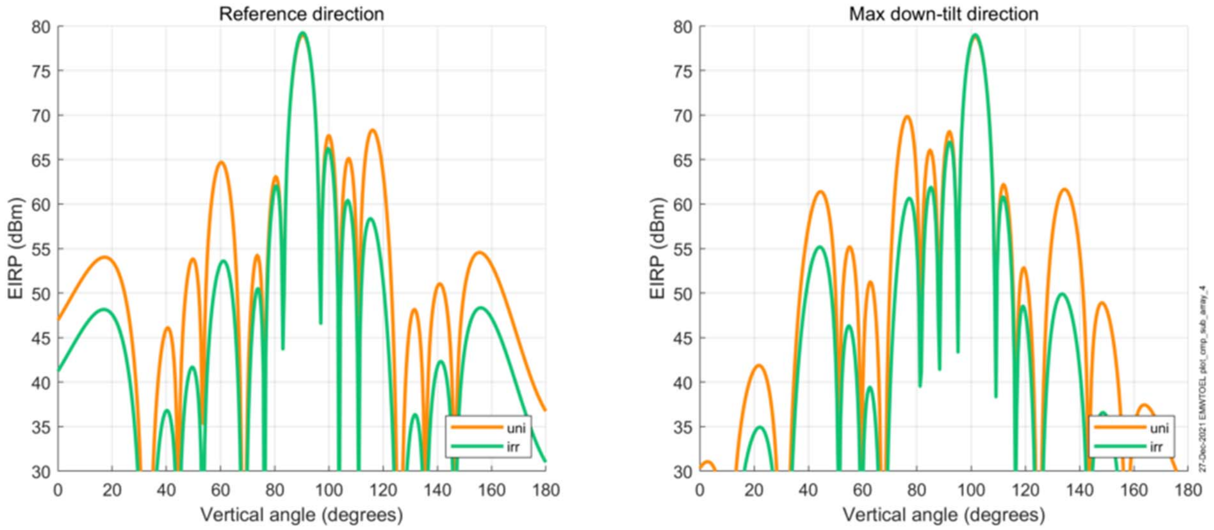

Figure 9.2.5-2: Irregular array geometries

It can be noticed that by applying the offset vector the grating lobe is spread out spatially suppressing the interference in a specific direction.

Annex A (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
2021-02	RAN4#98-e	R4-2101494				Agreed Text Proposal in RAN4#97-e: R4-2016903 Maintenance TP to TR38.921 R4-2016906 TP to TR38.921 : BS spurious emission R4-2016901 TP to TR 38.921: Clarification of system level simulation assumptions for study on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz R4-2017817 TP to TR38.921: uplink ACIR model R4-2014478 TP to TR 38.921: Clarification of BS array antenna element peak gain for study on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz R4-2016902 TP to TR 38.921: Correction to antenna parameter table in clause 3 and sub-clause 8.1 R4-2016907 TP on spatial emission and interference mitigation	0.3.0
2021-03	RAN#91-e	RP-210463				1. Agreed Text Proposal in RAN4#98-e: R4-2103408 TP to TR 38.921 UE transmitter requirements R4-2103398 TP to TR 38.921: BS remaining parameters R4-2103107 TP to TR 38.921 summary of simulation results R4-2101793 TP to TR 38.921: Clarification of BS maximum transmit power on system level simulation assumptions for study on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz R4-2103109 TP to TR 38.921: Addition of in-door antenna parameters and correction to model in subclause 8.1 1. Editorial changes to align the TR with drafting rules. 2. Submitted to RAN #91-e for 1-step Approval.	1.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2021-03	RAN#91					Approved by plenary – Rel-17 spec under change control	17.0.0
2022-03	RAN#95	RP-220341	0002	1	F	CR to TR 38.921: Update of information about interference management in subclause 6.1.4, 6.1.5, 8.1.2 and 9.2	17.1.0

History

Document history		
V17.1.0	May 2022	Publication