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TECHNICAL REPORT

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Contents

Foreword

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

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shall not	indicates an interdiction (prohibition) to do something

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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

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 to capture the background on new BS EIRP mask requirement for NR band n104 for protection of Fixed Satellite Service (FSS) UL within 6425 to 7125MHz and how to conduct the conformance testing for the compliance of the new BS EIRP mask requirement.

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

[2] ITU World Radiocommunication Conference 2023 (WRC-23) Final Acts, Resolution 220

3 Definitions, symbols and abbreviations

3.1 Definitions

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].

beam: beam (of the antenna) is the main lobe of the radiation pattern of an *antenna array*

NOTE: For certain BS *antenna array*, there may be more than one beam.

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

BS type 1-H: NR base station operating at FR1 with a *requirement set* consisting of conducted requirements defined at individual *TAB connectors* and OTA requirements defined at RIB

BS type 1-O: NR base station operating at FR1 with a *requirement set* consisting only of OTA requirements defined at the RIB.

3.2 Symbols

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

θ	elevation angle above horizon (defined between 0° and 90°)

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].

EIRP	Effective Isotropic Radiated Power
EEIRP	Expected EIRP
FSS	Fixed Satellite Service
NR	New Radio
RF	Radio Frequency

4 Background

The frequency band of 6425 to 7125 MHz and parts thereof was identified for International Mobile Telecommunications (IMT) use by WRC 23 in different ITU region as in the RR Footnotes 5.457D, 5.457E and 5.457F with associated technical condition of limits on the Expected Equivalent Isotropically Radiated Power (EEIRP) spectral density of IMT base-stations for protecting Earth-to-space fixed satellite services (FSS) as in the ITU Radio Regulation Resolution 220 (WRC-23). The EEIRP is a new regulatory requirement and is specified as a mask for over the horizon emissions. The Annex to the Resolution 220 (WRC-23) [2] outlines a theoretical calculation of EEIRP of an International Mobile Telecommunications (IMT) base station for assessing the compliance of the IMT base station equipment with the limit on EEIRP.

The aim of this report is the following:

- To capture the technical background information relevant for the core requirement in BS RF core specification.
- To capture the technical background information relevant for the test procedures in the conformance test specification.

Having the requirement included in a 3GPP standard would guarantee a harmonized terminology and conformance test method. Eventually, the concept for conformance testing can be adopted to similar situations with co-channel spectrum sharing between IMT and FSS UL.

The ITU Radio Regulations were updated at WRC-23 with Resolution 220 that contains this EEIRP technical requirement for a single IMT BS where it calculates the average radiating power for each of the seven elevation bins. Since the protection of FFS UL receiver is based on aggregated power from many base stations oriented in different directions over a large satellite footprint, the technical requirement can be easily broken down to a single BS based on the average EIRP emissions from a single BS, as used during normal operation. WRC-23 decided to adopt a concept where the average EIRP emissions are extracted based on measuring the EIRP emissions for several test beams over the specified elevation bins. The choice of this test beam set should be representative of the BS normal operation.

5 RF requirement

OTA spatial emission requirement is defined to set upper limits on radiated power in specific directions. This requirement shall be applied to BS operating in band n104 to protect FSS (Earth-to-Space) satellite receiver.

For BS type 1-H and BS type 1-O operating in band n104, the Expected EIRP (EEIRP) in the frequency range 6425 to 7075 MHz, shall not exceed the limits specified in table 5-1.

The expected EIRP (EEIRP) is defined as the average value of the EIRP, with the averaging being performed:

– over azimuth angles from −180° to +180° with reference to BS horizontal boresight, and

– over the specified angular range $\theta_{HLi} \leq \theta < \theta_{HHi}$, above the horizon, and

– over the supported beam directions.

Table 5-1: EEIRP limits as function of elevation above horizon

Bin number	Elevation angular range $\theta_{HLi} \leq \theta < \theta_{HHi}$ (Degrees)	EEIRP limit (dBm/MHz)
1	$0 \leq \theta < 5$	27
2	$5 \leq \theta < 10$	23
3	$10 \leq \theta < 15$	19
4	$15 \leq \theta < 20$	18
5	$20 \leq \theta < 30$	16
6	$30 \leq \theta < 60$	15
7	$60 \leq \theta < 90$	15
NOTE: The requirement shall apply to all supported mechanical tilts.		

The definitions of elevation angle θ_{HLi} and θ_{HHi} are illustrated in Figure 5-1.

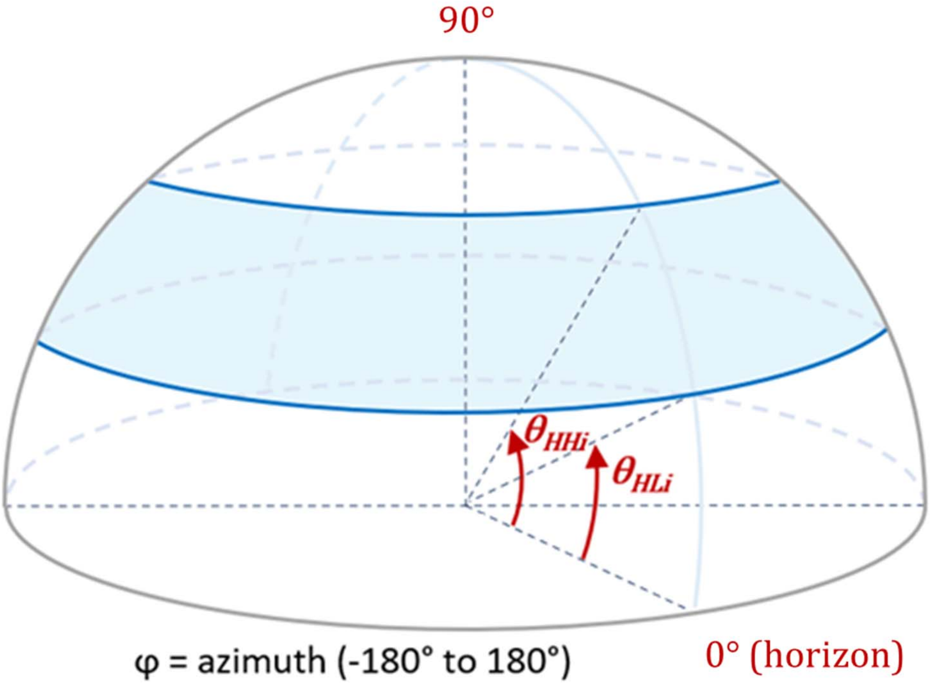


Figure 5-1: Definitions of θ_{HLi} and θ_{HHi} angles.

6 Conformance testing requirement and procedures

6.1 General

The key requirements of ITU Resolution 220 [2] are:

1. compliance with values of Expected EIRP (EEIRP) above the horizon and
2. providing a calculation methodology to the theoretical procedure given in the Annex to ITU Resolution 220 [2].

6.2 The calculation for EEIRP mask

6.2.1 General

The EEIRP calculation is based on two averaging processes:

- Averaging over the test beam directions in clause.
- Averaging over horizontal and vertical angles within specified vertical angles bins

These two averaging processes are inter-related and should not be viewed as the order in which the calculation is done.

The required sampling resolution for the EIRP pattern measured per test beam is described in clause 6.4.

6.2.2 Angle definition

The angles in the spherical coordinate system used in this section is as shown in figure 6.2.2-1, and the arrow indicates the direction of increasing angle from the base station perspective:

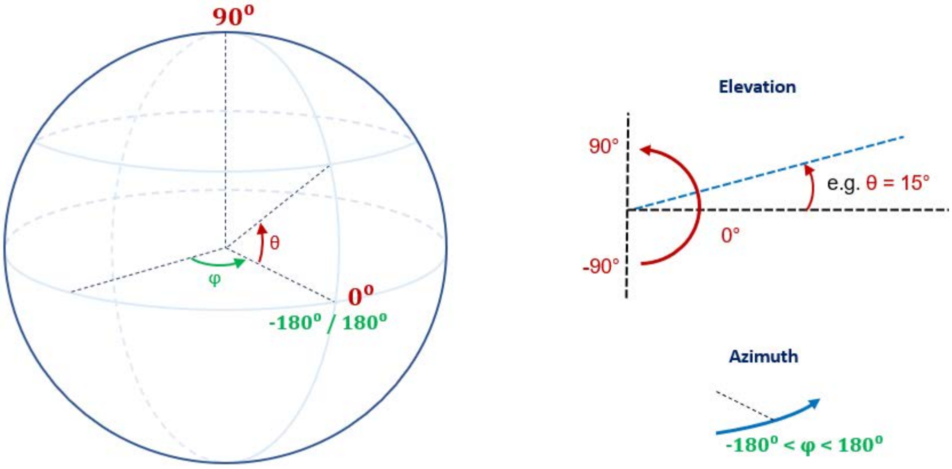


Figure 6.2.2-1: Angle definition for EEIRP

6.2.3 Averaging over horizontal and vertical angles

One of the average calculations for the EEIRP is averaging the EIRP over horizontal and vertical angles. There are seven elevation angular ranges with different elevation bin sizes. Each bin is effectively a spherical strip (or spherical cap for the last range) bounded by θ_{HLi} and θ_{HHi} as shown in Figure 6.2.3-1.

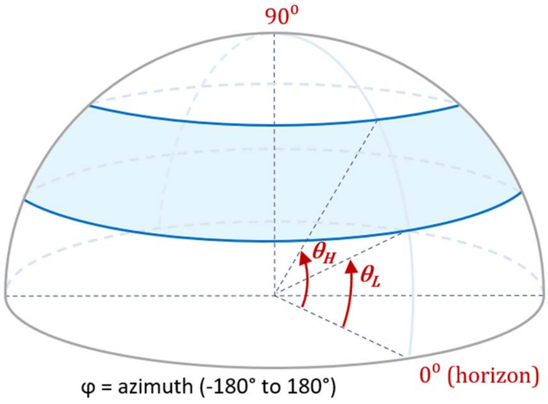


Figure 6.2.3-1: Spherical strip (blue shade)

The EEIRP for each elevation bin is defined as:

$$EEIRP(\theta_L\,,\theta_H) = \frac{1}{2\pi(sin\theta_H - sin\theta_L)}\int_{\theta_L}^{\theta_H}\int_{-\pi}^{\pi} EIRP(\theta,\varphi)\,cos(\theta)\,d\varphi\,d\theta \qquad , \qquad (1)$$

The $EIRP(\theta,\varphi)$ is be measured as an average pattern over a number of test beams in discrete steps and equation (1) needs to be written in discrete form, and the next section describes how this is considered.

Averaging is done on linear units.

6.2.4 Approximating the double integral in the EIRP averaging over an elevation angle range

Evaluation of the EEIRP over a spherical strip involves EIRP measurements, $EIRP(\theta,\varphi)$, around the ‘point source’ (i.e. the Base Station) bounded by the elevation range θ_{HLi} and θ_{HHi}. Figure 6.2.4-1 is an illustration of the measured EIRP points and the area of the spherical strip for one of the elevation bin. Note that the measured EIRP points are over two discrete elevation angles with equal number of points in azimuth.

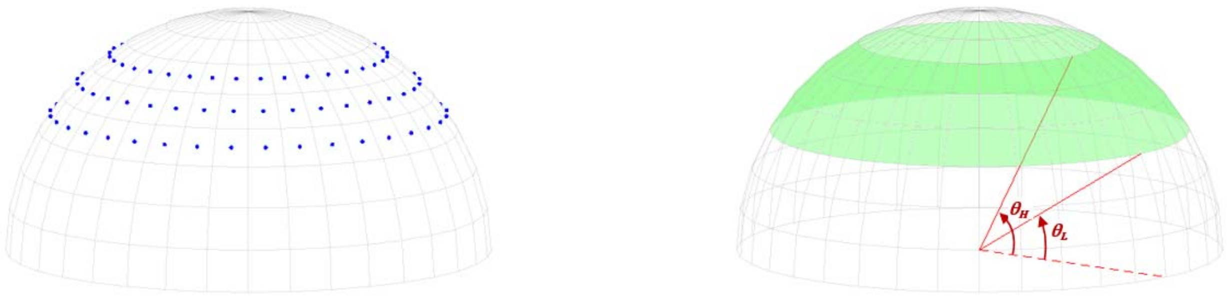


Figure 6.2.4-1: Measured EIRP points and the spherical strip

The double integral in equation (1) can be approximated in discrete form, and Figure 6.2.4-2 illustrates some of the relevant discrete parameters used in the approximation. This approximation is based on the assumption that measurement points are chosen on anequal angle grid.

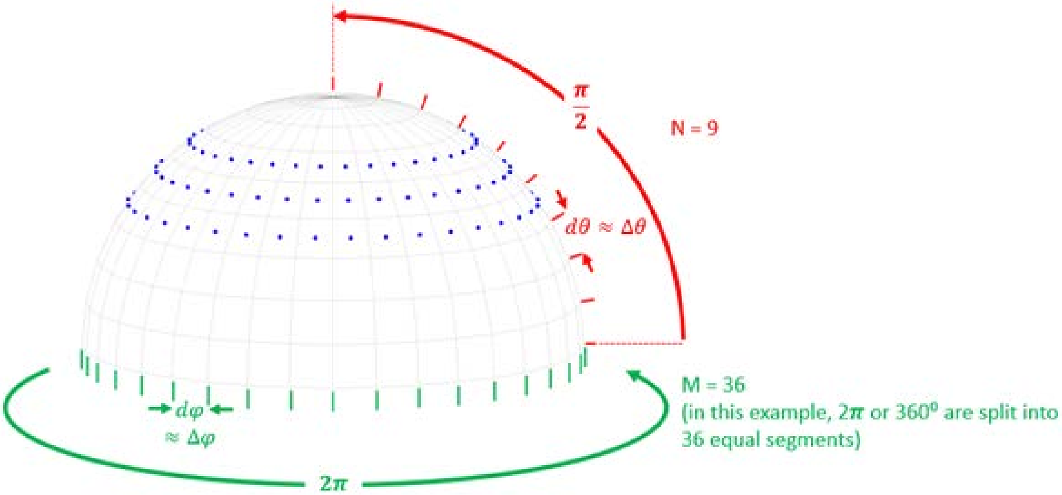


Figure 6.2.4-2: Illustration of the parameters involved

For an equal angle grid where the grid spacing is uniform in both the elevation θ (over the range of [θ_{HLi} to θ_{HHi}]) and azimuth φ (over the range of [-π to π]), with N and M points respectively, this EEIRP is calculated as:

$$EEIRP(\theta_{HLi}, \theta_{HHi}) = \frac{1}{2\pi \times (sin\theta_{HHi} - sin\theta_{HLi})} \sum_{\theta_L}^{\theta_H} \sum_{-\pi}^{\pi} \overline{EIRP}(\theta, \varphi)\, cos(\theta)\, \Delta\varphi\, \Delta\theta \quad , \qquad (2)$$

By substituting the following:

$$d\varphi \approx \Delta\varphi = \frac{2\pi}{M}$$

$$d\theta \approx \Delta\theta = \frac{(\theta_{HHi} - \theta_{HLi})}{N}$$

the overall equation (with input angles in degrees) can be written as:

$$EEIRP(\theta_{HLi}, \theta_{HHi}) = \frac{(\theta_{HHi} - \theta_{HLi}) \times \frac{\pi}{180^\circ}}{MN(sin\theta_{HHi} - sin\theta_{HLi})} \sum_{n=n_L}^{n_H} \sum_{m=1}^{M} \overline{EIRP}(\theta_n, \varphi_m)\, cos(\theta_n) \quad , \qquad (3)$$

where

$(\theta_{HLi}, \theta_{HHi})$	is the elevation angular range bounded by θ_{HLi} and θ_{HHi} in degrees, e.g. for bin 1, this will be 0° and 5° respectively.
θ_n	is the corresponding angle of the n^{th} midpoint between the elevation intervals,referenced from the horizon.Midpoint is the middle point between the intervals, e.g. for the interval 1°-2°, the midpoint is 1.5°.
φ_m	is the corresponding angle of the m^{th} midpoint between the azimuth intervals
n_L	is the lowest elevation index of sampling points within the $(\theta_{HLi}, \theta_{HHi})$ range
n_H	is the highest elevation index of sampling points within the $(\theta_{HLi}, \theta_{HHi})$ range
M	is the number of azimuth points within the (-180°, 180°) range
N	is the number of elevation points within the $(\theta_{HLi}, \theta_{HHi})$ range

Note: The equation is assuming the angles in radians and the elevation angle is from the geographical horizon rather than from the antenna panel as used in 3GPP technical specifications previously. Anyhow, these different angle definitions are related and can be easily mapped.

6.3 Test beams

6.3.1 General

The BS capability to provide coverage in different deployment situations is declared by the BS manufacturer in the form of a steering range determined by minimum and maximum angles along the θ and φ axis, as visualised in Figure 6.3-1. It is possible to declare multiple steering ranges for different types of deployment scenarios.

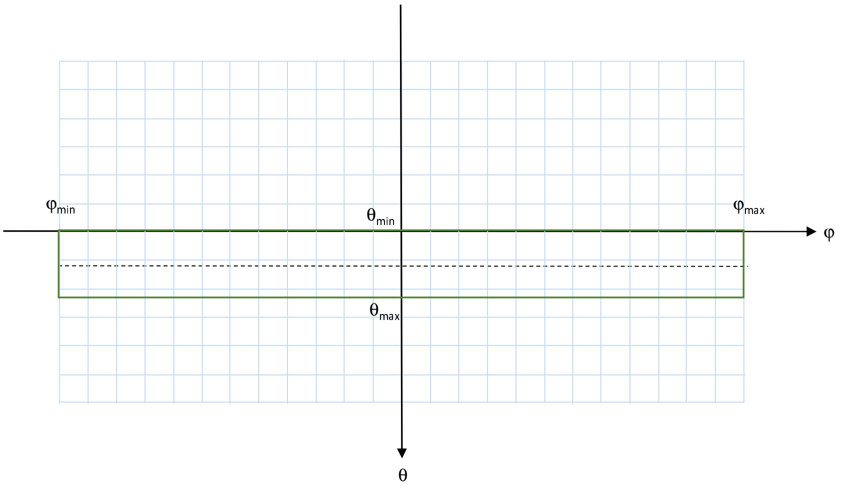


Figure 6.3-1: Declaration of steering range

Evaluation of Expected EIRP is based on the assumption that maximum carrier power of the BS is utilized together with the narrowest beam supported, generating the maximum EIRP. As the BS antenna array contains a large number of elements the number of narrow beams that can be generated in this steering range is also large.

Ideally, EEIRP would be the result of averaging the contributions of all beams generated by the BS, but such approach is impractical, as it will lead to an excessive testing effort. For this reason, in the following section, we are presenting the results of averaging a smaller number of representative beams, in an effort to identify the test beams set for which overall averaging of the EEIRP is sufficiently accurate (as described in the Annex to the ITU Resolution 220).

6.3.2 Test beam set evaluation

6.3.2.1 Evaluation method

The following method is utilized for determining the optimal set of test beams through simulations:

1. We assume a number of antenna array configurations that are supposed to reflect future realistic product implementation. We use the antenna modelling in TR38.803 to create the radiation pattern per test beam. Beams will be generated within declared steering range.

2. We define a reference case, consisting of a very large number of test beams, that will completely describe the BS beamforming capability in the declared steering range. Two reference cases are considered, one assuming a rectangular steering range and one assuming a more realistic ellipsoidal steering range. We calculate the reference EEIRP for this reference case according to the EEIRP formula as described in section 6.2.

3. We consider for evaluation a number of test beam sets in the range from 9 (3x3) to 25 (5x5) in different constellations. We calculate the EEIRP according to the EEIRP formula as described in section 6.2 for each of these limited sets. Each of the beams in their respective set have equal weight.

4. For each test beam set, we calculate the EEIRP difference relative to the reference case and draw conclusions about the accuracy of the EEIRP estimation.

6.3.2.2 Ericsson results

In the evaluation we consider a BS steering range -60 to 60 degrees along azimuth axis and 0 to 16 degrees along vertical axis. The beam sets are compared to a reference beam set defined as 17x121 beam constellation (2057 beams) within the steering range.

In our evaluation we have included 9 different beam constellations (4x3, 4x4, 6x3, 5x4, 4x5, 6x4, 5x5, 5x5 no corners, 17 beams in ellipsoid and 20 random beams), visualised in Figure 6.3.2.2-1, Figure 6.3.2.2-2 and Figure 6.3.2.2-3.

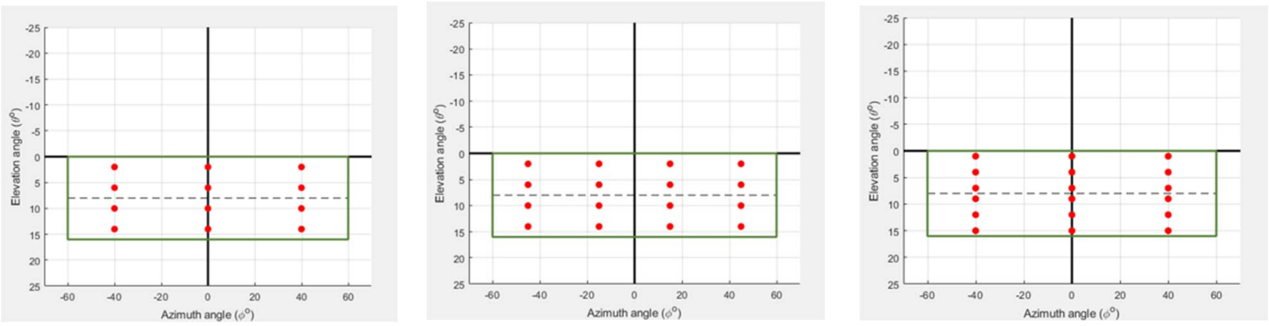


Figure 6.3.2.2-1: Beam constellation BS1 (left), BS2 (middle) and BS3 (right)

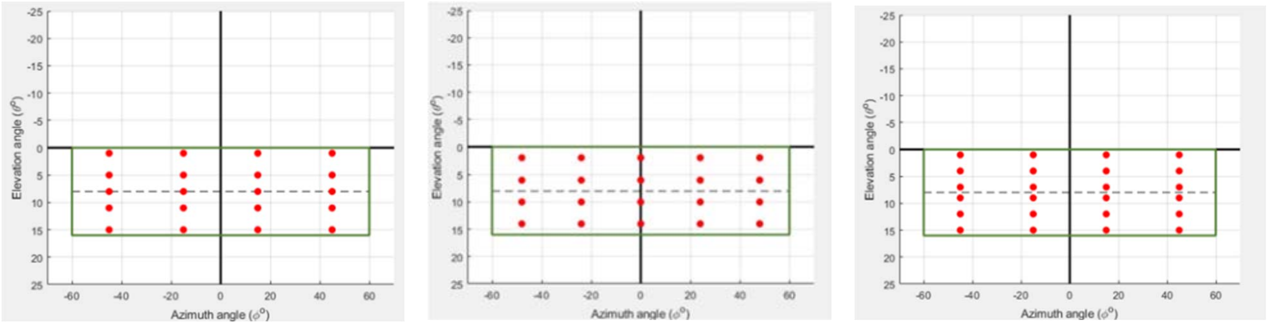


Figure 6.3.2.2-2: Beam constellation BS4 (left), BS5 (middle) and BS6 (right)

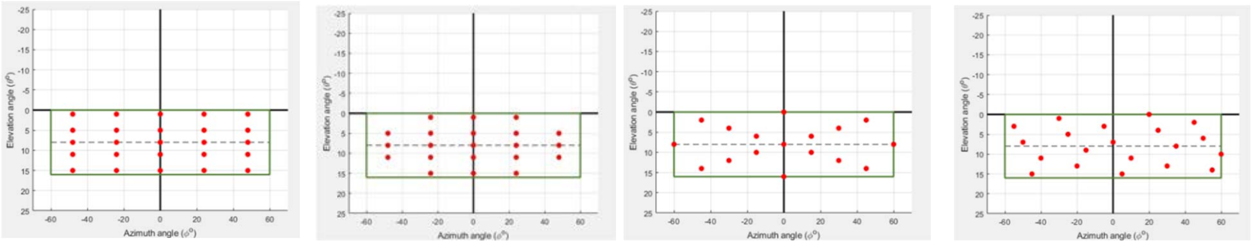


Figure 6.3.2.2-3: Beam constellation BS7 and BS7nc (left), BS8 (middle) and BS9 (right)

The beam sets have been constructed so that uniform (BS1, BS2, BS5) and non-uniform (BS3, BS4, BS6, BS7, BS8 and BS9) distributions with different number of total beams are included.

To include variations due to array antenna configuration several configurations including different array size and sub-array size were considered, as listed in Table 6.3.2.2-1.

Table 6.3.2.2-1: Array antenna configuration

Parameter		Value			
		Config 1	Config 2	Config 3	Config 4
Element	Vertical HPBW (°)	90	90	65	65
	Horizontal HPBW (°)	90	90	90	90
	Element gain (dBi)	-	-	-	-
	Front-to-back ratio (H/V) (dB)	30	30	30	30
	Element power (dBm/100 MHz)	0	0	0	0
Array configuration	Number of rows	16	32	8	8
	Number of columns	8	16	16	16
	Sub-array	-	-	3x1	4x1
	Sub-array pre-tilt (°)	-	-	6	6
	Vertical element separation (λ)	0.5	0.5	2.1	2.8
	Horizontal element separation (λ)	0.5	0.5	0.5	0.5

The simulation results are listed in Table 6.3.2.2-2, Table 6.3.2.2-3, Table 6.3.2.2-4 and Table 6.3.2.2-5. The rectangular reference case is considered as a baseline for all configurations. Additionally, for the BS7nc there are two set of values: the first one is for the rectangular reference case and the second one for the ellipse reference case.

Table 6.3.2.2-2: Config 1

Bin	Vertical range	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS7nc		BS8	BS9
1	$0<\theta<5$	-0,963	-0,993	-0,261	0,05	-0,999	-0,291	0,044	-0,66	0,407	-0,504	-0,2
2	$5<\theta<10$	-0,21	-0,233	-0,275	-0,393	-0,238	-0,298	-0,398	-0,311	-0,301	-0,042	0,02
3	$10<\theta<15$	-0,389	-0,403	-0,142	-0,021	-0,406	-0,155	-0,024	0,044	0,105	-0,001	-0,013
4	$15<\theta<20$	0,012	0,014	0,12	0,183	0,018	0,123	0,186	0,052	0,172	-0,076	-0,039
5	$20<\theta<30$	-0,048	-0,027	-0,077	-0,071	-0,016	-0,057	-0,059	0,093	-0,058	0,027	0,009
6	$30<\theta<60$	0,208	0,069	0,219	0,082	0,049	0,08	0,06	0,23	0,015	0,039	-0,057
7	$60<\theta<90$	-0,338	0,246	-0,369	0,273	0,089	0,271	0,087	0,629	0,055	0,064	-0,311
Average deviation		0,32	0,30	0,21	0,16	0,27	0,18	0,12	0,3	0,16	0,11	0,09
Max over-estimation		0,21	0,25	0,22	0,27	0,09	0,27	0,19	0,63	0,41	0,06	0,02
Max under-estimation		0,96	0,99	0,37	0,39	1,00	0,30	0,40	0,66	0,3	0,50	0,31
RMS el_bin		0,33	0,31	0,21	0,16	0,29	0,18	0,13	0,3	0,16	0,11	0,10

Table 6.3.2.2-3: Config 2

Bin	Vertical range	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS7nc		BS8	BS9
1	$0<\theta<5$	-3,351	-3,36	-0,6	-0,018	-3,372	-0,608	-0,03	-0,729	1,568	-0,421	-0,302
2	$5<\theta<10$	-0,505	-0,517	-0,33	-0,47	-0,527	-0,341	-0,481	-0,582	-0,208	-0,079	0,062
3	$10<\theta<15$	0,285	0,269	-0,141	-0,05	0,263	-0,156	-0,057	-0,041	-0,07	-0,017	-0,092
4	$15<\theta<20$	-0,537	-0,55	0,245	0,344	-0,557	0,231	0,34	0,377	0,331	-0,024	-0,021
5	$20<\theta<30$	0,177	0,175	-0,162	-0,241	0,161	-0,163	-0,257	-0,181	-0,317	0,036	0,025
6	$30<\theta<60$	0,093	-0,012	0,204	0,121	-0,04	0,098	0,086	0,23	-0,098	0,028	-0,058
7	$60<\theta<90$	0,011	-0,056	-0,356	0,493	0,224	0,393	0,086	0,53	-0,383	0,008	-0,09
Average deviation		0,87	0,87	0,29	0,25	0,89	0,29	0,19	0,39	0,45	0,09	0,09
Max over-estimation		0,29	0,27	0,24	0,49	0,26	0,39	0,34	0,53	1,37	0,04	0,06
Max under-estimation		3,35	3,36	0,60	0,47	3,37	0,61	0,48	0,73	0,38	0,42	0,30
RMS el_bin		1,08	1,08	0,30	0,26	1,10	0,29	0,20	0,39	0,49	0,09	0,09

Table 6.3.2.2-4: Config 3

Bin	Vertical range	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS7nc		BS8	BS9
1	0<θ<5	-3,234	-3,242	-0,539	-0,001	-3,255	-0,548	-0,014	-0,65	0,83	-0,39	-0,269
2	5<θ<10	-0,802	-0,814	-0,936	-1,043	-0,824	-0,948	-1,054	-1,265	-0,655	-0,048	-0,727
3	10<θ<15	-0,422	-0,445	-0,099	0,088	-0,447	-0,121	0,085	-0,646	0,213	-0,606	-0,214
4	15<θ<20	0,042	0,015	-0,031	-0,095	0,018	-0,058	-0,092	0,556	-0,104	0,327	0,444
5	20<θ<30	-0,418	-0,424	-0,042	0,114	-0,446	-0,05	0,095	-0,332	0,226	-0,443	1,064
6	30<θ<60	-0,039	-0,262	0,101	0,032	-0,44	-0,081	-0,113	-0,202	-0,106	0,02	2,849
7	60<θ<90	-0,557	0,224	-0,297	0,843	-0,517	0,612	-0,592	0,055	-0,685	0,366	6,869
Average deviation		0,93	0,92	0,30	0,34	0,98	0,36	0,31	0,55	0,41	0,32	2,51
Max over-estimation		0,04	0,22	0,10	0,84	0,02	0,61	0,10	0,56	0,83	0,37	6,87
Max under-estimation		3,23	3,24	0,94	1,04	3,26	0,95	1,05	1,27	0,68	0,61	0,73
RMS el_bin		1,10	1,10	0,32	0,36	1,15	0,37	0,32	0,56	0,42	0,32	3,42

Table 6.3.2.2-5: Config 4

Bin	Vertical range	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS7nc		BS8	BS9
1	0<θ<5	-4,447	-4,455	-1,105	-0,585	-4,467	-1,113	-0,597	-1,348	0,478	-0,355	-0,99
2	5<θ<10	0,415	0,405	0,047	0,011	0,396	0,037	0,003	-0,425	-0,19	-0,474	0,182
3	10<θ<15	1,211	1,194	0,088	0,355	1,188	0,07	0,349	1,03	0,205	0,66	0,165
4	15<θ<20	0,914	0,894	-0,058	-0,263	0,895	-0,077	-0,265	-0,702	-0,575	-0,509	0,605
5	20<θ<30	-0,833	-0,837	-0,299	-0,138	-0,854	-0,305	-0,151	-0,819	0,109	-0,532	0,722
6	30<θ<60	-0,472	-0,443	-0,088	-0,052	-0,391	-0,152	-0,022	0,491	0,156	-0,173	3,088
7	60<θ<90	-0,567	0,348	-0,73	0,805	0,822	0,109	1,234	1,958	1,07	1,68	6,215
Average deviation		1,51	1,48	0,36	0,32	1,53	0,28	0,39	1,00	0,41	0,65	2,30
Max over-estimation		1,21	1,19	0,09	0,81	1,19	0,11	1,23	1,96	1,07	1,68	6,22
Max under-estimation		4,45	4,46	1,11	0,59	4,47	1,11	0,60	1,35	0,58	0,53	0,99
RMS el_bin		1,83	1,81	0,38	0,33	1,85	0,30	0,41	1,03	0,42	0,68	3,02

Calculation methodology:

The EEIRP is calculated for each of the (seven) different elevation bins for each considered array antenna configuration and beam-set (BS1 to BS9) including the rectangular reference beam set with 2057 beams (17 along elevation axis and 121 along azimuth axis). An ellipsoidal reference case is also considered, by removing the corner areas of the rectangular reference case.

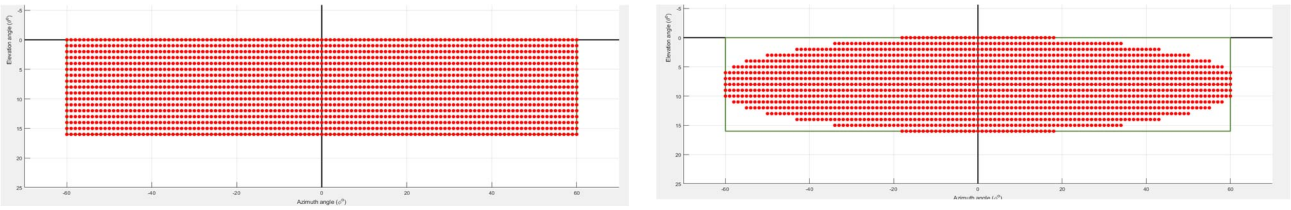


Figure 6.3.2.2-4 Illustration of reference cases

The EEIRP difference between each beam set and the reference grid is calculated for each of the elevation bins.

For every combination of array configuration and beam set, three metrics are then considered based on this difference.

- The average deviation "*AVG deviation*" is the linear average for each elevation bin (average of 7 values, one for each elevation bin) and is intended to represent the deviation of the calculated EEIRP compared to the reference beam set.
- The maximum over-estimation "*Max over-estimation*" is the maximum positive value over the 7 bins and is intended to represent the largest error that is observed ABOVE the levels of the reference EEIRP.
- The maximum under-estimation "*Max under-estimation*" is the minimum negative value over the 7 bins and is intended to represent the largest error that is observed BELOW the levels of the reference EEIRP.

The aggregated results per beam-set as presented in Table 2.2-2 are the WORST values observed over the different array configurations, i.e. the highest values of "*AVG deviation*", "*Max over-estimation*" and "*Max under-estimation*" between all considered antenna arrays.

The fourth metric "*RMS_TBS_dBm*" is the RMS representation of the error per beam set, over all antenna configurations and elevation bins where the error is considered as the difference of the beam-set specific EEIRP to that of the reference beam set.

i.e., for Beam Set (BS) 1 to 9, $RMS_{bs} = \; 10\log_{10}\left(\sqrt{\frac{\sum_m^M \frac{\sum_n^N \left(EEIRP_{nm_{bs}} - EEIRP_{nm_{ref}}\right)^2}{N}}{M}}\right)$

where $EEIRP_{nm}$ is the calculated EEIRP for antenna configuration m and elevation bin n.

The difference between the two variations of RMS ("on dB diff", "on linear diff") is that the EEIRP difference, $EEIRP_{nm_{bs}} - EEIRP_{nm_{ref}}$, is taken in linear scale in one case and on dB scale (and converting afterwards to linear) on the other.

In Table 6.3.2.2-4, the simulation results are presented for each considered Beam Set (BS1 to BS9). The Beam Set is defined as M_{column} x N_{row}. The rectangular reference case is considered as a baseline for all configurations. Additionally, for the BS7nc there are two set of values: the first one is for the rectangular reference case and the second one for the elipse reference case.

Table 6.3.2.2-6: Simulation results

	BS1 (4x3)	BS2 (4x4)	BS3 (6x3)	BS4 (5x4)	BS5 (4x5)	BS6 (6x4)	BS7 (5x5)	BS7nc (5x5 nc)	BS8 (Star)	BS9 (Random)	
AVG deviation	1,51	1,48	0,36	0,34	1,53	0,36	0,39	1,00 / 0,41	0,65	2,51	
Max over-estimation	1,21	1,19	0,24	0,84	1,19	0,61	1,23	1,96 / 1,07	1,68	6,87	
Max under-estimation	4,45	4,46	1,11	1,04	4,47	1,11	1,05	1,35 / 0,68	0,61	0,99	
RMS_TBS_dBm	0,56	0,55	0,15	0,14	0,57	0,14	0,13	0,59 / 0,33	0,15	0,97	**On dB diff**
RMS_TBS_dBm	-6,8	-6,8	-12,1	-15,3	-6,8	-12,0	-15,2	-10,7 / -13,1	-13,0	-12,7	**On Linear diff**

The result is colour coded to visualize good and bad beam sets. The simulation result shows BS3, BS4, BS6, BS7 and BS8 produce acceptable deviations with respect to the reference case. Note that the of beams along the vertical axis is essential to reduce the deviation.

6.3.2.3 Huawei results

6.3.2.3.1 Average Metric

3 different metrics have been used in the evaluation:

RMS average of the error in dB

$$RMS(dB) = \left(\left((E_{0-5}^2) + (E_{5-10}^2) + (E_{10-15}^2) + (E_{15-20}^2) + (E_{20-30}^2) + (E_{30-60}^2) + (E_{60-90}^2)\right)/7\right)^{0.5}$$

Average of the absolute dB values

$$ABS_{AV(dB)} = (|E_{0-5}| + |E_{5-10}| + |E_{10-15}| + |E_{15-20}| + |E_{20-30}| + |E_{30-60}| + |E_{60-90}|)/7$$

RMS average of the absolute error in linear units (displayed in dB)

$$Real_{AV(dB)} = 10 * log_{10}\left(\left(\left(\left(10^{\frac{|E_{0-5}|}{10}}\right) + \left(10^{\frac{|E_{5-10}|}{10}}\right) + \left(10^{\frac{|E_{10-15}|}{10}}\right) + \left(10^{\frac{|E_{15-20}|}{10}}\right) + \left(10^{\frac{|E_{20-30}|}{10}}\right) + \left(10^{\frac{|E_{30-60}|}{10}}\right) + \left(10^{\frac{|E_{60-90}|}{10}}\right)\right)\right)/7\right)$$

The 3 methods all use the absolute error in dB and form slightly different averages. Considering the 3 metrics, in the range of dB errors are experiencing (approx. 0 to 2dB), the difference in the resulting average is not huge as such it is probably not very important which is used.

In addition to the average metric the overestimate and underestimate values are also compared to ensure that no excessive error in individual angular bins are experienced.

6.3.2.3.2 Test cases

The test cases are based on ANT4 (see table 6.3.2.3.2-1) with 2 different steering range configurations.

Table 6.3.2.3.2-1: Antenna parameters

		Antenna					Unit
		1	2	3	4	5	
elevation	No elements/sub-arrays	16	8	24	8	16	
	elements per sub-array	1	2	1	3	2	
	element separation	0.7	0.7	0.7	0.7	0.7	λ
Azimuth	No elements	8	8	16	16	16	
	element separation	0.5	0.5	0.5	0.5	0.5	λ
Directivity (zero steer)		27.7	27.7	32.4	32.4	33.9	dBi
vertical BW		4.5	4.5	3	3	2.3	deg
horizontal BW		12.7	12.7	6.4	6.4	6.4	deg

The steering range configurations are:

Steering range 1
Mechanical tilt = 0deg
Electrical steering range = 0 to -12deg (0deg is perpendicular to the antenna, negative direction is towards the ground)
Electrical pre-set = -6deg

Steering range 2
Mechanical down-tilt = 4deg
Electrical steering range = 0 to -16deg (0deg is perpendicular to the antenna, negative direction is towards the ground)
Electrical pre-set = -6deg

The test beam direction sets currently under consideration are shown in figure 6.3.1.2.2-1:

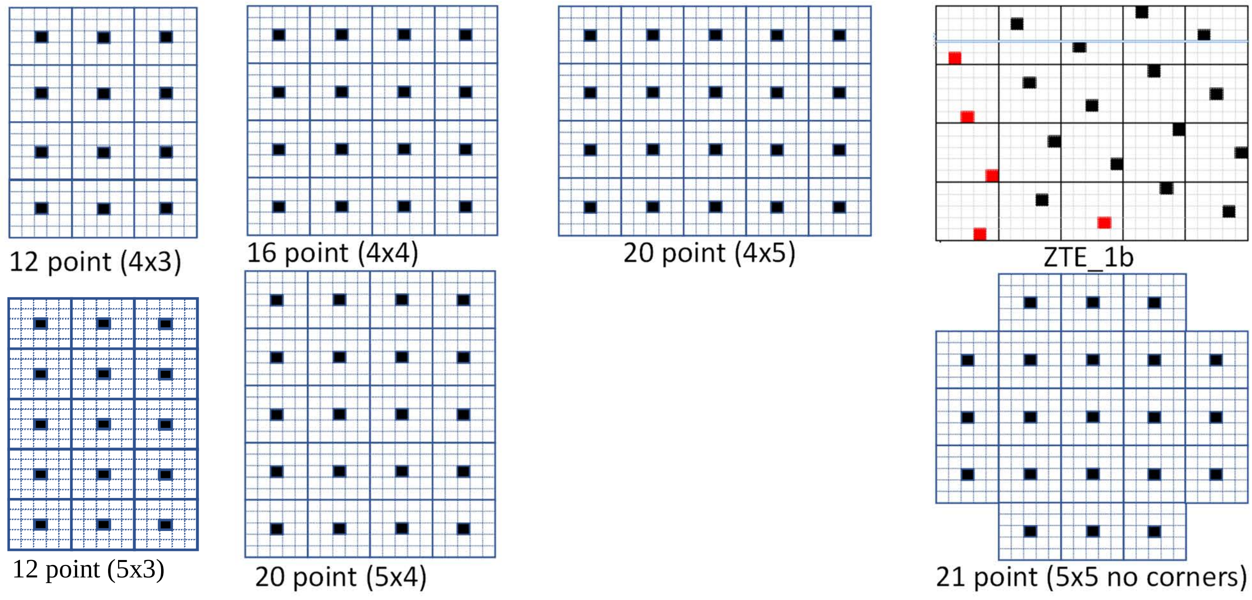


Figure 6.3.2.3.2-1. Test beam direction sets

The result is listed in Table 6.3.2.3.2-2, Table 6.3.2.3.2-3, Table 6.3.2.3.2-4 and Table 6.3.2.3.2-5.

Table 6.3.1.2.2-2: Results for ANT4, Steering range 1

ANT4 - 10k (mech=0, elec=0 to -12, sub-tilt=-6)															
Test beam direction set		Elevation Angle range (deg)							RMS Errors (dB)	abs av (dB)	linear RMS (dB)	over estimate (dB)	under estimate (dB)	Unit
		60-90	30-60	20-30	15-20	10-15	5-10	0-5						
		10k (mech=0, elec=0 to -12, sub-tilt=-6)												
20 point fixed (4x5)	ellipse	-1.12	-0.44	0.58	0.86	0.21	-0.35	1.01	0.73	0.65	0.66	1.01	-1.12	dB
	rect	-0.36	-0.61	-0.06	-0.02	-0.96	-0.60	-0.52	0.54	0.45	0.46	-0.02	-0.96	dB
20 point fixed (5x4)	ellipse	-0.48	-0.20	0.62	0.82	0.57	0.01	1.26	0.68	0.56	0.58	1.26	-0.48	dB
	rect	0.28	-0.37	-0.02	-0.06	-0.59	-0.24	-0.27	0.32	0.26	0.27	0.28	-0.59	dB
16 point(4x4) fixed	ellipse	-0.45	-0.41	0.58	0.84	0.19	-0.35	1.01	0.61	0.55	0.56	1.01	-0.45	dB
	rect	0.31	-0.58	-0.05	-0.04	-0.97	-0.60	-0.52	0.54	0.44	0.45	0.31	-0.97	dB
12 point fixed (4x3)	ellipse	-0.63	-0.01	0.58	0.85	0.20	-0.36	1.01	0.61	0.52	0.53	1.01	-0.63	dB
	rect	0.13	-0.18	-0.05	-0.03	-0.96	-0.60	-0.52	0.48	0.35	0.37	0.13	-0.96	dB
ZTE1b	ellipse	-1.35	0.13	0.68	0.80	1.05	0.24	1.57	0.97	0.83	0.86	1.57	-1.35	dB
	rect	-0.59	-0.04	0.05	-0.08	-0.12	0.00	0.05	0.23	0.13	0.14	0.05	-0.59	dB
25 point fixed (5x5) nc	ellipse	-0.40	-0.10	0.17	0.07	0.01	-0.07	0.28	0.20	0.16	0.16	0.28	-0.40	dB
	rect	0.36	-0.26	-0.46	-0.81	-1.15	-0.32	-1.25	0.76	0.66	0.68	0.36	-1.25	dB
15 point fixed (5x3)	ellipse	-0.56	0.18	0.61	0.83	0.58	0.00	1.26	0.69	0.57	0.59	1.26	-0.56	dB
	rect	0.20	0.01	-0.02	-0.05	-0.59	-0.24	-0.27	0.27	0.20	0.20	0.20	-0.59	dB

Table 6.3.1.2.2-3: Results for ANT 4, Steering range 2

ANT4 - 10k (mech=4, elec=0 to -16, sub-tilt=-6)														
Test beam direction set		Elevation Angle range (deg)							RMS Errors (dB)	abs av (dB)	linear RMS (dB)	over estimate (dB)	under estimate (dB)	Unit
		60-90	30-60	20-30	15-20	10-15	5-10	0-5						
		10k (mech=4, elec=0 to -16, sub-tilt=-6)												
20 point fixed (4x5)	ellipse	-0.98	0.19	0.69	-0.47	0.99	1.22	0.60	0.80	0.73	0.74	1.22	-0.98	dB
	rect	-0.12	-0.19	-0.19	-0.08	0.23	-0.28	-0.27	0.21	0.19	0.19	0.23	-0.28	dB
20 point fixed (5x4)	ellipse	-0.21	0.49	0.81	-0.71	0.76	1.21	1.00	0.80	0.74	0.75	1.21	-0.71	dB
	rect	0.65	0.12	-0.06	-0.32	0.00	-0.28	0.13	0.30	0.22	0.23	0.65	-0.32	dB
16 point(4x4) fixed	ellipse	-0.21	0.42	0.70	-0.64	0.97	1.23	0.58	0.75	0.68	0.69	1.23	-0.64	dB
	rect	0.64	0.05	-0.18	-0.25	0.21	-0.26	-0.29	0.32	0.27	0.27	0.64	-0.29	dB
12 point fixed (4x3)	ellipse	-0.70	0.67	0.71	-0.79	0.95	1.27	0.49	0.83	0.79	0.80	1.27	-0.79	dB
	rect	0.16	0.29	-0.17	-0.40	0.19	-0.22	-0.38	0.28	0.26	0.26	0.29	-0.40	dB
ZTE1b	ellipse	-1.33	0.35	0.99	-0.25	0.74	1.32	0.77	0.91	0.82	0.84	1.32	-1.33	dB
	rect	-0.48	-0.02	0.12	0.13	-0.02	-0.18	-0.10	0.21	0.15	0.15	0.13	-0.48	dB
25 point fixed (5x5) nc	ellipse	-0.48	0.03	0.10	-0.01	-0.06	0.37	0.43	0.29	0.21	0.22	0.43	-0.48	dB
	rect	0.37	-0.34	-0.77	0.38	-0.82	-1.12	-0.44	0.67	0.61	0.62	0.38	-1.12	dB
15 point fixed (5x3)	ellipse	-0.82	0.74	0.82	-0.82	0.72	1.22	0.99	0.89	0.88	0.88	1.22	-0.82	dB
	rect	0.03	0.36	-0.05	-0.43	-0.04	-0.27	0.12	0.24	0.19	0.19	0.36	-0.43	dB

Table 6.3.1.2.2-4: Results for ANT 1, Steering range 1

ANT1 - 10k (mech=0, elec=0 to -12, sub-tilt=-6)														
Test beam direction set		Elevation Angle range (deg)							RMS Errors (dB)	abs av (dB)	linear RMS (dB)	over estimate (dB)	under estimate (dB)	Unit
		60-90	30-60	20-30	15-20	10-15	5-10	0-5						
		10k (mech=0, elec=0 to -12, sub-tilt=-6)												
20 point fixed (4x5)	ellipse	-0.89	-0.28	0.02	-0.03	0.04	0.23	0.88	0.49	0.34	0.35	0.88	-0.89	dB
	rect	-0.09	0.02	0.05	-0.02	-0.01	0.04	-0.34	0.13	0.08	0.08	0.05	-0.34	dB
20 point fixed (5x4)	ellipse	-0.84	-0.24	0.01	-0.02	0.04	0.20	1.01	0.51	0.34	0.35	1.01	-0.84	dB
	rect	-0.04	0.07	0.04	-0.01	-0.01	0.01	-0.21	0.09	0.05	0.06	0.07	-0.21	dB
16 point(4x4) fixed	ellipse	-0.89	-0.25	0.01	-0.04	0.04	0.23	0.88	0.49	0.33	0.35	0.88	-0.89	dB
	rect	-0.08	0.05	0.04	-0.03	-0.01	0.04	-0.34	0.13	0.08	0.08	0.05	-0.34	dB
12 point fixed (4x3)	ellipse	-0.79	-0.18	-0.05	-0.07	0.03	0.23	0.88	0.46	0.32	0.33	0.88	-0.79	dB
	rect	0.01	0.12	-0.02	-0.06	-0.02	0.04	-0.33	0.14	0.09	0.09	0.12	-0.33	dB
ZTE1b	ellipse	-0.87	-0.30	-0.01	0.00	0.06	0.19	1.20	0.58	0.38	0.40	1.20	-0.87	dB
	rect	-0.07	0.00	0.02	0.01	0.01	0.00	-0.02	0.03	0.02	0.02	0.02	-0.07	dB
25 point fixed (5x5) nc	ellipse	-0.15	-0.03	0.02	0.00	0.00	0.01	0.14	0.08	0.05	0.05	0.14	-0.15	dB
	rect	0.66	0.28	0.05	0.01	-0.05	-0.18	-1.08	0.49	0.33	0.35	0.66	-1.08	dB
15 point fixed (5x3)	ellipse	-0.73	-0.16	-0.04	-0.05	0.03	0.20	1.01	0.48	0.32	0.33	1.01	-0.73	dB
	rect	0.07	0.14	-0.01	-0.04	-0.02	0.01	-0.21	0.10	0.07	0.07	0.14	-0.21	dB

Table 6.3.1.2.2-5: Results for ANT 1, Steering range 2

ANT1 - 10k (mech=4, elec=0 to -16, sub-tilt=-6)														
Test beam direction set		Elevation Angle range (deg)							RMS Errors (dB)	abs av (dB)	linear RMS (dB)	over estimate (dB)	under estimate (dB)	Unit
		60-90	30-60	20-30	15-20	10-15	5-10	0-5						
		10k (mech=4, elec=0 to -16, sub-tilt=-6)												
20 point fixed (4x5)	ellipse	-0.93	-0.19	0.06	0.09	0.08	0.09	0.33	0.38	0.25	0.26	0.33	-0.93	dB
	rect	-0.15	0.06	0.02	-0.04	-0.12	-0.26	-0.81	0.33	0.21	0.22	0.06	-0.81	dB
20 point fixed (5x4)	ellipse	-0.81	-0.17	0.06	0.10	0.13	0.18	0.46	0.37	0.27	0.28	0.46	-0.81	dB
	rect	-0.03	0.08	0.02	-0.03	-0.07	-0.18	-0.68	0.27	0.16	0.16	0.08	-0.68	dB
16 point(4x4) fixed	ellipse	-0.86	-0.16	0.04	0.07	0.07	0.08	0.28	0.35	0.22	0.23	0.28	-0.86	dB
	rect	-0.08	0.08	0.00	-0.06	-0.13	-0.28	-0.85	0.35	0.21	0.22	0.08	-0.85	dB
12 point fixed (4x3)	ellipse	-0.71	-0.10	-0.02	0.03	0.04	0.06	0.29	0.29	0.18	0.18	0.29	-0.71	dB
	rect	0.07	0.15	-0.06	-0.10	-0.16	-0.29	-0.85	0.35	0.24	0.25	0.15	-0.85	dB
ZTE1b	ellipse	-0.84	-0.22	0.01	0.10	0.12	0.19	0.50	0.39	0.28	0.29	0.50	-0.84	dB
	rect	-0.06	0.03	-0.03	-0.03	-0.07	-0.16	-0.64	0.25	0.15	0.15	0.03	-0.64	dB
25 point fixed (5x5) nc	ellipse	-0.18	0.00	0.03	0.04	0.03	0.01	-0.01	0.07	0.04	0.04	0.04	-0.18	dB
	rect	0.60	0.25	-0.01	-0.09	-0.17	-0.34	-1.15	0.52	0.37	0.39	0.60	-1.15	dB
15 point fixed (5x3)	ellipse	-0.66	-0.10	0.00	0.06	0.10	0.16	0.45	0.31	0.22	0.23	0.45	-0.66	dB
	rect	0.11	0.15	-0.04	-0.07	-0.10	-0.19	-0.68	0.28	0.19	0.20	0.15	-0.68	dB

Given these results the main conclusion is that it is very difficult to identify any test beam direction set as being significantly better than any other. As it has been seen previously, it seems at least 5 points in elevation for the the errors to be small.

6.3.2.4 Nokia results

6.3.2.4.1 Simulation results

The EEIRP calculation involves calculating the average EIRP over a defined set of elevation angles (around the base station, i.e. 360° azimuth) for the full range of beamforming directions. Two Reference Sets (RefSet1 and RefSet2) of the full range of beamforming directions is shown in Figure 6.3.2.4.1-1 and Figure 6.3.2.4.1-2, with the vertical steering range set to $-16° \leq \theta_{etilt} \leq 0°$ and $-12° \leq \theta_{etilt} \leq 0°$ respectively. The number of beamforming directions for these examples are 2057 and 1573 respectively, for a 1° steering resolution (i.e. 17 x 121 and 13 x 121). These figures are from the viewpoint of the UE into the BS antenna panel.

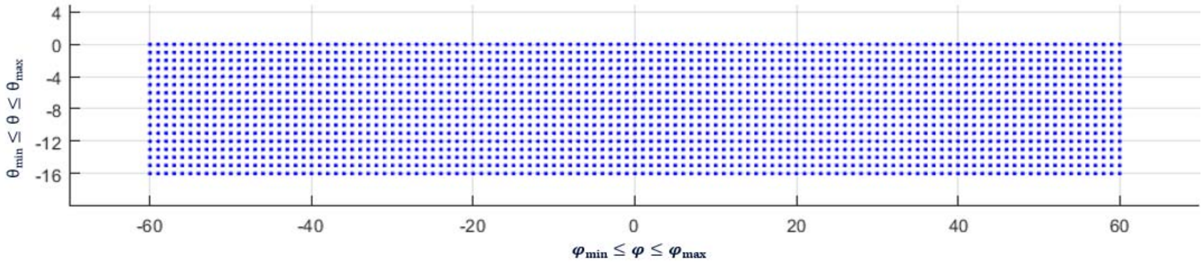


Figure 6.3.2.4.1-1: Reference Set 1 (RefSet1) of beamforming directions

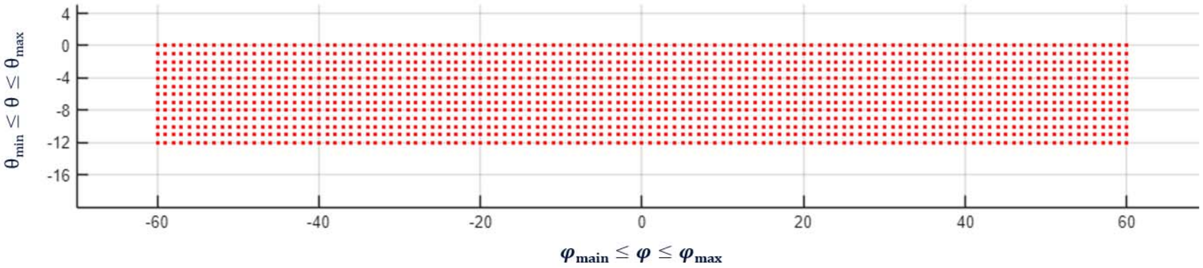
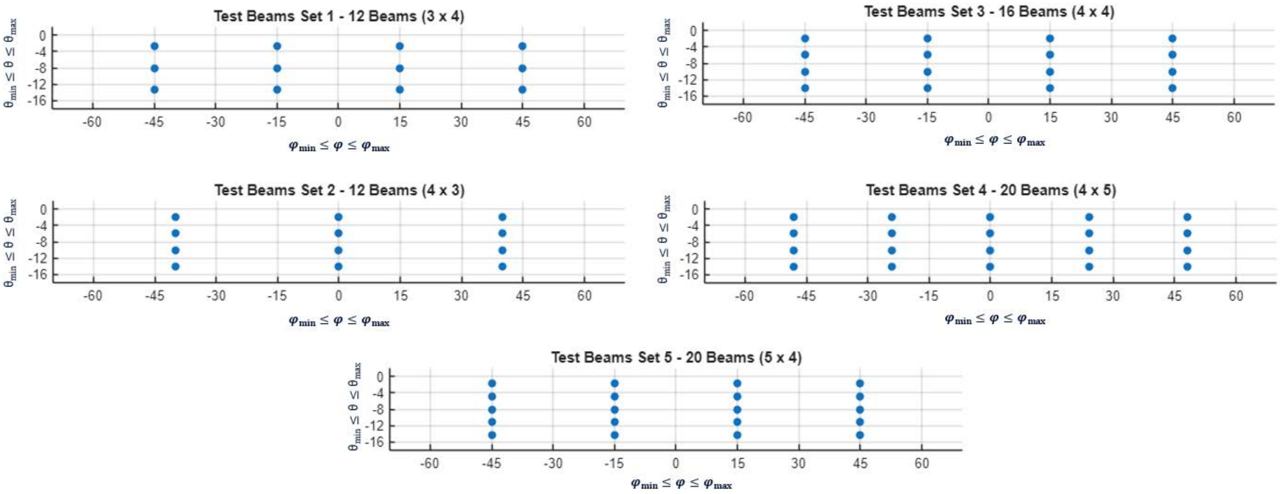


Figure 6.3.2.4.1-2: Reference Set 2 (RefSet2) of beamforming directions

6.3.2.4.2 Test Beams Sets

The following Test Beams Sets (TBSs) shown in Figure 6.3.2.4.2-1 and Figure 6.3.2.4.2-2 are evaluated against RefSet1 and RefSet2 respectively.


Test Beams Set 1 - 12 Beams (3 x 4)

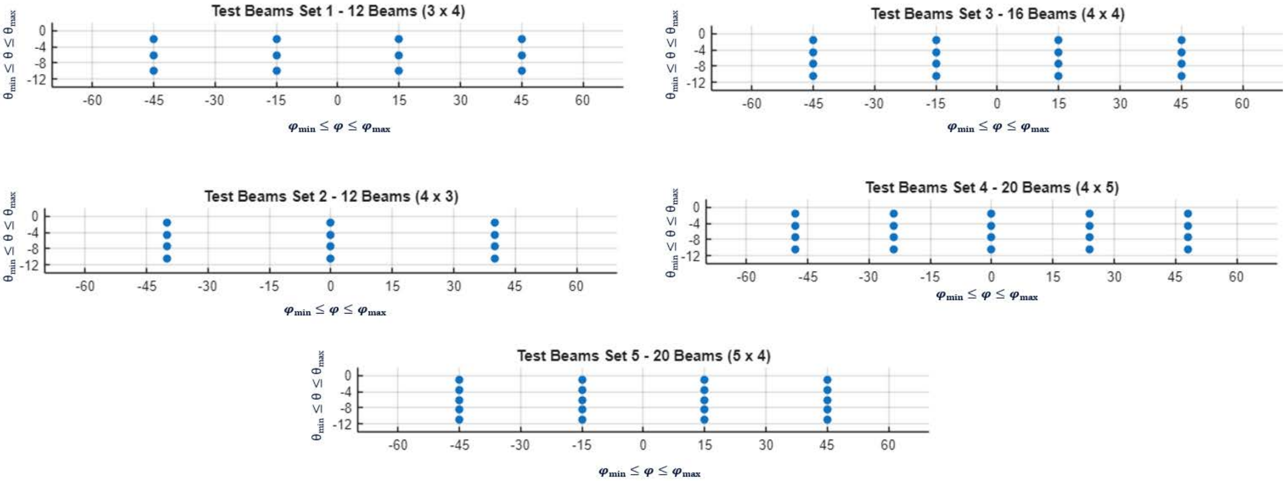
Test Beams Set 3 - 16 Beams (4 x 4)

Test Beams Set 2 - 12 Beams (4 x 3)

Test Beams Set 4 - 20 Beams (4 x 5)

Test Beams Set 5 - 20 Beams (5 x 4)

Figure 6.3.2.4.2-1: Test Beams Sets for RefSet1


Test Beams Set 1 - 12 Beams (3 x 4)

Test Beams Set 3 - 16 Beams (4 x 4)

Test Beams Set 2 - 12 Beams (4 x 3)

Test Beams Set 4 - 20 Beams (4 x 5)

Test Beams Set 5 - 20 Beams (5 x 4)

Figure 6.3.2.4.2-2: Test Beams Sets for RefSet2

6.3.2.4.3 Antenna configurations

These TBSs are evaluated over six different antenna configurations. The antenna parameters for these configurations are shown in Table 6.3.2.4.3-1 where Config 1 and 2 are non-sub-array antennas, whilst Config 3 to 6 contains sub-arrays.

Table 6.3.2.4.3-1: Antenna parameters

Parameter		Antenna					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
Element	Vertical HPBW (°)	90	65	65	65	65	65
	Horizontal HPBW (°)	90	90	90	90	90	90
	Element gain (dBi)	5.5	5.5	6.4	6.6	6.6	6.8
	Front-to-back ratio (H/V) (dB)	30	30	30	30	30	30
Array configuration	Number of rows	16	16	8	8	8	16
	Number of columns	8	8	16	8	16	16
	Sub-array	-	-	3x1	2x1	3x1	2x1
	Sub-array pre-tilt: (°)	-	-	6	0	0	0
	Vertical spacing (λ)	0.5	0.7	2.1	1.4	2.1	1.4
	Horizontal spacing (λ)	0.5	0.5	0.5	0.5	0.5	0.5

NOTE: These parameters are just some example antenna configurations for the purpose of evaluating the suitability of the Test Beams sets rather than for evaluating against the specific EEIRP values required for the different elevation ranges. In addition, the TRP for each of the configuration is set to 20 dBm/MHz and no specific antenna techniques such as sidelobe suppression are used where these techniques could potentially lower the EIRP level at various vertical and horizontal angles.

6.3.2.4.4 Evaluation of Test Beams Sets

The Test Beams sets in clause 6.3.2.4.2 are used to evaluate against the antenna configurations in clause 6.3.2.4.3. The Reference Sets illustrated in Figure 6.3.1.31-1 are based on 1° steering resolution, and the calculation of the EEIRP above the horizon (upper hemisphere) is based on 0.5° sampling resolution in order to capture the beam as accurately as possible.

The antenna pattern generated from these configurations were normalised, and just to note that the normalisation factor is only up to around 1.5 dB. The results shown in Table 6.3.2.4.4-1 to Table 6.3.2.4.4-10 is in the form of absolute difference (delta) in linear comparing the EEIRP generated from those Test Beams set to the Reference Set. This delta calculation is as shown below:

$$Delta_{bin1,\dots,7\_linear} = 10^{\frac{\left|EEIRP_{TBS\_dBm} - EEIRP_{ref\_dBm}\right|}{10}} ,$$

where $Delta_{bin1,\dots,7\_linear}$ is the linear multiple/fractional delta for elevation bin 1 to 7 (bin1 to bin7), and $\left|EEIRP_{TBS\_dBm} - EEIRP_{ref\_dBm}\right|$ is the absolute value of the difference between the EEIRP generated from the Test Beams set to the particular Reference Set in logarithmic scale. Just to note that the closer this delta to linear value of ‘1’, the better it represents the Reference Set.

The results benchmarking against Reference Set 1, RefSet1, is shown in Table 6.3.2.4.4-1 to Table 6.3.2.4.4-5.

Table 6.3.1.3.4-1: Difference of Test Beams Set 1 from RefSet1

Elevation Bin	Elevation angular range	Delta from Reference Set 1 (linear)					
		Test Beams Set 1: 12 Beams (3 x 4)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6

1	0≤q<5	1.40	2.12	3.22	2.03	2.96	2.87
2	5≤q<10	1.00	1.13	1.12	1.11	1.13	1.05
3	10≤q<15	1.22	1.07	1.15	1.08	1.03	1.01
4	15≤q<20	1.04	1.05	1.17	1.17	1.10	1.04
5	20≤q<30	1.02	1.03	1.17	1.10	1.03	1.03
6	30≤q<60	1.04	1.06	1.08	1.07	1.01	1.19
7	60≤q≤90	1.02	1.15	1.03	1.11	1.13	1.03

Table 6.3.1.3.4-2: Difference of Test Beams Set 2 from RefSet1

Elevation Bin	**Elevation angular range**	**Delta from Reference Set 1 (linear)**					
		Test Beams Set 2: 12 Beams (4 x 3)					
		Config 1	**Config 2**	**Config 3**	**Config 4**	**Config 5**	**Config 6**
1	0≤q<5	1.27	1.52	2.51	1.49	2.38	3.25
2	5≤q<10	1.04	1.01	1.14	1.00	1.15	1.11
3	10≤q<15	1.11	1.00	1.14	1.01	1.08	1.06
4	15≤q<20	1.00	1.00	1.02	1.06	1.00	1.08
5	20≤q<30	1.01	1.00	1.15	1.12	1.07	1.08
6	30≤q<60	1.05	1.03	1.00	1.09	1.08	1.02
7	60≤q≤90	1.08	1.05	1.01	1.08	1.24	1.13

Table 6.3.1.3.4-3: Difference of Test Beams Set 3 from RefSet1

Elevation Bin	**Elevation angular range**	**Delta from Reference Set 1 (linear)**					
		Test Beams Set 3: 16 Beams (4 x 4)					
		Config 1	**Config 2**	**Config 3**	**Config 4**	**Config 5**	**Config 6**
1	0≤q<5	1.27	1.52	2.51	1.49	2.38	3.25
2	5≤q<10	1.04	1.01	1.14	1.01	1.15	1.11
3	10≤q<15	1.11	1.01	1.14	1.01	1.07	1.06
4	15≤q<20	1.00	1.01	1.02	1.06	1.00	1.08
5	20≤q<30	1.00	1.01	1.14	1.11	1.07	1.07
6	30≤q<60	1.03	1.01	1.05	1.09	1.01	1.02
7	60≤q≤90	1.01	1.00	1.03	1.00	1.02	1.03

Table 6.3.1.3.4-4: Difference of Test Beams Set 4 from RefSet1

Elevation Bin	**Elevation angular range**	**Delta from Reference Set 1 (linear)**					
		Test Beams Set 4: 20 Beams (4 x 5)					
		Config 1	**Config 2**	**Config 3**	**Config 4**	**Config 5**	**Config 6**

1	0≤q<5	1.27	1.52	2.51	1.49	2.38	3.25
2	5≤q<10	1.04	1.01	1.14	1.01	1.14	1.11
3	10≤q<15	1.11	1.01	1.13	1.00	1.07	1.06
4	15≤q<20	1.01	1.01	1.02	1.05	1.01	1.08
5	20≤q<30	1.00	1.02	1.15	1.11	1.07	1.08
6	30≤q<60	1.02	1.00	1.11	1.08	1.02	1.02
7	60≤q≤90	1.03	1.00	1.12	1.00	1.02	1.03

Table 6.3.1.3.4-5: Difference of Test Beams Set 5 from RefSet1

Elevation Bin	Elevation angular range	Delta from Reference Set 1 (linear)					
		Test Beams Set 5: 20 Beams (5 x 4)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
1	0≤q<5	1.22	1.39	1.66	1.36	1.60	2.84
2	5≤q<10	1.04	1.02	1.53	1.02	1.55	1.09
3	10≤q<15	1.08	1.01	1.11	1.01	1.07	1.05
4	15≤q<20	1.01	1.00	1.05	1.05	1.05	1.08
5	20≤q<30	1.00	1.01	1.09	1.10	1.05	1.15
6	30≤q<60	1.02	1.02	1.06	1.09	1.01	1.12
7	60≤q≤90	1.01	1.00	1.04	1.01	1.10	1.03

The results benchmarking against Reference Set 2, RefSet2, is shown in Table 6.3.2.4.4-6 to Table 6.3.2.4.4-10.

Table 6.3.1.3.4-6: Difference of Test Beams Set 1 from RefSet2

Elevation Bin	Elevation angular range	Delta from Reference Set 2 (linear)					
		Test Beams Set 1: 12 Beams (3 x 4)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
1	0≤q<5	1.25	1.51	2.74	1.49	2.61	3.40
2	5≤q<10	1.02	1.01	1.09	1.01	1.10	1.12
3	10≤q<15	1.16	1.02	2.13	1.02	2.34	1.05
4	15≤q<20	1.01	1.03	1.02	1.02	1.02	1.06
5	20≤q<30	1.00	1.04	1.12	1.40	1.10	1.90
6	30≤q<60	1.04	1.00	1.25	1.08	1.14	1.04
7	60≤q≤90	1.03	1.05	1.05	1.03	1.00	1.01

Table 6.3.1.3.4-7: Difference of Test Beams Set 2 from RefSet2

Elevation Bin	Elevation angular range	Delta from Reference Set 2 (linear)					
		Test Beams Set 2: 12 Beams (4 x 3)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
1	0≤q<5	1.20	1.35	1.64	1.33	1.59	2.76
2	5≤q<10	1.03	1.01	1.25	1.01	1.23	1.09
3	10≤q<15	1.11	1.00	1.54	1.00	1.66	1.04
4	15≤q<20	1.01	1.00	1.02	1.01	1.01	1.04
5	20≤q<30	1.01	1.00	1.07	1.29	1.07	1.89
6	30≤q<60	1.05	1.03	1.14	1.06	1.03	1.06
7	60≤q≤90	1.09	1.02	1.01	1.05	1.09	1.11

Table 6.3.1.3.4-8: Difference of Test Beams Set 3 from RefSet2

Elevation Bin	Elevation angular range	Delta from Reference Set 2 (linear)					
		Test Beams Set 3: 16 Beams (4 x 4)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
1	0≤q<5	1.20	1.35	1.64	1.34	1.59	2.76
2	5≤q<10	1.03	1.01	1.25	1.01	1.23	1.10
3	10≤q<15	1.10	1.00	1.54	1.00	1.66	1.04
4	15≤q<20	1.00	1.01	1.02	1.00	1.01	1.04
5	20≤q<30	1.00	1.02	1.07	1.27	1.07	1.89
6	30≤q<60	1.03	1.02	1.26	1.06	1.13	1.06
7	60≤q≤90	1.02	1.01	1.05	1.01	1.12	1.02

Table 6.3.1.3.4-9: Difference of Test Beams Set 4 from RefSet2

Elevation Bin	Elevation angular range	Delta from Reference Set 2 (linear)					
		Test Beams Set 4: 20 Beams (4 x 5)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6
1	0≤q<5	1.20	1.35	1.64	1.34	1.59	2.76
2	5≤q<10	1.03	1.01	1.25	1.01	1.23	1.10
3	10≤q<15	1.10	1.00	1.54	1.00	1.65	1.04
4	15≤q<20	1.00	1.01	1.02	1.00	1.01	1.04
5	20≤q<30	1.01	1.02	1.07	1.27	1.07	1.90
6	30≤q<60	1.02	1.01	1.27	1.05	1.10	1.06
7	60≤q≤90	1.06	1.02	1.11	1.01	1.18	1.04

Table 6.3.2.4.4-10: Difference of Test Beams Set 5 from RefSet2

Elevation Bin	Elevation angular range	Delta from Reference Set 2 (linear)					
		Test Beams Set 5: 20 Beams (5 x 4)					
		Config 1	Config 2	Config 3	Config 4	Config 5	Config 6

1	0≤q<5	1.17	1.29	1.49	1.28	1.46	2.00
2	5≤q<10	1.02	1.02	1.14	1.02	1.13	1.01
3	10≤q<15	1.08	1.01	1.43	1.01	1.50	1.04
4	15≤q<20	1.00	1.00	1.04	1.01	1.00	1.07
5	20≤q<30	1.01	1.01	1.07	1.23	1.07	1.70
6	30≤q<60	1.03	1.02	1.21	1.05	1.12	1.05
7	60≤q≤90	1.02	1.00	1.05	1.01	1.12	1.08

A simple root-mean-square deviation (RMSD) metric can be used as a ‘figure of merit’ to rank the suitability of these Test Beams Sets, and the metric is shown below:

$$RMSD_{TBS\_dB} = 10 \times log_{10}\left(\sqrt[2]{\frac{{RMSD_{allbins\_linear\_A1}}^2+\cdots+{RMSD_{allbins\_linear\_A6}}^2}{6}}\right) ,$$

where the RMSD calculated for each antenna configuration, *Ax*, (over all elevation bins) is derived as

$$RMSD_{allbins\_linear\_Ax} = \left(\sqrt[2]{\frac{{Delta_{bin1\_linear\_Ax}}^2+\cdots+{Delta_{bin7\_linear\_Ax}}^2}{7}}\right)$$

and, $Delta_{bin1\_linear\_Ax}$, … , $Delta_{bin7\_linear\_Ax}$ indicating the linear delta for elevation bin 1 to 7 for the antenna configuration *Ax*.

Table 6.3.2.4.4-11: Summary of evaluation of TBSs for both Reference Sets

No	**Test Beams Set**	**RMSD (dB)**	
		RefSet1	**RefSet2**
1	12 Beams (3 x 4)	1.41	1.49
2	12 Beams (4 x 3)	1.10	0.91
3	16 Beams (4 x 4)	1.06	0.92
4	20 Beams (4 x 5)	1.07	0.93
5	20 Beams (5 x 4)	0.80	0.66

Just to note again that the closer this RMSD to logaritmic (dB) value of ‘0’, the better it represents the Reference Set.

6.3.2.4.5 Additional results

Additional simulations were carried out based on the rectangular Reference Set 2 (RefSet2) as illustrated earlier, and a corresponding elliptical reference set, Reference Set 3 (RefSet3), as shown in Figure 6.3.2.4.5-1.

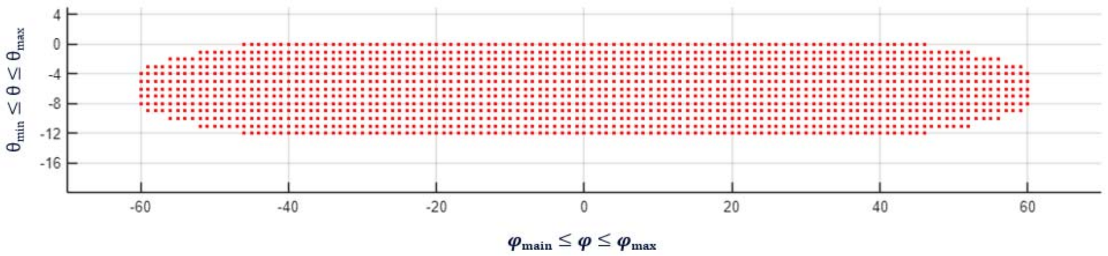
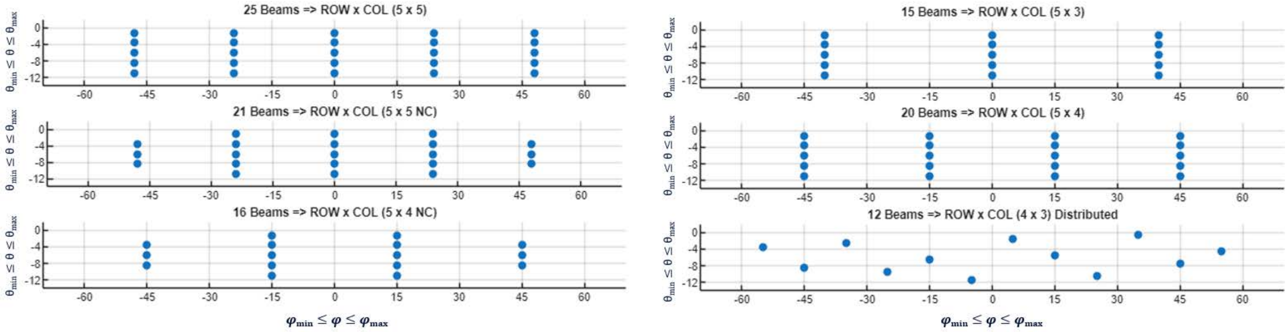


Figure 6.3.2.4.5-1: Reference Set 3 (RefSet3) of beamforming directions

There are six additional Test Beams Sets being simlated as shown in Figure 6.3.2.4.5-2 where a ‘distributed’ pattern was used in the last Set (shown in bottom right corner in the figure). The ‘distributed’ pattern is known to produce quite accurate results when compared to the Reference Set even with smaller number of Test Beams.


25 Beams => ROW x COL (5 x 5)

15 Beams => ROW x COL (5 x 3)

21 Beams => ROW x COL (5 x 5 NC)

20 Beams => ROW x COL (5 x 4)

16 Beams => ROW x COL (5 x 4 NC)

12 Beams => ROW x COL (4 x 3) Distributed

Figure 6.3.2.4.5-2: Additional Test Beams Sets

These additional simulations were carried out using antenna configuration Config 1 to Config 4 where the sub-array pre-tilt for Config 4 changed to 6° to be more common in sub-array designs.

Using the same RMSD formulation in as in the earlier section, the results for both Reference Sets, RefSet2 and RefSet3, is shown in

Table 6.3.2.4.5-1: Summary results from RefSet2

Reference Set 2 (Rectangle)				
No	**Test Beams Set**	**RMSD**	**Max Over-estimation**	**Min Under-estimation**
1	25 Beams (5 x 5)	**0.44**	**0.23**	**-1.72**
2	21 Beams (5 x 5) - NC	**0.82**	**0.90**	**-2.55**
3	16 Beams (5 x 4) - NC	**0.99**	**1.09**	**-2.85**
4	15 Beams (5 x 3)	**0.43**	**0.39**	**-1.73**
5	20 Beams (5 x 4)	**0.43**	**0.20**	**-1.72**
6	12 Beams (4 x 3) - Distributed	**0.33**	**0.08**	**-1.25**

Table 6.3.2.4.5-2: Summary results from RefSet3

Reference Set 3 (Ellipse)				
No	**Test Beams Set**	**RMSD**	**Max Over-estimation**	**Min Under-estimation**
1	25 Beams (5 x 5)	**0.34**	**0.08**	**-1.25**
2	21 Beams (5 x 5) - NC	**0.63**	**0.62**	**-2.08**
3	16 Beams (5 x 4) - NC	**0.79**	**0.81**	**-2.38**
4	15 Beams (5 x 3)	**0.29**	**0.11**	**-1.26**
5	20 Beams (5 x 4)	**0.32**	**0.07**	**-1.25**
6	12 Beams (4 x 3) - Distributed	**0.25**	**0.00**	**-0.89**

Based on the additional set of results, only the 12 Beams (4 x 3) – Distributed set are able to produce an under-estimation of less than 1 dB when compared to Reference Set 3 while offering the lowest under-estimation when compared to Reference Set 2. These additional simulations conclude that lower number of Test Beams can offer better accuracy than higher number of Test Beams given appropriate test beam pattern.

6.3.2.5 ZTE results

6.3.2.5.1 Methodology on how to create the reference testing beams

In order to get the reference/average EEIRP simulation results, the following extreme number of testing number e.g. 10K testing beams within rectangular steering range and 8k testing beams within ellipse steering range are evaluated. In the following section, the methodology on how to generate the beams within rectangular and ellipse steering range are clarified in detail.

6.3.2.5.2 Rectangular reference beam sets

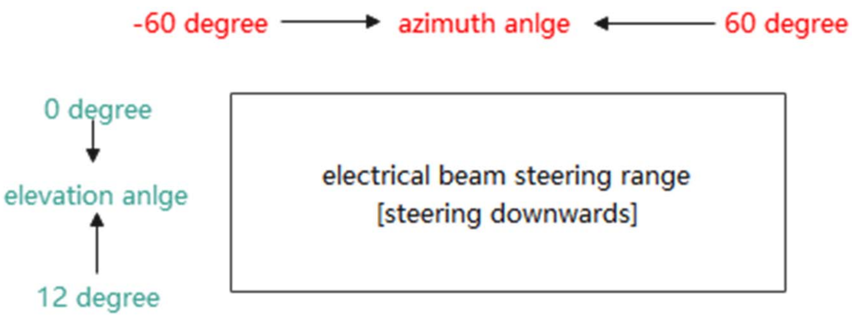


Figure 6.3.2.5.2-1. the illustration of beam steering range in the rectangular coverage

The methodology on how to generate the beams within rectangular steering range as shown in Figure 6.3.1.4.2-1 is described as following:

- To generate the 10k uniform distributed values between 0 degree to 12 degree, say X
- To generate the 10k uniform distributed values between -60 degree to 60 degree, say Y.
- To create rectangular reference beam sets as [X, Y] where Xi is electrical down-tilt of beam i and Yi is electrical scanning of beam i.

6.3.2.5.3 Ellipse reference beam sets

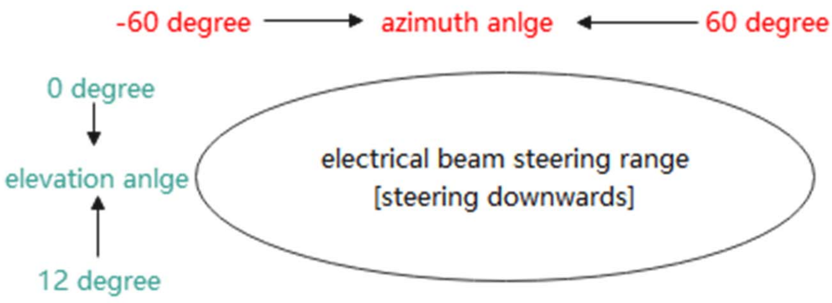


Figure 6.3.2.5.3-1. the illustration of beam steering range in the ellipse coverage

The methodology on how to generate the beams within ellipse steering range as shown in Figure 6.3.2.5.3-1 is described as following:

- To generate the 8k random values for the angle: theta=2 * pi * rand(N, 1) ;
- To generate the 8k random values for r: r=sqrt(rand(N, 1)) ;
- To create the 8k azimuth angle as following

  - Y= 0+maximum azimuth steering range * r .* cos(theta);
- To create the 8k elevation angle as following
  - X= 1/2* maximum elevation steering range + 1/2* maximum elevation steering range * r .* sin(theta)
- To create ellipse reference beam sets as [X, Y] where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i.

6.3.2.5.4 Candidate testing beams for EEIRP conformance testing

6.3.2.5.4.1 Random pattern with 20 testing beams

As shown in the figure 6.3.2.5.4.1-1, it is to use the random approach to get the sampling for the testing beams. The details could be found as following example:

- To calculate the step size for elevation angle as 12/20=0.6 degree
- To calculate the step size for azimuth angle as 120/25=4.8 degree
- To create option 1a beam sets as [X, Y] according to the above step size with beam peak steering direction located in the center of each indicated finer box where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i with elevation beam steering range from 0 degree to 12 degree and azimuth beam scanning range from -60 degree to 60 degree.

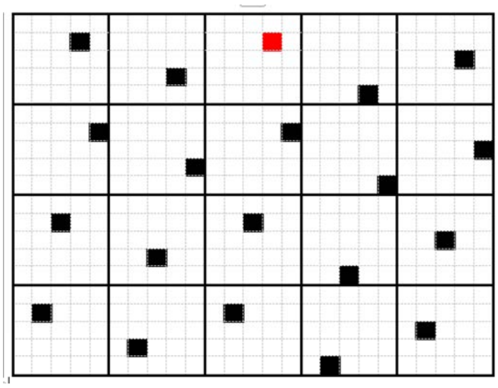


Figure 6.3.2.5.4.1-1. random approach to create the testing beams for EEIRP conformance testing

6.3.2.5.4.2 20 fixed testing beams

As shown in the figure 6.3.2.5.4.2-1, it is proposed to use the equally distributed approach to get the sampling for the testing beams. The details could be found as following example:

- To calculate the step size for elevation angle as 12/25=0.48 degree
- To calculate the step size for azimuth angle as 120/20=6 degree
- To create option 1a beam sets as [X, Y] according to the above step size with beam peak steering direction located in the center of each indicated finer box where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i with elevation beam steering range from 0 degree to 12 degree and azimuth beam scanning range from -60 degree to 60 degree.

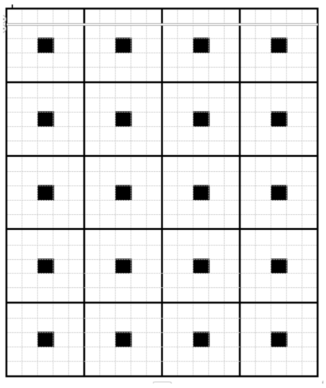


Figure 6.3.2.5.4.2-1. Equally distributed approach to create the 20 testing beams for EEIRP conformance testing

6.3.2.5.4.3 16 fixed testing beams

As shown in the figure 6.3.2.5.4.3-1, it is proposed to use the equally distributed approach to get the sampling for the testing beams. The details could be found as following example:

- To calculate the step size for elevation angle as 12/20=0.6 degree

- To calculate the step size for azimuth angle as 120/20=6 degree

- To create option 1a beam sets as [X, Y] according to the above step size with beam peak steering direction located in the center of each indicated finer box where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i with elevation beam steering range from 0 degree to 12 degree and azimuth beam scanning range from -60 degree to 60 degree.

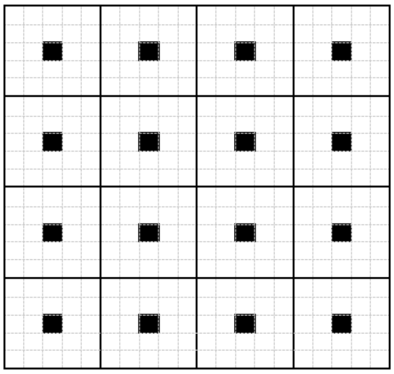


Figure 6.3.2.5.4.3-1. equally distributed approach to create the 16 testing beams for EEIRP conformance testing

6.3.2.5.4.4 25 fixed testing beams

As shown in the figure 6.3.2.5.4.4-1, it is proposed to use the equally distributed approach to get the sampling for the testing beams. The details could be found as following example:

- To calculate the step size for elevation angle as 12/25=0.48 degree
- To calculate the step size for azimuth angle as 120/25=4.8 degree

- To create option 1a beam sets as [X, Y] according to the above step size with beam peak steering direction located in the center of each indicated finer box where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i with elevation beam steering range from 0 degree to 12 degree and azimuth beam scanning range from -60 degree to 60 degree.

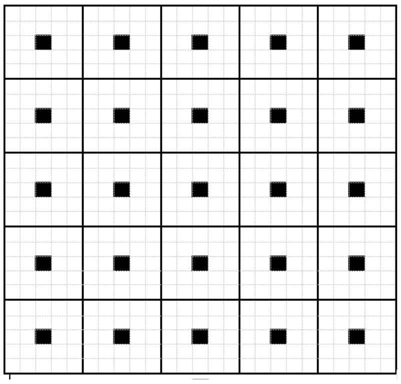


Figure 6.3.2.5.4.4-1. equally distributed approach to create the 25 testing beams for EEIRP conformance testing

6.3.2.5.4.5 Scaling testing beams

As shown in the figure 6.3.2.5.4.5-1/2/3, considering BS capable with different steering range in the elevation angle. For electrical downtilt as 12 degree, 16 testing beams is considered to be sufficient to get the accurate results compared with reference case EEIRP. For the case with 16 degree electrical down-tilt, a larger number of testing beams in the elevation angle achieves better accuracy.

Scaling testing beams is proposed as following with fixed step size in the elevation angle as following. If testing beams within the steering range could be select as conformance testing. e.g. if NR BS is capable of downtilt as 12 degree, then 16 test beams should be tested; if NR BS is capable of downtilt as 16 degree, then 20 test beams should be considered.

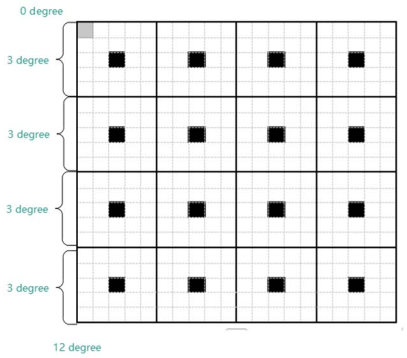


Figure 6.3.2.5.4.5-1: Equally distributed approach to create the 16 testing beams for EEIRP conformance testing

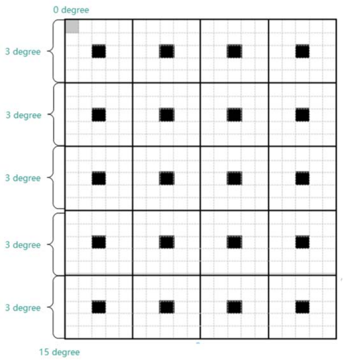


Figure 6.3.2.5.4.5-2: Equally distributed approach to create the 20 testing beams for EEIRP conformance testing

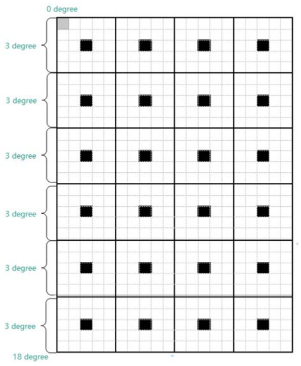


Figure 6.3.2.5.4.5-3: Equally distributed approach to create the 24 testing beams for EEIRP conformance testing

6.3.2.5.4.6 21 testing beam

As shown in the figure 6.3.2.5.4.6-1, it is proposed to use the equally distributed approach to get the sampling for the testing beams. The details could be found as following example:

- To calculate the step size for elevation angle as 12/25=0.48 degree
- To calculate the step size for azimuth angle as 120/25=4.8 degree
- To create option 1a beam sets as [X, Y] according to the above step size with beam peak steering direction located in the center of each indicated finer box where Xi is electrical downtilt of beam i and Yi is electrical scanning of beam i with elevation beam steering range from 0 degree to 12 degree and azimuth beam scanning range from -60 degree to 60 degree.
- 4 corner beams are not considered for the EEIRP evaluation.

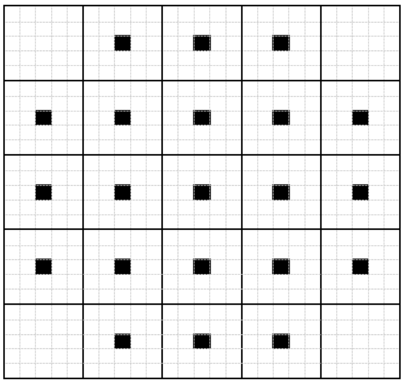


Figure 6.3.2.5.4.6: 5x5 without 4 corner beam for EEIRP conformance testing

6.3.3 Simulation results for EEIRP evaluation

The simulation results for above candidate testing beam are summarized in the following table.

Table 6.3.3-1. simulation results for Antenna configuration 4 with electrical downtilt 12 degrees

Candidate test beam	Ant 4 with electrical downtilt as 12 degrees					
	Rectangular reference			Ellipse reference		
	Mean error	OverEstimate	UnderEstimate	Mean error	OverEstimate	UnderEstimate
Random pattern	0.29	0.30	-0.64	0.67	1.53	-1.40
5x4	0.28	0.23	-0.49	0.46	0.76	-0.54
4x4	0.48	0.26	-0.87	0.48	0.57	-0.75
5x5	0.30	0.16	-0.49	0.55	0.75	-1.11
Scaling test beam	0.48	0.26	-0.87	0.48	0.57	-0.75
5x5 without corner	0.42	0.36	-0.98	0.18	0.25	-0.40

Table 6.3.3-2. simulation results for Antenna configuration 4 with electrical downtilt as 16 degrees

Candidate test beam	Ant 4 with electrical downtilt as 16 degrees					
	Rectangular reference			Ellipse reference		
	Mean error	OverEstimate	UnderEstimate	Mean error	OverEstimate	UnderEstimate
Random pattern	0.25	0.26	-0.49	0.81	1.42	-1.57
5x4	0.47	0.52	-1.20	0.59	1.05	-0.79
4x4	0.73	0.49	-2.94	0.74	0.93	-1.52
5x5	0.44	0.02	-1.21	0.69	1.05	-1.23
Scaling test beam	0.74	0.82	-1.52	0.43	0.90	-0.37
5x5 without corner	0.80	0.64	-1.51	0.33	0.38	-0.97

Table 6.3.3-3. simulation results for Antenna configuration 1 with electrical downtilt as 12 degrees

Candidate test beam	Ant 1 with electrical downtilt as 12 degrees					
	Rectangular reference			Ellipse reference		
	Mean error	OverEstimate	UnderEstimate	Mean error	OverEstimate	UnderEstimate
Random pattern	0.07	0.21	-0.05	0.46	1.32	-0.90
5x4	0.07	0.05	-0.31	0.35	0.80	-0.85
4x4	0.12	0.07	-0.50	0.33	0.61	-0.90
5x5	0.07	0.05	-0.32	0.34	0.79	-0.84
5x5 without corner	0.34	0.71	-0.89	0.08	0.22	-0.14

Table 6.3.3-4. simulation results for Antenna configuration 1 with electrical downtilt as 16 degrees

Candidate test beam	Ant 1 with electrical downtilt as 16 degrees					
	Rectangular reference			Ellipse reference		
	Mean error	OverEstimate	UnderEstimate	Mean error	OverEstimate	UnderEstimate
Random pattern	0.08	0.25	-0.01	0.50	1.52	-0.83
5x4	0.11	0.04	-0.53	0.35	0.74	-0.83
4x4	0.20	0.09	-0.94	0.29	0.32	-0.84
5x5	0.11	0.04	-0.53	0.34	0.73	-0.81
5x5 without corner	0.38	0.72	-1.13	0.07	0.14	-0.12

Based on the above simulation results, the performance metric for 5x4 and 5x5 is quite close. The underestimate performance for 5x5 is even around 0.5dB worse than 5x4 case if ellipse reference is considered. And performance metric for 5x4 and 4x4 is also quite close when electrical downtilt as 12 degree.

6.3.4 Conclusion on test beam set

According to the EEIRP evaluation in clause 6.3.3, 21 testing beam constellation could provide the accurate EEIRP estimation results compared with the reference beam set from both average error and also under-estimate /over-estimate performance.

Given the results presented in clause 6.3.3, RAN4 decided to define the test beams set consisting of 21 beams in a constellation of 5x5 without corners (i.e. 25 – 4=21), as shown in figure 6.3.4-1

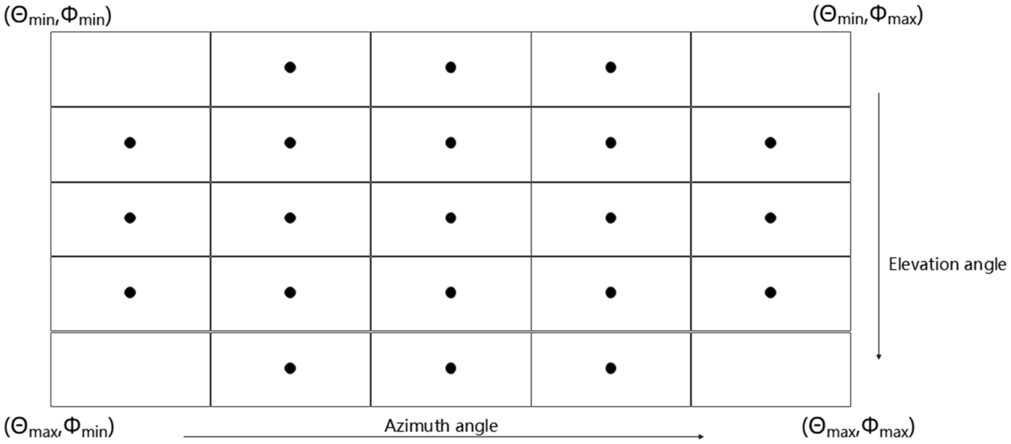


Figure 6.3.4-1 Test beam set for conformance testing

The main reasons for choosing this test beam set are:

- 5 beams in the elevation domain prove to be sufficient for accurate EEIRP estimation.
- Exclusion of the corner beams is justified by their low relevance towards real operation scenarios.
- A test beam constellation with 21 test beams could provide the sufficient coverage within the declared beam steering range.
- A test beam constellation with 21 test beams constellation guarantees accurate measurement for different array antenna geometry implementations.

Table 6.3.4-1: Test beam constellation

Beam index	Elevation angle	Azimuth angle	Weighting factor
1	$\Theta_{min}+2.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+7.5(\Phi_{max}-\Phi_{min})/25$	1/21
2	$\Theta_{min}+2.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+12.5(\Phi_{max}-\Phi_{min})/25$	1/21
3	$\Theta_{min}+2.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+17.5(\Phi_{max}-\Phi_{min})/25$	1/21
4	$\Theta_{min}+7.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+2.5(\Phi_{max}-\Phi_{min})/25$	1/21
5	$\Theta_{min}+7.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+7.5(\Phi_{max}-\Phi_{min})/25$	1/21
6	$\Theta_{min}+7.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+12.5(\Phi_{max}-\Phi_{min})/25$	1/21
7	$\Theta_{min}+7.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+17.5(\Phi_{max}-\Phi_{min})/25$	1/21
8	$\Theta_{min}+7.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+22.5(\Phi_{max}-\Phi_{min})/25$	1/21
9	$\Theta_{min}+12.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+2.5(\Phi_{max}-\Phi_{min})/25$	1/21
10	$\Theta_{min}+12.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+7.5(\Phi_{max}-\Phi_{min})/25$	1/21

11	$\Theta_{min}+12.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+12.5(\Phi_{max}-\Phi_{min})/25$	1/21
12	$\Theta_{min}+12.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+17.5(\Phi_{max}-\Phi_{min})/25$	1/21
13	$\Theta_{min}+12.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+22.5(\Phi_{max}-\Phi_{min})/25$	1/21
14	$\Theta_{min}+17.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+2.5(\Phi_{max}-\Phi_{min})/25$	1/21
15	$\Theta_{min}+17.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+7.5(\Phi_{max}-\Phi_{min})/25$	1/21
16	$\Theta_{min}+17.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+12.5(\Phi_{max}-\Phi_{min})/25$	1/21
17	$\Theta_{min}+17.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+17.5(\Phi_{max}-\Phi_{min})/25$	1/21
18	$\Theta_{min}+17.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+22.5(\Phi_{max}-\Phi_{min})/25$	1/21
19	$\Theta_{min}+22.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+7.5(\Phi_{max}-\Phi_{min})/25$	1/21
20	$\Theta_{min}+22.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+12.5(\Phi_{max}-\Phi_{min})/25$	1/21
21	$\Theta_{min}+22.5(\Theta_{max}-\Theta_{min})/25$	$\Phi_{min}+17.5(\Phi_{max}-\Phi_{min})/25$	1/21

6.4 Spatial sampling grid

For the maximum measurement/spatial sampling step size in the elevation angle, since the elevation angular range for some elevation bins bin is quite limited, especially for 1st, 2nd, 3rd and 4th elevation bin with only 5 degree angular range, in order to ensure the measurement accuracy of EEIRP measurement in the elevation angle to comply with WRC-23 resolution, RAN4 agree to use 1 degree as maximum measurement/spatial sampling step size in the elevation angle.

For the maximum measurement/spatial sampling step size in the azimuth angle, RAN4 agree to use the following approach similar as TRP measurement captured in Annex I in TS 38.141-2:

$$\begin{cases} \Delta\theta = 1 \\ \Delta\varphi = \dfrac{180}{\pi}\dfrac{\lambda}{D} \end{cases}$$

where, λ is the wavelength and D is the physical length of the array antenna diagonal. The physical length of the array antenna diagonal can be determined by following expression:

$$D = \sqrt{w^2 + h^2}$$

where, w is the array antenna width, and h is the array antenna height.

6.5 Method of test

6.5.1 General

Traditionally, the measurement can be divided into two different stages: Test range calibration and measurement. For an EEIRP measurement a third stage is introduced.

1. Test range pathloss calibration and measurement receiver absolute power level calibration.
2. EIRP pattern measurements for a set of defined test beam directions.
3. Post-processing to calculate EEIRP for defined elevation bins.

In the calibration stage the antenna test range transmission loss is characterized with the intention to minimize error sources related to test setup. A common approach used is the substitution method, where a reference antenna with known antenna gain is used to determine the transmission loss in the test range. The test range calibration is described in detail in TR 37.941, subclause 8.3.

In addition, the measurement uncertainty can be improved by calibrating the absolute power measurement uncertainty of the measurement receiver (spectrum analyzer with fairly high absolute power measurement uncertainty) using a power meter (with very low measurement uncertainty). A detailed description of suitable test ranges and corresponding calibration procedures can be found in TR 37.941, subclause 8.3.1.

6.5.2 Initial conditions

The initial conditions section contains the test set up initial conditions including:

- the test environment,
- the channels to be tested
- the beams to be tested or the test beam direction set in this case
- Mechanical tilt and steering rang condition for test

Test environment

EEIRP is to be measured under normal conditions

NOTE: Currently only a few parameters are measured under extreme conditions which is very challenging as the OTA chamber cannot be environmentally controlled. Controlling the temperature of the DUT locally is implemented for limited tests but this is not practical to EEIRP measurements.

RF channels

EEIRP measurement is a very long measurement, the number of channels tested will increase the test time.

The frequency variation across the EEIRP band is approximately 10%, over this range, the gain of the main beam will slightly change. However, EEIRP estimated value is dominated by the sidelobe behaviour of the antenna pattern rather than the main beam. As such, looking at the EEIRP performance of an antenna over the frequency range there is no clear worst case, the performance is no worse at Bottom channel or Top channel than it is at the Middle channel.

As no RF channel is worse than any other it could be argued any channel could be used, as such the Middle channel is the obvious choice.

Test signal and test model

As EEIRP requirement is based on power spectral density (PSD), testing should be carried out with the highest PSD the BS is capable to support

NOTE: Maximum PSD might be achieved when using the smallest channel bandwidth, despite limited output power.

The performance is dependent on the radiation beam shape, non-linearities or distortions potentially generated by multi-carrier signals will not significantly alter the beam shape of the wanted signal.

For this reason single carrier test signal is sufficient for the scope of conformance testing, together with test model NR-FR1-TM1.1.

Beams to be tested.

The test beam direction set is discussed in sub-clause 6.3. The set of beams used for the test should be described or referenced in the initial conditions.

Mechanical tilt and steering range conditions for test

The test beam direction set is applied to the BS steering range and applicable mechanical tilt conditions.

The BS should be compliant to the EEIRP requirement over all operational conditions however it can be seen from figure 6.5.2-1 that the worst case conditions with respect to steering range and mechanical tilt are quite clear.

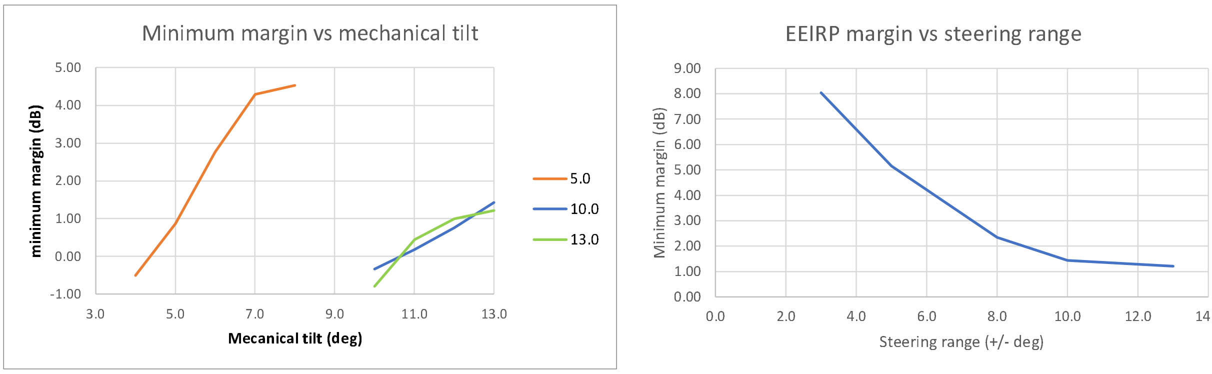


Figure 6.5.2-1. left: Margin vs mechanical down tilt, right margin vs electrical steering range

In figure 6.5.2-1 on the left hand graph the mechanical tilt is varied for various electrical steering ranges. In all cases it can be seen that as mechanical tilt increases the margin gets larger.

On the right hand graph the electrical steering range is varied (for a fixed mechanical tilt). It is clear that as the steering range increases the margin reduces

The worst-case condition is when mechanical tilt is minimum (closest to horizon) and the electrical steering range is maximum. As such this condition should be declared and tested.

In real products we should allow for that fact that these 2 conditions may not be declared simultaneously as such the following caveat should be added.

The minimum mechanical down tilt and the maximum electrical steering range shall be declared. If the maximum steering range and the minimum mechanical down tilt are not simultaneously supported, the manufacturer shall declare and test the following two instances:

- Minimum mechanical down tilt and the reduced electrical steering range
- Maximum electrical steering range and increased mechanical down tilt

The mechanical tilts and associated electrical steering ranges are declared.

6.5.3 Test procedure

The test procedure is based on a CATR/IAC where the BS is placed on a positioner and rotated so the required measurement direction is in line with the measurement antenna. The procedure has similarities to existing EIRP and TRP measurement procedures.

The test procedure is as follows:

The test range shall be calibrated the test range, according to calibration method described in TR 37.941, clause 8.3

1. Place the BS at the positioner, such that blocking effect in the vertical domain is minimized.

2. Align the manufacturer declared coordinate system orientation (D.2) of the BS with the coordinate system used by the test system. The configured EIRP for each of the test beams shall be in direct relation to the intended use of the BS.

3. The measurement device characteristics shall be: Detection mode: True RMS.

4. Set the BS to transmit on both polarizations according to applicable test configuration in TS 38.141-2, subclause 4.8 using the corresponding test model NR-FR1-TM1.1 described in TS 38.141-1, clause 4.9.2.

5. Orient the positioner (and the BS) to the angle at location for measurement point (θ_n, φ_m) for $m = 1..M$ and $n =$ 1.. N. Spatial sampling grid is defined in clause 6.4.

6. Configure test beam(s) and test equipment for measuring test beam k for k=1…K, as defined in clause 4.9.3.2.

7. Measure EIRP as a sum of two orthogonal polarizations:

$EIRP_k(\theta_n, \varphi_m) = EIRP_{p1} + EIRP_{p2}$ where p1 and p2 denote two orthogonal polarizations.

Follow either the order of steps 8a/9a or 8b/9b

8a. Repeat step 6 and 7 for all K test beams.

8b. Repeat step 5 and 7 for all M and N positioner angles

9a. Repeat step 5 and 8a for all M and N positioner angle.

9b. Repeat step 6 and 8b for all K test beams.

10. Calculate $EEIRP_i$ from measured $EIRP_k(\theta_n, \varphi_m)$ for bins i=1..7 as in clause 6.4.

6.6 Measurement uncertainty

6.6.1 General

The EEIRP measurement is very similar to the in-band TRP measurements, as such the in-band emission MU budgets from TR 37.941 can be used as a starting point for the EEIRP budgets.

As the confidence interval is referred to directly in the regulatory text [2] as follows:

> *The averaging processes in steps 1 and 2 shall allow for accurate averaging of the expected e.i.r.p (e.g. to the confidence interval of 95%).*

The averaging process in steps 1 and 2 refer to both the averaging of the angular measurement directions on the sampling grid and the number of beam steering directions inside the steering range.

Inaccuracies in these averaging processes occur when the number of angular measurement directions per beam and the number of test beams are reduced from an infinite number of sampling steps identified by the closed form equations to a discrete number of samples which are necessary for the practical measurement of the EEIRP calculation.

As such the accuracy referred to in the regulatory text is part of the measurement uncertainty analysed below.

The example of a 95% confidence interval is not a separate requirement, it is a statistical measure of how to represent that accuracy and is the same measure which applies to all legacy measurement uncertainty calculations.

As the EEIRP calculation uncertainty due to averaging has a standard deviation of 0.5dB as below, a confidence interval of 95% the accuracy of the averaging is supposed to be within 1dB (0.5 *1.96).

6.6.1 Uncertainties

Additional sources of uncertainty are:

Dynamic range uncertainty

One major difference with EEIRP, compared to TRP, is the necessity to measure complete EIRP pattern with focus on the sidelobe region (i.e. for a real-life site this is the region pointing towards the sky). This means measurement receiver must be considered in such way that the dynamic range can handle the power created by the peak main beam as the maximum level and detecting the low levels in the side lobe region with accurate power. The power level accuracy is typically different for high power with large SNR compared to coming closer to the noise floor of the measurement receiver.In addition, to avoid the impacts (reflections and refractions of the main beam within the chamber) from main beam to sidelobe beam, the chamber spatial isolation is necessary to remove the effect of the main beam.

The lowest EEIRP requirement is 15dBm/MHz

Currently, the dynamic range contribution is 0.51dB, in order to maintain that level of accuracy in the above scenario an isolation of approximately 58dB under the assumption of peak EIRP 63.7dBm for main beam would be required:

$$P_{int} = 10 * log_{10}\left(10^{\frac{63.7-58}{10}} + 10^{\frac{15}{10}}\right) = 15.5dBm/MHz \text{ i.e. 0.5dB error}$$

With this approach the error will be rectangular distributed.

EEIRP sampling Error

The EEIRP sampling error is caused by the fact that coverage steering range is sampled with a limited set of test beams.

According to the agreed test beam pattern, errors between the EEIRP simulation results of test beam and EEIRP simulation results of reference testing beams (e.g. 2.4K or 8K or 10K) are provided in the following table 6.6.1-1.

Table 6.6.-1: Errors per bin between the EEIRP simulation results of test beam and EEIRP simulation results of reference testing beams

		Bin index	**1**	**2**	**3**	**4**	**5**	**6**	**7**
ZTE	Ant 4, 12degree	Error for Rect Ref	-0.98	-0.17	-0.70	-0.28	-0.30	0.04	0.36
		Error for Ellipse Ref	0.25	-0.22	-0.03	0.07	0.21	-0.11	-0.40
	Ant 4, 16degree	Error for Rect Ref	-1.51	-1.38	-0.78	0.64	-0.42	-0.20	0.54
		Error for Ellipse Ref	-0.09	-0.97	0.38	-0.03	0.20	-0.05	-0.54
	Ant 1, 12degree	Error for Rect Ref	-0.98	-0.17	-0.70	-0.28	-0.30	0.04	0.36
		Error for Ellipse Ref	0.25	-0.22	-0.03	0.07	0.21	-0.11	-0.40
	Ant 1, 16degree	Error for Rect Ref	-1.13	-0.09	0.03	0.09	0.14	0.33	0.72
		Error for Ellipse Ref	0.14	0.10	0.03	0.02	-0.01	-0.06	-0.12
Huawei		Bin index	1	2	3	4	5	6	7
	Ant 4, 12degree	Error for Rect Ref	-1.25	-0.32	-1.15	-0.81	-0.46	-0.26	0.36
		Error for Ellipse Ref	0.28	0.07	0.01	0.07	0.17	0.10	-0.40
	Ant 4, 16degree	Error for Rect Ref	-0.44	-1.12	-0.82	0.38	-0.77	-0.34	0.37
		Error for Ellipse Ref	0.43	0.27	-0.06	-0.01	0.10	0.03	-0.48
	Ant 1, 12degree	Error for Rect Ref	-1.08	-0.18	-0.05	0.01	0.05	0.28	0.66
		Error for Ellipse Ref	0.14	0.01	0	0	0.02	-0.03	-0.15
	Ant 1, 16degree	Error for Rect Ref	-1.15	-0.34	-0.17	-0.09	-0.01	0.25	0.60
		Error for Ellipse Ref	-0.01	0.01	0.03	0.04	0.03	0	-0.18
Ericsson		Bin index	1	2	3	4	5	6	7
	Ant 4, 16degree	Error for Rect Ref	-1.35	-0.43	1.03	0.7	0.82	0.49	1.96
		Error for Ellipse Ref	0.48	-0.19	0.2	0.57	0.11	0.15	1.07
	Ant 1, 16degree	Error for Rect Ref	-0.66	-0.311	0.04	0.05	0.09	0.23	0.63
		Error for Ellipse Ref	0.41	-0.3	0.1	0.17	0.06	0.02	0.06
Nokia		Bin index	1	2	3	4	5	6	7
	Ant 1, 12degree	Error for Rect Ref	-1.47	-0.12	-0.33	-0.15	0.06	0.28	0.90
		Error for Ellipse Ref	1.16	-0.10	-0.26	-0.12	0.04	0.13	0.62

The errors provided in table 6.6.1-1 have a normal distribution as shown in the histogram in figure 6.6.1-2.

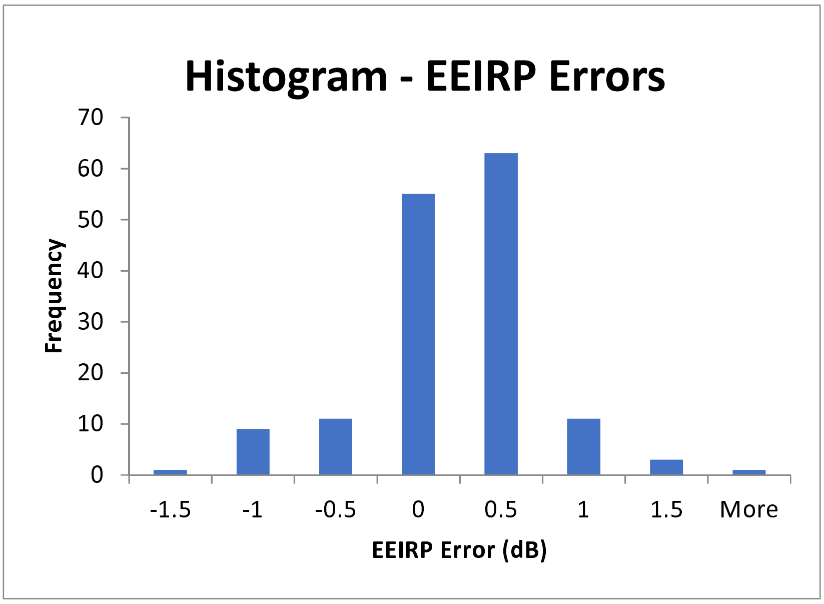


Figure 6.6.1-2 – Histogram of EEIRP Errors

The errors have a standard deviation of 0.5dB.

6.6.2 Measurement uncertainty budgets

These two errors have been added to the MU budget as follows:

Table 6.6.3-1: IAC MU value derivation for EEIRP measurement, FR1

IAC MU value derivation for EEIRP measurement, FR1										
UID	Uncertainty source	Uncertainty value (dB)			Distribution of the probability	Divisor based on distribution shape	c_i	Standard uncertainty ui (dB)		
				4.2<f≤7.125 GHz						4.2<f≤7.125 GHz
Stage 2: BS measurement										
A1-1	Positioning misalignment between the BS and the reference antenna			0.03	Rectangular	1.73	1			0.02
A1-2	Pointing misalignment between the BS and the receiving antenna			0.3	Rectangular	1.73	1			0.17
A1-3	Quality of quiet zone			0.1	Gaussian	1.00	1			0.10
A1-4a	Polarization mismatch between the BS and the receiving antenna			0.01	Rectangular	1.73	1			0.01
A1-5a	Mutual coupling between the BS and the receiving antenna			0	Rectangular	1.73	1			0.00
A1-6	Phase curvature			0.05	Gaussian	1.00	1			0.05
C1-1	Uncertainty of the RF power measurement equipment (e.g. spectrum analyzer, power meter)			[0.26]	Gaussian	1.00	1			0.26
A1-7	Impedance mismatch in the receiving chain			0.33	U-shaped	1.41	1			0.23
A1-8	Random uncertainty			0.1	Rectangular	1.73	1			0.06
A2-21	Measurement system dynamic range uncertainty			0.5	Rectangular	1.73	1			0.29
*new	EEIRP calculation uncertainty			0.5	Gaussian	1	1			0.5
Stage 1: Calibration measurement										
A1-9	Impedance mismatch between the receiving antenna and the network analyzer			0.05	U-shaped	1.41	1			0.04
A1-10	Positioning and pointing misalignment between the reference antenna and the receiving antenna			0.01	Rectangular	1.73	1			0.01

IAC MU value derivation for EEIRP measurement, FR1										
UID	Uncertainty source	Uncertainty value (dB)			Distribution of the probability	Divisor based on distribution shape	c_i	Standard uncertainty ui (dB)		
				4.2<f≤7.125 GHz						4.2<f≤7.125 GHz
Stage 2: BS measurement										
A1-11	Impedance mismatch between the reference antenna and the network analyzer			0.05	U-shaped	1.41	1			0.04
A1-3	Quality of quiet zone (normal test conditions)			0.10	Gaussian	1.00	1			0.10
A1-4b	Polarization mismatch between the reference antenna and the receiving antenna			0.01	Rectangular	1.73	1			0.01
A1-5b	Mutual coupling between the reference antenna and the receiving antenna			0.00	Rectangular	1.73	1			0.00
A1-6	Phase curvature			0.05	Gaussian	1.00	1			0.05
C1-3	Uncertainty of the network analyzer			[0.20]	Gaussian	1.00	1			0.20
A1-12	Influence of the reference antenna feed cable			0.05	Rectangular	1.73	1			0.03
A1-13	Reference antenna feed cable loss measurement uncertainty			0.06	Gaussian	1.00	1			0.06
A1-14	Influence of the receiving antenna feed cable			0.05	Rectangular	1.73	1			0.03
C1-4	Uncertainty of the absolute gain of the reference antenna			0.43	Rectangular	1.73	1			0.25
A1-15	Uncertainty of the absolute gain of the receiving antenna			0.00	Rectangular	1.73	1			0.00
Combined standard uncertainty (1σ) (dB)										**0.79**
Expanded uncertainty (1.96σ - confidence interval of 95 %) (dB)										**1.55**

Table 6.6.3-2. CATR MU value derivation for EEIRP measurement, FR1

CATR MU value derivation for EEIRP measurement, FR1										
UID	Uncertainty source	Uncertainty value (dB)			Distribution of the probability	Divisor based on distribution shape	c_i	Standard uncertainty ui (dB)		
				4.2<f≤7.125 GHz						4.2<f≤7.125 GHz
Stage 2: BS measurement										
A2-18a	Misalignment and pointing error of BS (for TRP)			0.30	Rectangular	1.73	1			0.173
C1-1	Uncertainty of the RF power measurement equipment (e.g. spectrum analyzer, power meter)			0.26	Gaussian	1.00	1			0.260
A2-2a	Standing wave between BS and test range antenna			0.21	U-shaped	1.41	1			0.148
A2-3	RF leakage (SGH connector terminated & test range antenna connector cable terminated)			0.00	Gaussian	1.00	1			0.001
A2-4a	QZ ripple experienced by BS			0.09	Gaussian	1.00	1			0.093
A2-12	Frequency flatness of test system			0.25	Gaussian	1.00	1			0.250
A2-17	Measurement system dynamic range uncertainty			0.5	Rectangular	1.73	1			0.29
*new	EEIRP calculation uncertainty			0.5	Gaussian	1	1			0.5
Stage 1: Calibration measurement										
C1-3	Uncertainty of the network analyzer			0.20	Gaussian	1.00	1			0.20
A2-5a	Mismatch of receiver chain between receiving antenna and measurement receiver			0.33	U-shaped	1.41	1			0.23
A2-6	Insertion loss of receiver chain			0.18	Rectangular	1.73	1			0.10
A2-3	RF leakage (SGH connector terminated & test range antenna connector cable terminated)			0.00	Gaussian	1.00	1			0.00

CATR MU value derivation for EEIRP measurement, FR1										
UID	**Uncertainty source**	**Uncertainty value (dB)**			**Distribution of the probability**	**Divisor based on distribution shape**	***c_i***	**Standard uncertainty ui (dB)**		
				4.2<f≤7.125 GHz						**4.2<f≤7.125 GHz**
Stage 2: BS measurement										
A2-7	Influence of the calibration antenna feed cable			0.02	U-shaped	1.41	1			0.02
C1-4	Uncertainty of the absolute gain of the reference antenna			0.43	Rectangular	1.73	1			0.25
A2-8	Misalignment positioning system			0.00	Exp. normal	2.00	1			0.00
A2-18b	Misalignment and pointing error of calibration antenna (for TRP)			0.50	Exp. normal	2.00	1			0.25
A2-9	Rotary joints			0.05	U-shaped	1.41	1			0.03
A2-2b	Standing wave between calibration antenna and test range antenna			0.09	U-shaped	1.41	1			0.06
A2-4b	QZ ripple experienced by calibration antenna (normal test conditions)			0.01	Gaussian	1.00	1			0.01
A2-11	Switching uncertainty			0.26	Rectangular	1.73	1			0.15
Combined standard uncertainty (1σ) (dB)										**0.88**
Expanded uncertainty (1.96σ - confidence interval of 95 %) (dB)										**1.73**

Table 6.6.3-3: PWS MU value derivation for EEIRP measurement, FR1

PWS MU value derivation for EEIRP measurement, FR1										
UID	**Uncertainty source**	**Uncertainty value (dB)**			**Distribution of the probability**	**Divisor based on distribution shape**	***c_i***	**Standard uncertainty ui (dB)**		
				4.2<f≤7.125 GHz						**4.2<f≤7.125 GHz**
Stage 2: BS measurement										
A7-1a	Misalignment and pointing error of BS			0.10	Rectangular	1.73	1			0.06
C1-1	Uncertainty of the RF power measurement equipment (e.g. spectrum analyzer, power meter)			0.26	Gaussian	1.00	1			0.26
A7-2a	Longitudinal position uncertainty (i.e. standing wave and imperfect field synthesis) for BS antenna			0.20	Rectangular	1.73	1			0.12
A7-3	RF leakage (calibration antenna connector terminated)			0.09	Gaussian	1.00	1			0.09
A7-4a	QZ ripple experienced by BS			0.77	Rectangular	1.73	1			0.44
A7-5	Miscellaneous uncertainty			0.00	Gaussian	1.00	1			0.00
A7-14	System non-linearity			0.22	Rectangular	1.73	1			0.13
A7-13	Frequency flatness of test system			0.13	Rectangular	1.73	1			0.08
A2-21	Measurement system dynamic range uncertainty			0.50	Rectangular	1.73	1			0.29
*new	EEIRP calculation uncertainty			0.5	Gaussian	1	1			0.5
Stage 1: Calibration measurement										

C1-3	Uncertainty of network analyzer			0.20	Gaussian	1.00	1			0.20
A7-6	Mismatch (i.e. reference antenna, network analyser and reference cable)			0.33	U-shaped	1.41	1			0.23
A7-7	Insertion loss of receiver chain			0.18	Rectangular	1.73	1			0.10
A7-3	RF leakage (calibration antenna connector terminated)			0.09	Gaussian	1.00	1			0.09
A7-8	Influence of the calibration antenna feed cable			0.10	Rectangular	1.73	1			0.06
C1-4	Uncertainty of the absolute gain of the reference antenna			0.43	Rectangular	1.73	1			0.25
A7-9	Misalignment of positioning system			0.00	Exp. normal	2.00	1			0.00
A7-1b	Misalignment and pointing error of calibration antenna			0.05	Rectangular	1.73	1			0.03
A7-10	Rotary joints			0.00	U-shaped	1.73	1			0.00
A7-2b	Longitudinal position uncertainty (i.e. standing wave and imperfect field synthesis) for calibration antenna			0.18	Rectangular	1.73	1			0.10
A7-4b	QZ ripple experienced by calibration antenna			0.20	Rectangular	1.73	1			0.12
A7-11	Switching uncertainty			0.02	Rectangular	1.73	1			0.01
A7-12	Field repeatability			0.20	Gaussian	1.00	1			0.20
Combined standard uncertainty (1σ) (dB)										**0.86**
Expanded uncertainty (1.96σ - confidence interval of 95 %) (dB)										**1.72**

In summary we have measurement uncertainty as presented in table 6.6.3-3:

Table 6.6.3-3: Measurement uncertainty (95% CI)

	Expanded uncertainty (dB)
	4.2 < f ≤ 7.125 GHz
Indoor anechoic	1.55
CATR	1.73
PWS	1.72
Common maximum accepted test system uncertainty	**1.70**

In previous MU analysis the common MU values are generally chosen based on the worst method so that as many methods as possible are included. Previously this has been the CATR. In this case the PWS is a new method, but it displays a worse measurement uncertainty than the CATR. The common uncertainty therefore has been based on the CATR, this does not mean that the PWS cannot be used but the test requirement must be adjusted by the additional measurement uncertainty.

Annex A (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2024-08	RAN4#112					Approved TPs at RAN4#112 meeting R4-2413575 TP to TR 38.908 Background of U6GHz EEIRP mask requirement R4-2413576 TP to TR 38.908 U6GHz EEIRP mask requirement	0.1.0
2024-09	RAN#105	RP-242012				First time to be presented to TSG RAN for information.	1.0.0
2024-10	RAN4#112bis					Withdraw	1.1.0
2024-11	RAN4#113					Approved TPs at RAN4#113 meeting R4-2419818 TP to TR38.908: clause 3 and 5 R4-2419821 TP to TR 38.908 – section 6.5 R4-2419822 TP to TR 38.908 – section 6.6 R4-2419819 TP to TR38.908: Clause 6.4 spatial sampling grid R4-2419824 TP to TR 38.908 clause 6 – Conformance testing	1.2.0
2025-02	RAN4#114					Approved TPs at RAN4#114 meeting R4-2502316 TP to TR 38.908 clause 6.2 The calculation for EEIRP mask R4-2502318 TP for TR 38.908: Conformance test aspects for EEIRP R4-2502320 TP to TR 38.908 – sections 6.5 and 6.6	1.3.0
2025-03	RAN#107	RP-250437				Second time to be presented to TSG RAN for agreement.	2.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2025-03	RAN#107					Approved by plenary – Rel-19 spec under change control	19.0.0
2025-06	RAN#108	RP-250944	0004	1	F	CR to TR 38.908: MU and others	19.1.0
2025-12	RAN#110	RP-253636	0006		F	CR to TR 38.908 with aligment for definitions and test procedure	19.2.0

History

Version	Date	Status
V19.1.0	January 2026	Publication
V19.2.0	February 2026	Publication