Operator Acceptance Values for Device Antenna Performance

Version 6.0

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1 Introduction

1.1 Overview

Mobile handset design has changed significantly over the past few years. Antennas, which were external in many cases, moved inside the terminal and evolved to be light-weight and low-volume.

The increasing focus on design conflicts with radio performance of the antenna systems can lead to service disruption and increased dropped call rates impacting customer experience. Increasing network density is not an option as it may not be viable in many cases.

Whilst the 3GPP standards define the absolute global minimum OTA performance requirements to be met by devices, numerous operators are already requesting higher values in their own procurement activities to serve customer needs and network rollout plans.

However, the test methods used, and antenna performance values requested by the various operators differ widely, leaving vendors with a fragmented requirements landscape.

To facilitate this alignment and agreement, the antenna experts of operators within the GSMA Terminal Steering Group have reviewed results of antenna performance tests (conducted within their own organisations as well as by the GSMA) and have aligned test methods and agreed on performance values to be used as guidelines for acceptable and achievable performance of antennas in Mobile devices. The values are supported by operators representing America, Europe, and Asia.

Following the publication of version four in February 2019 [TS.24], the TSG operators have now aligned performance - in addition to 2G/3G/LTE - also for 5G NR FR1 bands.

1.2 Scope

This document defines the Operator Acceptance Values for Device Antenna Performance. The values are determined taking into consideration.

- devices being held close to the head with left and right hand (BHH)
- devices being held with one hand only for the purpose of Browsing.
- devices being measured with the Free Space method.

The requirements (which include measurement uncertainty) are relevant for mobile devices, including feature phones, smart phones, tablets, and dongles. More details can be found in the relevant sections.

These GSMA Operator Acceptance Values for Device Antenna Performance are non-binding, and operators are free to request alternative values as required. It will be up to each individual operator to adopt and enforce the GSMA Operator OTA requirements.

These values serve to align, enhance and promote antenna performance requirements across the industry while seeking to improve device antenna performance and network interoperability.

Note 1: The alignment of the GSMA Operator Acceptance Values for Device Antenna Performance does not impact the test process; this will continue as it is the case today in Operator-Manufacturer bilateral agreements.

Each phase of the work carried out in updating TS.24 has also involved independent tests on commercially available smart phones. The purpose of these tests was to benchmark the Acceptance Values defined in TS.24. For 5G NR FR1 bands, network operators voluntarily provided antenna performance data for devices used in their device portfolio pool. Test campaign has been done in across 8 different labs.

In this version of TS.24 we publish the results of these tests and data collection campaign in the appendix.

1.3 Definition of Terms

Term	Description
3GPP	3rd Generation Partnership Project
BHH	Beside Head and Hand
AoA	Angle of Arrival
BHHL	Beside Head and Hand Left
BHHR	Beside Head and Hand Right
BS	Base Station
BW	Bandwidth
CBW	Channel bandwidth
CC	Component Carrier
CCSA	China Communications Standards Association
CPE	Consumer Premises Equipment
CS	Circuit Switched (voice mode)
CTIA	CTIA Certification™
EN-DC	E-UTRA New Radio-Dual Connectivity
DUT	Device Under Test
EPS	Equal Power Sharing. In EN-DC mode Tx power is equally shared between NR and LTE bands (Option B)
FDD	Frequency Division Duplex
E-UTRA	Evolved Universal Terrestrial Radio Access
FS	Free Space
FR1	5G Frequency Range 1 (410 MHz – 7125 MHz)
FR2	5G Frequency Range 2 (24250 MHz – 52600 MHz)
FWA	Fixed Wireless Access
GSM / E-GSM	Global System for Mobile Communication/ Extended-GSM
GSMA	GSM Association

HL	Browsing mode with Hand Left Only
HR	Browsing mode with Hand Right Only
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
MS	Mobile Station
NR	New Radio
NHPRP	Near-Horizon Partial Radiated Power
NHPIS	Near-Horizon Partial Isotropic Sensitivity
NR FR1	New Radio in frequency range 1 bands
NR FR2	New Radio in frequency range 2 bands
NSA	Non-Standalone
OEM	Original Equipment Manufacturer
Option A/B	Power sharing. Option A: max power on NR and min power on LTE. Option B: power is shared equally between NR and LTE
OTA	Over The Air (without cable)
RAG	Red, Amber, Green
PC	Power class. PC3=23 dBm; PC2=26 dBm conducted Tx power
RB	Resource Block
RMC	Reference Measurement Channel
TDD	Time Division Duplex
SA	5G Standalone
TRP	Total Radiated Power
TRS (TIS)	Total Radiated (Isotropic) Sensitivity
TSG	Terminal Steering Group
TSGFM	Terminal Steering Group Full Members
UE	User Equipment
VoLTE	Voice over LTE
VoNR	Voice over NR
VoIP	Voice over Internet Protocol
WCDMA	Wideband Code Division Multiple Access

1.4 Document Cross-References

Ref	Document Number	Title
CTIA	Latest Active version	The latest active version of the Test Plan, as identified at https://ctiacertification.org/test-plans/. © CTIA Certification. Referenced with permission. All testing referencing this test plan must be conducted in a CTIA Certification Authorized Test Lab by submitting an OTA Test Plan Use Request at https://certify.ctiacertification.org/.

3GPP	TS 25.144	User Equipment (UE) and Mobile Station (MS) over the air performance requirements
3GPP	TS 38.101	User Equipment (UE) transmission and reception for NR

2 Antenna Performance Requirements

The following table serves as an internal guideline for mobile operators, who are encouraged to apply the required values in their bilateral agreements with their vendors.

Req ID	Requirement
TS.24_2.0_REQ_001	For the scenario "**Head and Hand**" (BHH) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels, on both, the left (BHHL) and right (BHHR) hand-side, a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TS.24_2.0_REQ_002	For the scenario "**Browsing**" (HL or HR) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels, on both the left and right hand-side, a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TS.24_2.0_REQ_003	For the scenario "**Free Space**" (FS) and in line with CTIA, the terminal SHALL support an average value of the low, medium and high frequency channels a performance equal to or above the GSMA performance requirements for that frequency band listed in table 1 and 2 in section 2.2 for 2G/3G and table 3 and 4 in section 2.3 for LTE bands.
TS.24_2.0_REQ_004	No measured channel SHALL be 1 dB worse than the performance values defined for that frequency band.
TS.24_2.0_REQ_005	The CTIA/3GPP PDA hand SHALL be used for testing a device which is between 56 mm and 72 mm (inclusive) wide.
TS.24_2.0_REQ_006	The CTIA Wide Grip hand SHALL be used for testing a device which exceeds 72 mm but does not exceed 92 mm in width.
TS.24_2.0_REQ_007	TRP and TRS values agreed for 5G NR FR1 bands in EN-DC and SA modes
TS.24_2.0_REQ_008	Requirements for FWA devices added

2.1 Antenna Performance Calculation Formula

Note 2:

a) The values include measurement uncertainty.
b) Operators may accept alternative values for bands outside of their home market.
c) BHH and Browsing acceptance values are the same for devices tested using the PDA and Wide Grip hand phantom.

2.2 Operator Antenna Performance Acceptance Values for 2G and 3G Bands

The following tables list the Operator Antenna Performance Values per test scenario and frequency band (2G and 3G).

Test scenario:

Head and Hand (BHH):

Relevant for devices that support voice and do not exceed the maximum dimensions specified for hand phantom (92 mm) [CTIA]. The values are defined considering head and hand and are relevant for left or right hand.

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

Browsing (HL or HR):

Relevant for devices where the display is visible to the end user for data usage and where width ranges are between 56 mm and 92 mm [CTIA]. The values are defined considering one-hand only and are relevant for left or right hand. The 3G frequencies are measured, using a 12.2 Kbps reference measurement channel (RMC).

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

Free Space:

Relevant for any device that embeds an antenna and that supports voice and/or data. The applicable measurement method is voice (CS) mode. The 3G frequencies are measured, using a 12.2 Kbps reference measurement channel (RMC).

These acceptance values include measurement uncertainty.

Frequency Band 2G/3G	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
GSM 850	20.0	24.0	27.0
EGSM 900	20.0	25.0	28.0
GSM 1800	21.0	23.0	26.0
GSM 1900	21.0	23.0	26.0
WCDMA Band 1	15.0	17.0	20.0
WCDMA Band 2	16.5	17.0	20.0
WCDMA Band 3	13.5	14.7	17.7
WCDMA Band 5	11.0	14.7	17.7

Frequency Band 2G/3G	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
WCDMA Band 8	11.0	15.0	18.0
WCDMA Band 19	11.0	15.5	18.0

Table 1: GSMA Operator Acceptance Values for TRP for 2G and 3G bands

Frequency Band 2G/3G	GSMA Operator Acceptance Values for TRS [dBm]		
	BHH (Note 3)	Browsing	Free Space
GSM 850	-97.0	-99.0	-103.0
EGSM 900	-95.0	-99.0	-103.0
GSM 1800	-99.0	-100.0	-104.0
GSM 1900	-99.5	-100.0	-103.0
WCDMA Band 1	-101.0	-103.0	-106.0
WCDMA Band 2	-98.5	-101.0	-104.0
WCDMA Band 3	-98.5	-99.0	-102.0
WCDMA Band 5	-94.5	-100.0	-103.0
WCDMA Band 8	-96.0	-101.0	-104.0
WCDMA Band 19	-96.0	-102.0	-104.5

Table 2: GSMA Operator Acceptance Values for TRS for 2G and 3G bands

2.3 Operator Antenna Performance Acceptance Values for LTE Bands

The following tables list the Operator Antenna Performance Values per test scenario and frequency band (LTE).

Test scenario:

Head and Hand (BHH):

Relevant for devices that support voice (e.g., VoLTE, VoIP). The relevant hand phantom is to be used according to the device's width:

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

The values are relevant for left or right hand.

Browsing (HL or HR):
Relevant for devices where the display is visible to the end user for data usage and relevant hand phantom to be used according to the device's width:

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

The values are defined considering one-hand only and are relevant for left or right hand.

Free Space:

Relevant for any device that embeds an antenna and supports voice (e.g., VoLTE, VoIP) and /or data.

These acceptance values include measurement uncertainty.

Settings during testing

TRP:

Single antenna transmitting

Uplink RB Allocation: 12

TRS:

All receivers/antennas active

Downlink RB Allocation: 50

Bandwidth: 10 MHz

Frequency Band LTE	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
FDD Band 1	13.5	15.5	18.5
FDD Band 2	13.5	15.5	18.5
FDD Band 3	13.5	15.5	18.5
FDD Band 4	13.5	15.5	18.5
FDD Band 5	9.8	14.3	18.0
FDD Band 7	13.5	15.5	18.5
FDD Band 8	9.8	14.3	18.0
FDD Band 11	11.5	14.5	18.0
FDD Band 12	9.8	14.3	18.0
FDD Band 13	9.8	14.3	18.0
FDD Band 17	9.8	14.3	18.0
FDD Band 18	9.8	14.3	18.0
FDD Band 19	9.8	14.3	18.0
FDD Band 20	9.8	14.3	18.0

Frequency Band LTE	GSMA Operator Acceptance Values for TRP [dBm]		
	BHH (Note 3)	Browsing	Free Space
FDD Band 21	11.5	14.5	18.0
FDD Band 25	13.5	15.5	18.5
FDD Band 26	9.8	14.3	18.0
FDD Band 28	9.8	14.3	18.0
TDD Band 38	13.5	15.5	18.5
TDD Band 39	13.5	15.5	18.5
TDD Band 40	13.5	15.5	18.5
TDD Band 41	13.5	15.5	18.5
TDD Band 42	13.5	15.5	18.5
TDD Band 43	13.5	15.5	18.5

Table 3: GSMA Operator Acceptance Values for TRP for the LTE Bands

Frequency Band LTE	GSMA Operator Acceptance Values for TRS [dBm]		
	BHH (Note 3)	Browsing	Free Space
FDD Band 1	-89.0	-91.0	-94.0
FDD Band 2	-89.0	-91.0	-94.0
FDD Band 3	-89.0	-91.0	-94.0
FDD Band 4	-89.0	-91.0	-94.0
FDD Band 5	-85.0	-89.5	-93.5
FDD Band 7	-89.0	-91.0	-94.0
FDD Band 8	-85.0	-89.5	-93.5
FDD Band 11	-87.0	-90.0	-93.5
FDD Band 12	-85.0	-89.5	-93.5
FDD Band 13	-85.0	-89.5	-93.5
FDD Band 17	-85.0	-89.5	-93.5
FDD Band 18	-85.0	-89.5	-93.5
FDD Band 19	-85.0	-89.5	-93.5
FDD Band 20	-85.0	-89.5	-93.5
FDD Band 21	-87.0	-90.0	-93.5
FDD Band 25	-89.0	-91.0	-94.0
FDD Band 26	-85.0	-89.5	-93.5
FDD Band 28	-85.0	-89.5	-93.5
TDD Band 38	-89.0	-91.0	-94.0
TDD Band 39	-89.0	-91.0	-94.0
TDD Band 40	-89.0	-91.0	-94.0

Frequency Band LTE	GSMA Operator Acceptance Values for TRS [dBm]		
	BHH (Note 3)	Browsing	Free Space
TDD Band 41	-89.0	-91.0	-94.0
TDD Band 42	-89.0	-91.0	-94.0
TDD Band 43	-89.0	-91.0	-94.0

Table 4 GSMA Operator Acceptance Values for TRS for the LTE Bands

Note 3: BHH and Browsing acceptance values are the same for PDA and Wide Grip hand phantom.

2.4 Operator Antenna Performance Acceptance Values for 5G NR FR1

The following tables list the Operator Antenna Performance Values per test scenario and frequency band for 5G NR FR1.

Requirements are defined for EN-DC (NSA) and 5G SA.

If a device supports both NSA and SA it's up to the MNO to request which configuration they would like to test the device.

However, it is recommended for test optimization perspective to perform the full OTA test (TRP and TRS) in SA mode and in addition to test TRP at a mid-channel in EN-DC mode.

TRP requirements for PC3 are defined for all NR bands listed in this document.

Although 3GPP has not yet defined PC2 conducted values for the FDD bands, TRP requirements have been defined for PC2 in all FDD bands listed in this document.

Test scenario:

Head and Hand (BHH):

Relevant for devices that support voice (e.g., VoIP, VoNR). The relevant hand phantom is to be used according to the device's width:

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

The values are relevant for left or right hand.

Browsing (HL or HR):

Relevant for devices where the display is visible to the end user for data usage and relevant hand phantom to be used according to the device's width:

PDA hand is used for testing devices with widths 56 – 72 mm.

Wide Grip hand is used for testing devices with widths >72 - 92 mm.

The values are defined considering one-hand only and are relevant for left or right hand.

Note 4: Head and hand phantoms used for 2G/3G/LTE bands can also be used for the defined NR bands in this document.

Free Space:

Relevant for any device that embeds an antenna and supports voice (e.g., VoIP, VoNR) and /or data.

These acceptance values include measurement uncertainty.

Settings during testing

TRP:

Single antenna transmitting.

Option A: Max Tx power on NR, min Tx power on LTE (10 dBm regardless of device's PC for NR band).

Option B: Tx Power equally shared between LTE and NR (EPS).

TRS:

All receivers/antennas active.

Bandwidth: see table

Converting a measured TRS value with BW1 to a TRS value with BW2 is possible:

$\Delta = 10*\log(BW2/BW1)$

Example: BW1= 100 MHz; BW2 = 20 MHz

$\Delta = 10*\log(20/100) = -7$ dB

-86 dBm @ (100 MHz) → -93 dBm @ (20 MHz)

NR FR1 Frequency Band	GSMA Operator Acceptance Values for TRP [dBm] in EN-DC Mode for PC3					
	BHH (Note 4)		Browsing (Note 4)		Free Space	
Option	A	B	A	B	A	B
N1	14	12	16	14	18.5	16.5
N3	14	12	16	14	18.5	16.5

N5	10.5	8.5	14.5	12.5	18.5	16.5
N7	14	12	16	14	18.5	16.5
N8	10.5	8.5	14.5	12.5	18.5	16.5
N20	10.5	8.5	14.5	12.5	18.5	16.5
N26	10.5	8.5	14.5	12.5	18.5	16.5
N28	10.5	8.5	14.5	12.5	18.5	16.5
N40	14	12	16	14	18.5	16.5
N77	14	12	16	14	18.5	16.5
N78	14	12	16	14	18.5	16.5

Table 5GSMA Operator Acceptance Values for TRP for the NR FR1 Bands in EN-DC mode

NR FR1 Frequency Band (BW)	GSMA Operator Acceptance Values for TRS [dBm] in EN-DC Mode					
	BHH (Note 4)		Browsing (Note 4)		Free Space	
Option	A	B	A	B	A	B
N1 (20 MHz)	-90	-90	-92	-92	-94	-94
N3 (20 MHz)	-90	-90	-92	-92	-94	-94
N5 (10 MHz)	-86	-86	-90	-90	-94	-94
N7 (20 MHz)	-90	-90	-92	-92	-94	-94
N8 (10 MHz)	-86	-86	-90	-90	-94	-94
N20 (10 MHz)	-86	-86	-90	-90	-94	-94
N26 (10 MHz)	-86	-86	-90	-90	-94	-94
N28 (10 MHz)	-86	-86	-90	-90	-94	-94
N40 (20 MHz)	-90	-90	-92	-92	-94	-94
N77 (20 MHz)	-90	-90	-92	-92	-94	-94
N78 (20 MHz)	-90	-90	-92	-92	-94	-94

Table 6GSMA Operator Acceptance Values for TRS for the NR FR1 Bands in EN-DC mode

NR FR1 Frequency Band	GSMA Operator Acceptance Values for TRP [dBm] in SA Mode for PC3		
	BHH (Note 4)	Browsing (Note 4)	Free Space
N1	14	16	19

N3	14	16	19
N5	10.5	15	18.5
N7	14	16	19
N8	10.5	15	18.5
N20	10.5	15	18.5
N26	10.5	15	18.5
N28	10.5	15	18.5
N40	14	16	19
N77	14	16	19
N78	14	16	19

Table 7GSMA Operator Acceptance Values for TRP for the NR FR1 Bands in SA mode for PC3 (23 dBm)

NR FR1 Frequency Band	GSMA Operator Acceptance Values for TRP [dBm] in SA Mode for PC2		
	BHH (Note 4)	Browsing (Note 4)	Free Space
N1	17	19	22
N3	17	19	22
N5	13	17.5	21
N7	17	19	22
N8	13	17.5	21
N20	13	17.5	21
N26	13	17.5	21
N28	13	17.5	21
N40	17	19	22
N77	17	19	22
N78	17	19	22

Table 8GSMA Operator Acceptance Values for TRP for the NR FR1 Bands in SA mode for PC2 (26 dBm)

NR FR1 Frequency Band (BW)	GSMA Operator Acceptance Values for TRS [dBm] in SA Mode		
	BHH (Note 4)	Browsing (Note 4)	Free Space
N1 (20 MHz)	-90	-92	-94

N3 (20 MHz)	**-90**	**-92**	**-94**
N5 (10 MHz)	**-86**	**-90**	**-94**
N7 (20 MHz)	**-90**	**-92**	**-94**
N8 (10 MHz)	**-86**	**-90**	**-94**
N20 (10 MHz)	**-86**	**-90**	**-94**
N26 (10 MHz)	**-86**	**-90**	**-94**
N28 (10 MHz)	**-86**	**-90**	**-94**
N40 (20 MHz)	**-90**	**-92**	**-94**
N77 (20 MHz)	**-90**	**-92**	**-94**
N78 (20 MHz)	**-90**	**-92**	**-94**

Table 9GSMA Operator Acceptance Values for TRS for the NR FR1 Bands

2.5 Operator Antenna Performance Acceptance Values for FWA devices

In this section we define antenna performance acceptance values for products with integrated cellular modules which are mostly used as data access points. These are products like FWA (Fixed Wireless Access) devices, CPEs (Consumer Premises Equipment). In this section we will consider only LTE and 5G NR (FR1 and FR2) frequency bands. This kind of devices are normally not used close to human body like a mobile phone and thus used only for data transfer between device and base station (BS) via cellular network. However, there are different environments possible during operation, such as:

- Device mounted on a pole (e.g., an outdoor FWA device)
- Device mounted on a wall (e.g., an outdoor router, FWA device)
- Device on a desk (e.g., an indoor FWA device)

It’s also important to distinguish between indoor and outdoor use cases.

For indoor use case (e.g. device on a desk) an omnidirectional antenna pattern for the device is recommended since the Angle of Arrival (AoA) is not defined due to multiple arbitrary reflections of the Rx and Tx signals from the walls and obstacles.

Devices can also be installed outdoors by mounting on a pole or a wall.

. However, in this document DUTs utilizing an external antenna are not considered, because the external antenna is not part of the device and thus it’s designed independently from the device.

For indoor use case it is appropriate to measure TRP and TRS in all spherical directions (3D).

For outdoor use case with integrated directional antennas, it is more appropriate to consider only a part of the space above the horizon (e.g., +/- 30°). For this scenario the CTIA

certification near horizon metric could be used. Regardless which material the wall or pole consist of, we recommend using the CTIA defined near horizon parameters:

For radiated power:

- NHPRP=Near-Horizon Partial Radiated Power

For radiated sensitivity:

- NHPIS=Near-Horizon Partial Isotropic Sensitivity

As these devices are not used close to human body, we define the acceptance values for Free Space (FS) use case.

It is recommended to test device with near horizon metric when device's antenna is considered as directive one (based on manufacturer declaration estimated antenna gain of more than 6 dBi is considered as directive antenna). Otherwise, device's antenna is considered as non-directive one and therefore it is recommended to test the device in conventional way (3D).

Frequency Band LTE	GSMA Operator Acceptance Values for TRP [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPRP+/-30°
FDD Band 1	**19.5**	**17.5**
FDD Band 2	**19.5**	**17.5**
FDD Band 3	**19.5**	**17.5**
FDD Band 4	**19.5**	**17.5**
FDD Band 5	**19.0**	**17.0**
FDD Band 7	**19.5**	**17.5**
FDD Band 8	**19.0**	**17.0**
FDD Band 11	**19.0**	**17.0**
FDD Band 12	**19.0**	**17.0**
FDD Band 13	**19.0**	**17.0**
FDD Band 17	**19.0**	**17.0**
FDD Band 18	**19.0**	**17.0**
FDD Band 19	**19.0**	**17.0**
FDD Band 20	**19.0**	**17.0**
FDD Band 21	**19.0**	**17.0**
FDD Band 25	**19.5**	**17.5**
FDD Band 26	**19.0**	**17.0**
FDD Band 28	**19.0**	**17.0**
TDD Band 38	**19.5**	**17.5**
TDD Band 39	**19.5**	**17.5**
TDD Band 40	**19.5**	**17.5**
TDD Band 41	**19.5**	**17.5**

Frequency Band LTE	GSMA Operator Acceptance Values for TRP [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPRP+/-30°
TDD Band 42	19.5	17.5
TDD Band 43	19.5	17.5

Table 10GSMA Operator Acceptance Values for TRP for the LTE bands in Free Space for PC3

Frequency Band LTE	GSMA Operator Acceptance Values for TRS [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPIS+/-30°
FDD Band 1	-95.5	-93.5
FDD Band 2	-95.5	-93.5
FDD Band 3	-95.5	-93.5
FDD Band 4	-95.5	-93.5
FDD Band 5	-95.0	-93.0
FDD Band 7	-95.5	-93.5
FDD Band 8	-95.0	-93.0
FDD Band 11	-95.0	-93.0
FDD Band 12	-95.0	-93.0
FDD Band 13	-95.0	-93.0
FDD Band 17	-95.0	-93.0
FDD Band 18	-95.0	-93.0
FDD Band 19	-95.0	-93.0
FDD Band 20	-95.0	-93.0
FDD Band 21	-95.0	-93.0
FDD Band 25	-95.5	-93.5
FDD Band 26	-95.0	-93.0
FDD Band 28	-95.0	-93.0
TDD Band 38	-95.5	-93.5
TDD Band 39	-95.5	-93.5
TDD Band 40	-95.5	-93.5
TDD Band 41	-95.5	-93.5
TDD Band 42	-95.5	-93.5
TDD Band 43	-95.5	-93.5

Table 11GSMA Operator Acceptance Values for TRS for the LTE bands in Free Space with 10 MHz Bandwidth for all bands

Frequency Band NR	GSMA Operator Acceptance Values for TRP [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPRP+/-30°
N1	19.5	17.5
N3	19.5	17.5
N5	19.5	17.5
N7	19.5	17.5
N8	19.5	17.5
N20	19.5	17.5
N26	19.5	17.5
N28	19.5	17.5
N40	19.5	17.5
N77	19.5	17.5
N78	19.5	17.5

Table 12GSMA Operator Acceptance Values for TRP for the NR bands in Free Space in EN-DC for PC3

Note: Only mode A to be consider (Max Power on NR)

Frequency Band NR	GSMA Operator Acceptance Values for TRS [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPIS+/-30°
N1 (20 MHz)	-95.5	-93.5
N3 (20 MHz)	-95.5	-93.5
N5 (10 MHz)	-95.5	-93.5
N7 (20 MHz)	-95.5	-93.5
N8 (10 MHz)	-95.5	-93.5
N20 (10 MHz)	-95.5	-93.5
N26 (10 MHz)	-95.5	-93.5
N28 (10 MHz)	-95.5	-93.5
N40 (20 MHz)	-95.5	-93.5
N77 (20 MHz)	-95.5	-93.5
N78 (20 MHz)	-95.5	-93.5

Table 13GSMA Operator Acceptance Values for TRS for the NR bands in Free Space in EN-DC

Frequency Band NR	GSMA Operator Acceptance Values for TRP [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPRP+/-30°

N1	**20**	**18.0**
N3	**20**	**18.0**
N5	**19.5**	**17.5**
N7	**20**	**18.0**
N8	**19.5**	**17.5**
N20	**19.5**	**17.5**
N26	**19.5**	**17.5**
N28	**19.5**	**17.5**
N40	**20**	**18.0**
N77	**20**	**18.0**
N78	**20**	**18.0**

Table 14GSMA Operator Acceptance Values for TRP for the NR bands in Free Space in SA for PC3

Note: Only mode A to be consider (Max Power on NR)

Frequency Band NR	GSMA Operator Acceptance Values for TRP [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPRP+/-30°
N1	**23**	**21**
N3	**23**	**21**
N5	**22**	**20**
N7	**23**	**21**
N8	**22**	**20**
N20	**22**	**20**
N26	**22**	**20**
N28	**22**	**20**
N40	**23**	**21**
N77	**23**	**21**
N78	**23**	**21**

Table 15GSMA Operator Acceptance Values for TRP for the NR bands in Free Space in SA for PC2

Note: Only mode A to be consider (Max Power on NR)

Frequency Band NR	GSMA Operator Acceptance Values for TRS [dBm] for FWA devices	
	Non-Directional integrated antenna - Free Space - 3D	Directional integrated antenna - Free Space – NHPIS+/-30°
N1 (20 MHz)	**-95.5**	**-93.5**

N3 (20 MHz)	**-95.5**	**-93.5**
N5 (10 MHz)	**-95.5**	**-93.5**
N7 (20 MHz)	**-95.5**	**-93.5**
N8 (10 MHz)	**-95.5**	**-93.5**
N20 (10 MHz)	**-95.5**	**-93.5**
N26 (10 MHz)	**-95.5**	**-93.5**
N28 (10 MHz)	**-95.5**	**-93.5**
N40 (20 MHz)	**-95.5**	**-93.5**
N77 (20 MHz)	**-95.5**	**-93.5**
N78 (20 MHz)	**-95.5**	**-93.5**

Table 16 GSMA Operator Acceptance Values for TRS for the NR bands in Free Space in SA

3 Moving Forward

The GSMA operators will progress:

- To run tests with EN-DC mode in low-low bands (e.g., LTE 20 + N28). If necessary, to add acceptance limits for special EN-DC combinations.
- To run tests with PC2 in EN-DC mode. Add acceptance limits for PC2 in EN-DC mode.
- Define acceptance limits for 5G NR FR2

In addition, operators will continue to test antenna performance of market devices and actively monitor and/or engage in work driven in relevant industry bodies.

Annex A Measured Values

As part of the process to derive the harmonised Operator Acceptance Values published in this document the GSMA has, for each phase of the work, carried out independent tests on commercially available Smartphones. These devices are taken from consumer stock, and are not prototype or engineering samples provided by the OEMs.

In this appendix we have published the results from these tests.

The purpose of the tests was to benchmark the acceptance values defined in TS.24 and to ensure that they represent a realistic achievable target that manufacturers of devices can readily achieve.

All device results have been anonymised.

A.1 RAG Status Tables

The tables published in this appendix include a RAG (Red Amber Green) colour coding. This RAG status can be interpreted as follows:

Red = fails to meet the GSMA TS.24 acceptance value by a value greater than 2 dB

Amber = within 2 dB of the GSMA TS.24 acceptance value

Green = meets or surpasses the GSMA TS.24 acceptance value

The 2 dB margin used to define the Amber category reflects that the acceptance values published in this document are a harmonised average of the values contributed by operators who took part in this work.

It also recognises that some operators have a small tolerance in their acceptance values so that they do not block the launch of a device that marginally fails to meet their requirements. These tolerances are usually defined on a bilateral basis and are reviewed per device.

Because of the above the tables below try to reflect this reality through use of the 2 dB margin which defines values in Amber.

A.1.1 Test Methodology

Device selection was based on a random selection of commercially available devices at the time of measurement, typically these devices are from Tier 1 OEMs and are their Flagship or high-volume selling products.

The tests were carried out in an independent antenna lab, accredited by both CTIA (e.g., a CTIA Certification Authorized Test Lab) and GCF (Global Certification Forum).

The specific test methodologies used, followed the recommendations issued by CTIA.

A.1.2 Interpretation

For the purpose of this work these tables were used to assess the values defined in TS.24, and to ensure that when the 2 dB margin is taken into account, the significant majority of devices are able to meet or surpass the acceptance values published in TS.24.

A.1.3 Measured Results Tables

TRP and TRS [dBm]	Operator Acceptance		Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9	
2G/3G Frequency Band	Browsing	Free Space	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS	Browsing	FS
GSM 850	24,0	27,0																		
EGSM 900	25,0	28,0																		
GSM 1800	23,0	26,0																		
GSM 1900	23,0	26,0																		
WCDMA Band 1	17,0	20,0	14,72	17,99	14,55	16,79	19,50	21,57	16,97	20,21	16,45	19,46	17,62	19,84		20,15		18,30		16,72
WCDMA Band 2	17,0	20,0			15,66	18,97	17,98	20,21			16,11	18,96						17,82		14,24
WCDMA Band 5	14,7	17,7	12,73	15,94	6,13	19,45	14,68	19,34			13,79	17,56				16,43				14,76
WCDMA Band 6	14,7	17,7					14,77	19,65												
WCDMA Band 8	15,0	18,0	13,74	17,08	4,39	20,53			15,83	18,91	14,25	18,92				20,91		18,75		17,30
WCDMA Band 19	15,5	18,0											14,89	20,09						
GSM 850	-99,0	-103,0																		
EGSM 900	-99,0	-103,0																		
GSM 1800	-100,0	-104,0																		
GSM 1900	-100,0	-103,0																		
WCDMA Band 1	-103,0	-106,0	-107,16	-109,21	-105,12	-107,46	-109,19	-111,10	-103,28	-107,64	-108,08	-110,84	-109,65	-111,12		-108,27		-105,52		-106,86
WCDMA Band 2	-101,0	-104,0			-104,16	-106,71	-110,05	-111,57			-105,06	-108,11						-106,33		-107,68
WCDMA Band 5	-99,0	-102,0	-104,30	-107,39	-95,42	-110,94	-106,91	-109,64			-102,99	-107,05				-110,62				-103,39
WCDMA Band 6	-100,0	-103,0					-106,94	-109,73												
WCDMA Band 8	-101,0	-104,0	-100,89	-104,13	-98,98	-107,94			-102,08	-105,55	-102,47	-106,91				-110,36		-106,84		-104,32
WCDMA Band 19	-102,0	-104,5											-106,36	-110,03						

Table 17: TRP and TRS RAG status of tested devices in 2G/3G bands for the use cases Browsing and Free Space (status: 2013)

TRP and TRS [dBm]	Phone Type	Operator Acceptance	Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9	
2G/3G Frequency Band		BHH	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
GSM 850	Dual 2G+3G	20,0	20,53	20,73	22,65	17,88	21,83	21,73			18,05	18,62	13,26	16,37	15,27	17,43	22,78	22,31		
EGSM 900	Dual 2G+3G	20,0	20,49	19,95	20,89	16,03	20,47	22,26	17,54	19,25	17,33	19,12	16,44	17,90	20,19	22,54	22,00	22,06	16,88	16,79
GSM 1800	Dual 2G+3G	21,0	20,31	19,50	21,48	20,84	22,20	22,11	15,74	19,11	20,23	20,33	21,29	19,94	20,47	16,88	21,00	19,46	19,98	19,88
GSM 1900	Dual 2G+3G	21,0	19,90	19,69	20,32	20,35	21,18	20,72	18,02	17,80	20,91	20,01	21,76	20,41	20,71	18,62	23,42	21,99		
WCDMA Band 1	Dual 2G+3G	15,0	13,90	13,06	13,55	13,12	15,17	15,01	11,71	11,15	14,14	13,06	14,79	13,28	14,69	12,94	16,35	16,54	14,30	14,77
WCDMA Band 2	Dual 2G+3G	16,5																		
WCDMA Band 3	Dual 2G+3G	13,5																		
WCDMA Band 5	Dual 2G+3G	11,0																		
WCDMA Band 6	Dual 2G+3G	11,0																		
WCDMA Band 8	Dual 2G+3G	11,0			12,19	6,97	9,51	11,67			6,67	9,68	6,94	8,24	10,88	13,32			8,32	9,09
WCDMA Band 19	Dual 2G+3G	11,0																		
GSM 850	2G only	20,0																		
EGSM 900	2G only	21,0																		
GSM 1800	2G only	22,0																		
GSM 1900	2G only	21,0																		
GSM 850	Dual 2G+3G	-97,0	-97,16	-96,94	-96,02	-94,88	-97,29	-97,97			-93,54	-96,28	-90,06	-90,89	-96,14	-96,76	-98,79	-98,57		
EGSM 900	Dual 2G+3G	-95,0	-94,36	-93,89	-94,47	-91,94	-95,33	-96,62	-91,70	-93,12	-93,56	-95,12	-93,04	-93,76	-94,05	-96,89	-96,46	-95,84	-91,90	-92,82
GSM 1800	Dual 2G+3G	-99,0	-98,40	-97,64	-100,18	-99,63	-100,32	-99,78	-95,40	-96,61	-99,96	-99,39	-99,51	-98,88	-99,02	-96,29	-100,81	-100,10	-99,81	-99,65
GSM 1900	Dual 2G+3G	-99,5	-98,85	-97,89	-97,84	-97,90	-101,08	-100,52	-96,81	-97,03	-99,73	-98,66	94,63	-99,35	-98,47	-96,56	-99,98	-99,76		
WCDMA Band 1	Dual 2G+3G	-101,0	-97,88	-97,47	-100,01	-100,85	-102,28	-101,24	-99,04	-97,82	-99,75	-99,46	-102,99	-101,67	-100,53	-98,10	-101,30	-102,23	-101,65	-101,04
WCDMA Band 2	Dual 2G+3G	-98,5																		
WCDMA Band 3	Dual 2G+3G	-98,5																		
WCDMA Band 5	Dual 2G+3G	-94,5																		
WCDMA Band 6	Dual 2G+3G	-96,0																		
WCDMA Band 8	Dual 2G+3G	-96,0			-98,58	-94,33	-95,82	-97,69			-93,39	-96,08	-94,59	-94,90	-95,74	-98,76			-94,44	-95,29
WCDMA Band 19	Dual 2G+3G	-96,0																		
GSM 850	2G only	-97,0																		
EGSM 900	2G only	-97,0																		
GSM 1800	2G only	-99,0																		
GSM 1900	2G only	-99,5																		

TRP and TRS [dBm]	Phone Type	Operator Acceptance	Device 10		Device 11		Device 12		Device 13		Device 14		Device 15		Device 16		Device 17		Device 18	
2G/3G Frequency Band		BHH	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
GSM 850	Dual 2G+3G	20,0																		
EGSM 900	Dual 2G+3G	20,0	16,86	17,73	19,52	18,55	18,58	21,44	19,34	19,47	20,83	20,48	18,70	19,92	17,31	15,96	18,20	19,80	20,04	18,75
GSM 1800	Dual 2G+3G	21,0	23,55	19,35	21,49	23,19	20,10	20,32	20,86	21,79	19,74	19,17	19,91	20,85	19,38	17,62	21,44	20,53	21,13	20,94
GSM 1900	Dual 2G+3G	21,0																		
WCDMA Band 1	Dual 2G+3G	15,0	17,36	15,48	15,21	16,25	16,20	16,41	15,33	16,79	15,22	14,47	13,56	14,76	16,17	15,26	15,76	14,04	16,40	15,47
WCDMA Band 2	Dual 2G+3G	16,5																		
WCDMA Band 3	Dual 2G+3G	13,5																		
WCDMA Band 5	Dual 2G+3G	11,0																		
WCDMA Band 6	Dual 2G+3G	11,0																		
WCDMA Band 8	Dual 2G+3G	11,0	7,28	8,28	11,98	10,58	10,47	13,75			11,83	11,81	8,62	9,16	10,24	9,40	9,86	11,33	11,38	10,79
WCDMA Band 19	Dual 2G+3G	11,0																		
GSM 850	2G only	20,0																		
EGSM 900	2G only	21,0																		
GSM 1800	2G only	22,0																		
GSM 1900	2G only	21,0																		
GSM 850	Dual 2G+3G	-97,0																		
EGSM 900	Dual 2G+3G	-95,0	-91,57	-94,48	-95,93	-97,57	-93,73	-97,67	-96,32	-96,57	-96,66	-93,98	-93,06	-93,07	-93,12	-90,98	-93,74	-95,00	-94,66	-95,24
GSM 1800	Dual 2G+3G	-99,0	-102,05	-98,61	-101,71	-102,86	-98,96	-99,20	-101,02	-102,35	-99,44	-99,17	-100,00	-101,28	-98,86	-97,24	-100,89	-99,54	-100,68	-100,72
GSM 1900	Dual 2G+3G	-99,5																		
WCDMA Band 1	Dual 2G+3G	-101,0	-105,54	-102,90	-102,42	-102,42	-104,99	-104,73	-100,31	-102,30	-101,60	-101,77	-98,95	-99,55	-100,73	-100,69	-101,99	-101,01	-100,19	-99,45
WCDMA Band 2	Dual 2G+3G	-98,5																		
WCDMA Band 3	Dual 2G+3G	-98,5																		
WCDMA Band 5	Dual 2G+3G	-94,5																		
WCDMA Band 6	Dual 2G+3G	-96,0																		
WCDMA Band 8	Dual 2G+3G	-96,0	-93,81	-95,47	-98,30	-96,86	-97,30	-101,33			-99,96	-99,09	-95,24	-94,86	-94,96	-91,93	-95,98	-96,58	-96,53	-96,99
WCDMA Band 19	Dual 2G+3G	-96,0																		
GSM 850	2G only	-97,0																		
EGSM 900	2G only	-97,0																		
GSM 1800	2G only	-99,0																		
GSM 1900	2G only	-99,5																		

Table 18: TRP and TRS RAG status of tested devices in 2G/3G bands for head & hand use case (status: 2013)

TRP [dBm]	Operator Acceptance	Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9	
LTE Frequency Band	BHH	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
FDD Band 1	13,50	11,81	12,90			12,43	15,30									16,89	15,82	15,67	12,59
FDD Band 2	13,50					11,93	14,81												
FDD Band 3	13,50	13,60	13,26	12,52	13,83	13,36	16,21									15,18	13,16	14,92	12,90
FDD Band 4	13,50													16,95	12,81				
FDD Band 5	9,75	8,23	11,02			6,39	4,82												
FDD Band 7	13,50	10,98	12,79	14,50	9,62	11,74	17,45												
FDD Band 8	9,75	11,71	10,70			7,81	6,15												
FDD Band 11	11,50																		
FDD Band 12	9,75																		
FDD Band 13	9,75													10,96	11,24				
FDD Band 17	9,75																		
FDD Band 18	9,75																		
FDD Band 19	9,75															9,90	10,71	11,90	12,68
FDD Band 20	9,75	11,80	9,78	9,27	7,77	8,11	7,14												
FDD Band 21	11,50															13,04	9,73	11,33	11,95
FDD Band 25	13,50							15,59	16,02	14,98	13,30	13,33	11,48						
FDD Band 26	9,75							11,77	12,77	12,60	11,54	10,52	9,51						
FDD Band 28	9,75																		
TDD Band 38	13,50																		
TDD Band 39	13,50																		
TDD Band 40	13,50																		
TDD Band 41	13,50							12,24	16,65	13,70	15,87	13,63	4,31						
TDD Band 42	13,50																		
TDD Band 43	13,50																		

Table 19: TRP RAG status of tested devices in LTE bands for head & hand use case (status: 2015)

TRS [dBm]	Operator Acceptance	Device 1		Device 2		Device 3		Device 4		Device 5		Device 6		Device 7		Device 8		Device 9	
LTE Frequency Band	BHH/Both Antennas Active	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL	BHHR	BHHL
FDD Band 1	-89,00	-87,73	-88,31			-89,36	-89,49									-91,51	-90,20	-87,82	-86,95
FDD Band 2	-89,00					-90,35	-90,78												
FDD Band 3	-89,00	-91,37	-92,09	-89,03	-88,84	-88,79	-89,70									-92,28	-91,42	-89,55	-88,38
FDD Band 4	-89,00													-91,74	-92,00				
FDD Band 5	-85,00	-85,87	-86,87			-82,61	-81,86												
FDD Band 7	-89,00	-92,46	-93,47	-88,88	-84,24	-86,69	-89,01												
FDD Band 8	-85,00	-85,72	-84,99			-85,01	-84,34												
FDD Band 11	-87,00																		
FDD Band 12	-85,00																		
FDD Band 13	-85,00													-86,65	-89,06				
FDD Band 17	-85,00																		
FDD Band 18	-85,00																		
FDD Band 19	-85,00															-86,17	-87,97	-86,25	-86,66
FDD Band 20	-85,00	-86,68	-87,19	-87,08	-86,30	-83,99	-82,84												
FDD Band 21	-87,00															-89,46	-89,76	-89,74	-90,06
FDD Band 25	-89,00							-91,09	-91,95	-92,40	-92,04	-89,17	-87,24						
FDD Band 26	-85,00							-85,76	-86,08	-87,45	-86,66	-86,97	-85,02						
FDD Band 28	-85,00																		
TDD Band 38	-89,00																		
TDD Band 39	-89,00																		
TDD Band 40	-89,00																		
TDD Band 41	-89,00							-88,89	-92,02	-87,74	-89,16	-90,48	-84,86						
TDD Band 42	-89,00																		
TDD Band 43	-89,00																		

Table 20: TRS RAG status of tested devices in LTE bands for head & hand use case (status: 2015)

A.1.4 Further Analysis

As part of the analysis, it was noticed that there could be a perceived trend that demonstrates a difference between left hand and right hand performance. Further analysis of this trend is required to establish if this is a genuine trend or just an anomaly in the results. The TSGFM Group would like to draw attention to this as it was noted that accreditation in some regions is still limited to testing with the right hand, and therefore there could be a correlation between this and some products being optimized for performance in the right hand.

The sample of measured product is too small to establish if this trend is real, but it has been noted for further study during future measurement and test campaigns carried out by GSMA.

A.2 Study on Wide Grip Hand

More and more devices with big screens (including many flagship models) are introduced to the market and there are still no requirements on devices wider than 72 mm. Therefore **CCSA** (**C**hina **C**ommunications **S**tandards **A**ssociation) made a big study with many devices with widths between 72 – 92 mm using the CTIA Wide Grip hand phantom. TRP and TIS values in BHHR (“Talk” right) and HR (“Browsing” right) modes have been measured in 2G/3G/LTE bands used in China.

The study has shown an excellent correlation between GSMA BHH requirements for PDA hand phantom and results of devices tested with Wide Grip hand phantom. The values are selected so that 80% of the devices could pass the CCSA limit. The results show that there are no obvious differences for test results between devices with widths between 72 mm and 92 mm under CTIA Wide Grip hand phantom and devices with widths below 72 mm under PDA hand phantom. So, the limit values can stay unchanged with the test of the PDA hand phantom.

Band (Test Scenario)	TRP (80%)	TRP (TS.24)	TIS (80%)	TIS (TS.24)
GSM 900 (BHHR)	17	20	-93	-95
GSM1800 (BHHR)	19	21	-97	-99
WCDMA Band 1 (BHHR)	13.5	15	-100	-101
LTE Band 3（HR）	15.5	15.5	-91	-91
LTE Band 38（HR）	15	15.5	-86	-91
LTE Band 39（HR）	16	15.5	-88	-91
LTE Band 40（HR）	15	15.5	-86	-91
LTE Band 41（HR）	14.5	15.5	-85	-91

Table 21: Test results of devices with widths between 72 mm and 92 mm under CTIA Wide Grip hand phantom in comparison to TS.24 limits from the CCSA (status: 2017)

A.3 Data Collection Campaign on 5G NR FR1 Bands

We at first run a data collection campaign and asked the MNOs to provide TRP and TRS data of devices from their device pool. We received in total **313 TRP** and **282 TRS** values for more than 100 devices. Below is an extract with values for N78 band:

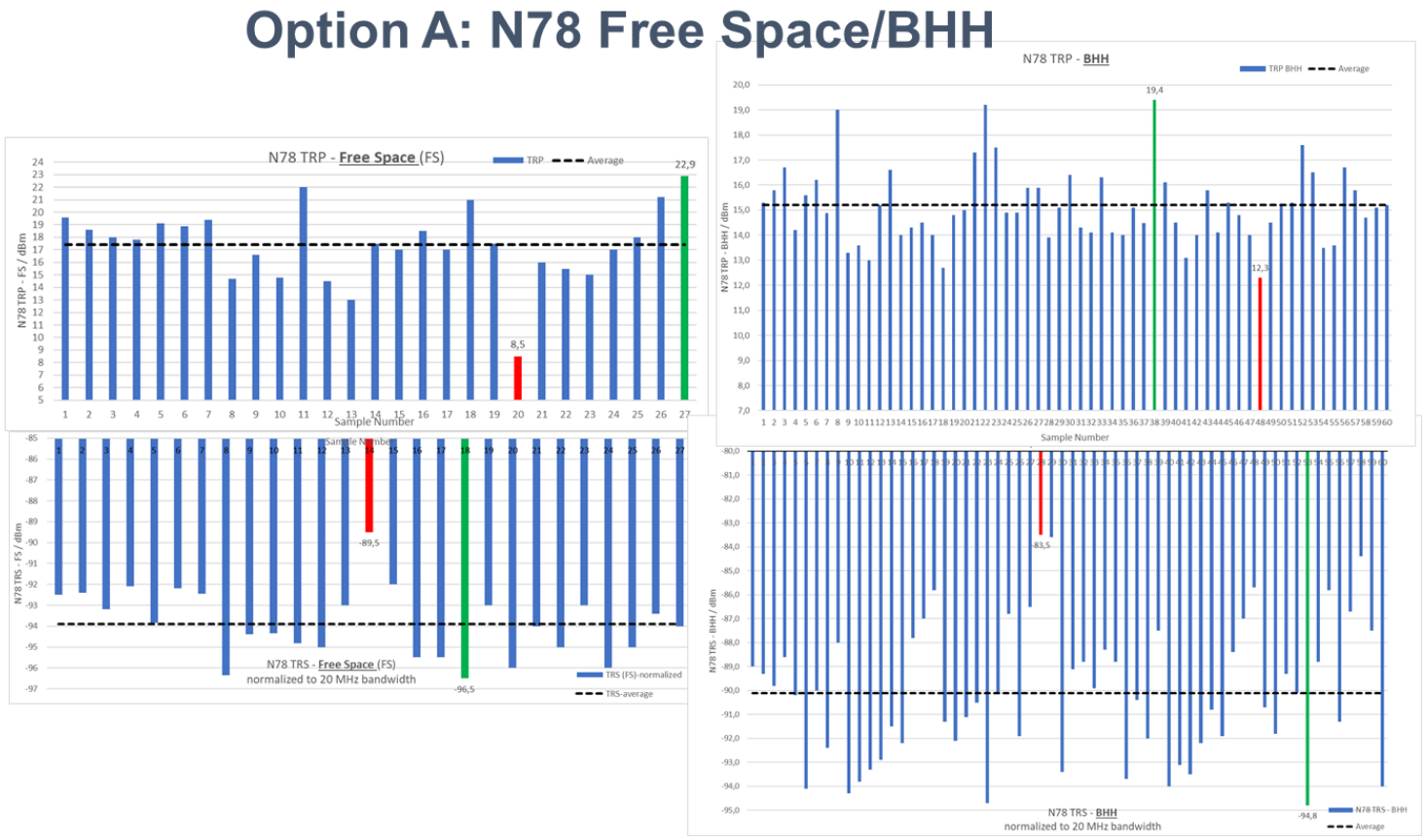

Table 22: TRP and TRS data from MNOs for N78 band (Free Space, Option A). Green: best performing device; Red: worst performing device

We then calculated the average of all received data (see below overview):

NR Max, LTE Min – TRP/dBm (Option A)			
NR Band	BHH	Browsing	Free Space
N78	**15.2**	**16.8**	**17,4**
N28	**11.2**	**13.5**	**20.1**

NR Max, LTE Min – TRS/dBm (Option A)			
NR Band	BHH	Browsing	Free Space
N78 (20 MHz)*	**-90.1**	**-92,2**	**-93.9**
N28 (10 MHz)	**-85.9**	**-88.9**	**-94.5**

EPS – TRP/dBm (Option B)			
NR Band	BHH	Browsing	Free Space
N78	-	-	**17.7**
LTE-28	-	-	**15.8**

EPS – TRS/dBm (Option B)			
NR Band	BHH	Browsing	Free Space
N78 (20 MHz)*	-	-	**-94**
LTE-28	-	-	-

Table 23: Average of all data from MNOs (313 TRP and 282 TRS values). TRS values for N78 are normalized to 20 MHz bandwidth.

A.4 Test Campaign on 5G NR FR1 Bands

We performed a small test campaign with 6 devices tested in 8 different labs.

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 8
D#1	18.2	17.7	17.8				18	17.7
D#2			19.5	19.5			19.5	19.6
D#3					15.2	15	16.6	
D#4	19.6	19			19	18	19.4	
D#5			14.7	14.8			14.7	12
D#6			14.8	14.8				

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 8
D#1	16.8	16.7	16.8				17	17.6
D#2			19.6	19.9			19.9	19.6
D#3					15.2	14.9	16.5	
D#4	19.4	19.4			17	16	19.7	
D#5			14.5	14.5			14.6	12
D#6			16.2	16.2				

Table 24: TRP results of test campaign with 6 devices tested in 8 different labs. Left: Option A; Right: Option B.

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 8
D#1	-93	-93	-93				-93.2	-92,9
D#2			-93.8	-94			-94.1	-94.3
D#3					-94.3	-93.2	-94.7	
D#4	-94.9	-94.1			-93.8	-93.5	-94.4	
D#5			-96.1	-95.7			-95.9	-93.5
D#6			-94.9	-94.3				

Table 25: TRS results of test campaign with 6 devices tested in 8 different labs

A.5 Survey on EN-DC Combinations

MNOs have been asked to provide their prioritized EN-DC combinations. The table below shows the most used EN-DC-combinations.

Bands	N1	N3	N7	N8	N20	N28	N40	N77	N78
LTE 1		XXX		X	X	XXXXXX	X	XXX	XXXXXXX
LTE 2					X			X	X
LTE 3	XXXXX	X				XXXXXX	X	XX	XXXXXXXX
LTE 5								X	XXX
LTE 7	XXX	XX		X	X	XXX		X	XXXXX
LTE 8	X	X			X	X			X
LTE 20	XXX	XX	X	X		XXXX			XXX
LTE 28	XX	X			X		X	X	XXXXXX
LTE 32	X	X				XX			X
LTE 38			X			X			
LTE 39									
LTE 40	X	X				X		X	X
LTE 66									X

Table 26: Most used EN-DC combinations from survey among MNOs

Annex B Document Management

B.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
V1.0	14 May 2013	Published on GSM world	TSG	Katrin Jordan, DT
V2.0	Feb 2014	Updated scope, references, requirements and added performance values for Free Space and Browsing.	TSG	Katrin Jordan, DT
V3.0	Sept. 2015	Performance values for LTE and Annex A added	TSG	Xiaolong Zhou, China Unicom Abbas Alpaslan, Vodafone
V4.0	February 2019	Clarifying the requirements for devices wider than 72 mm	TSG	Xiaolong Zhou, China Unicom Abbas Alpaslan, Vodafone Momar Goumballe, Orange
V4.1	June 2021	Updated in line with CTIA licence agreement	TSG	Paul Gosden GSMA
V5.0	October 2022	Antenna performance limits for 5G NR FR1 bands added	TSG#49	Abbas Alpaslan, Vodafone Momar Goumballe, Orange
V5.1	December 2022	Updated CTIA reference for new licence agreement	TSG#50	Paul Gosden GSMA
V6.0	Oct 2023	Updated with FWA section	TSG#53 ISAG#34	Abbas Alpaslan, Vodafone Momar Goumballe, Orange

Other Information

Type	Description
Document Owner	This document is owned and approved by TSG Full Members
Document Editor	Abbas Alpaslan, Vodafone and Momar Goumballe, Orange

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