Rohde&Schwarz Korea Webinar

5G NR FR2 RRM CONFORMANCE TEST와 2 AOA 시험

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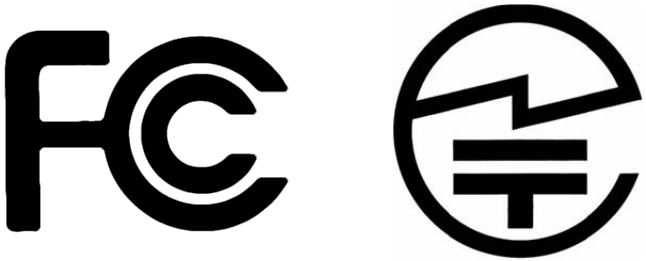
AGENDA

Conformance Test

WHY? CONFORMANCE TEST?

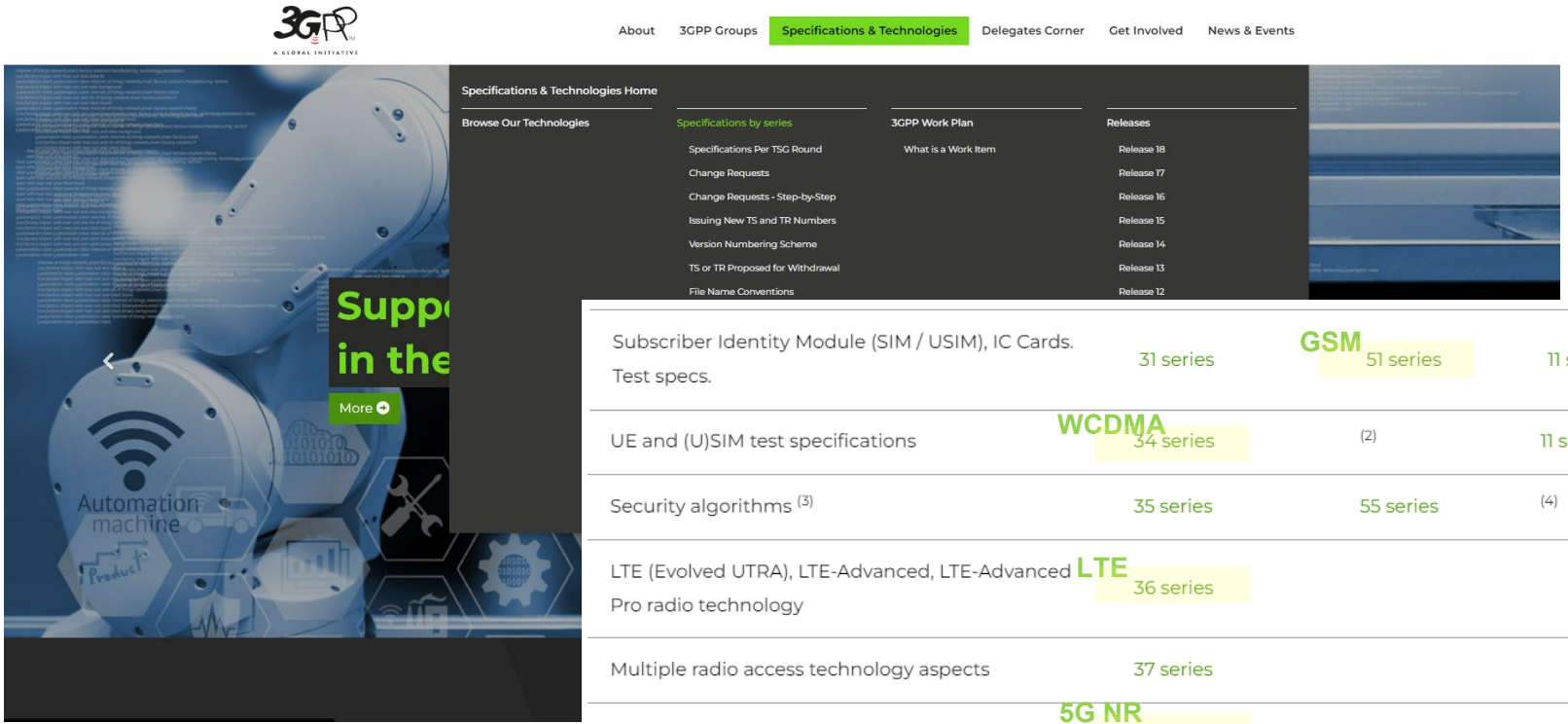
REGULATORY? CONFORMANCE?

Regulatory



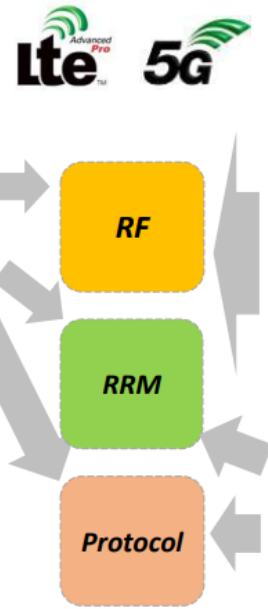
Conformance

3GPP SPECIFICATION DOCUMENT (3GPP.ORG)



3GPP SPECIFICATION MAPPING (LTE VS 5G NR)

Spec no.	Title
36.508	Common test environment
36.509	Special conformance testing functions
36.521-1	Radio transmission and reception
36.521-2	ICS
36.521-3	Radio resource management
36.523-1	Protocol
36.523-2	ICS
36.523-3	Test Suites



Spec no.	Title
38.508-1	Common test environment
38.508-2	Common Implementation Conformance Statement (ICS) proforma
38.509	Special conformance testing functions
38.521-1	Radio transmission and reception; Part 1: Range 1 Standalone
38.521-2	Radio transmission and reception; Part 2: Range 2 Standalone
38.521-3	Radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios
38.521-4	Radio transmission and reception; Part 4: Performance
38.522	Applicability of radio transmission, radio reception and radio resource management test cases
38.533	Radio resource management
38.523-1	Part 1: Protocol
38.523-2	Part 2: Applicability of protocol test cases
38.523-3	Part 3: Protocol Test Suites

3GPP SPECIFICATION DOCUMENT (CON'T)

Spec. number	Description (NR; User Equipment (UE) conformance specification)
TS 38.521-1	Radio transmission and reception; Part 1: **Range 1** standalone
TS 38.521-2	Radio transmission and reception; Part 2: **Range 2** standalone
TS 38.521-3	Radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios
TS 38.521-4	Radio transmission and reception; Part 4: Performance
TS 38.533	Applicability of radio transmission, radio reception and radio resource management test cases **(RRM)**

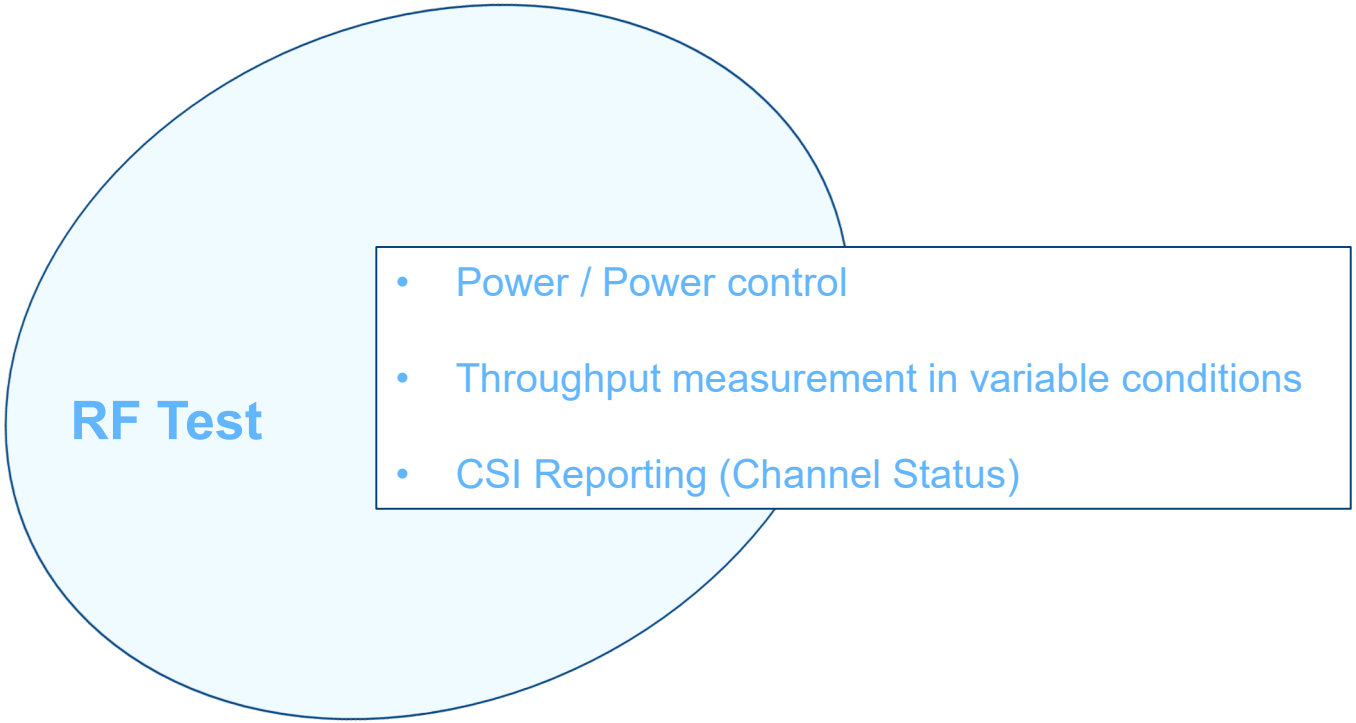
3GPP TS38.533

RRM CONFORMANCE TEST

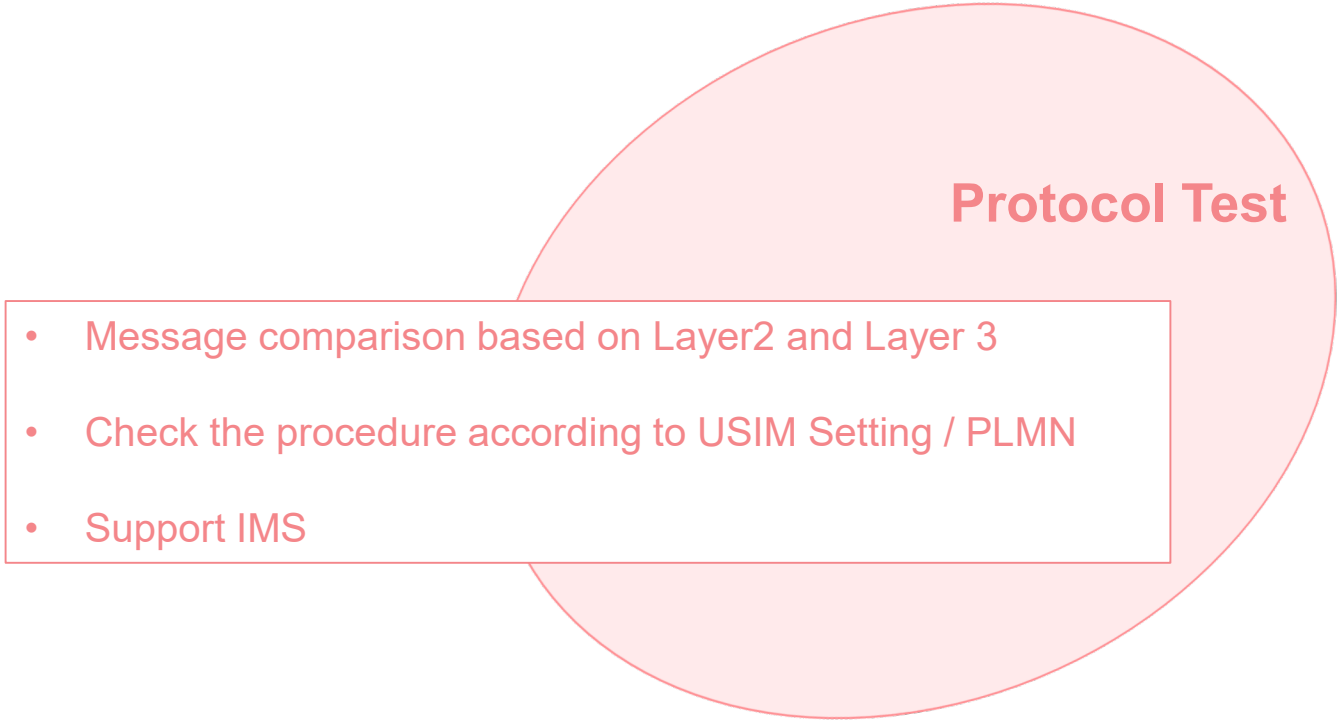
RRM (RADIO RESOURCE MANAGEMENT)

- 사용자의 현재 위치가 Cell 경계에 있는 경우
- 사용자가 휴대폰을 미 사용 중이나 소지하고 이동하는 경우
- 사용자가 통화를 하면서 이동하는 경우

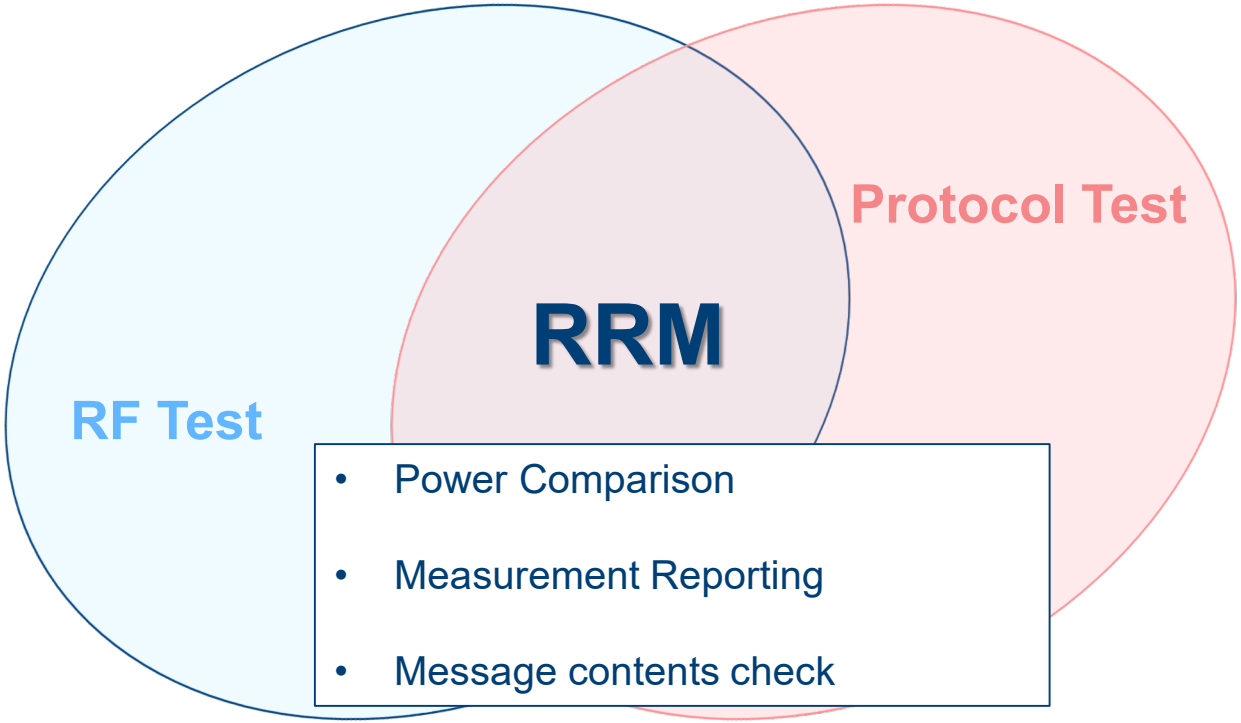
RRM TEST 영역



RRM TEST 영역



RRM TEST 영역



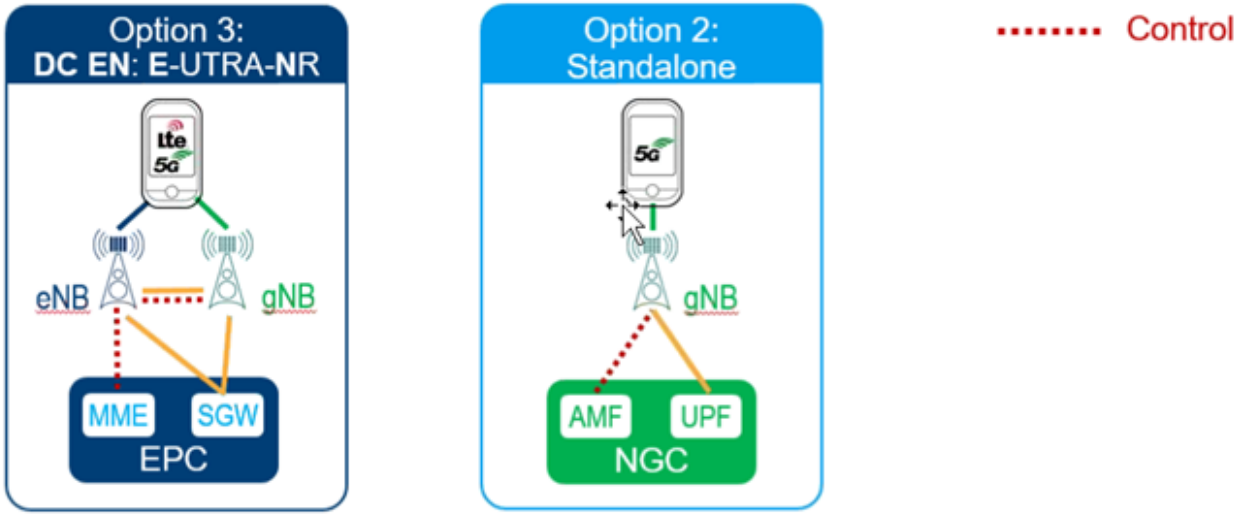
GCF/PTCRB WORK ITEMS FOR RRM: TP296

- GCF Work Items for NR
  - WI-501-EN-DC: RRM test cases for NR Non-Standalone – FR1 and FR2
  - WI-501-NR: RRM test cases for NR Standalone – FR1 and FR2
  - WI-513: RRM test cases for IRAT – FR1 and FR2
  - WI-510: CA
  - WI-525: Rel16 HST

- PTCRB Request For Tests for NR
  - RFT 501-3: RRM test cases for NR Non-Standalone – FR1 and FR2
  - RFT 501-1: RRM test cases for NR Standalone – FR1 and FR2
  - RFT 510: CA
  - RTF 525: Rel16 HST

NR NETWORK ARCHITECTURE

eNB is the Primary Node in EN-DC



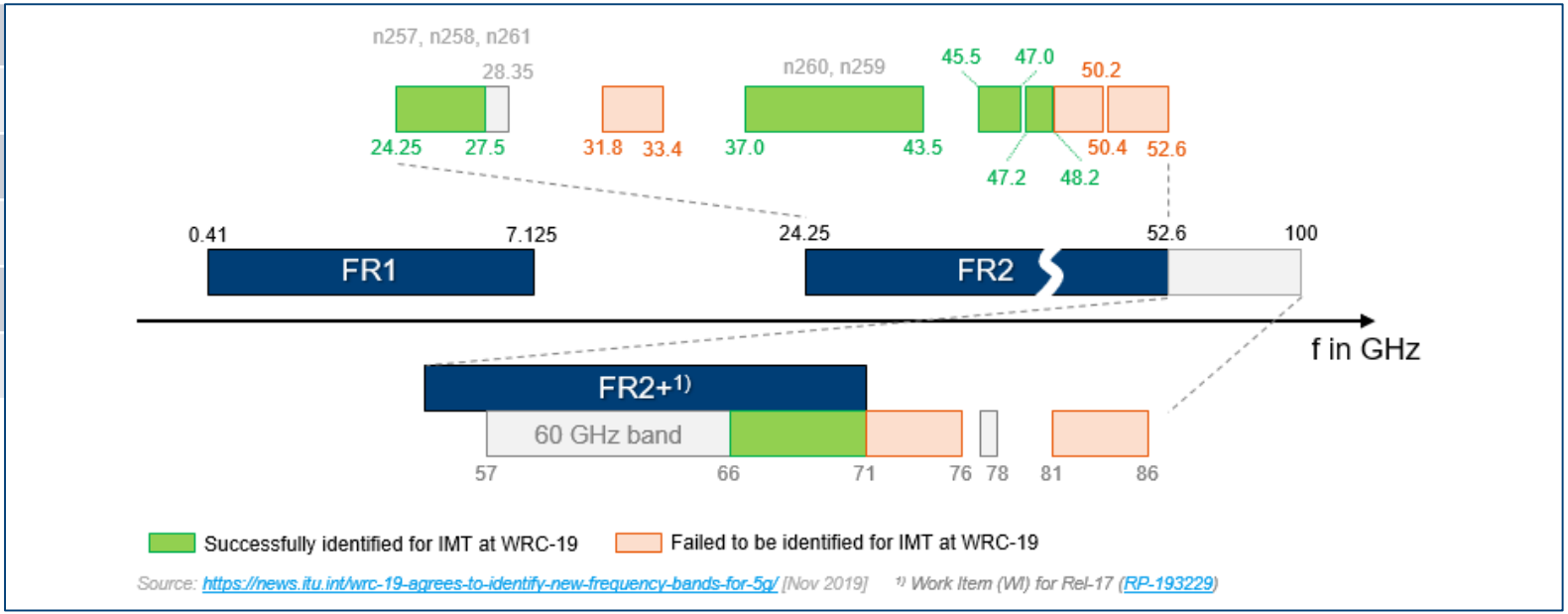
3GPP RRM TEST CASES CATEGORY

TC Main Chapter	Test category
4.X	EN-DC with all NR Cells in FR1
5.X	EN-DC with at least one NR Cell in FR2
6.X	NR Standalone in FR1
7.X	NR standalone with at least one NR Cell in FR2
8.x	E-UTRA – NR inter-RAT with E-UTRA serving cell
9.x	NR sidelink

Ref : 3GPP TS38.533 v17.3.1 (2022-09)

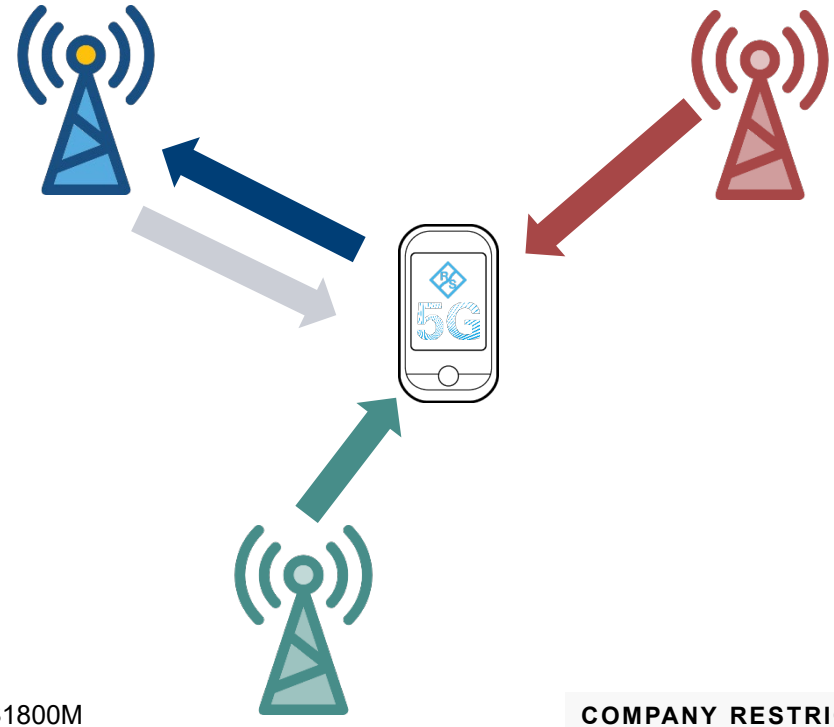
3GPP RRM TEST CASES CATEGORY

TC Main Chapter	Test category
4.X	
5.X	
6.X	
7.X	
8.x	
9.x	



3GPP RRM TEST CASES CATEGORY – CON'T

TC sub chapter	Test category
x.1	RRC_IDLE state mobility
x.2	RRC_INACTIVE state mobility
x.3	RRC_CONNECTED state mobility
x.4	Timing
x.5	Signaling Characteristics
x.6	Measurement Procedure
x.7	Measurement Performance Requirement



RRM OPERATING BAND CONFIGURATION

- Serving Cell 은 Neighbor CellI 과 주파수가 겹치지 않는 상황에서 시험이 진행되어야 함

- Table 3A.5-1 Inter-band Configuration

Band under test	Additional band (s)
n12	n66
n14	n66
n18	n1
n30	n66
n34	n41
n38	n41
n39	n41
n53	n41
n70	n66

  - 특히, 위 밴드에 대한 시험시 단말은 반드시 해당하는 Additional band도 지원해야 함

RRM BAND GROUP

Table 3A.4.1-1: NR frequency band groups for FR1

Group	NR FDD		NR TDD		NR SDL[5]	
	Band group notation	Operating bands	Band group notation	Operating bands	Band group notation	Operating bands
A	NR_FDD_FR1_A	n1, n18, n24, n70, n74[4]	NR_TDD_FR1_A	n34, n38[9], n39, n40, n50, n51, n53	NR_SDL_FR1_A	n75, n76
B	NR_FDD_FR1_B	n65, n66, n74[3]	NR_TDD_FR1_B	n38[7]	NR_SDL_FR1_B	-
C	NR_FDD_FR1_C	n30	NR_TDD_FR1_C	n48, n77[1], n78, n79	NR_SDL_FR1_C	-
D	NR_FDD_FR1_D	n28	NR_TDD_FR1_D	n77[2]	NR_SDL_FR1_D	-
E	NR_FDD_FR1_E	n2, n5, n7	NR_TDD_FR1_E	n41	NR_SDL_FR1_E	-
F	NR_FDD_FR1_F	n26[6]	NR_TDD_FR1_F	-	NR_SDL_FR1_F	-
G	NR_FDD_FR1_G	n3, n8, n12, n14, n20, n71	NR_TDD_FR1_G	-	NR_SDL_FR1_G	n29
H	NR_FDD_FR1_H	n25	NR_TDD_FR1_H	-		
J	NR_FDD_FR1_J	-	NR_TDD_FR1_J	n47[8]		

NR Band Group

Test condition example

Accuracy		Conditions				
			Io [Note 1] range			
Normal condition	Extreme condition	SSB Ês/Iot	NR operating band groups [Note 2]	Minimum Io		Maximum Io
				dBm / SCS_{SSB}		
dB	dB	dB		SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz	dBm/$BW_{Channel}$
			NR_FDD_FR1_A, NR_TDD_FR1_A, NR_SDL_FR1_A	-121	-118	N/A
			NR_FDD_FR1_B	-120.5	-117.5	N/A
			NR_TDD_FR1_C	-120	-117	N/A
+4.5	+9	> 6				

반복 측정과 결과 확인 (ANNEX. G)

- RRM 시험은 1번의 기능 검증으로 Pass/Fail을 따지는 것이 아니라, 반복 시험을 통한 성공 확률을 측정
  - Limit ER = 0.1 (success ratio = 90%)
  - Confidence Level CL = 95%

Table G.2.3-1: pass fail limits

ne	ns_p	ns_f	ne	ns_p	ns_f	ne	ns_p	ns_f	ne	ns_p	ns_f
0	33	NA	43	408	283	86	737	644	129	1056	1021
1	46	NA	44	416	291	87	745	653	130	1064	1030
2	58	NA	45	424	299	88	752	661	131	1071	1039
3	69	NA	46	432	307	89	760	67			
4	79	NA	47	440	315	90	767	67			
5	89	NA	48	447	324	91	775	687	134	1093	1066
6	99	NA	49	455	332	92	782	696	135	1100	1074
7	109	NA	50	463	340	93	790	705	136	1108	1083
8	118	NA	51	471	348	94	797	713	137	1115	1092
9	127	NA	52	478	356	95	804	722	138	1122	1101
10	136	39	53	486	365	96	812	731	139	1130	1110

기본 33회 반복 >> 최대 1181회 반복 ☹

NR UE MEASUREMENTS

- In LTE, RSRP and RSRQ are based on Cell specific Reference Signal (CRS).
- In NR there is no CRS. So RSRP / RSRQ definition in NR is based on other physical signals as shown in the following table.
  - Based on 38.215 - 5.1 UE measurement capabilities

Category	Physical Signal for Measurement
RSRP	SS reference signal received power (SS-RSRP)
	CSI reference signal received power (CSI-RSRP)
	SRS reference signal received power (SRS-RSRP)
RSRQ	SS reference signal received quality (SS-RSRQ)
	CSI reference signal received quality (CSI-RSRQ)
SINR	SS signal-to-noise and interference ratio (SS-SINR)
	CSI signal-to-noise and interference ratio (CSI-SINR)

  - NR measurement performed and reported at Layer 1 (Phy Layer) and Layer 3 (RRC Layer).

SS REFERENCE SIGNAL RECEIVED POWER SS-RSRP

- SS reference signal received power (SS-RSRP) is defined as **the linear average over the power contributions** [W] of the resource elements that carry secondary synchronization signals.
- The measurement time resource(s) for SS-RSRP are confined within SS/PBCH Block Measurement Time Configuration (SMTC) window duration.
- SS-RSRP shall be measured only among the reference signals corresponding to SS/PBCH blocks with the same SS/PBCH block index and the same physical-layer cell identity.

SS-RSRP is applicable for

RRC_IDLE
RRC_INACTIVE
RRC_CONNECTED

} Intra-frequency
Inter-frequency

RSRP	Power (dBm)
0	< -156
1	-156 to -155
2	-155 to -154
..	..
126	> -31

Absolute power measurement

SS REFERENCE SIGNAL RECEIVED QUALITY SS-RSRQ

- SS reference signal received quality (SS-RSRQ) is defined as the ratio of N×SS-RSRP and NR carrier RSSI, where N is the number of resource blocks in the RSSI measurement bandwidth
- RSSI includes also co-channel and non-serving cells, as well as ACI and thermal noise
- For cell selection the measurement time resources(s) for NR Carrier RSSI are not constrained, otherwise they are confined within SS/PBCH Block Measurement Time Configuration (SMTC) window duration.

SS-RSRQ is applicable for

RRC_IDLE
RRC_INACTIVE
RRC_CONNECTED

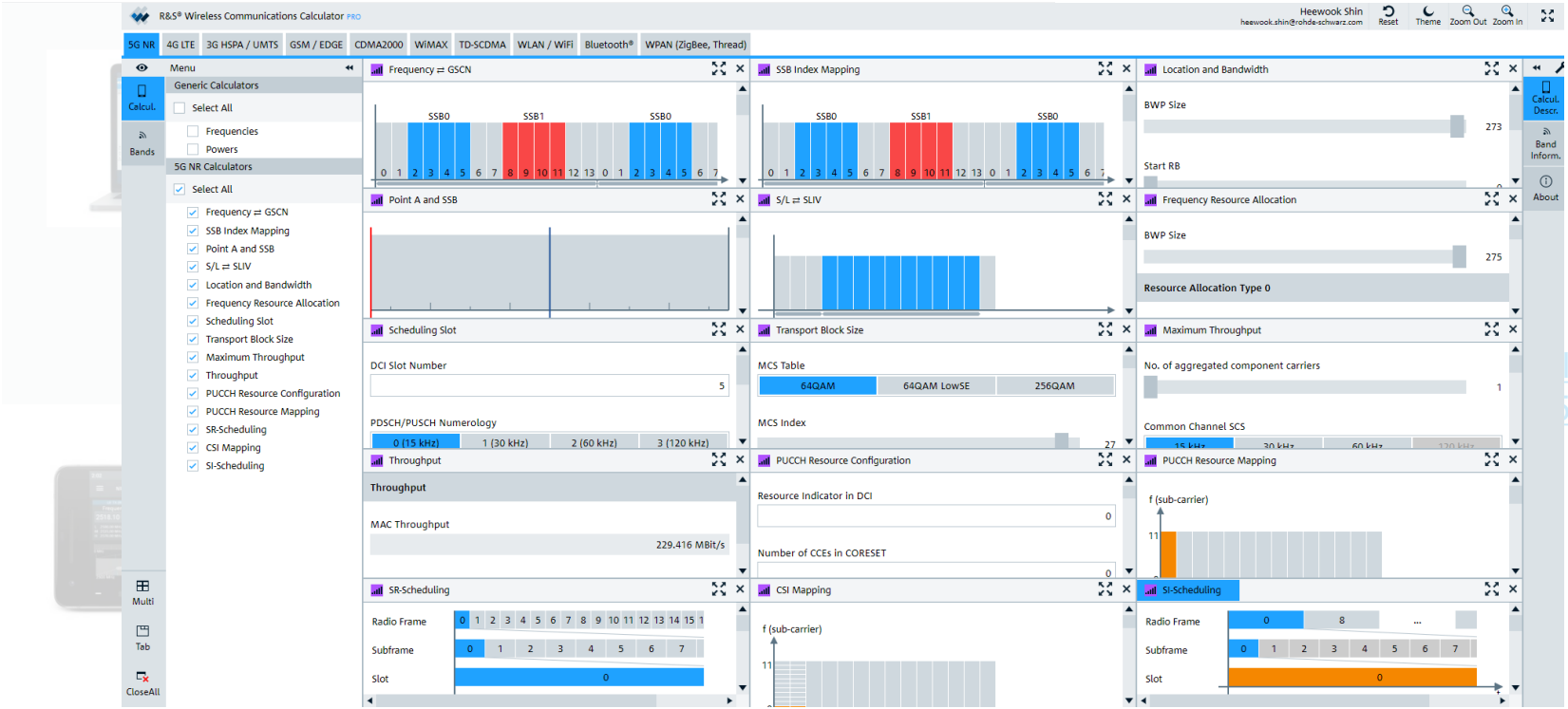
} Intra-frequency
Inter-frequency

RSRQ	Value (dB)
0	< -43
1	-43 to -42.5
2	-42.5 to -42
..	..
126	> +20

Signal to noise measurement

$$RSRQ \sim \frac{1}{1+\frac{1}{SNR}}$$

WCC (WIRELESS COMMUNICATION CALCULATOR)

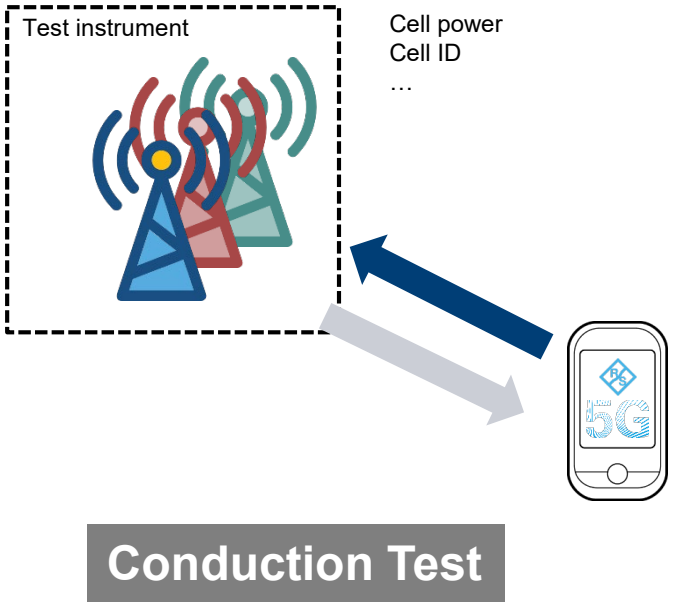


RRM 2AOA

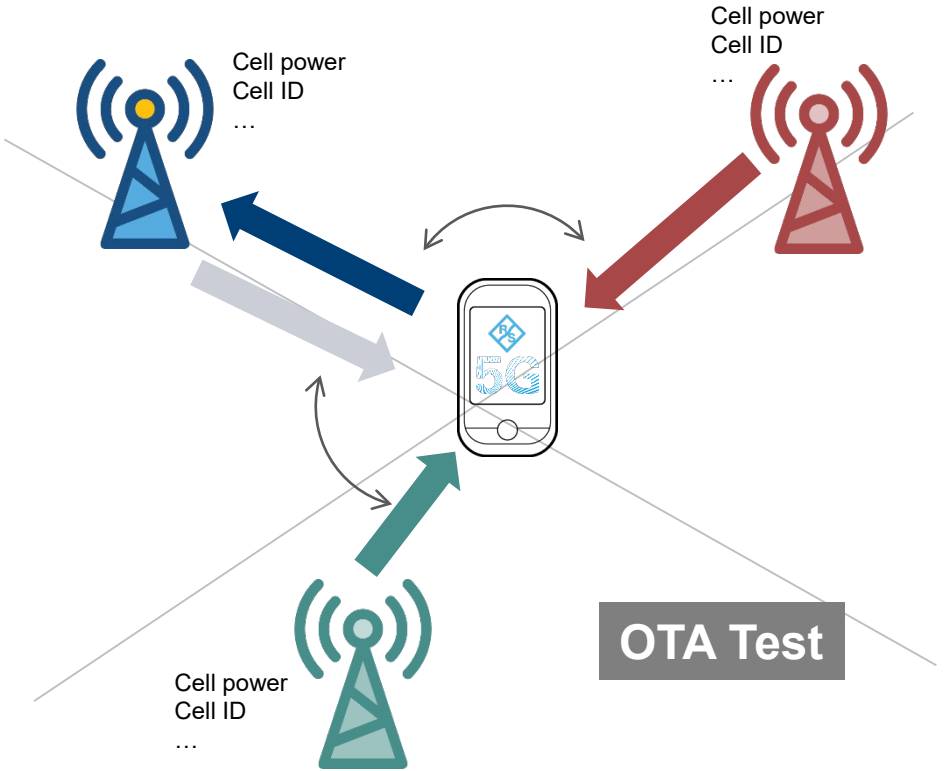
RRM TEST SETUP

ANGLE OF ARRIVAL (AOA) FOR FR2 TEST CASES

- AOA?



Conduction Test



OTA Test

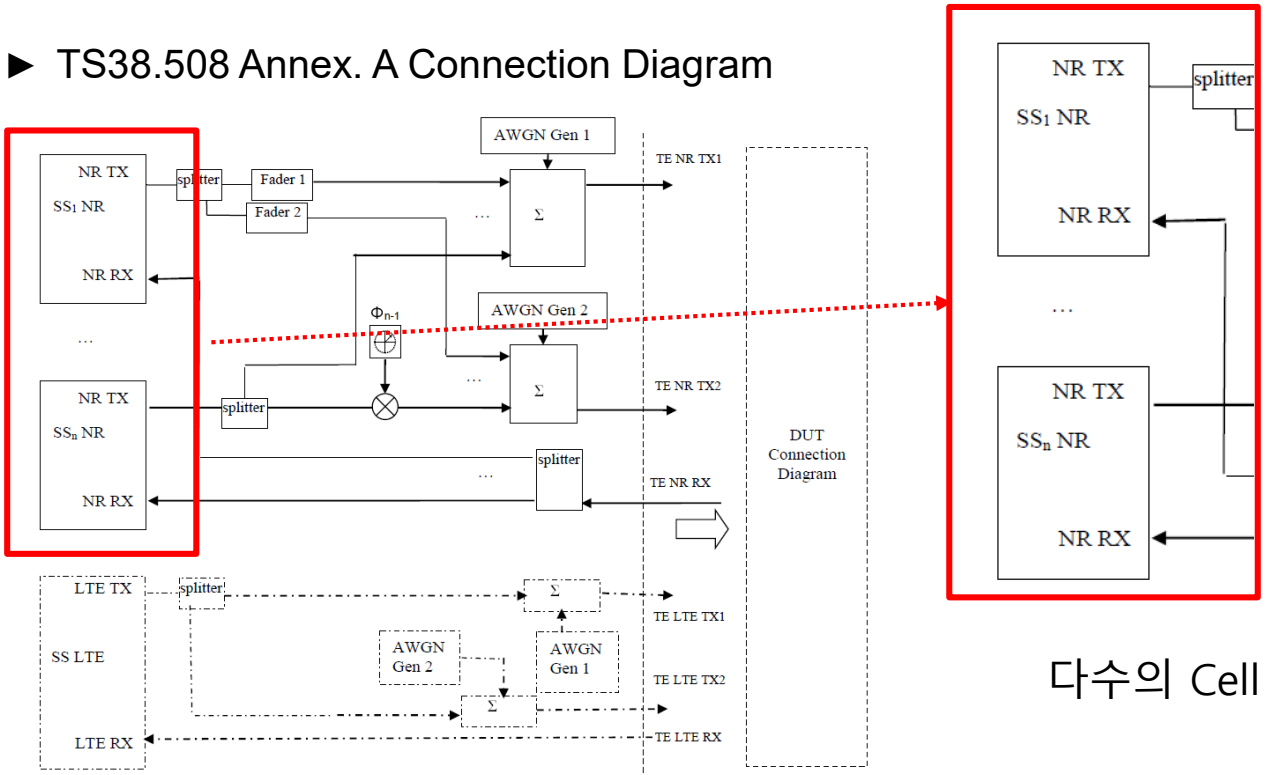
ANGLE OF ARRIVAL (AOA) FOR FR2 TEST CASES

- 3GPP TS38.533 Annex A.9 Test configurations

Setup	Chapter	Decryptions
1	A.9.1	Single AoA in Rx beam peak direction
2a	A.9.2.1	Single AoA in non Rx beam peak direction without change in direction
2b	A.9.2.2	Single AoA in non Rx beam peak direction with change in direction
3	A.9.3	2AOAs
4a	A.9.4.1	2AoAs; 1 AoA in Rx beam peak direction, 1 in non Rx beam peak
4b	A.9.4.2	2AoAs, 1 AoA in Rx beam peak direction, 1 in non Rx beam peak with change in direction

RRM FR1 TEST SETUP

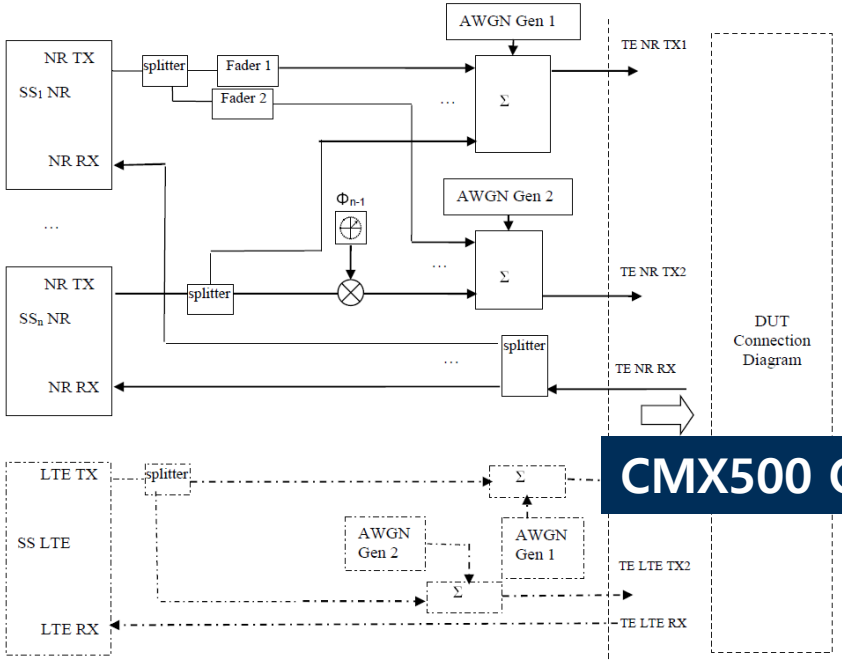
- TS38.508 Annex. A Connection Diagram



다수의 Cell 에뮬레이션 필요!!

RRM FR1 TEST SETUP

► TS38.508 Annex. A Connection Diagram



기지국 에뮬레이터
(R&S CMX500)

CMX500 OBT 1대로 Multi layer simulation!!

Test 단말(DUT)

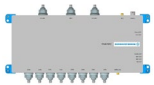
RRM/RF SETUP FOR NR FR2 1AOA

- Signaling
  1x CMW + 1x CMX500 2
  →4x IF Boards
  2→4x RRHs
- RF Combine / Amplify
  1x RF42
  (Second Step)
- Anechoic Chamber
  1x ATS1800C
  (IFF = 1xCATR)
- Application
  Contest

TS8980FTA-M1 (w/ ATS1800C)

RRHs

RF42



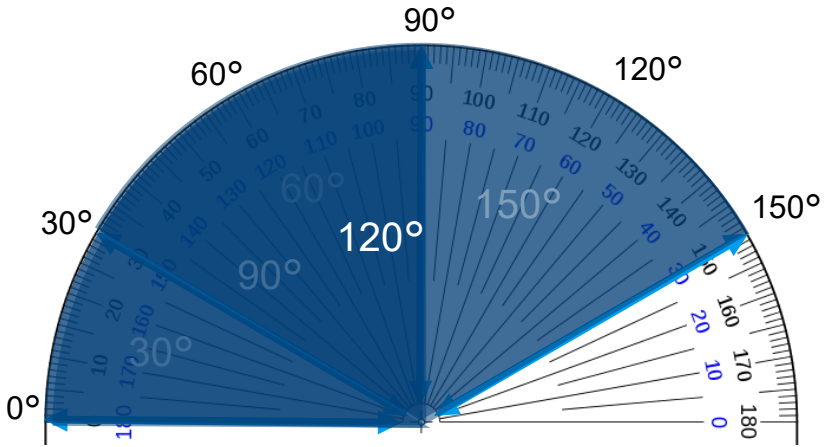
CMW + CMX

ATS1800C

RRM OTA 2AOA TEST

Table A.9.3-1: Set of relative angular offsets between active probes for each power class

UE Power class	Relative angular offset between active probes
1	FFS
2	FFS
3	30°, 60°, 90°, 120° and 150°
4	FFS



30°, 60°,90°, 120°, 150° 5개 방향 지원

새로운 형태의 OTA Test Chamber 필요

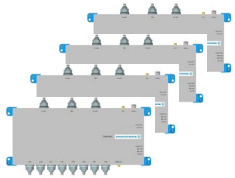
RRM SETUP FOR NR FR2 2AOA

- Signaling
  1x CMW + 1x CMX500 2 →4x IF Boards
  2→4x RRHs
- RF Combine / Amplify
  4x RF42 Boxes
- RF Switch
  1x OSP 220 (2 Modules)
  2x OSP Satellite (4 Modules)
- Anechoic Chamber
  1x ATS1800M
  (eIFF = 4xCATRs)
- Application
  Contest

TS8980FTA-M1 (w/ ATS1800M)

RRHs

RF42s

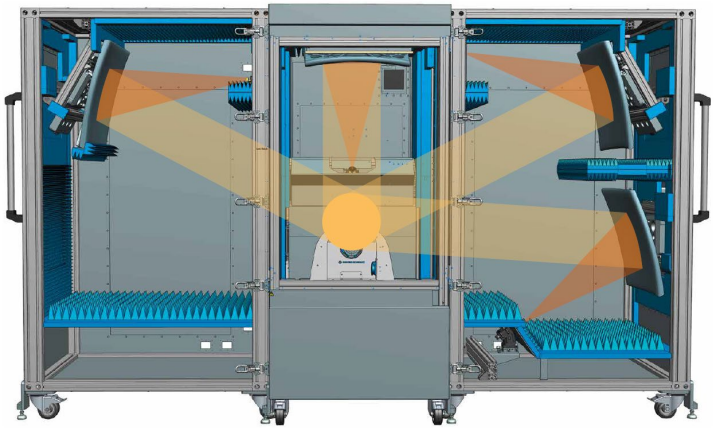


OSP

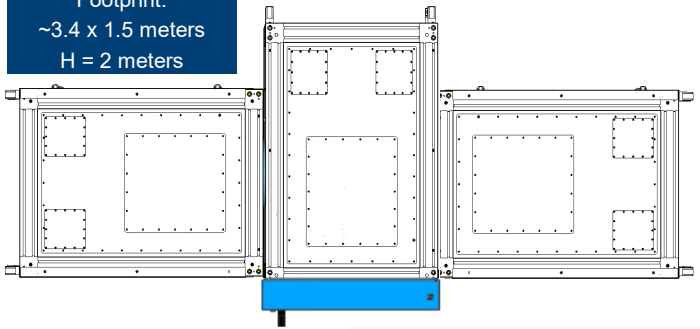
CMW + CMX

ATS1800M

ATS1800M is a multi CATR upgrade to existing ATS1800C through side chamber options



Footprint:
~3.4 x 1.5 meters
H = 2 meters

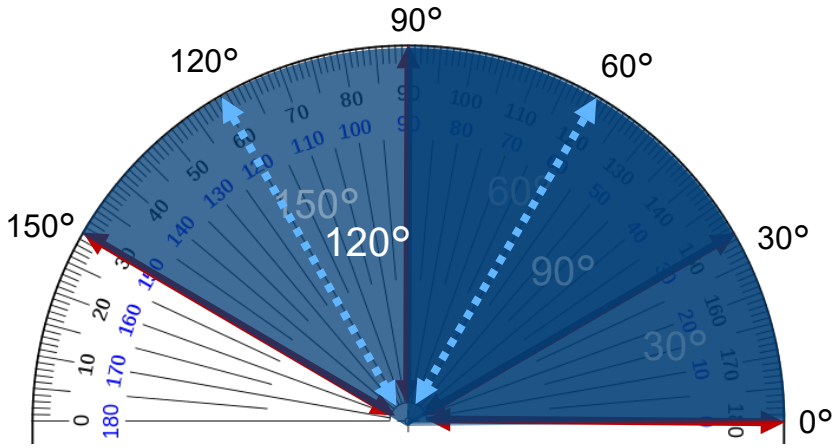


ATS1800M

THE GLOBAL 1ST VALIDATED MULTI CATR OTA CHAMBER

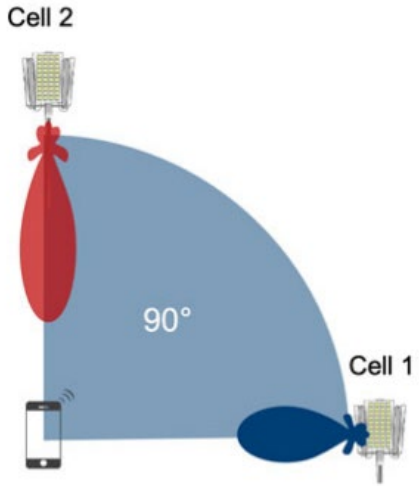
RRM REQUIREMENT

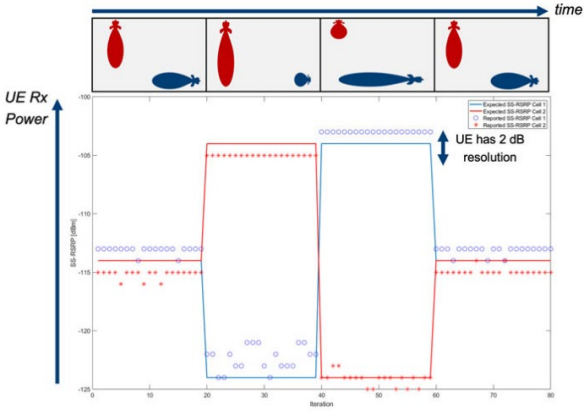
- Since Nov ‘19 in 3GPP (R&S Proposal)
  - low MU
    IFF with QZ of 30cm with (before DFF QZ 5cm)
  - increased MU
    DUT size of up to 40cm (before up to 30cm)



- RRM in 3GPP requires 2 Angles of Arrival
  - Angular Difference: 30°, 60°, 90°, 120°, 150°
  - 4 antennas required
    - @ 0°, 30°, 90°, 150° degrees
    - 60° = Ant3-Ant2
    - 120° = Ant4-Ant2

RRM REQUIREMENT





- Examples of RRM Scenario
  - Monitoring the power levels from different base stations
  - Handover to another base station when the signal from the first one goes below a given threshold
  - Assumed that these base station are located in Far-Field (FF)

3GPP AoA TEST SETUP

Table I.0-1 AoA Test Setup applicability per permitted test method

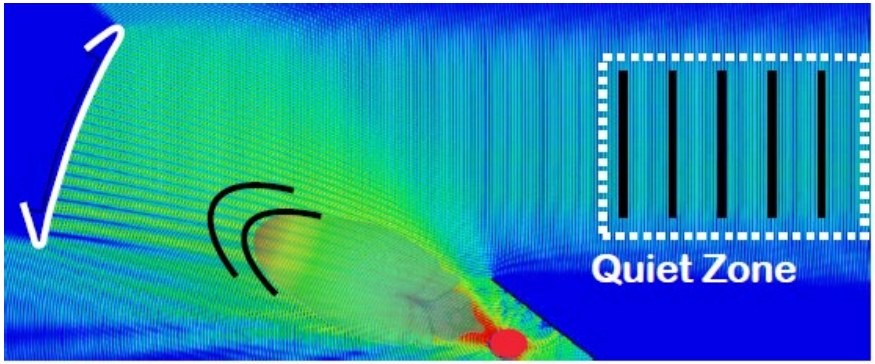
AoA Test Setup	D > 5cm or No declaration	D ≤ 5cm
Setup 1	IFF, Enhanced IFF	DFF, IFF, Enhanced IFF, IFF+DFF
Setup 2a	IFF, Enhanced IFF	DFF, IFF, Enhanced IFF, IFF+DFF
Setup 2b	IFF, Enhanced IFF	DFF, IFF, Enhanced IFF, IFF+DFF
Setup 3	Enhanced IFF	DFF, Enhanced IFF, IFF+DFF
Setup 4a	Enhanced IFF	DFF, Enhanced IFF, IFF+DFF
Setup 4b	Enhanced IFF	DFF, Enhanced IFF, IFF+DFF
NOTE1: D =The diameter of the smallest sphere that encloses the radiating parts of the phase coherent arra antenna(s) active at any one time during the test., declared by UE ven per Table 4.3.9-9 in TS 38.508-2		
NOTE2: DFF indicates both DF n in TR 38.810.		
NOTE3: For DFF and DFF part of IFF+DFF, minimum range length needs to meet the requirement as specified in 38.508-1 Annex B.2.2-4 with the declared D		

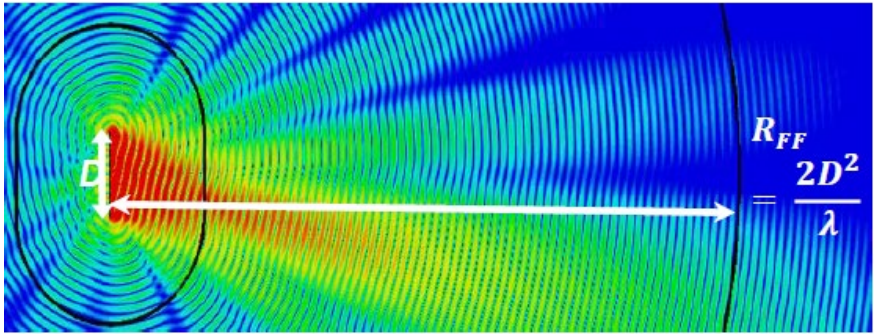
Multi-CATR

1 AoA

2 AoA

DIRECT FAR FIELD (DFF) VS CATR COMPARISON

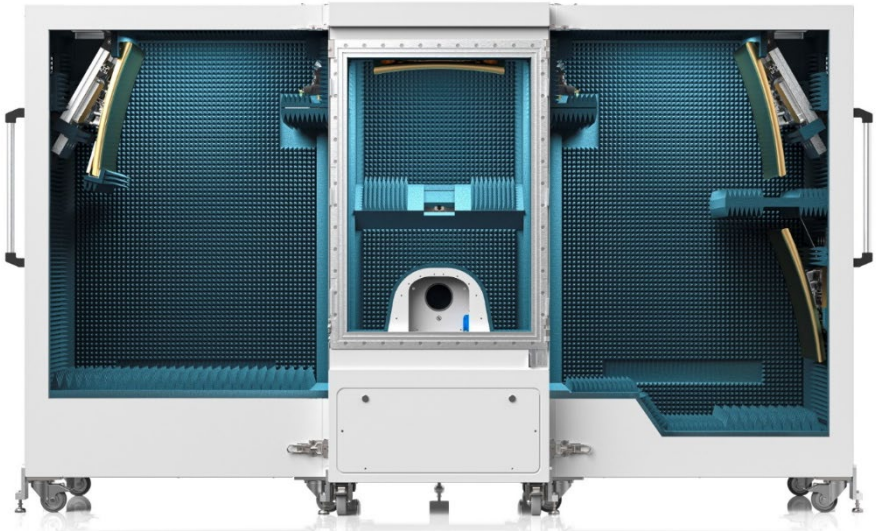




28GHz 20cm Quiet Zone	DFF	CATR
Distance feed to reflector	-	0.7 m
Distance to AUT	7.5 m	1.2 m
Path loss	79 dB	58 dB
Length of cables	Long	Short
Cable loss	High	Low
Size/cost of chamber	**high**	**moderate**

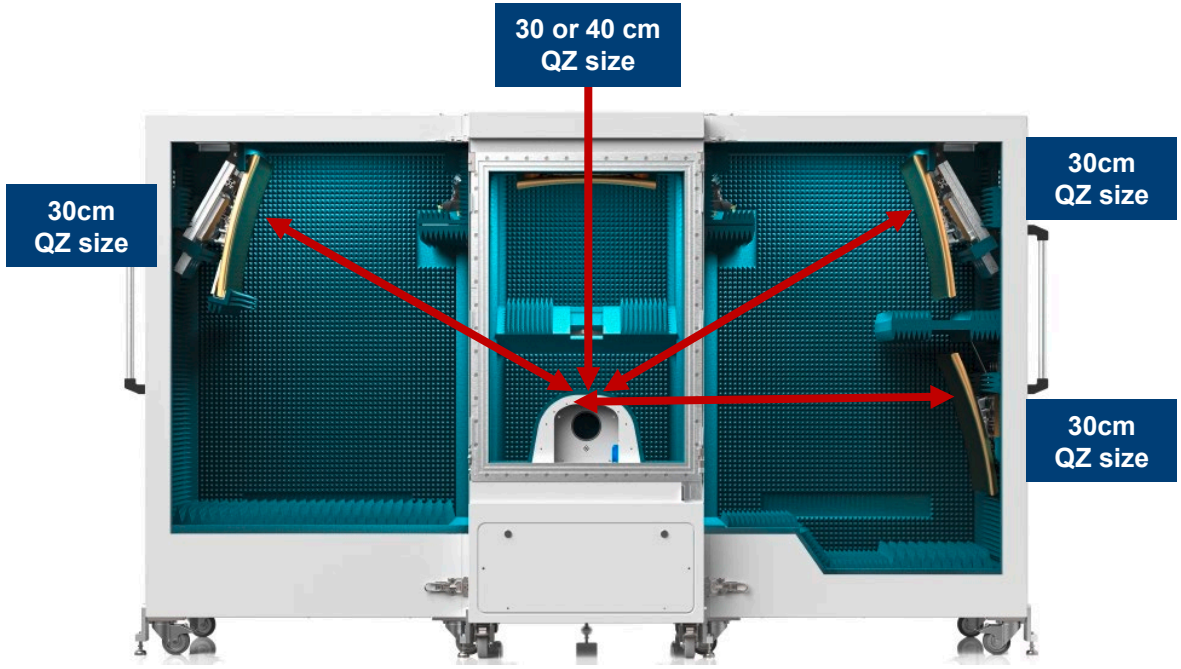
ATS1800M – MULTIPLE AOA (MULTI-CATR)

- RRM testing with multiple angles of arrival (AoA)
- Four reflectors generate four planar wave with different incidence angles
- 30cm QZ for each direction provides low measurement uncertainty



ATS1800M FOR RRM 2AOA

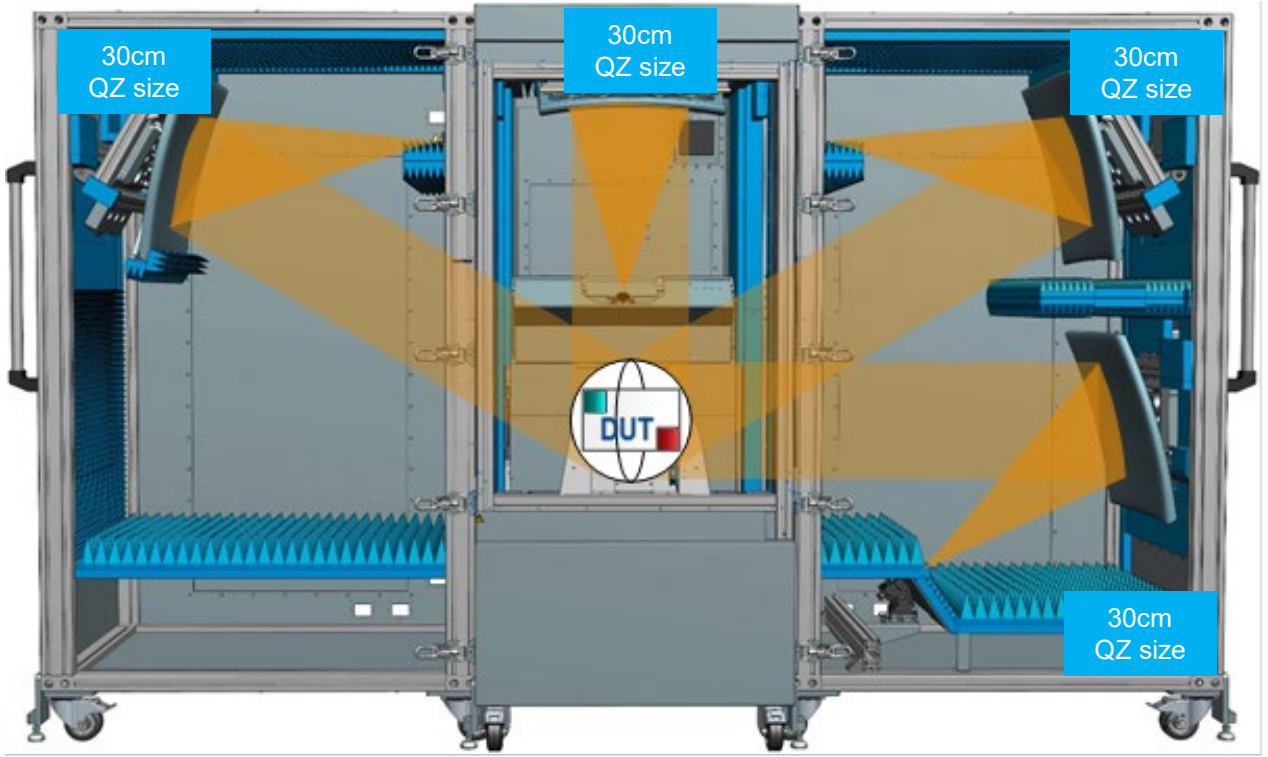
UE Ant. Config	Antennas	AoA	IFF-IFF (Enh. IFF)
1	Single Panel	1AoA	Yes
		2AoA	Yes
2	Multi Non-coh. Panel	1AoA	Yes
		2AoA	Yes
3	Multi Coherent Panel	1AoA	Yes
		2AoA	Yes



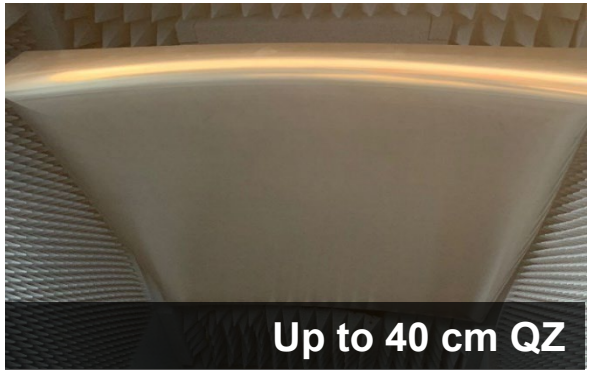
Only R&S supports all accurate test methods!

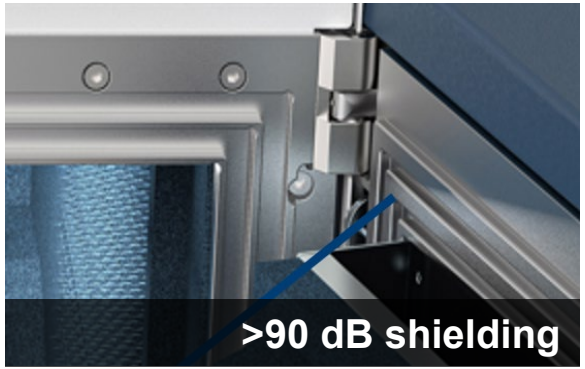
R&S ATS1800M ALL-IN-ONE SOLUTION

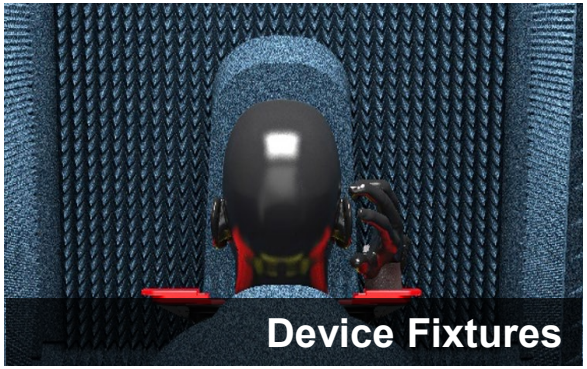
- RF
- RRM Up to 2 AoA
- PCT
- Data Performance
- Out-of-Band (OOB) with Automatic Feedswitcher

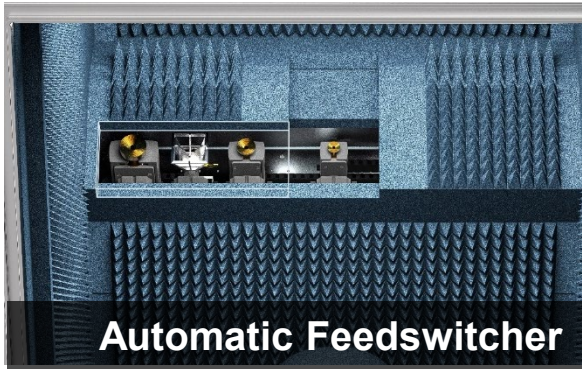


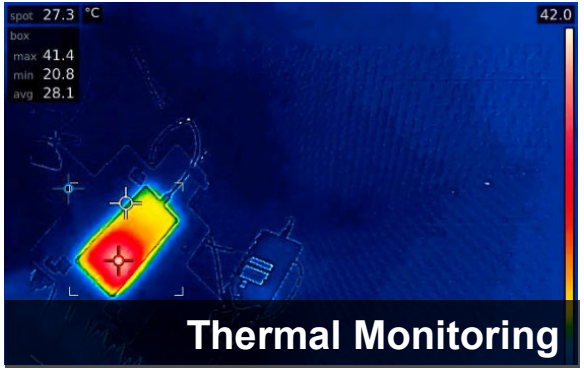
ATS1800 SERIES KEY FEATURES

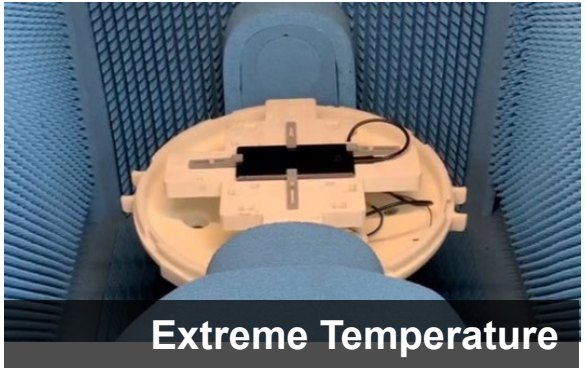












TS8980FTA-M1
CTIA SYSTEM VALIDATION IS DONE

- CTIA auditors have reviewed and approved
- Now officially listed
- R&S Press Release published

CTIA Certification

List of Authorized 5GmmW OTA Test Equipment

Version 1.1

June 2022

Munich / 13-Sep-2022

Rohde & Schwarz first to deliver CTIA authorized 5G mmWave test system with multi-AoA capabilities in FR2

Rohde & Schwarz has cooperated with the US based CTIA organization to authorize the first multiple angles of arrival (multi-AoA) test system for CTIA OTA performance certification. The solution is based on the successful conformance test system R&S TS8980 while also leveraging the R&S CMX500 5G tester together with the R&S ATS1800M mmWave (FR2) chamber from the advanced chamber portfolio from Rohde & Schwarz.

R&S TS8980 conformance test system is authorized for CTIA OTA performanc

R&S FR2 OTA IFF CATR SOLUTIONS OVERVIEW

	ATS800B	ATS800R	ATS1800C	ATS1800M
				
W x D x H [m]	1.2 x 0.6 x 0.8	0.6 x 1.2 x 2.0	0.9 x 1.5 x 2.0	~3.5 x 1.5 x 2.0
Application	Benchtop R&D, academia, research institutes	R&D, pre-conformance (RF, LBS, Netop, PCT, PQA)	R&D, Conformance & pre-conformance (RF, LBS, Netop, PCT, PQA)	R&D, Conformance (RF, LBS, Netop, PCT, PQA) RRM multiple AoA
Type	Black box CATR	Black box CATR	Black box CATR	Black box CATR
Freq. Range	20 - 50 GHz	20 - 50 GHz	(6) 23 - 90 GHz	(6) 23 - 90 GHz
Quiet zone	Ø 20 cm	Ø 20 cm	Ø 40 cm	4x Ø 30cm
Positioner	2D positioner (opt.)	3D Az over El (opt.)	3D Az over El	3D Az over El
Shielding Eff.	N/A	>60dB	>90 dB	>70dB
Extreme Temp.	N/A	1D	3D	3D

Thank you for your attention!

"If you want to go fast, go alone.
If you want to go far, go together!"

African proverb