



**Universal Mobile Telecommunications System (UMTS);
LTE;
Universal Terrestrial Radio Access (UTRA)
and Evolved Universal Terrestrial Radio Access (E-UTRA);
Verification of radiated multi-antenna reception performance of
User Equipment (UE)
(3GPP TR 37.977 version 14.5.0 Release 14)**



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1 Scope

The present document is the technical report for the work item on MIMO OTA, which was approved at TSG RAN#55 [13]. The scope of the WI is to define a 3GPP methodology or set of comparable methodologies for measuring the radiated performance of multiple antenna reception and MIMO receivers in the UE. The test methodology should be relevant for HSPA and LTE technologies, with particular focus on handheld devices and devices embedded in laptop computers.

RAN WG4 has been working on the study item "Measurement of radiated performance for MIMO and multi-antenna reception for HSPA and LTE terminals" with the objective to define a test methodology for measuring the radiated performance of MIMO and multi-antenna UE reception in UMTS and LTE.

RAN4 has done sufficient work to be confident that the definition of a meaningful test methodology is feasible; however RAN4 does not have sufficient evidence yet to conclude on a single test methodology that would fulfil all requirements for standardisation, and the standardisation of multiple test methodologies may be one eventual outcome, with a view to avoid differences in the decision of what is a "good" or "bad" device from the radiated receiver performance perspective.

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] RP-090352: "Proposed new study item: Measurement of radiated performance for MIMO and multi-antenna reception for HSPA and LTE terminals."
- [3] TD(09) 766, COST2100 SWG 2.2, Braunschweig, Germany, Pekka Kyösti et. al. "Proposal for standardized test procedure for OTA testing of multi-antenna terminals", Elektrotbit.
- [4] 3GPP TS 34.114: "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing".
- [5] 3GPP TS 25.214: "Physical layer procedures (FDD)"
- [6] TD(09) 742, COST 2100 SWG 2.2, Braunschweig, Germany, February 2009, J. Takada: "Handset MIMO Antenna Testing Using a RF-controlled Spatial Fading Emulator".
- [7] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".
- [8] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".
- [9] CTIA: "Test Plan for Wireless Device Over-the-Air Performance ".
- [10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".
- [11] 3GPP TR 25.914: "Measurements of radio performances for UMTS terminals in speech mode".
- [12] 3GPP TS 36.521-1: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification Radio transmission and reception; Part 1: Conformance testing"

- [13] RP-120368: Revised WID on "Verification of radiated multi-antenna reception performance of UEs in LTE/UMTS – performance aspects".
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- [20] 3GPP TS 36.978: "User Equipment (UE) antenna test function definition for two-stage Multiple Input Multiple Output (MIMO) Over The Air (OTA) test method".
- [21] P.M. Shankar, "Introduction to Wireless Systems," John Wiley & Sons, 2002, Section 2.5.
- [22] D. A. Hill, "Boundary Fields in Reverberation Chambers," IEEE Transactions on Electromagnetic Compatibility, Vol. 47, No. 2, May 2005.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 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 TR 21.905 [1].

3.2 Symbols

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

H	Channel matrix
ϕ	Adjacent probe separation angle
θ	Zenith angle in the spherical co-ordinate system
ϕ	Azimuth angle in the spherical co-ordinate system

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

ADTF	Absolute Data Throughput Framework
AoA	Angle of Arrival
AoD	Angle of Departure
BS	Base Station
BSE	Base Station Emulator
BTS	Base Transceiver Station
COST	Cooperation of Scientific and Technical
CTIA	Cellular and Telecommunication Industry Association
DL	Downlink
DUT	Device Under Test

FRC	Fixed Reference Measurement Channel
FTP	File Transfer Protocol
HSPA	High Speed Packet Access
HTTP	HyperText Transfer Protocol
LTE	Long Term Evolution
MCS	Modulation and Coding Scheme
MIMO	Multiple Input Multiple Output
MPAC	Multi-probe Anechoic
OTA	Over-the-Air
RC	Reverberation Chamber
RC + CE	Reverberation chamber plus channel emulator
RTS	Radiated Two-Stage
SCM	Spatial Channel Model
SCME	Spatial Channel Model Extension
SI	Study Item
SISO	Single Input Single Output
SIR	Signal-to-Interference Ratio
SNR	Signal-to-Noise Ratio
SS	System Simulator
TBS	Transport Block Size
TTI	Transmission Time Interval
UE	User Equipment
UDP	User Datagram Protocol
UL	Uplink
VRC	Variable Reference Measurement Channel

4 Introduction

4.1 Background

The use of MIMO and receiver diversity in the UE is expected to give large gains in downlink throughput performance for HSPA and LTE devices. 3GPP already defined conducted tests for MIMO and multiple antenna receivers (type 1 and type 3 in TS 25.101 for HSPA demodulation), but it is clear that the ability to duplicate these gains in the field is highly dependent on the performance of the receive-antenna system.

At TSG RAN#41, Sep 2008, it was indicated that there is a need for a test methodology to be created with the aim of measuring and verifying the radiated performance of multi-antenna and MIMO receiver in UEs for both HSPA and LTE devices. As an outcome of the discussion, an LS was sent to COST 2100 SWG2.2 and CTIA ERP to ask them for feedback on their plans/ongoing work in this area, and also the timescales for which such work could be completed to define such a methodology, with particular focus on handheld devices and devices embedded in laptop computers.

Since then, feedback from COST 2100 and CTIA has suggested they are happy to work on this topic. However, given that 3GPP is the customer for this work as well as being a potential contributor, it is important to aim for commonly-accepted measurement and test methodology to be used across the industry.

4.2 Work item objective

The high level objective of this work item is to define a test methodology (ies) for verifying the radiated performance of multiple antenna reception in the UE and such methodology shall be able to:

- Verify the radiated "Over-The-Air" (OTA) performance of multiple antenna reception in the UE.
- Accurately able to reflect MIMO and SIMO performance under realistic MIMO and SIMO channel conditions. Be able to distinguish between UEs of "Good" and "Bad" multi-Rx antenna OTA performance, and offer a good reflection of the likely experience in the field.
- Offer good reliability, repeatability and an acceptable level of measurement uncertainty.

Such test methodology(ies) shall enable performance verification for:

- Handheld devices, devices embedded in laptop computers, and other devices (such as M2M equipment).
- All transmission modes of LTE and HSDPA, including spatial multiplexing (MIMO) and single spatial layer operation. However the transmission modes used in the test shall be defined as part of the work.
 - Initially tests shall use of LTE Transmission Mode 3, Fixed Reference Channel, and forced Rank 2. As the work progresses, other transmission modes of LTE and HSPA shall be introduced.
 - The utilization of Variable Reference Channels and other-cell interference shall also be studied at a later stage.

The following is required for the analysis phase of this work item:

- In order to compare results across the different methods, absolute throughput shall be used as the Figure of Merit.
- In order to analyse and accurately validate a method(s) the following work shall be performed:
 - eNodeB settings shall be agreed.
 - Realistic MIMO conditions and realistic channel models shall be identified to be used as a reference radio environment.
 - The MIMO conditions and channel models shall be validated for the proposed test methods.
 - Calibration of the power levels in the methodology shall be performed.
 - The absolute throughput measured for each test method shall be compared with the absolute throughput measured in the reference radio environment, in order to identify the capability of each method to provide a measurement result that matches what is observed in realistic environments.
 - In order to minimize the variables associated with testing of production UEs with unknown antenna characteristics, utilize reference antennas in combination with a known UE baseband receiver (verified via conducted RF tests with and without channel impairments). This is intended to verify whether the characteristics of the receive antenna design (i.e. correlation, gain imbalance, etc) affecting receiver performance can be accurately distinguished by proposed test methods.

In the event that more than one test methodology is agreed to be standardised, differences between methodologies in the decision of what is a "good" or "bad" device from the radiated receiver performance perspective shall be avoided.

When selecting the method(s) for specification for LTE MIMO, applicability to LTE-SIMO UMTS-SIMO/MIMO shall be described.

During the course of this Work Item, maintain ongoing communication with COST and CTIA MOSG to ensure industry coordination on this topic and to distribute tasks according to expertise or resource availability.

TSG RAN should contact TSG GERAN to get feedback on the applicability of such a test methodology for GERAN.

4.3 High level requirements

The following high level requirements are agreed by RAN4:

1. Measurement of radiated performance for MIMO and multi-antenna reception for HSPA and LTE terminals must be performed over-the-air, i.e. without RF cable connections to the DUT.
 - NOTE 1: DUTs to the test house will have accessibility to temporary antenna port for conducted purposes.
 - NOTE 2: Temporary antenna port is used to assess to DUT receiver.
 - NOTE 3: UE special function to measure antenna pattern is not desirable for MIMO OTA purposes.
2. The MIMO OTA method(s) must be able to differentiate between a good terminal and a bad terminal in terms of MIMO OTA performance.