Feasibility Study for Building a Testing Laboratory

Testing Laboratories and Test Plant Infrastructure
Focus on mobile terminal testing process
Test Lists for Mobile Terminal Certification

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Testing Laboratories and Test Plant Infrastructure

- User Experience Lab
- Broadband Access Lab
- Electrical Safety & Protection Lab
- Electroacoustic Lab
- Electromagnetic Compatibility (EMC) Lab
- Powering Efficiency Lab
- Quality of Material Lab
- Wi-Fi & Personal Area Network (PAN) Lab
- Fixed & Mobile Test Plant

User Experience Laboratory

- Usability, ergonomics, user-centred planning, psycho-social research, psycho-metric statistics and communication test.
- The lab must be equipped with residential and business office testing areas, and a control room

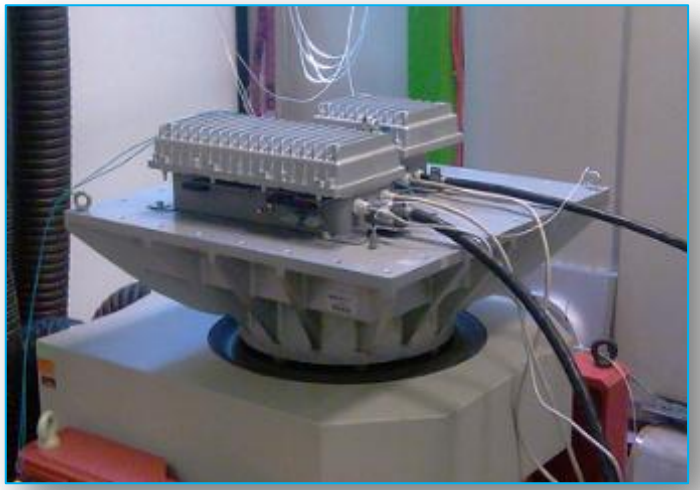
- QUALITATIVE SURVEYS on user needs & user requirements
- USABILITY TESTS with users in domestic and business contexts
- FOCUS GROUPS & BRAINSTORMING: groups of people are asked about their attitude towards a product Design, Technology and Services.
- TRIALS. Evaluate the Customer Experience in real context: from installation, configuration to software & hardware complete usage.
- PRODUCT&SERVICE CONCEPTS (user-centred user interface, navigation flows and layout)

Broadband Access Laboratory

- Evaluate equipment and functionalities used in Broadband Access networks and Next Generation Access networks.
- Ranging from physical layer to the networking aspects.

- xDSL Physical Layer Tests: functional and performance interoperability of the System Under Test (ADSL1, ADSL2+, SDSL, VDSL) against reference implementation
- GPON Optical Layer Tests: functional and performance interoperability of the System Under Test (GPON interface) against reference implementation
- Layer 2 Functional Tests: Consumer/Business/Wholesale service model implementation in the broadband access network equipment (stand-alone tests)

Electrical Safety & Protection Laboratory

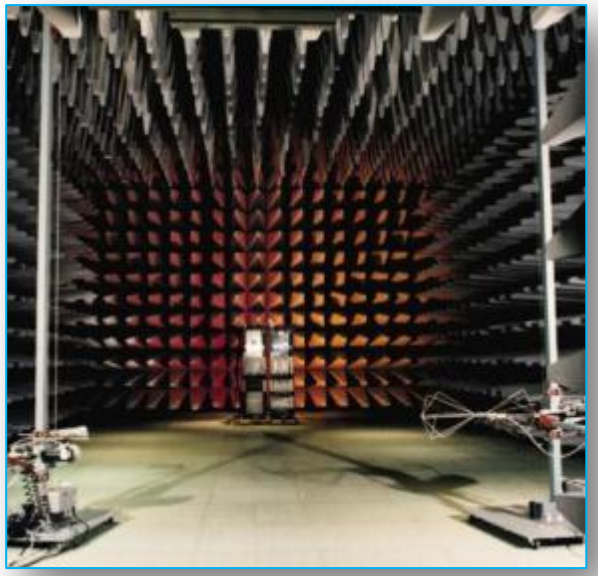


- This sector operates in order to evaluate safety and resistibility requirements for IT and TLC equipment with compliance to international standards.
- Protection against hazards not only in normal operation conditions but also in a single fault condition that may have an impact into the addition of safety guards, metallic protection screens and so on.
- Verification of electrical resistibility of TLC equipment exposed to over voltages and/or over currents
- Mechanical robustness of equipment respect to the stresses which could be experimented by the same during transportation, storage and during stationary (Sinusoidal vibrations, shock and random vibrations)

Electroacoustic Laboratory

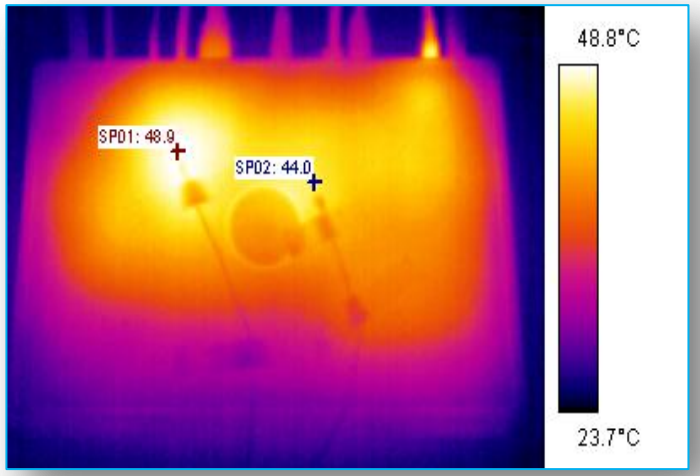
- Telephonometric characteristics of handset and hands free telephones. Test services for electric characteristics of analog terminal and interfaces. (handset and hands free telephones, analog interfaces of access gateway for xDSL access services and xDSL filters.)
- The main scope of this activity is test and consulting activity on terminals to guarantee the correct interworking with the network and to ensure a good audio quality.
- The typical test services are:
  - electroacoustic tests of hands free telephones;
  - electroacoustic tests of mobile phones;
  - electrical characteristics and transmission response of analog interfaces (FXS)
  - characterization of xDSL filters

Electromagnetic Compatibility (EMC) Laboratory



- Provides qualification and conformity testing, on radio communication system and apparatus, network equipment and telecommunication terminal, based on International standard (e.g. Field Uniformity and Normalized Site attenuation)
- The dimension of the shielding structure may be e.g. 22m length, 14 m width and 9m height.
- The EMC testing laboratory represent also the reference laboratory for the activities performed under the role of Notify Body for the EMC Directive 2004/108/EC. Moreover the EMC laboratory has been recognised as Conformity Assessment Body (CAB) under the Mutual Recognition Agreement between EC and US for the conformity to FCC CFr 47 part 15 and part 18 regulations.

Powering Efficiency Laboratory



- Evaluation of power consumption and power efficiency conversion for information technology and telecommunication equipment
- Energy efficiency improvement as a contribute to the reduction of global gas emission.
- Energy saving is the most cost-effective way to increase security of supply and reduce import dependency; therefore, substantial demand-side measures and targets should be adopted by all the countries.
- Energy consumption of energy-related products in stand-by or off-mode should be reduced to the minimum necessary for their proper functioning.
- Power conversion efficiency of external power
- Verify the compliance of the equipment respect to the electrical requirements prescribed by International Standards

Quality of Material Laboratory

- Evaluation of properties and field performances of materials employed in ICT networks and equipment.
- Physical and chemical tests are carried out to verify network materials compliance to technical specifications, to evaluate weathering resistance and to support end of life disposal.
- Environmental impact and safety of materials in field can also be investigated. The capabilities are applied to the materials in the following steps of their lifecycle:
  - before introduction, as a part of the qualification process
  - after type approval for the surveillance of dispatched lots
  - during field employment in case of early degradation or failures
  - at the end of life to find out the best disposal routes.

Wi-Fi & Personal Area Network (PAN) Laboratory

- Ensure the quality of the Access Gateway and others Wi-Fi devices in order to support commercial offer and, therefore, the quality of the service provided to the customers.
- Tests related to the higher levels of Zig Bee network architecture.
- Verify that the equipment under test meets the Wi-Fi specifications given to the product supplier and that the product complies with the IEEE 802.11 standards and with other country specific regulatory standards (for maximum radiated power, spectral mask, etc.).
- Functional/performance comparison between products of different vendors helping choice of best suited products for the offered service.
- Test the functional level of Zig Bee protocol for the application profiles: Telecom Application (TA), Home Automation (HA), Cluster Library

Fixed & Mobile Test Plant

- A conformance test center, offering several testing services on many different areas of ICT, has the necessity to use test plant in order to reproduce the real network to perform interoperability and end-to-end testing. Moreover in test plant it is possible to reproduce malfunction detected in the field and to find suitable workarounds.
- if the necessity is to reproduce the network of a medium/large operator, the location must be quite large and at least one for mobile and one for fixed network.

Focus on mobile terminal testing processes

- Specific Absorption Rate (SAR) Laboratory
- Radio testing
- Signaling mobile testing
- Throughput performances
- IOT testing
- Power efficiency testing
- WIFI interoperability
- Field testing
- Mobile Value Added Services (VAS) Laboratory

Specific Absorption Rate (SAR) Laboratory

- Compliance with the basic restrictions given in International Standards in terms of specific absorption rate (SAR, Specific Absorption Rate [W/kg])
- Perform SAR measurement on handheld or wireless RF devices used in close proximity to the ear or the human body.
- The measurement system consists of two robots: 1) for moving an electric field probe inside an anthropomorphic mannequin filled with a liquid, whose electromagnetic characteristics are similar to those of the brain. 2) for automatically aligning the handset with respect to the mannequin.
- SAR evaluations according to: Numerical communication systems (TETRA, GSM900, GSM850, DCS1800, PCS1900, DECT, UMTS I e VIII, HSPA) + IEEE 802.11b/g based wireless LAN devices

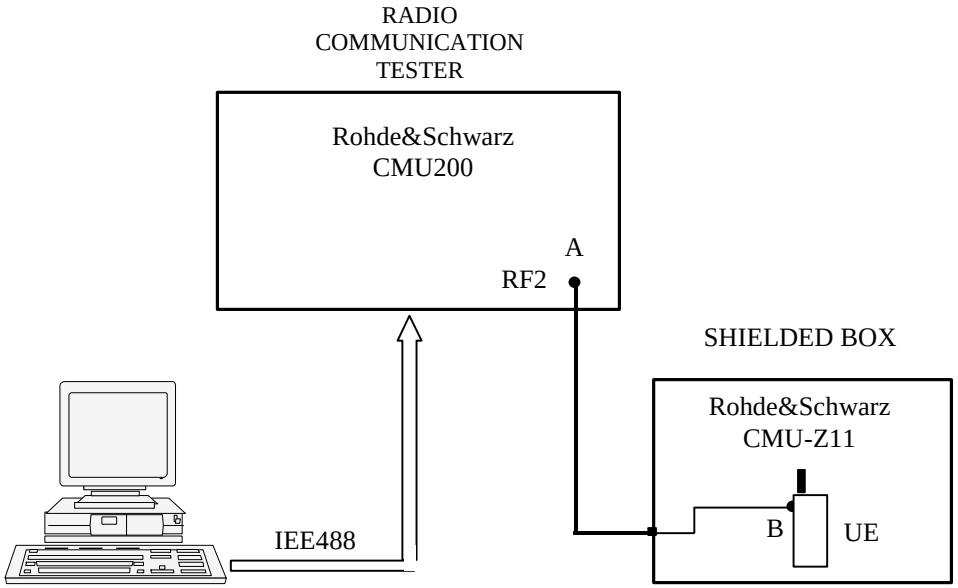
Radio Testing (from 3GPP)

- Radio testing aims to check the correct behaviour of the UE (User Equipment) from electromagnetical point of view
- Two tests typologies are defined: Conducted and OTA (Over the Air)
- **UE Maximum Output Power:** *"To verify that the error of the UE maximum output power does not exceed the range prescribed by the specified nominal maximum output power and tolerance" (TS 36.512)*
- **Reference Sensitivity Level:** "*To verify the UE's ability to receive data with a given average throughput for a specified reference measurement channel, under conditions of low signal level, ideal propagation and no added noise" (TS 36.512)*

Radio Testing (from CTIA)

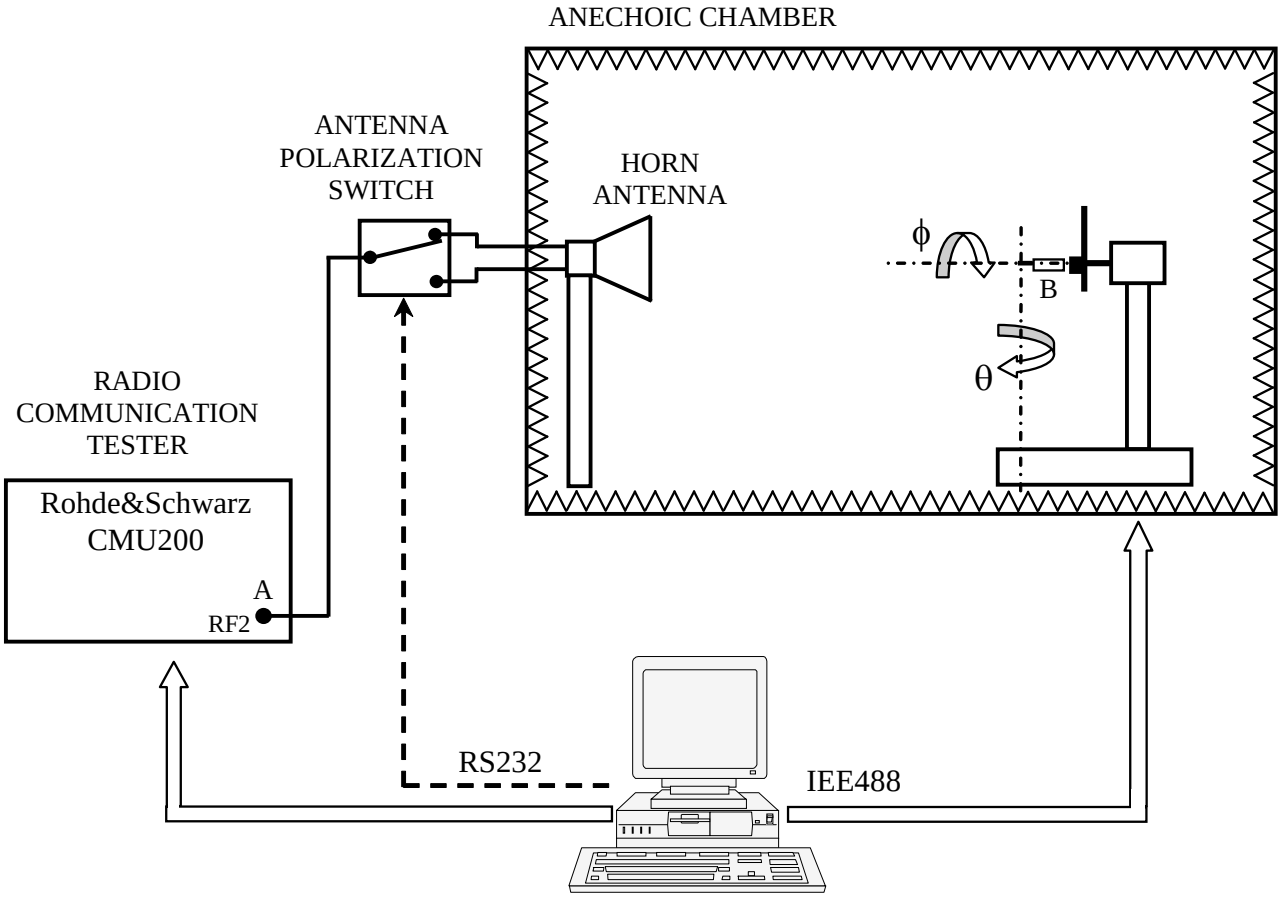
- Good radiated performance is critical to the effective operation of a wireless device in today's networks. As devices become smaller, radiated performance can often become compromised.
- Achieving an efficient antenna in a small size and over multiple frequency bands is a difficult task..
- Peak EIRP (Effective Isotropic Radiated Power) is not a good indication of wireless performance in the field (if radiation pattern of the EUT's antenna system is highly directive, peak EIRP would be high but coverage would be poor in other directions.
- Further, the human head and/or hand can alter the shape and peak value of the EUT radiation pattern
- => average spherical effective isotropic radiated power (termed **Total Radiated Power, TRP**) is to be measured.
- Poor receiver radiated performance will cause the user of the subscriber unit to hear a low quality voice signal, subscriber unit to lose the base station signal resulting in abrupt termination of the call.
- => average spherical effective radiated receiver sensitivity (termed **Total Isotropic Sensitivity, TIS**) is to be measured.

Radio Testing – Conducted



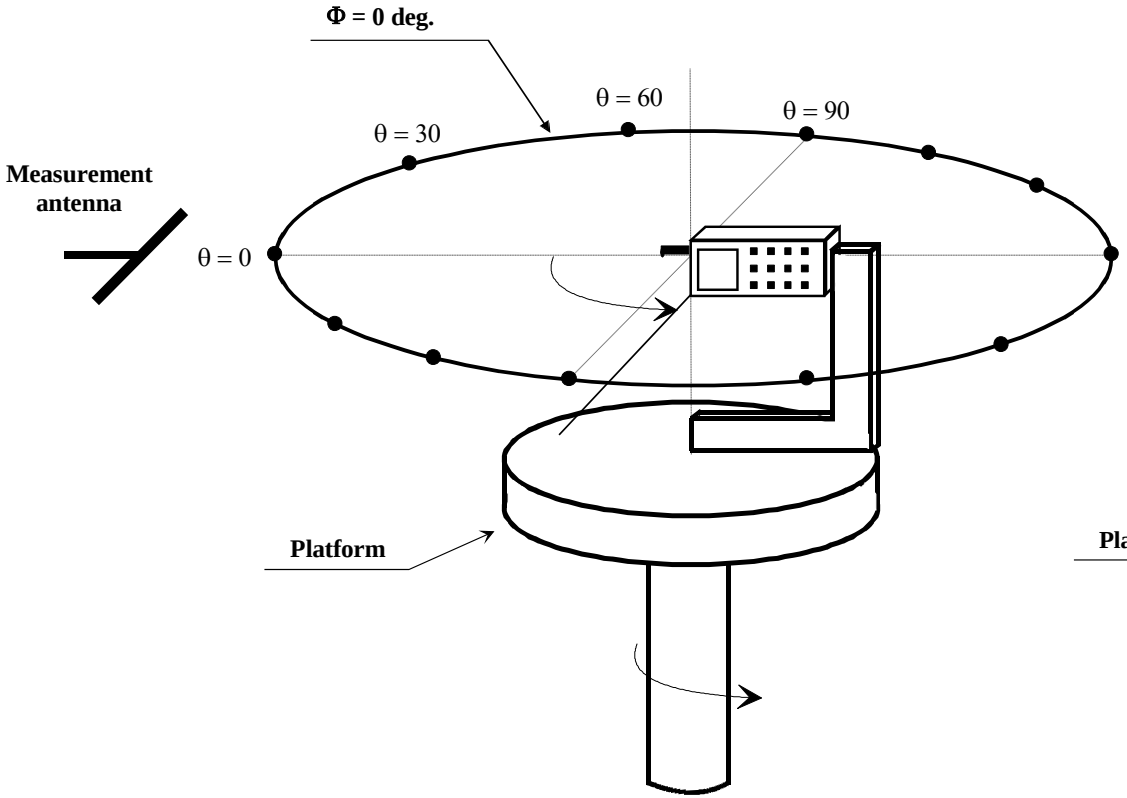
- Conducted measurements are carried out using a radio-frequency cable that connects the UE directly to the measuring bench. These measurements highlight the performance of the cellular phone without antenna. The measurements are made by connecting the UE's antenna connector to an instrument for measuring radio performance ("Radio Communication Tester Rohde&Schwarz CMU200") using a RF cable with known attenuation (static measurements).
- For measurements in which the radio environment typical of land radio mobile systems (fading) is simulated, a Channel Simulator (Rohde&Schwarz ABFS) is also used.

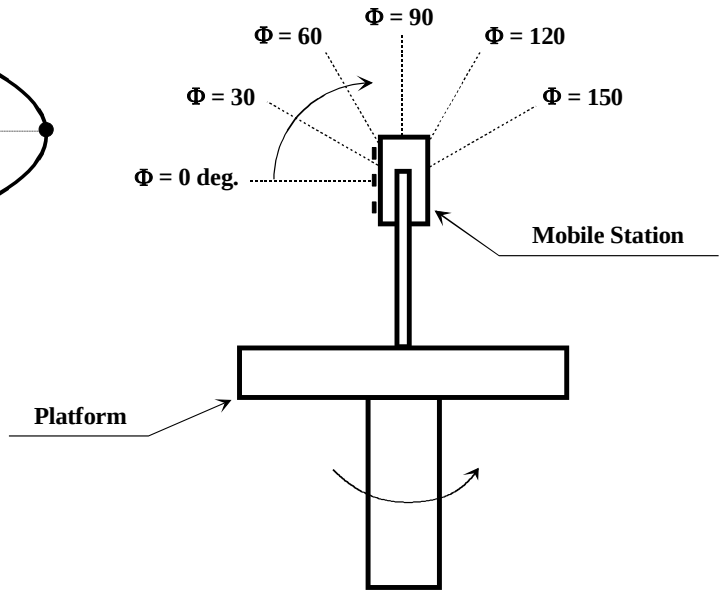
Radio Testing – Over The Air



- To perform the measurements, the UE is put on the turntable, in the anechoic chamber, in a horizontal position. The Radio Communication Tester is connected to the measurement antenna.

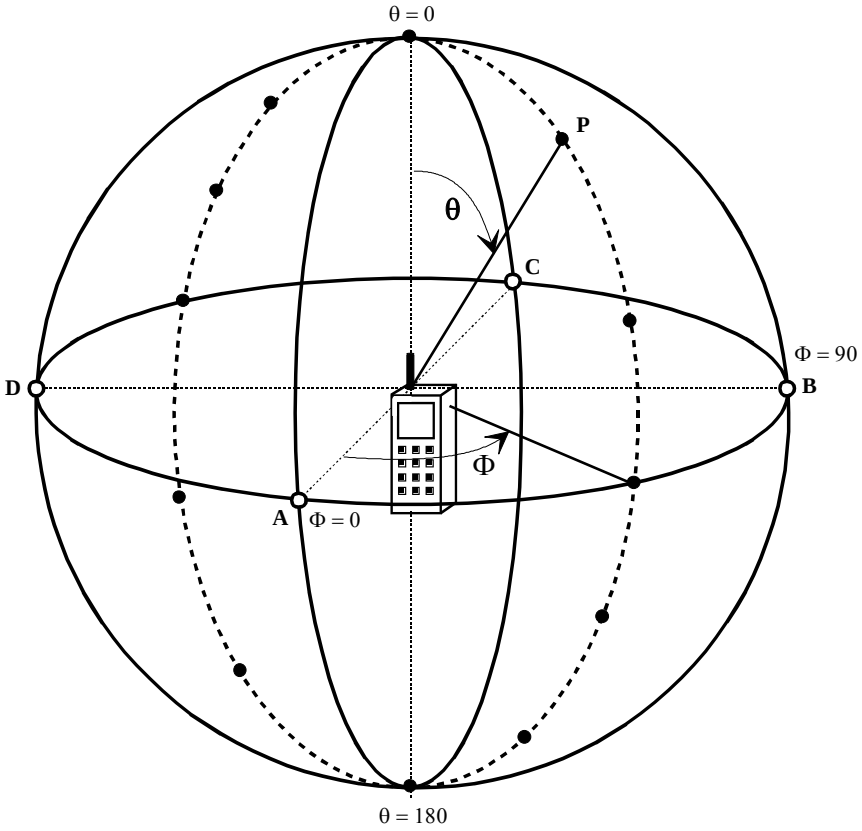
Radio Testing – Over The Air





- The elevation angle θ is the angle described from one rotation of the turntable.
- The second figure shows the measurement points on the meridian of the sphere correspondent to the azimuth angle φ=0.

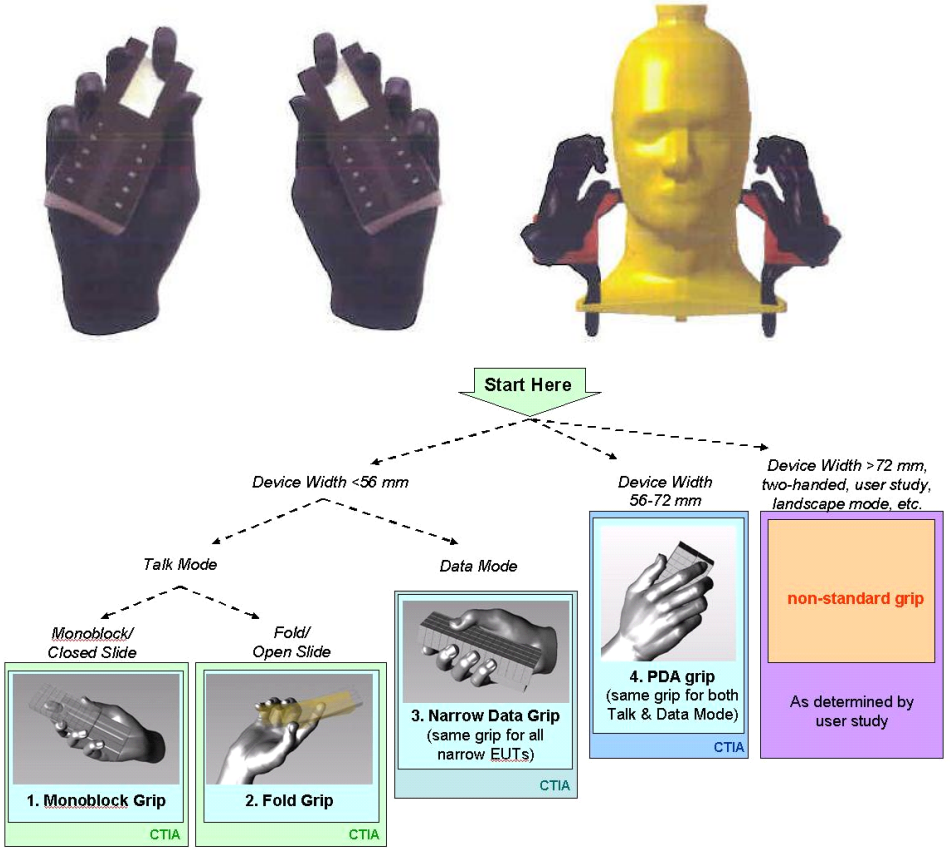
Radio Testing – Over The Air



- Figure shows with a dotted line a generic meridian, on which 12 measurement points are collected from a complete rotation of the elevation angle θ.
- All the measured values of sensitivity and TX power, in both polarizations, are weighted in function of the elevation angle, in order to emphasize the contributions near the equatorial plane and minimize them near the poles of the sphere
- This operation associates every measurement point to a weight coefficient directly proportional to the area of the spherical surface associated to that point. The weighted values are integrated to obtain a single value for the Total Isotropic Sensitivity (TIS) and for the Total Radiated Power (TRP).

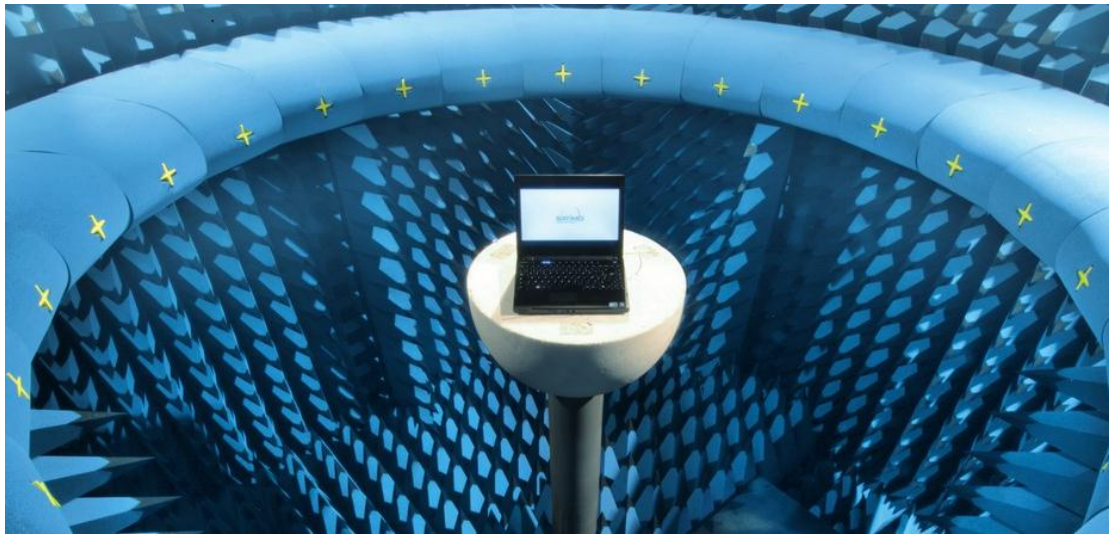
Radio Testing – Over The Air

With SAM Head



With SAM Head + Hands

Radio Testing – MIMO Chamber



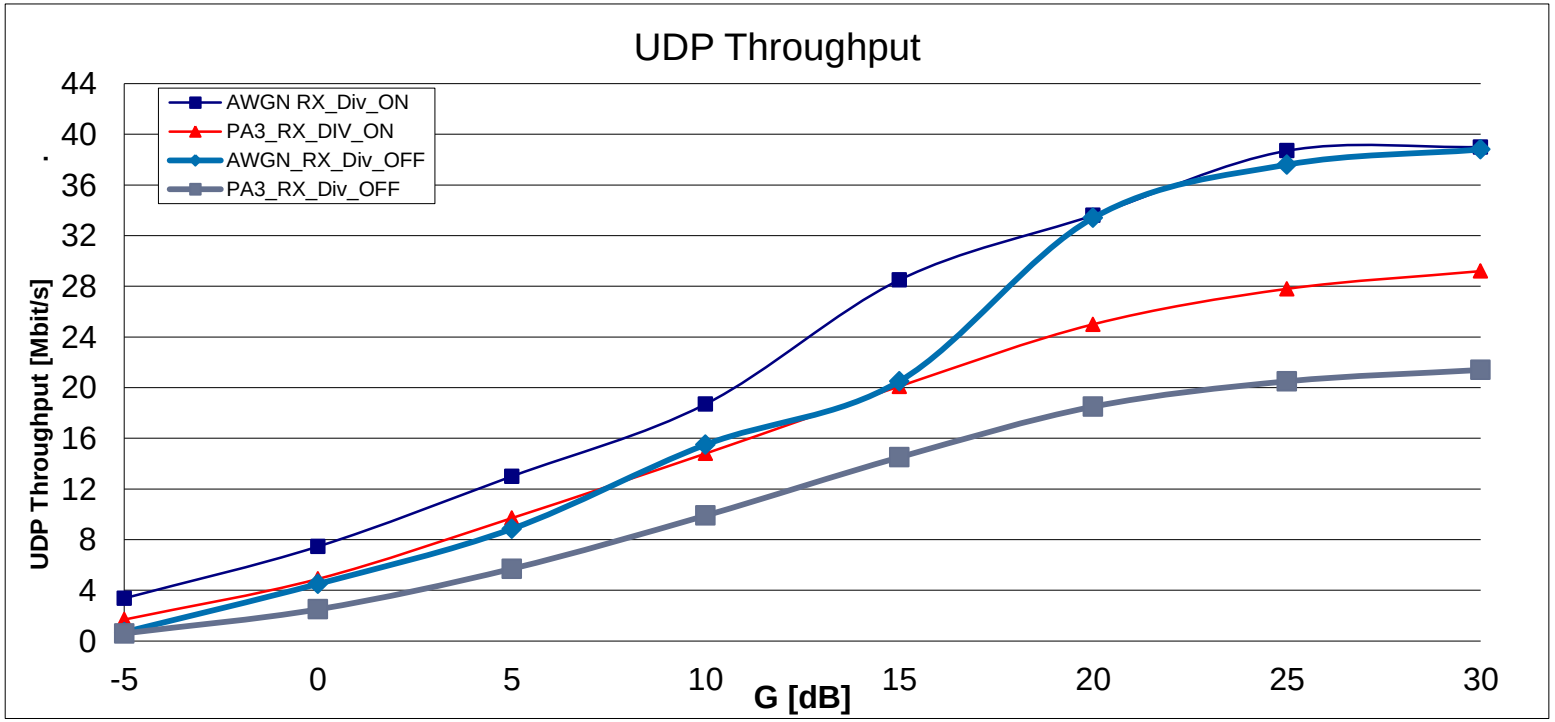
- Multiple-Input-Multiple-Output (MIMO) antenna techniques are a key factor in achieving the high data rates promised by next-generation wireless technologies such as LTE and LTE-Advanced. One area that experiences a renewed sense of importance with MIMO is the topic of Over-the-Air (OTA) device testing.
- The anechoic-based MIMO OTA method provides a means of accurately emulating all the spatial aspects of a wireless channel in a controlled and repeatable manner. In order to create a Rayleigh-faded multipath spatial channel environment inside the anechoic chamber, a channel emulator and relevant mapping software are used to distribute signals across both the horizontal and vertical elements of each transmitting antenna in the chamber.

Signaling Mobile Testing

- Protocol testing aims to check the correct interworking between the UE (User Equipment) and the Network.
- Protocol Simulators are usually used in TI Lab in order to avoid dependency on specific vendor implementation and to guarantee a stable testing environment.
- Some Examples of tested procedures are:
  - Cell Selection/Reselection
  - Recovery from Lack of coverage
  - Inter RAT mobility
  - Data Connection UE handling (i.e. PDP Context Reject)
  - RRC connection handling (i.e. State Transitions, Fast dormancy legacy, etc.)

Throughput Performances

- The aim of these measurements is to check the throughput performances of the receiver, with the exclusion of the antenna. The measurements are performed by connecting the UE's antenna connector to a Radio Communication Tester for measuring radio performance by using a RF cable with known attenuation.
- For measurements in which the radio environment typical of land radio mobile systems (fading) is required, a Baseband Fading Simulator is also used.

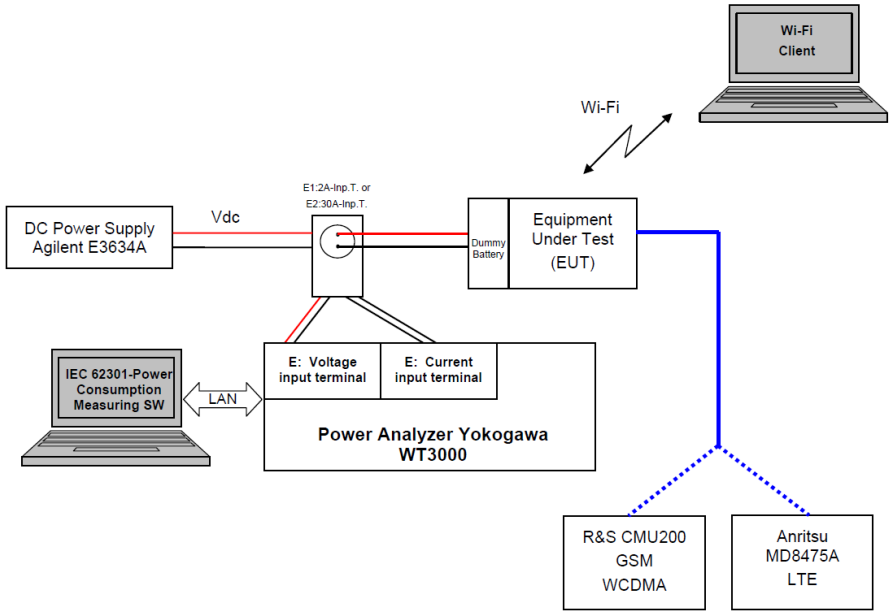


IOT testing

			Ericsson			Huawei			Nokia		
Area	TC Number	TC Description	Banda 3 1800 MHz	Banda 20 800 MHz	Banda 7 2600 MHz	Banda 3 1800 MHz	Banda 20 800 MHz	Banda 7 2600 MHz	Banda 3 1800 MHz	Banda 20 800 MHz	Banda 7 2600 MHz
1 Capability Audit											
1 Capability Au	**1.1**	UE Category (from 1 to 5 LTE) - To Verify the UE category signalled by the UE to the Network	P	P	P	P	P	P	P	P	P
1 Capability Au	**1.3**	UE Display ICON verification	P	P	P	P	P	P	P	P	P
2 Idle Mode Operations											
2.1.2 Mobility											
2.1.2 Mobility	**2.1.2.1**	Cell reselection intra-frequency									
2.1.2 Mobility	**2.1.2.2**	Cell reselection inter-frequency	P	P	P				P	P	P
2.2 Multimode Enviroment (3G/2G)											
#RIF!	**2.2.2.1**	LTE -> HSPA cell selection in Idle mode (only Default EPS bearer)	P	P	P						
#RIF!	**2.2.2.2**	LTE -> DC-HSPA cell selection in Idle mode (only Default EPS bearer)	P	P	P						
2.2.3 Mobility 2G											
2.2.3 Mobility	**2.2.3.1**	LTE -> OnlyGSM cell selection in Idle mode (only Default EPS bearer)							P	P	P
2.2.3 Mobility	**2.2.3.2**	LTE -> GPRS/EDGE cell selection in Idle mode (only Default EPS bearer)							P	P	P

- IOT testing aims to check the correct interworking between the UE (User Equipment) and the Network, in a Test Plant environment
- All different network vendors are tested
- Test lists may derive from frequent troubleshooting anomalies
- Typically PASS/FAIL testing, as in Signalling Mobile Testing

Power efficiency testing



The tests are carried out to verify the power consumption of mobile equipment (MS/UE), in several scenarios selected from the GSMA Official Document TS.09 - Battery Life Measurement and Current Consumption Technique.

3.3 LTE - Current Drain & Battery Life Time Measurement Check

Mode	hhh:mm(*)	Voltage mean [V]	Current mean drain [mA]	Current peak drain [mA]	Power mean [mW]
Idle (Wi-Fi enabled, no AP, Display Off)	**151:58**	4.305	**14.476**	416.003	62.281
Browsing (Wi-Fi enabled, no AP)	**5:29**	4.214	**400.927**	975.082	1688.772
Mp3 stream (Wi-Fi enabled, no AP, Display Off)	**8:21**	4.245	**263.014**	472.320	1116.169
Video Streaming (Wi-Fi enabled, no AP)	**4:21**	3.992	**503.670**	942.032	2009.205
File download (Wi-Fi enabled, no AP, Display Off)	**6:37**	4.109	**332.311**	560.470	1363.628
Hot-Spot WiFi File Up/Down Load (Display Off)	**5:10**	4.083	**424.465**	639.391	1730.929

WiFi Interoperability

1 Interoperability with Telecom Italia Access Gateways

1.1 Supported Encryption

	ENCRYPTION						
	OPEN	WEP	WPA PSK TKIP	WPA PSK AES	WPA PSK TKIP-AES	WRONG KEY (*)	HIDDEN SSID (*)
AG2007 Pirelli	OK	OK	OK	OK	OK	OK	OK
AG BHS ADB	OK	OK	OK	OK	OK	OK	OK
AG BHS Technicolor	OK	OK	OK	OK	OK	OK	OK
AG PLUS Technicolor 2.4 GHz	OK	OK	OK	OK	OK	OK	OK
AG PLUS Technicolor 5 GHz	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.
FRITZIBox 7270 2.4 GHz	Ok	OK	OK	OK	OK	OK	OK
FRITZIBox 7270 5 GHz	n.a.	n.a.	n.a.	n.a.	n.a.	n.a	n.a.

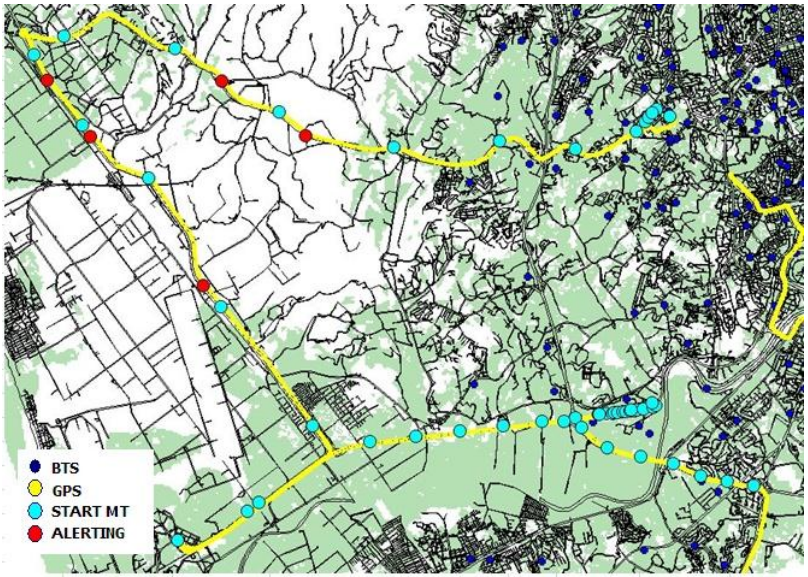
(*) WPA PSK TKIP-AES only

1.2 WPS (Wireless Protected Setup)

	WPS						
	Push Button			PIN AP	PIN Client		
	HW	GUI					
AG2007 Pirelli	n.a.						
AG BHS ADB	n.a.			n.a.	n.a.		
AG BHS Technicolor	n.a.			n.a.	n.a.		
AG PLUS Technicolor 2.4 GHz	n.a.	n.a.			n.a.		
AG PLUS Technicolor 5 GHz	n.a.	n.a.			n.a.		
AG PLUS Technicolor 2.4 GHz and 5 GHz at the same time, with the same SSID	n.a. Sel.Band:	2.4 GHz n.a. Sel. Band:	5 GHz n.a. Sel.Band:		2.4 GHz n.a. Sel. Band:	5 GHz n.a. Sel.Band:	
FRITZIBox 7270 2.4 GHz		n.a.		n.a.	n.a.		
FRITZIBox 7270 5 GHz		n.a.		n.a.	n.a.		

Field Testing

- Field tests activity has planned on all geographical area. Tests, in fact, are performed on three different network's infrastructures:
  - Ericsson
  - Siemens/Nokia
  - Huawei
- The device must be delivered to for field test ready to be logged with all necessary communication port enabled.
- Vendor has to provide the information to log the device with chipset's proprietary tool in order to analyse all the messages that DUT exchange with the network.



Troubleshooting

- In some cases, a customer problem cannot be solved via an ordinary process, because it's very difficult to understand if it is ascribable to the network or to the terminal itself.
- It is often useful to know the real context where the anomaly occurs, comprising the software and firmware version of the mobile terminal and the last release of software for all the radio equipment which are involved.
- The exact configuration has also to be reproduced in Test Plant, in order to verify in a monitored environment when and how the error may be detected.
- When the reason of the fault is properly found, a s/w patch for the terminal or for the mobile equipment is usually envisaged and regression tests may also be carried in Test Plant environment.
- Sometimes, field tests may help to focus the exact configuration and circumstances which turn on the observed trouble.
- The process may lead to an increase of IOT (or other tests) which are carried before accepting new terminals, enhancing existing test lists.

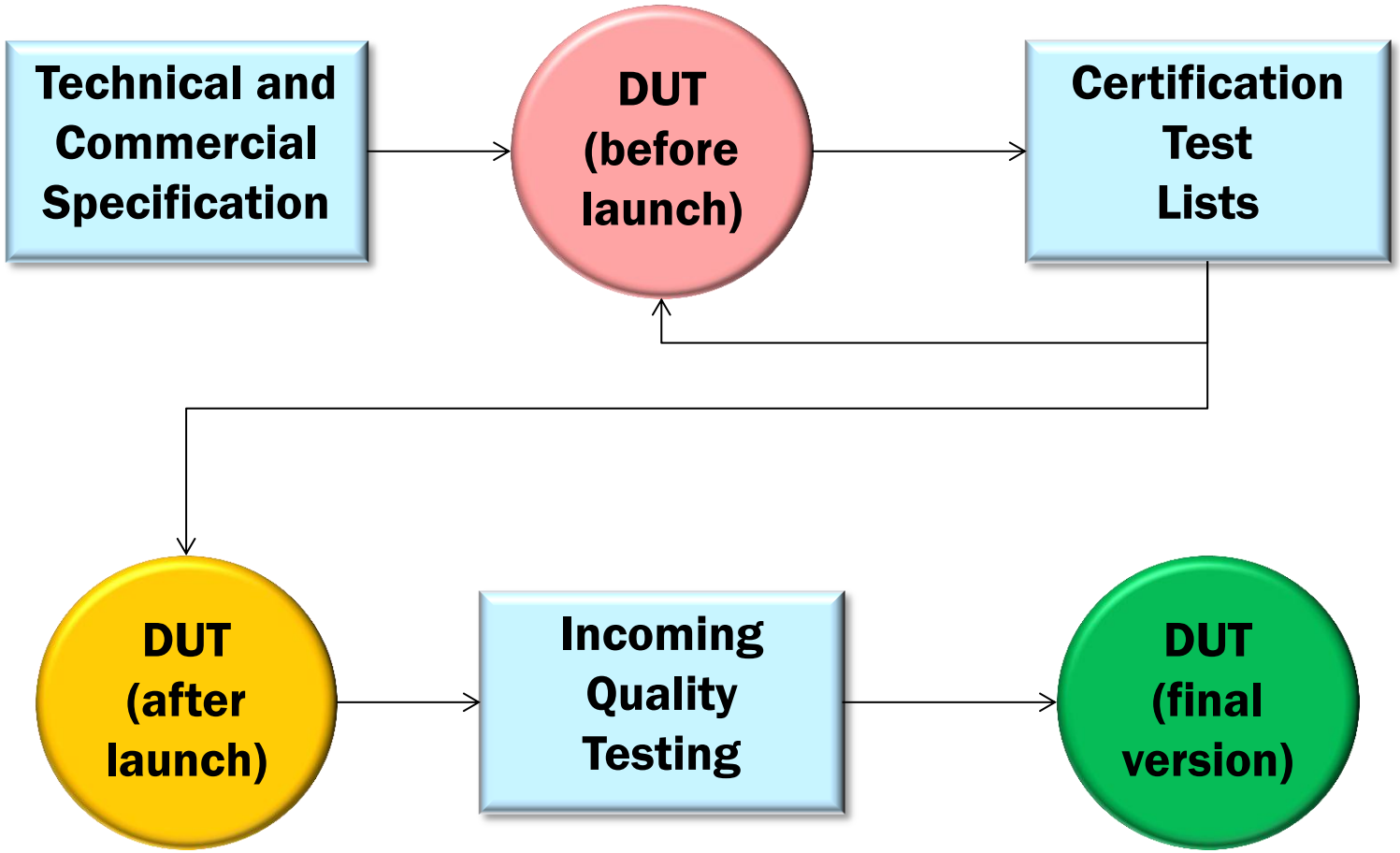
Mobile Value Added Services (VAS) Laboratory

- Typical tests: download of operator logos, wallpapers, ringtones, video tones, screensavers, games, apps, chat and social networks, news and infotainment, mass voting services,
- Test of new services or applications (commercial acceptance tests) which are being deployed with mobile terminals – commercially available – representing a meaningful sample of the whole market.
- Test of new mobile terminals which are being deployed with a subset of services or applications – commercially available – chosen among the most used ones by average customers.
- Monitoring of applications with mobile terminals both commercially available to check conformance to internal requirements, for statistical performances evaluation, correctness of the billing, etc.

Test Lists for Mobile Terminal Certification

- **Mobile Certification and Incoming Quality Processes**
- **Example of Certification Test Lists**
- **Example of a Test Case**

Mobile Certification and Incoming Quality Processes



Example of Certification Test Lists (#1/3)

Radio Lab

- Conducted measurements of transceiver performance
  - UE Report
  - Transmitted power measurements
    - *Maximum output power*
    - *Minimum output power*
    - *Uplink inner loop power control*
  - Static sensitivity measurement
  - Openloop Power
- Global radiated performance measurement
  - Sensitivity measurement in free space
  - Transmitted power measurement in free space
  - Sensitivity measurement using an artificial head
  - Transmitted power measurement using an artificial head
  - Antenna performance measurement

Example of Certification Test Lists (#2/3)

Signalling Lab

- Cell Selection and Cell Reselection
  - Cell Selection
  - Cell Selection 3G/2G
  - Cell Reselection and recovery time 3G
  - Cell Reselection and recovery time 3G/2G
- Location updating and Registration
  - Identity and Capability
  - Periodic Location Updating in lack of coverage
  - Location Updating Reject InterFrequency condition
  - Location Updating Equivalent PLMN
  - Location Updating Reject and Emergency Call
- Network Selection
  - Network Selection in International Roaming
  - Network Selection from “Operator Controlled PLMN Selector with AT”
  - Network Selection from “User Controlled PLMN Selector with AT”
  - Periodic HPLMN searching when in International Roaming
  - Steering of Roaming Cause#11 (PLMN not allowed)
  - Steering of Roaming Cause#17 (Network Failure)

Example of Certification Test Lists (#3/3)

Signalling Lab

- **Measurement Report**
  - **Measurement Report 3G**
  - **Measurement Report event1a-event1b**
  - **Measurement Report Soft-Handover (SHO)**
  - **Measurement Report 2G/3G (InterRAT HO 2G/3G)**
  - **Measurement Report event2d-event2f**
  - **Measurement Report event1f-event1e**
  - **Measurement Report event3a**
- **Packet Switched**
  - **Attach**
  - **PS Identity and Capability**
  - **PDP Context**
  - **PDP Context Reject**
  - **Fast Dormancy**

Example of a Test Case (#1/2)

Openloop Power

Test Purpose

Open loop power control in the uplink is the ability of the UE transmitter to set its output power to a specific value. The power measured by the UE of the received signal and the signaled BCCH information are used by the UE to control the power of the UE transmitted signal with the target to transmit at the lowest power acceptable for proper communication. An excess error of the open loop power control decreases the system capacity. Purpose of this test is to check the trends of the UE power error on PRACH.

Specification Reference

Such a test checks the terminal compliance with the TI requirement included in the TI document "Data Card Entry Level Technical and Commercial"(see DCB-14)

According to TS 34.121 specifications, section 5.4.1, the UE open loop power is defined as the mean power in a timeslot or ON power duration, whichever is available. The UE open loop power control tolerance is given in Table 2.15.

	Normal conditions (dB)	Extreme conditions (dB)
Open loop power control tolerance	**±9**	**±12**

Test Setup

The test set-up block diagram is described in Annex A.1

This measurement is carried out on TIM UARFCN channels 9688 and 9713. The settings of the random access preamble parameters are shown in Table 2.16.

Random Access Settings Preamble	Value	Unit
Max preamble cycles	**2**	
Step size	**3**	dB
AICH transmission timing	**3**	Slot
Max retransmission	**6**	
RACH Msg part power offset	**-5**	dB

Test Procedure

•The mobile phone is switched on;

•registration to the home network.

For each TIM UARFCN channel the tests are performed, with different open loop power control parameters (Table 2.17). Expected PRACH Power indicates the expected average initial preamble power of the UE, according to the settings and the formula below[1]

For each test five PRACH preamble mean power of the UE measurements are performed. Changing the LAC (Location Area Code) the UE synchronizes to the Radio Communication Tester signal and can attempt a registration. The absolute maximum error is the difference between PRACH preamble mean power and Expected PRACH Power.

Example of a Test Case (#2/2)

Openloop Power

Test	Reported P-CPICH Power (dBm)	UL Interference (dBm)	Constant Value (dB)	P-CPICH Level (dBm)
1	-10	-80	-29	-90
2	19	-80	-29	-90
3	30	-80	-29	-90

Acceptance requirements

Table 2.18 show the acceptance and desired limits for the Maximum PRACH preamble mean powe r on TIM UARFCN Channels 9688 and 9713.

Table 2.18 - Acceptance and desired limits

	Acceptance limit (dB)	Desired limit (dB)
Maximum PRACH preamble mean power error UARFCN 9688	≤ 9	≤ 6
Maximum PRACH preamble mean power error UARFCN 9713	≤ 9	≤ 6