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Title: Communication Performance Measurements for 3G User Equipment Including the Antenna

Agenda item: 8.1

Document for: Discussion

Communication Performance Measurements for 3G User Equipment Including the Antenna

Purpose

Propose to RAN4 to work together with COST 273 WG2.2 in defining a test method and performance requirements for UE antenna efficiency for 3G. Details on the specific issues related to 3G terminal antenna testing were presented in [1].

Introduction

For all modern systems for mobile communication where many vendors of both the infrastructure and the mobile phones deliver equipment, common interfaces are needed. One of the perhaps best specified interfaces is the radio interface where both the mobile phones as well as the base stations from different vendors need to communicate. This is ensured by a detailed description of its operation as well as a specification on how to test that the equipment fulfils the requirements. This is also the case for the mobile phones today but nearly all tests on the phones are done at the RF-terminal. The reason for using the RF connector and not the antenna output is purely practical. But as the phones have developed over time very different designs of antennas, transceivers and the phone cases, have been made and the communication performance has varied significantly. Especially the network operators which receive complaints from the mobile users and need to use more network resources to keep an accepted link quality for the poor designs have been concerned. For the second Generation systems (2G) this has lead to several self-made test procedures, which are very different from operator to operator and region to region, and some of the tests even contradict each other. It is not easy to make a test that reflects the real situation due to lack of solid technical knowledge in the area of communication performance of mobile equipment. The communication performance of mobile equipment including the antenna is very different to traditional fixed high gain antennas in the sense that no traditional antenna parameters are obvious. Typical parameters such as peak gain and co-polarisation cannot be used as the mobile end can literally take any position relative to the other end. Further, the mobile equipment is influenced by nearby objects, which often is the user. This was the reason why ETSI asked COST259 SWG2.2 (now COST273) to make work aiming at a standard for testing antenna performance of 3G User Equipment (UE). The COST projects are Co-Operation in the field of Scientific and Technical research and have members not only with in the COST area but institutions from non-COST countries may join COST Actions. At present there are institutions from Australia, Canada, India, Japan, China, Russia, USA, and other countries [http://www.cordis.lu/cost]. The first action of the COST259 working group 2.2 was to investigate different test methods for 2G and propose a common basis for test also suitable for 3G. The outcome was to base all tests on measurements of the radiated power and receiver sensitivity in both polarisations on a sphere surrounding the UE. Several studies of the communication performance of mobile phones in the real situation, i.e., typical mobile environments including a large number of persons, phones, positions etc., were used as reference. It is clear that the test needs to include the typical user position which is very different for different types of UE, e.g. phones, data terminals, video phones, arm wrist devises, pagers and other types of UE which can be expected to come in the future.

Missing knowledge for a 3G standard

Before a 3G standard can be made more solid technical knowledge is needed (even for a 2G standard more knowledge is needed). Some of the identified issues are listed below:

- Typically use positions (browsing position, on-the-belt position etc.).
- UE need to be grouped depending on type (phones, data terminals, Video phones etc.).
- How to test UE with antenna diversity or smart antennas.
- Practical Downlink measurement method for 3G.
- Which phantom match the real situation best, including body-worn positions.
- Are TRP and TRS sufficient or is MEG needed.

- If MEG is needed, standard models of the incoming power distribution for different propagation environments are necessary [2,3].
- How many frequencies are needed in the measurements.
- Measurement uncertainty.
- Spherical sampling density.

Several of the above mentioned points are currently being investigated but the solutions may be very different for 3G compared to existing 2G. As literally neither UE nor testers are available for UMTS today it cannot be expected to have all investigations completed in year 2002. Especially the wideband nature of the UMTS compared to 2G disqualifies many setups including spectrum analysers. To measure the downlink system testers are requires.

Measurements comparison campaign conducted by COST 273 WG 2.2

First a blind test including 6 commercial phones were conducted among all participants having the possibility to measure. The 6 phones were sent around in Europe and US and each laboratory measured the radiation pattern and the receiver sensitivity in the setup they had available. The test included not only radiated power and sensitivity on a sphere around the phone without a user (free space) but also for the phone including a user phantom. All results were then compared. As an example, the phones measured on the centre channel of the 900 and 1800 band in free space are shown in figure 1 and 2. The conclusion of these tests involving the Total Radiated Power (TRP) and Total Receiver Sensitivity (TRS) was that the different labs could measure the TRP and TRS very accurately, especially if a common reference is used. References monopole antennas have been manufactured and distributed to each laboratory for measurements and the results are expected to be much closer when compared to the same reference.
Whereas the measured TRP and TRS compare well the radiation patterns show much larger variation. The radiation patterns are needed for assessment of the Mean Effective Gain (MEG) in typical use. Measurements including a phantom show significant larger variation for the TRP and TRS especially when a hand is included. Studies conclude that the hand is effecting the radiation even more than the head phantom [4]. However, the hand is more difficult to implement and include in the measurements of phones and may therefore be omitted for repeatability and increased uncertainty reasons.

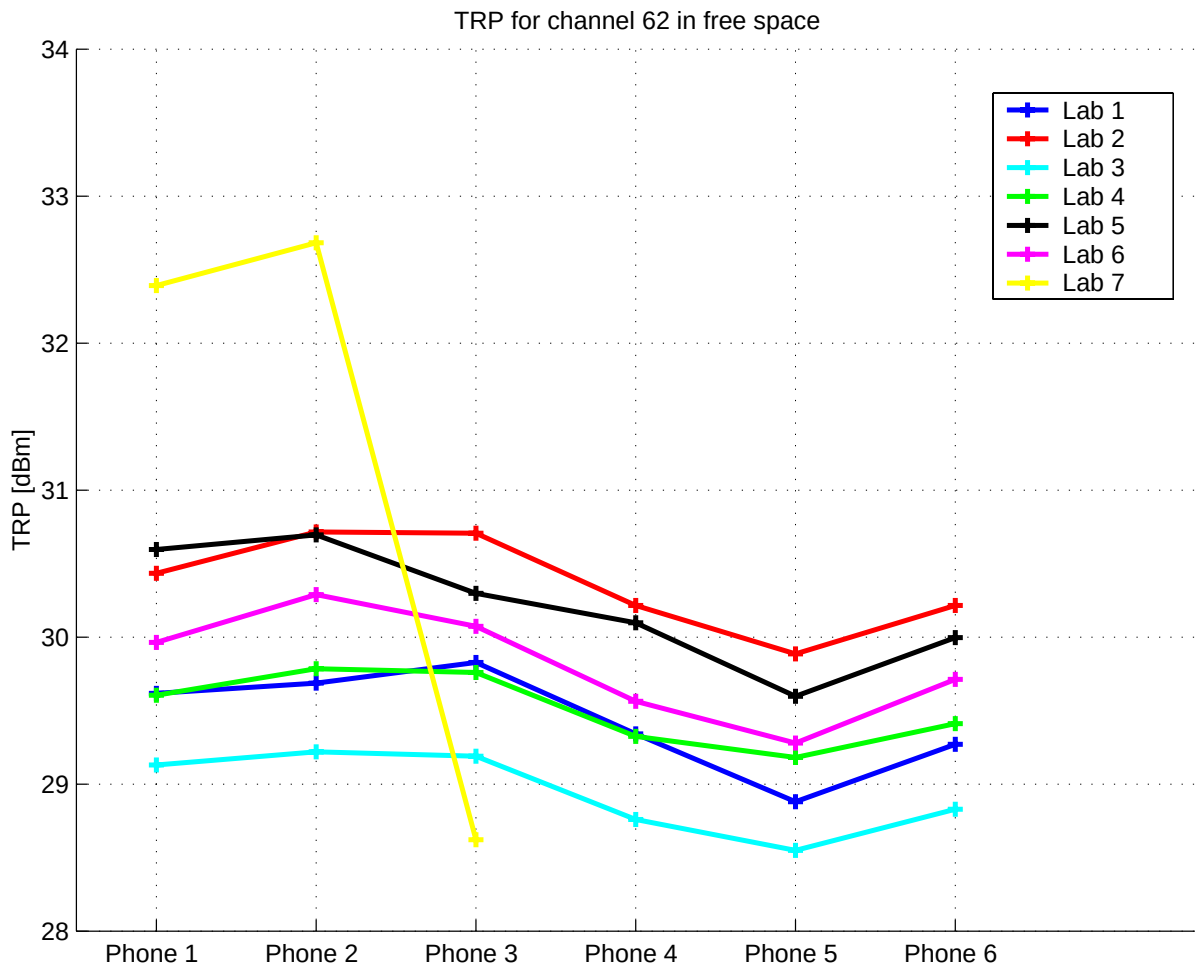

Figure 1. Total radiated power of 6 commercial available mobile phones measured by several different laboratories. The measurements are made for the phone only (free space) and in the 900MHz band. Lab 7 is not a standard anechoic room and this lab has after the test reported that their system was in error.

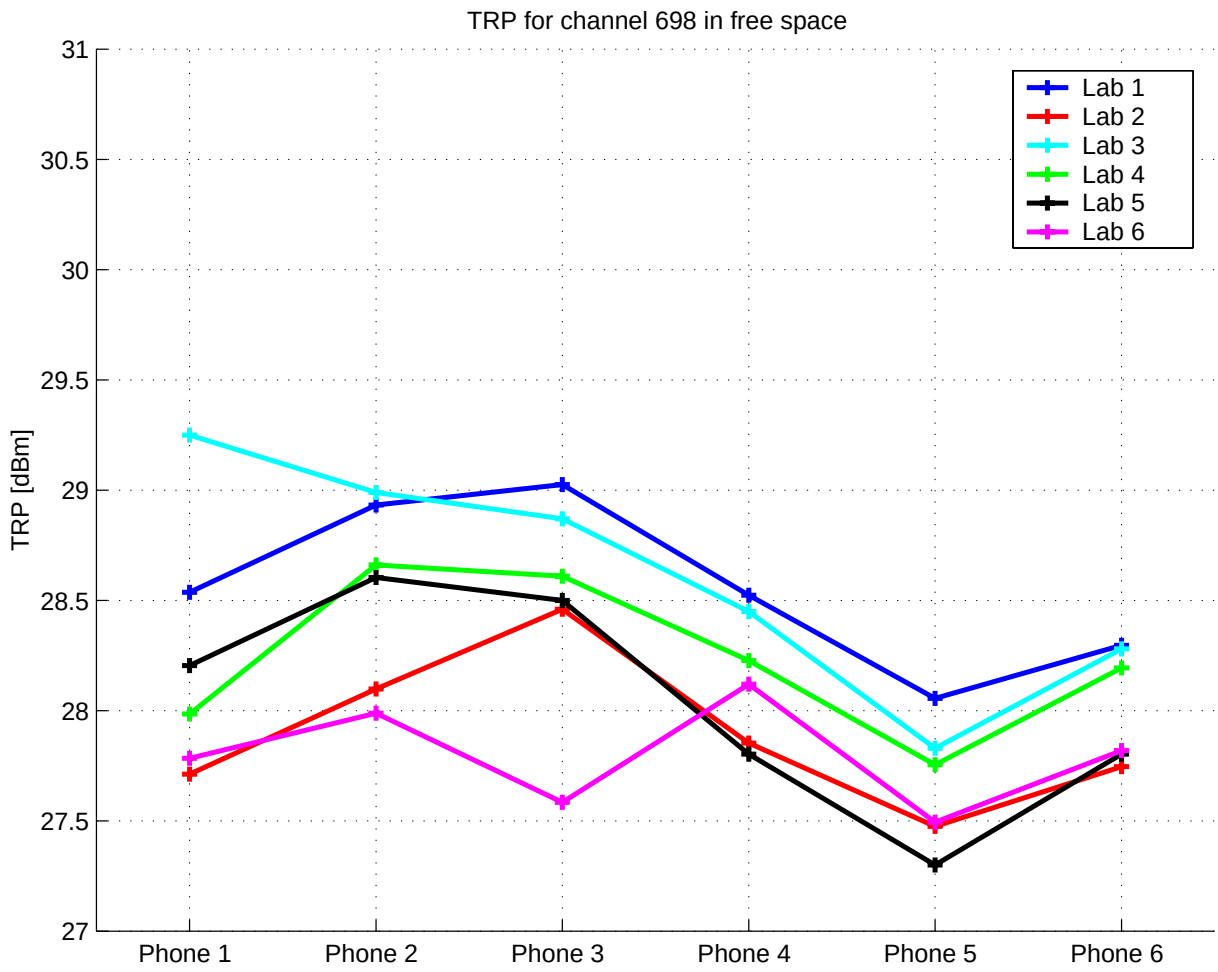

Figure 2. Total radiated power of 6 commercial available mobile phones measured by several different laboratories. The measurements are made for the phone only (free space) and in the 1800MHz band.

An example of what has recently been investigated – MEG vs. TRP and TRS

Basically, the radiation pattern is a recording of the power received or transmitted in all directions to or from the mobile, as measured on the surface of a sphere centred at the mobile. Given the uplink spherical radiation pattern the total power transmitted from the mobile can be obtained by an integration of the radiation patterns for the two polarizations. This is called the Total Radiated Power (TRP). While the TRP may be used for evaluating the efficiency of the antenna, the TRP result does not necessarily indicate how well the mobile works in practice. Due to the nature of the radio wave propagation in the mobile environment, the amount of power that actually reaches the receiver (base station) generally depends on the launching direction from the mobile antenna. As a simple example, for a mobile in an outdoor environment, any power transmitted upwards is not likely to reach the receiver. However, the TRP includes all the power transmitted from the mobile, and therefore the TRP may be misleading in the real situation.

A measure that takes the propagation channel into account is the so-called Mean Effective Gain (MEG). The MEG computation can be seen as weighted integration of the transmitted power, where the weights for the different directions depend on the mobile channel, i.e., the environment. Hence, the MEG takes into account the mobile channel whereas the TRP assumes a special or ideal channel. Further the MEG also weight the co-polarisation and cross-polarisation by the cross Polarisation Discriminator (XPD). The TRP and the MEG, as explained above, are performance measures for the

uplink. Similarly to the uplink case, the MEG may be defined for the downlink where also the TRS is defined.

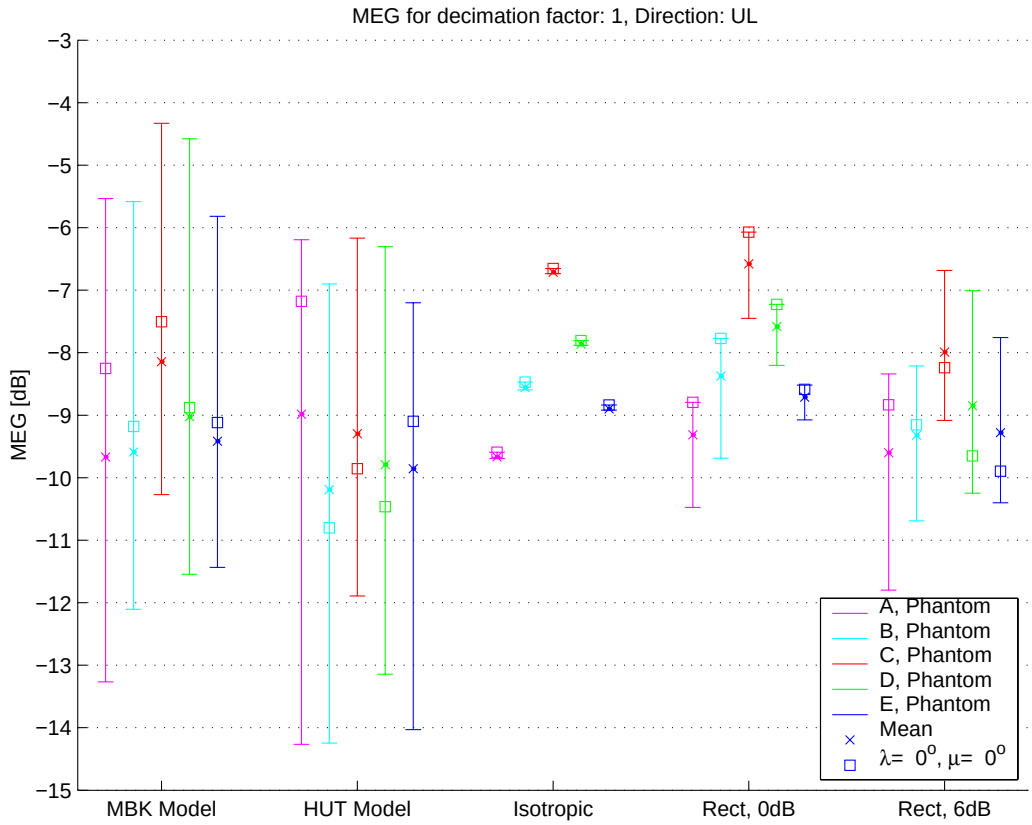

Figure 3. MEG values for different orientations of the phone and phantom. Also the TRP is shown under the label `Isotropic'. As can be seen the MEG varies significantly vs. Orientation of the phone and phantom and also that the correlation between MEG and TRP is weak [5].

This investigation includes [5]

- Measurements of 5 different handsets/antennas
- Free space and phantom
- Different environments
- Uplink and downlink
- Different orientations of the handset
- MEG in different environments

The radiation patterns are measured in the anechoic room in an upright position. However, in practice the mobiles are used in many different orientations with respect to the environment, and this must be included in the MEG computations. In this work different combinations of tilt angles from vertical of the mobile and azimuth rotation angles were used. The tilt angle varied from -60 to 60 degrees and the azimuth rotation angle varied from 0 to 345 degrees, both in steps of 15 degrees. As an example of the results that have been obtained, Figure 3 shows the MEG values computed for the uplink. The MEG values are computed for different mobile environments with two models based on measurements of the mobile channel (MBK and HUT [5,6]). The TRP can be seen as special a case of the MEG, where all the power radiated in the different directions is received, regardless of the direction and polarization. Similarly, the TRS for the downlink is a special case of the downlink MEG. The special environment where all the power transmitted by either the mobile or the base station is received in the other end has been labelled `isotropic' in the figure. Thus, the results for the isotropic environment are the TRP and TRS results. In addition, results for two `Rect' environments are included. As for the isotropic environment, these environments also have uniform weighting versus direction, but only within an area of 45 degrees above and below the horizon. Outside this area

no power is included. The difference between the two `Rect' environments is the cross Polarisation Discrimination (XPD) values of 0 dB and 6 dB, respectively. The XPD value is the difference in power between the polarisation in which the signals were transmitted and the power in the cross polarisation. The rectangular model with an XPD of 0 dB was suggested in [6] and therefore included in this work. On inspecting the results obtained with this model, another rectangular model with an XPD of 6 dB was included, as a possible simple improvement. For each of the five environments the MEG values are shown for all 5 mobile handsets, each mobile represented by a vertical line. The endpoints of each line are the minimum and maximum MEG values, respectively, obtained for the environment/mobile combination. From the figure two general observations can be made: Firstly, the MEG performance may vary widely for a mobile, depending on the orientation of the mobile with respect to the environment. For both the MBK and the HUT model the variation in more than 5 dB. The performance variation cannot be detected with the isotropic environment, since the TRP/TRS measure is insensitive towards the orientation of the mobile. A second important observation is that the MEG for the isotropic environment, i.e., the TRP, only shows a small variation among the mobiles as compared to the variation seen when the environment is taken into account, e.g., the HUT model. Thus, the TRP results are very different from the MEG results.

Conclusion

A test method of the communication performance of User Equipment including the antenna for 3G terminals cannot just be a minor modification of existing 2G tests. Several technical issues need to be investigated and solutions may be very different for 3G compared to existing 2G. As literally neither UE nor testers are available for UMTS today it cannot be expected to have all investigations completed in year 2002. Especially the wideband nature of the UMTS compared to 2G disqualifies many setups including spectrum analysers. To measure the downlink system testers are requires. COST273 WG 2.2 has the technical capabilities and is willing to take the action of making the pre-standard on the antenna test method for 3G terminals.

[1] "Proposal for establishing co-operation between 3GPP and COST273 WG2.2 for the further development of UE antenna performance test method", Document R4-011482, 3GPP TSG-RAN WG4 (Radio) meeting #20, East Brunswick, NJ, USA 12th -16th November 2001. Source: Nokia, Siemens, Telia.

[2] ``Statistical distribution of incident waves to mobile antenna in microcellular environment at 2.15 GHz,'' Helsinki University of Technology, K. Kalliola and H. Laitinen. COST 259 document, TD(99)045.

[3] ``Handset Performance Test including the Antenna,'' M. Bergholz Knudsen and G. Frølund Pedersen. Siemens Mobile Phones, Aalborg University, COST 273 document, TD(01)043.

[4] Wireless Flexible Personalised Communications, Edited by Luis M. Correia, John Wiley & Sons, ISBN 0 471 49836X.

[5] ``Comparison of Total Received Power and Mean Effective Gain for Mobile Handsets,'' Jesper Ødum Nielsen, Gert Frølund Pedersen. Aalborg University. COST 273 document, TD(02)021.

[6] ``CTIA Wireless Subscriber Station Certification Program. Method of Measurement for Radiated RF Power and Receiver Performance.'' Draft revision 1.0, May 2001. Cellular Telecommunications & Internet Association Certification Programs, 1250 Connecticut Ave. NW, Suite 800, Washington, DC 20036.