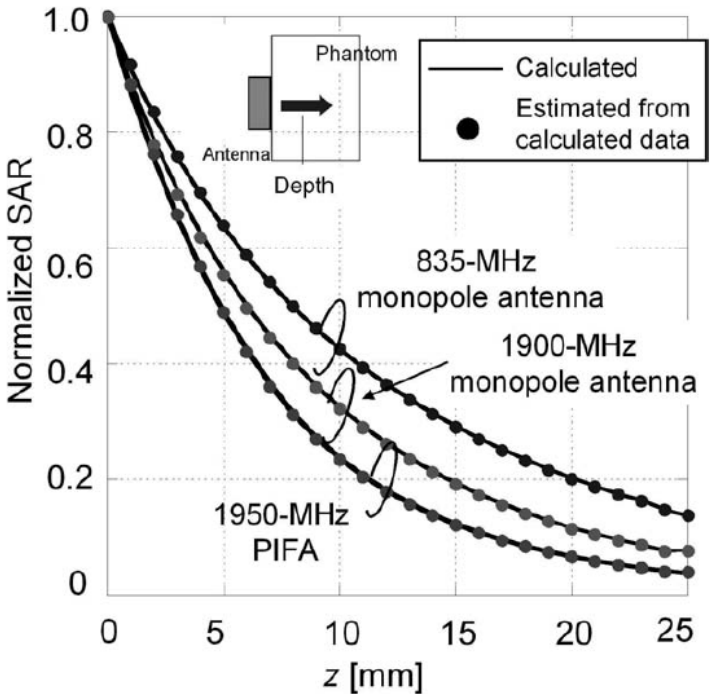

FIGURE 2. Estimated SAR distributions along z-axis when monopole antenna and PIFA are employed.

P-37 EVALUATION OF MEASUREMENT TECHNIQUES TO SHOW COMPLIANCE WITH RF SAFETY LIMITS IN HETEROGENEOUS FIELD DISTRIBUTIONS

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Objectives. Testing of compliance of base station transmitters when put into service with RF exposure safety limits should always include an experimental verification if the limits are met at the maximum RF output power of the transmitter. Such compliance tests involve in-situ free-space measurements at locations where the general public as well as the occupational personal have access. In particular, we focussed on testing compliance with respect to exposure of the general public, i.e., in mostly indoor environments. Here, it is in particular difficult to test compliance since typical field distributions at the sites of interest are strongly in-homogeneous.

The objective of this study was to evaluate and develop measurement methods and procedures that are practical and provide high repeatability with minimal uncertainty for in-situ testing of compliance of base station transmitters with RF safety limits.

Methods. In the study, the suitability of various measurement methods in a known indoor field distribution at 930 and 2140MHz was evaluated. We reviewed typical indoor field distributions in the vicinity of fixed base station transmitters and set up an indoor propagation test room according to these typical parameters.
We developed a semi-automated field scanner (Figure 1) equipped with miniature isotropic field probes to map the field distribution (E- and H-fields) with a resolution of 10 cm.
In the test room, the fields were mapped with low uncertainty (± 1 dB total uncertainty of the measured field) in a volume of $3\times3\times2\text{m}^3$ using the field scanner developed in the context of this study (Figure 2).
The mapped field distribution was then assessed using the methods described in prEN 50492 [1], ECC/REC/(02)04 [2] and Swiss Ordinance for Non-Ionizing Radiation (sweeping method) [3] with measurement antennas calibrated under plane-wave conditions.
Additionally, a maximum search was performed by sweeping the room with a miniature isotropic E-field probe.
The values thus determined were then compared to the target values of the mapped field distribution in the test room.

Results. It was found that the reproducibility of the sweeping method was $< \pm 2$ dB (maximum search according to [3]). The reproducibility of the averaged values by application of the averaging methods was found to be within the same range for six point averaging according to prEN 50492 [1] and considerably higher than for ECC/REC/(02)04 [2]. In all cases the maximum determined using directive antennas as well as the isotropically determined values with the ADD3d method were >6dB lower than the maximum determined during the field mapping and >4dB lower than the maximum determined by sweeping the test room with miniature field probes.

Conclusions. It can be concluded that averaging does not yield any advantage regarding the reproducibility of the results. These methods suffer from underestimation when using typical measurement antennas, e.g., conical dipoles or logarithmic periodic antennas.
In summary, the peak search method was found to be superior with respect to demonstrating compliance in strongly scattered field environments. It is fast and simple to apply and provides high reproducibility for a same antenna or probe. The uncertainty of this method and the repeatability between different instruments can be significantly improved using isotropic time-domain field probes instead of standard antennas.

Acknowledgements. We would like to acknowledge the financial support of the CTI, Switzerland and the Research Foundation on Mobile Communication, Switzerland
[1] CENELEC, "Basic standard for the in-situ measurement of electromagnetic field strength related to human exposure in the vicinity of base stations (DRAFT)", aug 2006.
[2] EC, "Measureing Non-Ionising Electromagnetic Radiation (9 kHz - 300 GHz) (DRAFT)", 2006.
[3] BUWAL, "Vollzugsempfehlung zur NISV," Nov. 2002.

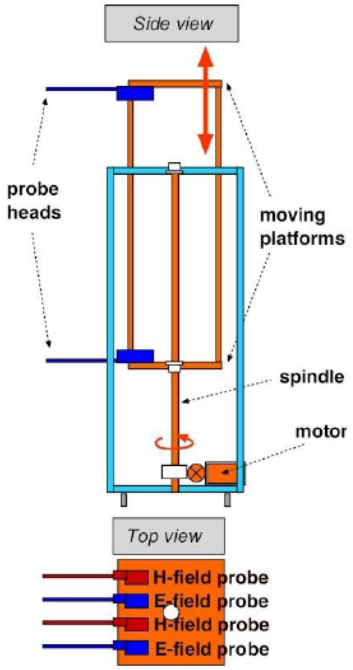

FIGURE 1. Schematic of the developed semi-automated field scanner equipped with E- and H-field probes

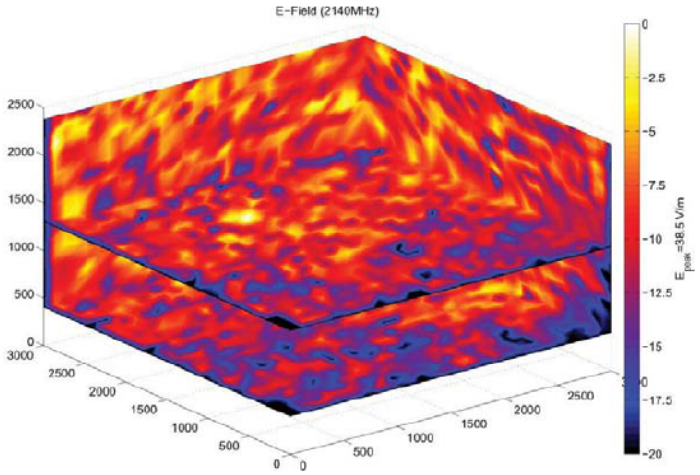

FIGURE 2. Slice view of the E-field distribution in the test room at 2140 MHz.