

LTE drive tests in one of Germany's first research mobile radio networks

The Technical University (TU) of Dresden is using an LTE research mobile radio network to investigate the range of individual sectors and the optimum tilt angles of antennas and to characterize individual channels by evaluating the channel impulse response. The R&S®TSMW universal radio network analyzer¹⁾ and a PC running the R&S®ROMES4 drive test software were installed in a test vehicle to obtain key data for this study.

Ten base stations with a total of 25 sectors

As part of a research project, the Technical University of Dresden set up an LTE research mobile radio network in downtown Dresden. The base stations used in the research network were configured from FPGA²⁾-based software defined radios and provide 10 W (40 dBm) of transmit power per sector at the amplifier output. Cross-polarized sector

antennas are used to send signals in UMTS frequency band 7. All of the LTE base stations were installed at UMTS sites operated by Vodafone and T-Mobile in order to create realistic scenarios with an average station distance of 700 m. Since the second quarter of 2009, the research mobile radio network has consisted of 10 sites with 25 sectors. The base stations at all of the sites are connected using IP-based directional radio and can be centrally controlled from TU Dresden.

1) NEWS from Rohde&Schwarz (2008) No. 197, pp. 6–8.

2) Field programmable gate array (FPGA).

FIG 1 LTE Top N view in R&S®ROMES4 with multiple cells, sorted by SINR.

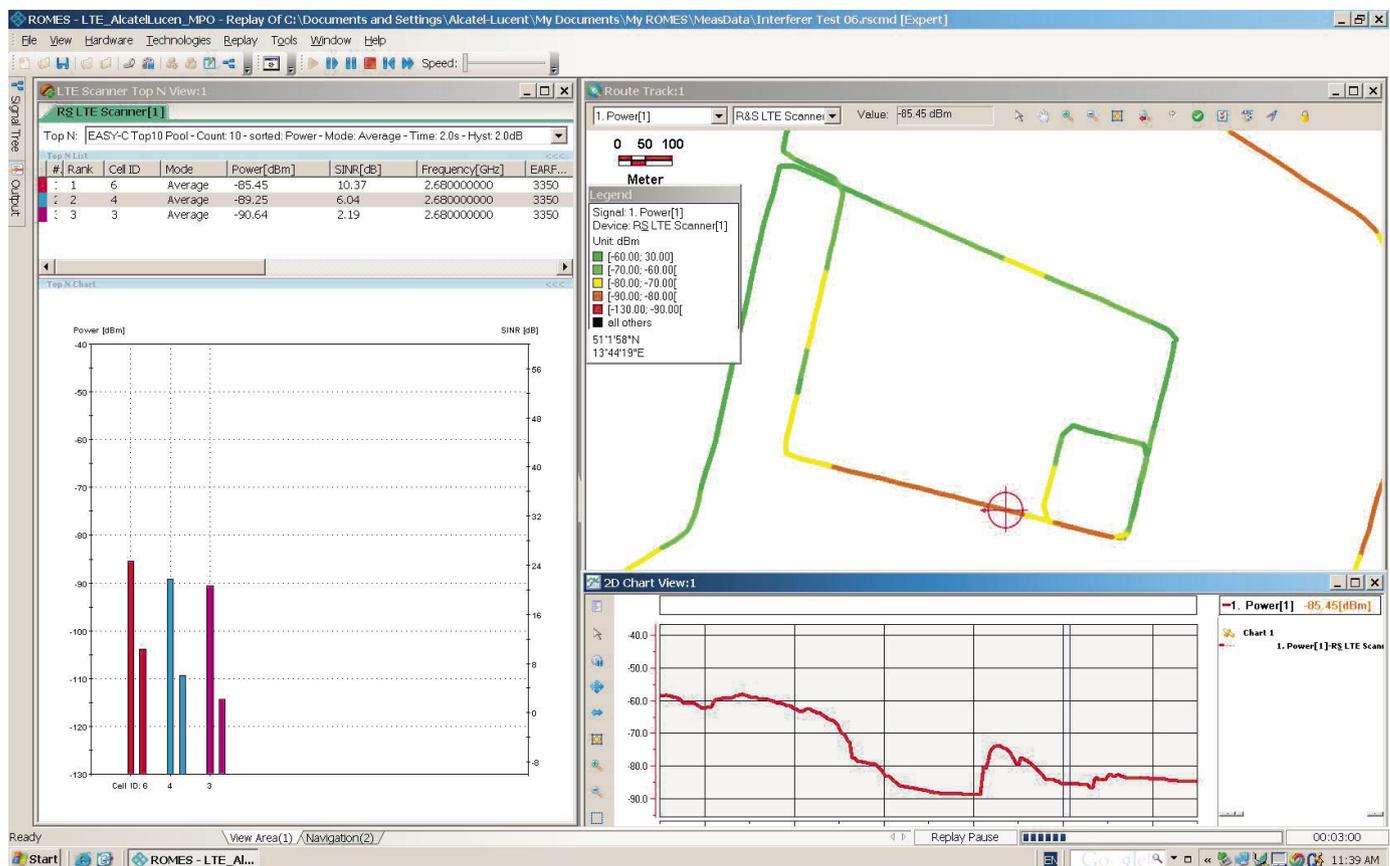
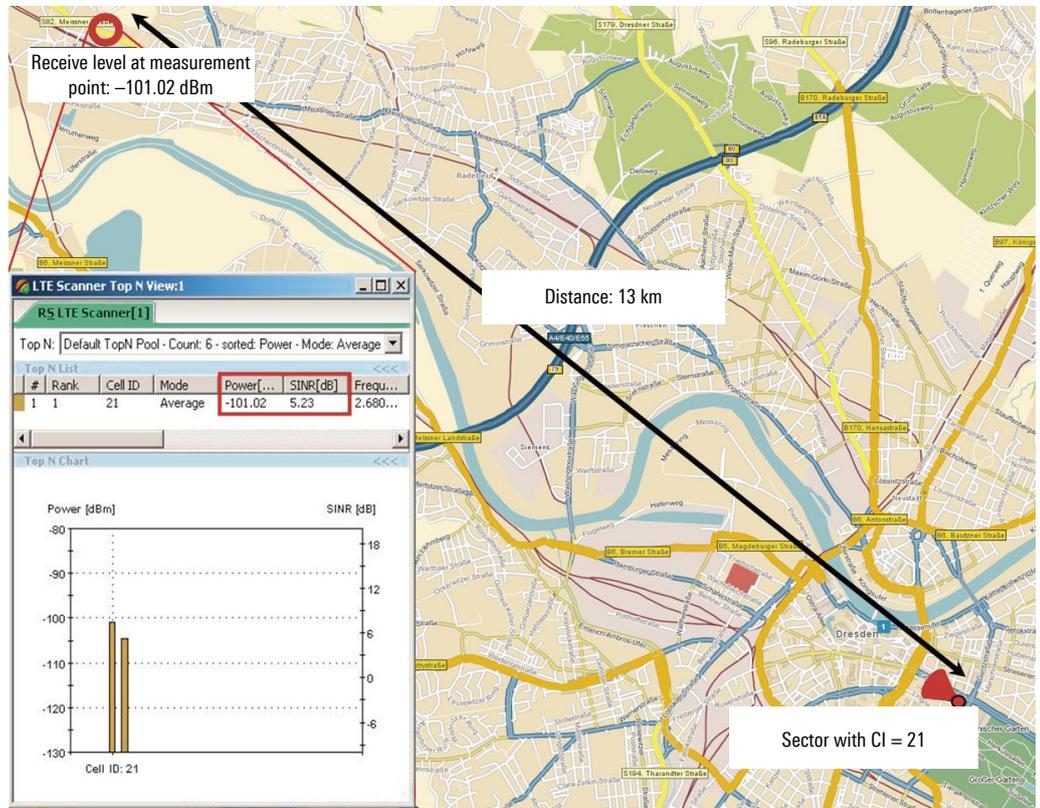


FIG 2 Measurement point in Radebeul in the transmit area of the Dresden base station with a receive power of -101.02 dBm (distance: 13 km).



Smooth startup

To perform functional testing of the base stations during startup and to characterize the coverage area, the R&S®TSMW universal radio network analyzer was installed in a test vehicle for use as a scanner in conjunction with a PC running the R&S®ROMES4 drive test software. The scanner receives the LTE and GPS signals via external antennas that are connected directly to the instrument. A network connection transmits the measurement data as well as the position data of the GPS receiver in the R&S®TSMW to the PC, where the R&S®ROMES4 drive test software can display the data (FIG 1) and store it in a file.

To verify that the R&S®TSMW is functioning properly, only the central base station (near Dresden's main station) that transmits in three sectors was activated following initial startup of the LTE test system. The test system was immediately ready for operation and the LTE scanner synchronized to the downlink frequency. It automatically detects the bandwidth used and immediately provides initial measurement data. Decoding the cell IDs of the three sectors yielded first results in the coverage area about the cell size as well as the signal strength fluctuations in non-line-of-sight (NLOS) connections and the shadow effects.

Measurement of the coverage area

Initial measurements focused on the range as well as the coverage area of individual sectors. A single base station was activated at a time to allow measurement of even relatively weak signals arriving at the base station from greater distances. The LTE scanner detected the signal without interference from adjacent cells, thus providing initial look at the range of an LTE transmitter at 2.68 GHz in an urban environment. These isolated, individual measurements were necessary since the dynamic range of receivers is limited. Even the receiver in the R&S®TSMW with its excellent dynamic range of approx. 40 dB would not be able to detect weak signals from distant transmitters when stronger signals from other base stations are present.

At a downlink frequency of 2.68 GHz (UMTS frequency band 7), amazing ranges were found to occur in Dresden's Elbe Valley (FIG 2). For example, the cell ID 21 (of a sector transmitting at a height of 55 m in downtown Dresden) could be received 13 km away in the locality of Radebeul at a level of about -101 dBm and could be decoded from the synchronization channels. The R&S®TSMW is capable of decoding signals all the way down to a level of -127 dBm. Even though a mobile phone cannot really use such a signal for reception, it is important – for characterizing the research network – to

detect such signals in order to identify possible interference from other cells. This approach also provides useful information about interference scenarios for simulations to include them in future test measurements.

Measurements with different antenna tilt angles

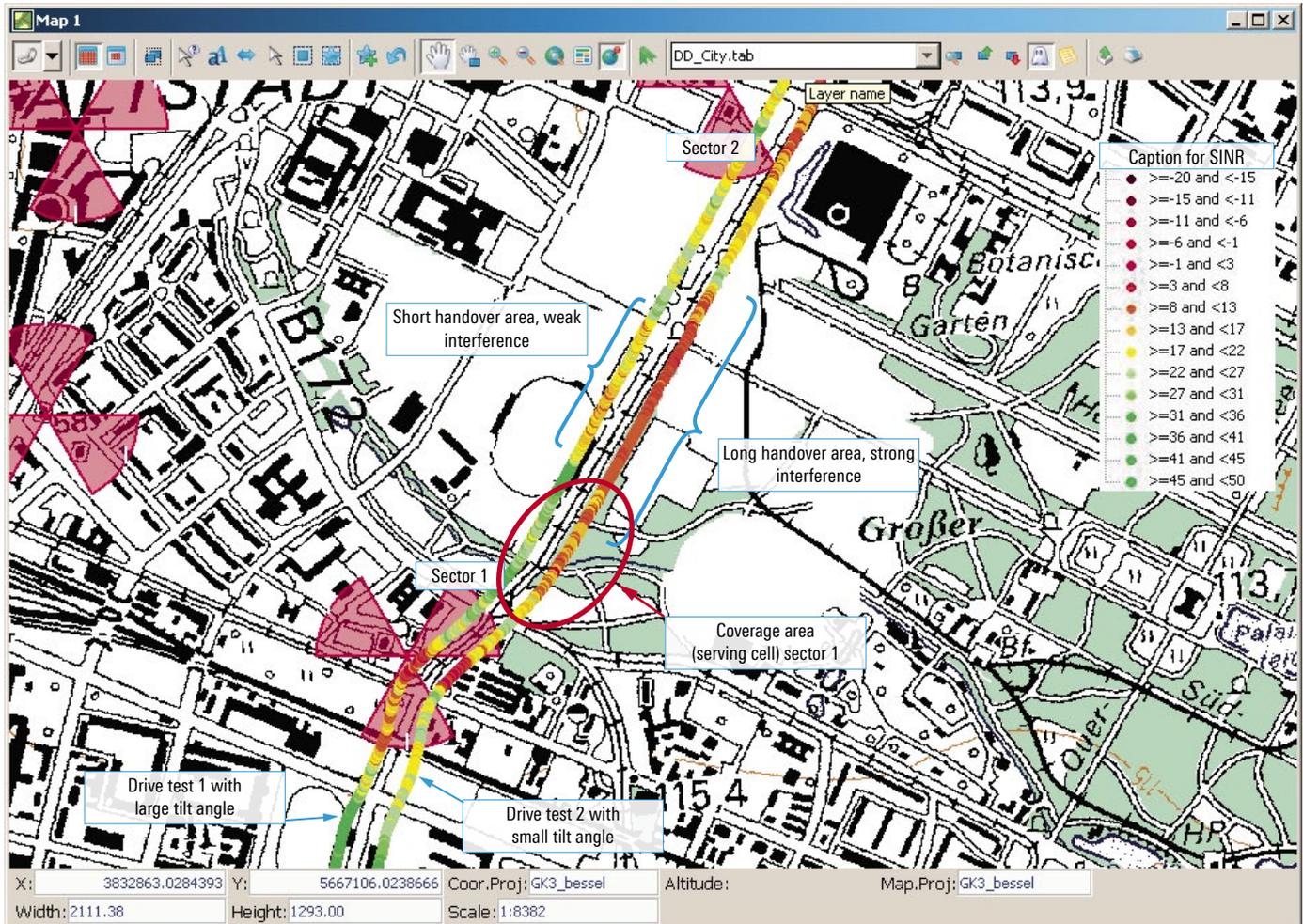
Further measurements were made to investigate the signal-to-interference-plus-noise ratio (SINR) and the cell boundaries as a function of the antenna tilt angle. Unlike the previous measurements, multiple base stations were transmitting simultaneously with different cell IDs. The R&S®TSMW can receive all of them in parallel and evaluate them simultaneously. The R&S®ROMES4 drive test software displays the decoded cell IDs using a Top N view and sorts the received signals by SINR or signal strength (FIG 1). When evaluating the Top1 SINR parameter with the MEDAS tool (see page 4), it is possible to carefully analyze the influence of the tilt angle of the LTE transmit antennas on the handover area (FIG 3).

The evaluation clearly reveals that the cell boundary is shifted and that the SINR is influenced in the transition area between two cells and in the current serving cell. It is apparent from FIG 3 that for larger antenna tilt angles, the SINR in the hand-over area is improved by 10 dB to 15 dB and is also noticeably better in the current serving cell (circled in red) during drive test 1. Moreover, using the data from the R&S®TSMW, it is very easy to determine the optimum antenna tilt angle for UE measurements between adjacent cells (cell edge scenario) in order to investigate various innovative transmission algorithms for future standards (e.g. 3GPP release 10).

Channel measurements

Other drive tests provided data to characterize the downlink channel. The R&S®TSMW also transmits the channel impulse response (CIR) to the R&S®ROMES4 drive test software. FIG 4 reveals a delay of almost 4 μs between the first and last peak of the CIR for the signal with cell ID 15 (in the immediate

FIG 3 Effect of the antenna tilt angle on the SINR and handover area.



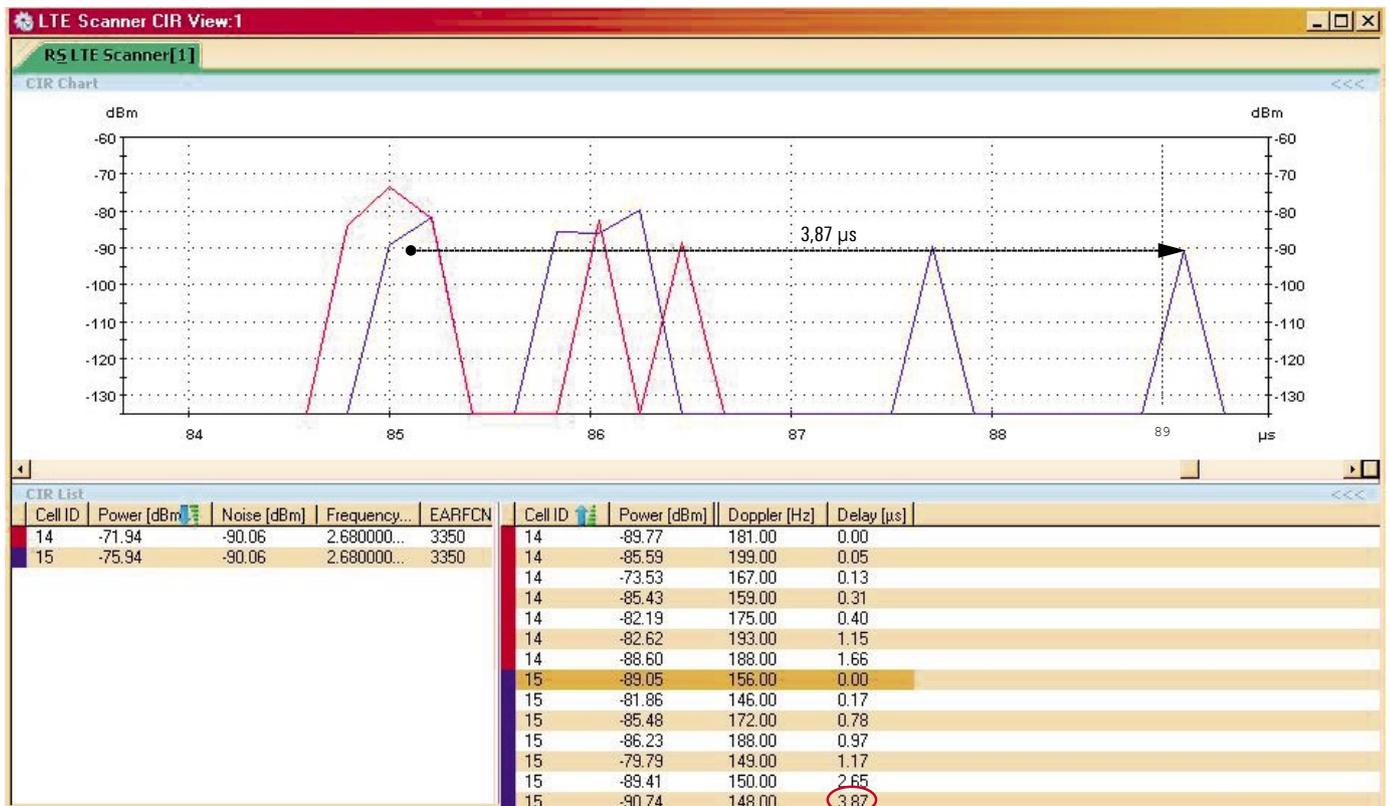


FIG 4 CIR view in R&S®ROMES4 for NLOS with two sectors directly at the site of the base station.

vicinity of the base station site with a NLOS connection). On the other hand, the CIR at a measurement point with a line-of-sight (LOS) connection consists of only one to two peaks with a minimum delay ($\ll 1 \mu\text{s}$). Moreover, this data can be used to characterize the channel and derive the delay spread and the average time delay, for example.

Data evaluation with MEDAS

MEDAS is a database-supported postprocessing suite from P3 communications GmbH, which has maintained a successful partnership with Rohde&Schwarz for many years. As part of this partnership, data evaluation between the R&S®ROMES test system and MEDAS has been further enhanced. MEDAS manages all of the data from the R&S®TSMW in a database, enabling evaluation that is independent of the file structure and file format. For example, it is possible to compile a large quantity of measurement data into new logical groups. Once defined, evaluations can be executed by applying nearly any filtering and aggregation of the measurement data (e.g. analysis of the transmission area based on all of the measurement data for a cluster). Moreover, statistical and geographical analyses encompassing multiple files are possible, as is geographical screening of nearly any measurement data. In a

before/after analysis, differences between comparable measurement parameters can be analyzed and displayed geographically (e.g. before/after comparison for optimization of the antenna tilt angle).

Especially to meet requirements in research activities at TU Dresden and also for the initial LTE test networks, MEDAS enables extended analysis of the discrete signal peaks from the CIR measurements made by the R&S®TSMW. Based on these signals, it is possible to display the number of peaks per physical cell ID on a map, for example, or analyze this data using statistical methods. Moreover, the relative delay difference that occurs in multipath propagation is computed for each physical cell ID at a measurement point.

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