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1. Introduction

In a circular letter issued in March 2008 [5/LCCE/2] ITU invited the submission of IMT-Advanced radio interface technology proposals. Furthermore, in the same circular letter ITU invited the formation of evaluation groups to take part in the evaluations of the candidate technology proposals. The WINNER+ project has decided to participate in the evaluations and has registered as an evaluation group with the ITU-R. At present there are fourteen registered evaluation groups.

The evaluations of the candidate technology proposals will be performed by means of inspection, analytical and link and system simulation procedures [M.2135]. All evaluations should follow the evaluation guidelines and assumptions in [M.2135]. In addition, some important corrections and clarifications are provided in [IMT-ADV/3] and [IMTA-guide], respectively.

In the WINNER+ project the evaluations will be performed by several partners using different simulation tools. To facilitate the usage of multiple simulation tools and to make sure that the different tools produce comparable output, WINNER+ has decided to calibrate some metrics across the different simulators. Similar calibration procedures have already been described in, e.g., 3GPP. This working document describes the present status of the WINNER+ calibration activities. The document will be updated when additional material is available.

Most of the calibration data presented in this document is also available in Excel form at the WINNER+ IMT-Advanced evaluation web page:

<http://projects.celtic-initiative.org/winner+/WINNER+%20Evaluation%20Group.html>

2. Calibration of System Level Simulation Tools

Multi-cell system level simulations are to be used for evaluating the IMT-Advanced requirements cell spectral efficiency, cell edge user throughput, VoIP capacity and mobility. Some important properties of the system simulations are determined by the environment description in [M.2135], including the propagation and channel models. Examples of such metrics are the pathloss and the wideband SINR, which are essentially technology independent and hence calibration of these metrics can be performed using just a few additional assumptions compared to what is given in [M.2135].

In addition, for a specific technology it may be helpful to calibrate a basic setup of the system to assure that the simulators produce comparable results for a reference configuration. Such a calibration is here performed for a basic setup of LTE Release 8.

2.1 Calibration of pathgain and wideband SINR

The pathgain between two nodes is the average difference between received and transmitted power and here we study pathgain distribution between all user terminals and their associated cell, i.e., the gain to the serving cell. The wideband SINR, sometimes also referred to as geometry, is the relation between the average power received from the serving cell and the average received power from all other cell in the network plus the noise power in the terminal receiver.

In addition to the evaluation principles and assumption in [M.2135] and the channel model clarifications in [IMTA-guide], the following assumptions have been used to derive the pathgain and wideband SINR distributions.

- Cell selection: 1 dB handover margin
- Feeder loss: 2 dB¹
- Base station antenna tilt (degrees)

InH	UMi	UMa	RMa	SMa
N.A	12	12	6	6

In the sub-sections 2.1.1 - 2.1.5 calibration results from up to six WINNER+ partners are presented.

2.1.1 Pathgain and wideband SINR for InH

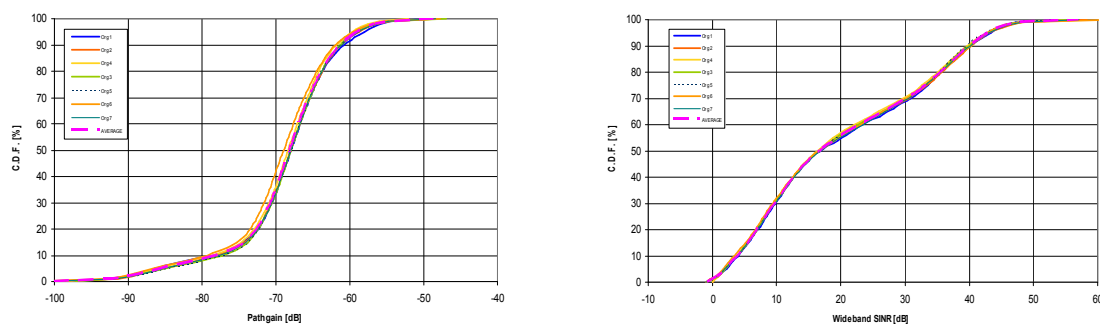


Figure 1: Pathgain and wideband SINR distributions in the InH scenario.

¹ For calibration purposes a 2 dB feeder loss has been assumed. This is consistent with the link budget template in [M.2133] but the feeder loss is not discussed in [M.2135].

2.1.2 Pathgain and wideband SINR for UMi

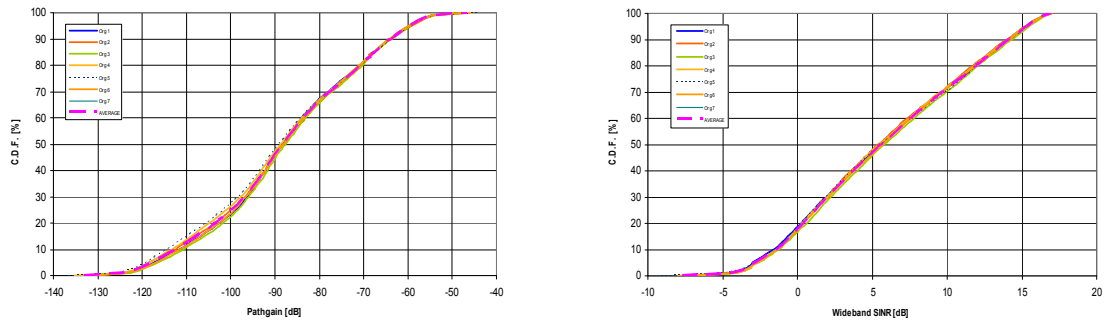


Figure 2: Pathgain and wideband SINR distributions in the UMi scenario.

2.1.3 Pathgain and wideband SINR for UMa

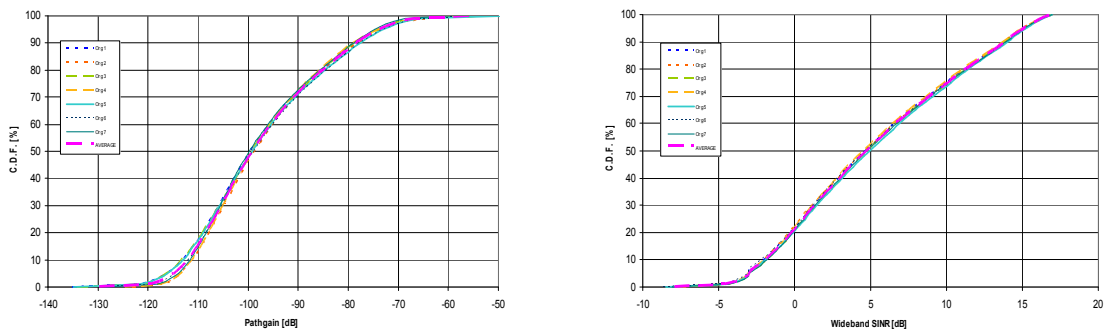


Figure 3: Pathgain and wideband SINR distributions in the UMa scenario.

2.1.4 Pathgain and wideband SINR for RMa

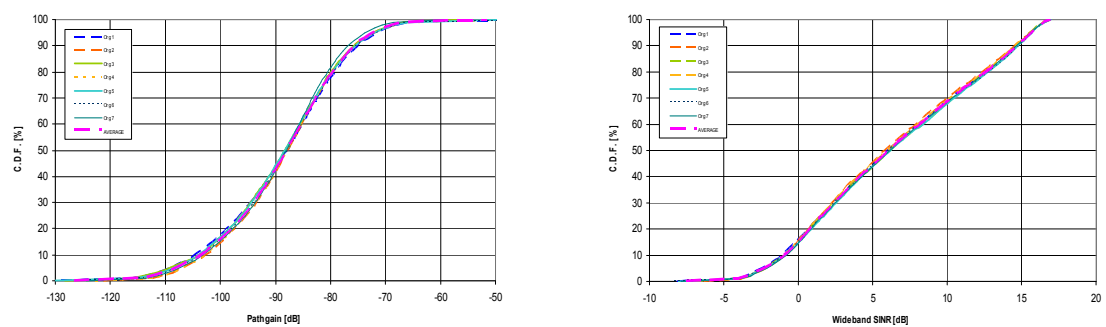


Figure 4: Pathgain and wideband SINR distributions in the RMa scenario.

2.1.5 Pathgain and wideband SINR for SMA

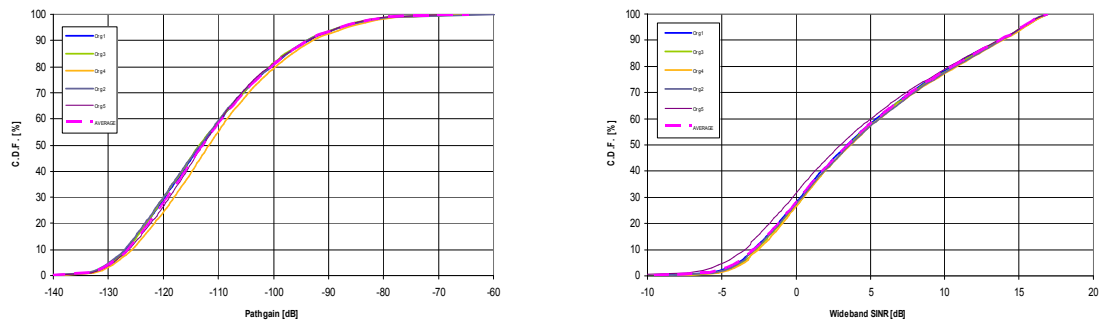


Figure 5: Pathgain and wideband SINR distributions in the SMA scenario.

2.2 Calibration of small-scale fading

In the small-scale fading characteristics we include the delay spread and the angular spread at the base station and at the user terminal. For simplicity, the small-scale fading calibration is performed using omni-directional antennas at both the base station and the user terminal. If other antenna patterns are assumed, e.g., a directional antenna pattern at the base station, the results will be different. Moreover, the calibrations are performed separately for LoS, NLoS and outdoor-to-indoor propagation conditions. Outdoor-to-indoor propagation is relevant only in the UMi scenario. For calibration of the angular spread for LoS propagation channels it is important to account for the correction under Section 3 in [IMT-ADV/3].

Now assume that each propagation channel comprises N clusters and that each cluster comprises M rays. Assume further that the delay of ray m in cluster n is denoted $\tau_{n,m}$ and that the associated power is denoted $p_{n,m}$. In case of LoS propagation the LoS ray is here included as a separate cluster for which, according [M.2135], only the first ray in the cluster has a non-zero power.

To calculate the delay spread the average delay $\bar{\tau}$ is first calculated according to equation (2.1).

$$\bar{\tau} = \frac{\sum_{n=1}^N \sum_{m=1}^M \tau_{n,m} \cdot p_{n,m}}{\sum_{n=1}^N \sum_{m=1}^M p_{n,m}} \quad (\text{eq. 2.1})$$

Then, the root-mean-square (RMS) delay spread (σ_τ) is calculated according to equation (2.2).

$$\sigma_\tau = \sqrt{\frac{\sum_{n=1}^N \sum_{m=1}^M (\tau_{n,m} - \bar{\tau})^2 \cdot p_{n,m}}{\sum_{n=1}^N \sum_{m=1}^M p_{n,m}}} \quad (\text{eq. 2.2})$$

For the angular spread we use the circular angular spread (σ_{AS}) as defined in Annex A of [3GPP 25.996], where the angular spread is the minimum spread over different linear shifts Δ . One small addition is used here, however. Before calculating $\theta_{n,m,\mu}(\Delta)$ we wrap the quantity $\mu_\theta(\Delta)$ into the interval $[-\pi, \pi]$ according to equation (2.3). This step is not explicitly stated in [3GPP 25.996].

$$\mu_\theta(\Delta) = \begin{cases} 2\pi + \mu_\theta(\Delta) & \text{if } \mu_\theta(\Delta) < -\pi \\ \mu_\theta(\Delta) & \text{if } |\mu_\theta(\Delta)| \leq \pi \\ \mu_\theta(\Delta) - 2\pi & \text{if } \mu_\theta(\Delta) > \pi \end{cases} \quad (\text{eq. 2.3})$$

The RMS delay spread (σ_τ) and the circular angular spread (σ_{AS}) at the base station and at the user terminal are calculated for a large number of radio links and in the calibrations we compare the corresponding distributions. Taking a downlink perspective on the radio channel, the angular spread at the base station and at the user terminal are often denoted angle of departure (AoD) and angle of arrival (AoA), respectively. This notation is also used here below.

2.2.1 Small-scale fading in InH

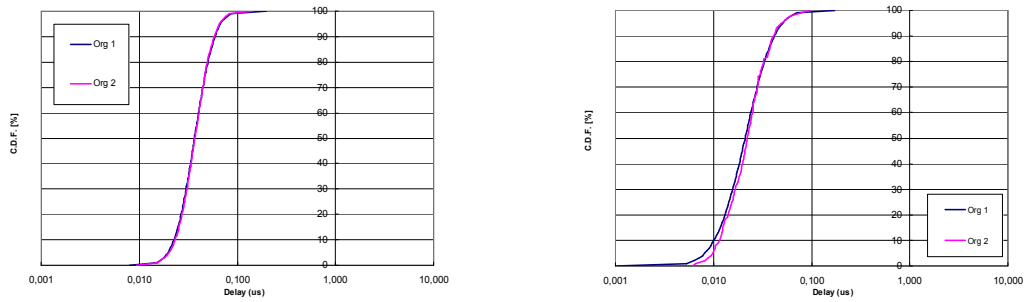


Figure 6: RMS delay spread for InH NLoS (left plot) and LoS (right plot).

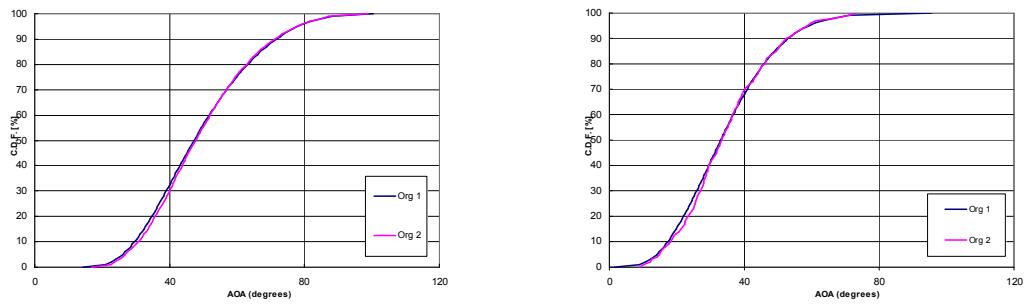


Figure 7: Circular AoA for InH NLoS (left plot) and LoS (right plot).

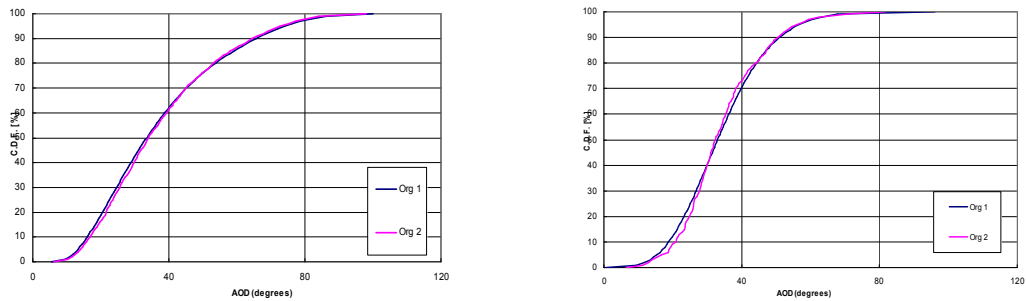


Figure 8: Circular AoD for InH NLoS (left plot) and LoS (right plot).

2.2.2 Small-scale fading in UMi

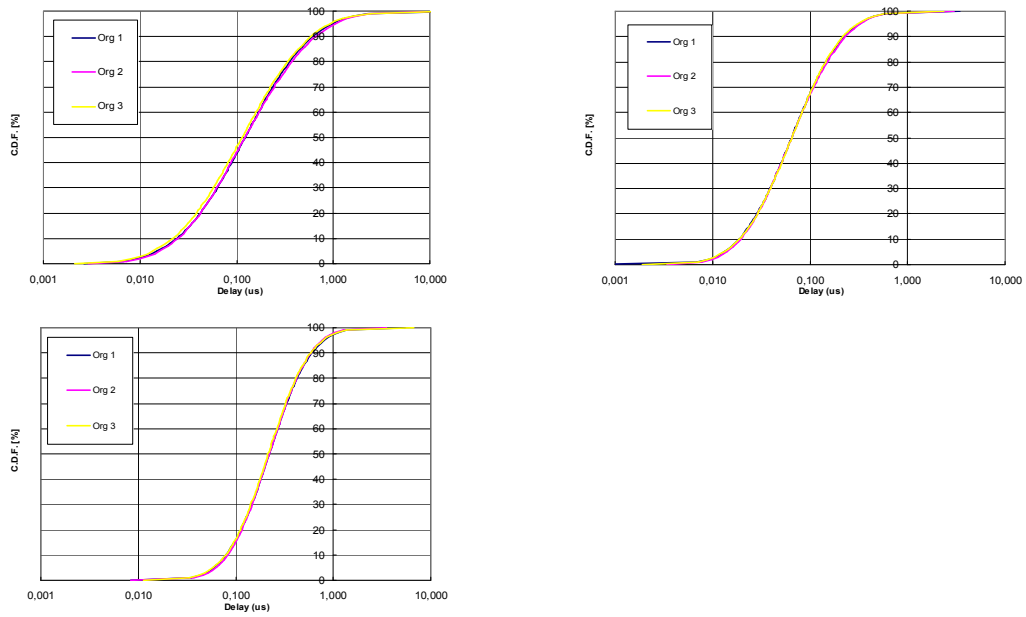


Figure 9: RMS delay spread for UMi NLoS (upper left plot), LoS (upper right plot) and outdoor-to-indoor (lower plot).

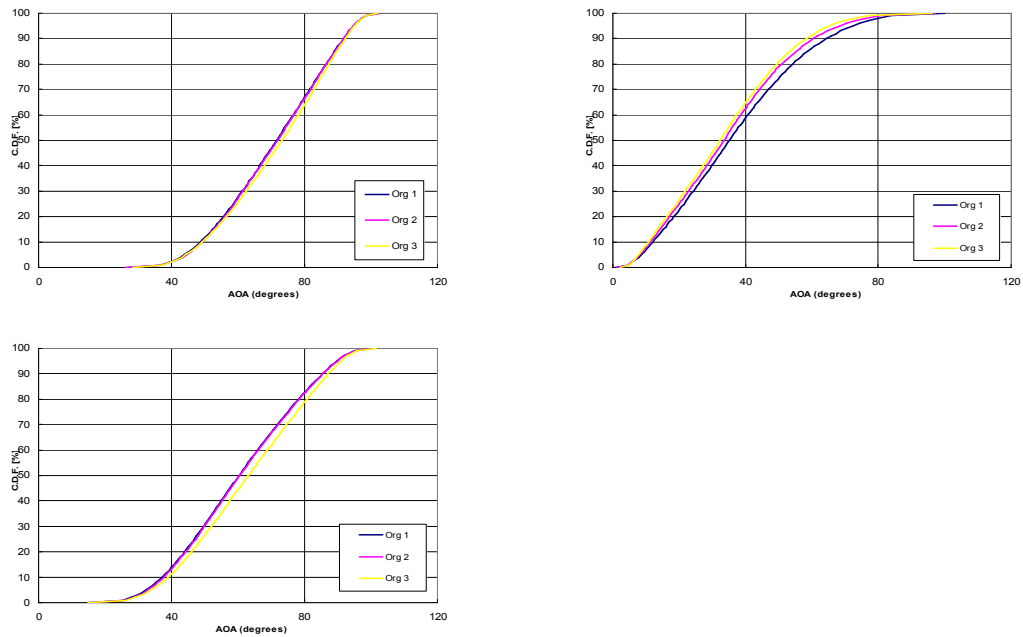


Figure 10: Circular AoA for UMi NLoS (upper left plot), LoS (upper right plot) and outdoor-to-indoor (lower plot).

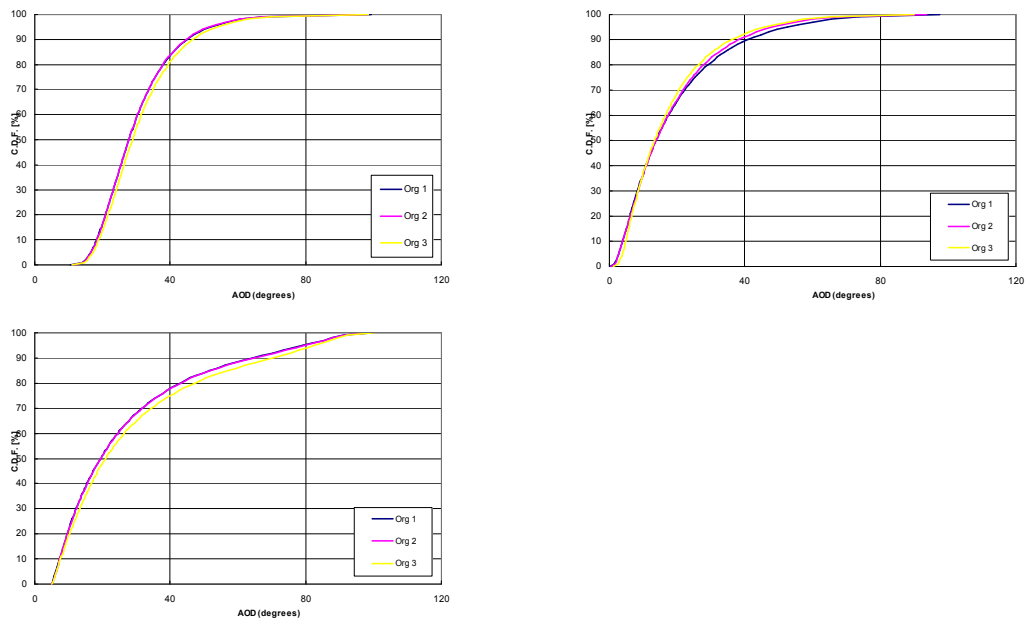


Figure 11: Circular AoD for UMi NLoS (upper left plot), LoS (upper right plot) and outdoor-to-indoor (lower plot).

2.2.3 Small-scale fading in UMa

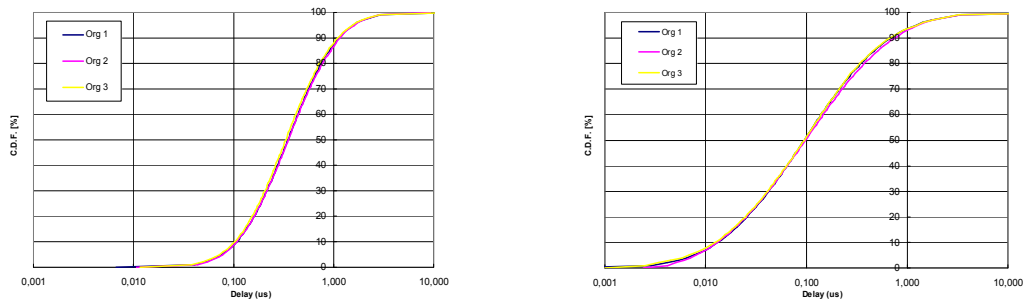


Figure 12: RMS delay spread for UMa NLoS (left plot) and LoS (right plot).

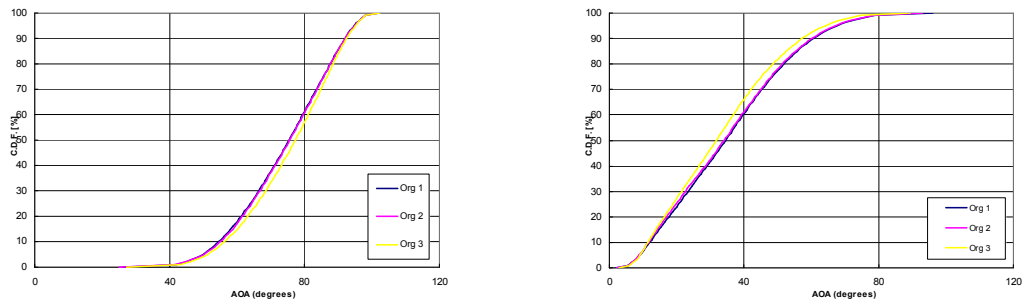


Figure 13: Circular AoA for UMa NLoS (left plot) and LoS (right plot).

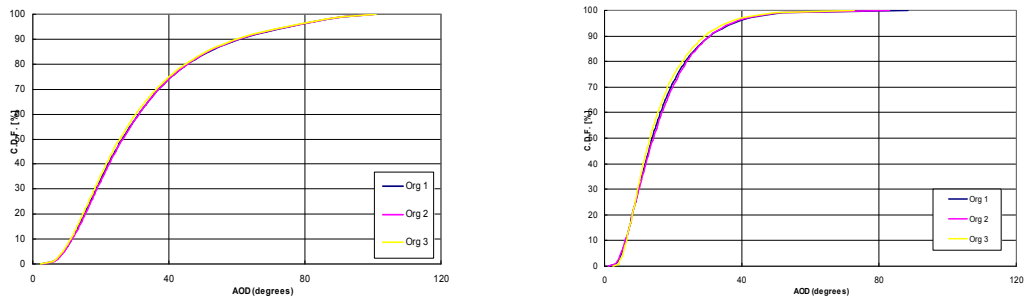


Figure 14: Circular AoD for UMa NLoS (left plot) and LoS (right plot).

2.2.4 Small-scale fading in RMa

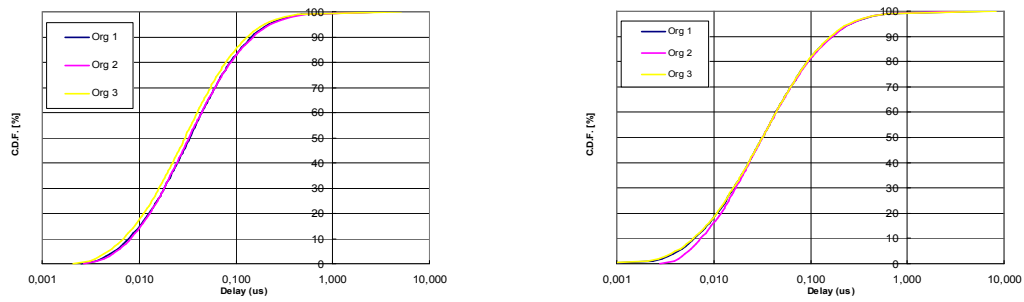


Figure 15: RMS delay spread for RMa NLoS (left plot) and LoS (right plot).

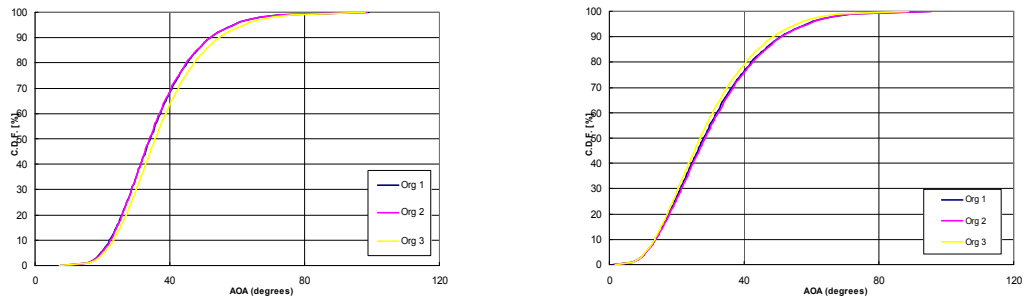


Figure 16: Circular AoA for RMa NLoS (left plot) and LoS (right plot).

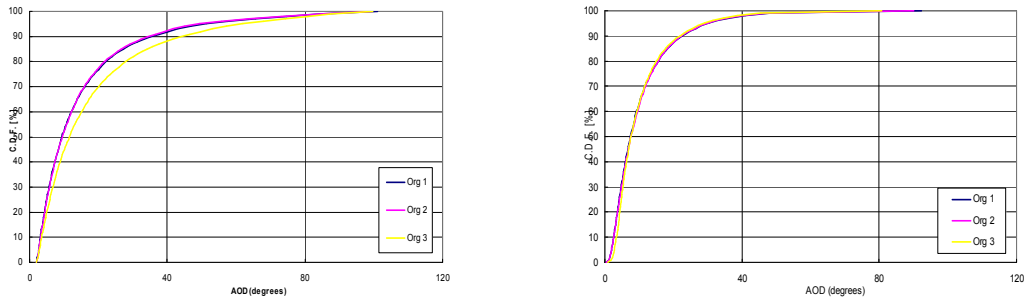


Figure 17: Circular AoD for RMa NLoS (left plot) and LoS (right plot).

2.2.5 Small-scale fading in SMa

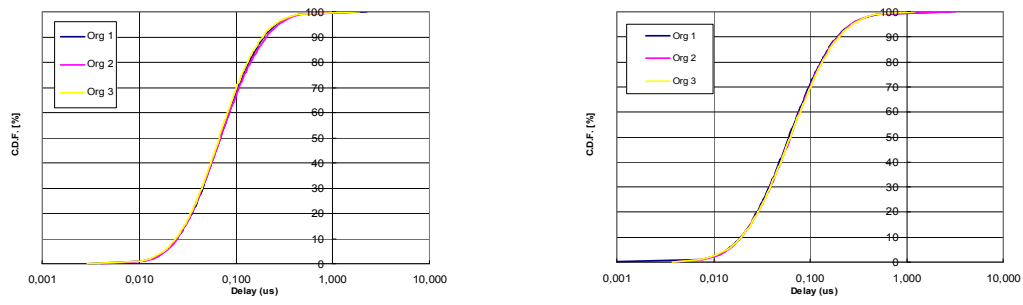


Figure 18: RMS delay spread for SMa NLoS (left plot) and LoS (right plot).

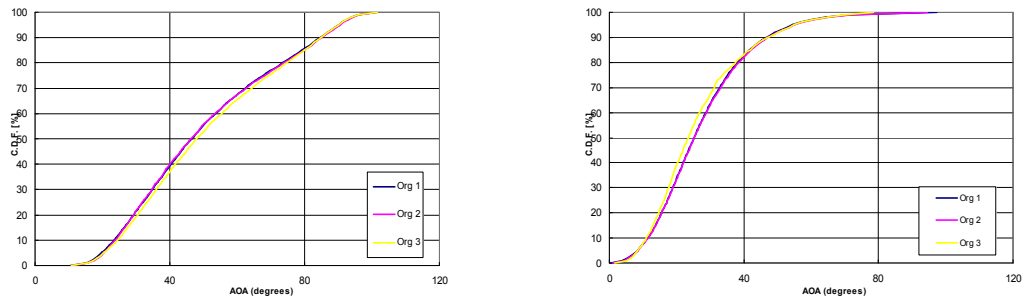


Figure 19: Circular AoA for SMa NLoS (left plot) and LoS (right plot).

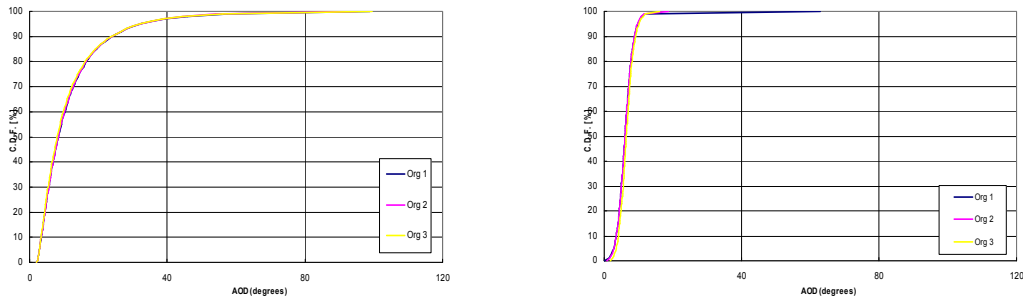


Figure 20: Circular AoD for SMa NLoS (left plot) and LoS (right plot).

2.3 Calibration of LTE Release 8 Performance

The evaluation group WINNER+ has a main focus on evaluating the 3GPP IMT-Advanced proposal and as a preparation of the system level evaluations a simulator calibration for a basic LTE Release 8 configuration is performed. The purpose of the calibration is hence to make sure that the different tools produce comparable output, and not to optimize the performance of the system. A similar calibration activity was performed by 3GPP and is presented in Annex A2.2 of [3GPP 36.814]. In the WINNER+ calibration the focus is on the user throughput distributions and the cell spectral efficiency as well as the cell-edge user throughput.

Below, in Figure 21 - Figure 25, the normalized downlink and uplink user throughput distributions are presented for the different test environments. Table 1 summarizes the average figures of the cell spectral efficiency and the cell-edge user throughput from the different calibration simulations. Table 2 presents the associated coefficients of variation. Note that in the uplink, the figures are based on only a few (two or three) simulation results.

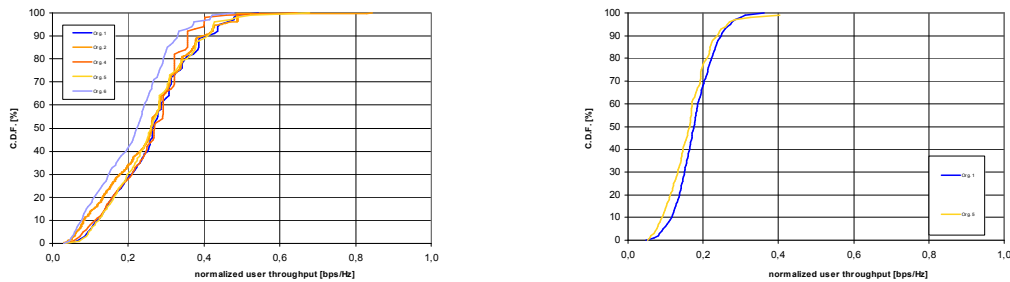


Figure 21: Downlink (left) and uplink (right) normalized user throughput distributions in the InH test environment.

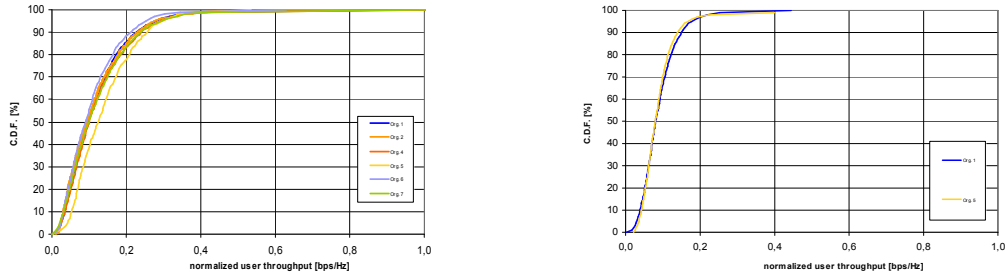


Figure 22: Downlink (left) and uplink (right) normalized user throughput distributions in the UMi test environment.

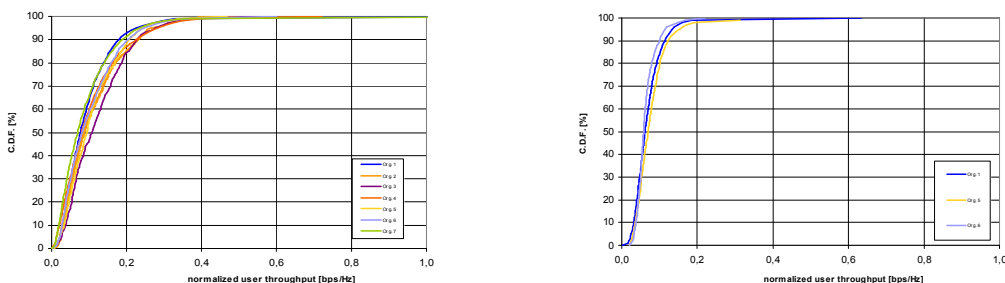


Figure 23: Downlink (left) and uplink (right) normalized user throughput distributions in the UMa test environment.

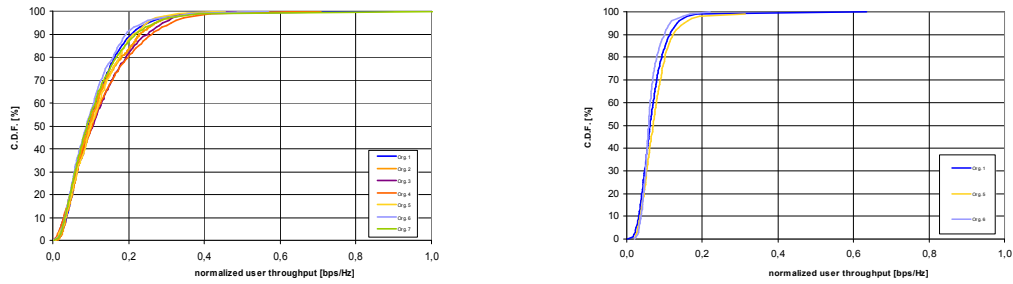


Figure 24: Downlink (left) and uplink (right) normalized user throughput distributions in the RMa test environment.

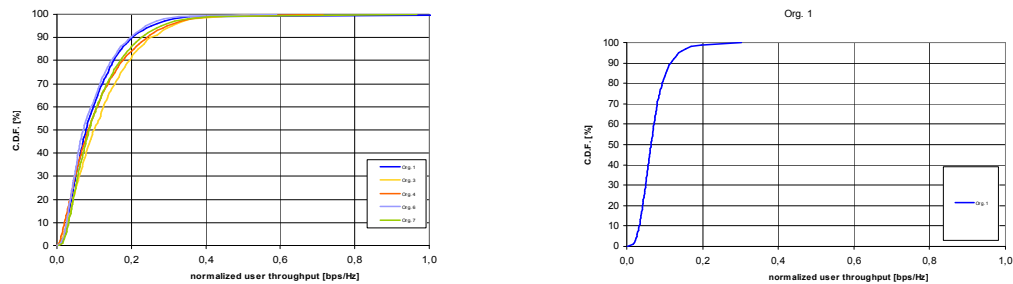


Figure 25: Downlink (left) and uplink (right) normalized user throughput distributions in the SMa test environment.

Table 1: The mean calibration simulation spectral efficiencies and cell-edge user throughputs.

Direction	Metric	InH	UMi	UMa	RMa	SMa
Downlink	Cell spectral efficiency [bps/Hz/cell]	2.6	1.2	1.1	1.2	1.1
	Cell-edge user spectral efficiency [bps/Hz]	0.083	0.027	0.020	0.022	0.020
Uplink	Cell spectral efficiency [bps/Hz/cell]	1.7	0.9	0.7	0.9	0.7
	Cell-edge user spectral efficiency [bps/Hz]	0.083	0.032	0.027	0.033	0.027

Table 2: Coefficients of variation for the calibration simulations.

Direction	Metric	InH	UMi	UMa	RMa	SMa
Downlink	Cell spectral efficiency [bps/Hz/cell]	3 %	9 %	12 %	8 %	9 %
	Cell-edge user spectral efficiency [bps/Hz]	17%	31 %	28 %	17 %	21 %
Uplink	Cell spectral efficiency [bps/Hz/cell]	7 %	4 %	6 %	< 1 %	N.A
	Cell-edge user spectral efficiency [bps/Hz]	18 %	9 %	8 %	7 %	N.A

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