Source: **Motorola**
Title: **SCM Micro-cell & Urban Canyon Model**
Document for: **Discussion**

1. SUMMARY

The urban micro-cell has been discussed recently, and some parameters have been identified as needing adjustment to become closer to measurements[1]. In this contribution, several adjustments are made to obtain a micro-cell model, along with plots of the micro-cell performance.

The urban canyon model has been modified in this contribution to address issues that were described in [2]. These issues relate to the mix of propagation effects that were originally included in the statistics, which diluted the probability of obtaining a set of arriving rays from a narrow set of angles. Results in [2] showed that the distribution of UE angle spreads were close to that of the standard model, and therefore proposed modifications to give more emphasis to the canyon effects.

2. MICRO-CELL

The path loss model being discussed in previous contributions consisted of a LOS component and a NLOS component with specific slopes. Since the LOS path is actually characterized by a street canyon, the street canyon model was proposed. The term LOS_{SC} is used here to indicate that the street canyon model, and its associated path loss slope is being discussed.

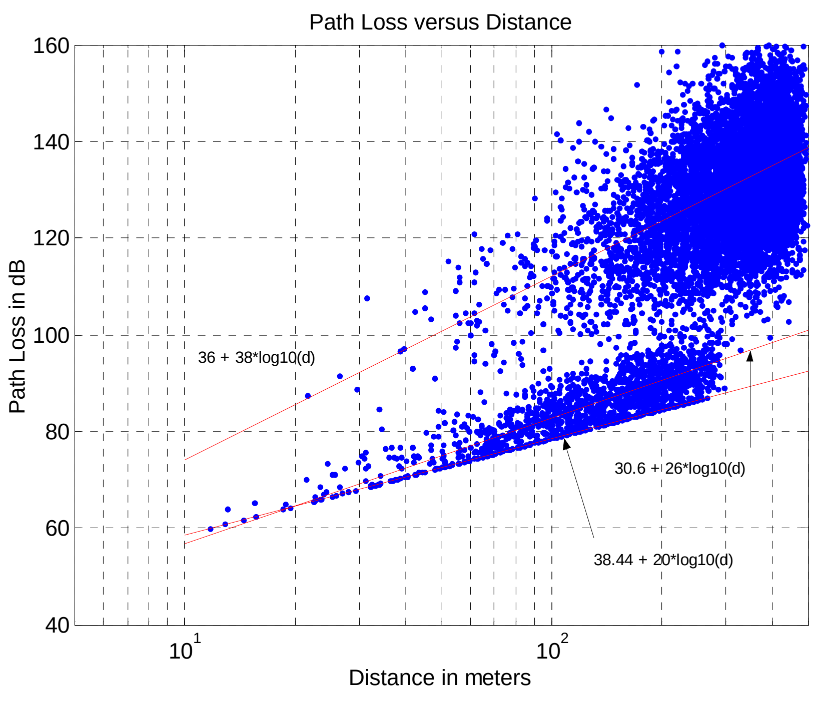

Figure 1, Path loss of the Micro-cell model where LOS_{SC} and NLOS paths are combined

LOS_{SC} Propagation: COST231 Walfish-Ikegami street canyon model[3] was proposed for the line-of-sight case, which has an equation of: L = 42.6 + 26log10(d)+20log(fc), d in Km, fc in MHz. At 2.0 GHz, this reduces to: 30.6 + 26*log10(d), d in meters.

NLOS: COST231 Walfish-Ikegami micro-cell model[3] was selected with the following parameters to be used for all orientations, (so that the intercept is a constant for all positions in the cell.) Once the slope and intercept are defined, the building information is no longer used.

Building = 12m Building to building distance = 50m
Antenna height = 12.5m Street width = 25m
Mobile height = 1.5m Orientation = 30 deg for all paths (produces an average value of intercept)
Resulting Slope = 38dB/dec Resulting 1Km intercept = 150 dB
This equation reduces to: 36 + 38*log10(d), d in meters.

Shadow Fading: The log normal shadow fading is 10dB for the NLOS path loss, and 4dB for the LOS_{SC} path loss. Since the LOS_{SC} slope with a 4dB sigma can produce a path loss that is sometimes less than LOS, the path loss value is clamped using the ideal LOS equation, which is: 38.44 + 20*log10(d), d in meters.

Mixing: The mixing between NLOS and LOS_{SC} is based on the equation discussed in[4]. Probability of LOS_{SC} = (300 – d)/300, for d in meters < 300m.

K-factor: As in [4], the K-factor is set by the equation K = 13.0 – 0.03*d, K in dB, d < 300m, which is used when the LOS_{SC} prop slope is used. When the location is NLOS, the K-factor is –infinity dB.

Cell size: 500m to the corner of the hexagon.

The complete path loss model with all the components described is shown in Figure 1, with respect to isotropic antennas.

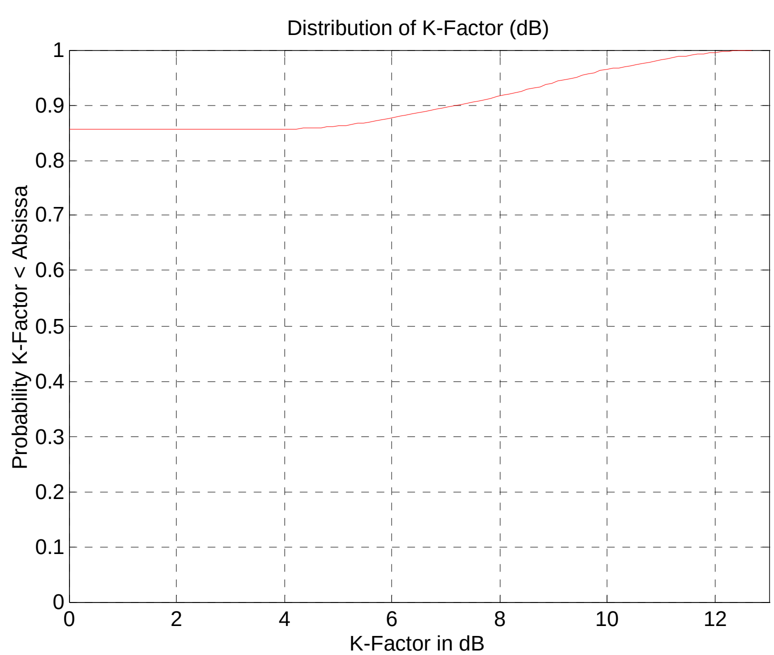

Figure 2, K-factor probability from simulation

Figure 2 describes the distribution of K-factors which results from simulations for a 500m micro-cell. The subscriber locations are modeled uniformly across the hexagon with the maximum radius = 500m. Based on this geometry 85% of the locations are NLOS which will have a K-factor = -infinity dB, to represent the Rayleigh fading environment. When the locations that are < 300m are found to be LOS_{SC} locations based on the probability of LOS equation, the K-factor is chosen based on the distance and varies from 4dB to 13 dB.

The following plots were obtained from simulations with the parameters shown below.

Angles chosen from: U(-40° to 40°),

Delays chosen from: U(0 to 1200nS),

Powers = 10^(τ/uS)

Path power sigma: 3dB

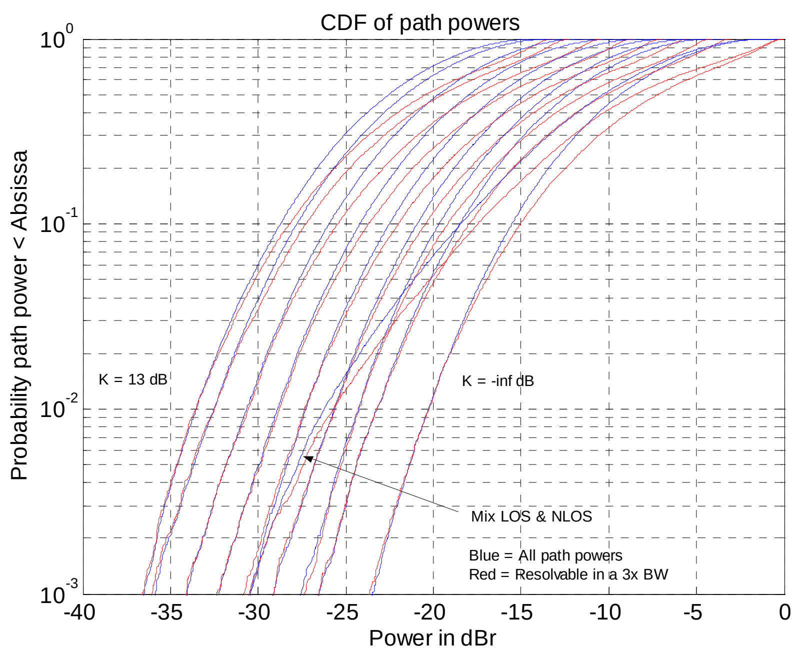

Figure 3, CDF of Path Powers for the Micro-cell model

Figure 3 and 4 illustrate the range of path powers that are seen for the micro-cell channels. Figure 3 combines all powers into a statistic of path powers, where Figure 4 looks at the dynamic range of each channel realization, plotted as a complementary cdf. The difference between the 1x and 3x channel bandwidths are shown in the resolvable dynamic range curves. (Powers are combined within a chip time as a simple way to estimate the resolvable powers.) The 1% highest value is approximately the same for both bandwidths. The dynamic range D is calculated from D = 10*log10(max pwr / min pwr) for each channel realization.

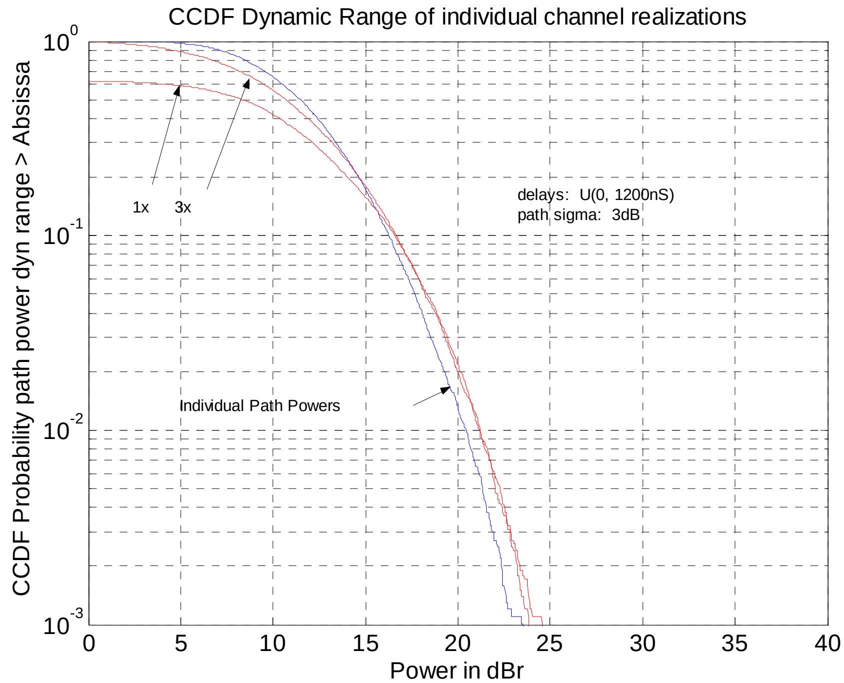

Figure 4, Dynamic Range of Path Powers per channel realization, (NLOS)

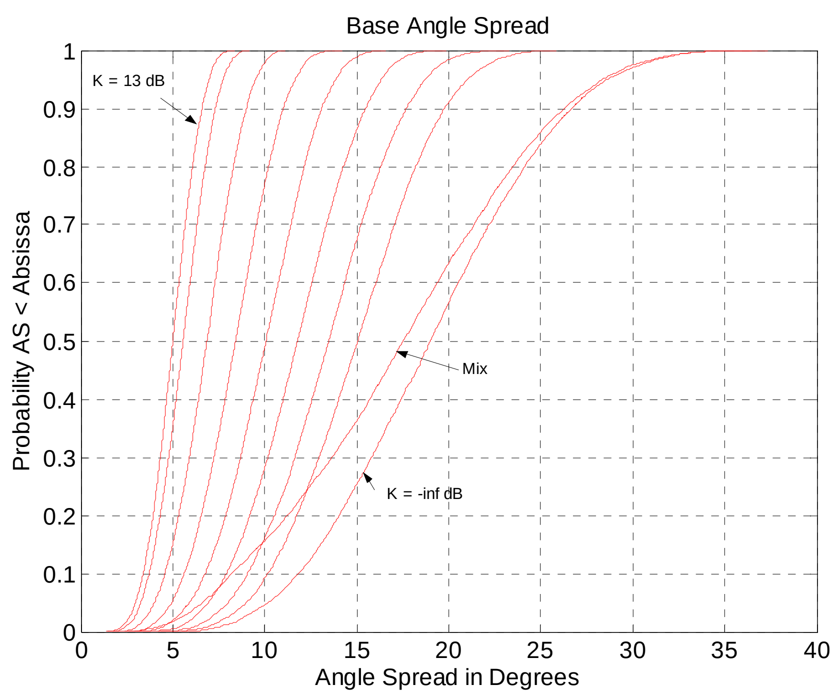

Figure 5, Composite Base Angle Spread

The composite angle spread at the base is described in Figure 5 for the various K-factors that are seen in the micro-cell model, along with the LOS/NLOS mix expected when the cell radius is 500m. For the NLOS case, the average composite Base AS = 19°, which was selected based on micro-cell measurements[5]. When experiencing LOS_{SC} paths with increased K-factors, the angle spreads are observed to decreased accordingly.

The simulated average composite Base AS for the NLOS model is: 19.2˚.

The simulated average composite Base AS for the mixed propagation model is: 17.6˚.

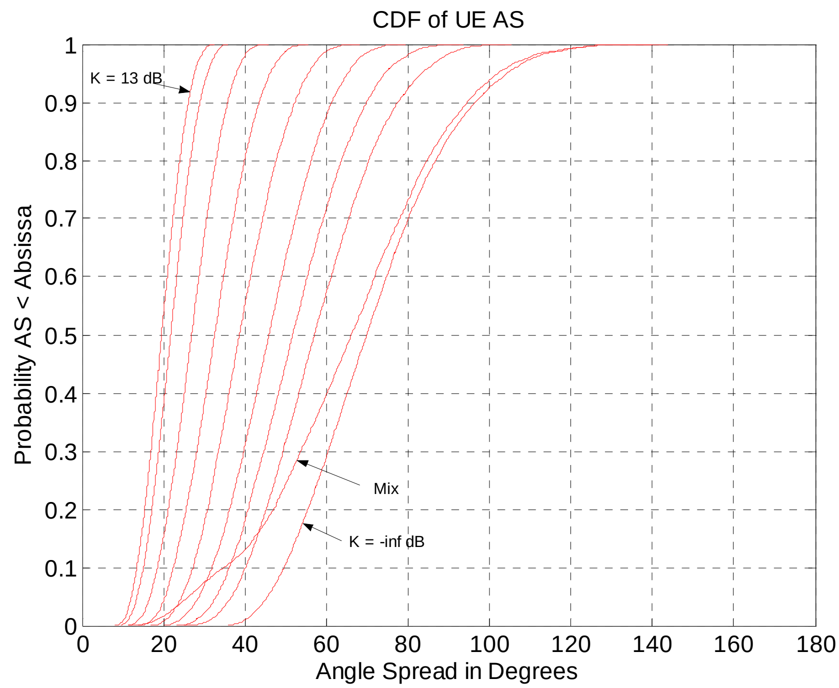

Figure 6, Composite UE angle Spread

The composite UE angle spread is described in Figure 6 for the various K-factors that are present in the micro-cell model. Increased K-factor from a LOS path, causes the composite AS to be decreased since more power is present in a single direct component. The mixed case is shown which has a slight decrease in the statistics due to the 15% of the locations experiencing the LOS_{SC} condition.

The simulated composite UE AS for the NLOS model is: 71.8˚.

The simulated composite UE AS for the mixed propagation model is: 65.8˚.

The delay spread is illustrated in Figure 7, which is also affected by the presence of a direct path. The mix is produced by the combination of LOS_{SC} and NLOS paths.

The simulated average delay spread for the NLOS condition is: 251 nS

The simulated average delay spread for the mixed case is: 231 nS

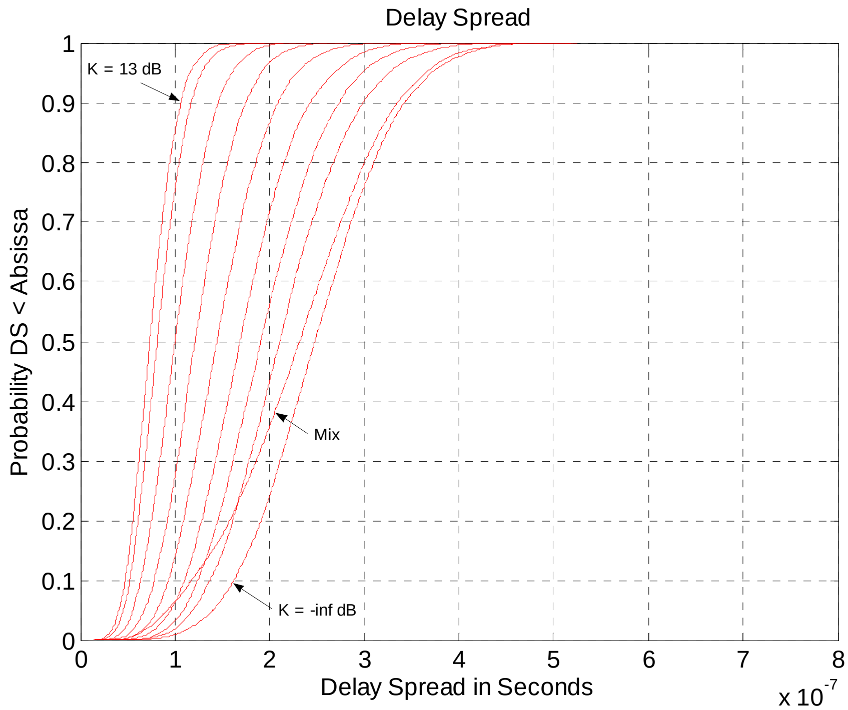

Figure 7, Micro-cell Delay Spread

3. URBAN CANYON PROPAGATION MODELS

In [6] and [7], an Urban Canyon model was presented which was based on measurements in a dense urban non-line-of-sight area. Since the data contained a mix of various environments, the urban canyon effects could only be seen over a portion of the measurement area. Therefore after gathering statistics over the entire area, the resulting behavior of the model produced distributions of UE angle spread that were similar to the urban model.

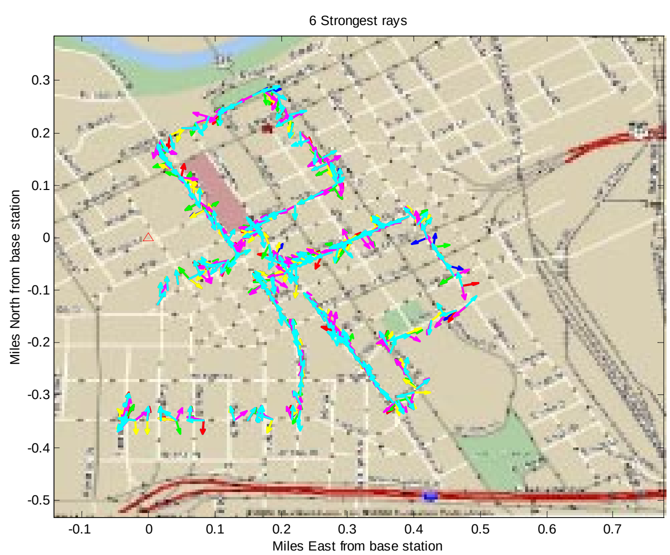

Figure 8, Measurements showing Urban Canyon directional effects

From these measurements, as seen in Figure 8, significant canyon effects can be seen along some streets, where other streets appear to have AoAs that are more random. In this figure the direction of arrival is shown for the six strongest paths. From this measurement data when all locations are combined, calculations with the per-path AS = 35˚ produce an average composite AS = 68.7˚, which is very close to the results from the current SCM UE angle spread model due to the mix of environments.

To be able to simulate the urban canyon effect, the distributions of UE angle spread need to emphasize the narrow arrivals that are characteristic of the effect. Therefore, a modified model for urban canyon is proposed to include the steps as described below:

1. Select a random street orientation from: U(0, 360˚) which also equals the direction of UE movement.
2. Select a random orientation for the subscriber antenna array from U(0, 360).
3. Given α, the predefined fraction of UEs to experience the urban canyon effect, Select a uniform random draw for the parameter β.
4. If $\beta <= \alpha$ Select the UE AoAs for all arriving paths to be equal, with 50% probability of being from the direction of the street orientation, 50% the street orientation plus an offset of 180°.
   If $\beta > \alpha$ Select the directions of arrival for all paths using the standard SCM UE AoA model.

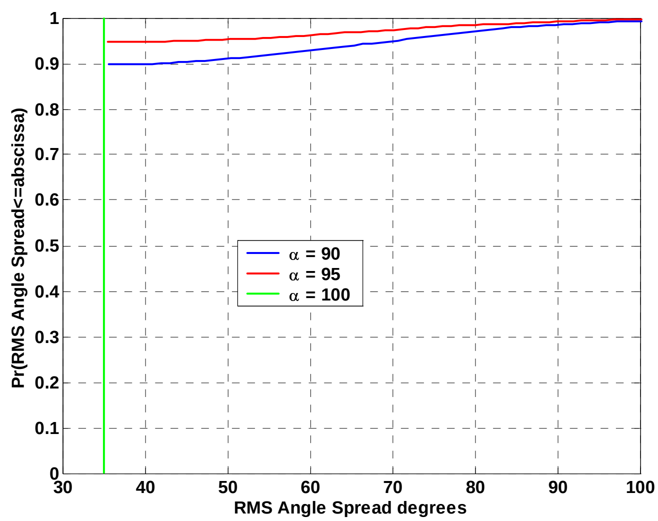

Figure 9, Simulate results of Proposed Urban Canyon Algorithm

In Figure 9, the modified urban canyon procedure is simulated to show the effects of the parameter α, which describes the percentage of mobiles that will experience the urban canyon effects. The figure illustrates the result of selecting the AoAs, where each of the paths has a fixed 35˚ angle spread.

In order to test the sensitivity to the paths arriving from narrow angles, a relatively high percentage of occurrence is needed in the urban canyon model to emphasize these effects. It may be desirable to have a small percentage of cases to deviate from the canyon effect to represent the mobiles at intersections and cases where signals arriving from between buildings or from unknown paths at various angles. We propose that α be selected to be 90% to represent this percentage of subscribers experiencing the urban canyon effect. By constructing the model with the parameter in this way, it is easy to select any value from 0-100% for testing purposes, however it would be useful for a single value to be used for comparisons such as 90%.

4. CONCLUSION

The micro-cell model has been simulated using parameters that have been discussed in various contributions. The main components of the model include setting pathloss and K-factors.

Log normal correlation is assumed on the NLOS paths. It is not obvious how to include shadow fading correlation when combining LOS and NLOS paths since the shadowing mechanisms are different, so this is an item for further study.

The SCM Urban Canyon model was simulated according an improved set of assumptions which give more emphasis to the case where all paths arrive from the same direction. A parameter α is used to allow a given percentage of cases to use the standard AoA model. The value for α is recommended to be 90% to allow a significant emphasis for the street canyon, with some cases representing intersections and other locations.

5. REFERENCES

[1] SCM Ad-Hoc Co-chair, SCM-097, "Spatial Channel Model AHG Ad Hoc Meeting 4 Summary," January 8th, 2003.

[2] Motorola, SCM-094r1, "SCM Urban Canyon Model Verification", San Diego, California, January 8th, 2003.

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[4] Mitsubishi Electric Research Lab, SCM-072, "Open Questions on the MIMO Channel Model", Quebec City, October 22 nd , 2002.

[5] L. M. Correia, Wireless Flexible Personalized Communications, COST 259: European Co-operation in Mobile Radio Research, Chichester: John Wiley & Sons, 2001.

[6] Motorola, SCM-067, "Urban Canyon & Parameters", Quebec City, October 22nd, 2002.

[7] Motorola, SCM-094, "Urban Canyon Model", San Diego, CA, January 8th, 2003.