Source: **Motorola**
Title: **Spatial Channel Model Validation Experiments**
Document for: **Discussion**

1. SUMMARY

In [1] some parameter modifications were presented to improve the Spatial and Temporal characteristics of the Spatial Channel Model. These modifications were simulated to produce the desired statistics shown.

The parameters described include:

- Slight adjustments to values of r_{DS} to improve the angle spread ratio & dynamic range
- Randomizing noise value resulting in the improved channel variation & dynamic range

Resulting Tables of parameter values and Plots confirming the expected behavior of the model are shown.

2. PATH POWERS, R-VALUES, AND RANDOMIZING NOISE

A number of effects have been shown to be a function of the relative path powers, including XPD and AoA models, thus it is important to properly characterize the path powers and their dynamic range. For this reason and to be more comparable to measured data, a randomizing noise model was included in the SCM to simulate the path powers being stronger or weaker than the average value.

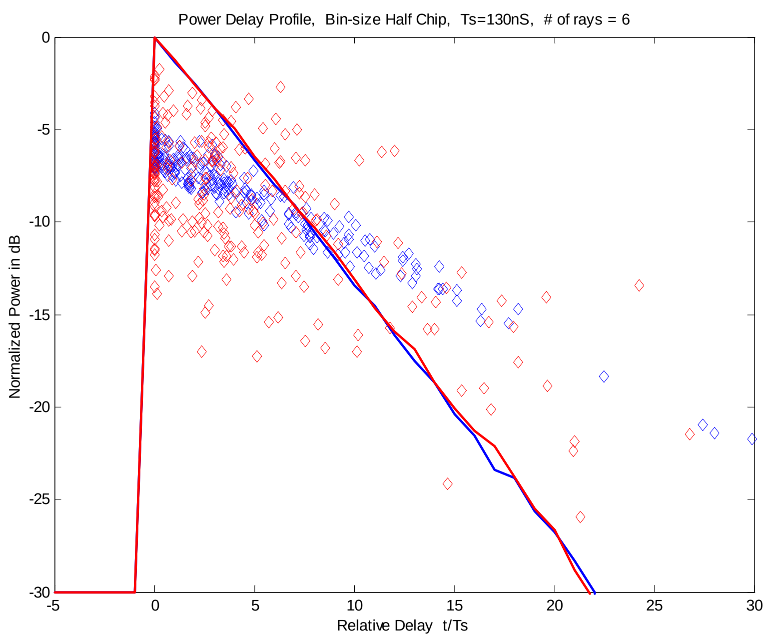

Figure 1, Example of an average Power Delay Profile with sample channel realizations

This randomization behavior emulates a number of characteristics that are seen in field measurements. First the randomization allows powers to be non-monotonically decreasing with delay. In addition, the occurrence of multiple path powers falling into the same time bin is now more representative of an actual field measurements since the powers are not defined by the envelope, which would make them nearly equal in power. Figure 1 illustrates this where the powers are indicated by the blue diamonds for the first 40 channel realizations. Since each group of 6 powers is normalized to unity power, there is effectively a small amount of randomness inherent in the process. There is a fairly narrow range of powers for typical draws of 6 path powers. With the addition of the randomizing noise, significant improvements in dynamic range are obtained as shown by the red diamonds in the figure. Also, path powers that are adjacent in time, or even in the same time bin, may now see significant relative differences between them. The same effect is also produced in the azimuth spectrum where significant powers can now be seen at larger angles, and in a randomized way. This is comparable to observations from field measurements.

Note that with a 3dB randomizing noise, the powers for each channel realization are no longer constrained to a monotonic behavior, but weak and strong paths can be next to each other. The decreasing trend of power versus delay is still evident, but with an increased dynamic range.

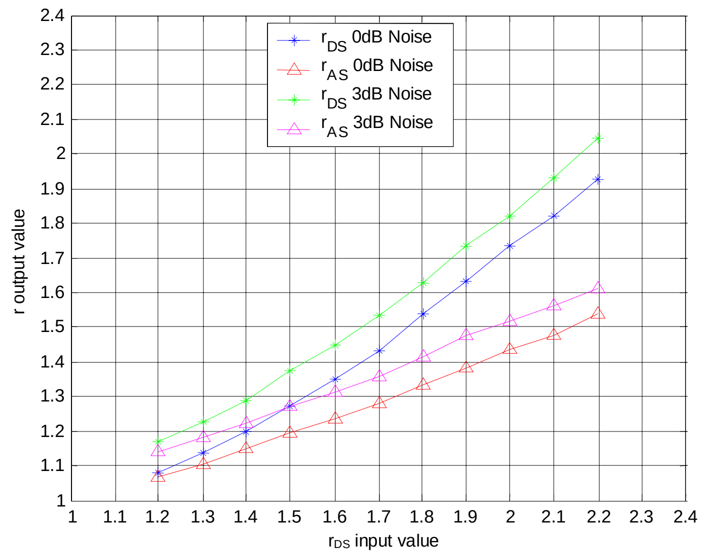

Figure 2, R-values with and without the 3dB noise value

The value of r_{DS}, the ratio of the value of the spread of the delays to the power weighted delay spread[2] is somewhat effected by the randomizing noise. The slight increase with the noise model is due to the fact that stronger relative powers can now occur more often, which tends to reduce the value of the delay spread slightly, but the value of the spread of the delays does not change. Figure 2 illustrates the behavior of r_{DS} and r_{AS} with and without the randomizing noise. The x axis represents the value of r_{DS} that is input to the simulator. This results in an output value for both r_{DS} and r_{AS}. The ratio is calculated as a statistically biased ratio. There is also a slight offset between the input and output r_{DS}, which is a consequence of only having a small number of rays.

As discussed in [1], the value of r_{AS} is only a function of r_{DS}, since the powers are defined by the equations that contain only r_{DS}. Thus to obtain the desired value of angle spread ratio, e.g. r_{AS} = 1.3, the value of r_{DS} must be increased slightly. This is in line with slightly higher r-values presented in [3] which illustrated how the values of r_{DS} are very sensitive to the measurement threshold used.

For reasons of placing r_{AS} in the proper range, improving the dynamic range, as well as producing an improved shape of the PAS (being more triangular), the following values for r_{DS} are selected.

For Urban with r_{DS} = 1.7 will produce the output values of: r_{DS} = 1.54, and r_{AS} = 1.37, when a randomizing noise of 3dB is used. (1.3 was the target value for the r_{AS} value)

For Suburban with r_{DS} = 1.4 will produce output values of: r_{DS} = 1.29, and r_{AS} = 1.22, when a randomizing noise of 3dB is used.

These new values are consistent with the numbers reported in [3], and produce the desired improvements in r_{AS} and dynamic range.

2.1 AoA model at the UE

With improvements to the distribution of powers and the dynamic range, previously defined parameters that are dependent on the relative powers must be adjusted to produce the desired output. The original equation proposed for the UE AoA was based on measurements where an excess of 20 paths were observed. In order to produce the expected value for the SCM model with N=6 paths and for a dynamic range of powers that results with the randomizing noise of 3 dB, the equation parameters must be adjusted to obtain: $E[\sigma_{AS}] = 72^o$.

The new equation is:

$$\sigma = 104.12(1 - e^{-0.3125|P_{dBr}|})$$

The results of the simulations produce values quite close to the desired value of 72^o. There are some variation between runs shown in Table 1, and it is also noted that the suburban statistics for path powers and dynamic range are somewhat different. This produces slight variations in the result as seen by the value for suburban being slightly higher at around 74^o. Although this can be adjusted by changing the equation parameters again, the value is considered to be close enough to the desired value. For the Urban-micro, it is likely that additional adjustments will be needed.

3. SIMULATION RESULTS SUMMARY:

The following table of parameters were used to simulate the Urban and Suburban channels. The values of r_{DS} were modified as shown to produce the improvements described above. In addition, a randomizing noise value of 3dB was used to produce the dynamic range improvements and channel variations comparable to measurements.

Table 1, SCM Parameter Summary with Angle Spread and Dynamic Range Improvements

Parameter	Urban 8° 3dB Noise		Urban 15° 3dB Noise		Suburban 5° 3dB Noise	
r_{DS}	Input	Output	Input	Output	Input	Output
	1.7	1.54	1.7	1.54	1.4	1.29
μ_{DS}	Input	Ideal	Input	Ideal	Input	Ideal
	-6.195	-6.26	-6.195	-6.26	-6.80	-6.92
ξ_{DS}	Input	Ideal	Input	Ideal	Input	Ideal
	0.18	0.25	0.18	0.25	0.288	0.363
r_{AS}	Input	Output	Input	Output	Input	Output
	1.3	1.37	1.3	1.37	1.2	1.22
μ_{AS}	Input	Ideal	Input	Ideal	Input	Ideal
	0.825	0.75*	1.1750	1.0938	0.74	0.66
ξ_{AS}	Input	Ideal	Input	Ideal	Input	Ideal
	0.34	0.37	0.225	0.2669	0.09	0.18
$E[\sigma_{DS}]$	Ideal	Measured	Ideal	Measured	Ideal	Measured
	0.65μs	0.63μs	0.65μs	0.63μs	0.17μs	0.172μs
$E[\sigma_{AS\ Node\ B}]$	Ideal	Measured	Ideal	Measured	Ideal	Measured
	8°	7.94°	15°	14.90°	5°	4.96°
$E[\sigma_{AS\ UE}]$	Ideal	Measured	Ideal	Measured	Ideal	Measured
	72°	72.05°	72°	72.69°	72°	74.07°

*This value was 0.77, however this will produce a value of $E[\sigma_{AS\ Node\ B}]$=8.5° instead of 8°.

The following figures illustrate the performance of the model for the Urban and Suburban scenarios with the input parameters which are given in Table 1. The results for various output statistics are also shown in the table, and match well to the desired values.

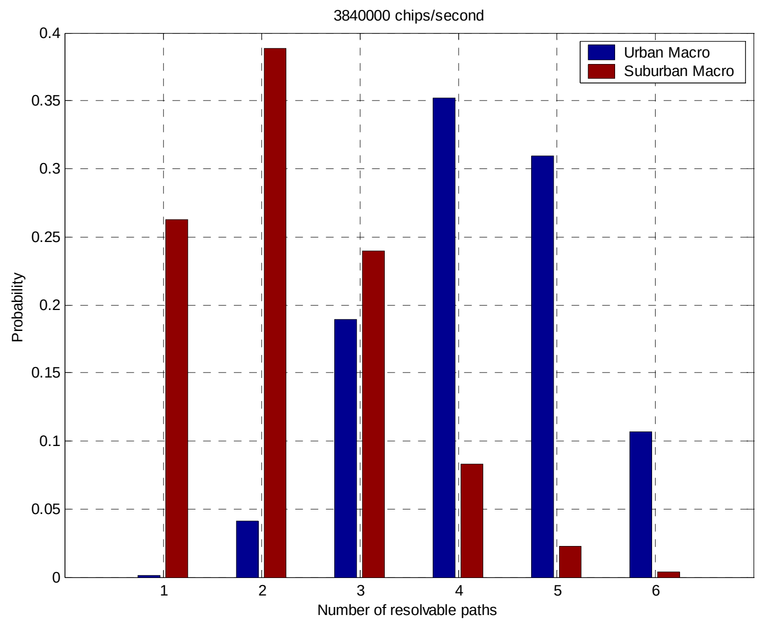

Figure 3, Probability of Urban and Suburban Time Resolvable Paths

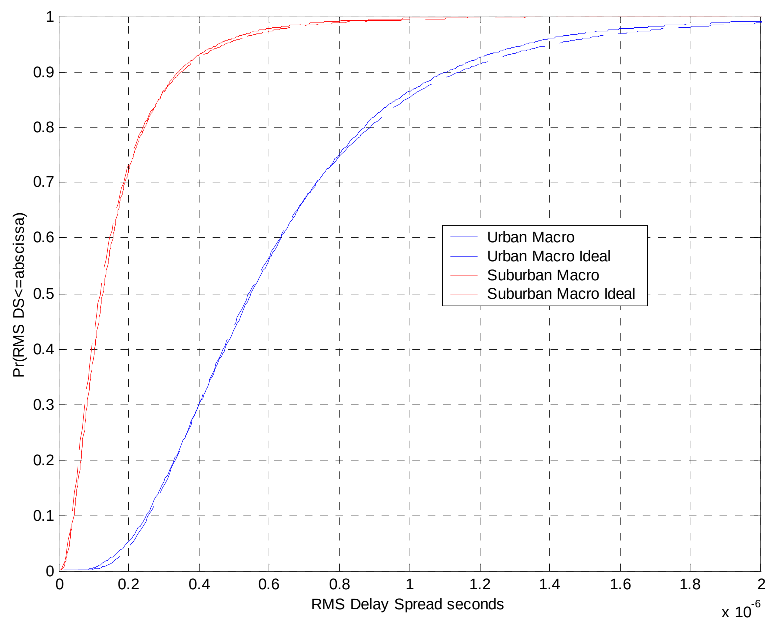

Figure 4, RMS Delay Spread, Simulated versus Ideal

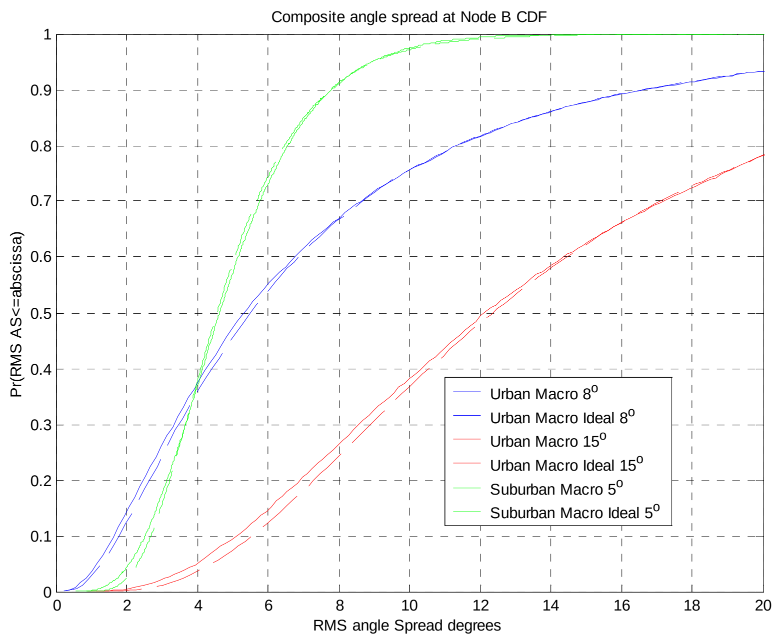

Figure 5, Node-B Composite Angle Spread, Simulated versus Ideal

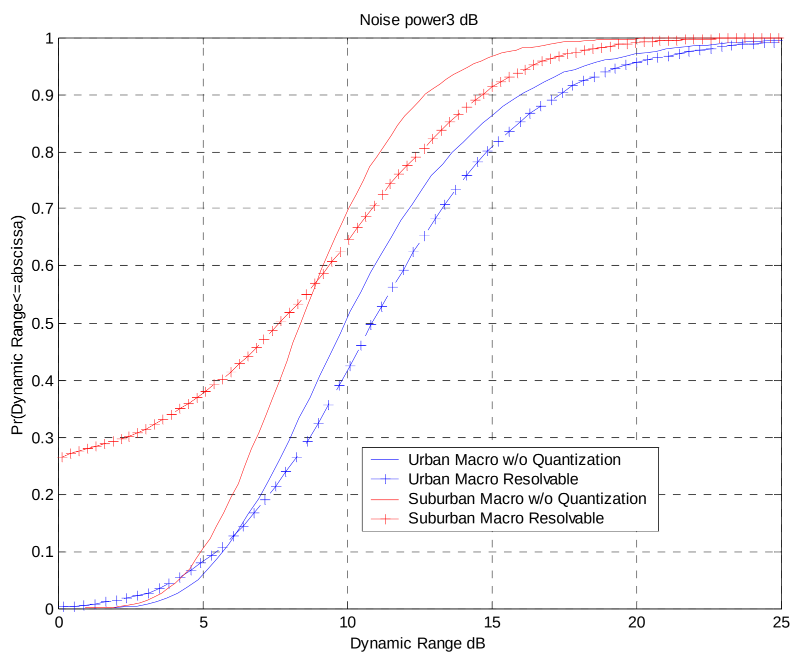

Figure 6, Dynamic Range (dB) for each channel model

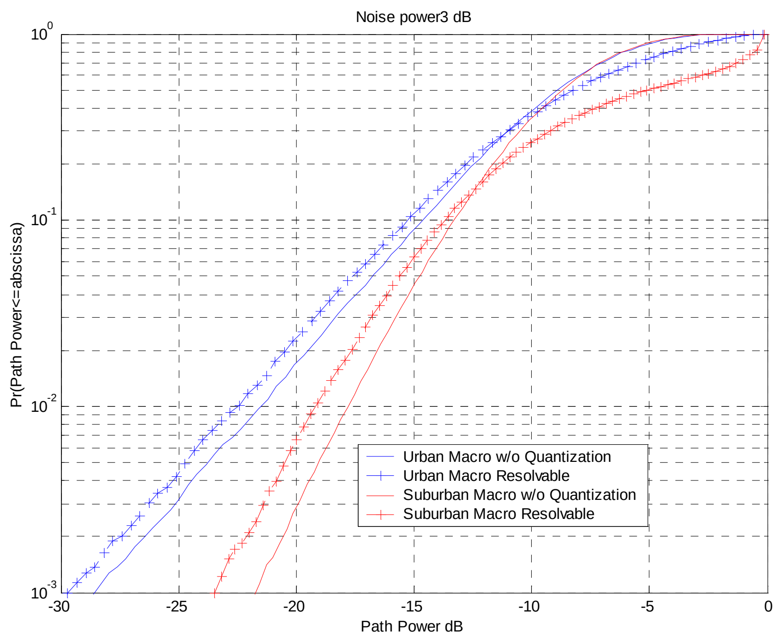

Figure 7, CDF of all Path Powers

4. URBAN MICRO PATH LOSS MODEL

A proposal was made to use Feuerstein [4] for the urban microcell path loss model as discussed in [5]. This model uses a very shallow slope for the NLOS path loss model. The proposed value of n_3=2.6 appears low.

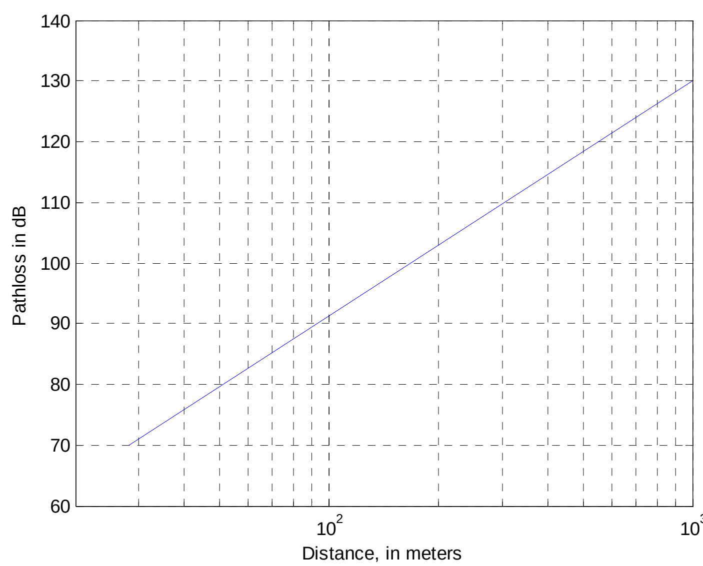

Figure 8. Pathloss Predicted by COST231 Walfisch-Ikegami

As illustrated in Figure 8, a pathloss exponent closer to n=3.8 is predicted by the COST231 Walfisch-Ikegami model (streetwidth=16 m, building height=16 m, inter-building distance=50 m, phi=90^o, large city, rooftop transmitter, receiver at 1.5m).

Thus based on the comparison, the path loss model by Feuerstein seems to be significantly different, i.e. n=2.6 compared to n=3.8 for Walfish-Ikegami. We recommend further comparing with measurements to determine if the proposed model is suitable.

5. CONCLUSION

In this contribution a number of items are described:

The noise model was implemented with σ=3dB, and shown to improve the dynamic range of the path powers and provide variation for each channel draw that is comparable to measurements.

Values of r_{DS} were selected to produce the desired r_{AS} values when the noise model was included. These values are very similar to previous values. The result of the two models produces reasonable values for r_{AS}, improvement in the dynamic range, and the shape of the PAS.

Validation experiments were run to show the result of the model for the given r_{DS} values and noise. Mu and epsilon for both the delay spread and angle spread equations were given.

Some questions about the propagation slope of the Urban micro-cell are presented requiring further investigation.

6. REFERENCES

[1] Motorola, "Urban Canyon, and Parameter Values for the Spatial Channel Model," SCM-067, Quebec City, CA, October 22, 2002.

[2] K. Pedersen, P. Morgensen, B. Fleury, "A Stochastic Model of the Temporal and Azimuthal Dispersion Seen at the Base Station in Outdoor Propagation Environments," IEEE Transactions on Vehicular Technology, VOL. 49, NO.2, March 2000, pp.437-447.

[3] Qualcomm, "Standard Deviation of Delays versus RMS Delay Spread", SCM-053, September 17, 2002.

[4] M. J. Feuerstein, K. L. Blackard, T. S. Rappaport, S. Y. Seidel, and H. H. Xia. Path loss, delay spread, and outage models as functions of antenna height for microcellular system design. IEEE Transactions on Vehicular Technology, vol. VT-43, no. 3, pp. 487-498, 1994.

[5] Mitsubishi Electric Research Lab, "On open questions of the MIMO channel model," SCM-072, Quebec City, CA, October 22, 2002.

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