Fade Margin Consideration with ICS telecom in Microcell (NLOS) Network Planning

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RF Modeling with Precision

ICS telecom offers a comprehensive range of propagation modeling options that allow its users to choose from a wide range of deterministic, statistical, and hybrid models based on the following criteria:

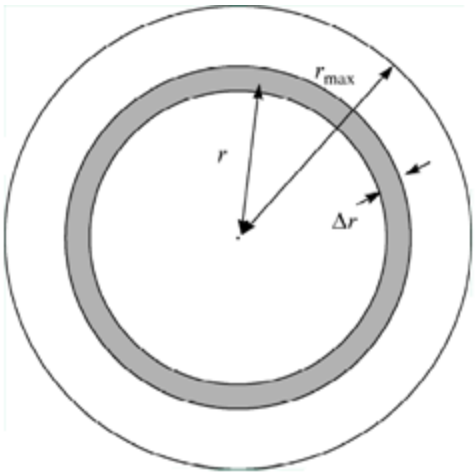
- Application/technological simulation requirements (operating frequency, computation requirements, network size)
- Possibility of acquiring measurement/calibration data
- Resolution of available cartography

ICS telecom even allows its users to compose propagation schemes by combining different propagation components available to them through ICS telecom's powerful propagation engine. This capability allows the ICS telecom user to augment aspects of a particular model that may contain the necessary propagation features to address the basic modeling requirements of a particular technology, but insufficient calibration to meet precision requirements or model that technology's reliability requirements. For example, some models that are very dependent on the resolution of the digital cartography, which are categorized as deterministic models, may not contain any component for making use of probability calculations to consider reliability requirements in a system's coverage. This is where ICS telecom's propagation engine and analytical options can allow a user to take the deterministic results and adjust the output to consider variable conditions such as fading, noise rise, and so forth not easily modeled through deterministic means.

Area Coverage

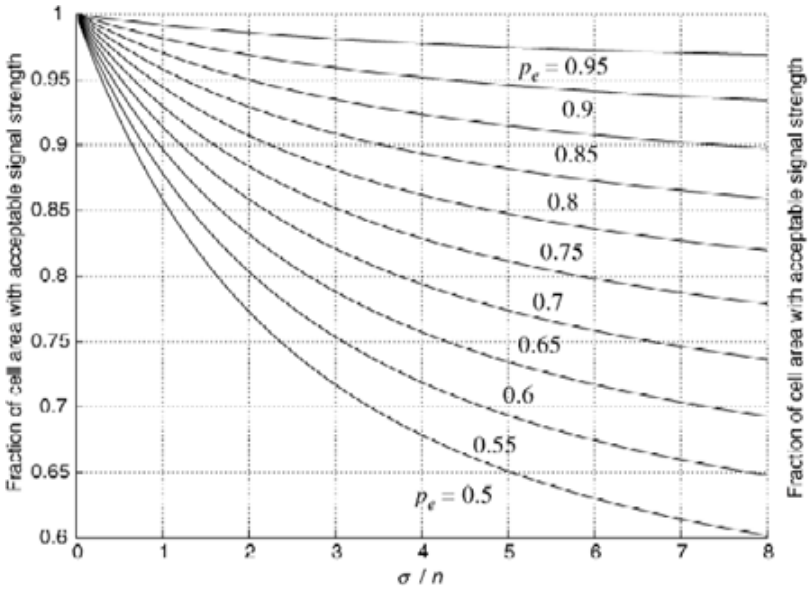
In order to appropriately design the network in terms of the coverage probability of the whole cell, an extra fade margin has to be considered according to the reliability required from the system to provide reliable communications over the entire cell coverage area.

The figure on the right shows a cell with two radii. The radius r_{max} represents the maximum range of the cell. The radius r represents any random point within r_{max} with Δr being its width. Within this r_{max} range, the coverage probability is $P_e(r)$. The area covered by the inner ring is $(2\pi*r)*\Delta r$.

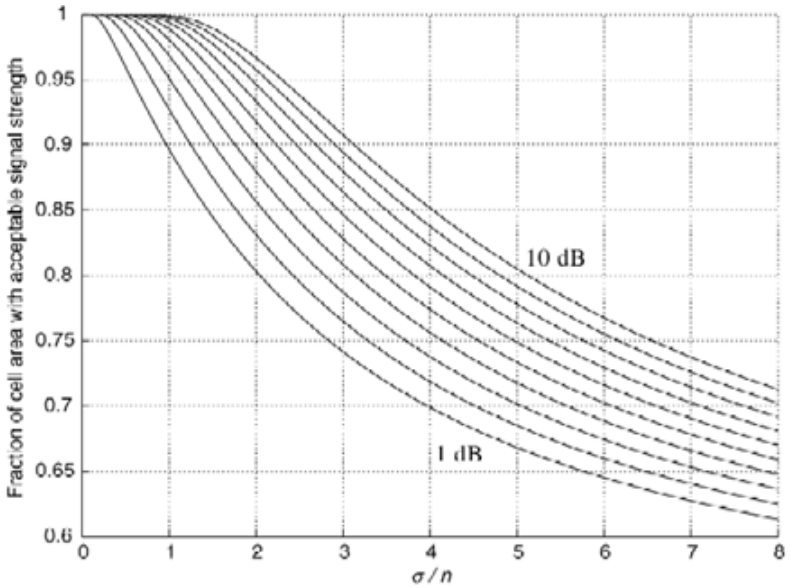


The coverage probability (or the complement of probability of outage) for the whole cell, P_{cell}, is then the sum of the area of all such associated rings from radius 0 to r_{max}, multiplied by the corresponding coverage percentages and divided by the area of the whole cell, $(\pi*r^2_{max})$. As the radius of the rings is reduced, the summation becomes an integral in the limit $\Delta r \rightarrow 0$.

Solving for P_{cell} based on desired probability of error (1 - reliability %) via use of the Q-function (aka erfc) and path loss exponent of 4 in the assumption of Non Line of Sight (NLOS) planning, the results are illustrated in the following graphs:



Probability of availability



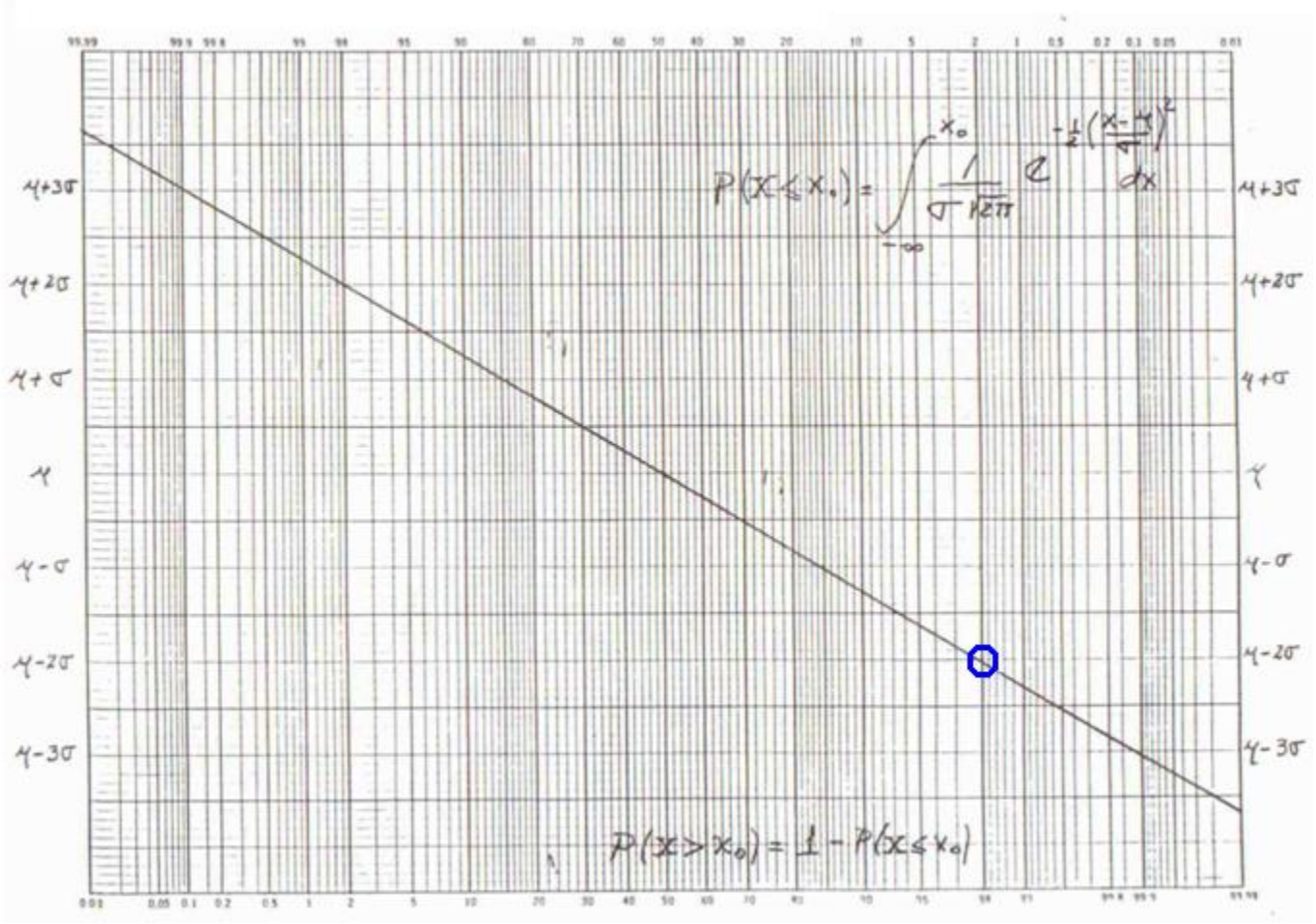
Probability of availability with fade margin varying 1 to 10 dB

The y-axis in both graphs represents the area coverage probability and the x-axis is a propagation index (σ/n) with σ equal to the standard deviation and n is a path loss exponent.

Rim Coverage (edge of cell)

The use of a fade margin can also determine reliability at a maximum cell range or at a particular distance essentially reducing the cell radius with an increasing reliability as a trade off.

The probability density function is given by the log-normal distribution with varying fade margin in the y-axis:



The fade margin is calculated by multiplying a standard deviation (σ) by a coefficient (Z_0).
For example, receiver threshold (X_0) of -100 dBm with received signal level (X_{RSL}) of -80 dBm with 10dB standard deviation (σ) will equate to,

$$\frac{X_0 - X_{RSL}}{\sigma} = Z_0 \rightarrow \frac{-100 - (-80)}{10} = -2$$

In reference to the graph above, the reliability of the received signal in this event will be 98% as circled in blue on the graph.

Considering Environmental Specific Standard Deviation in ICS telecom

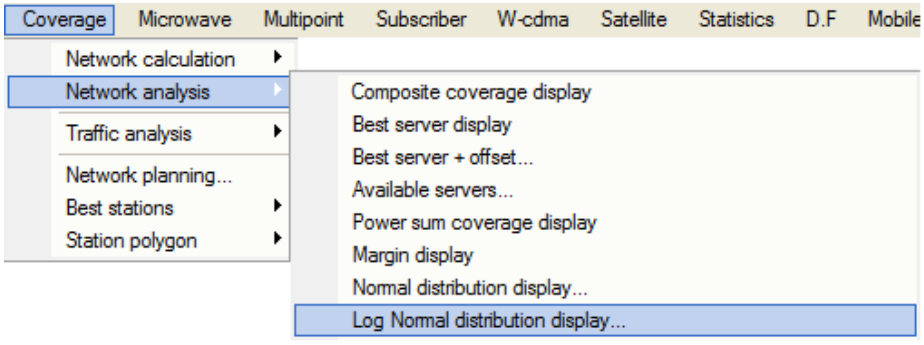
ICS telecom automates the process of reliability calculation focusing on different environmental conditions to derive a more realistic reliability percentage plot.

ICS telecom offers its users a clutter parameters configuration window to enter various standard deviations per clutter type to precisely characterize different environments in addition to penetration (skin-depth) loss, reflection coefficient, clutter heights to model diffraction loss, etc.

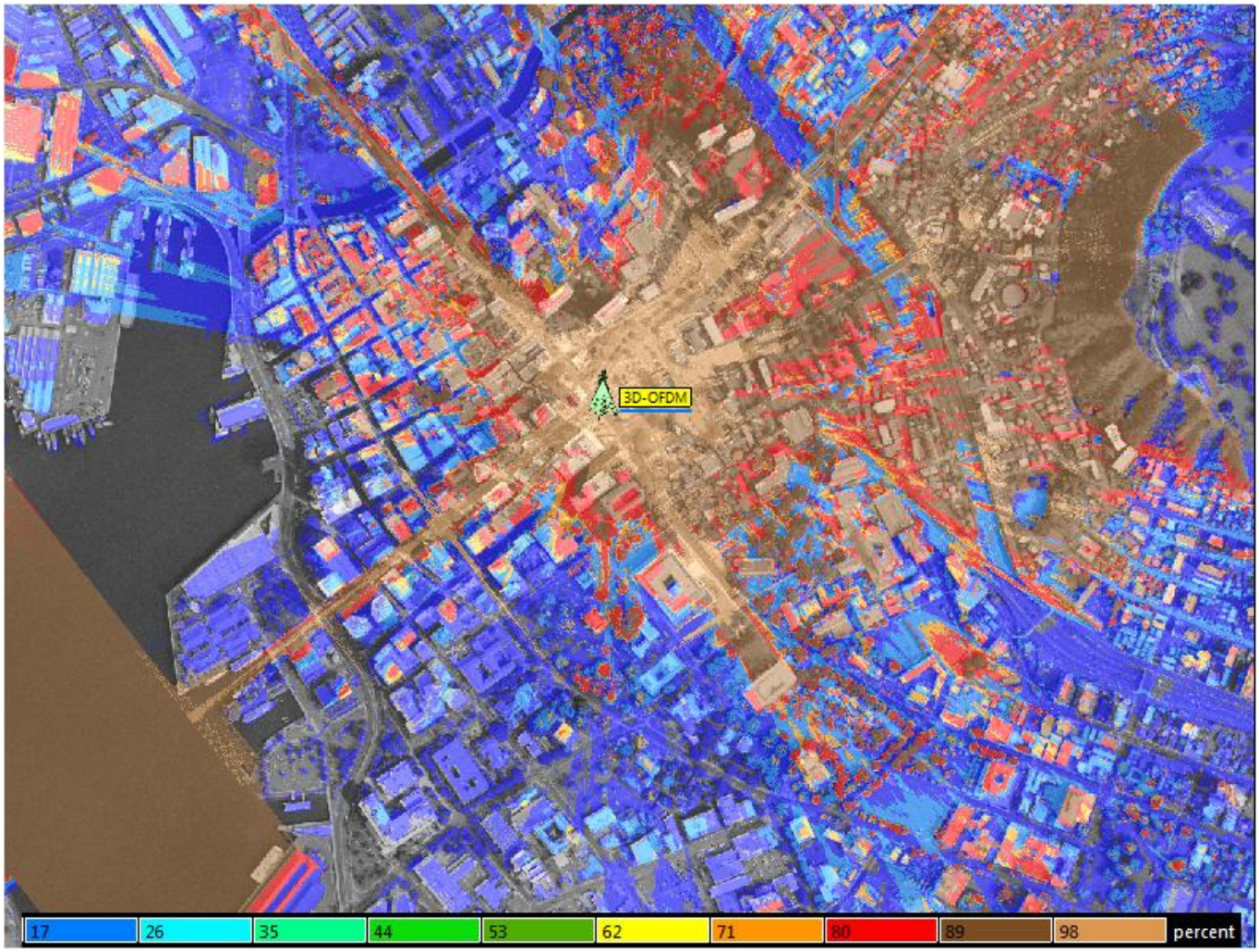
Clutter parameters

Clutter code	Name	Attenuation (dB)		Clutter height	Stddev (dB)
0	rural	0.0	0.0	0	3.00
1	suburban	500.0	0.0	6	3.00
2	urban 8 m	1000.0	0.0	8	6.00
3	urban 15 m	1000.0	0.0	15	6.00
4	urban 30 m	1000.0	0.0	30	10.00
5	forest	600.0	0.0	12	6.00
6	hydro	0.0	0.0	0	3.00
7	urban 50 m	1200.0	0.0	50	12.00
8	wood	500.0	0.0	4	6.00
9 *	road or roof	0.0	0.0	0	12.00

Upon completion of the propagation coverage analysis, additional display options are offered in ICS telecom. One of these options are the “Log-Normal distribution display” to automatically calculate reliability of the planned network with consideration of various standard deviations:



Running this automated feature in ICS telecom will calculate reliability in percentage over the entire coverage area for every base station loaded into the ICS telecom map interface. The following screen capture represents the output of the “Log-Normal distribution display” function where each color is used to represent different reliability levels.



Conclusion

In conclusion, ICS telecom is a complete tool for considering complex electromagnetic and probability theories as related to radio network planning. ICS telecom’s automated calculation features are the result of over 17 years of dedication to modeling radio communications network deployments and continuous product development. In particular, the case of working with deterministic propagation models that typically consider a percentage of reliability at 50%, consideration of fade margin would provide more reliable communications network planning!