Comments on Required Indoor Service Coverage Levels
Crown Castle/ATT DAS in Palos Verdes Estates
3/26/2016

Summary

Crown Castle/ATT is in the midst of a proposed Distributed Antenna System (DAS) deployment in Palos Verdes Estates (PVE). The site justification provided to PVE states that indoor wireless coverage is a goal of the DAS deployment. Coverage maps provided to PVE indicate signal levels of -75 dBm are targeted to provide indoor coverage. This value is inordinately high and is not supported by industry-standard building penetration loss values for indoor suburban environments. When correct penetration losses are used, coverage targets of only about -85 dBm are required, thus greatly increasing the coverage range of an individual site.

Use of this incorrect target value has resulted in an excessive number of unwarranted sites beyond that required to prevent significant coverage gaps. In addition, use of this incorrect target necessitated numerous highly intrusive sites be placed within residential neighborhoods rather than less intrusive locations away from homes. It is strongly advised that PVE reevaluate the technical justification provided by Crown Castle/ATT prior to approving additional sites. Network requirements can almost certainly be met with fewer, less intrusive sites.

Service Coverage Targets

Multi-color coverage maps provided by Crown Castle/ATT to PVE differentiate signal coverage levels by power density ranges. Values are expressed in dBm. The coverage map legend has corresponding attributes that describe the level of service provided. The legend is reproduced here:

Signal Coverage Map Legend

The legend indicates that the required outdoor signal level is a minimum of -98 dBm. Required indoor signal level is given as -75 dBm minimum, 23 dB higher than the outdoor signal level. This difference is attributed to *building penetration loss*, and it accounts for the fact that radio signals are attenuated (reduced) when passing through common building construction materials.

The quoted outdoor signal level of -98 dBm appears appropriate based on typical LTE/UMTS link budget assumptions. However, 23 dB of building penetration loss is excessive and is not warranted for the suburban environment found in PVE.

Building Penetration Loss

Penetration loss varies depending upon size, construction material, and density of a structure. For this reason, it is common practice to use different penetration losses depending on the neighborhood environment. Classifications used in the industry are rural, suburban, urban, and dense urban. The table below summarizes penetration loss values from multiple industry references. These values are given as typical for PCS/AWS wireless frequencies (1710-2170 MHz). UHF frequencies (698-904 MHz) are noted as being 3-4 dB lower as attenuation decreases as a function of frequency.

Typical Penetration Losses from Multiple Industry Sources

Source	Outdoor (reference)	Rural indoor (dB)	Suburban indoor (dB)	Urban indoor (dB)	Dense urban indoor (dB)
Nokia [1]	0	10	12	17	22
El-Nashar et al [2]	0	8	11	15	19
Baxter [3]	0	8-10	15	18-20	23-25
Huawei [4]	0	6-8	10-12	15-18	18-25
Song et al [5]	0	10	12	16	[-]
Average	**0**	**8.8**	**12.2**	**16.7**	**21.6**

Source notes:

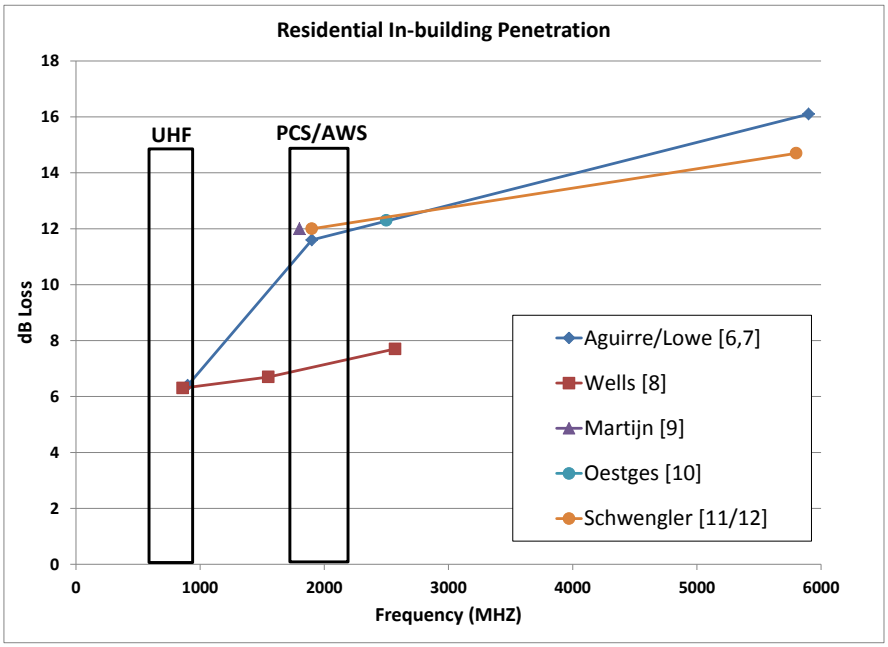
[1] LTE Dimensioning link budget parameters, Nokia Siemens Network
[2] Design, Deployment and Performance of 4G-LTE Networks: A practical Approach, El-Nashar
[3] LTE Basic Network Design, Scott Baxter and Associates
[4] LTE Radio Access Network Planning Guide, Huawei Technologies
[5] Evolved Cellular Network Planning and Optimization for UMTS and LTE, Song et al
[-] Category not included in source

Note that the values shown in the "suburban indoor" column are much lower than the 23 dB used by Crown Castle/ATT. There is sound justification for using lower values for suburban deployments.

Suburban neighborhoods such as PVE have low penetration losses as structures are small, have many windows, fewer internal walls, and are constructed with relatively RF-transparent materials such as wood stucco, and drywall. In a dense urban environment such as Manhattan or San Francisco, signals must penetrate far deeper into large multi-unit residential and commercial structures, usually passing through multiple walls. In addition, these structures typically use less transparent and thicker building materials (e.g. steel, concrete) as higher load bearing capability is required.

There is further evidence that Crown Castle/ATT incorrectly applied penetration loss from a review of the technical literature. Thomas Schwengler of the University of Colorado compiled residential structure penetration losses for from multiple published journals. Shwengler's compilation demonstrates that these suburban residential penetration losses range between 6 and 12 dB for UHF (~850 MHz) and PCS/AWS (~1900 MHz) frequency ranges. Shwengler's summary agrees well with that from industry references for suburban environments.

Suburban Residential Structure Building Penetration Losses from Published Literature



Source Notes:

[6] S. Aguirre, L.H. Loew, and L. Yeh, "Radio Propagation into Buildings at 912, 1920, and 5990 MHz Using Microcells" in *Proc. 3rd IEEE ICUPC*

[7] L.H. Loew, Y. Lo, M.G. Laflin, E.E. Pol, "Building Penetration Measurements From Low-height Base Stations At 912, 1920, and 5990 MHz" in NTIA Report 95-325

[8] P.I. Wells, "The attenuation of UHF radio signals by houses" in *IEEE Transactions on Vehicular Technology,* Vol. 26, Issue 4

[9] E.F.T. Martijn, M.H.A.J. Herben, "Characterization of radio wave propagation into buildings at 1800 MHz" in *Antennas and Wireless Propagation Letters*, Vol 2, Issue 1

[10] C. Oestges, A.J. Paulraj, "Propagation into buildings for broad-band wireless access" in *IEEE Transactions on Vehicular Technology*, Vol 53, Issue 2

[11] T. Schwengler, M. Gilbert, "Propagation models at 5.8 GHz – path loss and building penetration" in *Proc. 2000 IEEE Radio and Wireless Conference*

[12] T. Schwengler, personal measurements

PVE and the Palos Verdes Peninsula are light suburban in character, with some areas approximating a semi-rural atmosphere. In addition, the propagation maps provided by Crown Castle/ATT are for the UHF frequencies of 700 MHz and 850 MHz where attenuation is lower, not the higher frequency PCS/AWS bands.

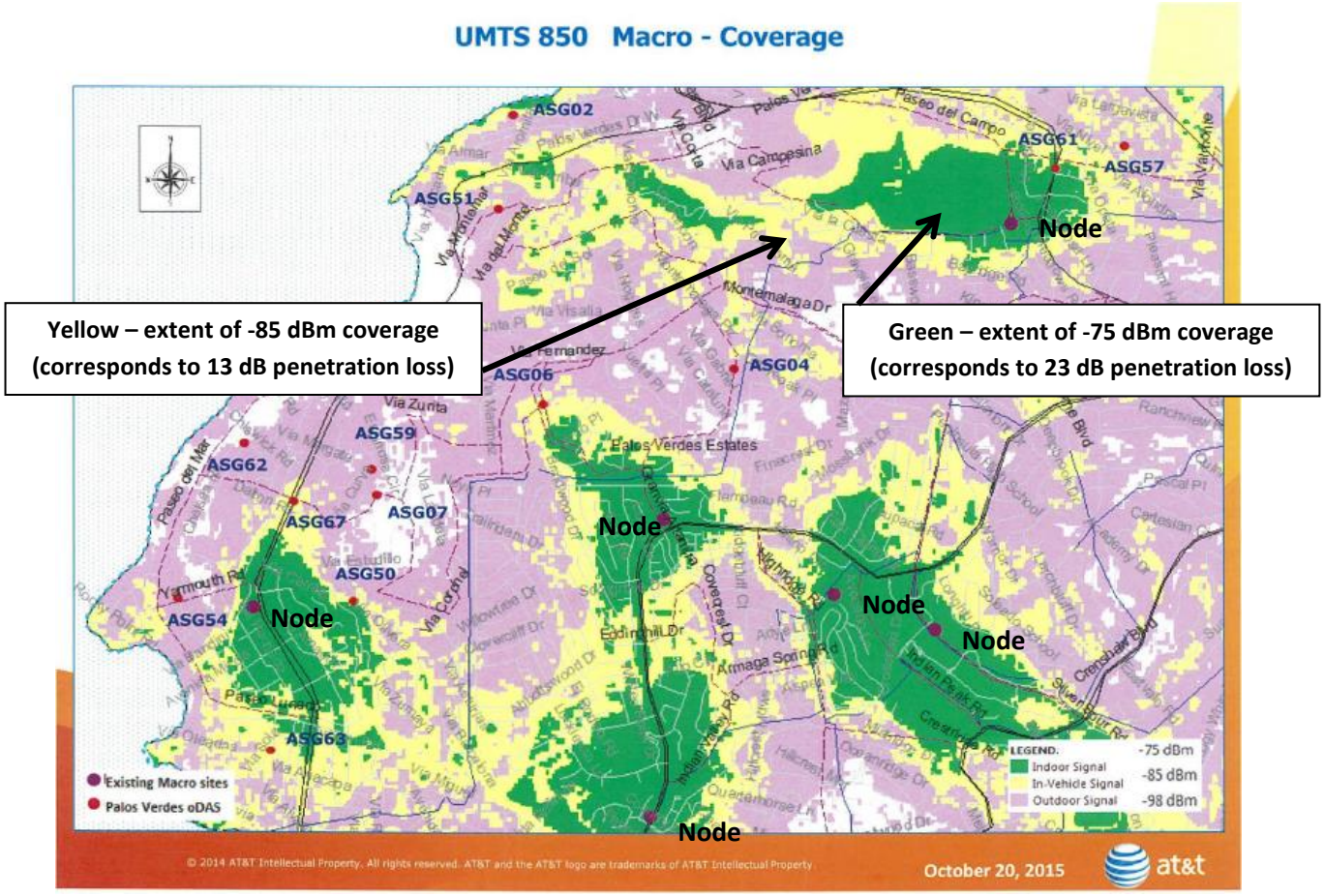
For the submitted UHF coverage maps, a maximum value of 11-12 dB is warranted for combined penetration loss and the associated statistical variance. (Note that the penetration loss variance must be root-sum-squared with the fading variance thus reducing its overall influence.) Even considering operation at the higher PCS/AWS frequencies (despite not being submitted by Crown Castle/ATT), combined penetration loss and variance is unlikely to exceed 15 dB. The table above also shows the value used by Crown Castle/ATT is more suited for high density environments. As evidenced by the

industry sources and technical literature cited, the 23 dB value used by Crown Castle/ATT is clearly excessive and erroneous.

While high penetration losses may be warranted in an urban/dense urban deployment analysis, it is entirely unwarranted and unjustified in the low density, light suburban neighborhoods of Palos Verdes Estates. This inappropriate usage results in the actual indoor coverage range of the proposed sites being significantly understated. This strongly indicates the proposed network is overdesigned with more sites proposed than required to prevent significant coverage gaps.

Impact on Indoor Coverage Range

Using coverage maps provided by Crown Castle/ATT, the site range impact of this error can clearly be seen. In the map below, coverage is shown for six sites (purple dots marked "node"). Coverage with a minimum of -75 dBm (corresponding to 23 dB penetration loss) is shown in the green patches. Coverage with a minimum of -85 dBm (corresponding to a more realistic and justifiable 13 dB penetration loss) is shown in the combined green and yellow patches. It is readily apparent that the area covered increases substantially using this lower threshold. This is unsurprising as area increases as the square of the coverage radius.



Coverage in Other Suburban Communities

The author has collected multiple Crown Castle applications submitted to other suburban communities for LTE DAS deployments. Previously, Crown Castle has stated that -85 dBm power density levels were acceptable for indoor suburban LTE coverage. As explained above, this is appropriate and contradicts the -75 dBm claims made in the PVE DAS deployment application. This is despite PVE's comparable suburban character.

It should also be noted that environmental characteristics unique to the Palos Verdes Peninsula such as topography and land cover are already included in the propagation model used to generate the service coverage plots. This is an important point; penetration loss solely includes the resulting signal decrease when moving from outdoors to indoors. Accordingly, it is only affected by the structures themselves and not by other environment variables.

PVE should require a factual substantiated technical explanation for this discrepancy. Any such explanation must include the utilized link budget, a clear explanation of how values are combined, justification of the utilized link budget values, and specific corroborated citations supporting and substantiating use of these values. This particularly applies to penetration loss as the value used is indefensible without a specific relevant rationale and a strong justification.

Coverage Requirement Claims by Crown Castle/ATT

The site justification provided by Crown Castle/ATT to PVE makes the following claims regarding in-building coverage:

> *The courts have upheld the use of in-building minimum standards as a proper benchmark for determining whether a significant gap in coverage exists. (See, e.g., MetroPCS Inc. v. City and County of San Francisco (N.D.Cal. 2006) 2006 U.S. Dist. LEXIS 43985 ["careful reading of existing cases that contain a significant gap analysis persuades the court that any analysis should include consideration of a wireless carrier's in-building coverage."].)*

Crown Castle characterizes "*in-building minimum standards as a proper benchmark*" for the significant gap test. It must be stressed that this is Crown Castle's interpretation and not the court's actual words. As quoted above, the court states it "*should include consideration of a wireless carrier's in-building coverage*".

The same court continues in a later passage "*that in-building coverage may appropriately be considered as part of a significant gap analysis"*. This conveys that in-building coverage is a proper factor (i.e. appropriate consideration) but it specifically does not require pristine in-building service coverage levels as defined by the carrier. In fact, the same court goes on to state:

> *In so holding, the court is mindful that the TCA [Ed: Telecommunications Act] does not guarantee MetroPCS seamless coverage in every location within the Richmond district. Indeed, courts have expressly recognized that the presence of "dead zones," or pockets in which coverage does not exist, are not actionable for purposes of arguing effective prohibition claims under the TCA. (MetroPCS Inc. v. City and County of San Francisco (N.D.Cal. 2006) 2006 U.S. Dist. LEXIS 43985)*

It is notable that Crown Castle only quotes from a 2006 district court ruling when there are additional recent court rulings that further clarify this topic. Closer to home, *Sprint PCS Assets v. the City of Palos Verdes Estates* (9th Cir, 2009) discusses "significant gap in coverage" in the context of carrier-provided propagation maps. The court was unequivocally clear in that the submission of such maps does not in and of itself establish a gap in coverage and that these *"determinations are extremely fact-specific inquiries that defy any bright-line legal rule".* The court continued:

> *The district court simply declared, as a matter of fact and fiat, that there was "a significant gap" in Sprint's coverage in the City. Sprint defends this factual finding on appeal, arguing that its presentation of radio frequency propagation maps was sufficient to establish a "significant gap" in coverage. We disagree.* (*Sprint PCS Assets v. the City of Palos Verdes Estates (9th Cir, 2009))*

This discussion is not meant to imply that the existing service coverage is free of gaps. However, it does demonstrate that PVE need not accept an excessive, overdesigned network (including superfluous sites and highly intrusive locations) to achieve unnecessarily high carrier-defined service coverage levels under the guise of closing a "significant gap".

It also draws attention to the large penetration loss discrepancy and the resulting flawed indoor coverage propagation maps. This is a serious defect and thus is not "extremely fact-specific". Furthermore, it invalidates the technical coverage requirement claims made by Crown Castle/ATT.

Conclusion

The analysis provided by Crown Castle/ATT to PVE includes an erroneous and inappropriate allocation for penetration loss that undermines required service coverage claims. This error likely resulted in the proposed placement of more wireless facilities throughout the city than would otherwise be required if the correct value had been used. This error also likely resulted in highly intrusive facility placement close to homes in residential neighborhoods rather than less intrusive sites on arteries or collector roads. PVE should immediately reevaluate these technical claims prior to approving any additional sites.