Independent and joint statistics of clutter loss and building entry loss – initial measurements

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***Abstract*—Models and measurements exist for building entry loss (BEL) and for loss due to local clutter. There appears to be less information on the combined effects of the two mechanisms, however. This paper reports on an initial set of measurements made at 3.5 GHz, in which the loss mechanisms were measured separately and in combination.**

***Index Terms*—radio, propagation, buildings, clutter, attenuation, measurement, 5G**

I. Motivation

The ITU-R has recently published two new Recommendations, one [1] giving a method for the estimation of building entry loss (BEL) at frequencies between 100 MHz and 100 GHz and the other an empirical model for the additional path loss due to local terminal clutter [2]. In the case of the BEL model, a necessary simplifying assumption in model development was that the building can be considered in isolation from its immediate environment.

While each model gives appropriate predictions for the specific loss cases in isolation, the general requirement is to predict the overall loss in cases where a building is surrounded by other buildings, trees and similar local clutter.

A simplistic approach would be to assume that the losses due to clutter and BEL would be multiplicative (i.e. that the overall excess path loss would be the sum, in dB, of the individual losses). Brief consideration suggests that this is unlikely to be the case. Once a certain level of screening is reached due to attenuation on one path geometry, it is likely that other geometries will provide lower loss coupling mechanisms.

Unfortunately, there appears to be little or no empirical data currently available that would allow this issue to be investigated in a quantitative manner. A set of pilot measurements has therefore been undertaken and is reported here.

II. Experimental arrangement

Measurements were made in and around two conveniently located buildings ('Arts A' and the 'Meeting House') on the campus of the University of Sussex (Fig 1).

Figure 1: Measurement geometry (image data: © 2018 Google)

The aim of the measurements was to gather three sets of statistical data for each location investigated:

- Building entry loss (BEL, in isolation)
- Clutter loss (to façade of building)
- Overall loss (clutter and BEL combined)

A rooftop transmitter site ('TX' in Figure 1) was chosen to give paths obstructed by clutter to both test locations. With the transmitter at this location, measurements were made of the fields immediately outside, and inside, the buildings.

The transmitter was then moved to locations that were line of sight to each building, and the outdoor and indoor measurements repeated.

An Ettus 'B200mini' software defined radio was used to generate a wideband sounding signal at a frequency of 3.5 GHz. This was amplified and used to drive a 12dBi antenna to give an EIRP of 25dBW. A software-defined receiver, with a 10dBi omnidirectional antenna logged power values are continuously, at around 5 samples.

The measurements procedure sought only to characterise the statistics of signal variation within individual rooms of each building. It was found, by following a semi-random path within each room, that independent measurements could reproduce the cumulative path loss distribution to within 1dB.

The building entry loss distributions shown below are derived in line with the method given in ITU-R Recommendation P.2040 [4], with the indoor measurements normalised on the basis of the median field measured immediately outside the building.

III. Results

A. *Building loss in isolation*

The BEL measurements made with the transmitter in line of sight to the buildings follow the method used in the measurements underlying the model of [1].

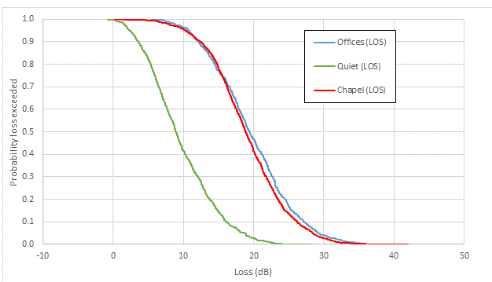

Figure 2: 'Meeting House BEL' (local TX)

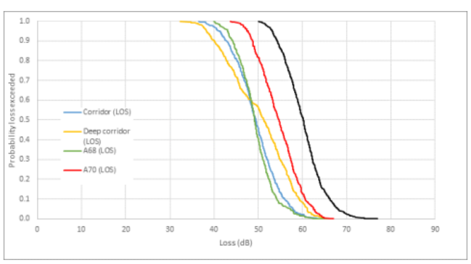

Figure 3: 'Arts A' BEL (local TX)

Figures 2 and 3 show contrasting loss distributions; those for the 'Meeting House' are typical of results for traditional buildings with light masonry walls and plain glass windows, while those for the 'Arts A' building are high, even by the standards of thermally-efficient buildings using a high proportion of metallised material in their construction.

B. *Building loss measured over a cluttered path*

BEL statistics measured with a cluttered path to the transmitter were derived in the same way as those above, with the indoor measurements normalised to the field measured immediately outside the building in the direction of the test transmitter.

The median clutter losses in excess of the free space loss were estimated by comparing the median received field measured at each building façade with the predicted free space field strength; clutter losses were 43dB on the 'Meeting House' path and 32dB on the 'Arts A' path.

The BEL values derived using cluttered path data (Figures 4 & 5) were significantly smaller than those using uncluttered test transmitters, by some 10dB in the case of the 'Meeting House' and around 30dB in the case of the 'Arts A' building.

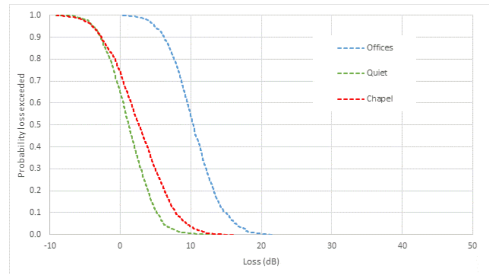

Figure 4: 'Meeting House BEL' (cluttered TX)

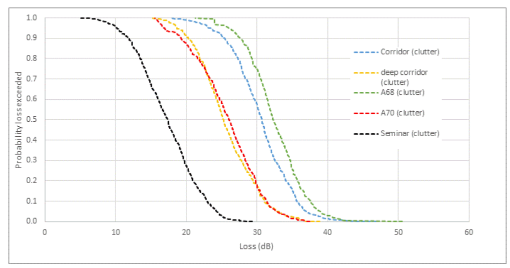

Figure 5: 'Arts A' BEL (cluttered TX)

IV. Conclusions

These initial results tend to confirm the presumption made above, namely that building entry loss and clutter loss cannot be treated as multiplicative, and that the ultimate combined loss will tend to an asymptotic value determined by the details of building geometry and the surrounding environment. Further measurements are planned

References

[1] "Prediction of Building Entry Loss", Recommendation ITU-R P.2109-0, Geneva, 2017.

[2] "Prediction of Clutter Loss", Recommendation ITU-R P.2108-0, Geneva, 2017

[3] "The development of the new ITU-R model for building entry loss, Richard Rudd et al, 12th European Conference on Antennas & Propagation 2018 (EuCAP 2018), London, April 2018

[4] "Effects of building materials and structures on radiowave propagation above about 100 MHz", Recommendation ITU-R P.2040-1, Geneva, 2015