

Multihop ART-to-ART Path Loss Model

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Purpose:

To adopt the recommended path loss model for above rooftop (ART) links

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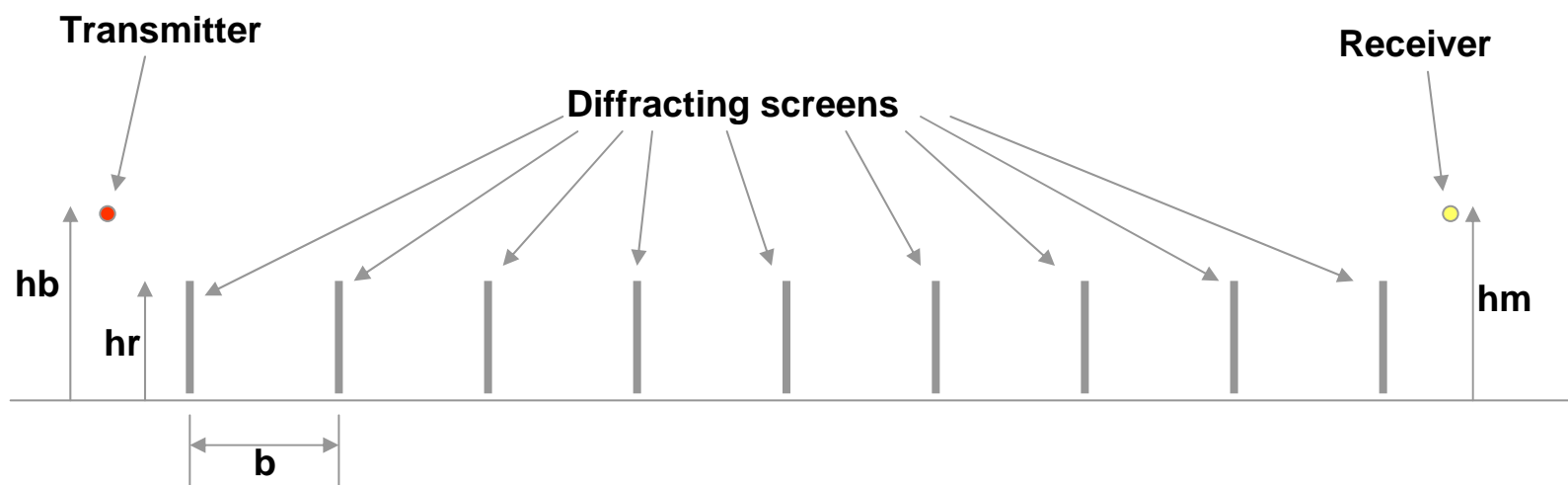
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Introduction

- This presentation considers path loss models for links where the transmit and receive antennas are both located Above Roof Top level (ART) in an urban environment
- Within the context of IEEE 802.16j this covers BS-RS and RS-RS links (BS = Base Station, RS = Relay Station)
- A modified COST 231 W-I path loss model has been proposed earlier. This model is compared in this presentation to Vogler's multi-screen diffraction model, and it is also compared to some measured data at 5.3GHz from the IST MIND project
- The model is shown to give reasonable performance, and it is recommended that it be adopted

Multi-screen diffraction scenario



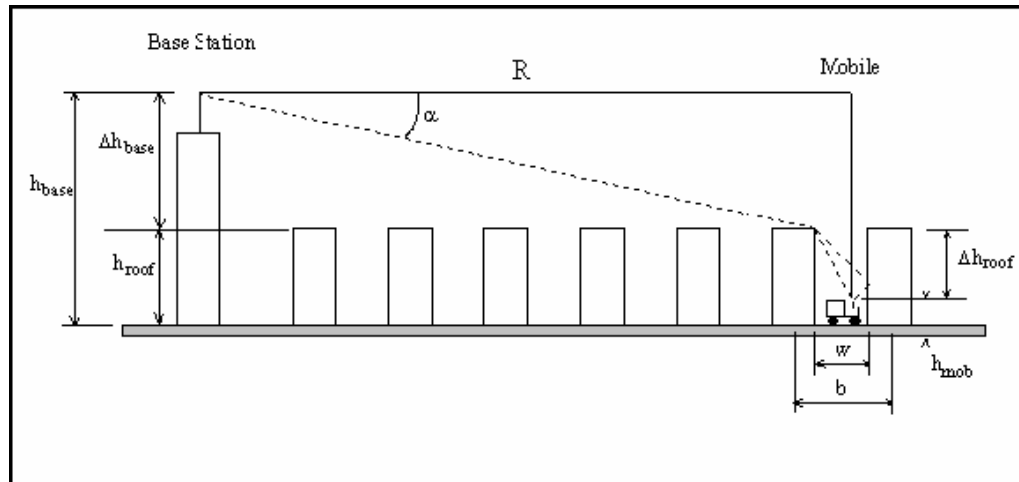
b = Distance between diffracting screens

hb = Transmit antenna height

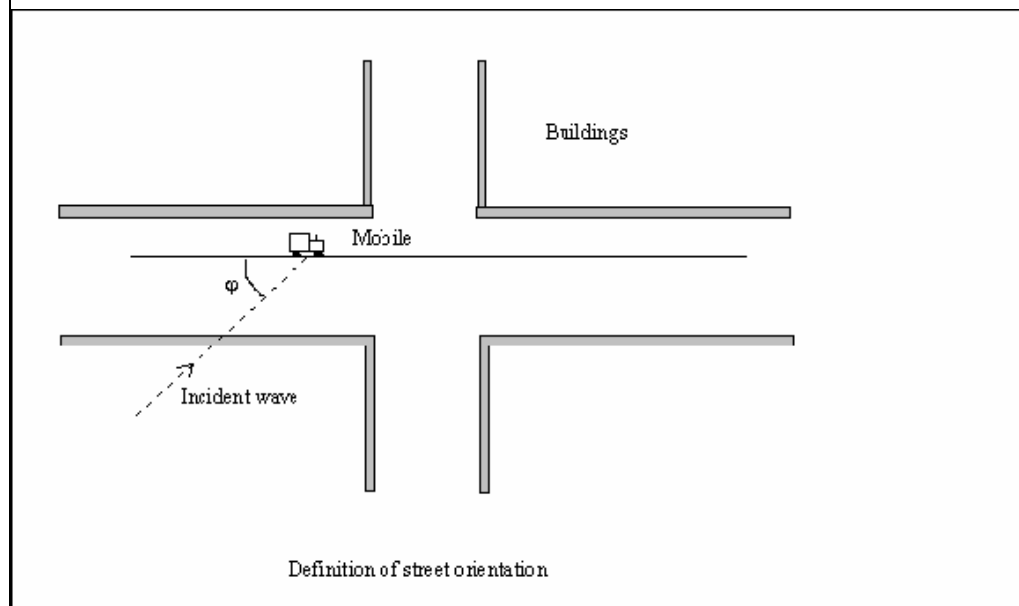
hr = Height of diffracting screens

hm = Receive antenna height

Parameters for COST 231 W-I Model



The parameters used in the COST 231 W-I model are as shown in the illustrations on the left



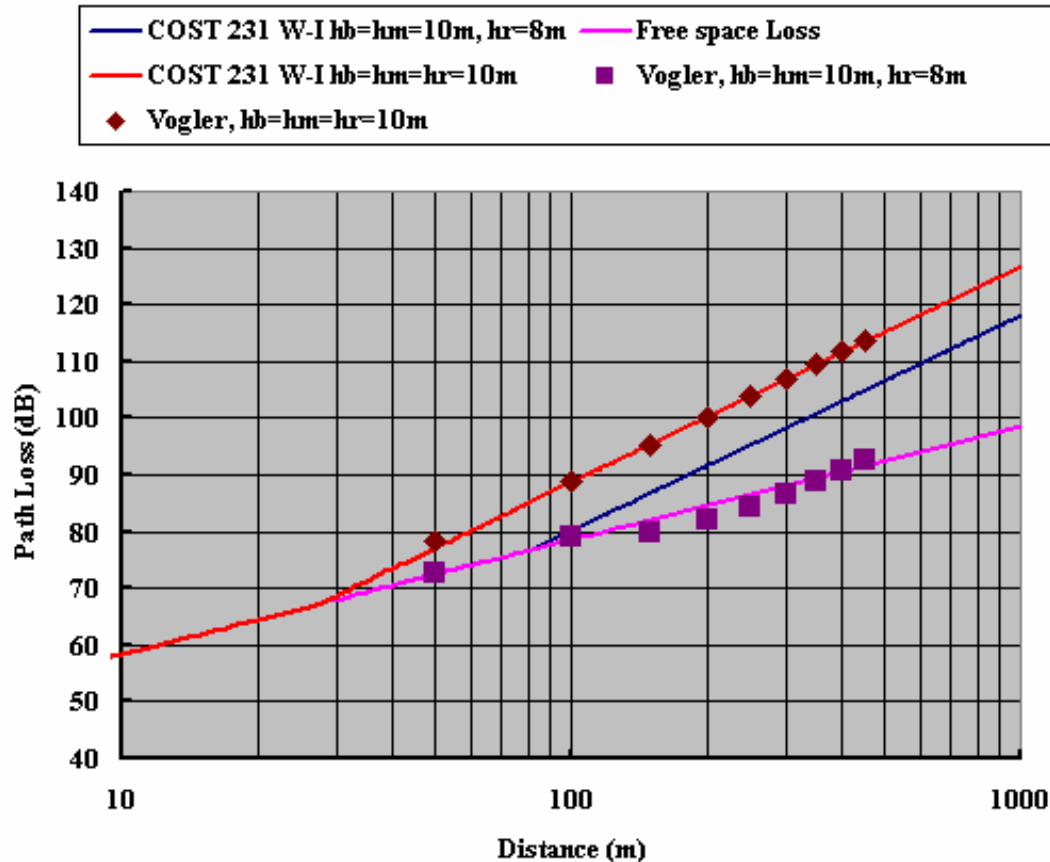
Modified COST 231 W-I Model

- The COST 231 W-I model consists of three terms:-
 - Free space loss
 - Multi-screen diffraction loss
 - Rooftop-to-street diffraction loss
- For the ART scenario there is no rooftop-to-street diffraction and so the third component is dropped. The free space and multi-screen diffraction terms only are then used to estimate the ART-to-ART path loss

Parameter Settings for Comparison

- Building/diffraction screen spacing, $b = 50\text{m}$
- Width of street, $w = 30\text{m}$
- Tx antenna height, $h_b = 10\text{m}$
- Rx antenna height, $h_m = 10\text{m}$
- Roof/diffraction screen heights, $h_r = 8\text{m}, 10\text{m}$
- Street orientation, $\phi = 90^\circ$
- Frequency, $f = 2\text{GHz}$

Results of Comparison



Results show that when the Tx and Rx antennas are mounted at the rooftop height, the Vogler multi-screen diffraction analysis agrees with the modified COST 231 W-I model

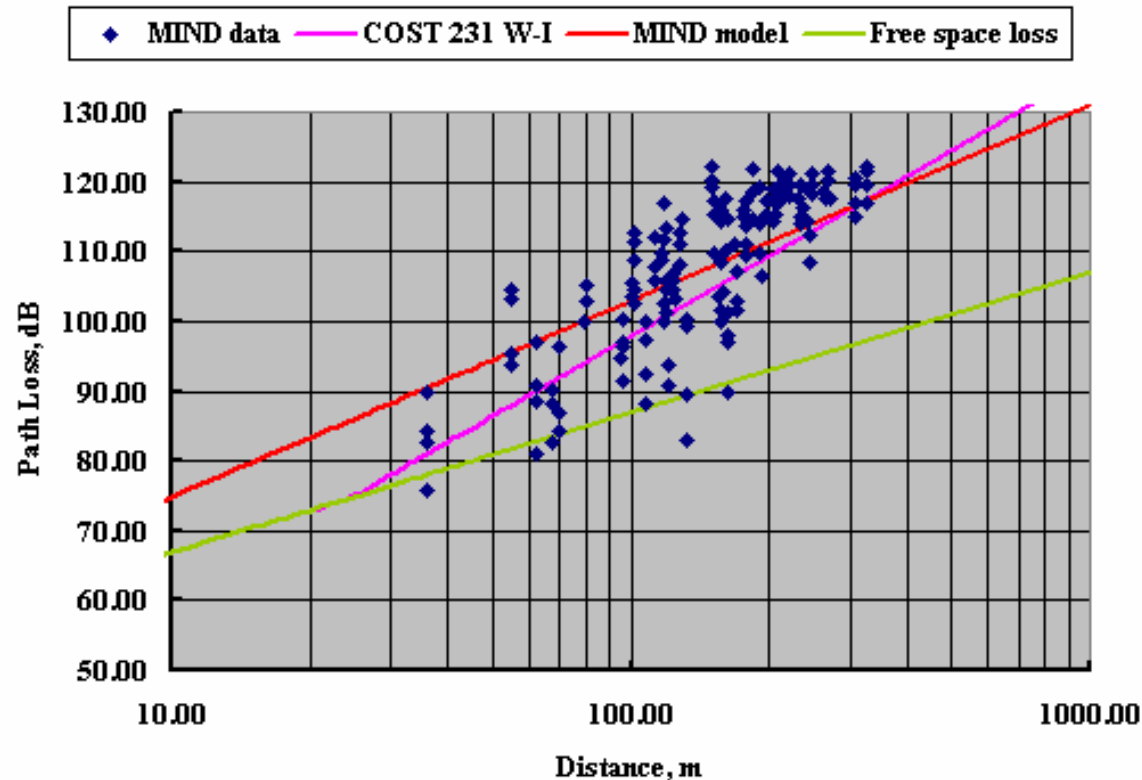
As the Tx and Rx antennas are raised above the diffraction screens, the Vogler analysis quickly predicts a path loss close to free space path loss

From the Vogler results should we expect close to free space path loss for the ART-to-ART links?

IST MIND Results at 5.3GHz

- Rooftop radio channel measurement campaign in Latokaski, a suburban area outside Helsinki
- Most houses were greater than 5m in height but less than 8m, with trees taller than the houses in between
- Measurements at 5.3GHz
- Measurements were made with Tx and Rx antenna heights of 5 and 8m

Comparison of COST 231 W-I with IST MIND Measurements



The plot shows a comparison of the modified COST 231 W-I model with the measured data from IST MIND, and the IST MIND empirical path loss model

For this case:-

$b = 50\text{m}$

$w = 30\text{m}$

$h_r = 6.5\text{m}$

$h_b = h_m = 8\text{m}$

$f = 5.3\text{GHz}$

Measured above rooftop path loss does not correspond to free space loss, having an exponent >2 . The modified COST 231 W-I model gives a reasonable estimate of the path loss, although it appears to slightly underestimate it (note: the model is being used a long way out of its specified frequency range)

Discussion

- The path loss for (limited) above rooftop measurements at 5.3GHz has been found to be greater than free space path loss
- This is due to the effects of trees/foilage
- Shadowing effects due to trees or perhaps very tall buildings are likely to have a similar effect in urban areas
- A simple uniform height multi-screen diffraction model therefore leads to an optimistic path loss for the above rooftop case
- The modified COST 231 W-I model appears to give a reasonable estimate of the path loss, even at 5GHz

References

- ‘The Attenuation of Electromagnetic Waves by Multiple Knife-Edge Diffraction’, L.E.Vogler, NTIA Report 81-86, October 1981
- ‘On the Propagation Characteristics of the 5GHz Roof-to-Rooftop Meshed Network’, IST Mobile & Wireless Telecommunications Summit, 17-19 June 2002, Thessaloniki, Greece