

Measurements of Propagation of Sound over Water at Low to Mid Frequencies Applicable to Wind Turbine Noise Calculation

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Propagation Over Water

- No accepted model for noise from offshore noise sources like wind farms.
- ISO 9613(2) intended for land, not water.
- Not many good measurements.
- Need loud isolated noise source close to or on the water.

Burlington Skyway



Measurement Location 2010

- The Skyway is probably the loudest noise source on the lakeshore, estimated at 142 dBA re 10^{-12} W at night,
- Burlington Skyway is 3km long and 75m high, and offshore wind farms could have similar dimensions
- Traffic noise is quite stable as demonstrated by repeat of 2km measurement

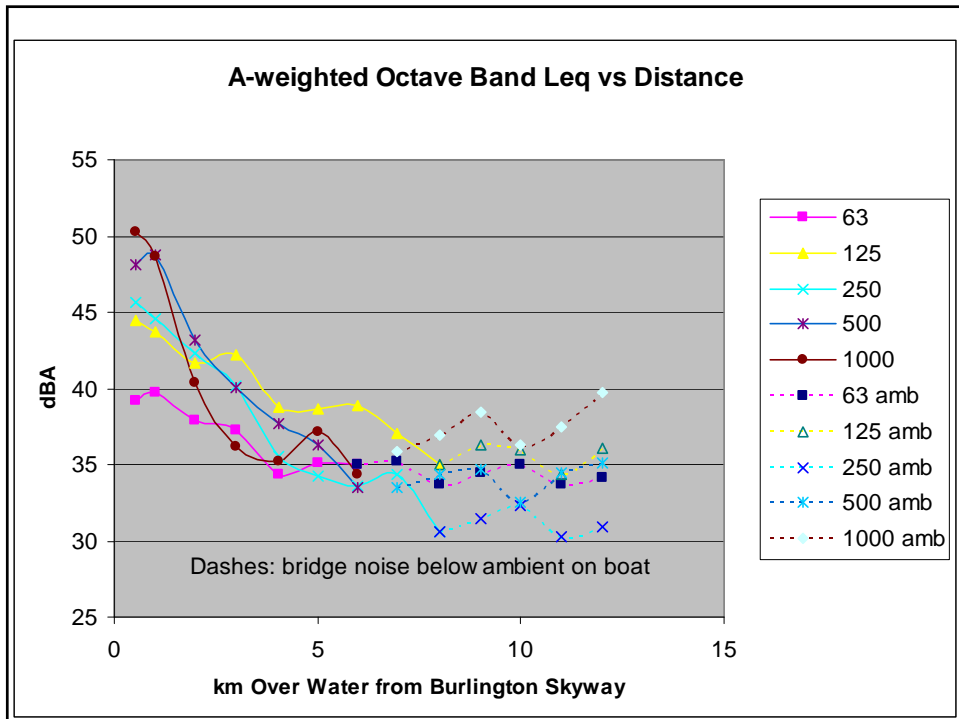
Microphone



Measurement Points



A-weighted Octave Band Leq vs Distance



ISO 9613(2) Prediction

$$L_{pT}(DW) = L_w + D_c - A$$

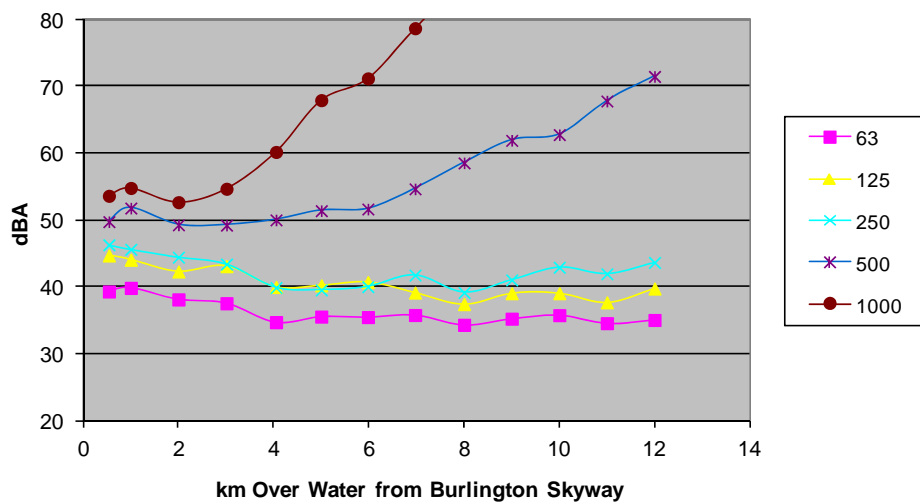
Where DW = Downwind
Dc = Directivity and

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$

where

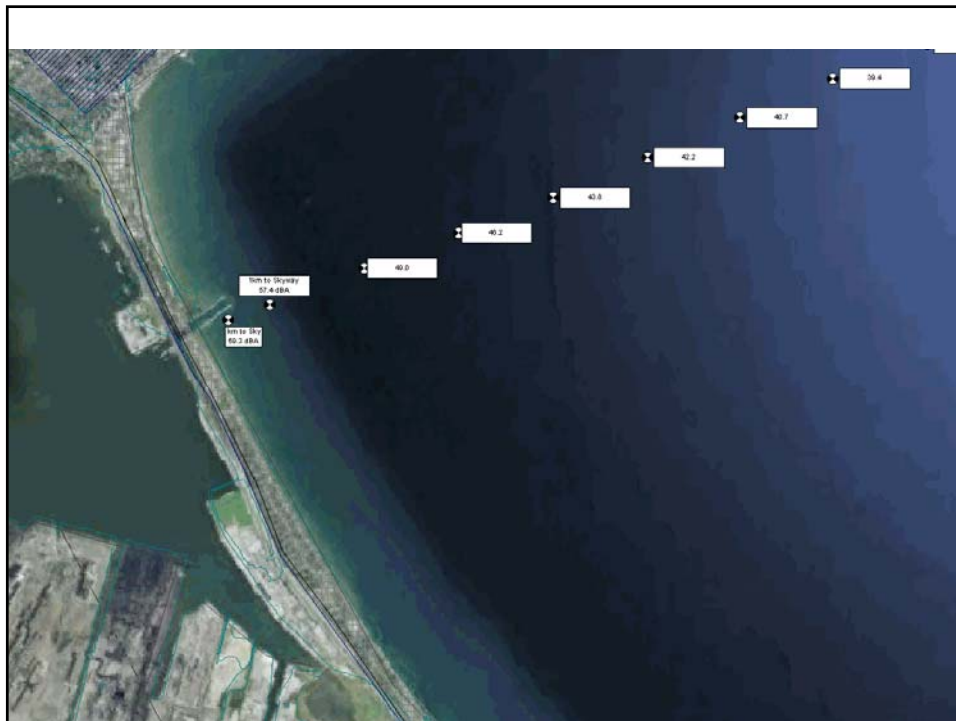
- A_{div} is the attenuation due to geometrical divergence (see 7.1);
- A_{atm} is the attenuation due to atmospheric absorption (see 7.2);
- A_{gr} is the attenuation due to the ground effect (see 7.3);
- A_{bar} is the attenuation due to a barrier (see 7.4);
- A_{misc} is the attenuation due to miscellaneous other effects (see annex A).

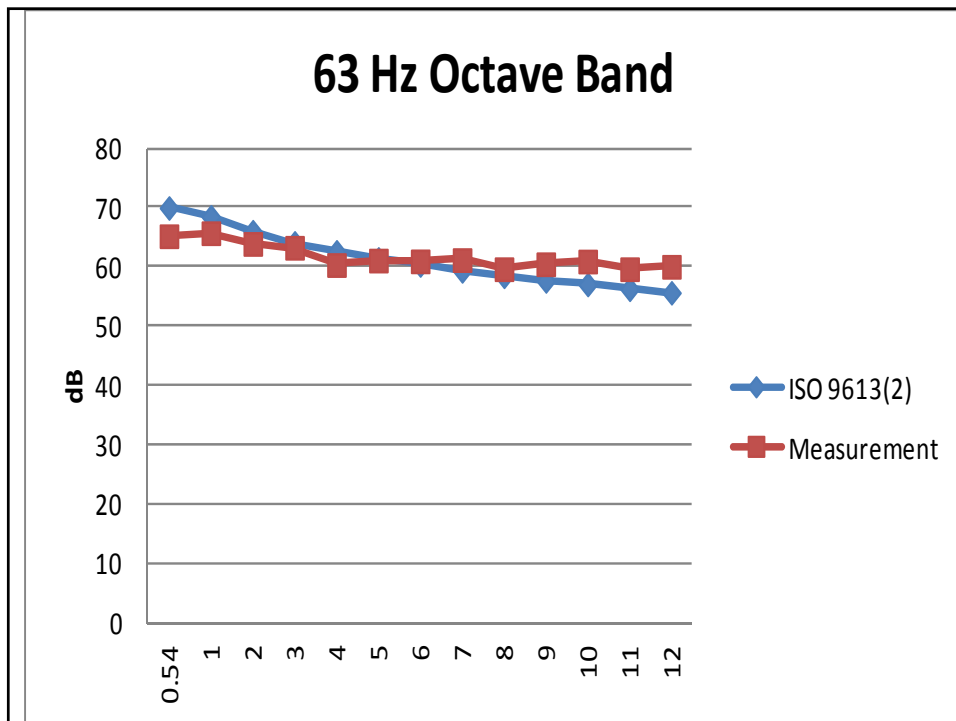
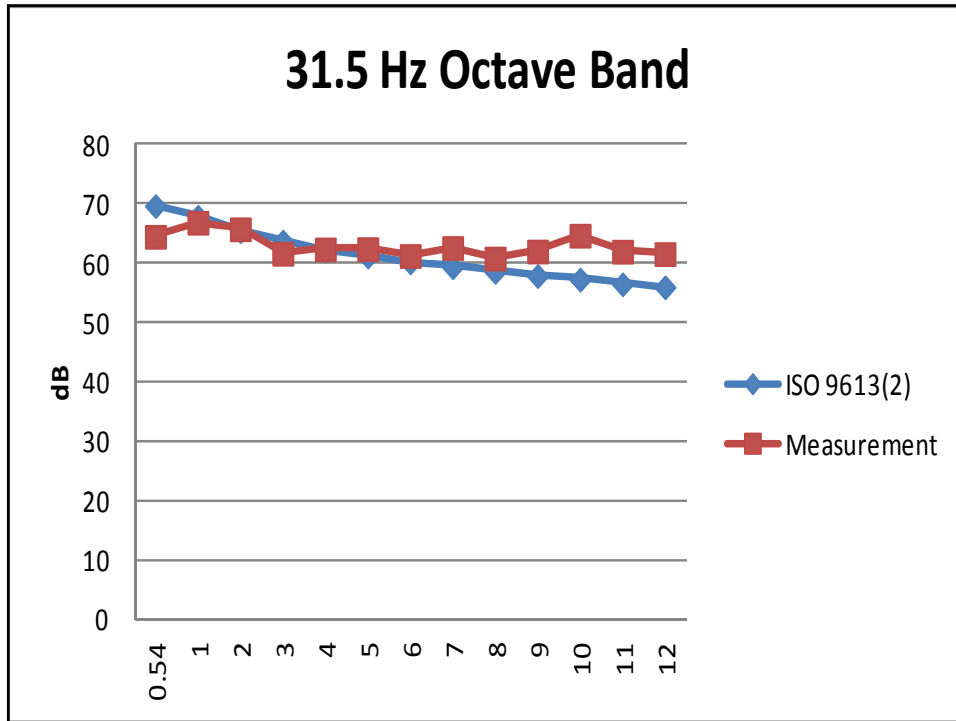
A-weighted Octave Band Leq vs Distance from QEW With Air Absorption Added Back In

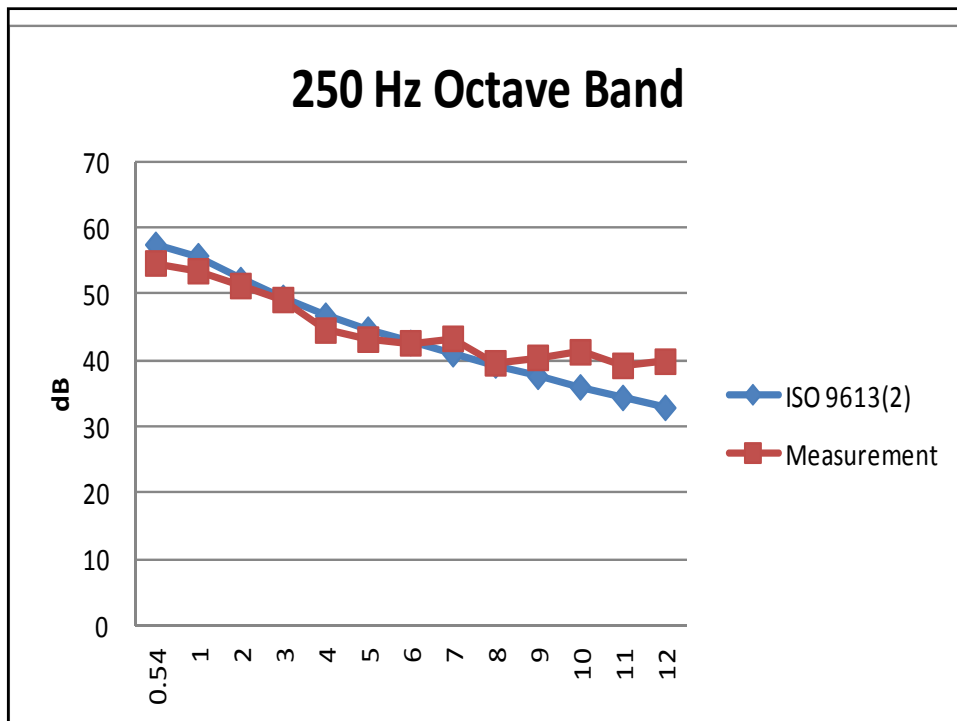
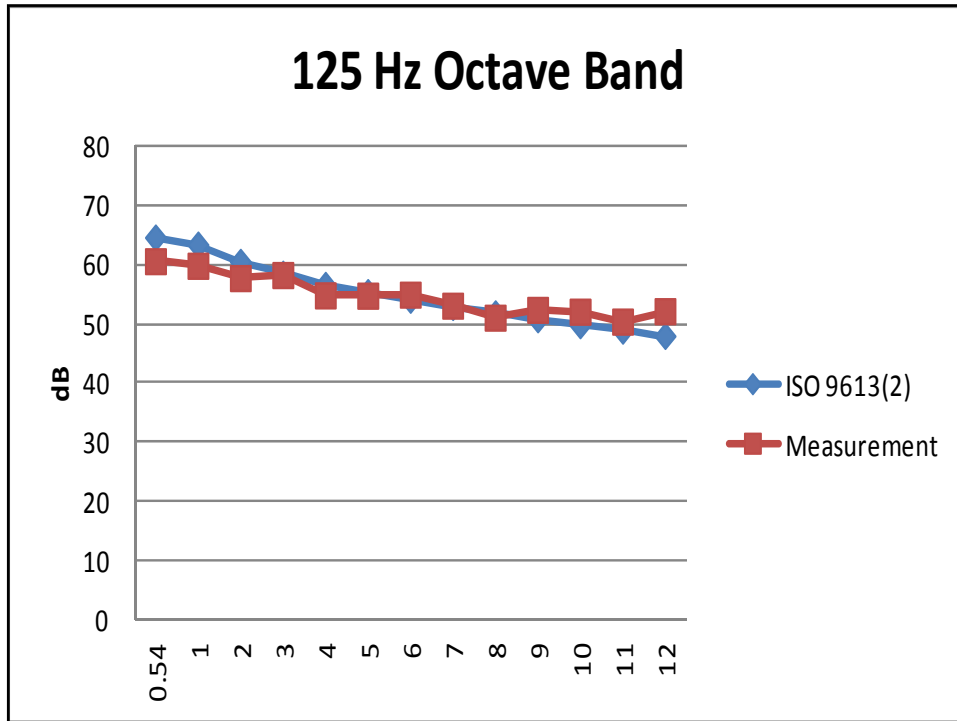


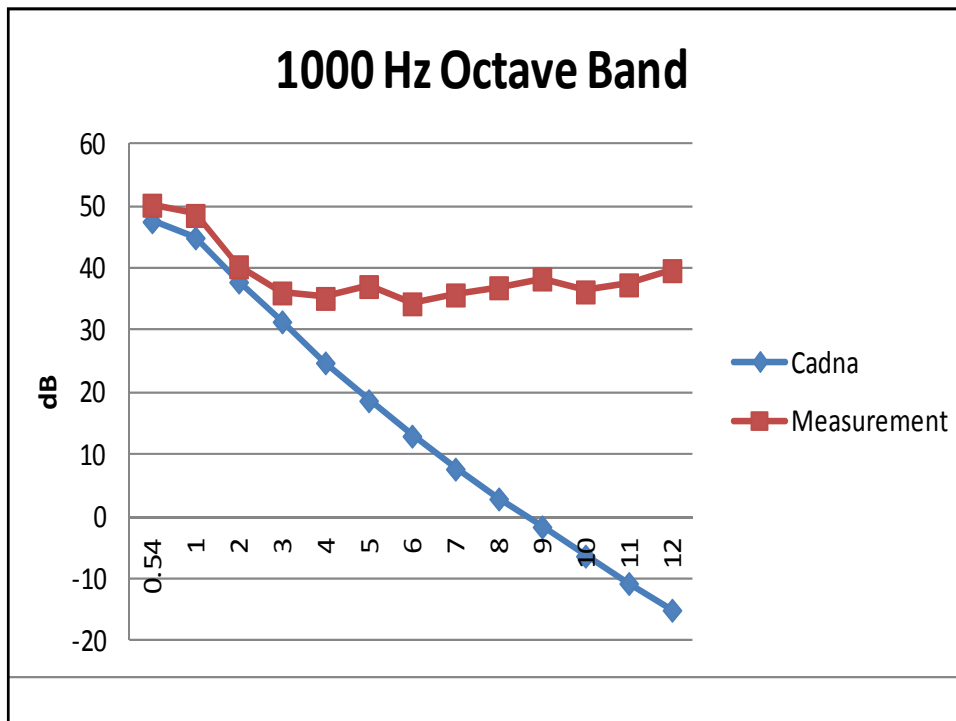
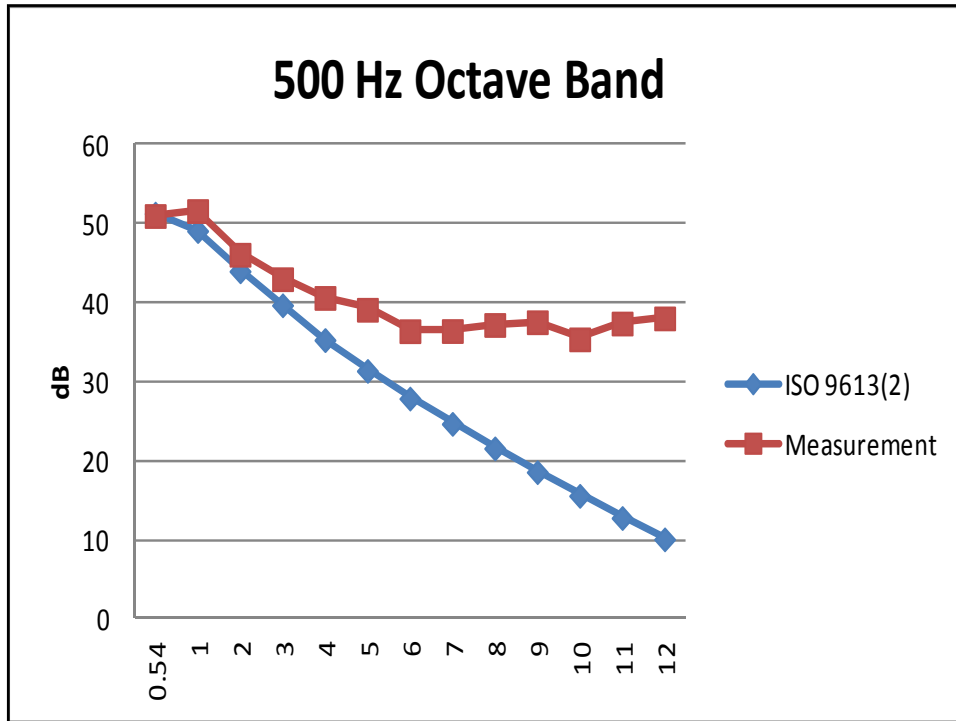
Cadna-A Model

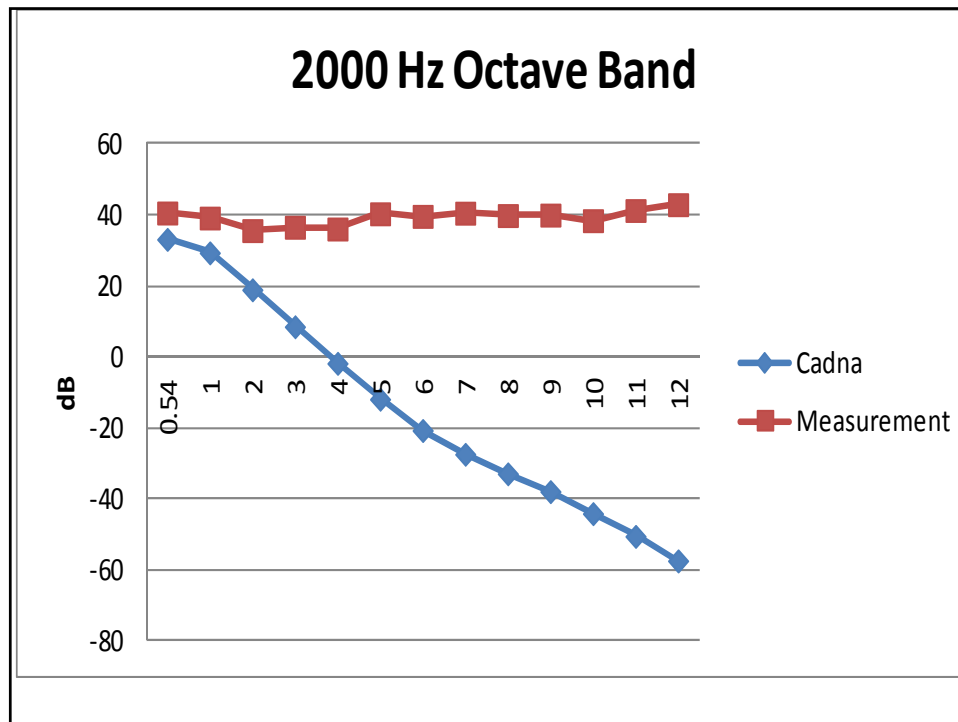
- ISO 9613(2) acoustical model
- Line sources representing east and west bound QEW lanes
- Ground Absorption of zero over water 0.5 over land
- Residential area modelled as scattered buildings
- Bridge parapets modelled as barriers.











Conclusions

- ISO 9613(2) agreement with measurements adequate up to 500 Hz and 3-4 km (the limit of these measurements).
- Air absorption at 500 Hz is 13.5 dB at 5 km.
- It roughly doubles for each octave above 500 Hz.
- Therefore for practical purposes ISO 9613(2) appears to be useful for modeling wind turbines and other broadband noise sources over water.
- Further measurements needed to confirm.

ACKNOWLEDGEMENTS

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