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Propagation Predictions and Verification for Communication and Radar

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RESEARCH QUESTION

For any communication system (of which radar is a special case), a transmitter, propagation media and receiver is needed. Modern electronics has changed the transmitter and receiver complexity tremendously during the last few decades. The propagation media, which is the lower atmosphere for terrestrial point-to-point type communications and radar, is not under human control, but is controlled by physical laws. We can only strive to understand the physical laws, model them, and build our transmitters and receivers for optimal use of the available resource.

CSIR Defence, Peace, Safety and Security is using propagation prediction software to predict the propagation effects of both communication and radar systems. The available software is based on different models. Some of these models are based on physical principles. To make it possible to implement the models for use by non-scientific users on computers readily available, assumptions are made to simplify the models. Other models are based on empirical data. Before the software is used on a large scale, and important decisions made on the basis of results obtained from studies conducted with the software, it is important to understand the effect of the assumptions made, and to validate the models used.

EXPERIMENTAL SET-UP

The propagation models that were used in the study included the following:

- Free Space Model;
- R^n Model;
- Ground Reflection Model (GRM);
- Egli Model; and
- Advanced Propagation Model (APM) (marked AREPS in the figures).

Most of the effort was expended on the APM model, as it is the most sophisticated, and should give the best results. The APM is a hybrid model that consists of four sub-models namely:

- A flat earth model;
- A ray optics model;
- An extended optics model; and
- A split-step parabolic equation (PE) model.

The measurements were performed using a transmitter on a helicopter and a spectrum analyser based receiver on the ground. Two types of experiments were performed. In the first, the distance was kept constant, and the height varied over a range where large variations in signal levels were predicted. In the second type of experiment, the height was kept constant and the distance varied over a distance and height combination where little variation in signal strength was predicted.

RESULTS

Figure 1 and **Figure 2** show the comparison for one specific experiment at very high frequency (VHF) and at ultra-high frequency (UHF). Not one of the models gives an excellent fit. The total unsuitability of the free space and R^n models can immediately be seen. The Ground Reflection and Egli models give the correct curve form at VHF frequencies, but fail at UHF frequencies to give the correct curve. The APM model gives a good fit at greater heights, but underestimates the loss at lower heights. As the terrain was covered with trees, it was suspected that at UHF frequencies, the effective ground height is the height of the tree tops. To test this theory, the height was changed to the tree top height and **Figure 3** shows the results. There is now a very good match between the APM results and the measured data.

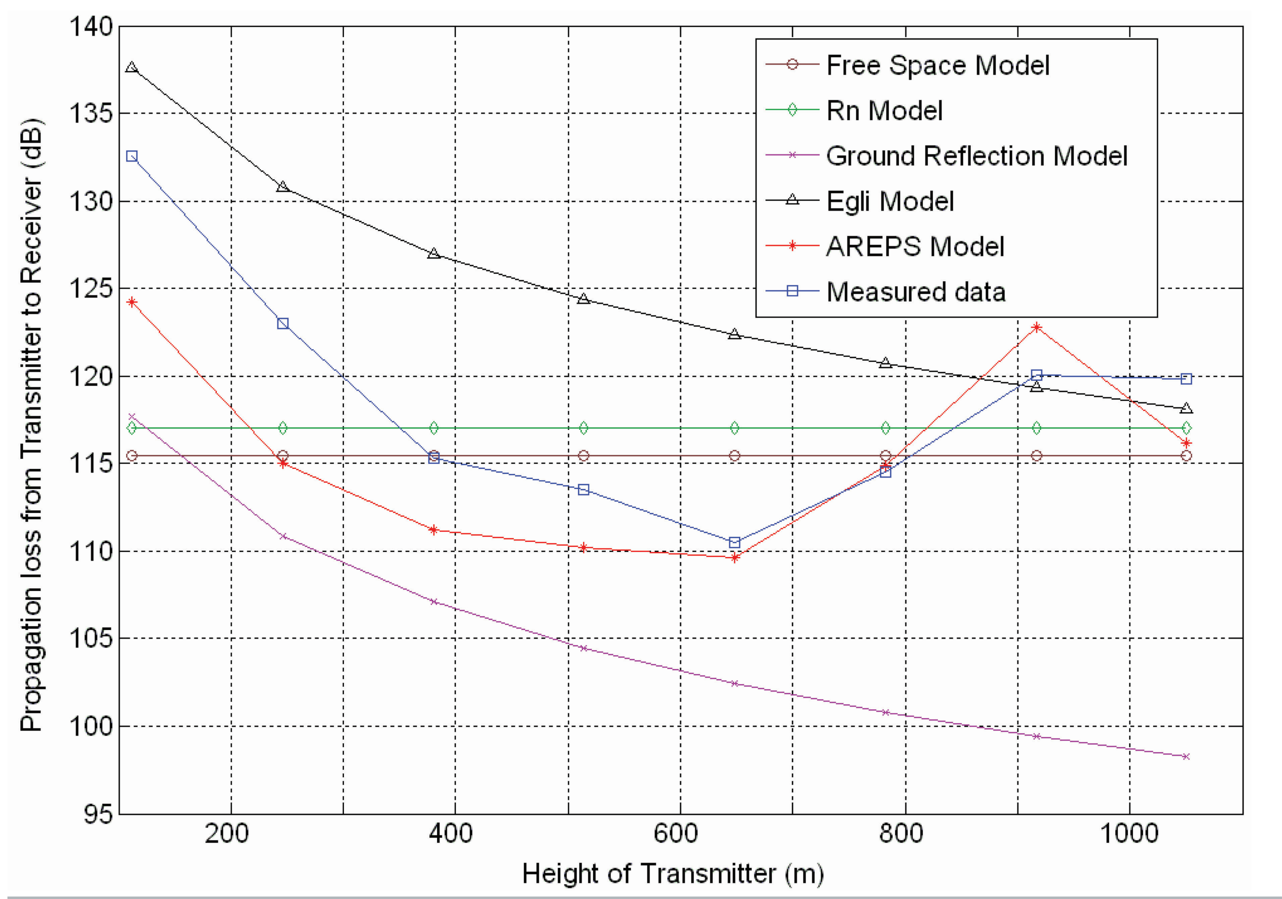

Figure 2: Comparison between Predicted and Measured Propagation Loss at UHF frequencies.

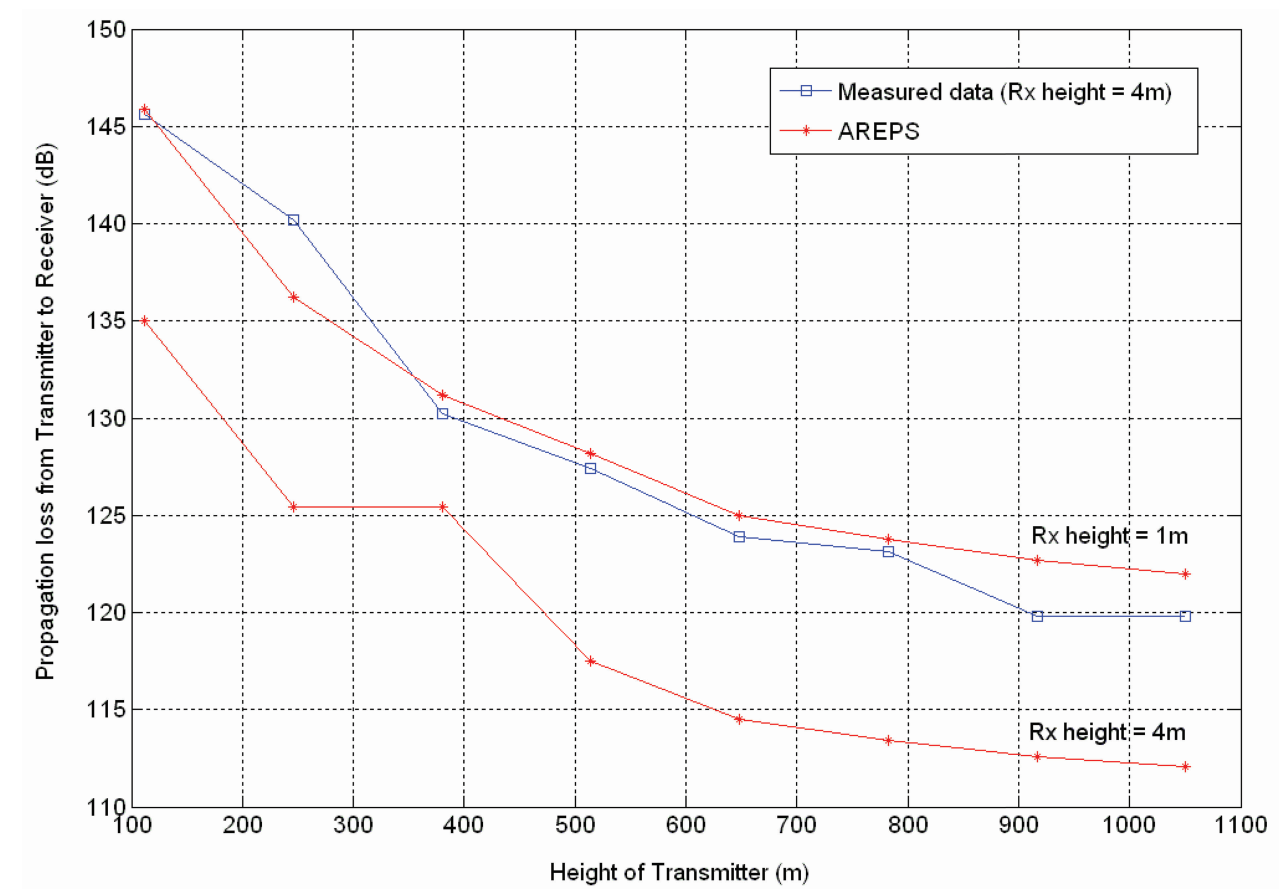

Figure 3: Comparison between Predicted and Measured Propagation Loss at UHF frequencies with changed height.

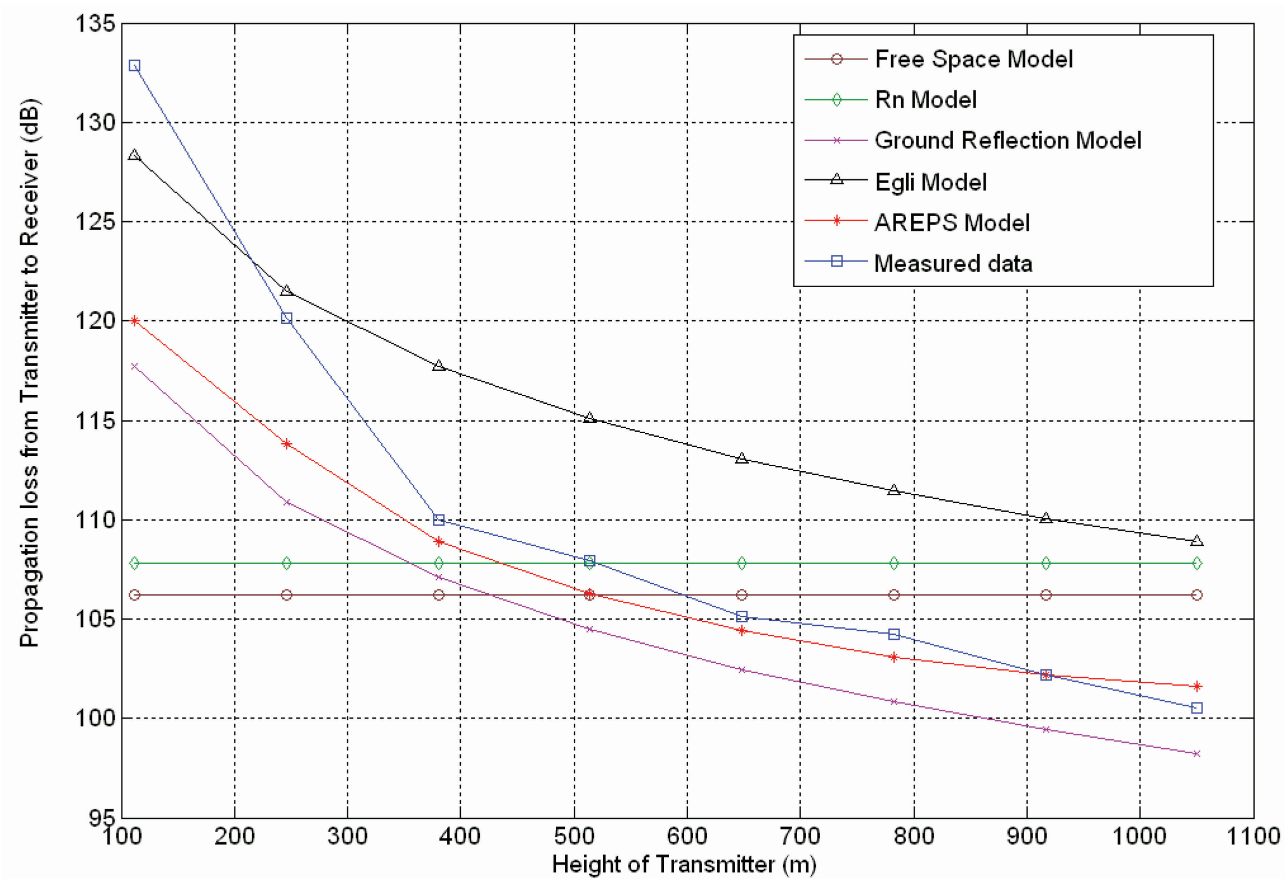

Figure 1: Comparison between Predicted and Measured Propagation Loss at VHF frequencies.

CONCLUSION

It was found that the AREPS model is the most accurate model. The Ground Reflection Model is very optimistic while the Egli model is very pessimistic.

It was found that to obtain accurate results, it is important to understand the effects of the terrain, and especially the fact that the effective height is influenced by trees at different frequencies.

In future, it is intended that the APM programme will be validated for the operation of radar over the sea.

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